HYDROLOGY AND HYDRAULICS REPORT

Overview and Purpose

Mill Bridge carries Mill Creek Road over Mill Creek in the Town of Islesboro in Waldo County, Maine. The existing structure, built in 1937, is a reinforced concrete slab on dry laid granite block abutments. Mill Creek is a tidal waterway and located east of the State Ferry Terminal in a protected area of Gilkey Harbor. Mill Creek Road is an important island route connecting much of the island to the ferry terminal. The existing bridge is 22'-0" curb to curb, which is too narrow to safely accommodate the vehicular, and bicycle traffic that share the road. The deck, superstructure and substructure all have a condition rating of 4 - poor. The bridge is a candidate for replacement because it is structurally deficient.

The purpose of this hydrology and hydraulics report is to model and predict the water surface elevations, velocities, and flows at various flood and tidal events. After comparing the predicted flows and corresponding elevations to predicted high tide elevations, the predicted high tide elevations were used as design criteria for setting the bottom of superstructure elevation for the proposed replacement bridge.

Observed Flooding

There is no record of observed flooding or overtopping at the existing bridge site.

Peak Flows

The Mill Creek drainage basin characteristics produced by the Hydrology Section of the MaineDOT Environmental Office are tabulated in the table below. In accordance with MaineDOT policy, the USGS regression equations (Hodgkins, 1999) were used to compute the peak discharges, see Appendix D for additional data. The USGS regression equation peak discharges are as follows:

USGS Regression Equations Peak Discharges	
Drainage Area	0.74 sq. mi.
Wetlands Area	0.03 sq. mi.
Design Discharge (Q50)	193.8 cfs
Check Dishcarge (Q100)	232.5 cfs
Scour Check Discharge (Q500)	333.4 cfs
Ordinary High Water (Q1.1)	20.5 cfs

Tidal Data

Tidal elevations at Islesboro were calculated by applying specific time differences and height ratios to the predictions listed for the closet reference station, Bar Harbor, in accordance with the Bridge Design Guide, Chapter 2. Below is a summary of the predicted tidal elevations for Islesboro, ME.

Mean Lower Low Water (MLLW)	-5.662 ft
Mean Low Water (MLW)	-5.300 ft
Mean Tide Level (MTL)	-0.312 ft
Mean High Water (MHW)	4.676 ft
Mean Higher High Water (MHHW)	5.853 ft
2011 Predicted High Tide	7.103 ft

HY-8 Analysis

Hydraulic analyses of the existing bridge were performed using FHWA's HY-8 program using the hydrologic and tidal data noted above. The headwater elevations were computed with tailwater at mean high water (MHW) to maximize the headwater elevations. The discharge velocities were computed with tailwater at mean low water (MLW) to maximize discharge velocity. Below is a summary of the HY-8 results:

	Existing Bridge (22-foot span)
Mean High Water (MHW)	4.68 ft
Headwater Elev. @ Q10	4.69 ft
Headwater Elev. @ Q50	4.71 ft
Headwater Elev. @ Q100	4.72 ft
Discharge Velocity @ Q50	6.99 ft/s
Discharge Velocity @ Q100	7.39 ft/s
Discharge Velocity @ Q1.1	1.03 ft/s
Freeboard @ 2011 Predicted High Tide	1.0 ft

These results show that the headwater elevation at Q10 and Q50 is only 0.01 feet and 0.03 feet higher than the tailwater elevation (MHW), respectively. Based on this finding, it can be concluded that the headwater heights are governed by tidal elevations. It is recommended that the hydraulics of the replacement structure be designed based on high tide information with minimal consideration given to stream flow and that further hydraulic analysis of the proposed structure is not required.

Correlation between Predicted and Observed Tidal Elevations

The Town of Islesboro took a photograph of the high tide water level at the bridge site on September 29, 2011. Using MaineDOT survey data and the Town photo, we were able to find a close correlation between the predicted and observed water elevations. We calculated the predicted high tide on Islesboro to be Elevation 6.9' by interpolating data between the subordinate stations at Castine and Pulpit Harbor on North Haven Island. (See Appendix D for photographs and calculations). Next, using the Town photo, MaineDOT survey information and field measurements we took on October 4, 2011, we roughly estimated the observed high tide on September 29th to be Elevation 7.44'. The

0.5' difference can be accounted for by the actual high tides in Portland and Bar Harbor on September 29th being recorded at 0.2 to 0.5 feet higher than predicated. Applying the upper bound of this information yields a predicted high tide elevation of 7.4' which closely correlates to the observed elevation of 7.44'. Using the correlated data, we have estimated that the freeboard between the structure and water surface in the September 29th photo to be approximately 1.2 feet. (Elev. 8.652' – Elev. 7.44').

Proposed Structure

As noted above it is recommended that the minimum bottom of beam elevation of replacement structure be based on high tide information with minimal consideration given to stream flow.

The BDG does not provide specific guidance for this condition other than the statement that "bridges on tidal rivers/streams should be designed to protect the bridge structure itself". We are recommending that the minimum bottom of beam elevation for the replacement structure be determined by adding 1.6' for sea level rise and 1.0' for minimum freeboard to the 2011 Predicted high Tide Elevation of 7.1' which equates to Elevation 9.7' This approach would raise the bottom of beam elevation of the replacement structure by approximately 1 foot compared to the existing structure.

The proposed structure is founded on a pile supported integral abutment. The structure length will be increased from 22 feet to 56 feet. The channel width will remain the same, and the stream banks will slope back to the proposed substructure units at a 1.75H:1V slope. The proposed abutments will have riprap countermeasures. The existing bridge shows little evidence of scour, and the longer structure will increase the hydraulic opening, which will in turn reduce the water velocities and scour potential.

Scour Countermeasures

The existing bridge structure shows little evidence of scour. The water velocities are very low and are related to the ebb and flow of the tides. The proposed structure is approximately 35 feet longer than the existing structure. The increased structure length increases the hydraulic opening, and in doing so will decrease the water velocities and scour potential at the site. Riprap slope protection will be provided as a scour countermeasure in front of the proposed abutments and at the approach side slopes.

Conclusion

The proposed bridge replacement will improve the hydraulics of Mill Bridge. By lengthening the structure, the hydraulic opening at the bridge will be approximately double the size of the existing opening. The anticipated freeboard at 2011 predicted high tide elevation will be increased by 1 foot from the existing condition. By investigating existing conditions and low water velocities at the site, it was determined that this bridge has low scour potential, and riprap slope protection will be an adequate scour countermeasure.