HYDROLOGY REPORT

The drainage basin characteristics for Heald Bridge in Sumner over the West Branch of the Nezinscot River were provided by the MaineDOT Environmental Office Hydrology Unit. The peak flows were calculated using the USGS peak flow regression equations for small, ungaged streams in Maine (see USGS Scientific Investigations Report 2015-5049). The bridge is not located in a FEMA detailed study area. The flood flows reported by MaineDOT were calculated with the NRCS TR-20 rainfall/runoff model. The USGS peak flow regression equations are considered more reliable and are the basis of the peak flow rate summary below.

SUMMARY

Drainage Area	13.5	mi^2
Q1.1	282.9	ft^3/s
Q2	605.2	ft^3/s
Q5	974.9	ft^3/s
Q10	1256.7	ft^3/s
Q25	1642.3	ft^3/s
Q50	1950.6	ft^3/s
Q100	2280.7	ft^3/s
Q500	3118.8	ft^3/s

Reported by: Anna Giraldi, P.E.
Date: April 3, 2018

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

HYDRAULIC REPORT

The existing and proposed bridges were analyzed using GeoHECRAS version 1.4.0.12361, developed by CivilGEO Engineering Software. The bridge is not in a FEMA detailed study area; therefore no comparison to FEMA could be done. The hydraulic model for this project represents approximately 600 feet of the West Branch of the Nezinscot River, including Heald Bridge. A total of seven cross sections, four downstream and three upstream, were used to model the stream. Cross section information outside the limits of survey was taken from USGS Topographic Maps.

The hydraulic analysis assumes steady flow. Default coefficients for expansion and contraction were utilized in the upstream and downstream cross sections, but were adjusted at the bridge to represent the constriction caused by the structure. The flood flows utilized were provided by MaineDOT. All of the flood flows were analyzed using a normal depth boundary condition with upstream and downstream slopes of 0.0065 ft/ft and 0.00065 ft/ft, respectively. Theses slopes were determined based on USGS Topographic maps. The bridge is in a rural area with banks consisting of light to heavy brush and trees; therefore a Manning's n of 0.08 was used for the banks on all cross sections. The channel was modeled using a Manning's n of 0.035.

EXISTING SINGLE-SPAN BRIDGE WITH CONCRETE SLAB

The existing bridge is a 23-foot single span steel beam structure with a clear span of 20 feet and a hydraulic opening of 132 square feet. The superstructure consists of a variety of steel beams with a concrete deck. The substructure consists of dry laid stone abutments with a concrete cap. Based on a field review of the bridge, the existing bridge causes a constriction in the river, which is verified by the differences in both channel slope and water surface elevations upstream and downstream of the bridge as shown in the model's Water Surface Profile. The profile indicates a hydraulic jump in the bridge, which is also an indication of a constriction. The jump is a result of a velocity decrease as the water is exiting the bridge into the wider channel.

The bridge is frequently closed due to high water. Relatively minor rain storms will result in a bridge closure with water less than a foot from the low chord. The hydraulic model appears to correlate well with these observations and indicates that the existing bridge only passes up to the 5-year storm with a freeboard of 1.4 feet. All other storms overtop the roadway approach/bridge up to a depth of 13 inches for the 100-year storm. The greatest scour potential will occur just as the structure is overtopped when the structure is filled to capacity. This occurs somewhere between the 5-year and 10-year storms. The 5-year storm has a velocity of 9.74 ft/s, which is the maximum velocity of all the storm flows evaluated. Once the structure is overtopped, the velocity inside the structure begins to decrease as water is diverted over the road. The velocities for the 50- and 100-year storms are 7.69 ft/s and 6.18 ft/s, respectively, inside the bridge at the upstream entrance.

A scour analysis was performed utilizing a D50 of 0.92mm as determined from a particle size analysis on streambed materials and assuming pressure flow with overtopping. The resulting potential contraction scour depths were determined to be 11.9 feet and 8.6 feet for the 50-year and 100-year storms, respectively. The calculations indicate live bed scour is the primary type of contraction scour through the structure. The decrease in potential contraction scour from the 50-year storm to the 100-year storm is likely due to the additional volume of water flowing over the road for the 100-year storm resulting in decreased velocities through the structure. Potential local abutment scour was calculated to be 11.2 feet and 11.5 feet for the 50-year and 100-year storm, respectively, at Abutment 2 and 16.2 feet and 17.5 feet at Abutment 1. Combining the contraction scour depths and the maximum of the two local scour depths, the maximum total potential scour depth is 28.1 feet and 26.1 feet for the 50-year and 100-year storms, respectively.

PROPOSED SINGLE-SPAN BRIDGE WITH 15-INCH DEEP PRECAST CONCRETE VOIDED SLABS

Heald Bridge is slated for a complete bridge replacement, therefore a single span bridge with a larger span is recommended. The upstream channel banks were carried through the structure and matched into the downstream banks, and the abutments were set behind the banks. The resulting clear hydraulic span is approximately 42 feet, which exceeds the estimated 32-foot bankfull width. The resulting hydraulic opening area is 233 square feet, which exceeds the hydraulic opening of the existing bridge by 101 square feet. The hydraulic model for this proposed structure indicates that it will pass up to and including the 25-year storm without overtopping the road. The freeboard is approximately 1.5 feet for the 5-year storm and 0.8 feet for the 10-year storm. The 25-year storm flows through the proposed structure under pressure flow indicating the flow will submerge the underside of the bridge, but will not overtop the road.

Per the Maine Bridge Design Guide (BDG) Section 2.3.10.2, a “major riverine bridge” requires a freeboard depth of four feet for the design 50-year storm and “other riverine bridges” require a depth of two feet on smaller bridges where there has been no history of ice jams. Although the West Branch of the Nezinscot River is not a smaller stream, due to the low traffic volume and rural location, as well as no known history of ice jams, it was assumed this crossing would be considered an “other riverine bridge”. The proposed structure is overtopped for the 50-year storm resulting in no freeboard. The rural location, priority, and low traffic volumes make increasing the span further or raising the roadway profile cost prohibitive. The 50- and 100-year storms will overtop the road with flow depths of approximately 5 inches and 10 inches, respectively. The 25-, 50-, and 100-year storm velocities are 6.54 ft/s, 6.89 ft/s, and

6.05 ft/s, respectively, inside the bridge at the upstream entrance. In this case, the maximum velocity occurs somewhere between the 25- and 50-year storms.

A scour analysis was performed utilizing a D50 of 0.92mm as determined from a particle size analysis on streambed materials and assuming pressure flow with overtopping. The resulting potential contraction scour depths were determined to be 8.1 feet and 6.8 feet for the 50-year and 100-year storms, respectively. The calculations indicate live bed scour is the primary type of contraction scour through the structure. The decrease in potential contraction scour from the 50-year storm to the 100-year storm is likely due to the additional volume of water flowing over the road for the 100-year storm resulting in decreased velocities through the structure. Potential local abutment scour was calculated to be 7.4 feet and 6.9 feet for the 50-year and 100-year storm, respectively, at Abutment 2 and 10.5 feet and 11.3 feet at Abutment 1. Combining the contraction scour depths and the maximum of the two local scour depths, the maximum total potential scour depth is 18.6 feet and 18.2 feet for the 50-year and 100-year storms, respectively. Although these depths seem large, the important thing to note is that these potential scour depths are 9.5 feet and 8.0 feet less than the existing condition, which is a significant improvement. Local abutment scour calculations are notoriously conservative. The proposed abutments will be pile supported, designed with consideration for scour, and protected with heavy riprap. These facts combined with the priority and low volume of the road support the case for the proposed bridge.

CONCLUSIONS

A 15-inch deep single-span voided slab bridge with a cast-in-place concrete composite deck will provide the shallowest superstructure. The low chord will be approximately 4.8 inches above the existing low chord, and the new structure will provide a hydraulic opening that is significantly greater than the existing structure. This larger opening passes approximately 89% of the 50-year storm flow and 67% of the 100-year storm flow as compared to the existing structure that passes only 63% and 46% respectively. The velocities also significantly decrease through the bridge, which decreases the scour potential. Although the increased opening area results in decreases to the water surface elevations immediately upstream of the bridge for the 10-year storm and greater, the proposed structure actually results in an increase in water surface elevations for the 5-year storm and below. This occurs as a result of significantly decreased velocities because of the lack of constriction at the crossing. This change in water surface elevation will not adversely affect fish passage and will not result in additional flooding. The proposed bridge does not satisfy the Maine BDG section 2.3.10.2 requirement of two feet of freeboard for the design 50-year storm; however the replacement structure provides a significant improvement over existing. In order to meet this guideline, a significantly larger bridge would be required, and the road would need to be raised.

SUMMARY

		Existing Structure	Recommended Structure
		23' Single-Span Bridge	45' Single-Span Bridge
Total Area of Waterway Opening	ft^2	132	233
Headwater elevation @ $Q_{1.1}$	ft	481.18	481.01
Headwater elevation @ Q_2	ft	482.63	482.18
Headwater elevation @ Q_5	ft	484.11	483.08
Headwater elevation @ Q_{10}	ft	486.54	483.69
Headwater elevation @ Q_{25}	ft	486.90	485.07
Headwater elevation @ Q_{50}	ft	487.16	486.82
Headwater elevation @ Q_{100}	ft	487.46	487.28
Headwater elevation @ Q_{500}	ft	487.80	487.69
Freeboard @ Q_{50}	ft	-2.69	-1.94
Freeboard @ Q_{100}	ft	-2.98	-2.41
Outlet Velocity @ $Q_{1.1}$	ft/s	4.01	2.85
Outlet Velocity @ Q_2	ft/s	6.61	4.35
Outlet Velocity @ Q_5	ft/s	9.03	5.49
Outlet Velocity @ Q_{10}	ft/s	8.12	6.20
Outlet Velocity @ Q_{25}	ft/s	8.06	7.04
Outlet Velocity @ Q_{50}	ft/s	7.48	7.43
Outlet Velocity @ Q_{100}	ft/s	6.06	6.17
Outlet Velocity @ Q_{500}	ft/s	5.91	5.89

Reported by: Anna Giraldi, P.E./R. Myers, P.E.
Date: April 19, 2018

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