Hydrology & Hydraulics Report

Higgins Bridge #2370
over
Douglas Brook

Gorham, Maine

WIN 023899.00

Maine Department of Transportation
Bridge Program

HYDRAULICS/HYDROLOGY REPORT

The twin 6'-0" pipes installed on the weekend of 4/7 – 4/8 are intended to be a temporary maintenance fix to allow enough time to design, fabricate and install a permanent structure. These pipes were estimated to be able to pass a Q10 event, but overtop before reaching proposed flows from a Q20 event, per an HY-8 analysis performed by the MaineDOT Hydrology group. The flow rates used for the HY-8 analysis were computed using the 1999 U.S.G.S. full regression equation, and are defined below.

A summary of the calculated flow rates for Douglas Brook is shown below:

SUMMARY		
Drainage Area	4.7	mi^2
Q1.1	68.1	ft^3/s
Q10	270.1	ft^3/s
Q25	354.4	ft^3/s
Q50	409.4	ft^3/s
Q100	479.5	ft^3/s
Q500	639.9	ft^3/s

The minimum span of the proposed structure will be 21'-0", based on the calculated 1.2*BFW. This span, along with the defined flow rates, were used as inputs for an HY-8 model to determine the rise of a replacement structure. The proposed structure was chosen to be a precast concrete box, as local fabricators and contractors routinely deal with precast concrete boxes, which should yield highly competitive bidding. The rise was determined based on meeting a head water to depth ratio (HW/D) of less than 0.9 for a Q50 water depth per the Bridge Design Guide (BDG). Iterations with various box rises were run through HY-8 until an alternative that met the appropriate HW/D ratio was determined. These iterations resulted in a required rise of 8'-0", including 2'-0" of embedment for a natural stream bed simulation in the box (see Appendix for supporting documentation).

Headwater elevations and stream velocities from peak flows for the existing and proposed structures are reported in the table below.

SUMMARY

		Existing Structure	Recommended Structure
		13'-11" span x 8'-7" rise Pipe Arch	21'-0" span x 8'-0" rise concrete box
Total Area of Waterway Opening	ft^2	93	126
Headwater elevation @ $Q_{1.1}$	ft	219.78	219.67
Headwater elevation @ Q_{10}	ft	222.24	221.45
Headwater elevation @ Q_{25}	ft	223.06	222.02
Headwater elevation @ Q_{50}	ft	223.64	222.42
Headwater elevation @ Q_{100}	ft	224.29	222.86
Headwater elevation @ Q_{500}	ft	225.74	223.8
Freeboard @ Q_{50}	ft	2.44	1.58
Freeboard @ Q_{100}	ft	0.34	1.14
Velocity @ $Q_{1.1}$	ft/s	3.24	3.09
Velocity @ Q_{10}	ft/s	8.24	6.84
Velocity @ Q_{25}	ft/s	9.37	8.02
Velocity @ Q_{50}	ft/s	9.9	8.55
Velocity @ Q_{100}	ft/s	10.48	9.01
Velocity @ Q_{500}	ft/s	11.73	9.96

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

APPENDIX

Hydrology & Hydraulic Documentation

WIN:	23899.00	**Project Name:**	Higgins Bridge
Town:	Gorham	**Stream Name:**	Douglas Brook
Route No.	25	**Bridge Name:**	Higgins Bridge
Asset ID:		**Analysis by:**	
Lat:	**Long:**	**Date:**	

Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

	km^2	mi^2	ac	***Enter data in [mi^2]***
A	12.17	4.70	3008.0	Watershed Area *DRNAREA*
W	1.67	0.6	412.1	Wetlands area (by NWI)

P_c	376157	4841060	watershed centroid (E, N; UTM 19N; meters)
County	Cumberland SE		*choose county from drop-down menu*
pptA	44.4		mean annual precipitation (inches; by look-up)
SG	0.00		sand & gravel aquifer as decimal fraction of watershed A

A (km^2)	12.17	**Conf Lvl**	0.67
W (%)	13.70		NWI Wetlands % *STORNWI*
	3		

Ret Pd	**Peak Flow Estimate**			
T (yr)	**Lower**	**Q_T (m^3/s)**	**Upper**	**Q_T (ft^3/s)**
1.1		1.93		68.1
2		3.92		138.5
5		6.14		216.7
10		7.65		270.1
25		10.04		354.4
50		11.59		409.4
100		13.58		479.5
500		18.12		639.9

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ver. 2017 Jun. 09

References:

Hodgkins, G.A., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
WRIR 99-4008, USGS Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2015.
Peak flow regression equations for small, ungaged streams in Maine - Comparing map-based to field-based variables
SIR 2015-4059, USGS, Augusta, ME

$Q_T = b \times A^a \times 10^{-wW}$

PRELIM. BY PCE DATE 4/12/18 PROJ. NO. 23899.00 FILE NO. ____ OF ____
FINAL CHK. BY ____ DATE ____ LOCATION Gorham SHEET NO. 1 OF 1
ITEM NO. ____ SUBJECT ____

HW/D ratio

Box dimensions: 21' x 9'

2' embedment ∴ 9' - 2' = 7' = D

Elevation of Stream bed = 217.5'

R1) Q50 = 410 cfs

HW elevation = 223.63' - 217.5' = 6.13'
(from HY-8)

HW/D = 6.13'/7' = 0.876 ≤ 0.9 per BDG ∴ good

R2) Q50 = 410 cfs

Box Dimensions: 21' x X' 4/24/18

Stream bed elevation: 217.5

HW elevation = 222.24'
(from HY-8)

HW - Streambed = 222.24 - 217.5 = 4.74'

HW/D ≤ 0.9 ⇒ 4.74/0.9 = 5.267 ⇒ say 6'

X = 6' + 2' embedment = 8' opening

Box Dimensions = 21' x 8'
(span) (rise)

R3) Q50 = 410 cfs

Box Dimensions = 21' x Y' ~~5/15/18~~ 8/17/18

Stream bed elevation = 217.5

HW elevation = ~~221.88~~ 222.42 cfs
(from HY-8)

HW - Stream bed = ~~221.88 - 217.5 = 4.38'~~ 222.42 - 218.5 = 3.92

HW/D ≤ 0.9 ⇒ ~~4.38/0.9 = 4.867~~ 3.92/0.9 = 4.355 ⇒ say 5' ⇒ use 6' ~~for~~ to be conservative

X = 6' + 2' embedment = 8' opening

Box Dimensions = 21' x 8'
(span) (rise)

MaineDOT MaineDOT

KMR-1

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Higgins Br

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	21' Box Discharge (cfs)	Roadway Discharge (cfs)	Iterations
219.67	1 year	70.00	70.00	0.00	1
220.39	2 year	140.00	140.00	0.00	1
221.02	5 year	215.00	215.00	0.00	1
221.45	10 year	270.00	270.00	0.00	1
222.02	25 year	350.00	350.00	0.00	1
222.42	50 year	410.00	410.00	0.00	1
222.86	100 year	480.00	480.00	0.00	1
223.80	500 year	640.00	640.00	0.00	1
228.98	Overtopping	1426.22	0.00	1.00	

HY-8 Analysis Results

Culvert Summary Table - 21' Box

Culvert Crossing: Higgins Br

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)	Tailwater Velocity (ft/s)
1 year	70.00	70.00	219.67	1.28	1.67	3-M2t	1.53	0.95	1.33	1.13	3.09	2.15
2 year	140.00	140.00	220.39	1.89	2.39	3-M2t	2.20	1.36	1.69	1.49	4.63	2.56
5 year	215.00	215.00	221.02	2.43	3.02	3-M2t	2.79	1.73	1.96	1.76	5.97	2.85
10 year	270.00	270.00	221.45	2.79	3.45	3-M2t	3.17	1.98	2.13	1.93	6.84	3.01
25 year	350.00	350.00	222.02	3.26	4.02	3-M2t	3.68	2.30	2.33	2.13	8.02	3.24
50 year	410.00	410.00	222.42	3.60	4.42	2-M2c	4.03	2.53	2.53	2.26	8.55	3.40
100 year	480.00	480.00	222.86	4.00	4.86	2-M2c	4.42	2.79	2.79	2.40	9.01	3.56
500 year	640.00	640.00	223.80	4.90	5.80	2-M2c	5.23	3.31	3.31	2.68	9.96	3.86

HY-8 Analysis Results

Water Surface Profiles

Culvert Crossing: Higgins Br

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Length Full (ft)	Length Free (ft)
1 year	70.00	70.00	219.67	1.28	1.67	3-M2t	0.00	80.00
2 year	140.00	140.00	220.39	1.89	2.39	3-M2t	0.00	80.00
5 year	215.00	215.00	221.02	2.43	3.02	3-M2t	0.00	80.00
10 year	270.00	270.00	221.45	2.79	3.45	3-M2t	0.00	80.00
25 year	350.00	350.00	222.02	3.26	4.02	3-M2t	0.00	80.00
50 year	410.00	410.00	222.42	3.60	4.42	2-M2c	0.00	80.00
100 year	480.00	480.00	222.86	4.00	4.86	2-M2c	0.00	80.00
500 year	640.00	640.00	223.80	4.90	5.80	2-M2c	0.00	80.00

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Higgins Br - Existing

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Existing Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
219.77	1 year	70.00	70.00	0.00	1
220.74	2 year	140.00	140.00	0.00	1
221.63	5 year	215.00	215.00	0.00	1
222.22	10 year	270.00	270.00	0.00	1
223.04	25 year	350.00	350.00	0.00	1
223.62	50 year	410.00	410.00	0.00	1
224.27	100 year	480.00	480.00	0.00	1
225.72	500 year	640.00	640.00	0.00	1
228.98	Overtopping	996.02	0.00	1.00	

HY-8 Analysis Results

Culvert Summary Table - Existing Culvert

Culvert Crossing: Higgins Br - Existing

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)	Tailwater Velocity (ft/s)
1 year	70.00	70.00	219.77	2.04	2.27	3-M1t	1.77	1.36	2.03	1.13	3.24	2.15
2 year	140.00	140.00	220.74	2.98	3.24	3-M2t	2.53	1.93	2.39	1.49	5.26	2.56
5 year	215.00	215.00	221.63	3.81	4.13	3-M2t	3.23	2.42	2.66	1.76	7.06	2.85
10 year	270.00	270.00	222.22	4.36	4.72	3-M2t	3.73	2.74	2.83	1.93	8.24	3.01
25 year	350.00	350.00	223.04	5.14	5.54	2-M2c	4.45	3.17	3.17	2.13	9.37	3.24
50 year	410.00	410.00	223.62	5.68	6.12	2-M2c	5.01	3.46	3.46	2.26	9.90	3.40
100 year	480.00	480.00	224.27	6.28	6.77	2-M2c	5.71	3.79	3.79	2.40	10.48	3.56
500 year	640.00	640.00	225.72	7.59	8.22	2-M2c	8.58	4.46	4.46	2.68	11.73	3.86

HY-8 Analysis Results

Water Surface Profiles

Culvert Crossing: Higgins Br - Existing

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Length Full (ft)	Length Free (ft)
1 year	70.00	70.00	219.77	2.04	2.27	3-M1t	0.00	80.00
2 year	140.00	140.00	220.74	2.98	3.24	3-M2t	0.00	80.00
5 year	215.00	215.00	221.63	3.81	4.13	3-M2t	0.00	80.00
10 year	270.00	270.00	222.22	4.36	4.72	3-M2t	0.00	80.00
25 year	350.00	350.00	223.04	5.14	5.54	2-M2c	0.00	80.00
50 year	410.00	410.00	223.62	5.68	6.12	2-M2c	0.00	80.00
100 year	480.00	480.00	224.27	6.28	6.77	2-M2c	0.00	80.00
500 year	640.00	640.00	225.72	7.59	8.22	2-M2c	0.00	80.00