Plainville, MA

Whiting Pond Bypass Culvert at West Bacon St

MassDOT P12007-973-MUN-BRI

June 2021

CULVERT EVALUATION REPORT

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CULVERT EVALUATION REPORT

Prepared by: BETA GROUP, INC.
Prepared for: Town of Plainville

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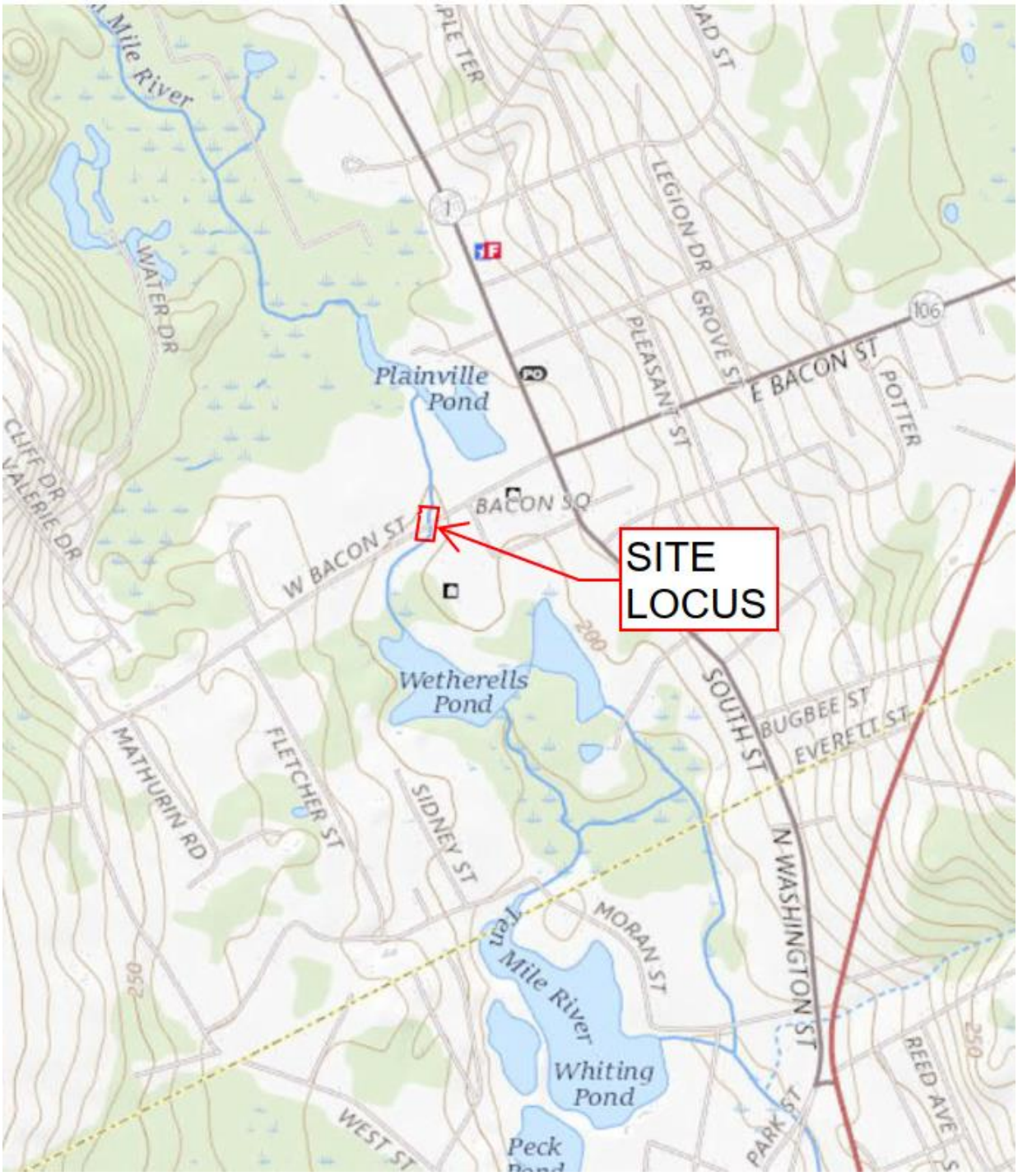
1.0 PROJECT LOCUS

Figure 1-1: Project Locus – USGS



2.0 Objective of Report

This report is provided to document the existing condition, capacity and vulnerable of this culvert to climate change. It is meant to evaluate potential issues such structural stability and flooding issues associated with higher current rainfall depths. This information will be utilized to prioritize capital improvement projects for the protection of public infrastructure, roadway and utilities, potentially improve the environment and connectivity of the stream.

The culvert was analyzed for the 25- and 100-year storm events for capacity and flooding purposes

3.0 Calculation Methods and Assumptions

The hydrologic and hydraulic flow calculations were completed stormwater runoff is analyzed using the following:

- Flood Insurance Study revised June 9, 2014
- Flood Insurance Rate Map Norfolk County. Massachusetts 25021C0339F effective July 16, 2015 provided by Federal Emergency Management Agency
- Culvert information was obtained via a field observation completed in May 2021.
- StreamStats flows data (workspace ID: MA20210504144106929000) (see Appendix C)
- HY-8 Culvert Hydraulic Analysis Program provided by the Federal Highway Administration
- Technical Paper No. 40 (TP-40) Rainfall Frequency Atlas of the United States
- NOAA Atlas 14 Point Precipitation Frequency Estimates

Note FEMA information for the outlets

4.0 Project Area Location and Culvert Description

Plainville Pond has two outlets. The first is a culvert system located on the south side of the Pond with an inlet 54 inch wide by 72-inch-deep box that transitions to twin 30-inch RCPs that outlet into a stream off the southwest corner of the parking lot on the southwest quadrant of the intersection of South Street and West Bacon Street. The second is a dam control structure off Ten Mile River north of the Plainville Pond. FEMA labels the first outlet as Ten Mile River and the second as Whiting Pond Bypass. This evaluation is of the culvert that crosses West Bacon Street from the stream from the second outlet

Whiting Pond Bypass flows out of the north end of Plainville Pond, 840± ft south, then passes under West Bacon Street and then another 840± ft to Wetherells Pond.

This structure consists of a two-span granite masonry culvert, which was completed in 1844. The out-to-out length of the structure is approximately 45’-6” with 6’-9” wide spans, 4’-6” high. The pier has a width of about 3’-6”. The depth of fill over the structure is about 6”. The depth of flow at the time of inspection was approximately 8” at each entrance while flowing southward.

The roadway width from edge of pavement to edge of pavement is 29’-0”. There is a 4’-6” wide sidewalk on the north side and a shoulder area on the south side. There is an entrance to a cemetery directly before the culvert, on the south side of the east approach

There are overhead wires on the north side. There is an elevated manhole present in the brush to the northeast side of the culvert (See Photo 13). Guardrail is present on the north side, while the south side

has a fence present over the culvert. The waterway on both sides contains some debris and heavy vegetation.

5.0 Culvert Condition

The overall condition of the structure is fair with some deficiencies noted. There are voids, loose and/or missing mortar joints, and loose and/or missing chinking stones typical throughout. There is cracking and active leakage on the roof of the masonry slab, present in each span. The south side of the west span has a 1/8" wide crack that is fully through the clapper (Photo 12). There are voids along the water line at each abutment, with a 29" deep void at the northeast abutment corner (Photo 11). The northwest abutment corner has voids up to 27" deep and is slightly displaced up to 4" (Photo 10).

The pier also exhibits typical areas of voids, loose and/or missing mortar joints, and lose and/or missing chinking stones. There is a gap between the slab and the pier, measuring at 6" max. The wingwalls also have deteriorated mortar joints and loose and/or missing chinking stones.

The embankments on both sides have overgrowth into the channel. There is debris present throughout, which is worse in the west span (See Photo 9). At the south end of the pier there is a tree growing with vegetation blocking flow (See Photo 8).

The roadways at either approach are in good condition, but the roadway over the culvert is in poor condition. The roadway over the culvert is at a higher elevation than the approaches (Photo 15 and 16). This change in elevation creates a speed bump for travel over the structure. The north sidewalk is in poor condition with numerous cracks and settlement (Photo 16). The south shoulder area also has settlement (Photo 18). The safety rails over the structure are in poor condition. The guardrail on the north side is not secure throughout and exhibits corrosion at the base of the posts. The metal fence on the south side is heavily corroded and is leaning off towards the river.

6.0 Data Collection

The following are the data sources and hydrologic data use for this evaluation

Table 6-1: Data Sources

Data Type	Source	Details
Culvert Data	BETA Group, Inc. (2021)	Field Measurements
Structural Evaluation	BETA Group, Inc. (2021)	
Project Locus	USGS	
Aerial Mapping	Google Earth (2020)	
Flood Data	Flood Insurance Rate Map (FIRM) Zone AE –elevation 200	Community Panel No. 25021C 0339F
Stream Profile	FEMA – FIS Norfolk County, MA	Ten Mile River Flood Profile 208P
StreamStats Report	USGS (2020)	Workspace ID: MA20210504144936011000

Table 6-2: Hydrologic Data

Hydraulic Design Data				
Drain Area	3.32 sq. mi.		Design Flood Discharge	384 cfs*
Bank Full Width	23.3 ft		Design Flood Frequency	25-year
Base (100-year) Flood Data*				
Base Flood Discharge*	552 cfs*		Base Flood Elevation	199 (NGVD)
Flood of Record				
Discharge	Unknown		Maximum Elevation	Unknown
Frequency	Unknown		Date	March 1968

*Adjusted for Climate Change

7.0 HY-8 Model – Existing Culverts

Field measurements were taken to develop a basic hydraulic model using HY-8 program. The results indicate that the combination of the two culverts is insufficient to convey the 25-year storm flows (384 cfs – Streamstats data modified for climate change). The following figures and table show that the road overtops during the design (25-year storm).

Note elevations are based on an assumed datum.

Figure 7-1 HY-8 Model Input Data

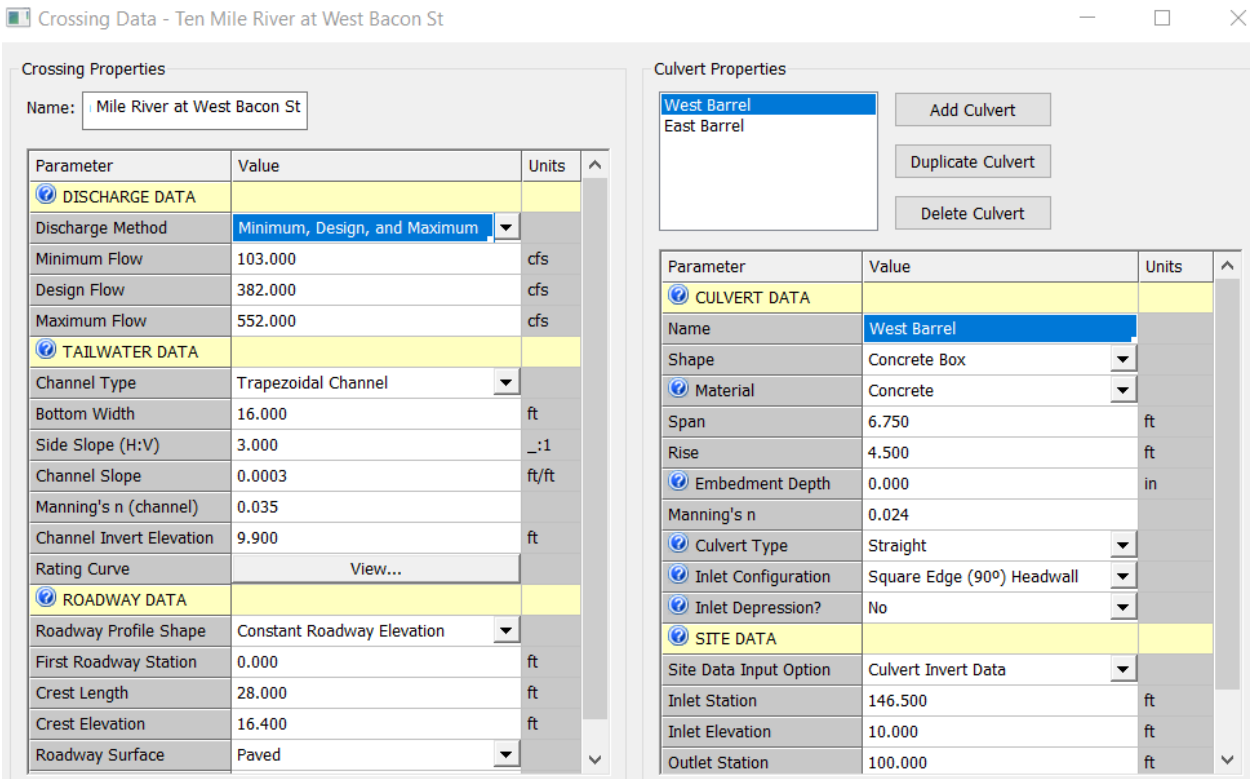


Figure 7-2 HY-8 Existing Model Overview

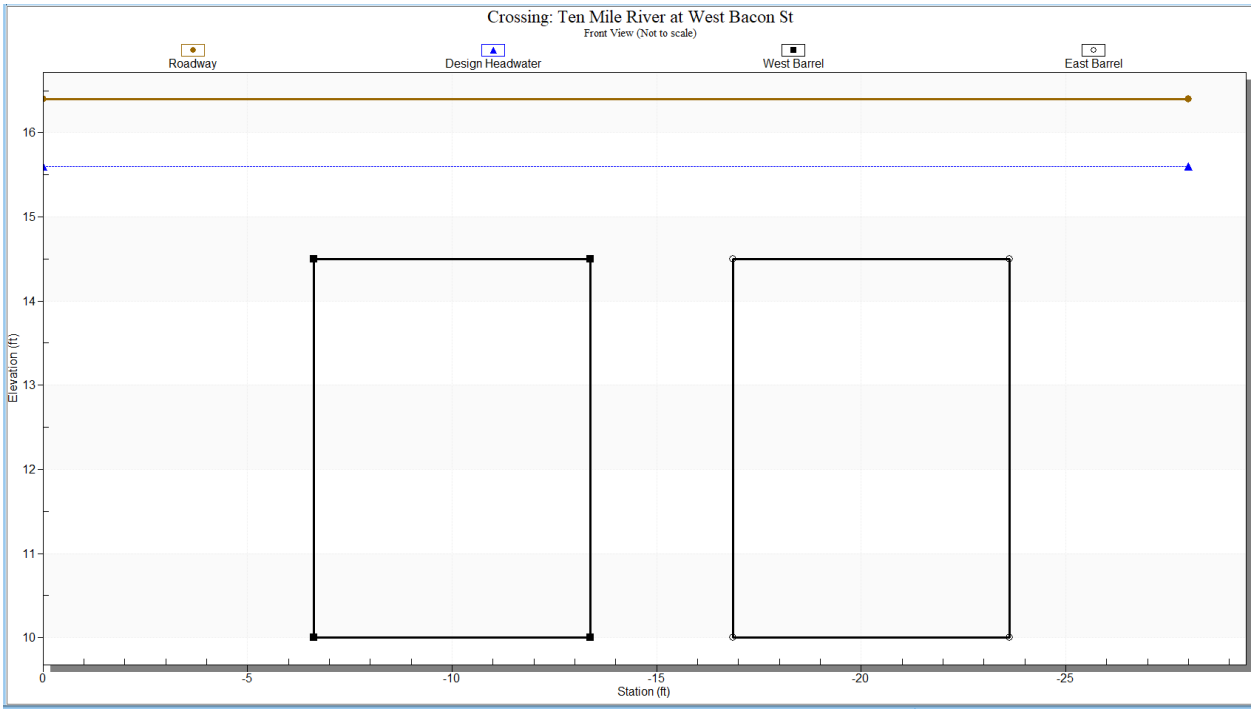


Figure 7-3 Existing West 6.75'x4.5' Barrel

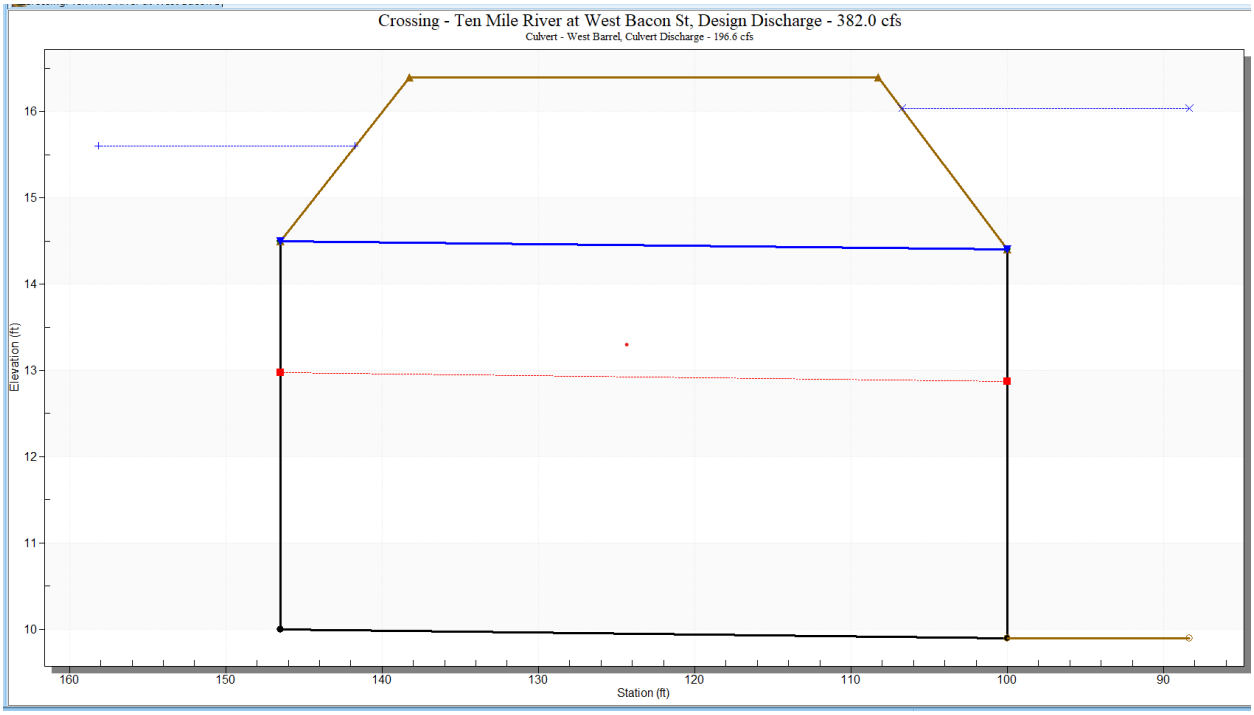


Figure 7-4 Existing East 6.75'x4.5' Barrel

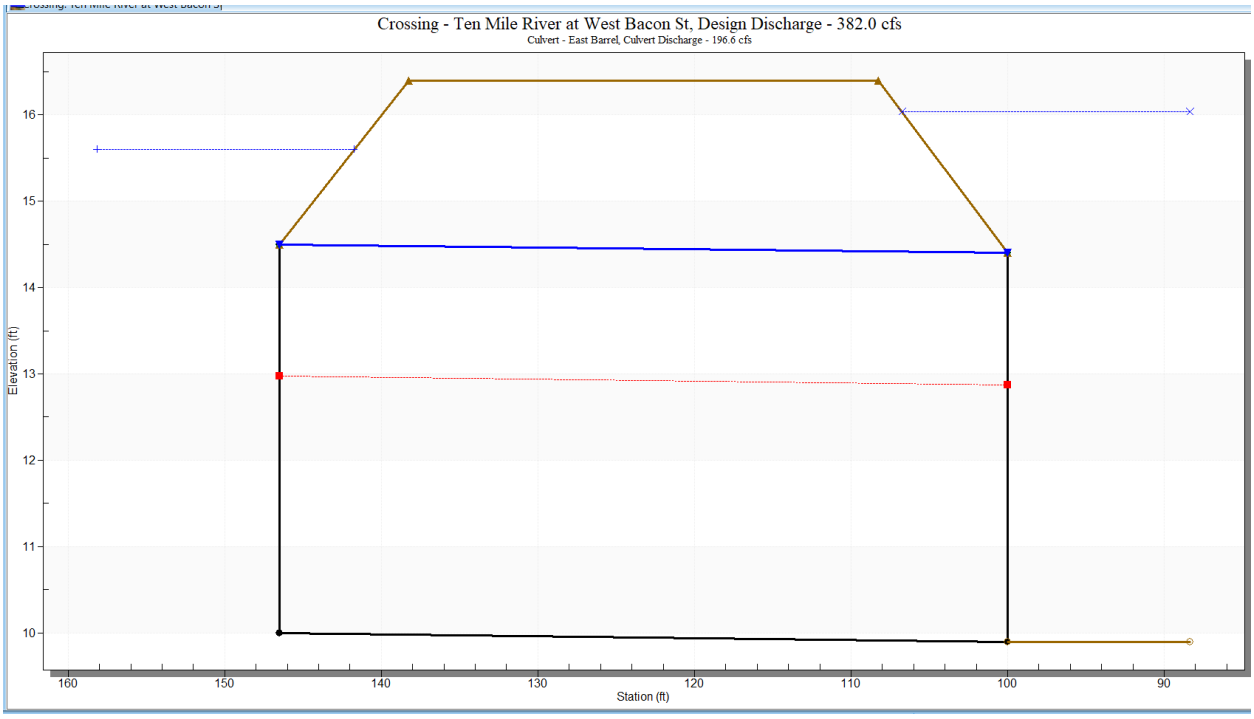


Table 7-1 Existing Crossing Summary Table

Headwater Elevation (ft)	Total Discharge (cfs)	West Barrel Discharge (cfs)	East Barrel Discharge (cfs)	Roadway Discharge (cfs)	Iterations
13.09	103.00	74.14	74.14	0.00	2
13.10	147.90	74.68	74.68	0.00	36
14.29	192.80	128.82	128.82	0.00	3
14.29	237.70	128.84	128.84	0.00	18
14.54	282.60	141.36	141.36	0.00	7
15.60	327.50	196.63	196.63	0.00	3
15.60	372.40	196.64	196.64	0.00	19
15.60	382.00	196.64	196.64	0.00	10
16.63	462.20	235.12	235.12	4.89	7
16.93	507.10	246.76	246.76	12.90	5
17.23	552.00	257.57	257.57	37.32	6
16.40	452.75	226.37	226.37	0.00	Overtopping

FEMA Flood maps indicate that the flood elevation is above the road elevation and equal on both sides of the road. The outlet to the downstream lake is the controlling restriction for the 100-year storm event.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1. STRUCTURE

The overall condition of the structure is fair and the roadway over the culvert is poor. Based on the 2019 MassDOT repot and the recent inspection findings, BETA recommends that the following items be addressed:

- Replace the roof slab to lower the roadway elevation over the structure to align with the approach roadway elevations. The existing hydraulic opening should remain.
- Replace the north sidewalk as it is heavily fragmented and allows water to leak into the structure. This should be done to preserve the integrity of the substructure.
- The north guardrail and the south fence should be replaced with a crash tested guardrail to maintain safety conditions.
- Fill in all voids in the masonry abutments, pier, and wingwalls.
- Replace all missing and/or loose chinking stones in the masonry abutments, pier, and wingwalls.
- Repoint all masonry joints to the masonry abutments, pier, and wingwalls.
- Scale back vegetation and remove debris in river on both sides to focus and control water flow.

Inspections should be conducted at intervals not exceeding 12 months to monitor overall culvert conditions.

8.2. FLOOD IMPACTS

The flood elevations are impacted by the elevation of Wetherellis Pond and the associated dam controls. This evaluation did not consider impacts associated with the dam outlet.

If there is adequate outlet capacity to the Wetherillis dam the HY-8 model indicates that the existing culverts are of sufficient size to convey the design storm (25 year) without over topping the road.

The culvert cannot convey the 100-year storm event flows without overtopping the road.

8.3. COST ESTIMATE

BUDGETARY COST ESTIMATE

Repairs

Construction:	$180,000
Engineering:	$45,000
Total:	$225,000

APPENDIX A
Structures Inspection Field Report

Town of Plainville, Massachusetts

Bridge/Culvert Inspection Checklist

P-12-007

General:

Street Name: West Bacon Street Waterway: Whiting Pond Bypass Culvert ID: P-12-007

Inspectors:

Name: Peter Kotowski Position: Senior Structural Engineer

Name: Brandon Nelson Position: Staff Engineer

Name: Position:

Inspection Conditions:

Date: 5/12/2021 Weather: Sunny Temp: 59°F

General Information:

Bridge Type: 2-Span Granite Block Construction Date: 1844

Hydraulic Opening Height (Feet): 4'-7" Out-To-Out Length (Feet): 17

Hydraulic Opening Width/Span Length (Feet): (2) 6'-9" Spans = 13'-6" (Total) Depth of Fill Over Culvert Inches: 6"

Depth of Flow During Inspection: 8" Direction of Flow: South

Utilities Carried By Structure: Sewer & Water

Drainage Structures: Catch Basin in SE Approach

Recommendations: Replace roof slab to improve vert. clearance; Replace north sidewalk; install crash-tested guard rail, fill masonry voids, replace chinking stones, repoint, remove overgrown veg.

Abutments/Culvert Sidewalls:

North Sidewall: NA

South Sidewall: NA

Center Pier: Typ. Voids at waterline; Missing and loose chinking stone (typical); 29" deep void @ NE corner

Channel Walls: Typ. Voids at waterline; Missing and loose chinking stone (typical); 27" deep void @ NW corner

Abutment North Sidewall Rating: NA Abutment South Sidewall Rating: NA

Center Pier Rating: 6 Channel Wall Rating: 6

Superstructure/Culvert Roof:

Condition Notes: Active water leakage & staining typical in both barrels; full width crack in west barrel (no stone movement)

Rating: 5

Culvert Floor/Channel

Scour: Debris: Floor/Channel Rating: 5

Floor/Channel Notes: Minor scour noted; undercuts of embankment; overgrown veg.; minor stream aggradation in west barrel

Town of Plainville, Massachusetts

Bridge/Culvert Inspection Checklist

P-12-007

Training/Wingwalls:

North East Wall:	Wingwall	North West Wall Type:	Masonry	North West Wall Rating:	6
North East Wall:	Loose/Missing chinking stone & mortart detioration is typical				
North West Wall:	Wingwall	North West Wall Type:	Masonry	North West Wall Rating:	6
North West Wall:	Loose/Missing chinking stone & mortart detioration is typical				
South East Wall:	Wingwall	South East Wall Type:	Masonry	South East Wall Rating:	6
South East Wall:	Loose/Missing chinking stone & mortart detioration is typical				
South West Wall:	Wingwall	South West Wall Type:	Masonry	South West Wall Rating:	6
South West Wall:	Loose/Missing chinking stone & mortart detioration is typical				
Head Wall:	NA	Head Wall Type:	NA	Head Wall Rating:	NA
Head Wall Notes:	NA				

Roadway Condition:

Culvert/Bridge Roadway Condition:	N. Sidewalk widespread cracking; Minor cracking	Culvert/Roadway (Feet):	29.0'
Culvert/Bridge Roadway Settlement:	Raised over structure; N. Sdwk settlement	Culvert/Roadway Rating:	4
Culvert/Bridge Roadway Alignment:	Straight		
North Roadway Approach Condition:	NA	North Roadway (Feet):	NA
North Roadway Approach Settlement:	NA	North Roadway Rating:	NA
North Roadway Approach Alignement:	NA		
South Roadway Approach Condition:	NA	South Roadway (Feet):	NA
South Roadway Approach Settlement:	NA	South Roadway Rating:	NA
South Roadway Approach Alignement:	NA		
East Roadway Approach Condition:	Good - Newly Paved	East Roadway (Feet):	29.0'
East Roadway Approach Settlement:	NA - newly paved	East Roadway Rating:	7
East Roadway Approach Alignement:	Entrance to cemetary		
West Roadway Approach Condition:	Good - Newly Paved	West Roadway (Feet):	29.0'
West Roadway Approach Settlement:	NA - Newly Paved	West Roadway Rating:	7
West Roadway Approach Alignement:	Straight		

Safety Barrier

Bridge Rail Type: Metal Pipe

Bridge Rail Condition: Poor - Hvy corr. of bolts & Conn's.; S. rail leaning; Unstable

Bridge Rail Rating: 1

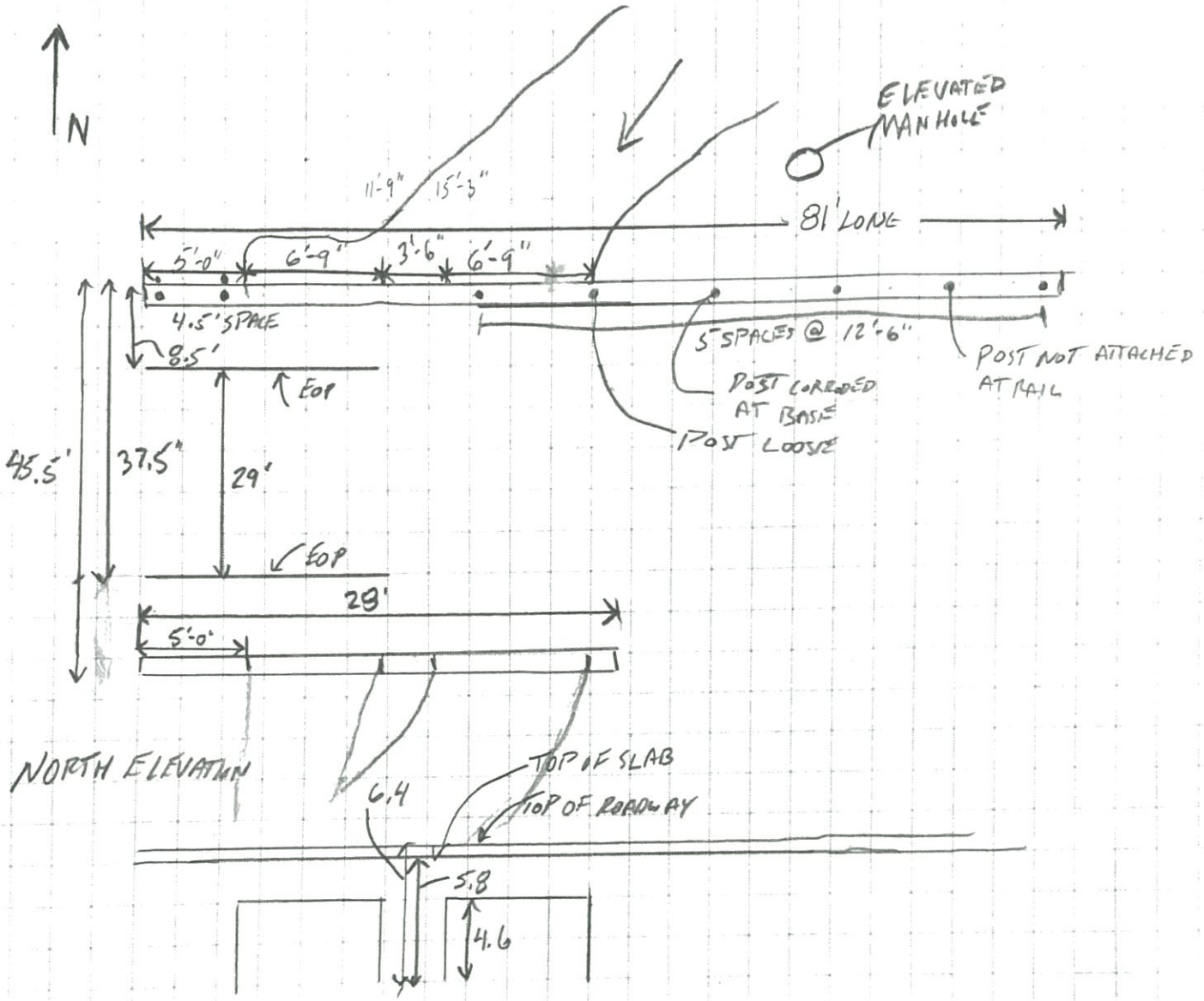
Approach Rail Notes: No transitions; N. barrier non-standard & in poor condition

VERSA-LOK®
Retaining Wall Systems
Northeast Offices
Nashua, NH / Milford, CT
(800) 523-2937

Project _____

Date _____ Prepared By _____

Scale _____ Sheet _____ of _____



APPENDIX B
Photo Survey

Photo 1 Looking Southwest: North Bridge Elevation

Photo 2 Looking Southwest: Center Pier at North Side

Photo 3 Looking South: West Span

Photo 4 Looking South: East Span

Photo 5 Looking West: Northwest Wingwall

Photo 6 Looking South: Northeast Wingwall

Photo 7 Looking North: South Bridge Elevation

Photo 8 Looking South: Center Pier at South Side

Photo 9 Looking North: West Barrel

Photo 10 Looking West: Northwest Corner Voids

Photo 11 Looking East: Northeast Corner Voids

Photo 12 Looking North: Crack in Roof on South Side of West Span

Photo 13 Looking Southeast: Elevated Manhole

Photo 14 Looking East: West Approach

Photo 15 Looking West: East Approach

Photo 16 Looking East: North Sidewalk Area

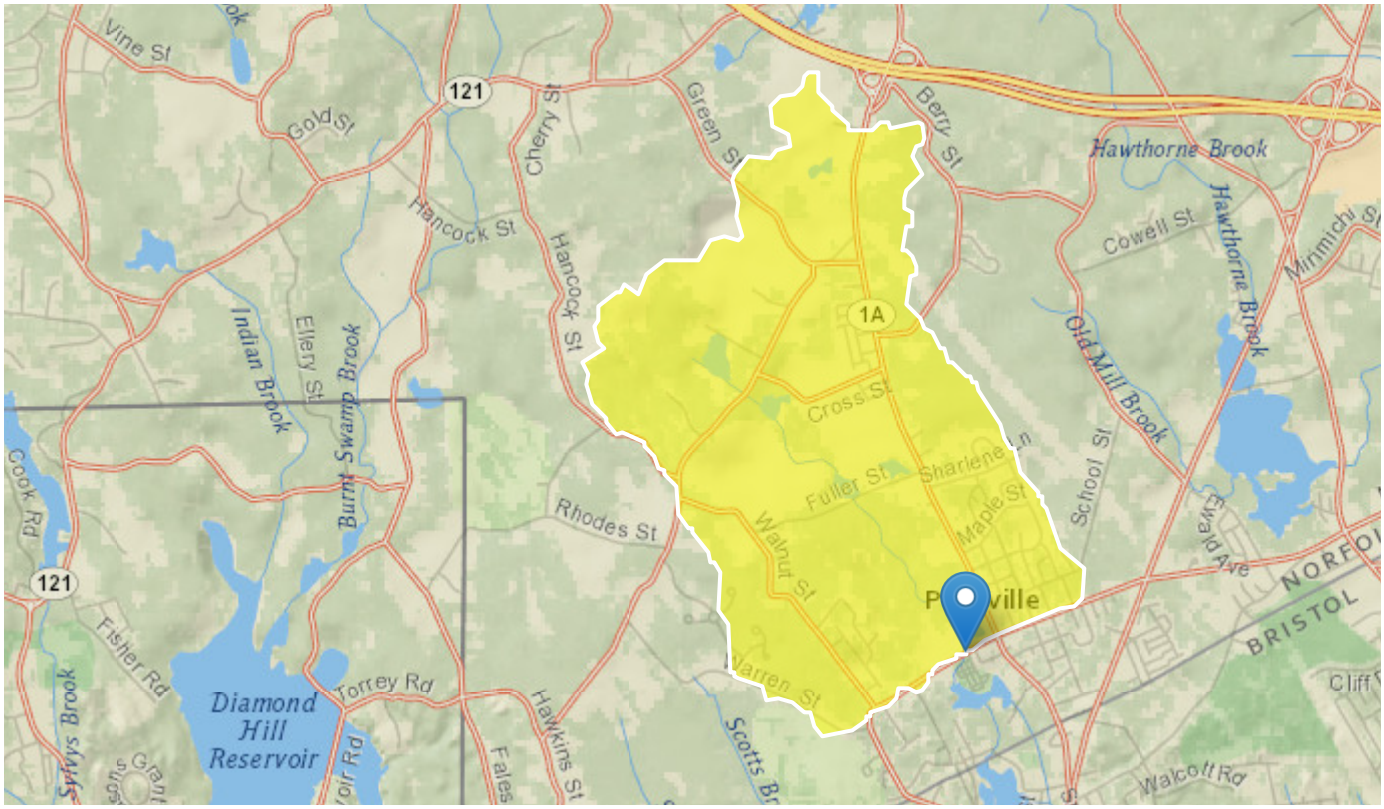
Photo 17 Looking Northeast: North Railing

Photo 18 Looking South: South Railing

APPENDIX C
StreamStats Data

West Bacon St Culvert - StreamStats Report

Region ID: MA
Workspace ID: MA20210504144936011000
Clicked Point (Latitude, Longitude): 42.00280, -71.33846
Time: 2021-05-04 10:49:52 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	3.32	square miles
ELEV	Mean Basin Elevation	280	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	7.46	percent
BSLDEM10M	Mean basin slope computed from 10 m DEM	5.893	percent

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.32	square miles	0.16	512
ELEV	Mean Basin Elevation	280	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	7.46	percent	0	32.3

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

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

Statistic	Value	Unit	PII	PIu	SEp
50-percent AEP flood	103	ft^3/s	52.6	202	42.3
20-percent AEP flood	171	ft^3/s	86.2	339	43.4
10-percent AEP flood	224	ft^3/s	110	455	44.7
4-percent AEP flood	302	ft^3/s	144	635	47.1
2-percent AEP flood	366	ft^3/s	169	795	49.4
1-percent AEP flood	435	ft^3/s	194	974	51.8
0.5-percent AEP flood	510	ft^3/s	221	1180	54.1
0.2-percent AEP flood	617	ft^3/s	255	1490	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)

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.32	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	5.893	percent	2.2	23.9

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

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

Statistic	Value	Unit	SEp
Bankfull Width	23.3	ft	21.3
Bankfull Depth	1.31	ft	19.8
Bankfull Area	30.2	ft^2	29
Bankfull Streamflow	79.4	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: 4.5.2
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.1

APPENDIX D
FEMA and FIS Study Information

FEMA Flood Insurance Study (FIS) Information

Flooding in the Town of Plainville can occur anytime; however, major flooding usually occurs during the spring as a result of heavy rain combined with snowmelt or late summer-early fall due to tropical storms. The greatest flood in the memory of town officials occurred in March 1968. During that flood, overflow from Turnpike Lake flooded sections of U. S. Route 1 and Shepard Street, and the Ten Mile River flooded part of West Bacon Street.

In Plainville, with the exception of the Ten Mile River and the Whiting Pond Bypass, peak discharges for floods with 10-, 2-, 1- and 0.2-percent-annual-chance recurrence intervals were estimated by use of formula developed by S. William Wandle, Jr. (Reference 90). Discharges for the Ten Mile River and the Whiting Pond Bypass were estimated by the USDA NRCS during the preparation of an Federal Insurance Agency (currently FEMA) Type 15 study of the adjoining Town of North Attleborough (Reference 116). Near the corporate limits, peak discharge of the Ten Mile River does not relate to drainage area because of flow diversion into the Whiting Pond Bypass.

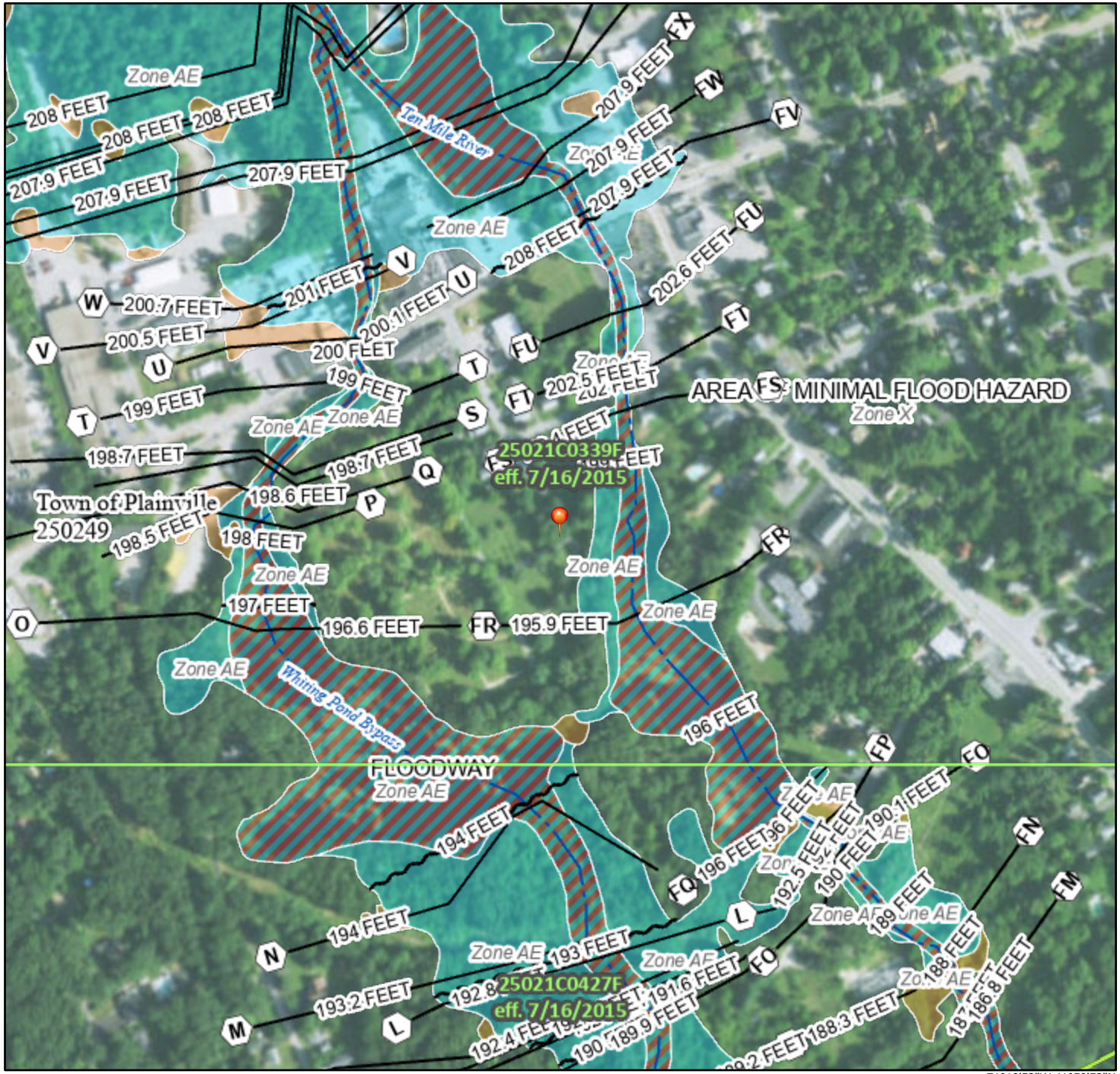
With the exception of the Ten Mile River and the Whiting Pond Bypass, water-surface elevations of floods of the selected recurrence intervals in Plainville were computed using USGS step-backwater computer program E431 (Reference 160). The elevations for the Ten Mile River and the Whiting Pond Bypass were computed at the time of the USDA NRCS Flood Insurance Study of the Town of North Attleboro (Reference 116). Elevations obtained for the Ten Mile River using USDA NRCS field data in the USGS computer program verify those obtained by the USDA NRCS. The flood elevations of Lake Mirimichi were used as starting elevations for Turtle Brook. The starting elevations on Brook No. 1 were determined by dam computations.

		PEAK DISCHARGES (CUBIC FEET PER SECOND)			
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQUARE MILES)	10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
SUCKER BROOK					
At confluence with Massapoag Lake	1.10	63	92	104	141
TEN MILE RIVER					
At Plainville downstream corporate limits	4.23	86	150	200	390
At confluence with Whiting Pond Bypass	3.48	94	180	230	420

National Flood Hazard Layer FIRMette

FEMA

71°20'30"W 42°0'19"N



71°19'52"W 41°59'52"N

Feet 1:6,000

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

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
- 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 6/9/2021 at 4:13 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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

APPENDIX E
Hydrologic Data/Climate Change Adjustment

Hydrologic Data

StreamStats flows data (workspace ID: MA20210504144936011000) will be used to evaluate the culvert which are listed as follows:

10 Yr = 224 cfs 25 Yr. = 302 cfs 50 Yr = 366 cfs 100 Yr = 435 cfs

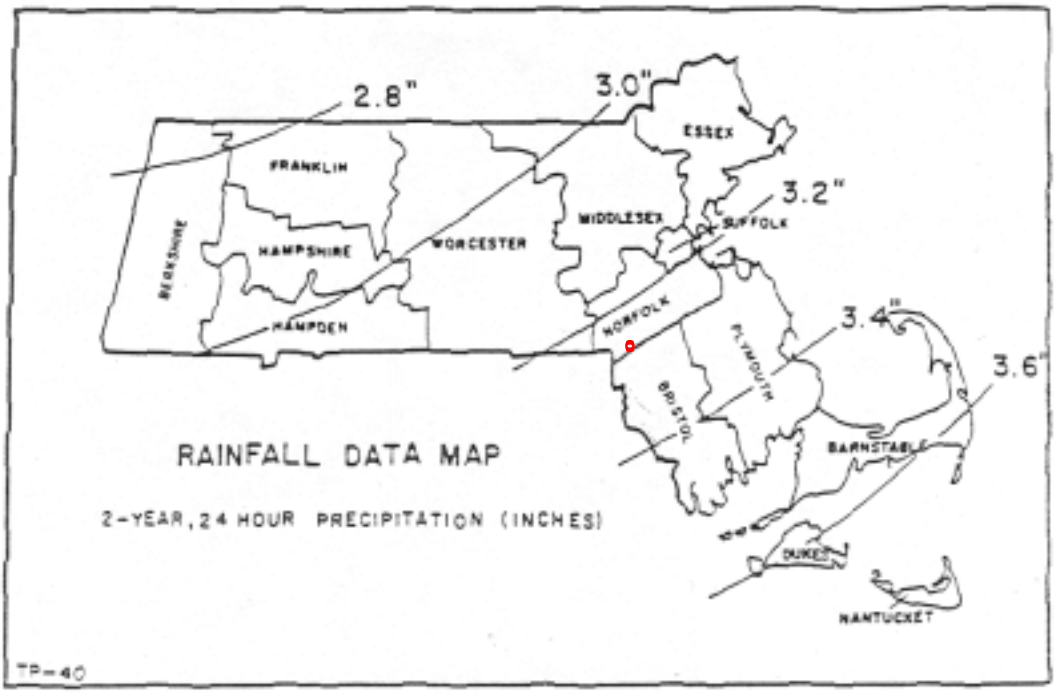
Climate Change Adjustment

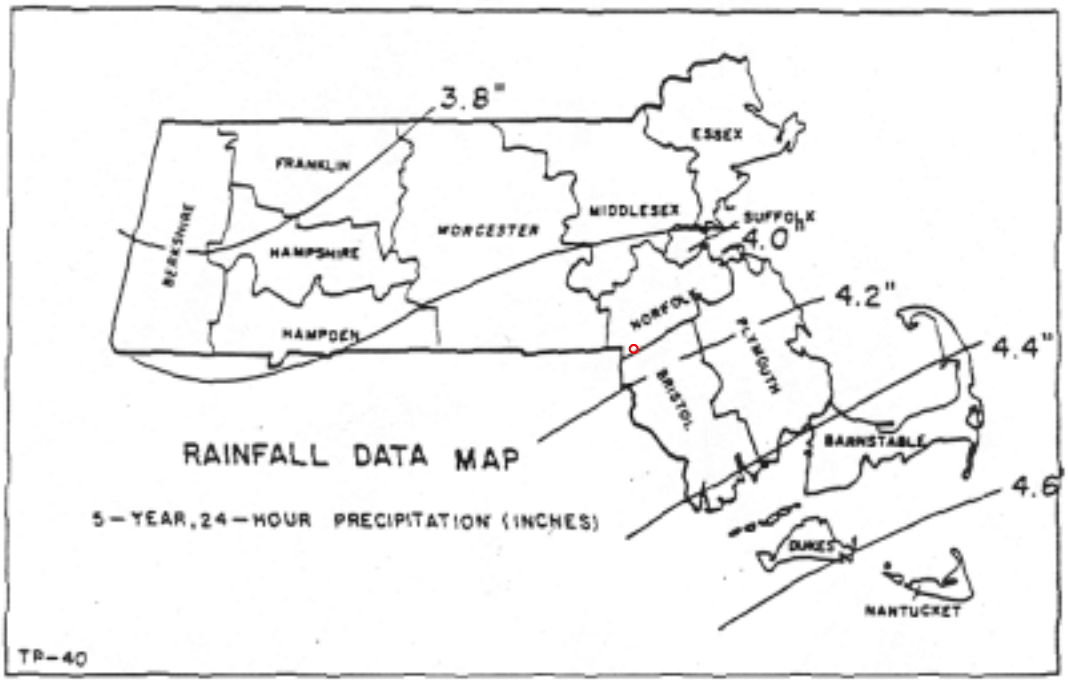
To adjust for climate change, BETA incorporated an adjustment of the StreamStats peak flow data using current (NOAA Atlas 14) rainfall data compared to the outdated TP-40 data.

Accommodate Climate Change/Resiliancy
Adjust Streamstats/FEMA FIS Flow Data
By Ratio of TP 40 to NOAA Atlas 14 Rainfall Data

	1	2	3	4	5	
Storm Event (Yr)	**Rainfall TP-40 (in)**	**Δ**	**Flow Data (Streamstata) (cfs)**	**Δ**	**Rainfall Atlas-14 (in)**	**Adjusted Flow (cfs)**
2	3.25		103		3.4	114
		0.9		68		
5	4.15		171		4.38	194
		0.54		53		
10	4.69		224		5.2	271
		0.85		78		
25	5.54		302		6.32	384
		0.61		64		
50	6.15		366		7.15	472
		0.65		69		
100	6.80	3.55	435	332	8.05	552

Adjusted Flow = 3+((5-1)/2)x4


2.8"
3.0"
3.2"
3.4"
3.6"
ESSEX
FRANKLIN
MIDDLESEX
SUFFOLK
BERKSHIRE
HAMPSHIRE
WORCESTER
NORFOLK
HAMPDEN
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
2-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40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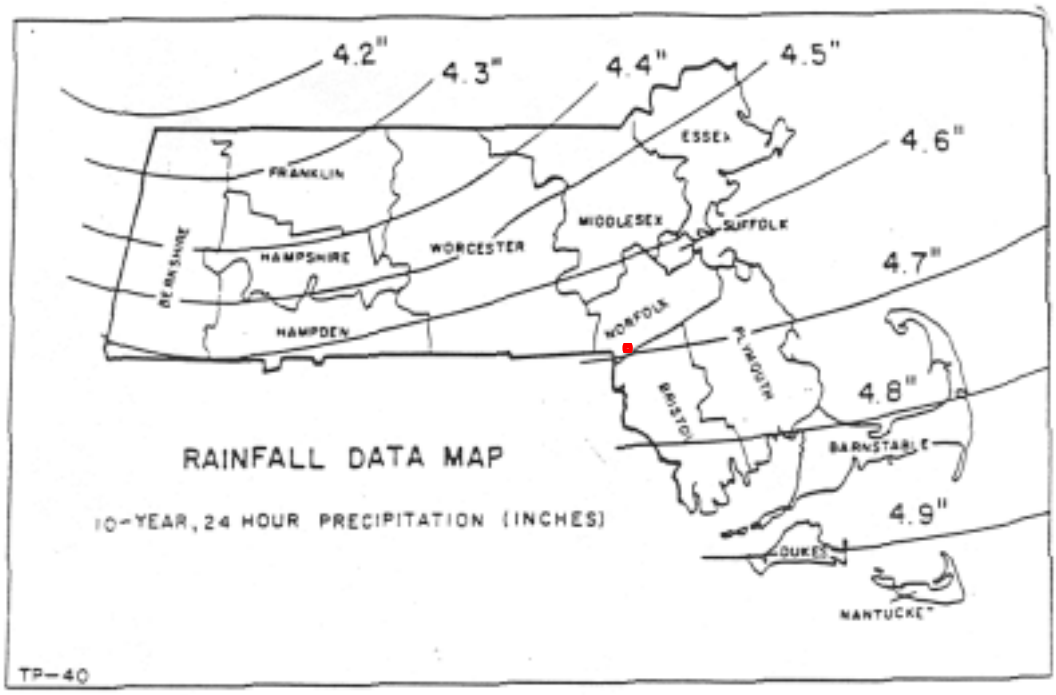
4.4"
4.6"
ESSEX
FRANKLIN
MIDDLESEX
SUFFOLK
BERKSHIRE
HAMPSHIRE
WORCESTER
NORFOLK
HAMPDEN
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
5-YEAR, 24-HOUR PRECIPITATION (INCHES)
TP-40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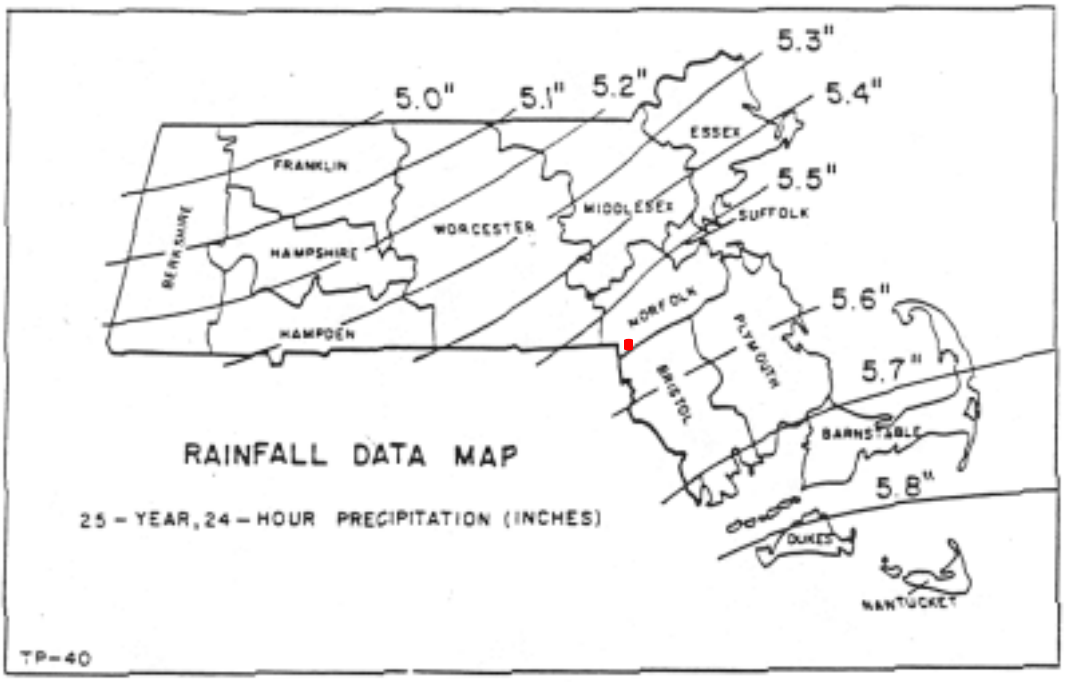
BERKSHIRE
HAMPSHIRE
WORCESTER
NORFOLK
HAMPDEN
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
10-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40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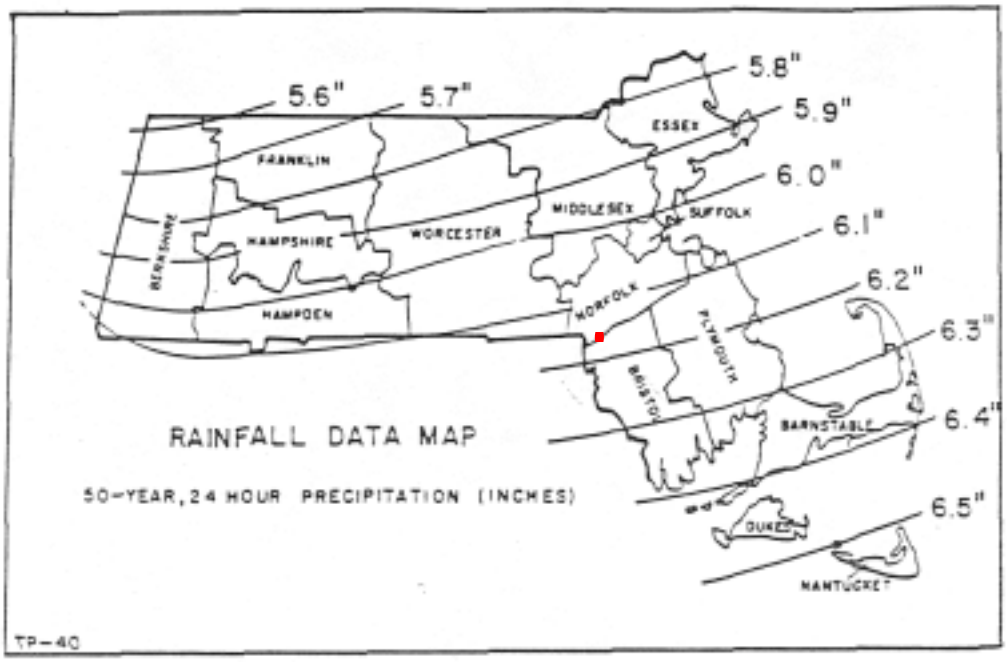
BERKSHIRE
HAMPSHIRE
WORCESTER
NORFOLK
HAMPDEN
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
25 - YEAR, 24 - HOUR PRECIPITATION (INCHES)
TP-40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MIDDLESEX
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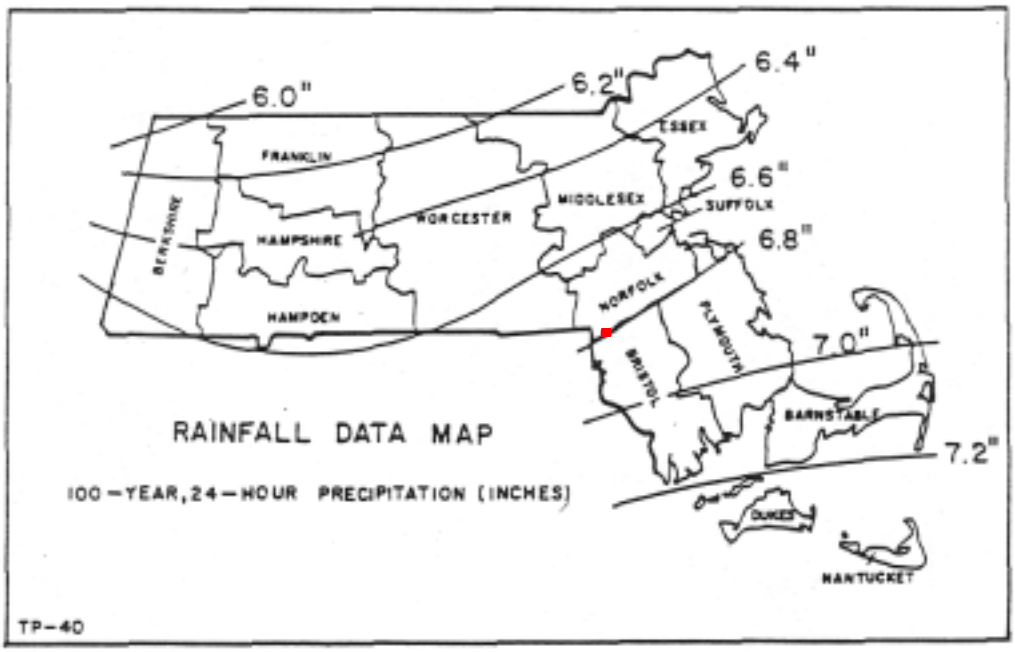
HAMPSHIRE
WORCESTER
BERKSHIRE
HAMPDEN
NORFOLK
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
50-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40


6.0"
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6.4"
6.6"
6.8"
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7.2"
FRANKLIN
ESSEX
MIDDLESEX
SUFFOLK
HAMPSHIRE
WORCESTER
BERKSHIRE
HAMPDEN
NORFOLK
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
100-YEAR, 24-HOUR PRECIPITATION (INCHES)
TP-40

NOAA Atlas 14, Volume 10, Version 3
Location name: Plainville, Massachusetts, USA*
Latitude: 42.0193°, Longitude: -71.3159°
Elevation: 199.23 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.314 (0.249-0.393)	0.386 (0.306-0.483)	0.503 (0.397-0.632)	0.600 (0.471-0.758)	0.734 (0.556-0.970)	0.834 (0.619-1.13)	0.940 (0.677-1.32)	1.06 (0.719-1.52)	1.24 (0.808-1.84)	1.40 (0.884-2.10)
10-min	0.445 (0.353-0.557)	0.547 (0.433-0.684)	0.713 (0.563-0.896)	0.850 (0.667-1.07)	1.04 (0.788-1.38)	1.18 (0.876-1.60)	1.33 (0.959-1.87)	1.51 (1.02-2.15)	1.76 (1.14-2.61)	1.98 (1.25-2.98)
15-min	0.524 (0.415-0.655)	0.643 (0.509-0.805)	0.838 (0.661-1.05)	1.00 (0.784-1.26)	1.22 (0.927-1.62)	1.39 (1.03-1.88)	1.57 (1.13-2.20)	1.77 (1.20-2.53)	2.07 (1.35-3.07)	2.33 (1.47-3.51)
30-min	0.723 (0.574-0.905)	0.891 (0.706-1.12)	1.17 (0.920-1.46)	1.39 (1.09-1.76)	1.71 (1.29-2.26)	1.94 (1.44-2.62)	2.19 (1.58-3.08)	2.48 (1.68-3.54)	2.91 (1.89-4.30)	3.26 (2.07-4.92)
60-min	0.923 (0.732-1.16)	1.14 (0.902-1.43)	1.49 (1.18-1.87)	1.79 (1.40-2.26)	2.19 (1.66-2.90)	2.49 (1.85-3.37)	2.81 (2.03-3.95)	3.19 (2.15-4.55)	3.74 (2.42-5.53)	4.20 (2.66-6.33)
2-hr	1.18 (0.942-1.46)	1.47 (1.18-1.83)	1.96 (1.56-2.44)	2.36 (1.86-2.95)	2.91 (2.22-3.82)	3.31 (2.48-4.46)	3.75 (2.73-5.27)	4.28 (2.91-6.07)	5.09 (3.32-7.46)	5.78 (3.67-8.62)
3-hr	1.37 (1.10-1.69)	1.71 (1.37-2.12)	2.27 (1.82-2.82)	2.74 (2.17-3.42)	3.38 (2.60-4.43)	3.86 (2.90-5.17)	4.37 (3.20-6.11)	5.00 (3.41-7.04)	5.95 (3.89-8.67)	6.77 (4.32-10.1)
6-hr	1.78 (1.44-2.18)	2.21 (1.79-2.71)	2.90 (2.34-3.57)	3.48 (2.78-4.30)	4.27 (3.30-5.54)	4.86 (3.68-6.45)	5.49 (4.04-7.60)	6.26 (4.29-8.74)	7.43 (4.88-10.7)	8.43 (5.40-12.4)
12-hr	2.31 (1.89-2.81)	2.81 (2.29-3.42)	3.63 (2.95-4.43)	4.31 (3.48-5.29)	5.24 (4.08-6.73)	5.94 (4.52-7.79)	6.69 (4.94-9.12)	7.57 (5.22-10.5)	8.89 (5.88-12.7)	10.0 (6.44-14.6)
24-hr	2.80 (2.30-3.37)	3.40 (2.79-4.10)	4.38 (3.59-5.30)	5.20 (4.23-6.32)	6.32 (4.96-8.05)	7.15 (5.49-9.31)	8.05 (5.99-10.9)	9.12 (6.33-12.5)	10.7 (7.12-15.2)	12.1 (7.82-17.4)
2-day	3.16 (2.62-3.77)	3.89 (3.22-4.65)	5.09 (4.20-6.10)	6.09 (4.99-7.33)	7.45 (5.90-9.43)	8.47 (6.56-11.0)	9.57 (7.19-12.9)	10.9 (7.62-14.8)	13.0 (8.68-18.3)	14.8 (9.62-21.2)

APPENDIX F
Order of Magnitude Construction Costs

www.BETA-Inc.com

JOB	Plainville	No.	7624
CALCULATED BY	TMW	DATE	6/25/2021
CHECKED BY		DATE	
DESCRIPTION	Cost Analysis	SHEET NO.	

West Bacon Street over Whiting Pond Bypass

Rehabilitation:

Roof Slab Replacement

Slab Length over Bridge =	45.50	sf		
Slab Width =	17.00	sf		
Slab Thickness =	1.00	sf		
Volume of Slab =	773.50	cf		
=	28.65	cy		
Say =	29.00			
Assumed Cost for Concrete Slab =	$1,500.00	Per CY	Roof Slab =	$43,500
Assume 100lbs Steel / CY =	2900.00	LBS		
Steel Reinforcing Unit Cost (Item 910.) =	$3.00	Per LB	Reinforcing Cost =	$8,700

Masonry Repairs (Replace Stones, Repoint Joints, Fill Voids)

Approximate Area of Abutment Faces=	409.50	sf		
Approximate Area of Pier Faces=	409.50	sf		
Approximate Area of Wingwall Faces=	100.00			
Approximate Depth of Repairs =	1.00	ft		
Total Area =	34.04	cy		
Repair Area in CY (67% due to fair condition) =	22.69	cy		
Stone Masonry Wall in Cement Mortar (Item 685.) =	$900.00	Per CY	Masonry Repairs =	$20,422

Bridge Railing =	$150.00	Per LF		
Railing Length =	109.00	LF	Bridge Rail =	$16,350
Roadway Work =	30.00%	of culvert cost	Roadway Work =	$26,692
LS Cost of Water Diversion =	$10,000.00	LS	Water Diversion =	$10,000
Contingency & Misc. Items =	30.00%	of construction cost	Contingency & Misc. Items =	$37,699
Mobilization/Demobilization =	10.00%	of total construction cost	Mobilization/Demobilization =	$16,336
			Cost of Repairs =	$179,699
			Call =	**$180,000**
			25% Engineering Cost =	**$45,000**
			TOTAL COST =	**$225,000**