Hydrology and Hydraulics Report

Route 16
Bartlett Bridge over Gilman Stream
New Portland, Maine

By: Northstar Hydro, Inc.

For: T.Y. Lin International
And
Maine Department of Transportation
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1.0 Introduction

This report details hydrologic and hydraulic analyses associated with the replacement of the Bartlett Bridge, which conveys Route 16 over Gilman Stream in New Portland, Maine. The bridge is located just upstream of a dam used for generation of hydroelectric power. The dam impounds an area of approximately 790 acres, or about 1.25 square miles. The bridge replacement is designed to address safety concerns at the bridge associated with a curve, steep hill, width, and sight distances. The hydraulic analysis is designed to assure that the bridge opening can safely convey a 50-year storm with at least 2 feet of clearance, and that the 100-year storm will not overtop the bridge.

No Flood Insurance Study is available for this stream location.

2.0 Hydrology

The Bartlett Bridge crosses Gilman Stream at a location where the drainage area is 61.97 square miles. The watershed is primarily wooded and undeveloped. The dam just downstream of the bridge impounds an area of 790 acres, or approximately 2% of the watershed. The dam and immediate upstream watershed are shown in Figure 1, and the total watershed is shown in Figure 2.

Peak flow computations were provided by Maine Department of Transportation, using the USGS regional flow formula. To account for the impact of the impoundment and other storage within the watershed, the NWI wetlands inventory information was used to estimate a total wetlands area in the watershed of 6.02 square miles, or 9.7% of the watershed.

The following table summarizes peak flow calculations. MDOT's worksheet is included in Section Q. The table also shows the relative impact on flow of storage in the watershed, assuming no storage (0%). The flows utilized are shown in the first column, with wetland area of 9.7%.

Return Interval	Wetland area 9.7% Flow, cfs	Wetland Area assumed 0% Flow, cfs
1.1-year	811	
2 – year	1566	2100
10 – year	2915	5700
25 – year	3660	7300
50 – year	4234	8700
100-year	4844	10100
500-year	6335	13600

Additional hydrologic Information:

1987 Flood

21

0 0.6 1.2 1.8 2.4 3 km

0 0.4 0.8 1.2 1.6 2 mi

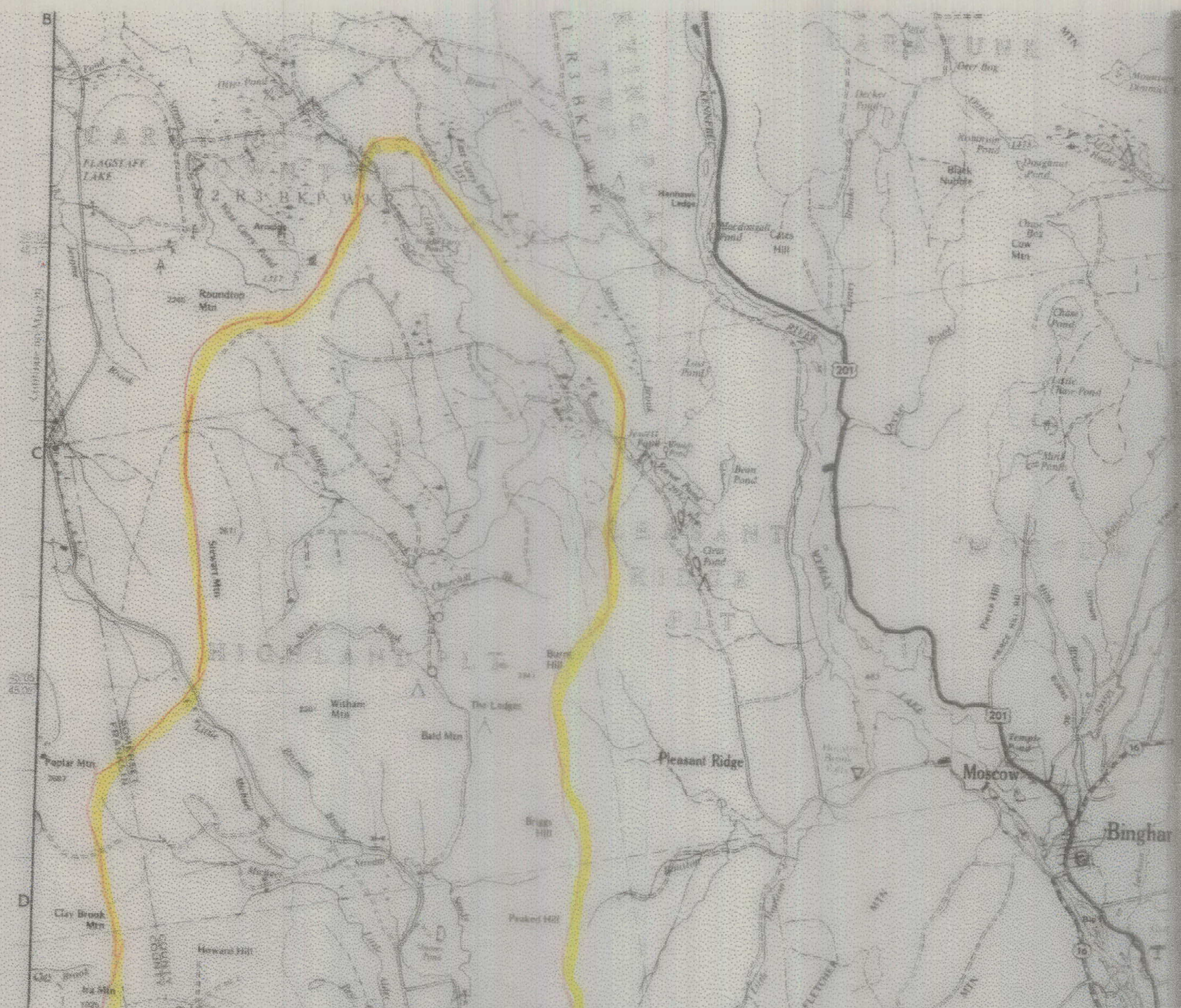
Map center is UTM 19 419168E 4975110N (WGS84/NAD83)

New Portland quadrangle

Projection is UTM Zone 19 NAD83 Datum

M=-17.175
G=-0.723

FIGURE 1



DeLorme

FIGURE 2 Gilman Stream Watershed

In April, 1987, the flood of record occurred in this region of Maine. The following information reflects research on regional data available for that flood. (References 6 ,7. and 8.)

Gages near this site on the Kennebec River and the Carrabassett River list the 1987 flood as 75-year and >100-year respectively for their locations.

24-hour rainfall was about 6" in the watershed of Gilman Stream plus snowmelt. 24-hour, 100-year rainfall for this area is 5.7".

This suggests that the 1987 flood was most likely at least a 100-year, or it may have exceeded a 100-year at this location, and been in the range of 200-500-year. Regardless of frequency of occurrence, the flood clearly occurred, could occur again, and is the flood of record.

The owner of the dam furnished a video of the 1987 flood, which clearly shows the '87 flood just passing. The water is backing up slightly above the low chord (like a standing wave) and nearly flowing over the road in the low area to the west of the bridge. This suggests an upstream elevation of 381-381.5. Under the bridge, the water surface elevation is closer to 380 (the low chord). The video also indicates water surface elevations at the dam of approximately 379, and shows very fast flow between the bridge and dam. (Ref. 9)

Information on calibrating the hydraulic model to this flood information is discussed under hydraulics.

Information related to Gilman Pond:

The dam owner furnished some information related to hydrology at the dam.

- When the pond is about 372', a heavy rainstorm will cause an increase of about 5" per hour in the pond, and within 6 hours, the dam will be overtopped. In his experience, raising the gates has little effect on water levels once they start to rise in this manner. Calculations would show that 5" an hour on 790 acres is about 4000 cubic feet per second. The capacity of the very large gate on the dam (22' X 5') would be in the range of 600-700 cfs, less than the 1- year flood event.
- The operating range (by permit) for the dam is a high of 372.5', a summer low of 369.5 and winter low of 367.5.
- Typical high water is listed as 375' for FERC and suggested as 378' for spring of '05.

Summary Hydrologic Data:

Drainage Area:	61.97 square miles
Design Discharge (Q50)	4234 cfs
Check Discharge (Q100)	4844 cfs

Scour Check Discharge (Q500)	6335 cfs
Ordinary High Water (Q1.1)	811 cfs
Flood of Record (1987), Est.	5500 cfs, elev. 381.0-381.5

3.0 Hydraulic Analysis

Condition of dam: Modeling and the 1987 video showed that the large washed out area on the left side of the dam (facing DOWNSTREAM) provides significant flow relief during high flow events. Normal dam operations are not impacted by this washout area (according to the dam owner), so it is not expected that this area would be changed or repaired in the near future. For purposes of this analysis, the dam was assumed to remain either in the condition it is today or completely removed.

Calibration: The existing condition model at the dam was calibrated to a water surface profile matching the 1987 flood. Calibration adjustments included skewing the abutments and pier to match the angle of attack shown on plans (approx 30°), and assuming that the dam gates are closed as the video indicates. The most closely matched water surface profile is in the range of a 200-500-year event. The model shows that the bridge acts as one control point during high flow and that the dam acts as a second control point. This indicates that slightly raising and enlarging the bridge opening, as well as eliminating the pier, results in lower water surface elevations even with the dam remaining unchanged.

HECRAS Model Discussion: Computer model HECRAS was used for the hydraulic analysis of the bridge and the dam immediately downstream of the bridge. Discussions were held with the dam owner to ascertain typical dam operations during flood events. During the 1987 flood (flood of record), the dam gates were not opened. The dam owner said, and modeling verified that opening the gates has very little impact on high water levels due to the relatively small size of the gate openings relative to the rate of flow of water during a flood event.

Model geometry was gathered from several sources. MDOT surveyed selected stream cross sections and the existing Bartlett Bridge. Dam information was also provided by the dam owner with field verification. Model elevation datum is NAVD 1988.

Several model scenarios were run:

- Existing conditions with dam gates open
- Existing conditions with dam gates shut
- Existing conditions with dam assumed removed
- Proposed bridge with pier with dam, gates shut
- Proposed bridge with pier, dam assumed removed
- Proposed bridge, single span, with dam, gates shut, new abutments with bench (alt 1)
- Proposed bridge, single span, dam assumed removed, alt 1
- Proposed bridge, single span with dam gates shut, no bench on existing abutments (alt 2)

- Proposed bridge, single span, dam assumed removed, alt 2

Existing condition model: The existing condition model demonstrated that the dam gates have very little impact on water levels during high flow, so to be conservative, all proposed condition models were run with the gates assumed shut.

Starting water surface elevation was based on "normal depth" using an estimated energy slope of 0.01. This slope was derived following several trial slopes, which demonstrated that the water level downstream of the dam had very little impact on water levels above the dam, and that 0.01 appeared to be very similar to the stream slope downstream. Flow below the dam is fast, and not operating in a backwater condition.

Channel "n" values ranged from 0.04 to 0.05 and overbank "n" values ranged from 0.07 to 0.08. Adjusting "n" values in the model had very little to no impact on water levels due to the high percentage of flow that occurs in the channel even during flood events, and due to the hydraulic controls being at the dam and bridge and not a "normal flow" situation where natural channel geometry and roughness define water levels.

Existing condition runs showed that even with the dam in place, the bridge also acts as a constriction during high flows. The angle of flow relative to the angle of the bridge, as well as the pier provide significant obstructions to flow.

As discussed above, the dam was assumed to remain either in the condition that it is in today, or completely removed.

Proposed condition models:

Modeling indicated that the single span option is preferable to the two span with pier option. The angle of flow is not optimal for the use of a pier, and the pier provides significant obstruction to flow. Models also showed that elimination of the pier improves the bridge hydraulics enough that the existing low chord elevation can be used, and that the bridge will pass the 50- and 100-year storms within MDOT guidelines.

The following table summarizes results of the hydraulic analysis:

Flow Data with Dam in Place

	Existing Bridge With pier	Alt 1	Alt 2
Headwater El. @ Q50, ft	378.2	377.8	377.8
Headwater El. @ Q100, ft.	378.7	378.2	378.3
Discharge Velocity @ Q50, fps	9.3	6.2	6.2
Discharge Velocity @ Q100. fps.	10.6	6.9	6.9
Ordinary High Water, Q1.1, ft.	376.8	376.8	376.9
Discharge Velocity @ Q1.1, fps	1.8	1.2	1.2
Clearance @ Q50, ft.	1.8	2.2	2.2

Flow Data with Dam Removed

	Existing Bridge With pier	Alt 1	Alt 2
Headwater El. @ Q50, ft.	377.5	375.0	375.0
Headwater El. @ Q100, ft.	378.5	375.8	375.8
Discharge Velocity @ Q50, fps	14.2	12.9	12.9
Discharge Velocity @ Q100, fps	14.9	13.5	13.5
Ordinary High Water, Q1.1, ft.	370.5	369.6	369.6
Discharge Velocity @ Q1.1, fps	8.2	5.1	5.1
Clearance @ Q50, fps	2.5	5.1	5.1

Detailed model input and output is included in Section R.

Scour Considerations:

Current information is that the abutments are seated on bedrock. Scour is a minor consideration when foundations are directly on rock. If needed for final design, potential scour can be evaluated based on competency tests of the rock. Foundation components should be designed such that it is assumed that any overburden is removed by scour. This is a likely scenario should the dam be removed in the future.

4.0 Summary and Conclusions:

Replacing the existing bridge with a single span will improve the hydraulic function of the opening. With a low chord of 380.00, the 50-year storm will pass with more than 2.0' of clearance, and the 100-year flood will not overtop the road. Hydraulically, the two alternatives show very little difference in terms of water surface elevation and flow velocities. Thus, the preferred alternative (alt 1 with bench) has been selected based on costs, maintenance, construction schedule, and constructability rather than hydraulics.

The dam exerts significant control over water surface elevations and velocities at this site. However the bridge also causes a constriction and resulting rise in water levels. With a single span replacement, flood elevations would be lower, because removal of the pier allows significant enlargement of the bridge opening. Should the dam be removed, water levels would be lower and velocities would be higher as shown in the tables above. With the dam in place, the difference between existing and proposed conditions is approximately 0.5'. Should the dam be removed, the difference from existing to proposed is more than two feet.

5.0 References:

1. Maine Department of Transportation, Bridge Design Guide. August 2003

2. Maine Department of Transportation, Urban and Arterial Highway Design Guide. Chapter 12, Drainage Design, January 2005.

3. Maine Department of Transportation. Best Management Practices for Erosion and Sediment Control. Sept. 1997.

4. U.S. Dept. of the Interior, Geological Survey. Topographic Map. New Portland, Maine.

5. U.S. Dept. of the Interior, Geological Survey. Estimating the Magnitude and Frequency of Peak Flows for Streams in Maine for Selected Recurrence Intervals. WRI 99-4008

6. U.S. Dept. of the Interior, Geological Survey. Flood of April, 1987 in Maine. OFR 92-141

7. U. S. Dept. of the Interior, Geological Survey. Flood of April, 1987, in Maine, Massachusetts and New Hampshire. OFR 87-460

8. Sun Journal Sunday. Rivers on the Rampage. April 1-3, 1987

9. John Bertl. *Personal Video of 1987 flood in New Portland.* North New Portland, ME.