HYDROLOGY REPORT

Mitchell Bridge carries Mitchell Hill Road over the Nonesuch River in the town of Gorham, Maine. A hydrology report for the Nonesuch River watershed was developed and used with flow data from FEMA flood insurance study (FIS) report, and peak flow estimates provided by the Maine Department of Transportation (MaineDOT) Hydrology Section and calculated using the 1999 & 2015 United States Geological Survey Agency (USGS) full regression equation (see Appendix C – Hydro Appendices). The summary of the site hydrology is located in the table below.

SUMMARY

Drainage Area	12.3	mi^2
Q1.1	139	ft^3/s
Q10	516	ft^3/s
Q25	654	ft^3/s
Q50	760	ft^3/s
Q100	875	ft^3/s
Q500	1154	ft^3/s

Reported by: Brewer, Erin D.
Date: September 29, 2020

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

HYDRAULIC REPORT

The hydraulic model was created using HEC-RAS 5.0.7. The existing twin pipes as well as the box culvert alternative were analyzed. Cross-sections were taken from the survey data and LiDAR data gathered for this project. LiDAR data was used to create upstream cross sections that would be able to contain the flow at higher flow rates. LiDAR data is not able to read streambed data below the water. Therefore, this hydraulic model better models higher flows.

The BDG states that riverine bridges with culvert-type structures should be designed for Q50 so that the headwater depth versus structure depth ratio (HW/D) should be approximately equal to or less than 0.9. The HEC-RAS model concluded that the box culvert satisfies this requirement, with HW/D equal to 0.71. The existing twin pipe arch also satisfies this requirement, with a HW/D of 0.60. Also, in the BDG, a minimum of 1' of freeboard at Q100 is required on culvert-type structures. The Q100 freeboard for the box culvert is 1.58' and for the existing pipe arch is 3.12'.

Immediately downstream of the river is a ponded condition, which suggests that the culvert is downstream controlled. The bridge was modeled with a downstream boundary condition of normal depth with a slope of 0.01. No recent flood data was available for the Nonesuch River in Gorham and the FIS provided no flow or elevation data for the Nonsuch River. This slope was approximated using a topographic map. A good outlet controlled HEC-RAS model is not sensitive to the downstream boundary condition. The slope was varied to test the sensitivity.

The sensitivity analysis showed that the existing bridge was sensitive to the downstream slope, which suggests some inlet control. Other data was found to help calibrate the model. The 1988 PDR of the existing bridge included some hydraulic information. That PDR stated that at a Q50 flow of 1200 cfs the pipe arches flow 88% full. Microstation was used to determine that an approximate elevation of 34.5 to 34.6 feet in the pipes would correspond to an 88% full flow. The existing HEC-RAS model ran the Q50 flow of 1200 cfs from the 1988 PDR and varied the downstream slope to try and calibrate the model. At a downstream slope of 0.01, the existing bridge had a headwater surface elevation of 34.57 feet.

Survey data shows that the water surface is at elevation 30 feet downstream of the bridge. This survey data was collected on June 13, 2017. June typically has a lower flow rate than average. The existing model was run with the Q1.1 flow calculated in the Hydrology Report with varied downstream slopes to try and calibrate it with the water surface data calculated on the day of survey. Decreasing the slope, increased the water surface elevation downstream. With the Q1.1 flow, which is higher than the flow rate would be in June, a slope of 0.001 has an elevation of 30.05 feet in the model. Since the actual flow rate in June is lower, the slope of the water would also have to decrease to keep the water surface elevation at approximately 30 feet. This is an unreliable way to calibrate the model since the flow rate is low in a typical June and since the LIDAR data makes this a better model for higher flow rates.

A 0.008 downstream slope was the final slope used for the model. This is close to the 0.01 slope used in the Q50 calibration but skewed down due to the uncertainty with the low flow model. The table below shows the sensitivity of the precast concrete box model by varying the downstream slope. The sensitivity analysis shows that the HW/D ratio is met until slope 0.001.

DS Slope	HW Elevation (ft) at Q50	HW/D
0.001	33.81	0.92
0.005	32.48	0.73
0.008	32.35	0.71
0.01	32.31	0.70
0.015	32.29	0.70

Table 1. Slope sensitivity analysis of box culvert hydraulic model

See Appendix C for HEC-RAS outputs. The summary of the findings from HEC-RAS is below.

SUMMARY

		Existing Structure	Recommended Structure
		14' Twin Span Pipe Arch	25' Concrete Box Culvert
Total Area of Waterway Opening	ft^2	200	175
Headwater elevation @ $Q_{1.1}$	ft	29.48	29.03
Headwater elevation @ Q_{10}	ft	31.73	31.28
Headwater elevation @ Q_{25}	ft	32.35	31.89
Headwater elevation @ Q_{50}	ft	32.80	32.35
Headwater elevation @ Q_{100}	ft	33.28	32.82
Headwater elevation @ Q_{500}	ft	34.41	33.89
Freeboard @ Q_{50}	ft	3.60	2.05
Freeboard @ Q_{100}	ft	3.12	1.58
Outlet Velocity @ $Q_{1.1}$	ft/s	4.19	3.53
Outlet Velocity @ Q_{10}	ft/s	6.26	6.25
Outlet Velocity @ Q_{25}	ft/s	6.99	7.03
Outlet Velocity @ Q_{50}	ft/s	7.46	7.56
Outlet Velocity @ Q_{100}	ft/s	7.94	8.09
Outlet Velocity @ Q_{500}	ft/s	9.09	9.24

Reported by: Brewer, Erin D.
Date: March 12, 2024

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