HYDROLOGY AND HYDRAULICS REPORTS
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(excerpted from the PDR)

HYDROLOGY REPORT

The drainage basin characteristics for Cain Bridge on Rte. 11 in Clinton over Twelve Mile Brook were provided by the MaineDOT Environmental Office. The peak flows are calculated using the 1999 USGS full regression equations. The FEMA Flood Insurance Study for the town of Clinton dated May 3, 1990 does not include hydrologic analysis for Twelve Mile Brook.

Since the confluence with the Sebasticook River is approximately 0.3 miles downstream of Cain Bridge, the bridge is in the backwater of the Sebasticook River, and the Flood Insurance Study does give Sebasticook River flood elevations for the Flood of Record in 1987 approximately 0.15 miles upstream of the mouth of Twelve Mile Brook.

SUMMARY

Drainage Area	22.12	mi^2
April Flows	76.18	ft^3/s
August Flows	4.88	ft^3/s
Q1.1	402.9	ft^3/s
Q10	1672.9	ft^3/s
Q25	2159.2	ft^3/s
Q50	2544.4	ft^3/s
Q100	2955.2	ft^3/s
Q500	3986.4	ft^3/s
Flood of Record Elevation 1987	115.3	ft

Reported by: Joshua Hasbrouck
Date: September 17, 2014

HYDRAULIC REPORT

The existing bridge and proposed structures were analyzed using HEC-RAS 4.1.0, developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center. The hydraulic model for this project represents a 383' long section of Twelve Mile Brook, including Cain Bridge on state routes 11/100. Four cross-sections upstream of the bridge and three downstream were used to model the brook.

Benton Falls Hydroelectric Dam is on the Sebasticook River 5 miles downstream of Twelve Mile Brook. The dam is licensed until 2034 and there have been no proposals to remove it, so the hydraulic analysis assumes that the dam remains in place.

The hydraulic analysis assumes steady flow and default coefficients for expansion and contraction. Three boundary conditions were evaluated. All of the calculated flood flows were analyzed using a normal depth boundary condition with a downstream slope of 0.002 ft/ft. Because the stream flows are frequently controlled by the Sebasticook River, the Q100 flow was also evaluated for specific downstream water elevations. Two elevations were used, the FEMA 100 yr flood elevation of 112 ft (from the June 16, 2011 Flood Insurance Rate Map for Kennebec County, Panel 44) and the Sebasticook 1987 flood of record elevation of 115.3 ft (as shown in the May 3, 1990 FEMA Flood Insurance Study for Clinton, ME and converted from 116 ft NGVD).

The bridge is in a moderately built up area, with stream banks varying from mowed lawn to thick brush. To account for this, the Manning's n for the banks was varied from 0.030 (pasture, short grass) to 0.100 (medium to dense brush in summer), depending on the cross-section. The channel was modeled with a Manning's n of 0.033 (clean, straight, some stones and weeds). Additional information on the setup of the hydraulic model and detailed results may be found in Appendix E.

EXISTING BRIDGE

Looking at the water elevations at the cross sections immediately upstream of the bridge, at the bridge, and immediately downstream of the bridge, it is evident that the model is calculating a sudden increase in water velocity and decrease in elevation due to constriction at the bridge. The stream profile view shows this very clearly. Since the hydraulic conditions at the bridge are controlled by the Sebasticook backwater and the behavior in the model has not been observed in the field, elevation comparisons will use the cross sections upstream and downstream, ignoring the elevations at the bridge to try and get a more accurate picture of behavior.

Using the boundary condition of 0.002 downstream slope, the water elevation at the bridge for Q100 flow is approximately 112 ft, matching the elevation given on the FEMA flood maps. At the Preliminary Public Meeting, local residents stated that the water elevation had reached the bottom of the structure during flooding in the past, and that in the flood of 1987, the roadway had overtopped at the bridge. Q500 flows with this boundary condition are above the bottom chord of the structure, but do not overtop. Changing the boundary condition to a downstream water elevation of 116 ft (recorded Sebasticook River flood elevation in 1987 just upstream of the mouth of Twelve Mile Brook) combined with a Q100 flow results in a water surface just over 116 ft, which is still below the roadway. If significant debris caught on the pier (4'×30') is added to the model, however, a Flood of Record flow results in overtopping. Since the 1987 flood was between a 100 yr and 500 yr occurrence, and there is record of frequent debris upstream of the bridge, assuming some debris was present in the 1987 flood is valid and the model appears to be reasonably accurate.

The total hydraulic opening is 327 ft^2. The freeboard to the lowest point on the existing bridge is estimated at 0.66 ft at Q100 based on stream slope, and 0.56 ft with a downstream water elevation set at 112 ft. The water velocity for the high monthly flow in April is 0.72 ft/s.

55' SINGLE SPAN WITH INTEGRAL ABUTMENTS BEHIND EXISTING

The integral abutment option is modeled as a 55' clear width single span. The 55' single span replacement has two integral abutments with 1.5:1 riprap slopes in front, which start 2' below the bottom of the beams. The superstructure depth is 34”. The total hydraulic opening is 435 ft^2. The freeboard to the lowest point on the bridge is estimated at 1.33 ft at Q100 based on stream slope, and 1.26 ft with a downstream water elevation set at 112 ft. For the flood of record, the water surface is above the bottom chord of the structure and overtopping the lower approach. The water velocity for April is 1.11 ft/s.

49' SINGLE SPAN WITH ONE ABUTMENT IN FRONT OF EXISTING AND ONE BEHIND

The 49' clear width single span replacement has one full-height abutment built in front of the existing abutment and extending down below the calculated scour depth. According to the Scour POA for Cain Bridge, the contraction scour depth is 11.7 ft; however, based on some quick calculations to check, this is almost certainly conservative. The other abutment is a standard integral abutment built behind existing and has a 1.5:1 riprap slope in front of it. The superstructure depth is 34”. The total hydraulic opening is 414 ft^2. The freeboard to the lowest point on the bridge is estimated at 1.68 ft at Q100 based on stream slope, and 1.45 ft with a downstream water elevation set at 112 ft. For the flood of record, the water surface is above the bottom chord of the structure and overtopping the lower approach. The water velocity for April is 0.80 ft/s.

CONCLUSIONS

Based on visual observation of the site, the water is always very slow moving and deep enough for fish passage, so the velocities can be used to compare qualitatively between options, but are likely not the velocities actually present. The water velocities are higher for April flows for both of the replacement options, but still low enough that there should be no issues with fish passage.

Both the 55' span integral abutment option and the 49' span full-height/integral abutment option have sufficient freeboard. The 49' option has less riprap in the channel than the conventional slope option, and so has slightly improved freeboard and velocities as well. Based on this information, both spans are feasible options, and the final decision will be made based on other factors than hydraulics.

SUMMARY

		Existing Structure	Recommended Structure	49' Voided Slab Full-Height Abutment
		2 19' Spans Concrete Slab	55' Voided Slab Integral	
Total Area of Waterway Opening	ft^2	327	435	414
Headwater elevation @ $Q_{1.1}$	ft	106.99	107.06	107.00
Headwater elevation @ Q_{10}	ft	110.26	110.34	110.16
Headwater elevation @ Q_{25}	ft	111.22	111.30	110.97
Headwater elevation @ Q_{50}	ft	112.06	112.03	111.66
Headwater elevation @ Q_{100}	ft	113.02	112.84	112.49
Headwater elevation @ Q_{500}	ft	115.12	114.60	114.35
Freeboard @ Q_{50}	ft	1.62	2.14	2.51
Freeboard @ Q_{100}	ft	0.66	1.33	1.68
Flood Of Record (1987) Elevation 116 ft				
Outlet Velocity @ $Q_{1.1}$	ft/s	2.41	3.42	2.64
Outlet Velocity @ Q_{10}	ft/s	6.07	7.58	6.38
Outlet Velocity @ Q_{25}	ft/s	7.17	8.73	7.46
Outlet Velocity @ Q_{50}	ft/s	7.98	9.54	8.24
Outlet Velocity @ Q_{100}	ft/s	8.81	10.36	9.03
Outlet Velocity @ Q_{500}	ft/s	10.71	12.07	10.78

Reported by: Joshua Hasbrouck
Date: October 16, 2014

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