HYDROLOGY REPORT

Black Stream crosses Routes 43 & 151, a corridor priority 4 roadway with AADT of 1000, at an 11 degree skew, flowing northerly toward Moose Pond. The waterway is carried under the roadway with a 21' span steel arch supported on concrete footings, which have been undermined by the stream. Due to the scour and the deterioration of the steel arch, the bridge has been programmed for replacement.

Black Stream's watershed at the bridge is 11.8 square miles. About half of the watershed is tributary to Tuttle Brook which is attenuated near the top of its watershed by Barker Pond. Tuttle Brook joins Black Stream about 8300 feet upstream. The watershed is about as wide as it is long. The watershed is largely undeveloped and has large wetland areas associated with the stream channel, especially in the upper reaches of the Black Stream watershed.

Some 1200 feet downstream, Black Stream empties into Great Moose lake. The dam spillway elevation at the outlet end of the lake is at elevation 243.24 feet, significantly lower than the 249 foot elevation of the proposed culvert outlet. Records from the Hartland town office indicate that the water level in Great Moose Lake is maintained within 12 inches of the dam crest. No storm water routing studies were conducted to determine the peak lake water surface elevations associated with peak discharges at the bridge site. Nevertheless, it is concluded that backwater from the lake is extremely unlikely to affect bridge hydraulics.

Rust patterns in the existing culvert are 3-4 feet higher than the normal water depth currently exhibited by Black Stream at the bridge. Suspicion of the existence of downstream beaver dams over long periods of the past service life of the existing steel arch culvert bridge was confirmed after conversations with the adjacent land owner and the regional wildlife biologist from the Maine Department of Inland Fisheries and Wildlife.

The peak discharge rates for the various design storms were predicted by Charles Hebson of the Maine DOT Environmental Office and are tabulated below. See appendix E for Charles Hebson's complete report.

SUMMARY

Drainage Area	11.8	mi^2
Q1.1	150.1	ft^3/s
Q10	579.7	ft^3/s
Q25	739.3	ft^3/s
Q50	863.8	ft^3/s
Q100	997.9	ft^3/s
Q500	1325.8	ft^3/s

Reported by: Charles S. Hebson, PE
Date: July 24, 2016

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

HYDRAULIC REPORT

CONTEXT

Corson Corner Bridge in Athens-Hartland carries State Routes 43 &151 over a northerly flowing reach of Black Stream. The existing bridge has been classified as scour critical with a supporting report prepared in August of 2011 by T.Y. Lin International. The existing 21-foot span corrugated galvanized steel arch is supported on four-foot deep concrete footings. SCS mapping shows the soils to be Dixmont gravelly silt loam. The footings have been undermined in one location by more than 4 feet although soft sediment has filled in the hole next to the easterly footing at the southern third point. Footings are exposed on both ends. The scour analysis performed in 2011 states a moderate probability of contraction scour and a high probability of abutment scour. The stream channel under the bridge is currently at about the same elevation as it was in 1957 when the bridge was constructed per the existing bridge plans. The existing scour that this structure has experienced can therefore be assumed to be abutment scour rather than contraction scour and the stream channel can be assumed to be reasonably stable in terms of aggradation or degradation. The elevation of the inside top of the steel culvert is approximately 261.4.

ISSUES INVESTIGATED

Scour stability, design flood levels for clearance under the bridge and hydraulic capacity are the primary issues to be investigated for this bridge. The stream stage elevations and average velocities for the design storms were calculated for the Q1.1, Q25, Q50, Q100 and Q500 design storms. Peak flow rates for each of these design storms was provided by the Maine DOT Hydrology group. See the appendix for further information.

METHODOLOGY AND DESIGN PARAMETERS

HEC-RAS River Analysis System 5.0.1 April 2016 software was used to predict stream velocities and water surface elevations for both the existing bridge and the proposed bridges.

Stream cross sections were obtained from the topographic survey provided by the Department. HEC-RAS' steady flow, mixed flow regime algorithm was utilized. The upstream and downstream boundary condition selected was normal depth with a slope of 0.005.

Hydraulic design is based on the Q50 storm with a desired clearance of 2' with the Q100 storm checked for passage. Scour design is based on the Q100 storm with the Q500 storm checked for survivability.

HEC-RAS models were created for both the existing and proposed bridge configurations. The existing and proposed bridge models utilized two upstream cross sections and two downstream cross sections. The existing bridge is modeled as an 41 – Arch, 21' wide by 11' rise corrugated metal mitered to slope. Manning's n values used were 0.024 for the sides and 0.03 for the bottom. The proposed box culvert is modelled with a HEC RAS 59 rectangular box with more favorable edges, a 24' span and a 10' rise. Manning's n values used were 0.013 for the sides and 0.03 for the bottom. The bottom of the box culvert will have a 2' thick layer of stream bank material, comprised of HEC 23, Design Guideline 4, Riprap Revetment, Class III riprap top dressed with the finer grain sizes of stream bank material. See riprap sizing calculations in Appendix E.

ANALYSIS RESULTS

		Existing Bridge			**Box Culvert**			**Box Culvert at Hydraulic Jump**		
Design Storm	Peak Flow cfs	W.S. Elev	Ave. Vel. fps	Flow Area sf	W.S. Elev	Ave. Vel. fps	Flow Area sf	Water Depth - ft	Ave. Vel. fps	Flow Area sf
Q1.1	150.1	252.1	6.0	25.1	251.3	5.6	26.7	1.1	5.7	26.4
Q25	739.3	255.7	10.1	73.0	253.8	7.5	98.7	2.9	10.6	69.6
Q50	863.8	256.4	10.6	81.2	254.3	8.0	108.1	3.2	11.1	77.8
Q100	997.9	257.1	11.2	89.4	254.8	8.5	117.1	3.5	11.9	84.0
Q500	1325.8	258.6	12.3	108.1	255.8	9.8	245.4	4.1	13.3	99.4
Bridge Bottom Elev			261.0			260.0				
Q50 Clearance ft			4.6			5.7				
Q100 Clearance ft			3.9			5.3				
Q500 Clearance ft			2.4			4.2				

The record drawings for the existing steel arch give three water surface elevations for flood stages. Ordinary high water (compare with Q1.1) is 254.4 feet. Unusual high water (compare with Q50) is 257.4 feet. Extreme high water (compare with Q100) is 259.9 feet. These elevations are two to three feet higher than predicted by the HEC RAS analysis. This discrepancy can be explained by the past presence (and possible future presence) of downstream beaver dams. As noted earlier, the rust line on the existing steel culvert is 3 or more feet higher than current ordinary stream water elevations at the bridge. It is likely that beaver dams are the cause of this discrepancy. Without some knowledge of the configuration of the beaver dam, including the crest elevation, crest length and side slope geometry beyond the dam crests, it is not possible to create a head discharge curve to define the downstream boundary condition that would be needed to confirm this suspicion and create a more rigorous comparison.

Water surface elevations predicted for the box culvert are over 2' lower for the larger storms than are predicted for the existing arch structure. The inside roof elevation of the box culvert is about a foot lower than the corresponding elevation of the existing arch, but flood clearances remain well within acceptable clearance ranges. Velocities through the bridge are significantly reduced just beyond the outlet of the box as reported in the chart above. However, the HEC RAS model predicts a minor hydraulic jump in the barrel of the box culvert, probably caused by the reduced side friction of the concrete walls over the corrugated steel. These velocities are slightly higher than is predicted to currently exist, but within parameters to resist movement of the stream bed material at the Q500 storm level. Refer to the riprap sizing calculations in Appendix E.

Scour

The existing bridge has experienced abutment scour. The SCS mapping indicates that soils surrounding the tributary streams are silt loams with varying amounts of gravelly soil mixed in. HEC 23, Design Guide 8, recommends that protection from erosive forces associated with the velocities through bridge and culvert structures be placed at least 1.0 channel widths upstream of the bridge or culvert entrance and at least 1.5 channel widths downstream of the bridge or culvert exit. Consideration should be given to extending the riprap channel material upstream 24’ and downstream 36’ from the box culvert ends to avoid loss of stream bed associated with constricted flow through the box culvert for the larger storm events.