HYDROLOGY REPORT

Lisbon- Lisbon CTR Bridge – Lisbon, Androscoggin BR #5007

General Information and Scope

This study is prepared to provide hydrologic information from water resources agencies on the Lisbon CTR Bridge crossing over the Sabattus River. The information will be used in the hydraulic evaluation of the existing and the proposed bridge openings. Based on survey information, the existing bridge opening is approximately 66 feet wide along the centerline of the roadway including a pier, and 15 feet deep from the top of the roadway at the bridge to the stream bed. The flow direction is west to east, and the upstream channel is not in alignment with the bridge; such that the flow is skewed with respect to the abutments and the pier, and the far abutment pinches the stream.

Less than 100' downstream, the Farnsworth Mill Dam extends all the way between channel banks. With a height of about 10' and a length of approximately 143', it forms a closed pool and an overflow weir that backs up water and directly affects the water surface elevations at the bridge. It is therefore considered a major hydraulic factor in determining the water stages during floods. It was built primarily to retain water for the Farnsworth Mill that exists no more, and hence the name of both the street and the bridge. The downstream pool that the dam forms is used as water storage and source, and there is a submerged draw pipe at one of the embankments, which will become exposed if the dam is removed and the water level drops.

The scope of this study is to determine the effects of the dam on the flood flow elevations at the bridge, and the resulting hydraulic conditions. The Atlantic Salmon Federation wants the dam removed, and the dam has been breached such that a 10' long notch was opened in the dam to reduce the difference in water levels directly upstream and downstream of the dam. However, the removal of the dam has been put on hold indefinitely due to many factors such as money, mercury contamination in the pool, and ownership.

The hydrologic information was obtained from different sources as per the following:

1- Federal Emergency Management Agency (FEMA)

2- United States Geological Survey (USGS)

3- Maine DOT Hydrology Department

Federal Emergency Management Agency (FEMA)

FEMA flood insurance studies (FIS) conducted for Androscoggin County in 1984 covered the entire Sabattus River; from its source at Sabattus Lake to its confluence with the Androscoggin River at route 196 in Lisbon. It indicated discharges at the bridge location as follows:

Location	Drainage Area (Sq.miles)	Q10 (cfs)	Q50 (cfs)	Q100 (cfs)	Q500 (cfs)
1- At Mill Street	72.5	4,550	7,170	7,950	9,700

The flood profiles generated by FEMA for the Sabattus River provided other valuable hydrologic information at the dam including flood stage elevations and hydraulic depth above the dam during flood flows. Since the dam acts as an overflow weir, the flood flow magnitudes were manually calculated and compared with the flood data. The results validated the above data as being reasonable amounts with a maximum and minimum margin of error of 8% and 1% respectively.

FEMA also provided a flood map for the bridge and its vicinity showing 100 and 500 year flood boundaries and flood stages at 100 years of 157.7' immediately upstream, and 155.3' immediately downstream.

United States Geological Survey

The USGS does not maintain any gaging stations on the Sabattus River. It only has station #01059000 on the Androscoggin River in Auburn. Since the Sabbatus River is a tributary to the Androscoggin River, the gaging station data on the Androscoggin cannot be used to estimate flows on the Sabattus River. A water shed analysis would rather be required at the point of outlet.

Maine DOT Hydrology Data

The Maine DOT Hydrology section computed flood flows using gage-adjusted regression equations. Peak flows at the bridge were estimated by typical regression equations, and adjusted based on gage data from the little Androscoggin River (gage #01057000) near South Paris whose watershed has a similar drainage area and wetland percentage. Please, see the discussion provided in the hydrology memo in Appendix E for additional information. The Maine DOT

Hydrology section recommended using a combination of the regression estimates and the adjusted values from the Little Androscoggin River Gage near South Paris as follows:

Flood Event	Q1.1	Q10	Q25	Q50	Q100	Q500
Flow(cfs)	635	2217	2769	3198	3627	4668

The Maine DOT results do not correlate well with the FEMA results with large differences in flow values, but is considered the most reliable up-to-date source of information for hydrologic evaluation, and it will be used for the existing and proposed bridge hydraulic analysis.

SUMMARY		
Drainage Area	73.4	mi^2
Q1.1	635	ft^3/s
Q10	2217	ft^3/s
Q25	2769	ft^3/s
Q50	3198	ft^3/s
Q100	3627	ft^3/s
Q500	4668	ft^3/s

Reported by: Naous, Roger, P.E.
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Existing Bridge Analysis Results

A hydraulic analysis using Maine DOT flow data was performed for the existing bridge channel in order to determine its hydraulic parameters. The existing channel sections were defined, cut using Micro-station In-Roads, and transformed into a GIS file. It was imported into HEC-RAS to form a river model that best represents the geometry of the existing channel. The model was calibrated by varying the slope along the stream by using normal water boundary condition, and comparing stage elevations with the observed ones. The results of the hydraulic analysis were as follows:

Results including downstream dam

	Flow (cfs)	Headwater Elevation (ft)	Channel Velocity (ft/s)
$Q_{1.1}$	635	149.29	1.34
Q_{10}	2217	151.35	3.49
Q_{25}	2769	151.93	4.05
Q_{50}	3198	153.11	4.08
Q_{100}	3627	153.30	4.54
Q_{500}	4668	154.19	5.33

Freeboard @ Q_{50} = 0 ft
Freeboard@Q_{100} = 0 ft
Existing Opening = 510 sq.ft

With the existing lowest chord elevation at 152.30 ft, there is no available freeboard for the existing bridge at flood flows Q50, and Q100. This indicates that the existing bridge opening is hydraulically unsatisfactory, and there is a risk of overflow at the bridge and embankments. A larger bridge opening should be considered to reduce headwater elevations, reduce scour potential, and remove pinching of the stream by the north abutment. The results correlate well with FEMA flood maps indicating a 100 year flood stage of 153 feet, which is the case based on the above analysis.

If the dam is removed, the flow velocities will be expected to increase resulting in stream bed drop in stage elevations at the bridge, scour of streambed material, embankment erosion, and collapse of any riprap protection to substructure and embankments.

From the above, it is apparent that a larger bridge opening is to be considered; especially with the dam remaining. The profile grade may have to be raised to improve freeboard; especially with a deeper superstructure due to removal of the pier.

Proposed Channel Analysis

The proposed span and grade of the new bridge must be set to meet geometric requirements. In this site, the grade at the bridge is raised 1.5' to provide acceptable freeboard at Q50, and to compensate for an increase in superstructure depth due to pier removal. The span is increased to 85 ft from the existing 66 ft. This results in even more favorable hydraulic conditions with a larger flow area.

The hydraulic analysis results for the 85' span integral abutments bridge are as follows:

	Flow (cfs)	Headwater Elevation (ft)	Channel Velocity (ft/s)
$Q_{1.1}$	635	149.28	1.16
Q_{10}	2217	151.23	3.02
Q_{25}	2769	151.75	3.52
Q_{50}	3198	152.14	3.87
Q_{100}	3627	152.42	4.25
Q_{500}	4668	153.11	5.05

Freeboard @ Q_{50} = 0.70 ft
Freeboard@Q_{100} = 0.42 ft
Proposed Opening = 782 sq. ft

With the lowest chord elevation of the proposed bridge set at El 152.84' and with the pier removal, widening of the channel at the bridge, and increased flow area, the freeboard at Q50 flows is improved to 0.70' as compared with 0' with the existing bridge. The channel flow velocities for the proposed bridge are less than those of the existing bridge; which should result in improved scour conditions.

Scour

As long as the dam is in place, there shouldn't be much scour because the material has nowhere to go. If the dam is removed, it is most likely that the stream bed will scour down to bedrock, because there are only few feet of overburden or built up sediment in the stream bed. The above conclusions strengthen the argument to use spread footings placed on seals on bedrock for both substructure units.

Conclusion and comments

From the above, a proposed 85' long bridge, a widened channel, and a corresponding increase in flow area, results in a small drop in velocities and water stages at the bridge at all flows. This is mainly due to the downstream dam that controls the hydraulic conditions at the bridge. There is however an advantage in overall improvement of hydraulic conditions, increased free board, and reduction in overall scour, especially with the removal of the pier from the stream.

		Existing Structure	Recommended Structure
		Existing 66' two span bridge	Proposed 85' single span bridge
Total Area of Waterway Opening	ft^2	510	782
Headwater elevation @ $Q_{1.1}$	ft	149.29	149.28
Headwater elevation @ Q_{10}	ft	151.35	151.23
Headwater elevation @ Q_{25}	ft	151.93	151.75
Headwater elevation @ Q_{50}	ft	153.11	152.14
Headwater elevation @ Q_{100}	ft	153.30	152.42
Headwater elevation @ Q_{500}	ft	154.19	153.11
Freeboard @ Q_{50}	ft	0	0.7
Freeboard @ Q_{100}	ft	0	0.42
Outlet Velocity @ $Q_{1.1}$	ft/s	1.34	1.16
Outlet Velocity @ Q_{10}	ft/s	3.49	3.02
Outlet Velocity @ Q_{25}	ft/s	4.05	3.52
Outlet Velocity @ Q_{50}	ft/s	4.08	3.87
Outlet Velocity @ Q_{100}	ft/s	4.54	4.25
Outlet Velocity @ Q_{500}	ft/s	5.33	5.05

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Date: May 18, 2017

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