Plainville, MA

# Sawmill Brook Culvert at Taunton St

*Southern Outlet from Turnpike Lake*

*June 2021*

# CULVERT EVALUATION REPORT

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Plainville, MA

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# CULVERT EVALUATION REPORT

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

June 2021

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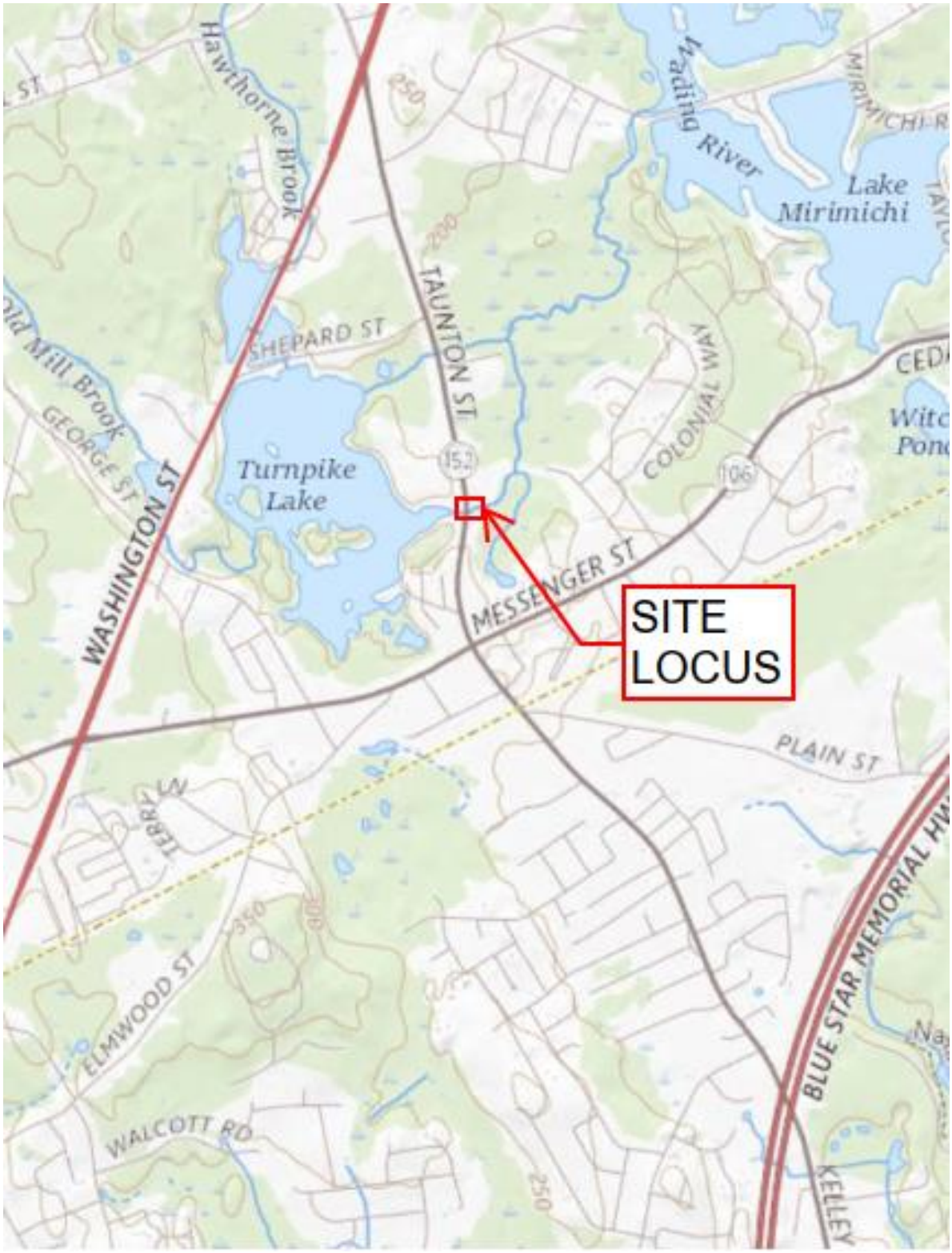
## 1.0 PROJECT LOCUS

**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 10- 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:

- HY-8 Culvert Hydraulic Analysis Program provided by the Federal Highway Administration
- 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):
- Technical Paper No. 40 (TP-40) Rainfall Frequency Atlas of the United States
- NOAA Atlas 14 Point Precipitation Frequency Estimates

## 4.0 Project Area Location and Bridge/Culvert Description

This structure consists of a concrete pipe supported by a masonry wall on each side. The concrete pipe is 3’-0” in diameter and approximately 55’-6” in length. The masonry wall on the east side is approximately 20’-0” long and extends about 3’-3” above the top of the concrete pipe. The masonry wall on the west side is smaller, measuring approximately 10’-0” long and extending about 1’-0” above the top of the concrete pipe. There is fill above the masonry walls up to the roadway. The approximate depth of fill was measured at 1’-10” on the east side and 1’-0” on the west side. The direction of flow is west to east and the depth of flow was recorded at 1’-0” at the east entrance and 7” at the west entrance.

The roadway width over the culvert is approximately 40’-0” curb-to-curb. The sidewalk on the east side was measured to be about 4’-6”. There is a driveway located at the north approach.

There are overhead wires on both the west and east sides. A catch basin is present on the southwest corner of the road over the culvert. Existing guardrail is present on the east side only.

The waterway on both sides contains debris and heavy vegetation.

## 5.0 Culvert Condition

The overall condition of the structure is fair with several deficiencies noted. The concrete pipe through the culvert is in fair condition. Abrasion is present across the pipe, continuing approximately to the center. There is spalling with exposed rebar on the outside of the concrete pipe on the east side, measuring 10’ long and 1” deep (Photo 2). There is a drainpipe present on the east side, potentially from the catch basin on the west side. The drainpipe is in poor condition, showing heavy deterioration up to 2’ deep into the pipe (Photo 5).

The stone masonry wall on the east side is in poor condition. There are several boulders that have fallen off into the water at the base and there are areas of loose stones and missing mortar throughout. There is also a horizontal crack that runs the full length of the wall, approximately 16" above the top of the pipe (Photo 1). Vegetation and debris are present on the east side (Photo 8). The stone masonry wall on the west side is in fair condition with a few deficiencies noted. There is some missing mortar and an area of potential washout on the northwest embankment (Photo 10). On the west side, there is heavy vegetation on the embankments and over the waterway (Photo 3 and 9).

The roadway over the culvert and at both approaches is in good condition. It is noted that the road appears to have heavy traffic. The guardrail present on the east side is in good condition. There is no guardrail present on the west side, although it is not necessarily because the wall is set back approximately 15'-0" from the curb line.

## 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 199 | Community Panel No. 25021C 0343F |
| Stream Profile | FEMA – FIS Norfolk County, MA | Turtle Brook<br>Flood Profile 228P |
| StreamStats Report | USGS (2020) | Workspace ID:<br>MA20210504145620931000 |

**Table 6-2: Hydrologic Data**

| **Hydraulic Design Data** | | | **Flood of Record** | |
|---|---|---|---|---|
| Drain Area | 4.28 sq. mi. | | Discharge | Unknown |
| Bank Full Width | | | Frequency | Unknown |
| Design Flood Discharge | 421 cfs* | | Maximum Elevation | Unknown |
| Design Flood Frequency | 25-year | | Date | March 1968 |
| **Base (100-year) Flood Data*** | | | | |
| Base Flood Discharge* | 605 cfs* | | Base Flood Elevation | 199 (NGVD) |

*Adjusted for Climate Change – See Appendix E

## 7.0 HY-8 Model – Existing Culverts

Field measurements were taken to develop a basic hydraulic model using HY-8 program. Turnpike Lake has two dam-controlled outlets. The north outlet (Turtle Brook) is conveyed under Taunton Street in a 6-foot wide by 4-foot-high concrete box culvert (24 sq. ft.). While the southern outlet (Sawmill Brook) is conveyed under Taunton Street in a 36-inch diameter reinforced concrete pipe (7.1 sq. ft.). To evaluate the capacity of the culvert two methodologies were considered. The first is using a proportioned flow based on the relative capacity of the two culverts crossing Taunton Street and the second is a 50/50 split of the flow.

Note elevations in these calculations refer to an assumed datum.

### 7.1 Option 1 – Proportioned Flow

If outflow of the two dams is managed based on the capacity of the Taunton Street culverts the southern culvert will need to pass 96± cfs (23%) of the flow.

The results indicate that the culvert is sufficient to convey the 25-year storm flows (96 cfs – Streamstats data modified for climate change and proportioned based on culvert size with the Turtle Book outlet). The following figures and table show that the road is not overtopped during the design (25-year storm).

**Figure 7-1 HY-8 Existing Model Overview**

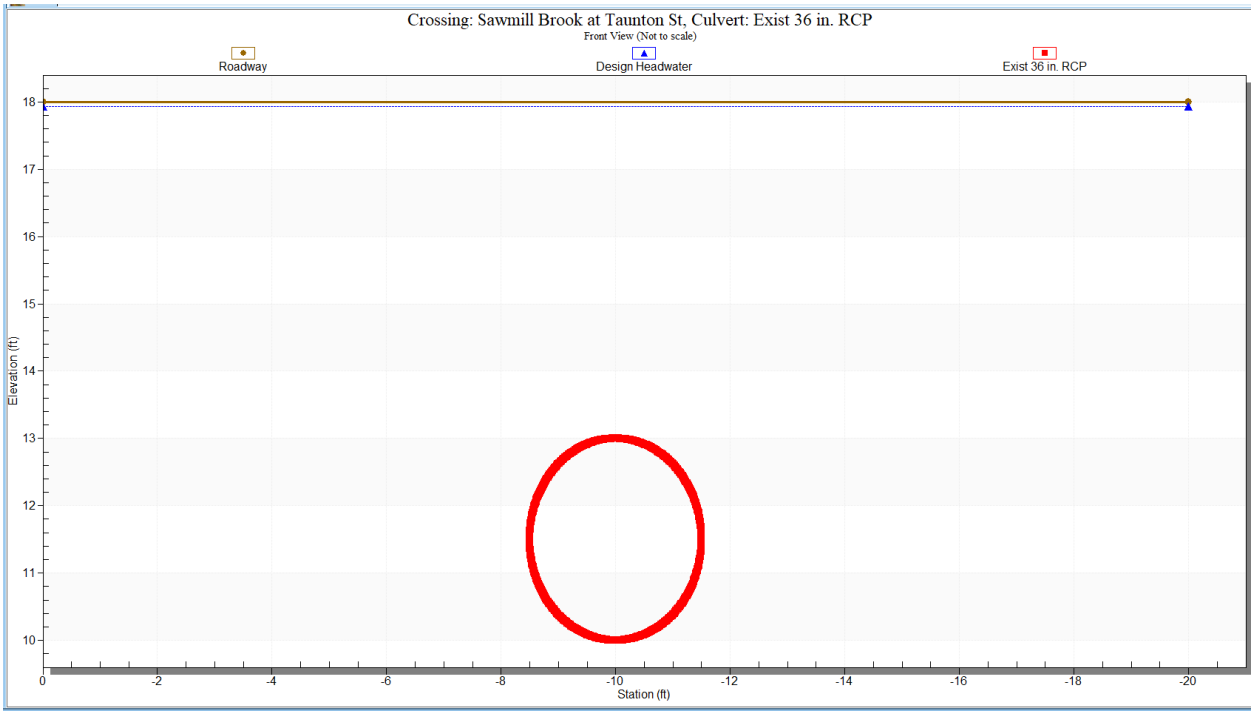


**Figure 7-2 Existing 36" RCP Profile**

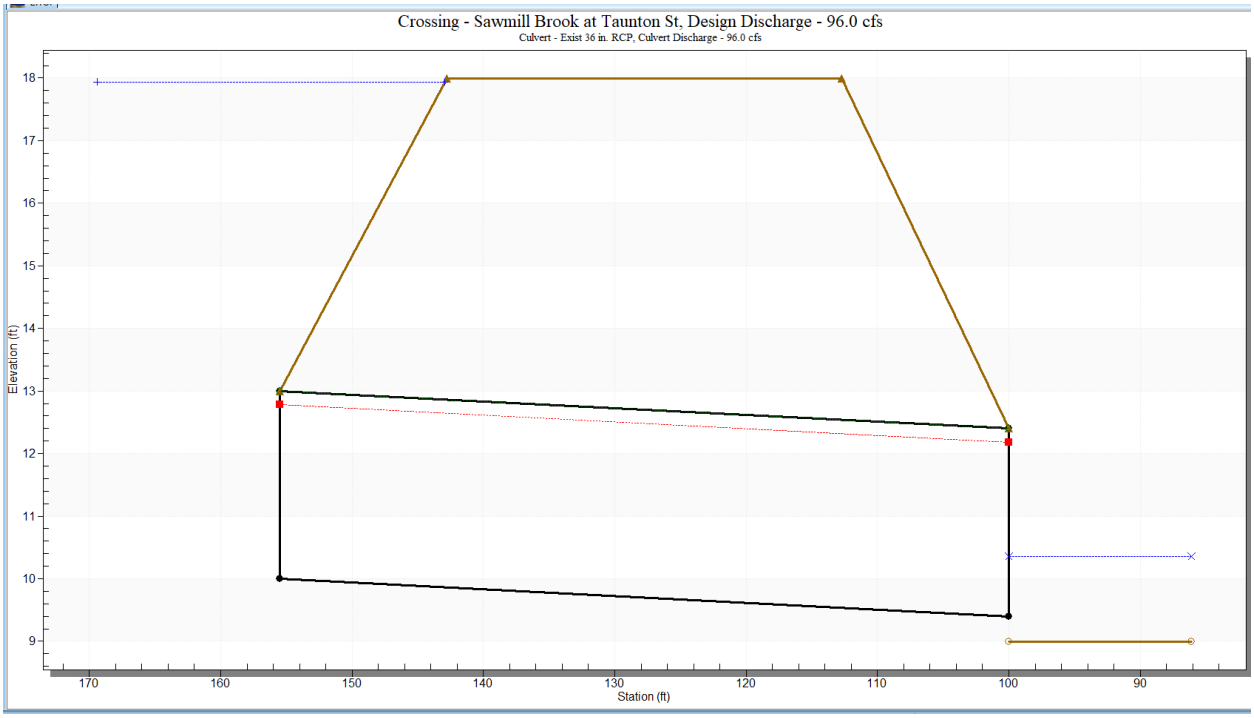



**Table 7-1 Existing Crossing Summary Table**

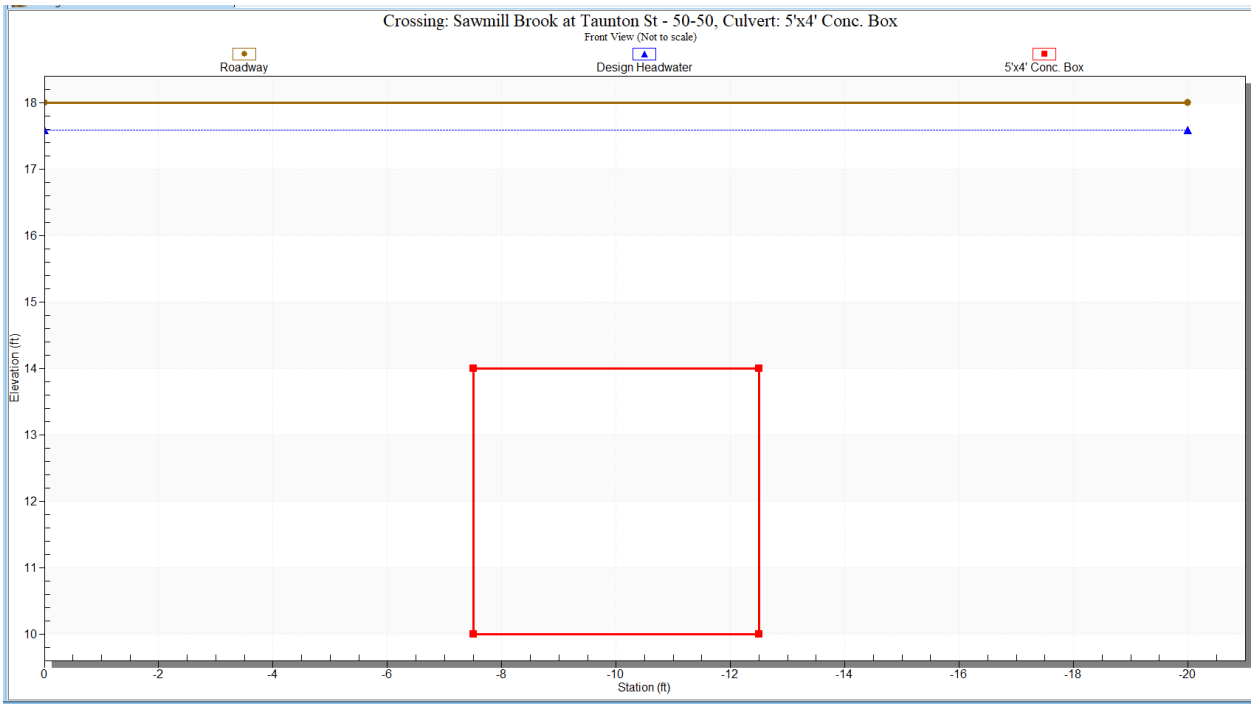
| Headwater Elevation (ft) | Total Discharge (cfs) | Exist 36 in. RCP Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 12.14 | 22.00 | 22.00 | 0.00 | 1 |
| 12.75 | 33.70 | 33.70 | 0.00 | 1 |
| 13.37 | 45.40 | 45.40 | 0.00 | 1 |
| 14.12 | 57.10 | 57.10 | 0.00 | 1 |
| 15.05 | 68.80 | 68.80 | 0.00 | 1 |
| 16.17 | 80.50 | 80.50 | 0.00 | 1 |
| 17.47 | 92.20 | 92.20 | 0.00 | 1 |
| 17.93 | 96.00 | 96.00 | 0.00 | 1 |
| 18.41 | 115.60 | 99.80 | 15.79 | 6 |
| 18.57 | 127.30 | 101.07 | 26.20 | 5 |
| 18.72 | 139.00 | 102.19 | 36.73 | 4 |
| 18.00 | 96.54 | 96.54 | 0.00 | Overtopping |

FEMA Flood maps indicate that the flood elevation is below the road elevation and equal on both sides of the road.

## 7.2 Even Split Flow

If outflow of the two dams is not strictly managed flow out of these structures will likely be split close to 50% each. The following includes an analysis of the minimum culvert size required to convey the 25-year storm flows (211 cfs – 50% Streamstats data modified for climate change).

## Figure 7-3 New 4'x4' Conc. Box Overview




## Figure 7-4 New 5'x4' Conc. Box Profile

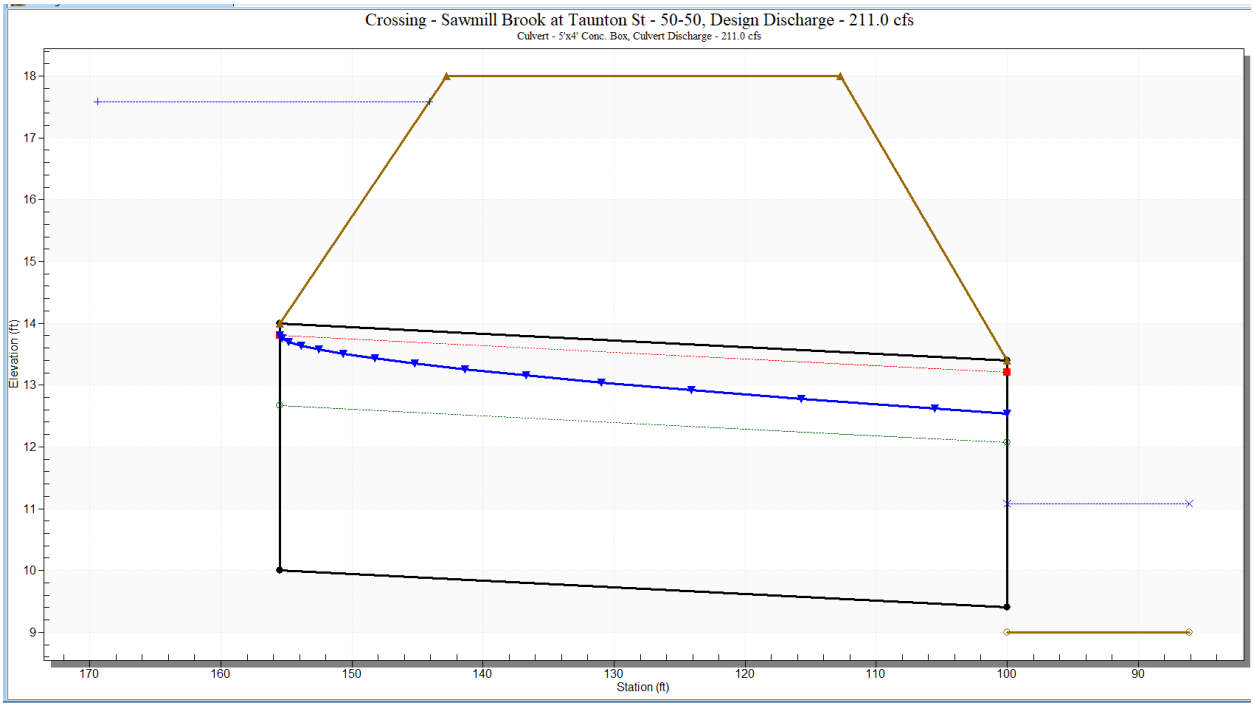


**Table 7-2 New 5'x4' Conc. Box Crossing Summary Table**

| Headwater Elevation (ft) | Total Discharge (cfs) | 5'x4' Conc. Box Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|
| 12.90 | 64.00 | 64.00 | 0.00 | 1 |
| 13.57 | 87.90 | 87.90 | 0.00 | 1 |
| 14.23 | 111.80 | 111.80 | 0.00 | 1 |
| 14.91 | 135.70 | 135.70 | 0.00 | 1 |
| 15.65 | 159.60 | 159.60 | 0.00 | 1 |
| 16.49 | 183.50 | 183.50 | 0.00 | 1 |
| 17.43 | 207.40 | 207.40 | 0.00 | 1 |
| 17.58 | 211.00 | 211.00 | 0.00 | 1 |
| 18.53 | 255.20 | 232.10 | 23.03 | 3 |
| 18.78 | 279.10 | 237.40 | 41.62 | 4 |
| 19.00 | 303.00 | 242.01 | 60.94 | 4 |
| 18.00 | 220.66 | 220.66 | 0.00 | Overtopping |

# 8.0 Conclusions and Recommendations

## 8.1 Structure:

The overall condition of the structure is fair, while the east masonry wall is poor. Based on recent inspection findings, BETA recommends a full replacement of the east wall. Considering the condition of the wall, with cracking and voids at the base, replacing the wall with a C.I.P. concrete wall is the best long-term solution. In order to prevent further deterioration, the following items should be addressed in the interim:

- Replace all missing and/or loose stones in the stone masonry walls, especially at the base of the east wall.
- Repoint all masonry joints to the stone masonry walls on both sides.

## 8.2 Flood Impacts:

If flows to the two outlets to the Turnpike are managed based on the capacity of the two culverts crossing Taunton Street there is sufficient capacity to accommodate the 25-year storm. Stated another way, the 36-inch RCP can convey 23% of the flow out of Turnpike Lake for the 25-year storm event.

If the flow is closer to 50% then the minimum size culvert necessary to convey the 25 Year storm is a 4'x4' box culvert. If the culvert is to be replaced, consider upsizing to meet the stream crossing guidelines.

## 8.3 COST ESTIMATE

BUDGETARY COST ESTIMATE

### Interim Repairs

| | |
|---|---|
| Construction: | $32,000 |
| Engineering: | $8,000 |
| Total: | $40,000 |

### Full-Replacement

| | |
|---|---|
| Construction: | $250,000 |
| Engineering: | $65,000 |
| Total: | $315,000 |

# APPENDIX A
# Structures Inspection Field Report

# Town of Plainville, Massachusetts

## Bridge/Culvert Inspection Checklist

### General:

Street Name: Taunton Street  Waterway: Sawmill Brook Inlet  Culvert ID:

### 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: Reinforced Concrete Pipe (RCP)  Construction Date: Unknown

Hydraulic Opening Height (Feet): 3'-0" Diameter Pipe  Out-To-Out Length (Feet): 3

Hydraulic Opening Width/Span Length (Feet): 3'-0" Diameter Pier  Depth of Fill Over Culvert Inches: Varies 12" (Min.) - 2

Depth of Flow During Inspection: 12" +/-  Direction of Flow: East

Utilities Carried By Structure: Overhead Wires, Gas, Hydrant in North Approach

Drainage Structures: Catch Basin in NW Approach

Recommendations: Replace missing/loose chinking stones in headwall; Repoint masonry headwalls (Does not address hydraulic issues)

### Abutments/Culvert Sidewalls:

North Sidewall: NA

South Sidewall: NA

Center Pier: Hvy. Detierioration of drain pipe; Overall poor condition; Missing and loose stones typical; full length horiz crack; Hvy vegitation & debris

Channel Walls: Fair condition; Hvy vegiation; Few areas of missing mortar

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

Center Pier Rating: 4  Channel Wall Rating: 6

### Superstructure/Culvert Roof:

Condition Notes: NA

Rating: NA

### Culvert Floor/Channel

Scour:  Debris:  Floor/Channel Rating: 5

Floor/Channel Notes: Concrete pipe in fair condtion; Minor abrasion typical at water line

# Town of Plainville, Massachusetts

## Bridge/Culvert Inspection Checklist

### Training/Wingwalls:

| | | | | | |
|---|---|---|---|---|---|
| North East Wall: | Headwall | North West Wall Type: | Masonry | North West Wall Rating: | See East Wall |
| North East Wall: | See East Wall notes | | | | |
| North West Wall: | NA | North West Wall Type: | NA | North West Wall Rating: | NA |
| North West Wall: | NA | | | | |
| South East Wall: | NA | South East Wall Type: | NA | South East Wall Rating: | NA |
| South East Wall: | NA | | | | |
| South West Wall: | Headwall | South West Wall Type: | Masonry | South West Wall Rating: | See West Wal |
| South West Wall: | See West Wall notes | | | | |
| Head Wall: | See Sidewall Notes | Head Wall Type: | See Sidewall Note | Head Wall Rating: | |
| Head Wall Notes: | See Sidewall Notes | | | | |

### Roadway Condition:

| | | | |
|---|---|---|---|
| Culvert/Bridge Roadway Condition: | Good condition | Culvert/Roadway (Feet): | 40'-0" +/- |
| Culvert/Bridge Roadway Settlement: | No settlement noted | Culvert/Roadway Rating: | 7 |
| Culvert/Bridge Roadway Alignment: | Straight | | |
| North Roadway Approach Condition: | Good | North Roadway (Feet): | 40'-0" +/- |
| North Roadway Approach Settlement: | No settlement | North Roadway Rating: | 7 |
| North Roadway Approach Alignement: | Straight | | |
| 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: | NA | East Roadway (Feet): | NA |
| East Roadway Approach Settlement: | NA | East Roadway Rating: | NA |
| East Roadway Approach Alignement: | NA | | |
| West Roadway Approach Condition: | Good condition | West Roadway (Feet): | 40'-0" +/- |
| West Roadway Approach Settlement: | No settlement noted | West Roadway Rating: | 7 |
| West Roadway Approach Alignement: | Straight | | |

### Safety Barrier

Bridge Rail Type: Steel GR on East side of road

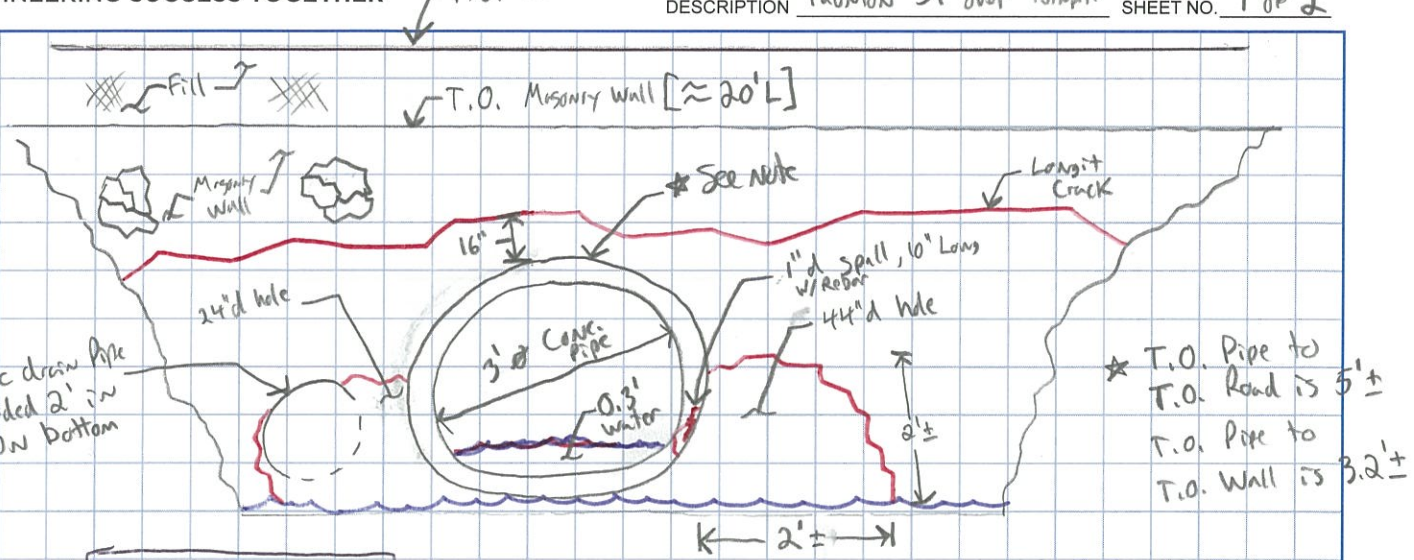
Bridge Rail Condition: GR on East in Good condition; No GR on West side of road

Bridge Rail Rating: 6

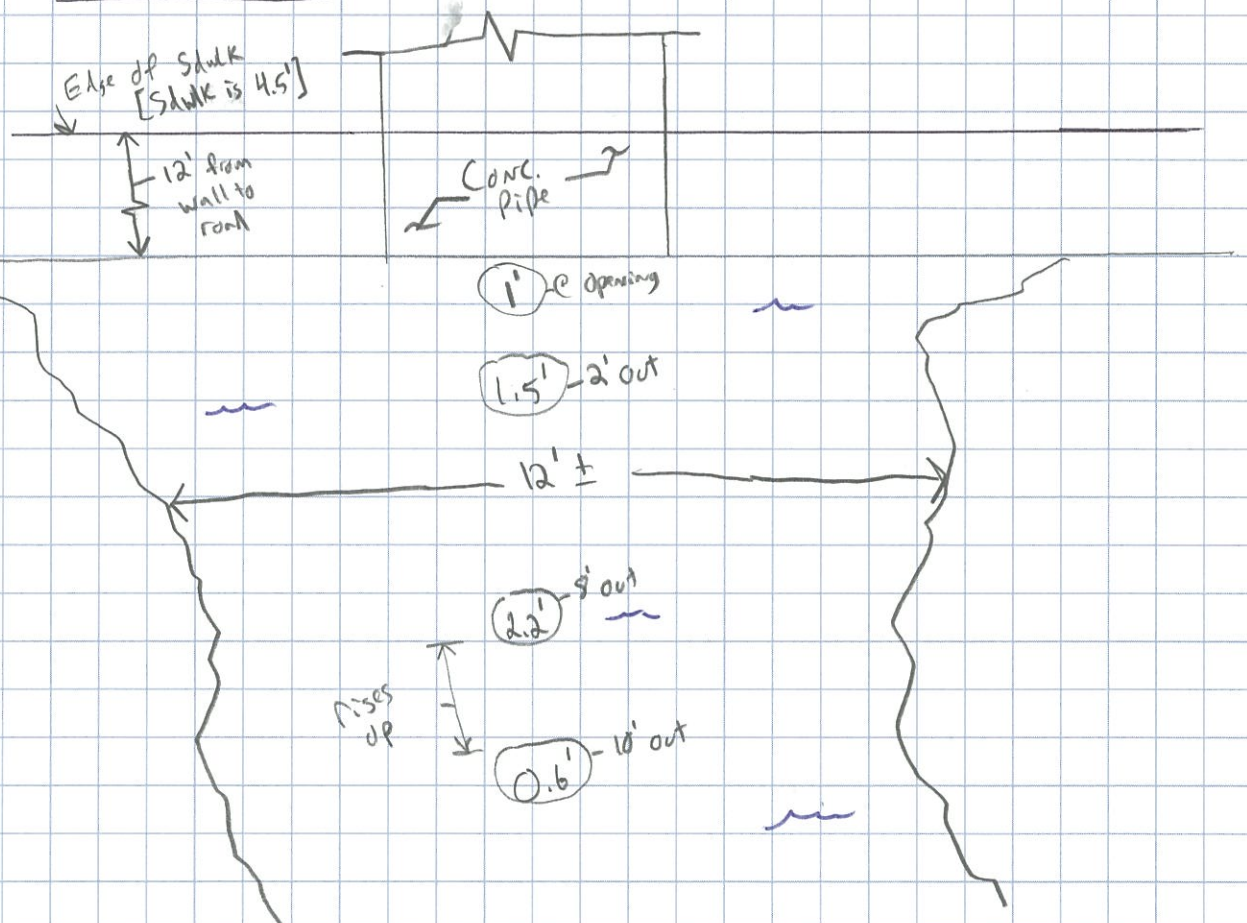
Approach Rail Notes: East side rail in Good condition

BETA
ENGINEERING SUCCESS TOGETHER

JOB Plainville Inspections No. 7624
CALCULATED BY Brandon Nelson DATE 5/12/21
CHECKED BY _____ DATE _____
DESCRIPTION Taunton St over Turnpike Lake SHEET NO. 1 OF 2




East Elev [Looking W]

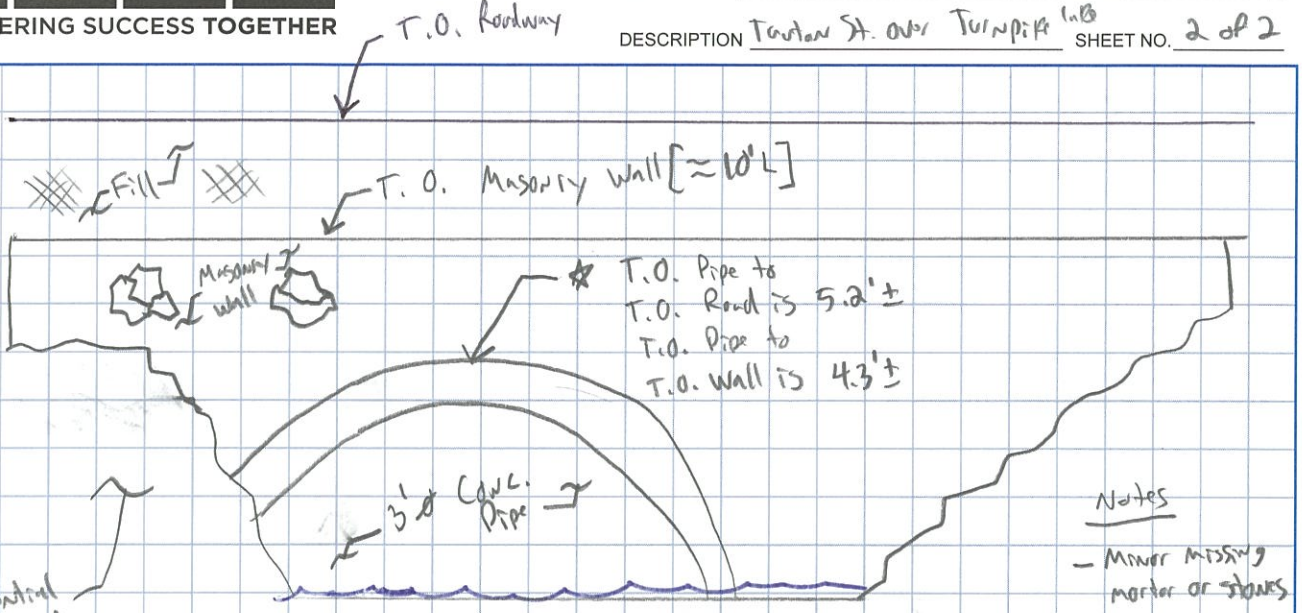



East Plan

(#) = Water Elev

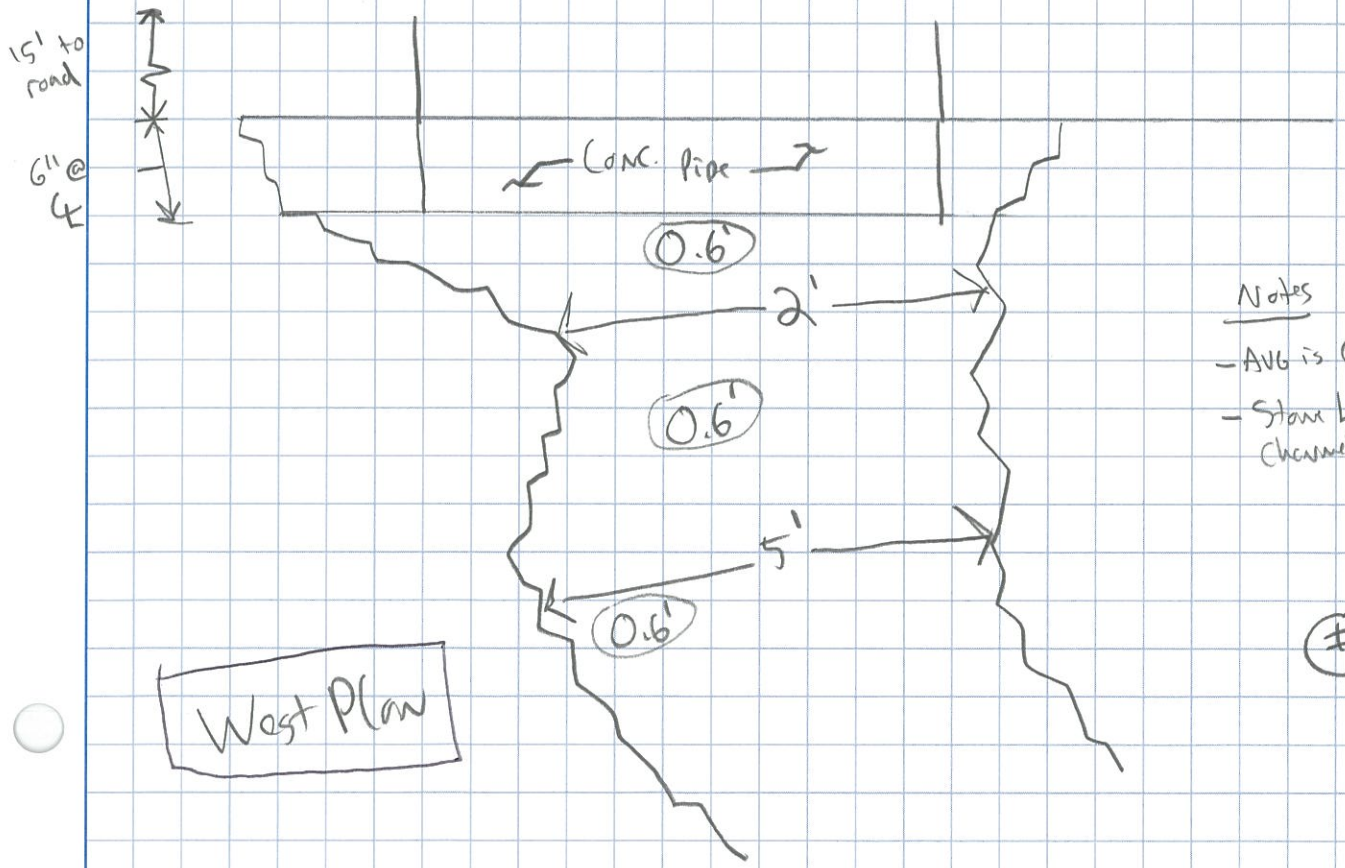
BETA
ENGINEERING SUCCESS TOGETHER

JOB Plainville Inspections No. 7624
CALCULATED BY Braden Nelson DATE 5/12/21
CHECKED BY _____ DATE _____
DESCRIPTION Taunton St. over Turnpike NB SHEET NO. 2 of 2




West Elev [Looking E]

Notes
- Minor missing mortar or stones
- Stones Falling N End of Wall




West Plan

Notes
- AVG is 0.6'
- Stone Lined Channel Bank

(#) = Water Elev

# APPENDIX B
# Photo Survey

Photo 1 Looking West: East Elevation

Photo 2 Looking West: East View of Pipe

Photo 3 Looking East: West Elevation

Photo 4 Looking East: Water Through Pipe

Photo 5 Looking East: Secondary Pipe Deteriorated

Photo 6 Looking North: Northeast Embankment

Photo 7 Looking Southwest: Southeast Embankment

Photo 8 Looking East: Water Flow

Photo 9 Looking West: Water Flow

Photo 10 Looking Northeast: Northwest Embankment


Photo 11 Looking South: North Approach

Photo 12 Looking North: South Approach

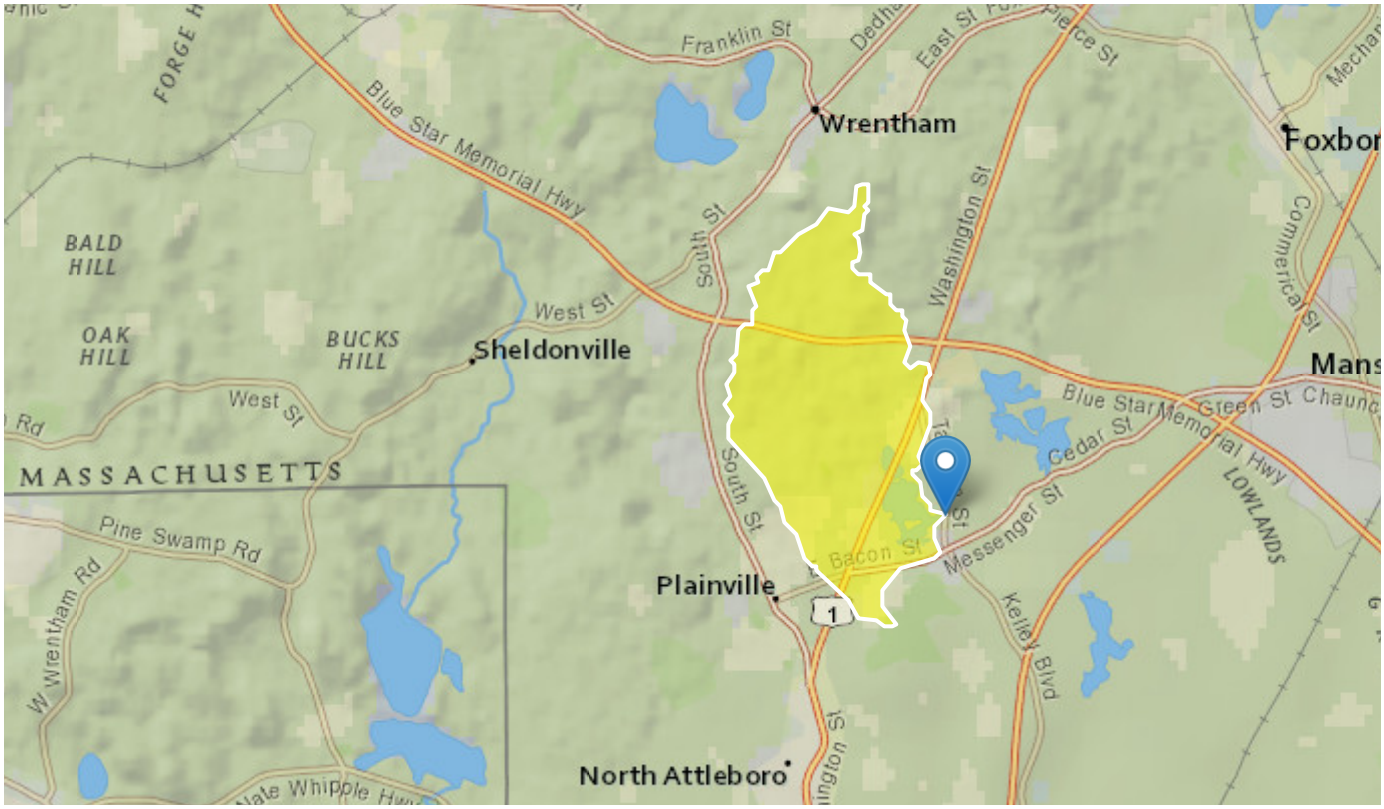
Photo 13 Looking West: West Side Curb

Photo 14 Looking South: East Sidewalk

# APPENDIX C
# StreamStats Data

# Taunton St Culvert - StreamStats Report

**Region ID:** MA
**Workspace ID:** MA20210504145620931000
**Clicked Point (Latitude, Longitude):** 42.01491, -71.30595
**Time:** 2021-05-04 10:56:38 -0400




Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| DRNAREA | Area that drains to a point on a stream | 4.28 | square miles |
| ELEV | Mean Basin Elevation | 273 | feet |
| LC06STOR | Percentage of water bodies and wetlands determined from the NLCD 2006 | 11.21 | percent |
| BSLDEM10M | Mean basin slope computed from 10 m DEM | 5.801 | percent |

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

| Parameter Code | Parameter Name | Value | Units | Min Limit | Max Limit |
|---|---|---|---|---|---|
| DRNAREA | Drainage Area | 4.28 | square miles | 0.16 | 512 |
| ELEV | Mean Basin Elevation | 273 | feet | 80.6 | 1948 |
| LC06STOR | Percent Storage from NLCD2006 | 11.21 | 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 | 114 | ft^3/s | 58.4 | 223 | 42.3 |
| 20-percent AEP flood | 189 | ft^3/s | 95.5 | 374 | 43.4 |
| 10-percent AEP flood | 247 | ft^3/s | 122 | 501 | 44.7 |
| 4-percent AEP flood | 332 | ft^3/s | 158 | 696 | 47.1 |
| 2-percent AEP flood | 403 | ft^3/s | 186 | 872 | 49.4 |
| 1-percent AEP flood | 477 | ft^3/s | 214 | 1060 | 51.8 |
| 0.5-percent AEP flood | 558 | ft^3/s | 243 | 1280 | 54.1 |
| 0.2-percent AEP flood | 674 | ft^3/s | 280 | 1620 | 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 | 4.28 | square miles | 0.6 | 329 |
| BSLDEM10M | Mean Basin Slope from 10m DEM | 5.801 | 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 | 25.7 | ft | 21.3 |
| Bankfull Depth | 1.4 | ft | 19.8 |
| Bankfull Area | 35.8 | ft^2 | 29 |
| Bankfull Streamflow | 95 | 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.

On Turnpike Lake in Plainville there are two small dams. The Plainville Highway Department removes the flashboards of these dams when the water level of the lake approaches flood stage. For the dam computations it has been assumed that all flashboards would be removed. Water can be diverted from Turtle Brook into a canal just below Turnpike Lake Dam No.1. The diverted water can be returned to Turtle Brook upstream from the site of an abandoned mill at Taunton Street. Furthermore, there is a leakage from the canal which is at a higher elevation than the brook. However, because there is no way of knowing how much, if any, water would be diverted into the canal during a flood, it has been assumed that canal flow would be negligible.

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.

| FLOODING SOURCE AND LOCATION | DRAINAGE AREA (SQUARE MILES) | PEAK DISCHARGES (CUBIC FEET PER SECOND) 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 |
| TURTLE BROOK | | | | | |
| At Mirimichi Street | 5.29 | 260 | 440 | 540 | 830 |
| Above confluence with Sawmill Brook | 3.50 | 145 | 215 | 285 | 495 |
| At Shepard Street | 1.88 | 110 | 190 | 235 | 365 |

# National Flood Hazard Layer FIRMette

71°18'42"W 42°1'6"N


71°18'5"W 42°0'40"N

Feet

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

1:6,000

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

## Legend

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

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

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

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

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

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

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

N

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

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 5/4/2021 at 11:51 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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

# APPENDIX E
# Hydrologic Data/Climate Change Adjustment

## Hydrologic Data

StreamStats flows data (workspace ID: MA20210504145620931000) will be used to evaluate the culvert which are listed as follows:

10 Yr = 247 cfs 25 Yr. = 332 cfs 50 Yr = 403 cfs 100 Yr = 477 cfs

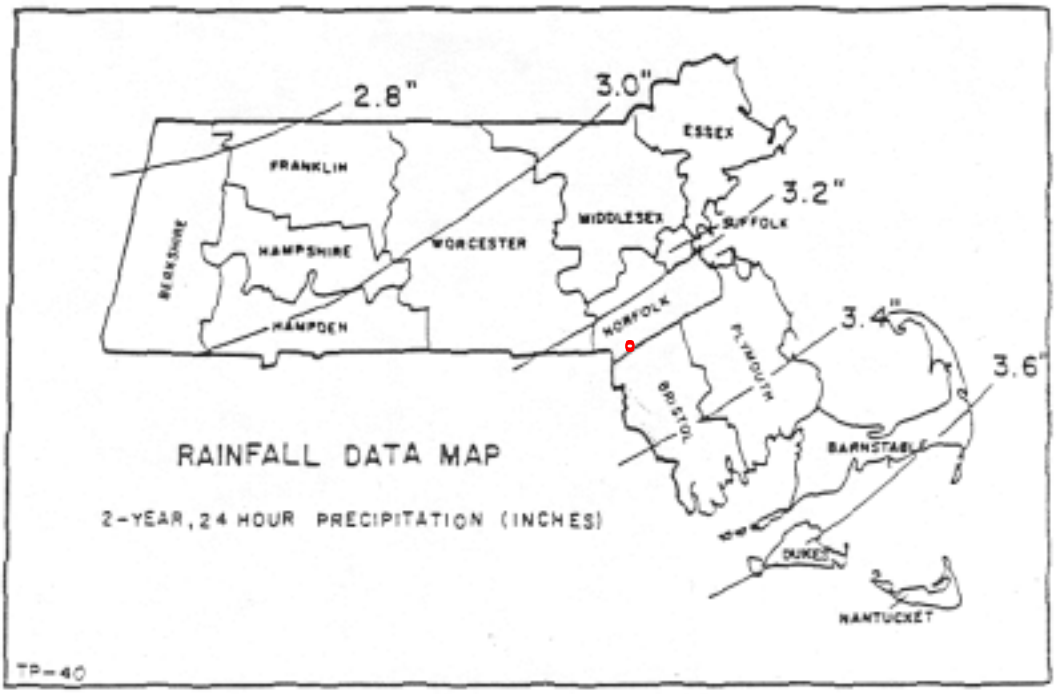
## Climate Change Adjustment

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 | | 114 | | 3.4 | 127 |
| | | 0.9 | | 75 | | |
| 5 | 4.15 | | 189 | | 4.38 | 214 |
| | | 0.54 | | 58 | | |
| 10 | 4.69 | | 247 | | 5.2 | 298 |
| | | 0.85 | | 85 | | |
| 25 | 5.54 | | 332 | | 6.32 | 423 |
| | | 0.61 | | 71 | | |
| 50 | 6.15 | | 403 | | 7.15 | 517 |
| | | 0.65 | | 74 | | |
| 100 | 6.80 | 3.55 | 477 | 363 | 8.05 | 605 |

Adjusted Flow = 3+((5-1)/2)x4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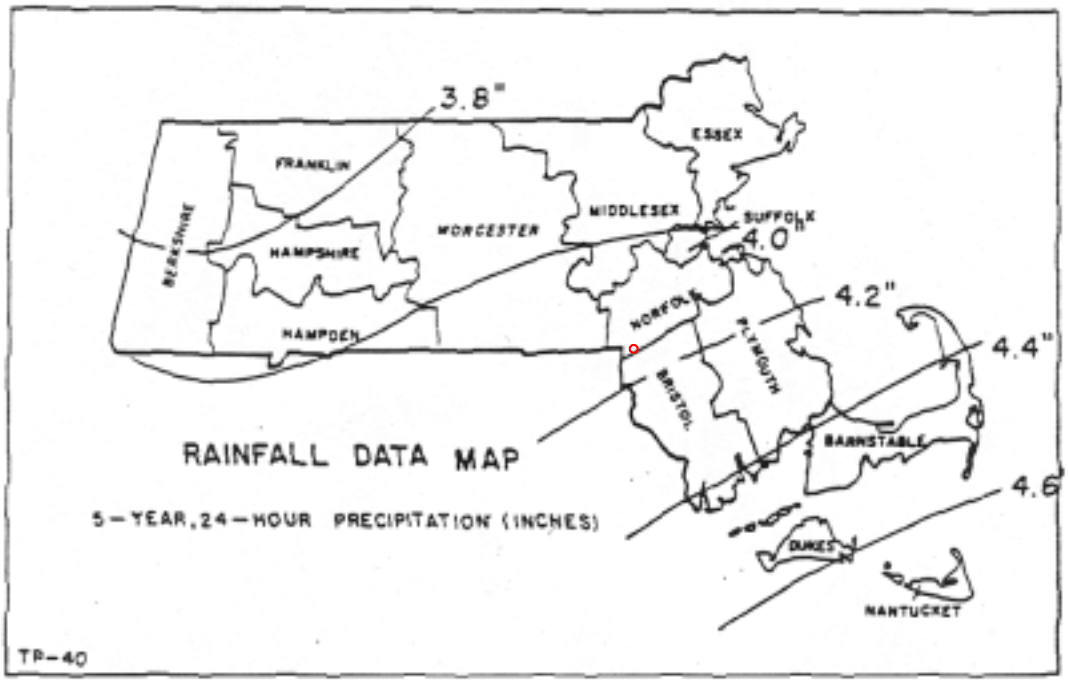
NORFOLK
HAMPDEN
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
2-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40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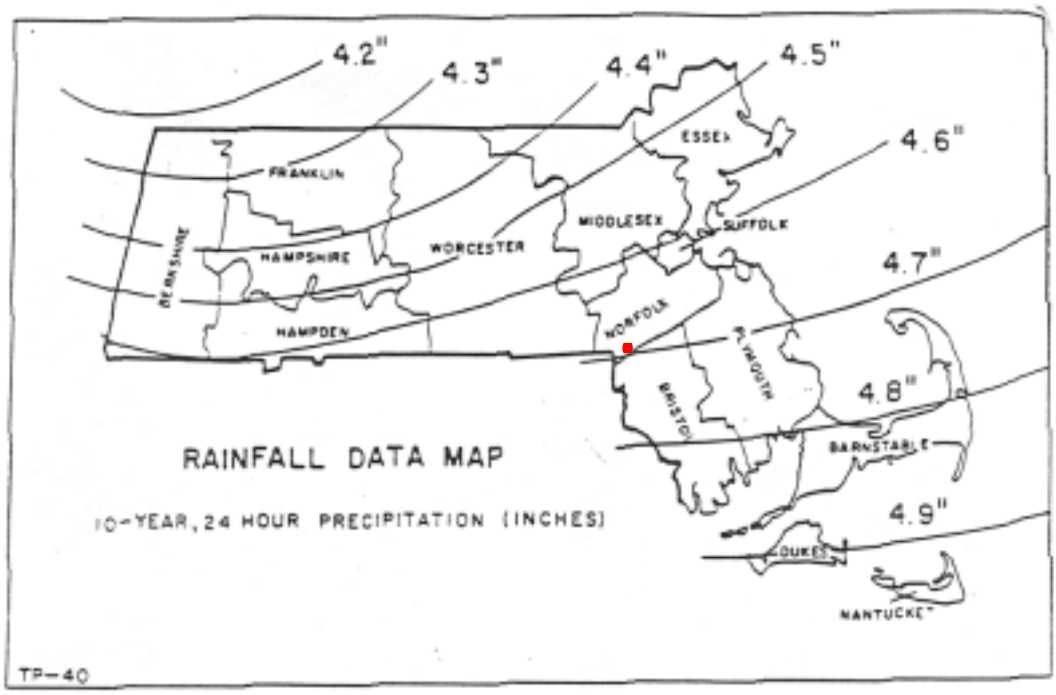
DUKES
NANTUCKET
RAINFALL DATA MAP
5-YEAR, 24-HOUR PRECIPITATION (INCHES)
TP-40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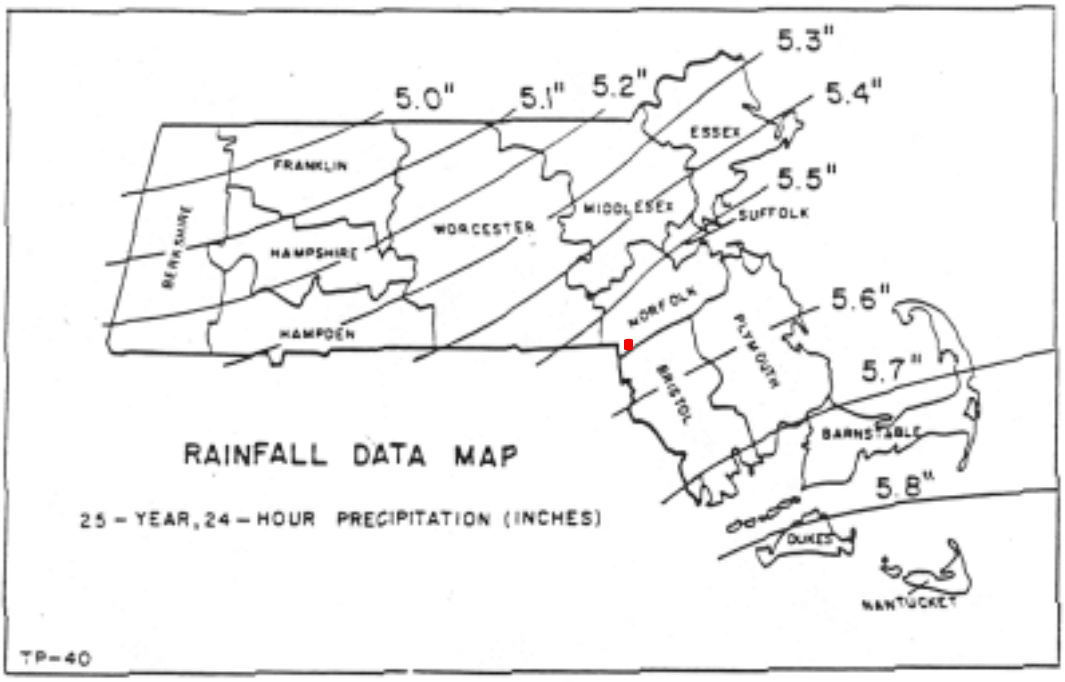
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
10-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40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PLYMOUTH
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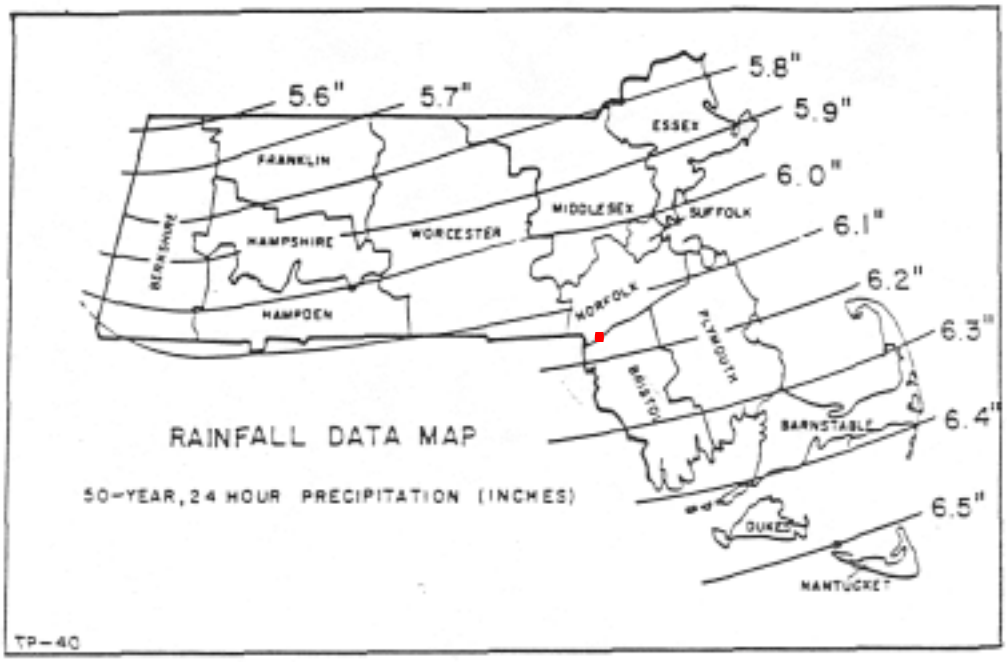
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
25 - YEAR, 24 - HOUR PRECIPITATION (INCHES)
TP-40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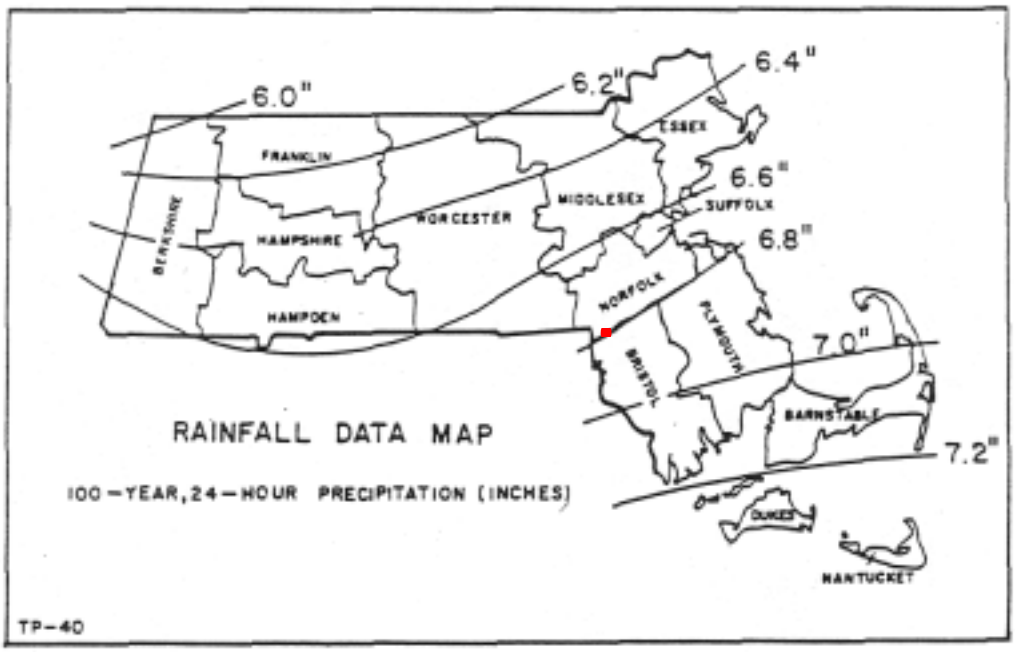
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
50-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40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HAMPSHIRE
WORCESTER
BERKSHIRE
HAMPDEN
NORFOLK
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
100-YEAR, 24-HOUR PRECIPITATION (INCHES)
TP-40

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. | |

**Taunton Street over Sawmill Brook/Turnpike Lake**

Interim Repairs:

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

| | | | | |
|---|---|---|---|---|
| Approximate Wall Length (East Side) = | 20.00 | ft | | |
| Approximate Wall Height (East Side) = | 6.87 | ft | | |
| Approximate Wall Depth (East Side) = | 1.00 | ft | | |
| Approximate Wall Length (West Side) = | 10.00 | ft | | |
| Approximate Wall Height (West Side) = | 4.30 | ft | | |
| Approximate Wall Depth (West Side) = | 1.00 | ft | | |
| Volume of Repairs = | 180.33 | cf | | |
| = | 6.68 | cy | | |
| Say = | 7.00 | | | |
| Stone Masonry Wall in Cement Mortar (Item 685.) = | $900.00 | Per CY | Masonry Repairs = | $6,300 |
| Contingency & Misc. Items = | 30.00% | of construction cost | Contingency & Misc. Items = | $1,890 |
| Mobilization/Demobilization = | 10.00% | of total construction cost | Mobilization/Demobilization = | $819 |
| | | | Cost of Interim Repairs = | $9,009.00 |
| | | | Call = | **$10,000.00** |
| | | | 25% Engineering Cost = | **$3,000** |
| | | | **TOTAL COST =** | **$13,000** |

Replacement:

| | | | | |
|---|---|---|---|---|
| Hydraulic Opening = | 20.00 | sf | | |
| Length to be Replaced = | 55.50 | ft | | |
| Total Volume = | 1110.00 | CF | | |
| Precast Box Unit Cost = | $30.00 | Per CF *(Wingwalls Included)* | | |
| Material Cost = | $33,300.00 | | | |
| Labor & Installation Cost = x | 2.30 | | Culvert Cost = | $76,590 |
| | | | | |
| Estimated Footing Length = | 57.50 | ft | | |
| Estimated Footing Width = | 4.00 | ft | | |
| Estimated Footing Depth = | 2.00 | ft | | |
| $ of Footings = | 2.00 | ea | | |
| = | 920.00 | cf | | |
| Total Volume = | 34.07 | cy | | |
| Say = | 40.00 | CY | | |
| 4000 PSI Concrete Unit Cost = | $750.00 | Per CY (Item 904.) | Footing Cost = | $30,000 |
| | | | | |
| Assume 100lbs Steel / CY = | 4000.00 | LBS | | |
| Steel Reinforcing Unit Cost = | $3.00 | Per LB (Item 910.) | Reinforcing Cost = | $12,000 |
| | | | | |
| Bridge Railing = | $150.00 | Per LF | | |
| Railing Length = | 50.00 | LF | Bridge Rail = | $7,500 |
| | | | | |
| Roadway Work = | 30.00% | of culvert cost | Roadway Work = | $37,827 |
| | | | | |
| LS Cost of Water Diversion = | $10,000.00 | LS | Water Diversion = | $10,000 |
| | | | | |
| Contingency & Misc. Items = | 30.00% | of construction cost | Contingency & Misc. Items = | $52,175 |
| | | | | |
| Mobilization/Demobilization = | 10.00% | of total construction cost | Mobilization/Demobilization = | $22,609 |
| | | | Cost of Replacement = | $248,701 |
| | | | Call = | **$250,000** |
| | | | | |
| | | | 25% Engineering Cost = | **$65,000** |
| | | | | |
| | | | **TOTAL COST =** | **$315,000** |