
Subject	Hop Brook Hydraulic Memo	Project Name	Bruce Freeman Rail Trail over Hop Brook
Attention	Hanan Fouad, MassDOT	Project No.	608164
From	Aaron Seaman, Jacobs		
Date	4/20/2020		
Copies to	File		

The proposed project involves replacement of a timber railroad bridge deck over Hop Brook in Sudbury, Massachusetts. The existing bridge deck is supported by steel girders with stone masonry abutments, and spans over the National Flood Insurance Program (NFIP) Special Flood Hazard Area (SFHA) Zone AE and regulatory floodway delineations determined for Hop Brook during the 2016 Middlesex County NFIP Flood Insurance Study (FIS). The existing bridge span is approximately 27 feet and crosses Hop Brook with no skew. The hydraulic design flood for this project is the 10-year event.

At a meeting with MassDOT that occurred on March 4, 2020, it was determined that a full hydraulic analysis with “no-rise” and scour analyses would not be required for this project. This determination was made because the proposed project will not change the existing hydraulic opening of the structure and there was no evidence of scour observed. In lieu of a full hydraulic analysis and report, this hydraulic memo combined with information from the FEMA Flood Insurance Study (FIS) will provide the necessary information for sketch plans.

The drainage area was determined by using StreamStats. The Flood discharges and elevations were determined from the 2016 Middlesex County Flood Insurance Study. The Design and Base Flood Discharges were interpolated from Table 8 “Summary of Discharges for Hop Brook” and Design and Base Flood Elevations were determined from the Hop Brook Flood Profiles “Panel # 256P”. These pages from the FIS are included with this memo.

A culvert analysis (see included culvert report) was performed for the design flow to determine the water velocity at the crossing. To complete this analysis, the height of hydraulic opening was obtained from the Preliminary Structures Report by VHB, dated September 2017, where the recorded clearance below the interior girders is 7'-3". All the hydraulic information collected for this crossing is provided in the following hydraulic design table:

Hydraulic Design Data Table

Hydraulic Design Data:

Drainage Area	14.7 Square Miles
Design Flood Frequency	10-Years
Design Flood Discharge	452 cubic feet per second
Design Flood Velocity	2.66 feet per second
Design Flood Elevation	136.7 feet (NAVD 88)

Base (100-Year) Flood Data:

Discharge	881 cubic feet per second
Water Surface Elevation	138.2 feet (NAVD 88)

Design and Check Scour Data:

Design Scour Return Frequency	25 Years
Check Scour Return Frequency	50 Years

Flood of Record:

Discharge	Unknown
Frequency (If Known)	Unknown
Maximum Elevation	Unknown
Date:	Unknown
History of Ice Floes:	Unknown
Evidence of Scour and Erosion:	Unknown

not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations (BFEs)** and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Massachusetts State Plane Mainland Zone (FIPS zone 2001). The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov> or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at <http://www.ngs.noaa.gov>.

Base map information shown on this FIRM was derived from orthophotography provided by MassGIS at a scale of 1:500 from photography dated April 2008.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

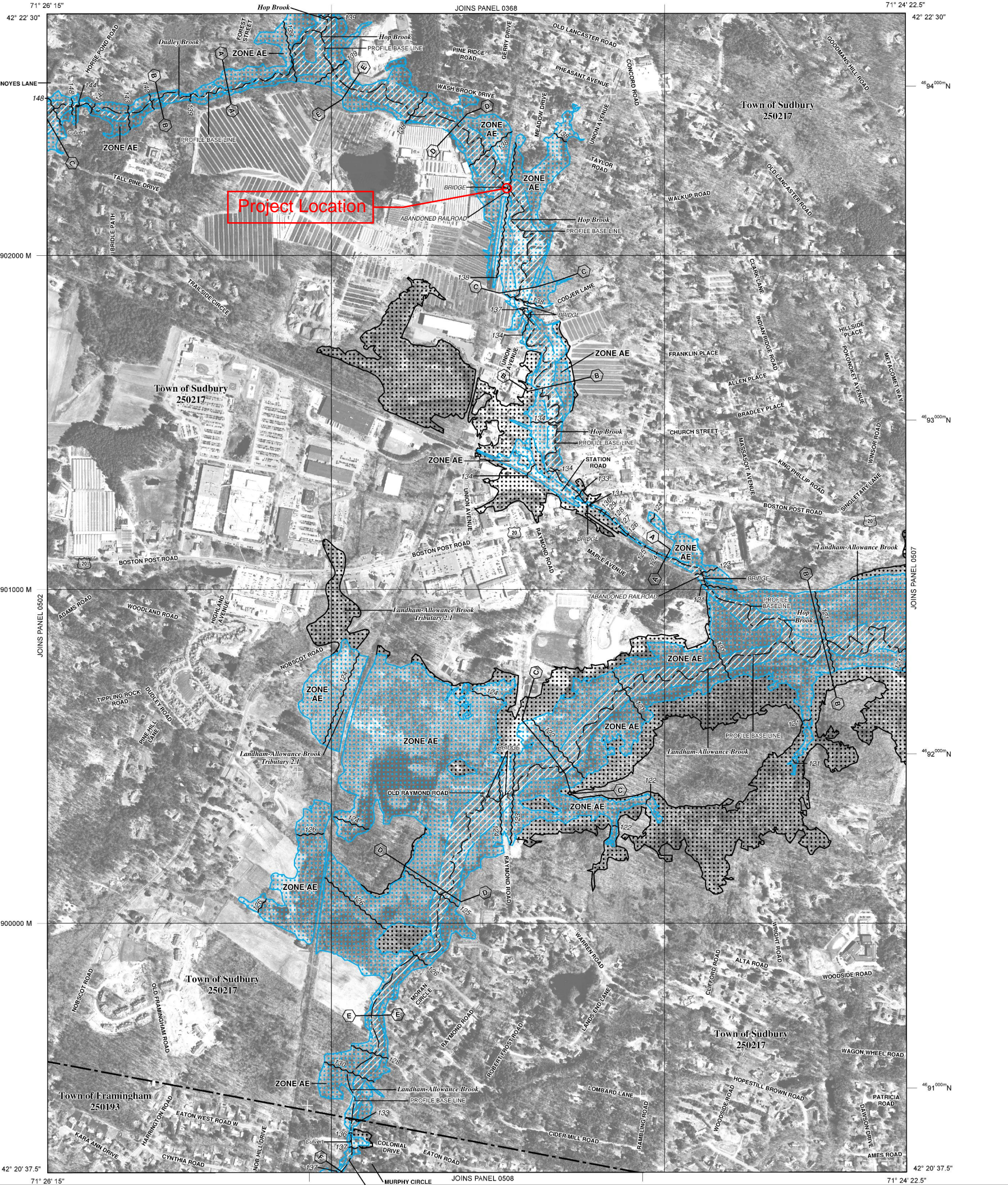
This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables for multiple streams in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at <http://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map**, how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov/business/nfp>.



The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently derelict. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% Annual Chance Floodplain Boundary
0.2% Annual Chance Floodplain Boundary
Floodway boundary
Zone D boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
Base Flood Elevation line and value; elevation in feet*
Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — **A** Cross section line
23 - - - **23** Transect line
45° 02' 08", 93° 02' 12" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
4989000 M 1000-meter ticks; Massachusetts State Plane Mainland Zone (FIPS Zone 2001), Lambert Conformal Conic projection
4989000 N 1000-meter Universal Transverse Mercator grid values, zone 19
DX5510 X Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5 River Mile
MAP REPOSITORIES
Refer to Map Index for Firm Panel Layout
EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
June 4, 2010
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
July 7, 2014 - to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to add roads and road names, and to incorporate previously issued Letters of Map Revision.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.
To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'
250 0 500 1000
150 0 150 300
FEET
METERS

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0506F

FIRM
FLOOD INSURANCE RATE MAP
MIDDLESEX COUNTY, MASSACHUSETTS (ALL JURISDICTIONS)

PANEL 506 OF 656
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
FRAMINGHAM, TOWN OF	250193	0506	F
SUDBURY, TOWN OF	250217	0506	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
25017C0506F

TABLE 8 - SUMMARY OF DISCHARGES – continued

<u>FLOODING SOURCE AND LOCATION</u>	<u>DRAINAGE AREA (sq. miles)</u>	<u>PEAK DISCHARGES (cfs)</u>			
		<u>10-PERCENT</u>	<u>2-PERCENT</u>	<u>1-PERCENT</u>	<u>0.2-PERCENT</u>
HEATH HEN MEADOW BROOK					
At the confluence with Fort Pond Brook	5.8	280	450	540	730
About 1.7 miles downstream of West Acton Road	5.0	160	290	370	560
HOBBS BROOK 1					
At confluence with Stony Brook 1	24.7	300	400	525	775
At inlet to pond upstream of North Avenue	8.6	280	380	500	730
At Weston/Waltham corporate limits	7.2	150	200	260	390
HOBBS BROOK 2					
At Lexington Road	2.4	97	145	167	221
HOG BROOK					
At confluence with Assabet River	3.5	214	341	400	583
HOP BROOK					
At confluence with Landham-Allowance Brook	15.6	470	770	920	1,300
Above confluence of Dudley Brook	11.7	390	630	750	1,050
Above confluence of Run Brook	9.2	320	530	630	890
At Dutton Road	3.5	160	260	310	440
At the Sudbury/Framingham corporate limits	2.0	180	280	320	440
At the Marlborough/Sudbury corporate limits	1.3	160	260	310	435
HORN POND BROOK/ FOWLE BROOK					
At confluence with Aberjona River	9.8	200	430	610	1,240
At Horn Pond Dam	8.8	180	400	570	1,080
Downstream of confluence of Cummings Brook and Shakers Glen Brook	6.2	170	350	490	910

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Hobbs Brook 2								
A	160 ¹	67	410	0.4	172.6	172.6	173.6	1.0
B	760 ¹	79	232	0.7	173.4	173.4	174.4	1.0
C	1,660 ¹	21	25	6.3	176.4	176.4	176.4	0.0
Hog Brook								
A	355 ²	16	43	9.4	212.4	210.1 ⁴	210.1	0.0
B	475 ²	16	58	6.9	212.4	211.6 ⁴	212.2	0.6
C	608 ²	235	998	0.4	214.5	214.5	214.5	0.0
D	1,595 ²	31	54	7.5	220.5	220.5	220.5	0.0
E	2,662 ²	30	53	7.6	234.7	234.7	235.3	0.6
F	3,515 ²	22	48	8.4	238.6	238.6	238.8	0.2
Hop Brook								
A	1,910 ³	30	165	5.6	123.5	123.5	124.5	1.0
B	4,560 ³	163	724	1.3	133.6	133.6	134.3	0.7
C	6,000 ³	165	703	1.3	137.8	137.8	137.8	0.0
D	8,500 ³	125	720	1.3	138.2	138.2	138.4	0.2
E	9,830 ³	90	311	2.4	138.4	138.4	138.7	0.3
F	11,220 ³	226	914	0.8	138.7	138.7	139.1	0.4
G	12,700 ³	155	574	1.3	141.2	141.2	141.2	0.0
H	14,800 ³	325	1,443	0.5	145.7	145.7	146.3	0.6
I	16,155 ³	54	225	3.3	146.0	146.0	146.7	0.7
J	17,170 ³	45	204	3.7	146.5	146.5	147.3	0.8
K	19,050 ³	55	239	2.7	147.9	147.9	148.9	1.0
L	21,270 ³	60	239	2.6	148.8	148.8	149.8	1.0
M	22,520 ³	124	357	1.8	150.3	150.3	151.3	1.0

¹ Feet above limit of detailed study, limit of detailed study is approximately 660 feet downstream of Mill Street

² Feet above confluence with Assabet River

³ Feet above confluence with Landham-Allowance Brook

⁴ Elevation computed without consideration of backwater effects from Assabet River

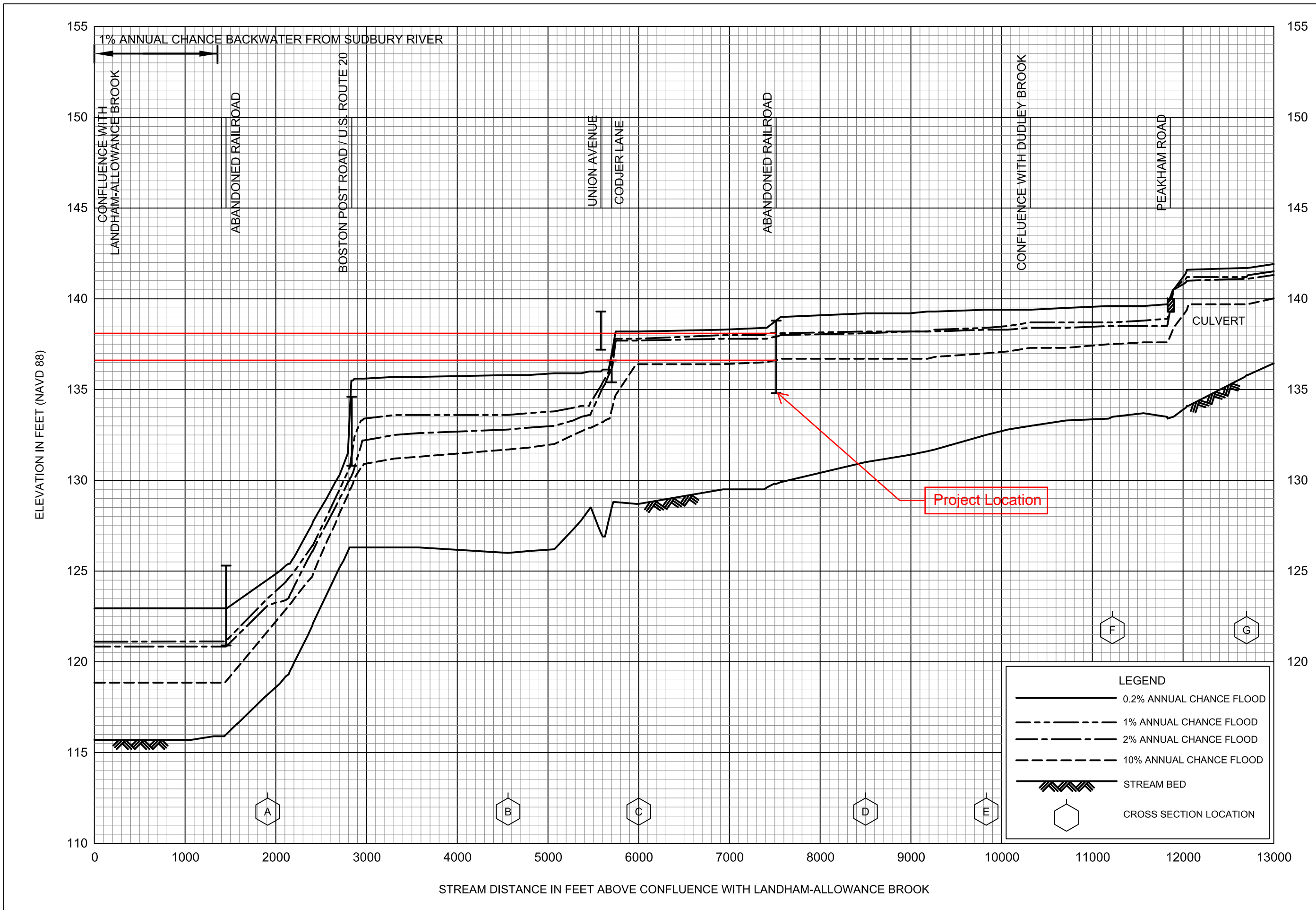
TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

**MIDDLESEX COUNTY, MA
(ALL JURISDICTIONS)**

FLOODWAY DATA

HOBBS BROOK 2 – HOG BROOK – HOP BROOK



FLOOD PROFILES

HOP BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MIDDLESEX COUNTY, MA

(ALL JURISDICTIONS)

Culvert Report

1 2020 Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Bruce Freeman Rail Trail over Hop Brook

Invert Elev Dn (ft)	=	129.75
Pipe Length (ft)	=	16.00
Slope (%)	=	0.06
Invert Elev Up (ft)	=	129.76
Rise (in)	=	87.0
Shape	=	Box
Span (in)	=	282.0
No. Barrels	=	1
n-Value	=	0.045
Culvert Type	=	Flared Wingwalls
Culvert Entrance	=	90D and 15D wingwall flares
Coeff. K,M,c,Y,k	=	0.061, 0.75, 0.04, 0.8, 0.5

Embankment

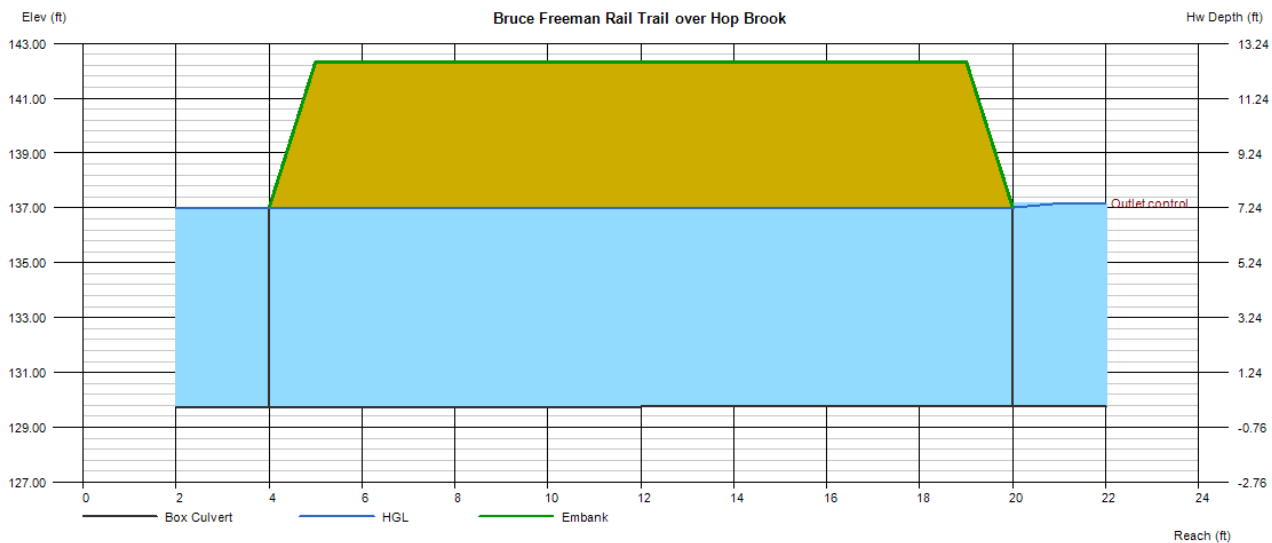
Top Elevation (ft)	=	142.33
Top Width (ft)	=	14.00
Crest Width (ft)	=	200.00

Calculations

Qmin (cfs)	=	452.00
Qmax (cfs)	=	452.00
Tailwater Elev (ft)	=	Normal

Highlighted

Qtotal (cfs)	=	452.00
Qpipe (cfs)	=	452.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	2.65
Veloc Up (ft/s)	=	2.66
HGL Dn (ft)	=	137.00
HGL Up (ft)	=	137.00
Hw Elev (ft)	=	137.17
Hw/D (ft)	=	1.02
Flow Regime	=	Outlet Control



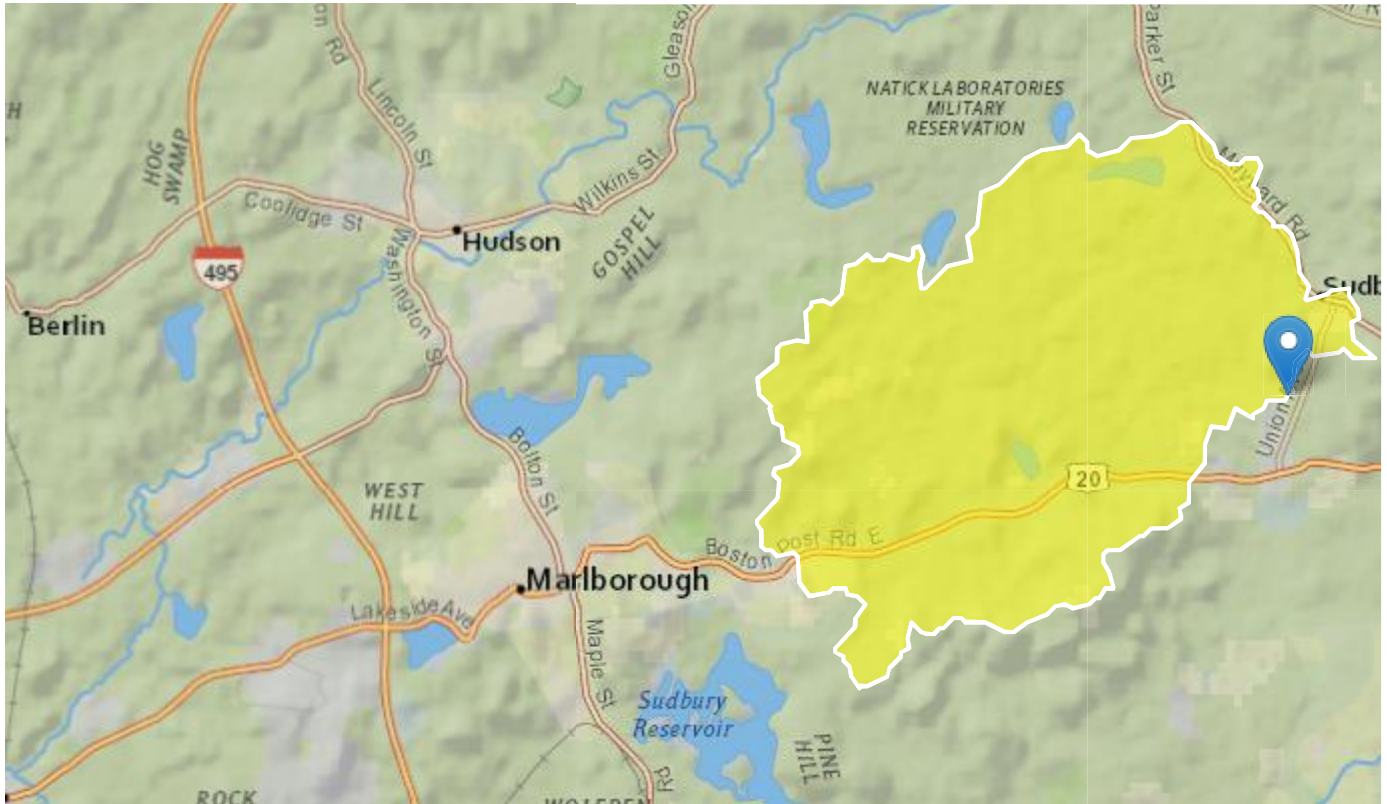
Hop Brook StreamStats Report

Region ID: MA

Workspace ID: MA20200420155510750000

Clicked Point (Latitude, Longitude): 42.37045, -71.42096

Time: 2020-04-20 11:55:27 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	14.7	square miles
ELEV	Mean Basin Elevation	227	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	12.02	percent

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	14.7	square miles	0.16	512
ELEV	Mean Basin Elevation	227	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	12.02	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
2 Year Peak Flood	295	ft ³ /s	151	575	42.3
5 Year Peak Flood	479	ft ³ /s	243	945	43.4
10 Year Peak Flood	622	ft ³ /s	308	1260	44.7
25 Year Peak Flood	827	ft ³ /s	396	1730	47.1
50 Year Peak Flood	996	ft ³ /s	462	2150	49.4
100 Year Peak Flood	1170	ft ³ /s	528	2610	51.8
200 Year Peak Flood	1370	ft ³ /s	597	3120	54.1
500 Year Peak Flood	1640	ft ³ /s	684	3930	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>)

USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Although these data and associated metadata have been reviewed for accuracy and completeness and approved for release by the U.S. Geological Survey (USGS), no warranty expressed or implied is made regarding the display or utility of the data for other purposes, nor on all computer systems, nor shall the act of distribution constitute any such warranty.

USGS Software Disclaimer: This software has been approved for release by the U.S. Geological Survey (USGS). Although the software has been subjected to rigorous review, the USGS reserves the right to update the software as needed pursuant to further analysis and review. No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the software and related material nor shall the fact of release constitute any such warranty. Furthermore, the software is released on condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from its authorized or unauthorized use.