SUMMARY OF EXISTING UPSTREAM AND DOWNSTREAM BRIDGES

Upstream -	5 miles	**Town -**	Amherst	
		Name -	Sumner Bridge	**Br. No. -** 3138
		Hydraulic Opening -	75 ‘ Span x 24 ‘ Rise= 1800 SF	
		Known Ice, Flooding, Scour, and Debris Concerns: None		
Upstream -	6 miles	**Town -**	Amherst	
		Name -	Tannery Bridge	**Br. No. -** 3320
		Hydraulic Opening -	45 ‘ Span x 12 ‘ Rise= 540 SF	
		Known Ice, Flooding, Scour, and Debris Concerns: Ice jam break took bridge out in 1936		

HYDROLOGY REPORT

Design flows for the $Q_{1.1}$, Q_2, Q_{10}, Q25, Q_{50}, Q_{100} and Q_{500} discharges (derived using peak flow calculations by USGS Regression Equations) were provided by the Hydraulics Section of the Maine DOT:

Summary

Drainage Area	178.5	mi^2
$Q_{1.1}$	1,406	ft^3 / s
Q_2	2,424	ft^3 / s
Q_{10}	4,076	ft^3 / s
Q_{25}	4,930	ft^3 / s
Q_{50}	5,570	ft^3 / s
Q_{100}	6,249	ft^3 / s
Q_{500}	7,440	ft^3 / s

Reported By: Alexander Mann
Date: September 22, 2014

The water surface profiles were developed for steady flow at the peak discharge for the following design flows using HEC-RAS:

$Q_{1.1}$, ordinary high water
Q_{10}
$Q_{25,}$ used to evaluate cofferdam needs and temporary detour bridge hydraulic clearance
$Q_{50,}$ design discharge used to evaluate hydraulic clearance
$Q_{100,}$ check discharge used to evaluate hydraulic clearance and scour
$Q_{500,}$ super flood discharge used to evaluate scour

Specific river sections were requested by T.Y. Lin International and surveyed and provided by the Maine DOT Survey Section. Geometric data for the existing bridge was taken from the existing bridge plans. All elevations were referenced to the project datum (NAVD 1988). Geometric data for the proposed bridge was taken from the preliminary design and plans (see Appendix A). Other input data was obtained through research conducted for the preliminary design.

Goodwin Bridge is located at the headwater of the Graham Lake impoundment formed by the Graham Lake dam located in Ellsworth, approximately 12.5 miles south and downstream of the bridge. The water surface elevation for all design flows are highly influenced by the water surface of the Graham Lake impoundment. The Graham Lake dam is owned by Brookfield Renewable Power.

Three different reach boundary conditions were used to analyze discharges for the purpose of evaluating hydraulic clearance and scour. For the evaluation of high water surface elevations (clearance), a high lake level condition was assumed for the 100-year event, and normal maximum high lake level conditions were assumed for the 1.1-year, 10-year, 25-year, and 50-year events. Under the 100-year backwater conditions it is assumed the flood stage of Graham Lake occurs simultaneous to the peak discharge of the West Branch of the Union River. The reach boundary condition for the 100-year discharge was established using water surface profile data from the 2014 FEMA Flood Insurance Study (FIS) (water surface at the Graham Lake Dam, El. 107.3 ft). Lake levels were not available for other discharges, and developing a complex watershed routing model to evaluate these elevations is considered beyond the scope of this project. Normal maximum high lake level was referenced from documents provided by Brookfield Renewable Energy (owners and operators of the Graham Lake dam), El. 104.2 ft. At this elevation, the bridge site is still subject to backwater conditions, and the water surface elevations at the bridge are highly influenced by the lake level.

The low chord of the existing bridge is near the 100-year water surface elevation. The low point of the approach roadway is El. 107.8 and near the low chord elevation of the existing bridge (El. 107. 25). Because the water surface elevation is governed by the backwater conditions of the Graham Lake impoundment, a design low chord that matches the existing conditions was determined to be adequate considering the lack of documented historic flood issues, the low traffic volume, and impacts associated with raising the approach grade.

The high lake level conditions are not conservative for the evaluation of scour at the crossing location. High velocities occur under low lake level conditions (such as at the time of the survey). Hydraulic analysis shows the scour design discharges (Q_{100} and Q_{500}) are subject to supercritical flow conditions at a location downstream of the bridge for lake level elevations below 97.7 for the 100-year event and below 98.5 for the 500-year event. Under these conditions, the bridge opening experiences peak velocities for the design discharges. The lake level at the time of survey (early fall) was 97.0. Based on discussions with the Graham Lake dam owner (Brookfield Renewable) the lake level is highly regulated and it is common for the lake level to be drawn down beginning in the fall to provide storage for anticipated spring runoff. The target lake level for drawdown is variable and dependent on many factors such as snowpack and short term weather forecasts.

Scour analysis prepared for the replacement of Goodwin Bridge includes the following scour analysis computations for the Q_{100} and Q_{500} year events:

- Contraction Scour
- Local Pier Scour
- Abutment Scour

The replacement bridge will be founded on piles to bedrock or practical refusal with estimated embedment lengths of 49’ – 58’ – 69’ – 80’ respectively for Abutment 1, Pier 1, Pier 2, and Abutment 2. Abutment slopes will be protected using riprap.

The abutments and piers should be aligned with the upstream channel to minimize encroachment of abutment fill slopes within the channel and to reduce scour depths. In addition, aligning the piers with the flow will reduce the potential for debris collection at the pile bent piers and will reduce the transverse loading on the pier due to stream flow and dynamic ice loads. The existing riverbed material consists primarily of a deep layer of highly scourable silt and clay. Computed contraction scour for the replacement bridge is 1.9 ft and 2.1 ft respectively for the Q_{100} and Q_{500} events. Computed local pier scour with the piers skewed to align with the channel flow is 4.8 ft for both the Q_{100} and Q_{500} events. Total scour at the piers (contraction scour plus local pier scour) is 6.7 ft (El. 79.3) and 6.9 ft (El. 79.1) respectively for the Q_{100} and Q_{500} events. Keeping the piers normal to the roadway and not aligning with the flow will dramatically increase contraction and pier scour. The 100-year event contraction and local pier scour components with the piers not aligned with the flow are 4.4 ft and 15.8 ft respectively (total scour of 20.2 ft, El. 65.8). The final design of the pier will need to consider contraction and local pier scour in accordance with AASHTO.

HYDRAULIC REPORT

Summary

	Existing Structure	Recommended Structure
	3 Span Non-continuous Rolled Steel Beam	3 Span Continuous Rolled Steel Beam
$Q_{1.1}$ Headwater Elevation	104.2 ft	104.2 ft
Q_{10} Headwater Elevation	104.4 ft	104.3 ft
Q_{25} Headwater Elevation	104.6 ft	104.4 ft
Q_{50} Headwater Elevation	104.7 ft	104.4 ft
Q_{100} Headwater Elevation	107.6 ft	107.4 ft
$Q_{1.1}$ Discharge Velocity	0.9 ft / s	0.9 ft / s
Q_{50} Discharge Velocity	3.5 ft / s	3.6 ft / s
Q_{100} Discharge Velocity	6.1 ft / s	7.2 ft / s
Bottom Beam Elevation	107.25 ft	107.28 ft
Q_{50} Clearance *	2.6 ft	2.9 ft
Q_{100} Clearance**	0.0 ft	0.0 ft

Reported By: Rick Hebert
Date: February 13, 2015

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

* Clearance at Q50 was computed assuming normal maximum high lake level elevation for Graham Lake (El. 104.2 ft).

** Existing low chord elevation is maintained.