Final Design Hydrology and Hydraulics Report
Southwest Harbor and Tremont
Marsh Bridge # 2511

For VHB and MaineDOT

September 5, 2018

NORTHSTAR HYDRO

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STATE OF MAINE
ELLEN
KNIGHT O'BRIEN
No. 7845
LICENSED
PROFESSIONAL ENGINEER

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September, 2018

1.0 Introduction

Marsh Bridge over Marshall Brook in Tremont and Southwest Harbor, # 2511, is slated for partial replacement. Northstar Hydro, Inc. was retained by VHB to provide hydrologic, hydraulic, and scour assessments for preliminary and final design. Results of that work are detailed in this report.

Figure 1. Marsh Bridge, upstream face.

The bridge location is shown in Figure 2.

Figure 2. Site Location, Marsh Bridge

Marsh Bridge is located on Marshall Brook (according to 1931 bridge plans) or Bass Harbor Marsh according to USGS topo maps. The bridge opening is 23’3” from centerline abutment-to-centerline abutment and 20’ actual width perpendicular to flow. The bridge is upstream from the 15 ft span Clark Bridge in Tremont which controls rate of tidal flow into and out of the Bass Harbor Marsh. Clark Bridge has a minimum bottom elevation of 0.4’ NAVD which, with its narrow width also controls the flow of water into and out of the Marsh system. Clark Bridge is slated to be replaced with a span similar to the existing opening so flow dynamics are not expected to change.

During a typical daily tide, flow through the bridge was observed to be slow and water levels change by only a few feet over a tide cycle due to the geometry of the downstream Clark Bridge.


Figure 3. Looking downstream from Marsh Bridge

This bridge is a combination of tidal action and upland marsh flow. MaineDOT’s Bridge Design Guide recommends the following for tidal bridges:

“Bridges on tidal rivers/streams should be designed to protect the bridge structure itself. Most of the surrounding land and the approach roadways may be inundated by relatively frequent tidal storm surges. The minimum design freeboard in these areas is 2 feet above Q10 (based upon

MHW) including wave heights. The finished grade of the bridge will be set by considering this requirement, along with navigation clearance, the approach roadways, topography, and good engineering judgment".

Additional considerations for tidal bridges include flow rates for storm runoff from upland areas and velocity of tidal flow for analysis of scour for daily fluctuations and during 100- to 500-year type of events.

For upland bridges, MaineDOT recommends 2' clearance for the 50-year flood and that the 100-year flood not overtop the roadway.

This report summarizes both preliminary and final design data collected and analyses conducted to characterize expected water levels on either side of the bridge and rates of flow through the bridge. Analyses were conducted to:

- Identify normal and annual high and low tide levels on either side of the bridge
- Identify storm tide levels
- Evaluate rates and direction of flow through the bridge under normal tide and storm tide conditions
- Evaluate impacts of freshwater storm runoff combined with tidal flow.
- Evaluate impacts of bridge on water levels
- Evaluate potential wave impacts
- Evaluate potential scour impacts

The original bridge was built the early 1900's with repairs being done in 1931. Marsh Bridge and Clark Bridge are shown in aerial view in Figure 4.

Figure 4 Marsh and Clark Bridges, aerial view.

Figures 5 and 6 are site photographs of the bridge and surrounding area.

Figure 5. Downstream face of Marsh Bridge.

Figure 6. Looking upstream from Marsh Bridge.

The proposed bridge will have a clear span of 20', a slightly higher low chord and slightly lower top of fascia.

2.0 Existing Data Review, Project Survey and GIS Database

2.1 Data Review

Prior studies related to tidal flood elevations include a July, 2016 FEMA Flood Insurance Study, and the U.S. Army Corps of Engineers Tidal Flood Profiles, published in 2012. Existing tidal flood information is summarized in Table 1. Note that most available data relates to the ocean side of Clark Bridge and not to Bass Harbor Marsh. FEMA provides the only estimate of tidal flood elevation within the Marsh.

Source of Data	Datum	1.1-year	10-year	50-year	100-year	100-year plus waves	500-year
FEMA Effective Study, 2016- ocean side of Clark Bridge	NAVD88		8.5	9	9.2	13	9.7
FEMA Effective Study, 2016, Bass Harbor Marsh					10		
Est. surge plus waves-ocean side of Clark Bridge, FEMA	NAVD88		10.3-12.3			FEMA waves approx 3.8	
US Army Corps of Engineers Tidal Flood Elevations, 2012 – ocean side of Clark Bridge.	NAVD88	8	8.5	9.1	9.4		9.9

Table 1. Summary of Predicted Storm Tide data, Tremont and Southwest Harbor

FEMA analyzed flood levels in Tremont and Southwest Harbor. The FEMA map is shown below. Exposure to open water fetch for development of waves at the Marsh Bridge project site is very small in Bass Harbor Marsh, so no wave action is anticipated at this bridge. FEMA mapped the open ocean in this area as VE (storm-induced velocity wave action), elevation 13 and the Bass Harbor Marsh area as AE (1% flood elevation), elevation 10.

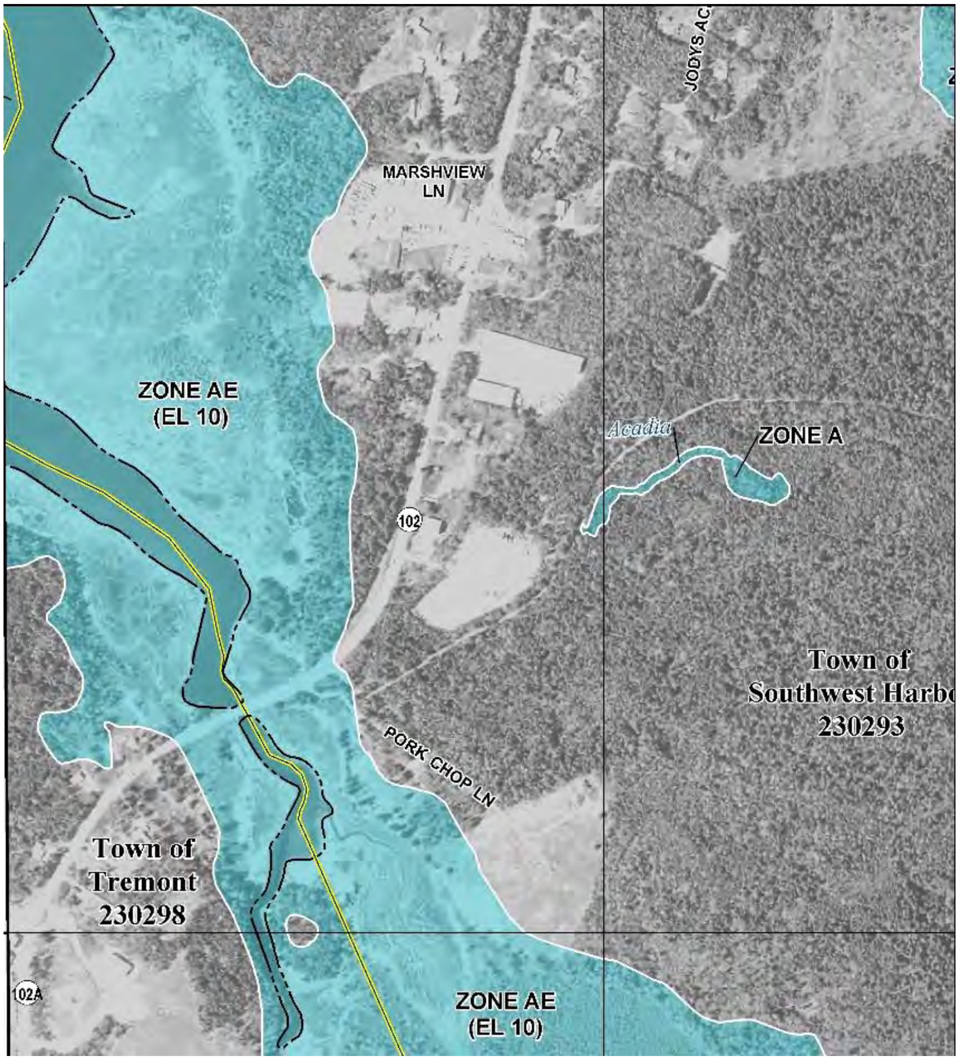

Figure 7. Extracted from FEMA FIS, July 20, 2016

A summary of storm tide data is listed in Table 2 based on the FEMA FIS, the NOAA tide gage at Bar Harbor and a USGS report on the storm of February 7, 1978.

Location	**Data Source**	**Date**	**Elev.**	**Datum**
Bar Harbor	FEMA FIS	2/7/1978	9	NGVD
		4/5/1979?	9.4	NGVD
		3/16/1976	9.7	NGVD
Southwest Harbor	FEMA FIS	2/7/1978	7.6	NGVD
		2/2/1976	8.9	
Bar Harbor	NOAA tide gage record	2/7/1978	8.8, 10.2	NAVD
Southwest Harbor	USGS 1978 storm report	2/7/1978	9.5	NGVD

Table 2. Recorded Storm Tide Data. Note NAVD is 0.62' above NGVD.

Other available data include the NOAA tide gage at Bar Harbor. Tidal datums at the Bar Harbor recording gage are shown in Table 3.

	Bar Harbor, Station #8413320
Elevation	NAVD 88
Potential Sea Level Rise at Bar Harbor	Up to 4' during 75-year bridge life span (NOAA)
HOWL – 2/7/1978	10.2
HAT – 2017	7.7
MHHW	5.4
MHW	5.0
NAVD 88	0.0
MSL	-0.31
MTL	-.31
MLW	-5.6
MLLW	-6.0

Table 3. Summary of NOAA tidal data at Bar Harbor which reflect tide levels at the downstream side of Clark Bridge.

2.2 Project Survey:

Project survey was conducted at Marsh Bridge and at the downstream Clark Bridge. Survey extended to either side of each bridge. Survey data was imported to ArcView and processed to depict relative depths at each bridge as shown in Figures 8 and 9.

Figure 8. Marsh Bridge TIN surface of relative elevations in feet based on project survey.

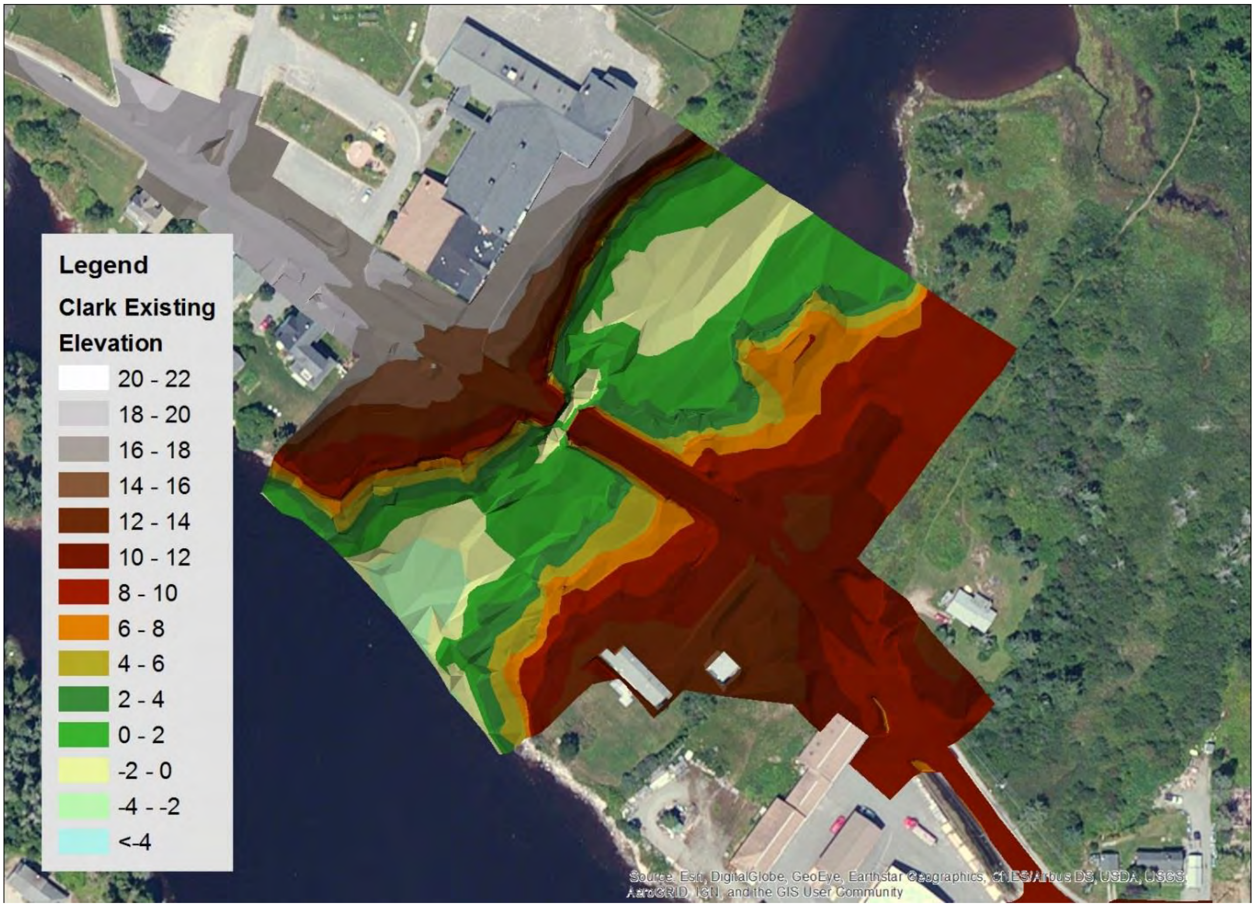

Figure 9. Clark Bridge TIN surface of relative elevations in feet NAVD based on project survey.

2.3 DEM and GIS database

A GIS database was assembled containing a triangulated terrain model of the surveyed areas, survey points, 2-meter digital elevation model with 2 foot contours of Tremont and Southwest Harbor from Maine GIS, and aerial photography. The GIS database was used to develop cross sections for the hydraulic model. Where cross sections extended onto land but were not included in the survey, the 2-meter DEM values were used. Upstream of project survey, depths below elevation 2.0 were estimated in Bass Harbor Marsh based on survey slope, air photos and field observation.

3.0 Field Data January 31, 2017

A site visit and field data measurements were conducted by the Northstar Hydro team on January 31, 2017. Data collection date was selected based on available daylight hours, weather, and high lunar tides. A partial falling and rising tide including time of low tide was measured.

For the Bar Harbor tide gage, MHHW to MLLW is 5.4 to -6.0. Highest annual tide predicted for 2017 was predicted for June 24 at 7.7' NAVD. Tides on the selected field day (1/31) ranged from +6.6 to -6.0 NAVD. Site water level and flow data was collected from low to high tide.

Data detail is included in the Appendix. Water level readings on each side of the bridge were taken approximately every 15- 30 minutes by measuring from top of rail (at edge of angled section) on the up- and down-stream sides of the bridge. Velocity was estimated through observation of time of travel through the bridge in the center of the channel.

Figure 10. Water level measurements were taken from the lip of the rail, at the bottom edge of the angled portion at the center of each side of the bridge.

The following observations summarize daily tide fluctuation at the site.

- The bridge site is perpendicular to flow with very slow rate of flow.
- The site does not dewater at low tide.
- The bridge offers little to no restriction to tidal flow.
- Water level changed very little on a rising tide. High tide was delayed at least two hours beyond predicted high tide at Bass Harbor.
- Estimated velocities as measured ranged up to 0.8 fps on an incoming tide and 0.5 fps outgoing.
- Measured tide levels vs. predicted tide levels at Bass Harbor are shown in Figure 11 below.
- Tidal influence is minimized at the Marsh Bridge due to the constriction at Clark Bridge.

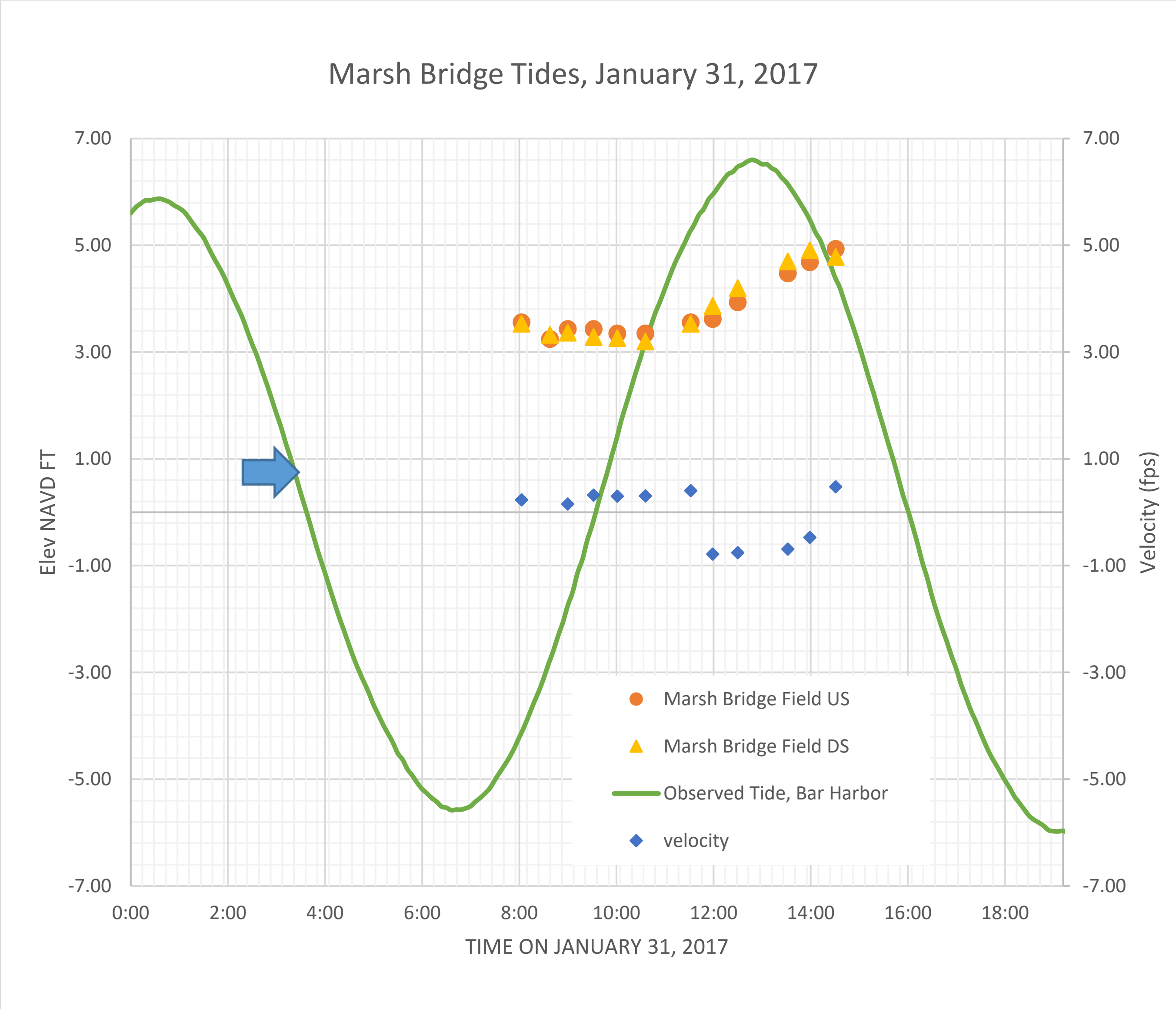

Figure 11. Measured tides at Marsh Bridge vs predicted tides at Clark Bridge. Blue arrow shows base of channel elevation at Clark Bridge. At Marsh Bridge, base of channel is at 1.99' NAVD.

4.0 Hydrology, Tidal, Upland and Sea Level Rise

4.1 Upland Hydrology

MaineDOT analyzed upland flows at the site using the USGS Regression Formula for Peak flows for Maine. The site drains approximately 2 square miles (1280 acres) of drainage area. Approximately 20 percent of the drainage basin is wetlands (256 acres). The high percentage of wetlands provides significant storage and limits peak outflows. Peak flows are summarized in Table 4 below. Clark Bridge flows are included in the table because this location is part of the Marsh Bridge hydraulic model. Drainage area at Clark Bridge is 8.6 square miles and 22% of the drainage basin is wetlands.

Storm Frequency	Marsh BR, Flow, cfs		Clark BR flow, cfs
Years	USGS Regression	Stream Stats	USGS Regression
1.1	29	12.8	71
50	157	100	354
100	184	117	405
500	241	150	526
DA, sq. mi.	2	2	8.6
% wetlands	20	30.9	22.4

Table 4. Upland Hydrology

4.2 Tidal Elevations

Tidal elevations as summarized in Section 2, Table 3 are recommended for model boundary input downstream of Clark Bridge. Hydraulic modeling was used to assist in identifying storm tide elevations upstream of Clark Bridge and at Marsh Bridge.

4.3 Sea Level Rise:

Adding Sea level rise according to MaineDOT Bridge Manual Chapter 12 recommendations, the Bar Harbor tide gage is used as the base gage, with projected SLR added to tides. Sea level rise estimate at the Portland gage by NOAA is 0.6' over the last 100-years. Straight line extrapolation leads to a continued estimate of about 1' of additional rise over the life of the bridge. However, per a MaineDOT memo dated July 9, 2017 (appendix), sea level trends are likely not linear. Following a trend labeled as Intermediate High suggests potential rise of 4' over the life of the bridge (est 75-years).

The reference for straight line sea level rise and the description for the Portland gage is:

http://www.co-ops.nos.noaa.gov/sltrends/sltrends.html

For the NOAA Sea Level Rise Viewer, the reference page is:

https://coast.noaa.gov/digitalcoast/tools/slr.html

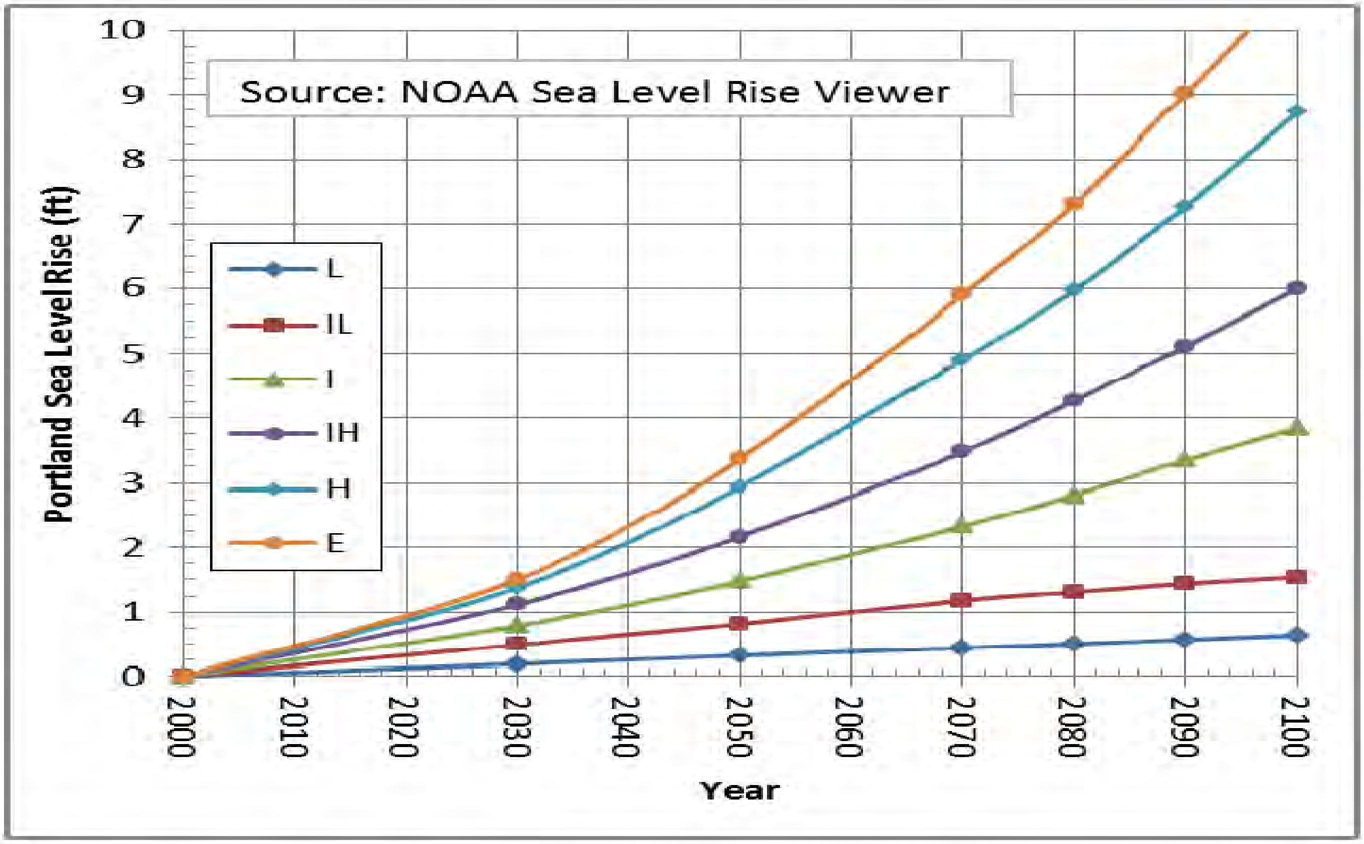

Figure 12. NOAA Sea Level Rise Viewer

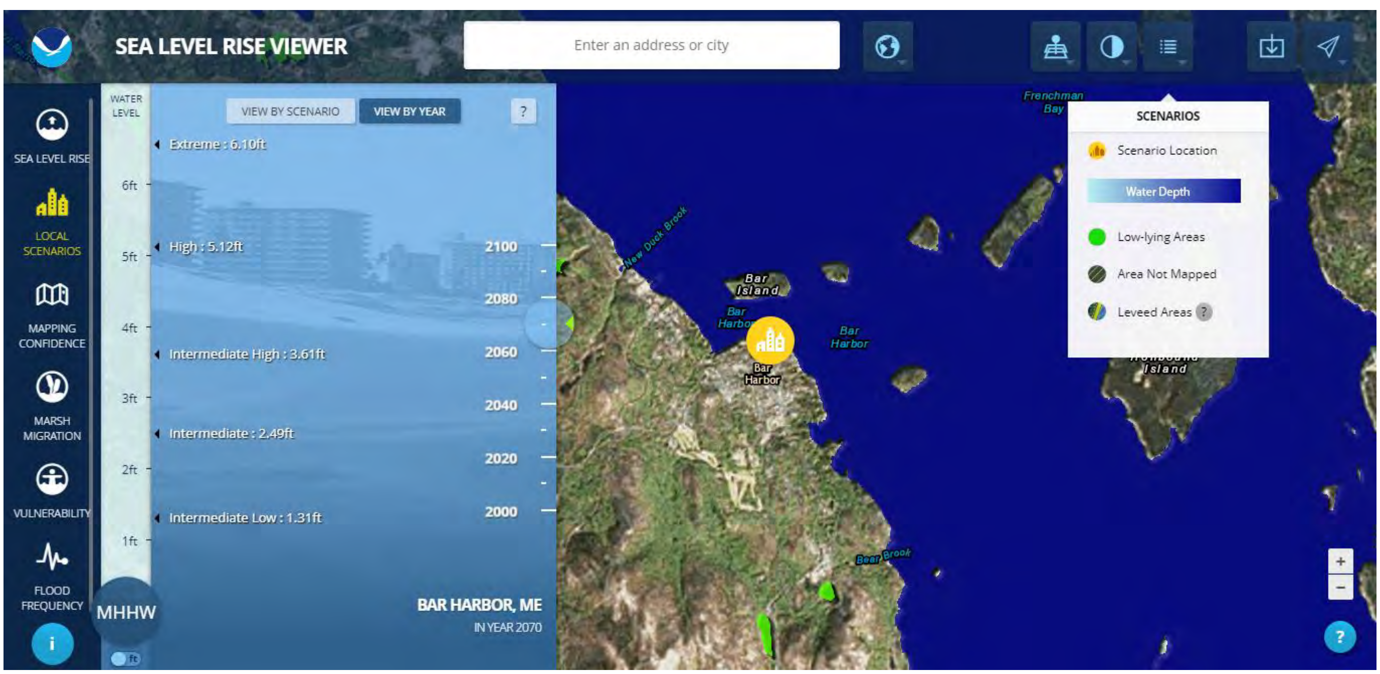

Figure 13. Screen shot from NOAA Sea Level Rise Viewer. For the Intermediate High Trend and a 75-year life span, a rise of 4' is projected by this tool.

5.0 Hydraulics

The hydraulic analysis was designed to identify flow characteristics at the bridge site that impact aspects of the bridge design. For combined tidal/upland flow bridges, goals include:

- Evaluate tide elevations on either side of the bridge
- Evaluate the potential impact of changes to bridge geometry on tidal flow and tidal elevations
- Evaluate velocity of flow through the bridge for purposes of scour evaluation
- Evaluate potential wave impacts
- Evaluate upland flows combined with typical tides such as Highest Annual Tide.

This site is impacted by tidal exchange at Clark Bridge, upland flows up-stream of Marsh Bridge and backwater and storage in Bass Harbor Marsh. The project site was modeled to include these impacts with the model starting downstream of Clark Bridge and extending throughout Bass Harbor Marsh and including upland flows into all of Bass Harbor Marsh.

5.1 HECRAS Hydraulic Model:

Several methods were utilized to evaluate flow at the bridge, including measuring flow on site, and development of a HECRAS hydraulic model in unsteady flow mode to simulate flow during storm events. Inputs for the unsteady flow model include a geometric model and a tidal hydrograph. Figures 12-14 show the layout for the geometric model at different scales.

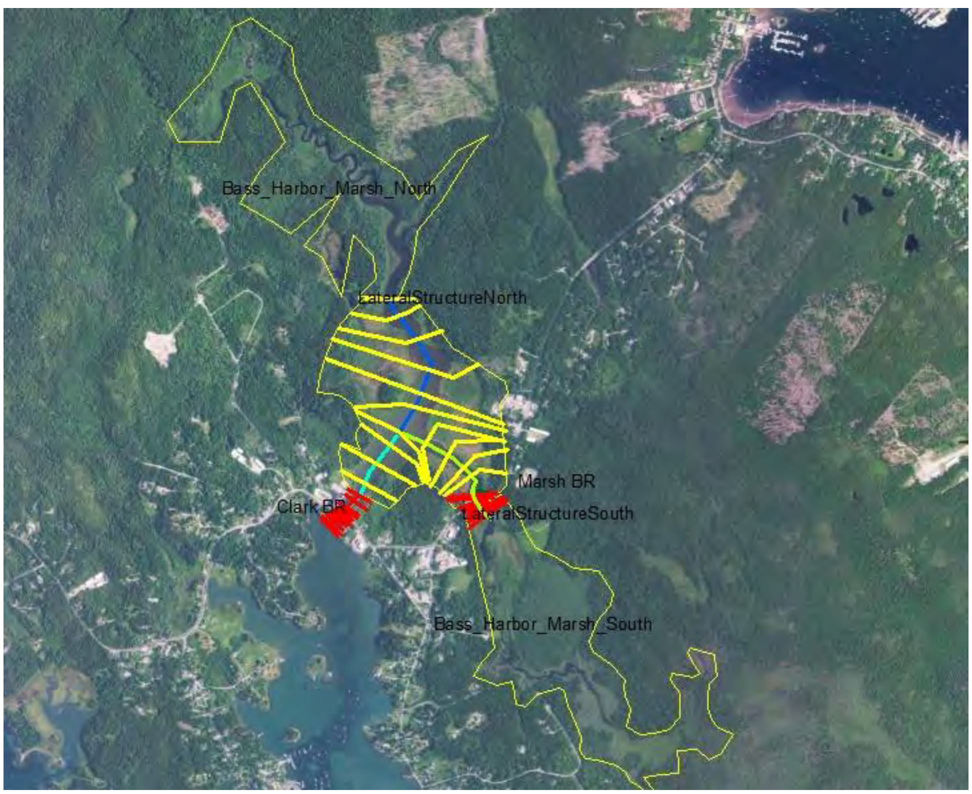

Figure 14: Marsh Bridge HECRAS model setup. Tidal boundary downstream of Clark Bridge. Survey in red at Clark Bridge and Marsh Bridge. Estimated river sections in yellow. Marsh storage areas outlined in yellow.

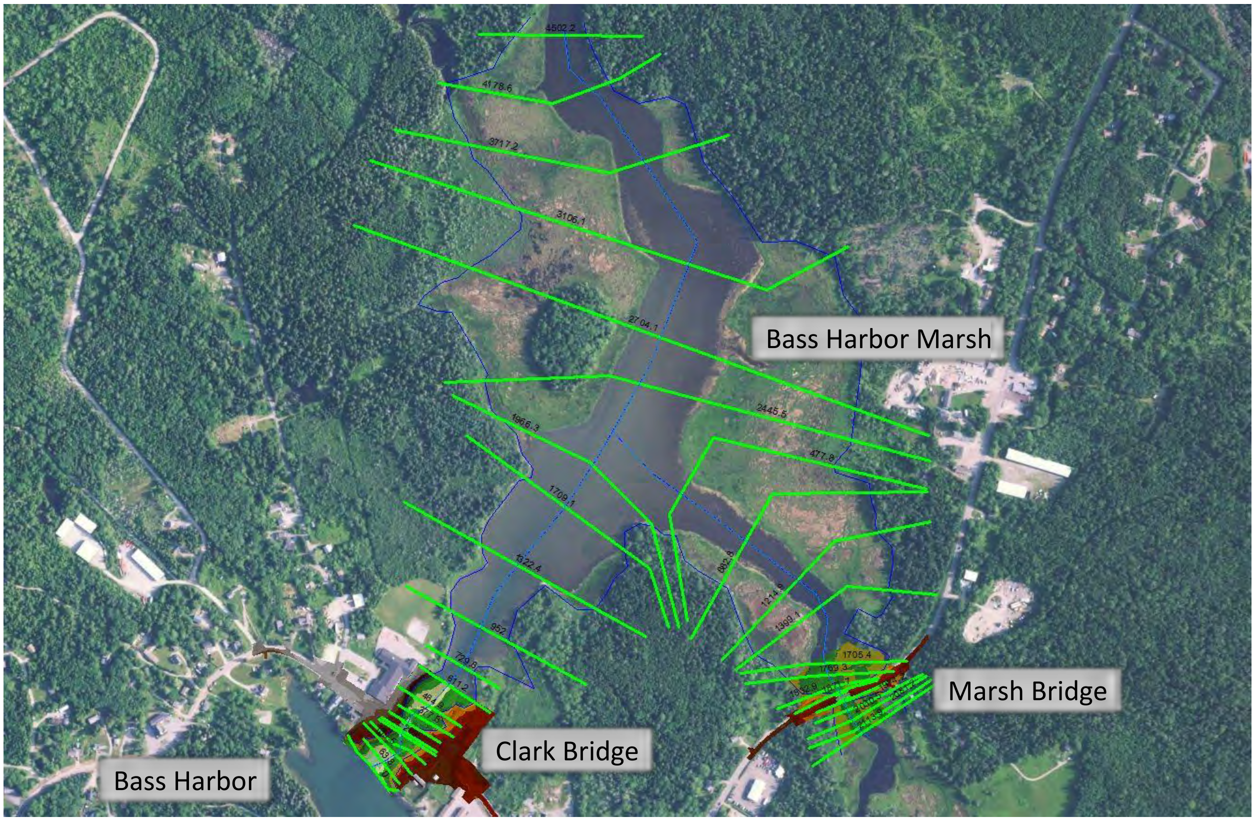

Figure 15: Model layout including Bass Harbor, Clark Bridge, and Marsh Bridge

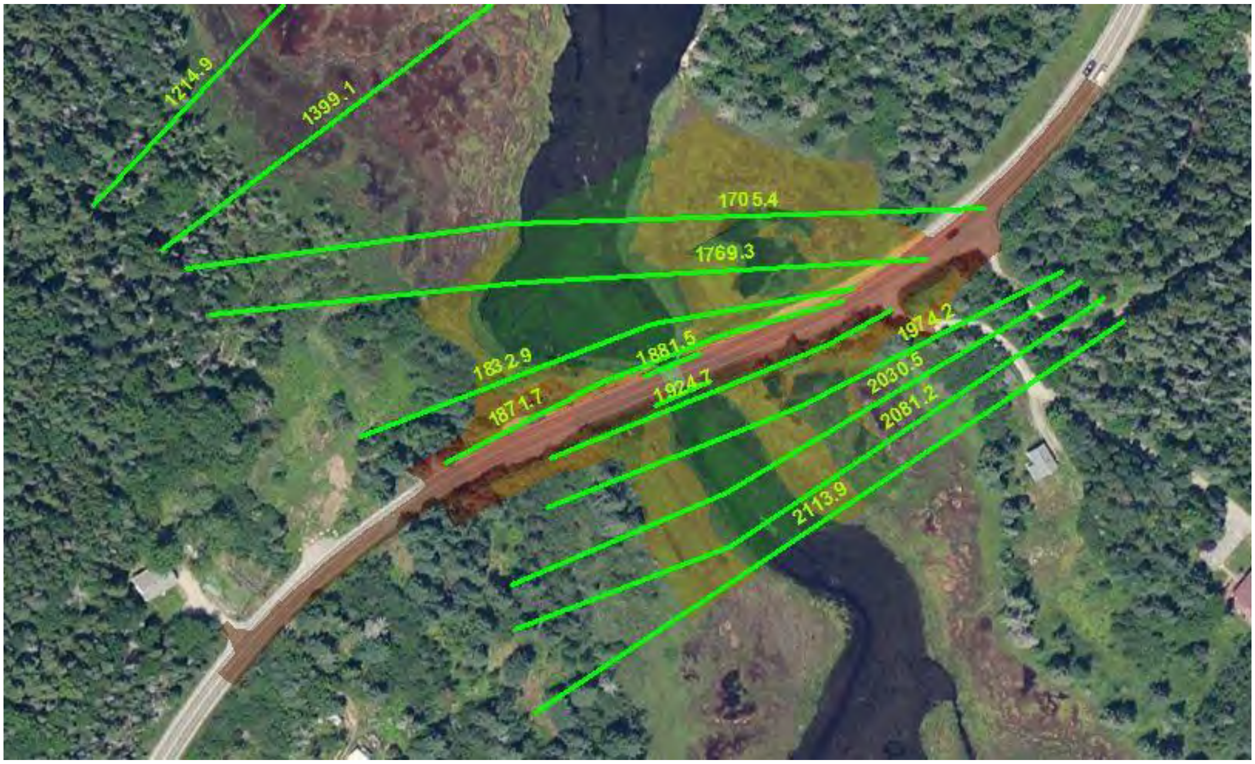

Figure 16: Model Layout at Marsh Bridge

The model includes three stream reaches:

- Downstream reach, from downstream of Clark Bridge to junction with Marshall Brook
- Marshall Brook through Marsh Bridge
- Upstream reach of Bass Harbor Marsh above the junction with Marshall Brook.

Bottom profiles for the Clark and Marshall Bridge reaches are shown in figure 15.

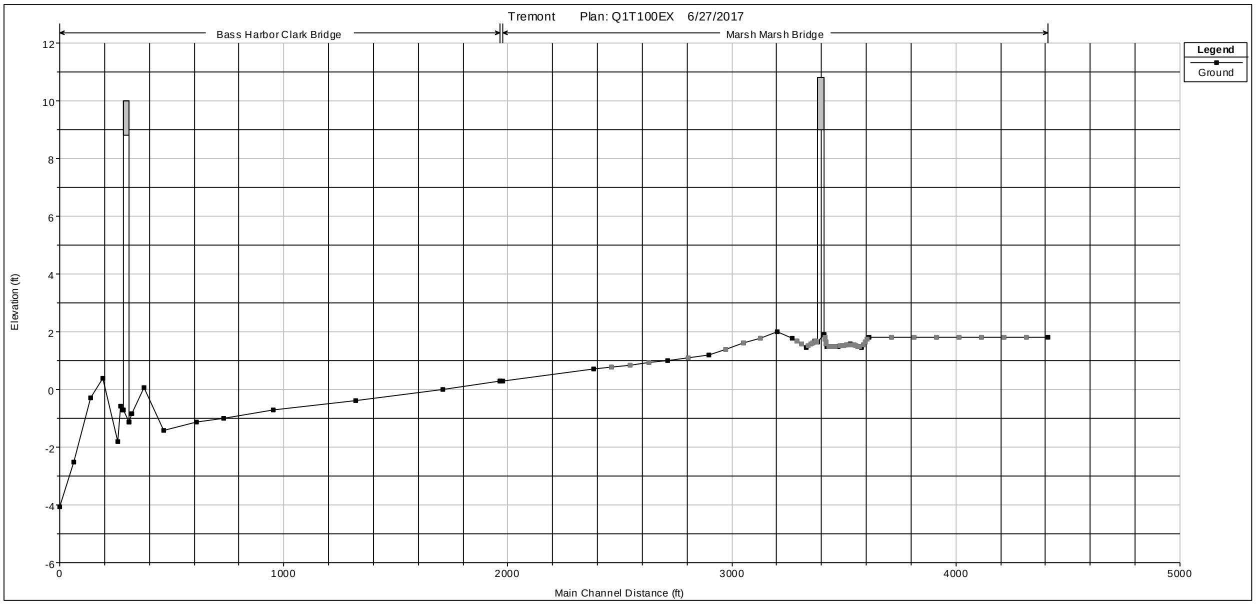

Figure 17. Clark Bridge and Marsh Bridge stream reach bottom profile. Note control elevation of 0.38' downstream of Clark Bridge and 2.0 at Marsh Bridge.

The hydraulic model was first run using existing condition bridges. Proposed replacement bridges are very similar to the existing condition. Modeled bridge sections are shown in figures 16-19.

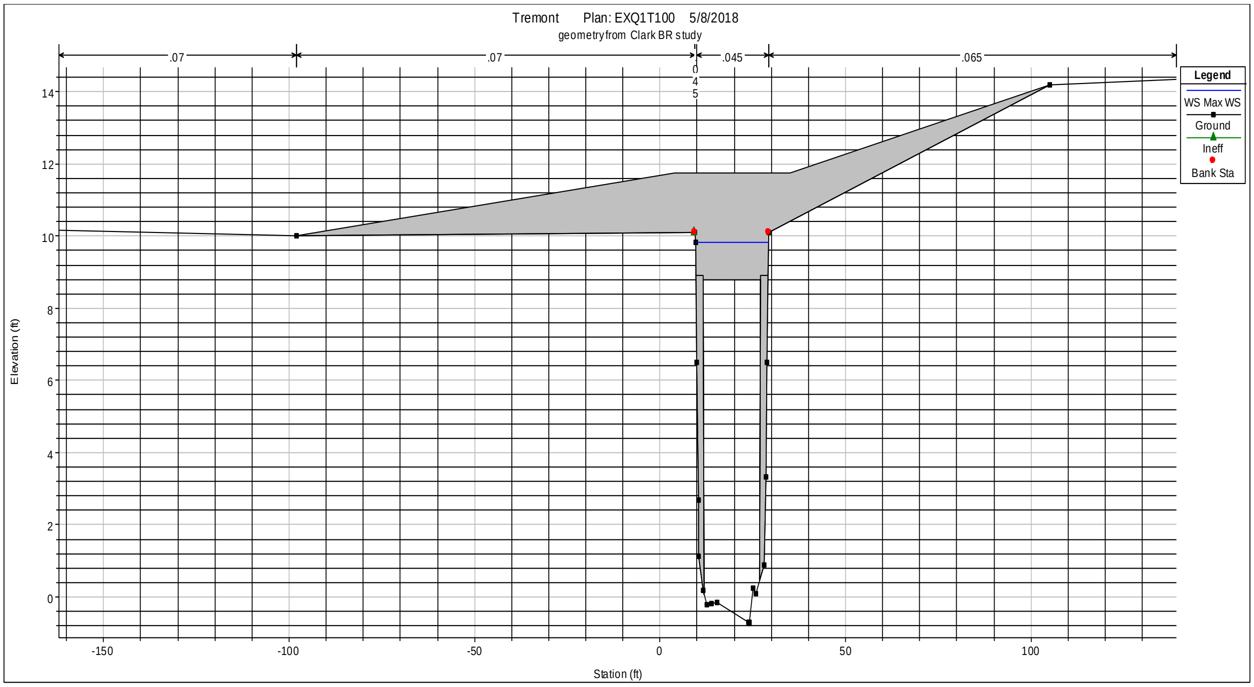

Figure 18. Clark Bridge, Existing Conditions

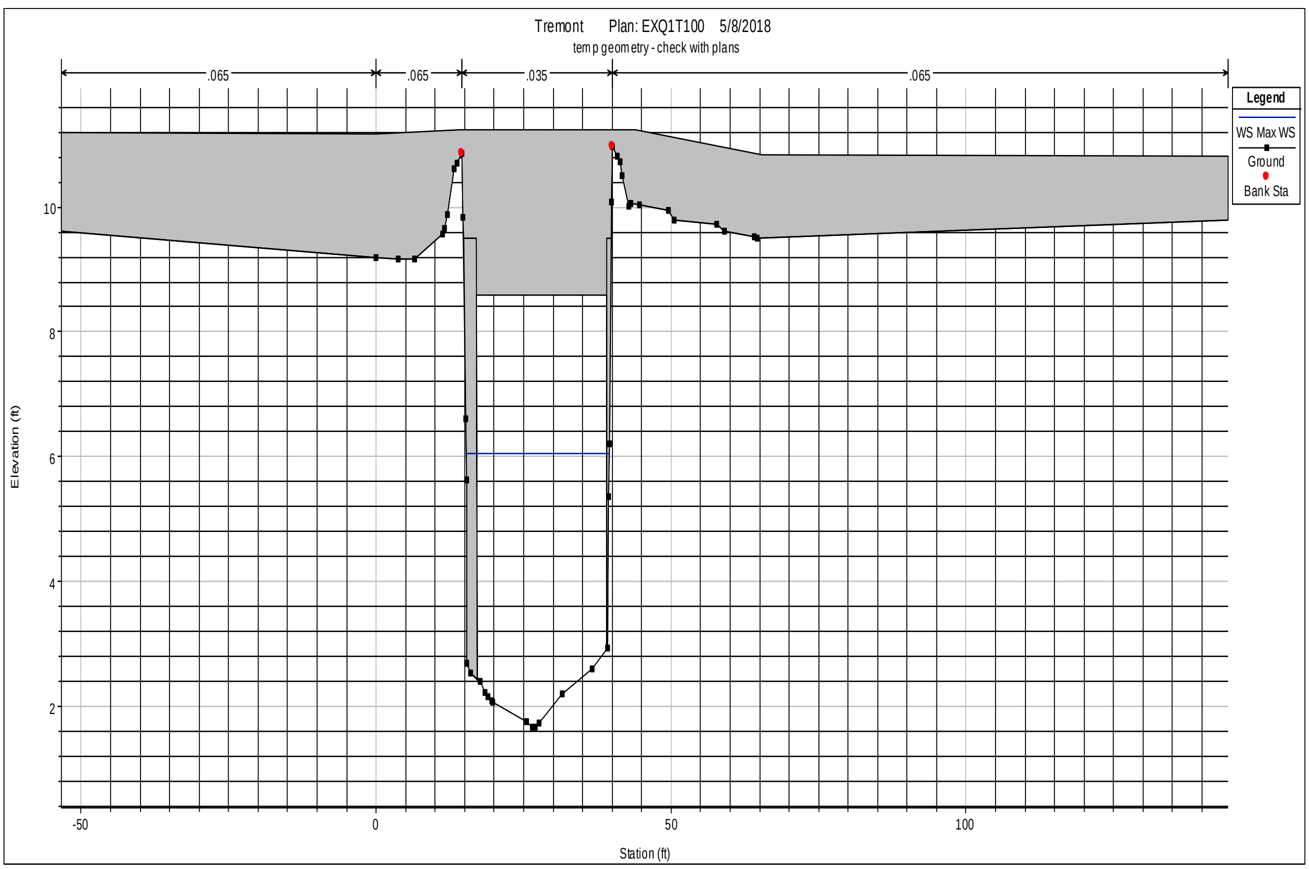

Figure 19. Marsh Bridge, Existing Conditions

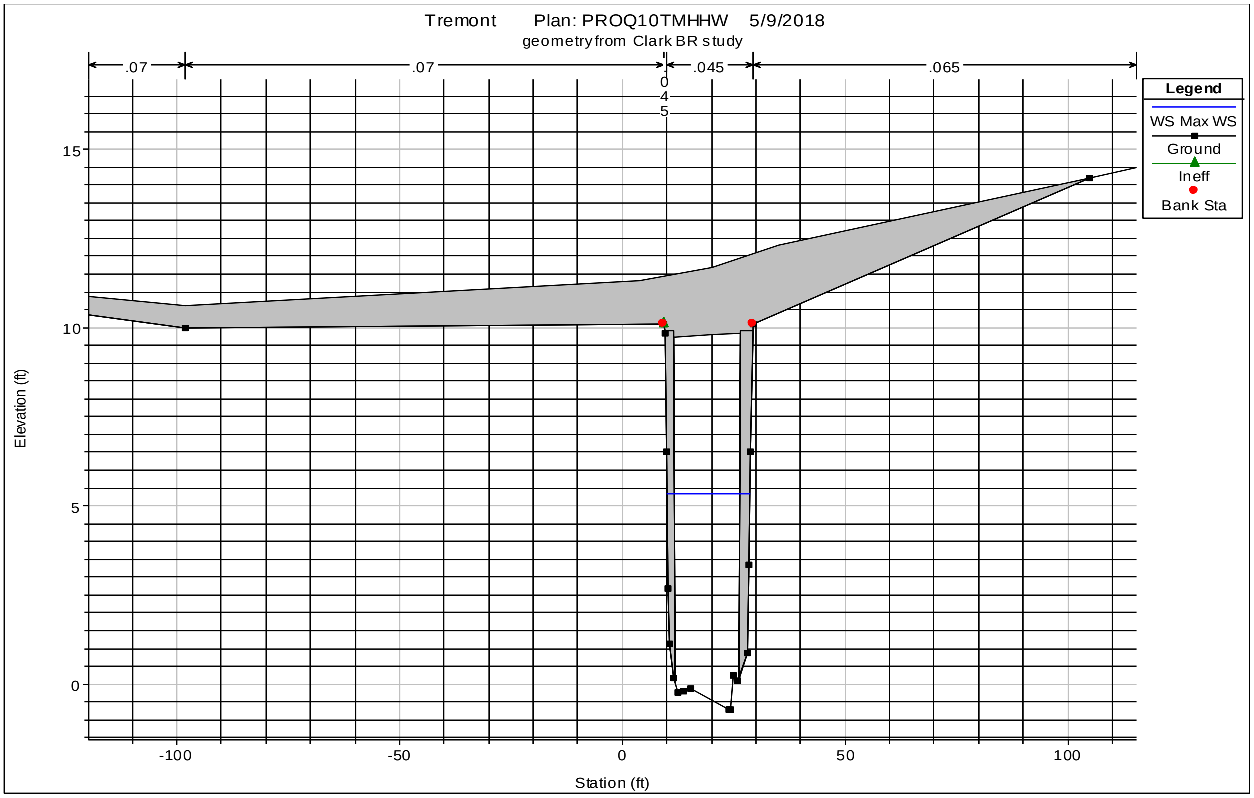

Figure 20. Clark Bridge, Proposed

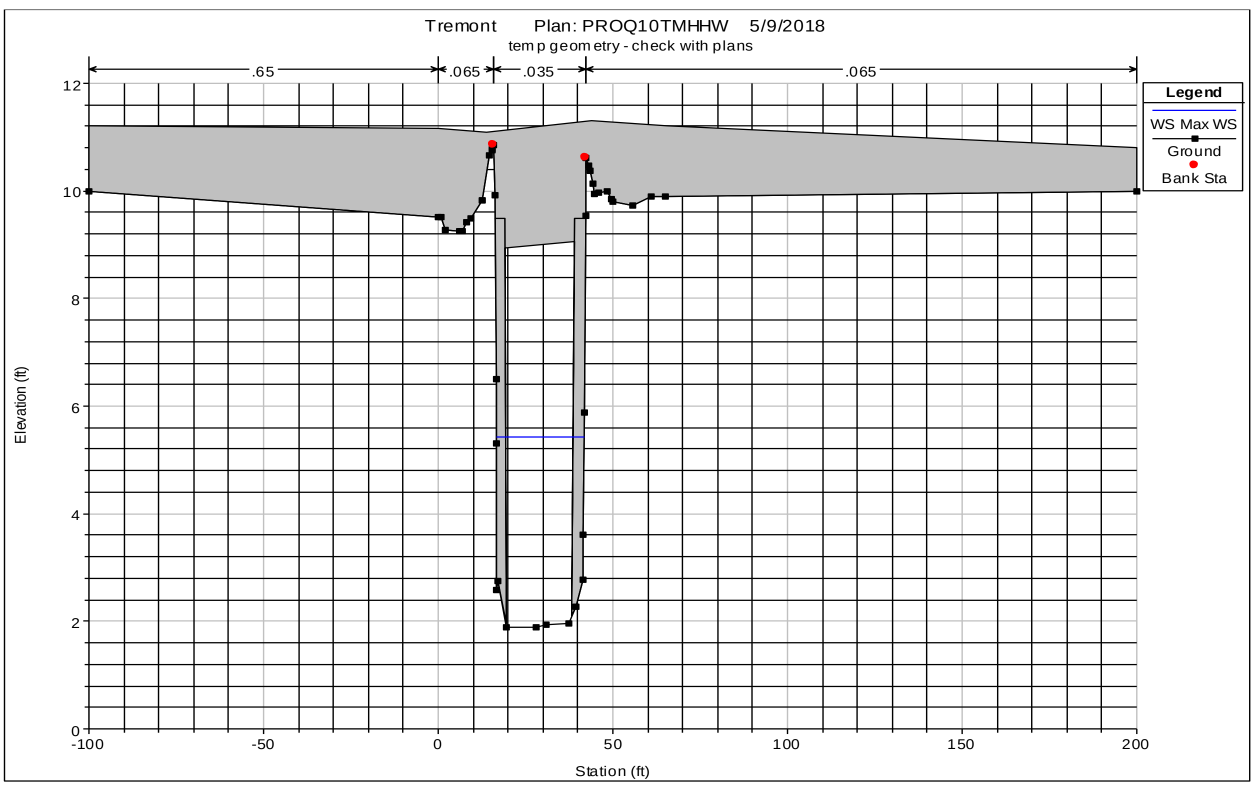

Figure 21. Marsh Bridge, Proposed

The model includes an unsteady tidal elevation boundary downstream of Clark Bridge with upland flow input as a steady flow boundary. The following combinations were modeled for final design:

Upland Flow,	**Tide hydrograph at Ocean side, Clark Bridge**		
Frequency	Frequency	Elev, NAVD	
-		high	low
1-year	MHHW	5.4	2.2
10-year	MHHW	5.4	2.2
January Ave.	1/31/2017 (calib)	6.2	2.2
1-year	1-year	6.8	2.2
50-year	1-year	6.8	2.2
100-year	1-year	6.8	2.2
1-year	10 year no SLR	8.5	2.2
1-year	100-year surge only (HRT)	10.2	2.2
1-year	10 year plus 4' SLR	12.5	2.2
1-year	100-year with waves (no SLR)	13	2.2

Table 5. Summary of Model Tide and Flow combinations

Note that tidal low elevations below the highest stream bottom point within the model created unstable conditions so tidal hydrographs were truncated at 2.2' NAVD.

Tidal hydrographs were developed using the Bar Harbor gage predicted highest annual tide (HAT) curve, and the tide hydrograph for the February, 1978, or highest recorded tide (HRT) as the 100-year tidal elevation. MaineDOT's surge generation spreadsheet was also checked, but did not generate surge levels to match the HRT. The tidal hydrograph for the 100-year storm surge without waves at the ocean side of Clark Bridge is shown in Figure 23.

The HECRAS model was run with the above scenarios to provide estimates of typical tidal elevations and velocities as well as the type of flow that may occur during a storm tide at Marsh Bridge.

Figure 22 shows the calibration model run with recorded tides at Bar Harbor, model tides outside of Clark Bridge, and modeled and measured tides at Marsh Bridge. Note that the model for the calibration day used average January flows for upland flow.

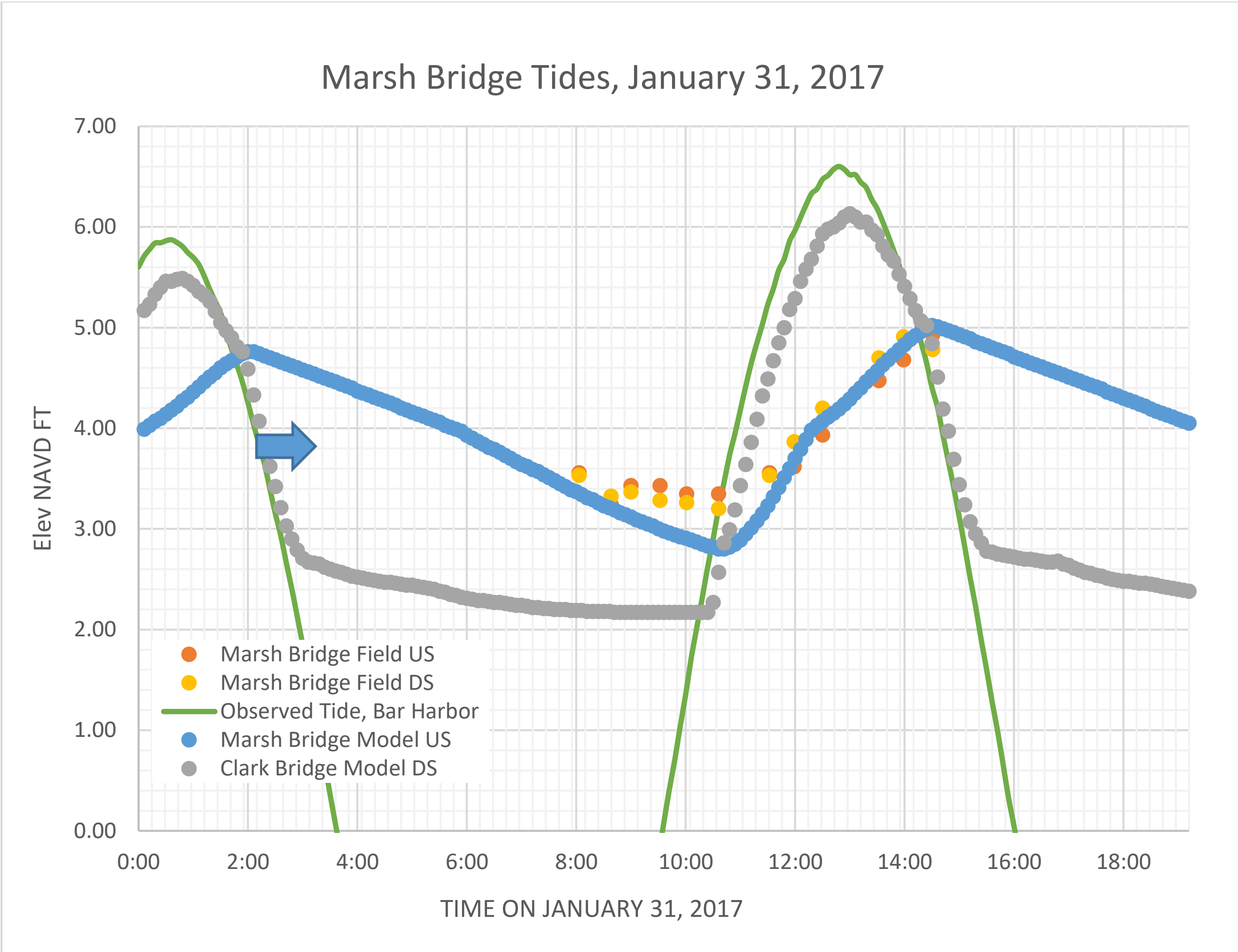

Figure 22. Modeled vs. Measured Tides at Marsh Bridge.

Additional modeled tidal hydrographs on the ocean side of Clark Bridge are shown in figures 23 and 24.

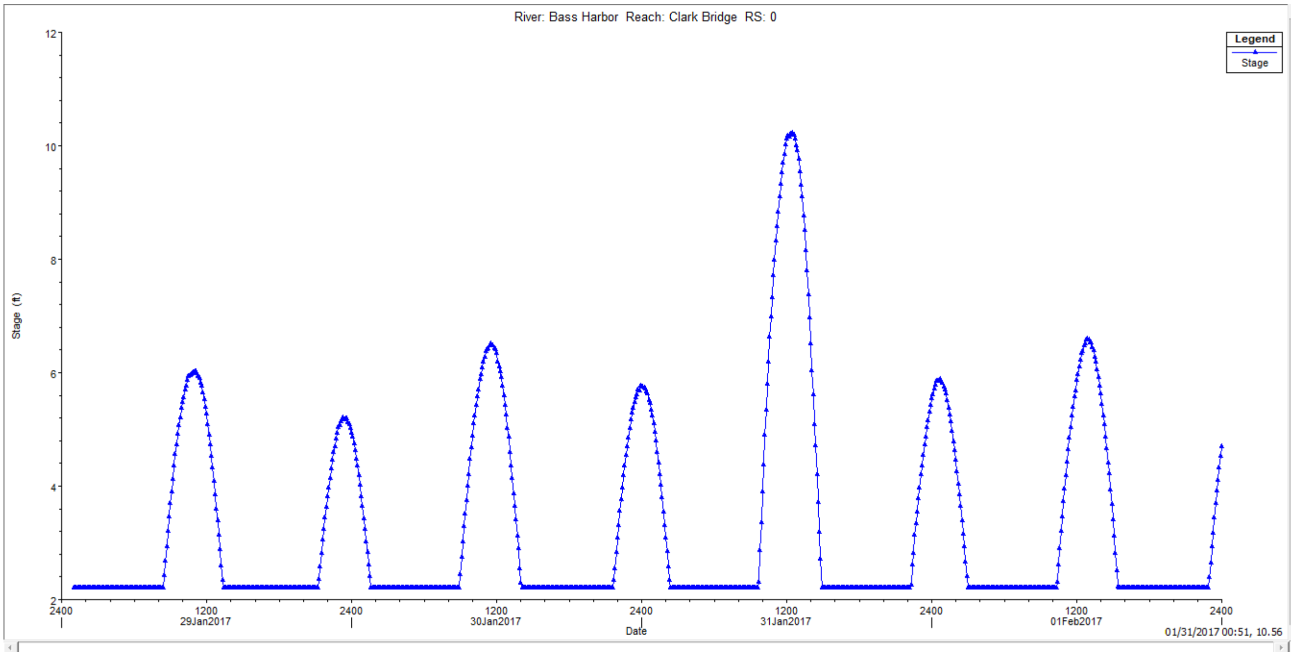

Figure 23. Tidal hydrograph showing 100-year storm surge without waves at ocean side of Clark Bridge.

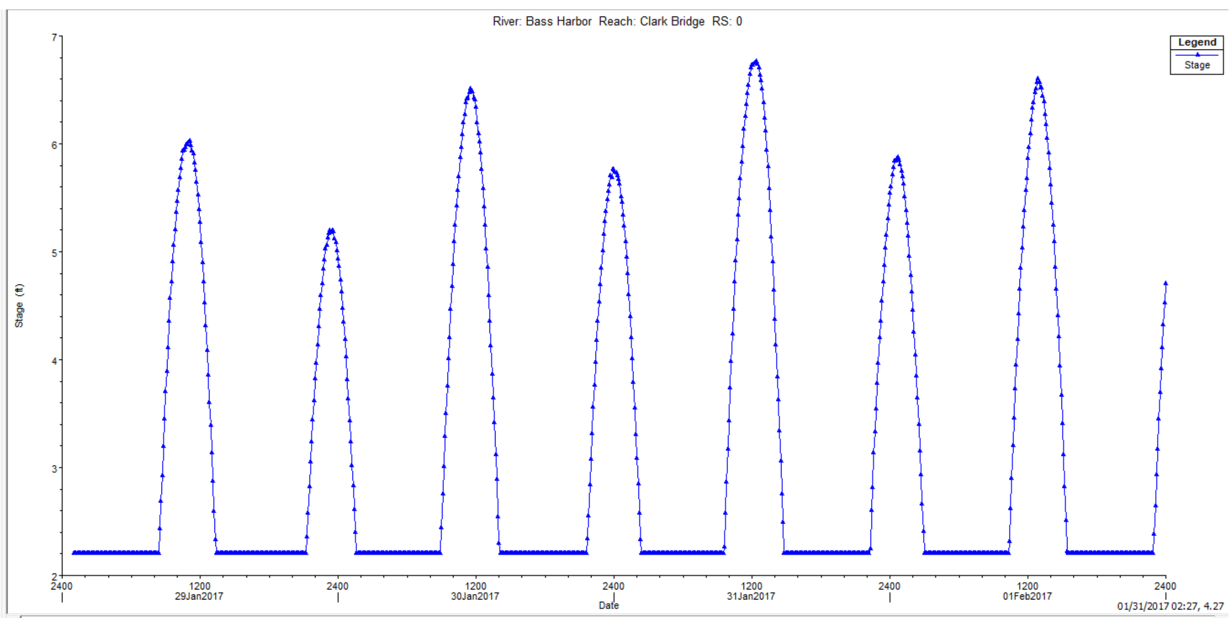

Figure 24. Tidal hydrographs for January 30, 2017, used for approx 1.1-year tide.in model.

5.2 Interaction between tides and upland flows.

The hydraulic model includes an unsteady flow boundary downstream of Clark Bridge, input as a tidal hydrograph, truncated to the minimum channel elevation. The upland flow boundary was considered to be a steady flow boundary using computed peak flows for selected recurrence intervals. Generally, high upland flows were combined with typical high tides and storm tides were combined with a 1-year type of streamflow. Using the upland flow as a steady state boundary likely overestimates inflow into the system, resulting in high storage in the marsh area in the model results. The model results likely show higher water elevations over time than would occur if modeling an upland hydrograph rather than steady flow. Figure 25 shows 1-year tide/100-year flow interaction:

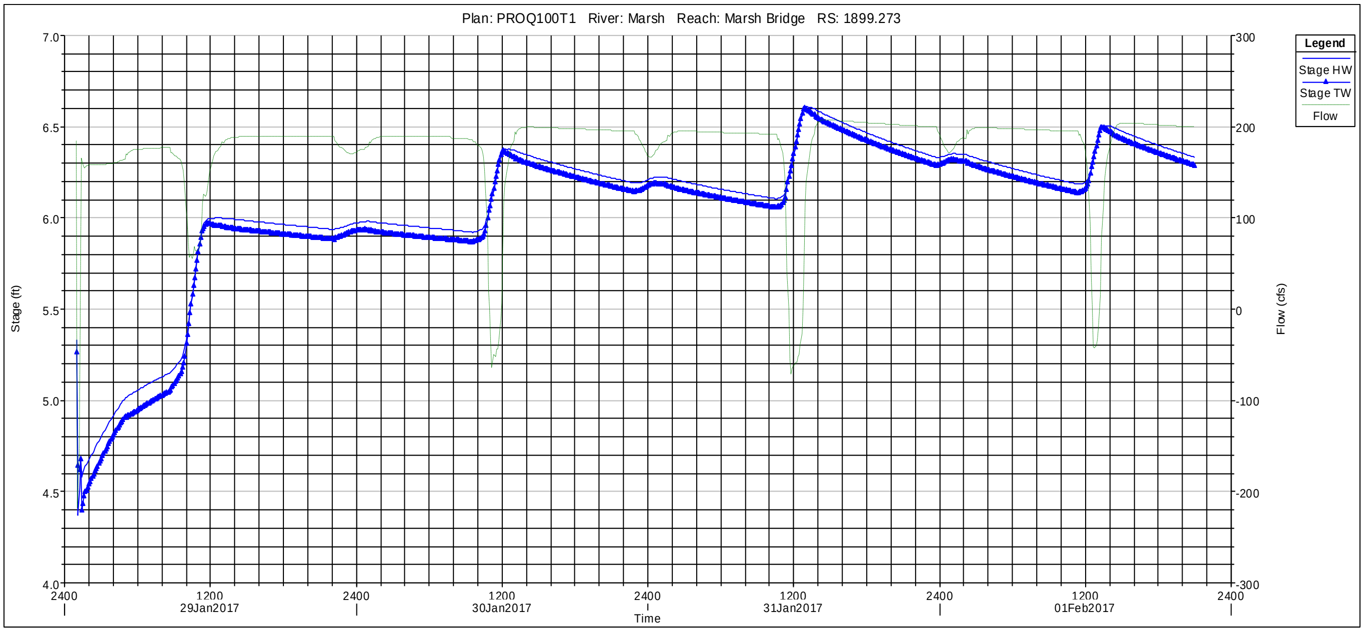

Figure 25. 100-year upland flow coupled with typical high tide over several days at Marsh Bridge.

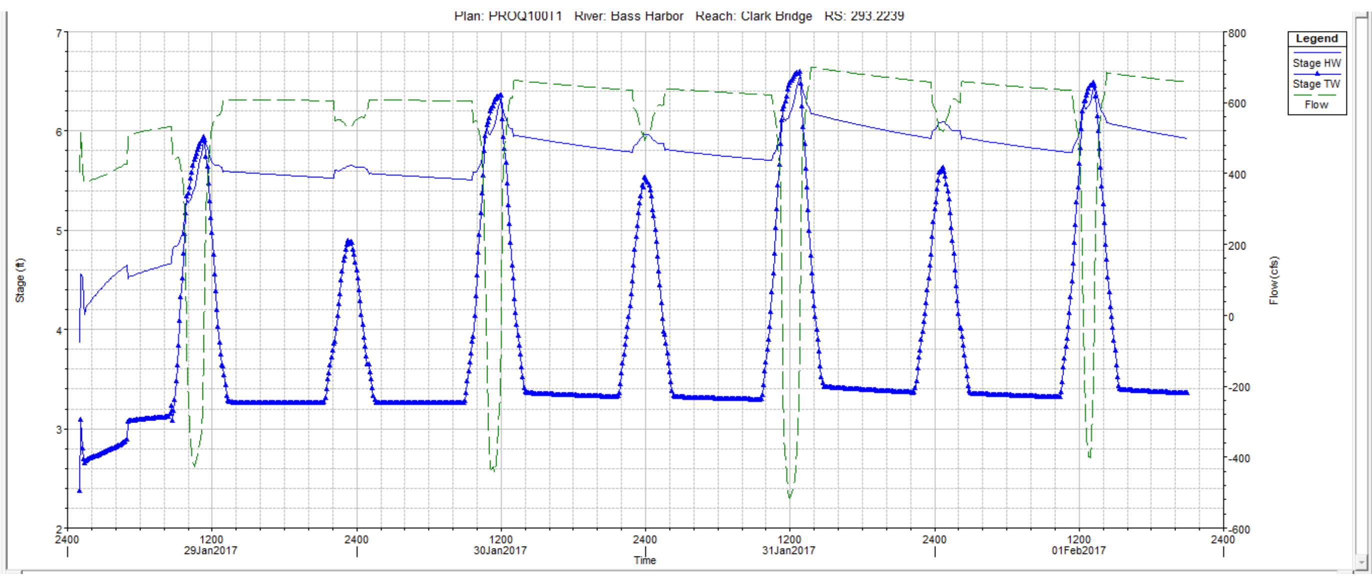

Figure 26. Water levels and flow during 100-year upland flow (steady) coupled with HAT at Clark Bridge.

5.2 Wave Heights

Damaging waves are not likely to occur at Marsh Bridge due to limited fetch and water depths. FEMA mapped this area as AE meaning not likely subject to wave action. FEMA mapped the area beyond Clark Bridge as a V zone, but wave heights are limited to 3'. To check the effect of wave action at Clark Bridge on Marsh Bridge, a tidal hydrograph was run to include 100-year surge plus waves on the ocean side of Clark Bridge.

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Tide, frequency in years,	Sea Level Rise, ft	Flow, cfs, Frequency, years	Elevation on ocean side of Clark Bridge	Elevation at Marsh Bridge, NAVD (Existing Bridges)	Elevation at Marsh Bridge, NAVD, (Proposed Bridges)
Calibration, Jan 31, 2107		Ave January	6.6' high, -6.0' low. Modeled low 2.2'.	Measured: 3.2 to 4.9', Modeled: 2.8 to 5.1' Velocity measured at -0.8fps, modeled at -2.2 to +0.8 fps.	Modeled 2.8-5.1
HOWL, 10.2		1-yr, 71/29 cfs Bass/Marsh	10.2	6.0	6.0
HAT, 2017		1-yr	7.7	Not modeled	Not modeled
MHHW		1-yr	5.4	4.7	4.7
MHHW	4'	1-yr	9.4	Not modeled	Not modeled
MHW		1-yr	5.0	Not modeled	Not modeled
MSL		1-yr	-0.31	2.6	2.6
NAVD 1988		1-yr	0.0	2.6	2.6
MLW		1-yr	-5.6	2.6	2.6
MLLW		1-yr	-6.0	2.6	2.6
LAT		1-yr		2.6	2.6
LOWL		1-yr		2.6	2.6
10-year		1-yr	8.0	5.7	5.6
10-year	4	1-yr	12.0	6.7	6.8
50-year		1-yr	9.0	Not modeled	Not modeled
50-year	4	1-yr	13.0		
100-year (1978, HOWL)		1-yr	10.2	6.0	6.0
100-year (FEMA)		1-yr	9.2	Not modeled	Not modeled
100-year	4	1-yr	11.2/14.2	Not modeled	Not modeled
100-year plus waves, FEMA		1-yr	13.0	9.7	Similar to existing, model unstable
500-year, FEMA		1-yr	9.7	Not modeled	Not modeled
1-year		100-year, 184/405 cfs Marsh and Bass H	6.7	6.6	6.6
1-year		50-year, 354/157 cfs Marsh/Bass	6.7	6.5	6.3
1-year		1-year, 71/29 cfs, Marsh/Bass	6.7	5.2	5.2

Table 6. Summary of Hydraulic Data.

Summary of Hydraulic Data Marsh Bridge, Tremont and Southwest Harbor	Existing Bridge NAVD	Proposed Bridge
Low Chord, ft	8.57	8.9-9.1
Low chord at Clark Bridge, ft	8.8	9.7-9.9
Abutment to abutment width, ft	20	20
Total width of piers	No piers	No piers
Minimum Elevation of Road Profile – East/West Approaches, ft	9.1 and 9.0	9.06 and 8.9
10-year surge, no SLR	5.6	5.6
10-yr surge, 4' SLR	6.7	6.8
100-yr surge, no SLR	6.0	6.0
50-year upland flow, 1-year tide	6.5	6.3
100-year upland flow, 1-year tide	6.7	6.7
Approximate Discharge Velocity at Q100, fps	2.1	2.1
Ordinary High Water Elevation ft (HAT 2017) with 1-year upland flow	5.2 to 2.8	5.2 to 2.8
Discharge Velocity, 10-yr tide with 4' SLR, fps	4.4	4.4
Discharge Velocity for typical tides (close to HAT)	2.2	2.2
Clearance @ 10-year surge, ft (current levels)	3.0	3.3
Clearance @ 50-year upland flow	2.1	2.4
Clearance @ 100-year upland flow	1.9	2.0
Clearance @ 100-year tide	2.6	2.7
Bridge Opening Area, ft^2	127	135

6.0 Scour

Scour analysis yielded the following results:

- The proposed reconstruction involves replacement of the deck only. No evidence of scour was reported by MaineDOT at this bridge. A scour inspection was not part of this study, but no obvious signs were noted during the site visit.
- Existing timber piles are assumed driven to bedrock according to the geotechnical report.
- It is recommended that scour protection be provided as shown on plans at the existing abutments.
- Geotechnical data describe the stream bed as fine silt clay. Estimate of D50 for this material is 0.06mm.
- Calculating critical velocity for fine silt clay gives approximately 0.8 fps for critical flow velocity. At flow velocities higher than 0.8 fps, suspension of bed material is likely and live bed contraction scour can occur.
- Potential live bed scour was calculated for the 100-year tide/1-year runoff event at 0.0' and for the 500-year runoff, 1-year tide as 7.7'. It is recommended that a number between these two is chosen. Tidal flow travels in both directions and can thus carry material back and forth through the opening. Tidal events do not last long and conditions change quite rapidly. In this case, the tide fluctuates only several feet, but flow reverses direction twice daily.

- This location does not show evidence of scour over time. Flow rates are very slow with maximum model velocities only reaching a little over 2 fps for any storm event. These velocities happen for a short time during the tide cycle, so scour will not reach its full extent as could occur for an inland bridge.
- Abutment scour is possible, but will be mitigated through use of scour protection at the base of the abutments.
- Long term bed: Estimated bed elevation of 1931 plans = 2.7'. Current bed level = approximately 2', indicating possible long term degradation. However, the bed profile shows some possible deposition on either side of the bridge and higher bed levels within the bridge than immediately up- or down-stream.
- The site has more flow from upstream to downstream due to upland freshwater runoff, so it is possible to have long term degradation even though flow reverses twice daily.
- Contraction scour at tidal bridges rarely reaches ultimate scour levels due to reversal of flow direction.
- Scour estimates are challenging at tidal bridges. This bridge experiences tidal and upland flow but rates of flow are mitigated by the wide marsh on either side of the bridge and the small width of flow at Clark Bridge. Many conditions were modeled and worst case velocities were chosen for scour computations. The calculations assume that modeled conditions continue for a long time, whereas at this bridge, flow will not be steady for more than a few hours at a time.
- At this location, the worst case appears to be 500-year upland runoff coupled with a typical annual high tide, resulting in potential scour of 7.7' due to the contraction.
- Given the unique flow characteristics at this bridge, it is likely that scour would be limited and a value of about half the computed value would be reasonable for design if new abutments were being constructed.
- Since the existing abutments are being retained the only recommendations are:
    - Consider riprap at base of abutments while maintaining existing bed levels.
    - Continue to monitor this location for potential scour under MaineDOT inspection program.

7.0 Summary and Conclusions

1. Marsh Bridge carries Route 102 over an arm of Bass Harbor Marsh labeled as Marshall Brook on the USGS Topographic Map. Water elevations in Bass Harbor Marsh are a combination of tidal waters that flow into the Marsh via Clark Bridge and upland runoff into the Marsh. Marsh Bridge has a 20' span, larger than the 15' span at Clark Bridge. Flow is very slow and water levels fluctuate by only a few feet. Water levels do not drop below Mean Sea Level, being limited by the Marsh Bridge bottom elevation of 2.0'.
2. Wave action is not expected to occur at this location. Small wind generated waves are possible, but not of a damaging nature. Fetch is limited and depths are shallow, thus limiting potential wave development.
3. Flow is generally perpendicular to the bridge span.
4. Maximum flow velocity measured in the field was less than 1 foot per second. Modeling with HECRAS for higher flows indicates generally low velocities at this bridge, even with 100-year runoff or tidal surge hydrograph.

5. The existing low chord is 8.57’ above NAVD. Proposed low chord will be 8.9-9.1’ above NAVD.
6. The new bridge will replace the existing single span bridge with a new single span bridge and will maintain the current abutment to abutment width of 20’. BFW calculated at this site is 11’ so the bridge is more than adequate for upland flows.
7. Sea level rise projections by NOAA vary greatly depending on the trend line selected. Using a linear extrapolation of Portland or Bar Harbor tide gage data yields about 1’ of possible rise in the life of the new bridge. Using NOAA’s intermediate High curve projection, a rise of 4’ is possible in the life of the bridge. With current MHHW at 5.4’, MHHW could potentially be 9.4’ at the ocean side of Clark Bridge and in the range of 5.8’ at Marsh Bridge (+about 1.2’over current conditions).
8. The profile and surrounding land at this bridge site limit options for any raise in bridge profile.
9. 100-year storm tide of 10.2 at Clark Bridge yields a storm elevation at Marsh Bridge of 6.0’. A surge level of 13’ yields a storm tide at Marsh Bridge of 9.4’ according to model results.
10. The 10-year surge level at Clark Bridge without SLR is 8.5 and with SLR is 9.5-12.5. 12.5’ at Clark Bridge yields a level at Marsh Bridge of about 12.0’ due to overtopping.
11. 10-year upland flow level at Marsh Bridge is 5.4’. 4’ of sea level rise could result in this level to rise about 1’ at Marsh Bridge.

Design recommendations include:

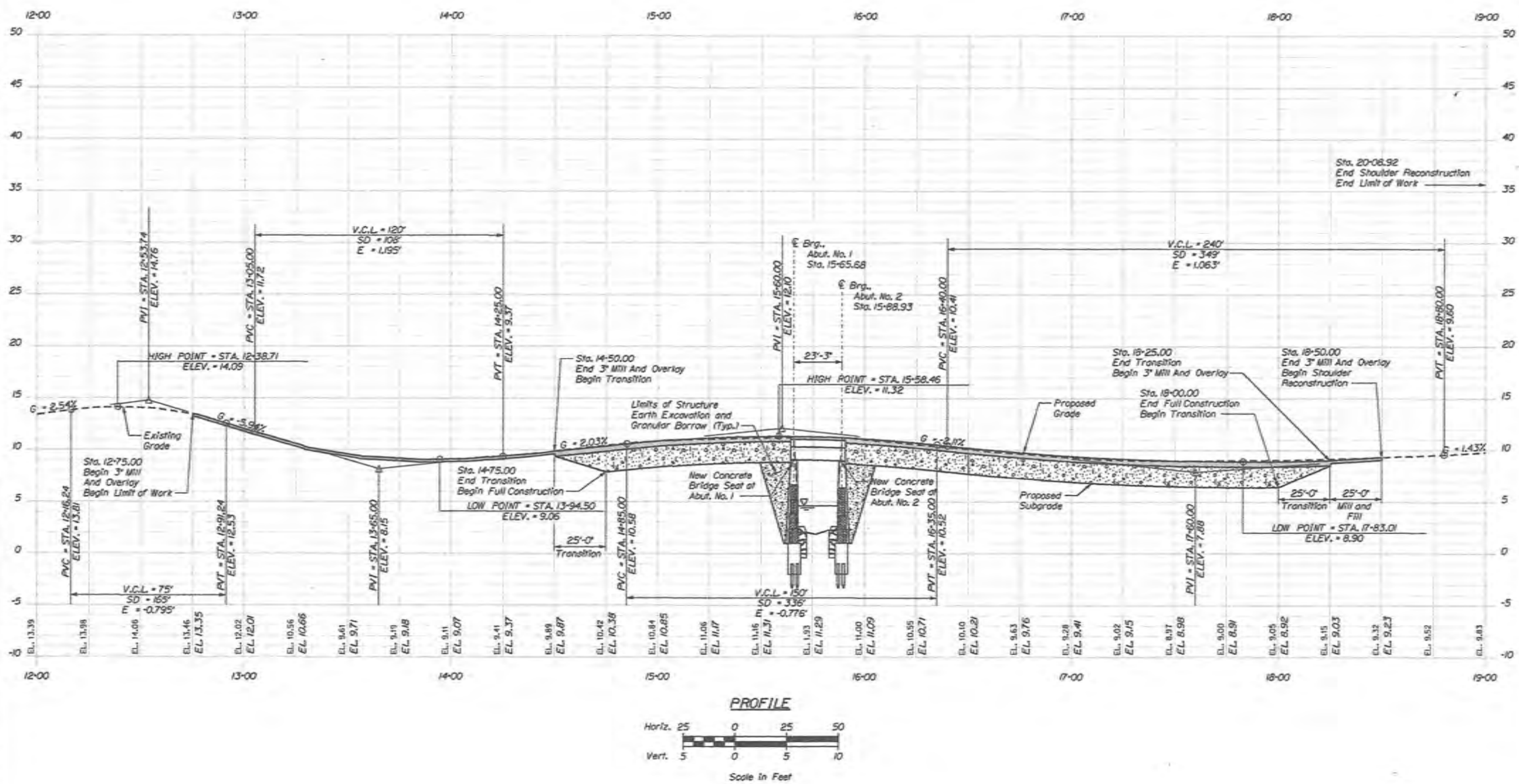
1. The existing span length does not impact water levels. Based on modeling of water levels, tidal flow and predicted upland flows the existing span is adequate.
2. The abutments are not being replaced, but it is recommended that regular inspections include checking for scour.

8.0 References

- State of Maine, Dept. of Transportation. STP 2170(200), Marsh Bridge, Bass Harbor Road Over Marsh Brook, Tremont/Southwest Harbor, Hancock County. July 18, 2018
- State of Maine, Dept. of Transportation. STP 2170(200) and STP-1930(210),Southwest Harbor/Tremont, Clark and Marsh Bridge, Hancock County. 85% Submission, 3/2/2018
- Golder Associates, Technical Memorandum. Preliminary Geotechnical Information, Draft PDR, Support, Marsh Bridge Replacement. July 14, 2016
- ESRI ArcMap, ArcGIS Desktop, Version 9.3.1, 2009. Arcview license. Data added from MEGIS website, project plans and ESRI
- Federal Emergency Management Agency. Flood Insurance Study and Flood Hazard Boundary Maps, Hancock County, Maine. July 2016
- Maine Dept. of Transportation. Bridge Design Manual. August 2012
- Maine DOT, Marsh Bridge over Marshall Brook, Bridge Plans, February 5, 1931
- VHB Draft Base Plan. Marsh Bridge, Marsh Brook. SW HBR and Tremont, Hancock County. STP 2170(200). Bridge 2511
- Maine GIS website was used for download of 2' contour data for Southport. http://www.maine.gov/megis/catalog/
- NOAA tide data, Bar Harbor and Portland: https://tidesandcurrents.noaa.gov/stationhome.html?id=8413320 https://tidesandcurrents.noaa.gov/stationhome.html?id=8418150
- NOAA coastal charts. Navigation Chart 13318, Frenchman Bay and Mount Desert Island
- NOAA Sea Level Trends http://www.co-ops.nos.noaa.gov/sltrends/sltrends.html, and https://coast.noaa.gov/digitalcoast/tools/slr.html
- U.S. Army Corps of Engineers, Hydrologic Engineering Center. HEC-RAS River Analysis System. Version 5.03. 2016 Davis, CA
- U.S. Army Corps of Engineers, Updated Tidal Flood Profiles, New England Coastline, March, 2012.
- U.S. Department of Transportation. Federal Highway Administration. Evaluating Scour at Bridges, 5th edition. HEC-18. April 2012 , Publication No. FHWA-HIF-12-003
- U.S. Department of Transportation. Federal Highway Administration. HEC 25, Highways in the Coastal Environment. 2nd Edition, June 2008
- U. S. Army Corps of Engineers. Coastal Engineering Research Center. Waterways Experiment Station. Shore Protection Manual. Vicksburgh, MI 1984 and 2002

Appendix.

Filename: ...\BRIDGE\MSTA\030_Profile_01.dgn   Division: BRIDGE   Username: PDonovan   Date:3/2/2018



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2170(200)

WIN 21702.00

BRIDGE NO. 2511   BRIDGE PLANS

85% SUBMISSION

NOT FOR CONSTRUCTION
03/02/2018

MARSH BRIDGE
BASS HARBOR ROAD OVER MARSH BROOK
TREMONT/SOUTHWEST HARBOR   HANCOCK COUNTY

PROFILE

SHEET NUMBER
30
OF 68

Environmental Office – Hydrology Section
16 State House Station
Augusta ME 04333-0016
207.557.1052
Charles.Hebson@maine.gov

Maine Department of Transportation

Memo

To: Jim Wentworth

From: Charles Hebson

CC: Mike Wight

Date: 2017 July 09

Re: 21677 Brooklin-Sedgewick River Bridge #3216 – Sea Level Rise

---

Summary and Recommendation

I recommend planning for 4-ft of sea level rise by year 2100; this corresponds to the "Intermediate" CO2 emissions scenario. A rise of 4-ft also equates to the "Intermediate High" scenario at year 2075. Thus, planning for 4-ft SLR provides protection against the Intermediate High forecast through 2075 and the Intermediate forecast through 2100. The ultimate SLR value chosen for design may differ from the accepted SLR projection due to project-specific considerations as well as program constraints. The minimum acceptable value for design should be 2-ft.

Discussion

Sea Level Rise (SLR) projections for Portland ME are shown in Figure 1 (based on NOAA Sea Level Rise Viewer). Six SLR scenarios are depicted: Low (L), Intermediate Low (IL), Intermediate (I), Intermediate High (IH), High (H) and Extreme (E), corresponding to CO2 emissions. These scenario names do not imply a probability of actually happening.

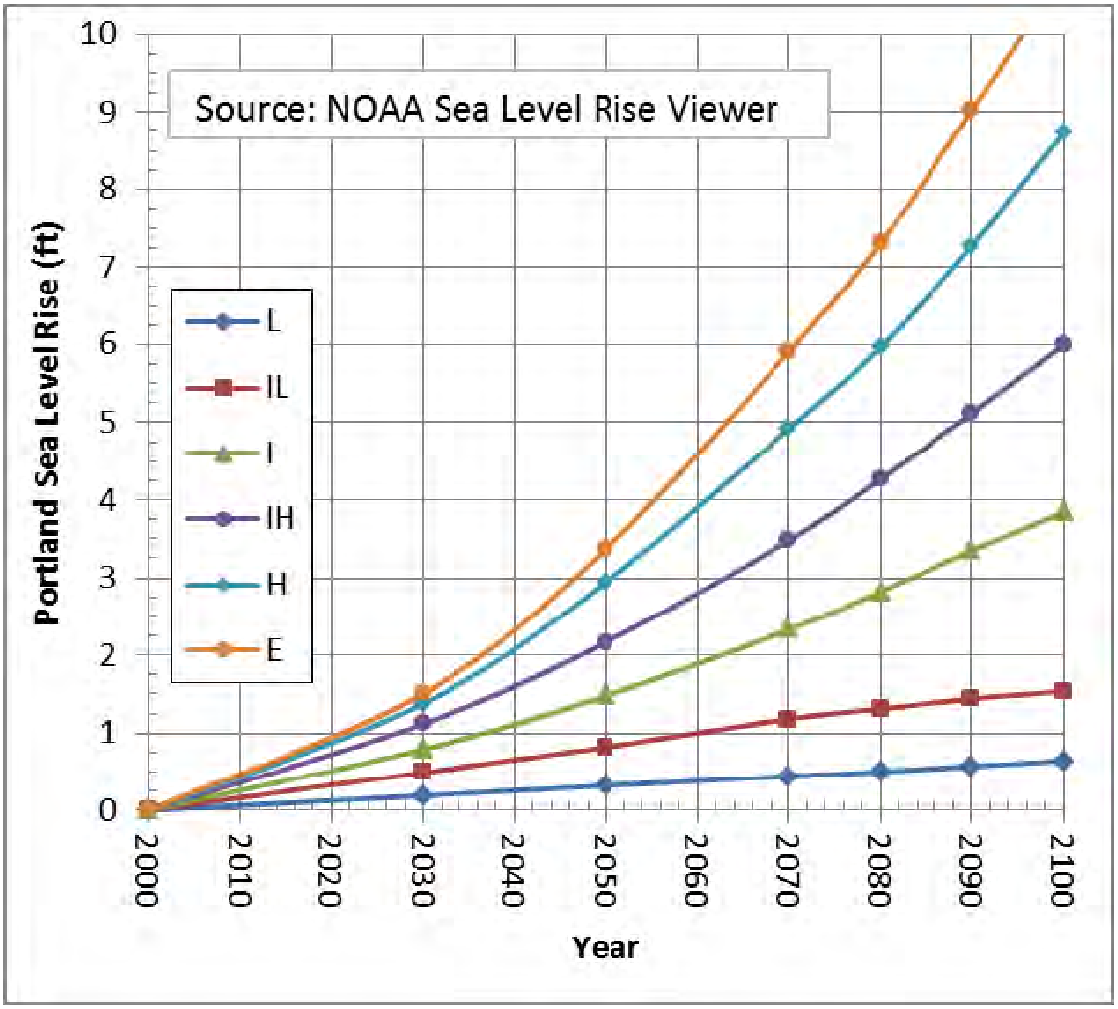
Scenario L is a simple linear extrapolation of the historic SLR trend at Portland over the past 100 years; it does not account for climate change and CO2 emissions. This would be the minimum SLR for design, at about 8-in. For design purposes, this would be rounded to 1-ft. However, general consensus is that CO2 emissions are increasing the rate of SLR change and so it is prudent to anticipate SLR greater than a simple extrapolation the historic trend.

The other scenarios are based on different assumptions about CO2 emissions through 2100. It is impractical to design for scenarios H and E. And even if one of these were to develop, the associated problems would be much greater than this particular bridge. Therefore, these scenarios have been eliminated from further consideration.

This leaves the three Intermediate scenarios (Low, Middle, High). Scenario IL (1.5-ft) isn't much different than L (as a practical matter and for our purposes, L could be folded into IL). Values similar to IL have been used on several recent MaineDOT projects. The IL value is consistent with State of Maine Sand Dune Rules (2006) that specify 2-ft SLR by 2100. The concern with IL is that given the observed CO2 emissions and temperature changes since 2000, many experts believe that it is increasingly unlikely that SLR will follow the IL path. This leaves scenarios I and IH as candidates for the basis of design, along with a value of 2-ft as the desirable minimum.

Choosing between I and IH comes down to one's opinion as to what CO2 scenario plays out, how good the climate models are, and what is "doable" from a MaineDOT perspective. The biggest unknown here is future CO2 emissions, which is ultimately a political uncertainty beyond and outside climate modeling. Following that are acknowledged issues and uncertainties with climate modeling. In the context of these unknowns and uncertainties, it is reasonable to start with the Intermediate projection of 4-ft SLR by 2100. Subsequent project considerations may alter this design assumption. This should be augmented by a minimum acceptable value of 2-ft SLR.

Figure 1: Sea Level Rise Projections for Portland (from NOAA Sea Level Rise Viewer)



Datums for 8413320, Bar Harbor ME

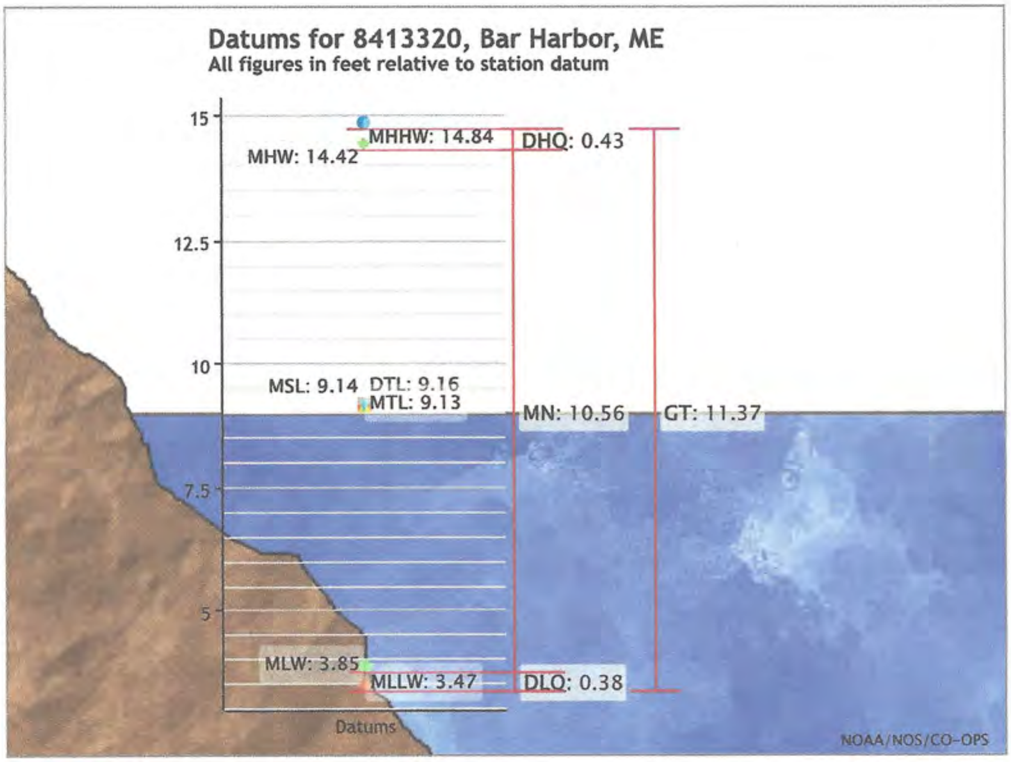
Elevations on Station Datum

Station: 8413320, Bar Harbor, ME
Status: Accepted (Nov 2 2012)
Units: Feet
T.M.: 0
Epoch: (/datum_options.html#NTDE) 1983-2001
Datum: STND

Datum	Value	Description
MHHW (/datum_options.html#MHHW)	14.84	Mean Higher-High Water
MHW (/datum_options.html#MHW)	14.42	Mean High Water
MTL (/datum_options.html#MTL)	9.13	Mean Tide Level
MSL (/datum_options.html#MSL)	9.14	Mean Sea Level
DTL (/datum_options.html#DTL)	9.16	Mean Diurnal Tide Level
MLW (/datum_options.html#MLW)	3.85	Mean Low Water
MLLW (/datum_options.html#MLLW)	3.47	Mean Lower-Low Water
NAVD88 (/datum_options.html)		
STND (/datum_options.html#STND)	0.00	Station Datum
GT (/datum_options.html#GT)	11.37	Great Diurnal Range
MN (/datum_options.html#MN)	10.56	Mean Range of Tide
DHQ (/datum_options.html#DHQ)	0.43	Mean Diurnal High Water Inequality
DLQ (/datum_options.html#DLQ)	0.38	Mean Diurnal Low Water Inequality
HWI (/datum_options.html#HWI)	3.29	Greenwich High Water Interval (in hours)
LWI (/datum_options.html#LWI)	9.51	Greenwich Low Water Interval (in hours)
Maximum	19.68	Highest Observed Water Level
Max Date & Time	02/07/1978 05:00	Highest Observed Water Level Date and Time
Minimum	0.56	Lowest Observed Water Level
Min Date & Time	03/21/2007 11:06	Lowest Observed Water Level Date and Time
HAT (/datum_options.html#HAT)	17.16	Highest Astronomical Tide
HAT Date & Time	12/23/1999 15:36	HAT Date and Time
LAT (/datum_options.html#LAT)	1.19	Lowest Astronomical Tide
LAT Date & Time	11/05/1998 22:18	LAT Date and Time

Tidal Datum Analysis Periods

01/01/1978 - 12/31/1994



Showing datums for

8413320 Bar Harbor, ME

Data Units ◉ Feet ○ Meters

Epoch ◉ Present (1983-2001) ○ Superseded (1960-1978)

Submit

Show nearby stations

Products available at 8413320 Bar Harbor, ME

TIDES/WATER LEVELS

Water Levels (/waterlevels.html?id=8413320)

NOAA Tide Predictions (/noaatidepredictions.html?id=8413320)

Harmonic Constituents (/harcon.html?id=8413320)

Sea Level Trends (/sltrends/sltrends_station.shtml?stnid=8413320)

Datums (/datums.html?id=8413320)

Tremont maine

Questions concerning the VERTCON process may be mailed to NGS

Latitude: 44 15 27.900

Longitude: 068 21 01.0

NGVD 29 height:

Datum shift(NAVD 88 minus NGVD 29): -0.190 meter

= 0.62'

WIN:	21702.00	**Project Name:**	Southwest Hbr-Tremont Marsh Br
Town:	Southwest Harbor	**Stream Name:**	Hancock Stream
Route No.	ME102	**Bridge Name:**	Marsh Bridge
Asset ID:	2511	**Analysis by:**	CSH
Lat:	44.2534 **Long:** -68.34073	**Date:**	5/18/2017

Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

	km^2	mi^2	ac	
				Enter data in [mi^2]
A	5.18	2.00	1280.0	Watershed Area *DRNAREA*
W	1.04	0.4	256.0	Wetlands area (by NWI)
P_c	553466	4899399		watershed centroid (E, N; UTM 19N; meters)
County	Hancock			*choose county from drop-down menu*
pptA	45.2			mean annual precipitation (inches; by look-up)
SG	0.00			sand & gravel aquifer as decimal fraction of watershed A

Worksheet prepared by:
Charles S. Hebson, PE
Environmental Office
Maine Dept. Transportation
Augusta, ME 04333-0016
207-557-1052
Charles.Hebson@maine.gov

ver. 2016 Feb 05

A (km^2)	5.18	**Conf Lvl**	0.67	
W (%)	20.00			NWI Wetlands % *STORNWI*

Ret Pd T (yr)	**Peak Flow Estimate** Lower	**Q_T (m^3/s)**	**Upper**	**Q_T (ft^3/s)**
1.1		0.81		28.5
2		1.59		56.1
5		2.44		86.1
10		2.99		105.5
25		3.91		138.1
50		4.45		157.0
100		5.20		183.7
500		6.83		241.1

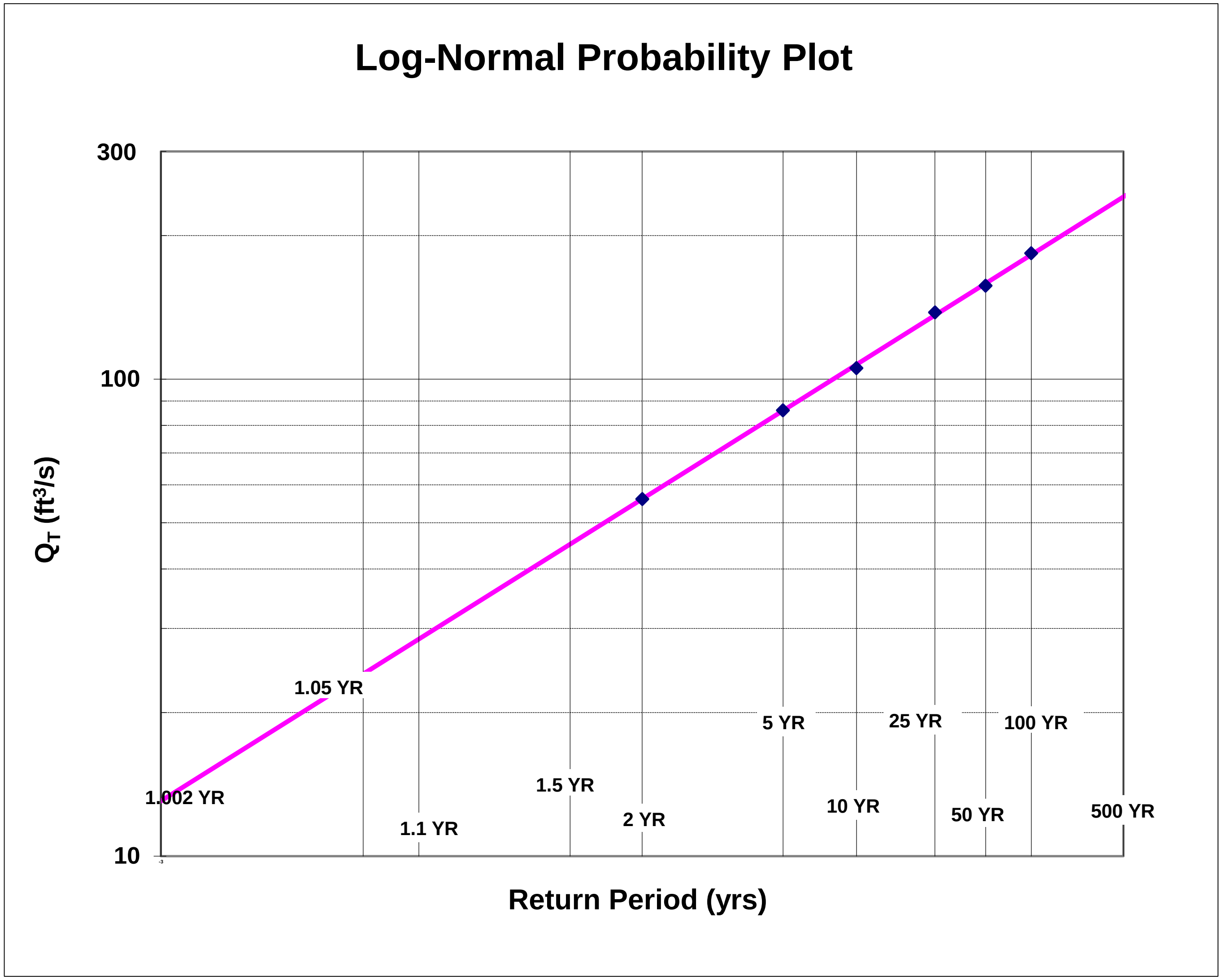
References:

Hodgkins, G.A., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
WRIR 99-4008, USGS Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2015.
Peak flow regression equations for small, ungaged streams in Maine - Comparing map-based to field-based variables
SIR 2015-4059, USGS, Augusta, ME

$Q_T = b \times A^a \times 10^{-wW}$

Note: NWI map value = 30.9% > data set limit = 20%, therefore 20% used here for conservative Qp estimates.



Log-Normal Probability Plot
300
100
10
Q_T (ft³/s)
1.002 YR
1.05 YR
1.1 YR
1.5 YR
2 YR
5 YR
10 YR
25 YR
50 YR
100 YR
500 YR
Return Period (yrs)

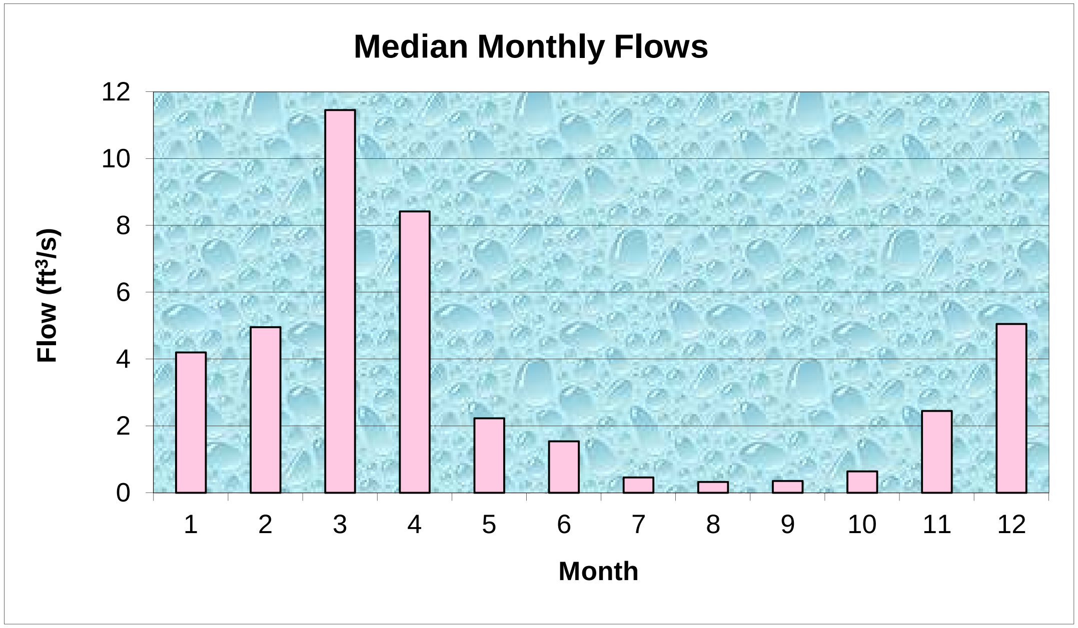
WIN:	21702.00	**Project Name:**	Southwest Hbr-Tremont Marsh Br
Town:	Southwest Harbor	**Stream Name:**	Hancock Stream
Route No.	ME102	**Bridge Name:**	Marsh Bridge
Asset ID:	2511	**Analysis by:**	CSH
Lat:	44.25336 **Long:** -68.34073	**Date:**	5/18/2017

DO NOT ENTER ANY DATA ON THIS PAGE; EVERYTHING IS CALCULATED

MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004)

	Value	Variable	Explanation
	2.00	*A*	Area (mi^2)
553465.6	4899399	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	20.83	*DIST*	Distance from Coastal reference line (mi)
	45.2	*pptA*	Mean Annual Precipitation (inches)
	0.00	*SG*	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft3/s)	(m^3/s)
Jan	**4.20**	0.1190
Feb	**4.96**	0.1405
Mar	**11.46**	0.3246
Apr	**8.43**	0.2388
May	**2.23**	0.0632
Jun	**1.55**	0.0439
Jul	**0.47**	0.0132
Aug	**0.33**	0.0094
Sep	**0.36**	0.0102
Oct	**0.65**	0.0183
Nov	**2.45**	0.0695
Dec	**5.06**	0.1433



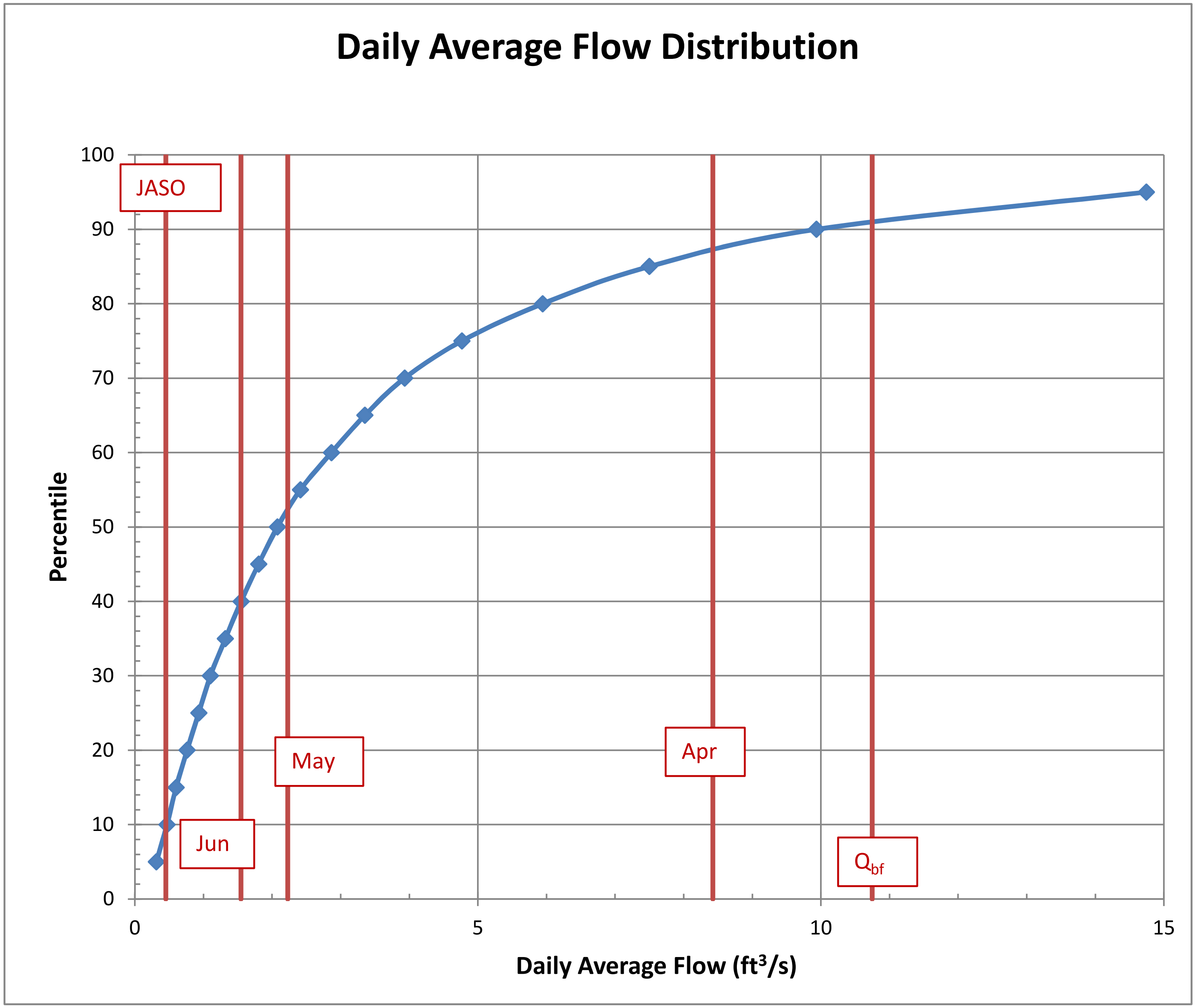
Q_{bf}	**10.7**	
ann avg	**4.2**	
ann med	**2.1**	
$Q_{1.002}$	**13.0**	
$Q_{1.01}$	**17.2**	
$Q_{1.05}$	**24.1**	
Q_{bf}	**33.1**	assume v = 4ft/s

W_{bf}	**11.0**	estimated bankfull width (ft)
d_{bf}	**0.8**	estimated bankfull depth (ft)
A_{bf}	**8.3**	estimated bankfull flow area (ft^2)

References

Dudley, R.W., 2004. Hydraulic Geometry Relations ..., SIR 2004-5042

Dudley, R.W., 2004. Estimating Monthly Streamflows … , SIR 2004-5026



Daily Avg Flow Dist

A_{ws} = (mi²) 2.0

Q (ft³/s)

Pctl	Median	84th pctl
5	0.31	0.51
10	0.47	0.70
15	0.60	0.88
20	0.76	1.06
25	0.93	1.25
30	1.10	1.42
35	1.32	1.62
40	1.55	1.87
45	1.80	2.11
50	2.08	2.49
55	2.41	2.90
60	2.87	3.41
65	3.35	3.97
70	3.93	4.63
75	4.77	5.57
80	5.94	6.65
85	7.50	8.52
90	9.94	11.44
95	14.75	17.79

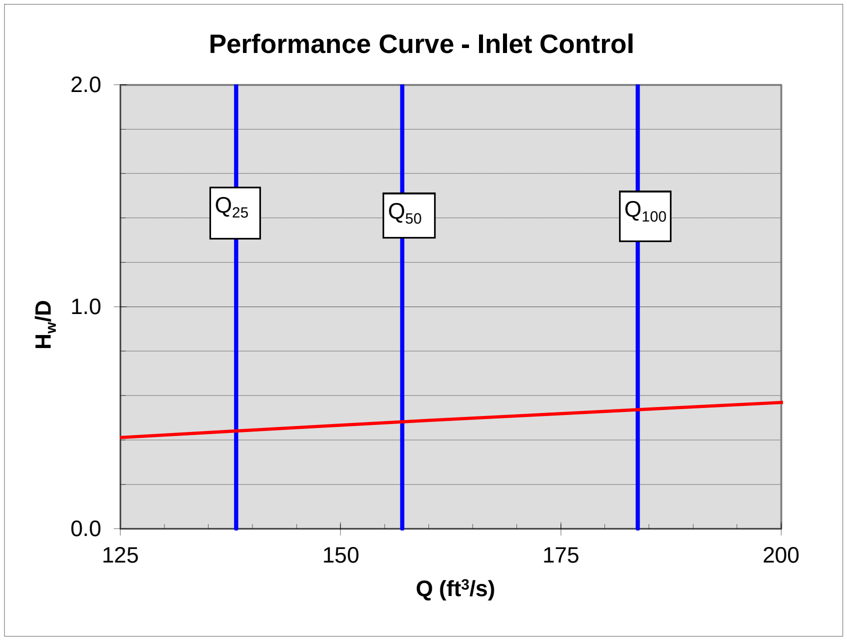
Q_{bf}	10.7
$Q_{1.002}$	13.0
$Q_{1.1}$	28.5
Q_2	56.1

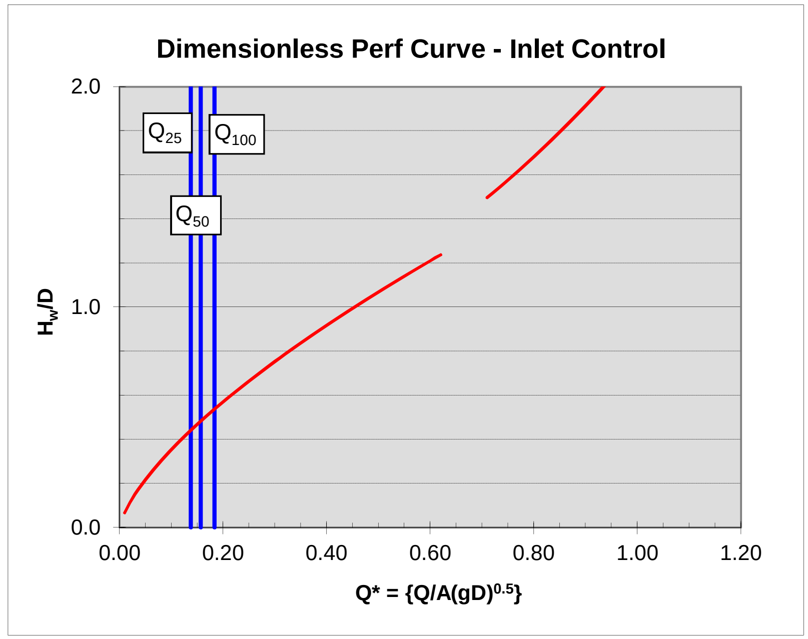
NOTE: ***This page is for preliminary sizing only.***
Final design should be done with HY8 or HDS-5

Preliminary Culvert Sizing - Round & Box Culverts

Shape:	Box					
Type:	Box 0 ww		Q_{25}	138.1		
D or R (ft)	6		Q_{50}	157.0	trial D / R =	6.3
w (ft)	*12*	*box width*	Q_{100}	183.7	trial w: BFW =	11.0
Slope (ft/ft)	0.02					
A (ft^2)	72.00					
g (ft/s^2)	32.2					

Note:
culvert dimensions are for open flow area; adjust for lost capacity due to embedding / backfilling (min {2' / 25% rise} embedment)






Manset
Kings Point
Mount Height Cemetery
Union Cemetery
Hio Hill
Marshall Brook
Tremont
Adam Bridge
Seawall
Anns Point
Sawyers
Island
Seawall Point
Seawall Campground
Seawall Pond
Big Rocks
Johns Island
Marshall Brook
Seawall Picnic Area
Bass Harbor
Bass Harbor Post Office
Bass Harbor Public Landing
Bass Harbor Marine
Wonderland
Bass Harbor Campground
Cobble Beach
Weaver
Long
HILLCREST CIR
LONG HILL RD
102
102A
KINGS LN
HADLOCK LN
MEADOW LN
TRAP MILL RD
BALSAM WAY
SECREEK DR
MCKINLEY LN
MARSH RD
SHORE RD
100
50

Southwest Harbor - Tremont 21702 Marsh Bridge #2511

Region ID:

ME

Workspace ID:

ME20170518104626041000

Clicked Point (Latitude, Longitude):

44.25336, -68.34073

Time:

2017-05-18 12:51:43 -0400

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	2	square miles
STORNWI	Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory	30.86	percent
ELEV	Mean Basin Elevation	36.1	feet
PRECIP	Mean Annual Precipitation	49.4	inches
SANDGRAVAP	Percentage of land surface underlain by sand and gravel aquifers	0	percent
COASTDIST	Shortest distance from the coastline to the basin centroid	21.5	miles
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	553465.59	State plane coordinates
CENTROIDY	Basin centroid vertical (y) location in state plane units	4899399.25	State plane coordinates
SANDGRAVAF	Fraction of land surface underlain by sand and gravel aquifers	0	dimensionless
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	1.97	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	4.95	percent
LC06WATER	Percent of open water, class 11, from NLCD 2006	0	percent
ELEVMAX	Maximum basin elevation	159.8	feet
BSLDEM10M	Mean basin slope computed from 10 m DEM	4.11	percent
STATSGOA	Percentage of area of Hydrologic Soil Type A from STATSGO	11	percent

Bankfull Statistics Parameters [100 Percent (1.97 square miles) Central and Coastal Bankfull 2004 5042]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2	square miles	2.92	298

Bankfull Statistics Disclaimers [100 Percent (1.97 square miles) Central and Coastal Bankfull 2004 5042]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Bankfull Statistics Flow Report [100 Percent (1.97 square miles) Central and Coastal Bankfull 2004 5042]

Statistic	Value	Unit
Bankfull Streamflow	10.7	ft^3/s
Bankfull Width	11	ft
Bankfull Depth	0.752	ft
Bankfull Area	8.26	ft^2

Bankfull Statistics Citations

Dudley, R.W.,2004, Hydraulic-Geometry Relations for Rivers in Coastal and Central Maine: U.S. Geological Survey Scientific Investigations Report 2004-5042, 30 p (http://pubs.usgs.gov/sir/2004/5042/pdf/sir2004-5042.pdf)

Peak-Flow Statistics Parameters [100 Percent (1.97 square miles) Statewide Peak Flow DA LT 12sqmi 2015 5049]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2	square miles	0.31	12
STORNWI	Percentage of Storage from NWI	30.86	percent	0	22.2

Peak-Flow Statistics Disclaimers [100 Percent (1.97 square miles) Statewide Peak Flow DA LT 12sqmi 2015 5049]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Peak-Flow Statistics Flow Report [100 Percent (1.97 square miles) Statewide Peak Flow DA LT 12sqmi 2015 5049]

Statistic	Value	Unit
1.01 Year Peak Flood	12.8	ft^3/s
2 Year Peak Flood	38.5	ft^3/s
5 Year Peak Flood	57.7	ft^3/s
10 Year Peak Flood	68.9	ft^3/s
25 Year Peak Flood	90.2	ft^3/s
50 Year Peak Flood	100	ft^3/s
100 Year Peak Flood	117	ft^3/s
250 Year Peak Flood	126	ft^3/s
500 Year Peak Flood	150	ft^3/s

Peak-Flow Statistics Citations

Lombard, P.J., and Hodgkins, G.A.,2015, Peak flow regression equations for small, ungaged streams in Maine— Comparing map-based to field-based variables: U.S. Geological Survey Scientific Investigations Report 2015–5049, 12 p. (http://dx.doi.org/10.3133/sir20155049)

geometry files	
name	number
GISExport	.g01
Edited	.g02
Existing	.g03
PROPOSED	.g04
PROPOSEDcoffer	.g05

flow files		Q, freq	Tide, freq	SLR
name	number			
Q100tide1yr	.u01	100	1	0
Q1tide1yr	.u02	1	1	
Q1tide100yr	.u03	1	100	
Q1tide100yrwwaves	.u04	1	100W	
Q50tide1yr	.u05	50	1	
Q1tideFielddata	.u06	1	calib	
Q1T10SLR4	.u07	1	10	4
Q1T10	.u08	1	10	
Q1Tmhhw	.u09	1	MHHW	
Q10TMHHW	.u10	10	MHHW	

Upland Flow,	**Tide hydrograph at Ocean side, Clark Bridge**		
Frequency	Frequency	Elev, NAVD	
		high	low
1-year	MHHW	5.4	2.2
10-year	MHHW	5.4	2.2
January Ave.	1/31/2017 (calib)	6.2	2.2
1-year	1-year	6.8	2.2
50-year	1-year	6.8	2.2
100-year	1-year	6.8	2.2
1-year	10 year no SLR	8.5	2.2
1-year	100-year surge only (HRT)	10.2	2.2
1-year	10 year plus 4' SLR	12.5	2.2
1-year	100-year with waves (no SLR	13	2.2

		geometry					Tide								
Plan #	name	EX	PRO	PROcoff	Flow	Qfreq	field	MWH	MHHW	1	10	50	100	100w	SLR4
.p01	PROQ50T1		.g04		.u05	50				1					
.p02	EXQ50T1	.g03			.u05	50				1					
.p03	EXQ100T1	.g03			.u01	100				1					
.p04	PROQ100T1		.g04		.u01	100				1					
.p06	EXQ1T100	.g03			.u03	1							100		
.p07	PROQ1Tfield		.g04		.u06	1	field								
.p08	Q1T100wavesEX	.g03			.u04	1								100W	
.p09	PROQ1T10SLR4		.g04		.u07	1					10				SLR4
.p10	EXQ1T100	.g03			.u03	1							100		
.p11	PROQ1T100		.g04		.u03	1							100		
.p12	PROQ1T1		.g04		.u02	1				1					
.p13	PROQ1T10		.g04		.u08	1					10				
.p14	PROcoffQ1Tfield			.g05	.u06	1	field								
.p15	PROQ1TMHHW		.g04		.u09	1			MHHW						
.p16	EXQ1MHHW	.g03			.u09	1			MHHW						
.p17	EXQ1Tfield	.g03			.u06	1	field								
.p18	PROcoffQ50T1			.g05	.u05	50				1					
.p19	PROcofQ1T100			.g05	.u03	1							100		
.p20	PROcofQ100T1			.g05	.u01	100				1					
.p21	PROcofQ1T1			.g05	.u02	1				1					
.p22	PROcofQ1T10SLR4			.g05	.u07	1					10				SLR4
.p23	PROcofQ1T10			.g05	.u08	1					10				
.p24	PROcofQ1MHW			.g05	.u09	1			MHHW						
.p25	EXQ10TMHHW	.g03			.u10	10			MHHW						
.p26	PROQ10TMHHW		.g04		.u10	10			MHHW						
.p27	PROcofQ10TMHHW			.g05	.u10	10			MHHw						
.p28	EXQ1T10SLR4	.g03			.u07	1					10				SLR4
.p29	EXQ1T10	.g03			.u08	1					10				
.p30	Q1T100wavesPRO		.g04		.u04	1								100W	

Tremont Marsh Bridge Tides 31-Jan-17

MLLW MLLW to NAVD -5.7244 ft

Date Time		Water Level (MLLW-ft) Bass Harbor	TY	ft) Bass Harbor
0:39	0:39	10.41	H	4.69
6:14	6:14	0.01	L	-5.71
12:43	12:43	10.99	H	5.27
18:41	18:41	-0.062	L	-5.79

Measurements Elev. Bridge Rail

12.17 this is top of fascia not rail.. Correct

14.45 The Northside (ds) top of rail elevation on average is 14.45'

14.39 The Southside (us) top of rail elevation on average is 14.39'

		Center elev=	DS center =	Added Dist	Depth to Measurement (in.)						AVE Secon	velocity
Time		US Center	DS center =	Tape length Correction	US center	DS center	US Elev	DS Elev	US->DS	DS->US	Time Seconds	29
8:03		116.00	117.00	14.00	130.00	131.00	3.56	3.53	0.02		125.8	0.23
8:38		119.75	119.50	14.00	133.75	133.50	3.24	3.33	-0.08			
9:00		117.50	119.00	14.00	131.50	133.00	3.43	3.37	0.07		187.0	0.16
9:32		117.50	120.00	14.00	131.50	134.00	3.43	3.28	0.15		89.8	0.32
10:01		118.50	120.25	14.00	132.50	134.25	3.35	3.26	0.09		96.0	0.30
10:36		118.50	121.00	14.00	132.50	135.00	3.35	3.20	0.15		94.7	0.31
11:32		116.00	117.00	14.00	130.00	131.00	3.56	3.53	Direction Change		71.9	0.40
11:59		115.25	113.00	14.00	129.25	127.00	3.62	3.87	-0.25		37.05	-0.78
12:30		111.5	109.00	14.00	125.50	123.00	3.93	4.20	-0.27		38.15	-0.76
13:32		105.00	103.00	14.00	119.00	117.00	4.47	4.70	-0.23		41.89	-0.69
13:59		102.50	100.50	14.00	116.50	114.50	4.68	4.91	-0.23		61.78	-0.47
14:31		99.50	102.00	14.00	113.50	116.00	4.93	4.78	Direction Change		60.78	0.48

Other surge levels worksheet

10-year 8.50
SLR 4.00
waves NA

Enter historical hydrograph in column B				NOAA	ADCIRC	semi-	NWS 38			MHW -	5		
MHHW =	5.40			Ht/2-ft	sp	diurnal	D=R/f			MLW	-5.6		
MLLW =	-6.00			5.495	2.1	2	0.94						
				10yrsurge	3.02								
NGVD	0.00	0.65	MHW-MLV	5			hr						
NAVD	-0.65	0											
Time	ADCIRC Surge only	**1/2 MHHW-MLLW tide**	**MHHW plus 4' SLR**	**10 yr at 8.5 plus start up**	**10yrplus 4ft SLR**	**surge = 2.1 Surge at High tide**	**SLR min 2.2**	**stable 10 SLR 2.2 min**	10 yr at 8.5	10-yr at 8.5 min 2.2		MHW - MLW tide	
0	0.08	5.42	9.42	**-4.68**	9.54	5.50	9.54	2.20	-4.68	2.20		-4.86	2.20
0.5	0.08	5.47	9.47	**-4.47**	9.59	5.55	9.59	2.20	-4.47	2.20		-4.41	2.20
1	0.08	5.17	9.17	**-3.91**	9.29	5.25	9.29	2.20	-3.91	2.20		-3.68	2.20
1.5	0.08	4.54	8.54	**-3.06**	8.66	4.62	8.66	2.20	-3.06	2.20		-2.71	2.20
2	0.08	3.62	7.62	**-1.97**	7.75	3.71	7.75	2.20	-1.97	2.20		-1.58	2.20
2.5	0.09	2.48	6.48	**-0.70**	6.60	2.56	6.60	3.18	-0.70	2.20		-0.34	2.20
3	0.09	1.17	5.17	**0.64**	5.29	1.26	5.29	4.55	0.64	2.20		0.92	2.20
3.5	0.09	-0.21	3.79	**1.99**	3.92	-0.12	3.92	5.91	1.99	1.99		2.12	2.20
4	0.09	-1.58	2.42	**3.25**	2.55	-1.49	2.55	7.17	3.25	3.25		3.19	3.19
4.5	0.09	-2.85	1.15	**4.33**	1.29	-2.75	2.20	8.23	4.33	4.33		4.05	4.05
5	0.10	-3.93	0.07	**5.18**	0.21	-3.84	2.20	9.05	5.18	5.18		4.65	4.65
5.5	0.10	-4.77	-0.77	5.54	-0.63	-4.67	2.20	9.54	5.54	5.54		4.94	4.94
6	0.10	-5.30	-1.30	5.59	-1.15	-5.20	2.20	9.59	5.59	5.59		4.98	4.98
6.5	0.10	-5.49	-1.49	5.29	-1.34	-5.39	2.20	9.29	5.29	5.29		4.71	4.71
7	0.11	-5.34	-1.34	4.66	-1.19	-5.23	2.20	8.66	4.66	4.66		4.13	4.13
7.5	0.11	-4.84	-0.84	3.75	-0.69	-4.74	2.20	7.75	3.75	3.75		3.30	3.30
8	0.11	-4.04	-0.04	2.60	0.12	-3.93	2.20	6.60	2.60	2.60		2.25	2.25
8.5	0.12	-2.98	1.02	1.29	1.19	-2.87	2.20	5.29	1.29	1.29		1.06	2.20
9	0.12	-1.73	2.27	-0.08	2.44	-1.61	2.44	3.92	-0.08	2.20		-0.19	2.20
9.5	0.12	-0.37	3.63	-1.45	3.81	-0.25	3.81	2.55	-1.45	2.20		-1.44	2.20
10	0.13	1.01	5.01	-2.71	5.20	1.14	5.20	2.20	-2.71	2.20		-2.59	2.20
10.5	0.13	2.33	6.33	-3.79	6.52	2.46	6.52	2.20	-3.79	2.20		-3.58	2.20
11	0.14	3.50	7.50	-4.63	7.70	3.64	7.70	2.20	-4.63	2.20		-4.34	2.20
11.5	0.14	4.45	8.45	-5.15	8.65	4.59	8.65	2.20	-5.15	2.20		-4.82	2.20
12	0.15	5.12	9.12	-5.34	9.33	5.26	9.33	2.20	-5.34	2.20		-5.00	2.20
12.5	0.15	5.45	9.45	-5.19	9.67	5.61	9.67	2.20	-5.19	2.20		-4.86	2.20
13	0.16	5.45	9.45	-4.69	9.67	5.61	9.67	2.20	-4.69	2.20		-4.41	2.20
13.5	0.16	5.09	9.09	-3.88	9.33	5.26	9.33	2.20	-3.88	2.20		-3.68	2.20
14	0.17	4.41	8.41	-2.81	8.66	4.59	8.66	2.20	-2.81	2.20		-2.71	2.20
14.5	0.18	3.45	7.45	-1.56	7.71	3.63	7.71	2.44	-1.56	2.20		-1.58	2.20
15	0.19	2.28	6.28	-0.19	6.55	2.46	6.55	3.81	-0.19	2.20		-0.34	2.20
15.5	0.20	0.95	4.95	1.20	5.24	1.15	5.24	5.20	1.20	1.20		0.92	2.20
16	0.21	-0.43	3.57	2.52	3.87	-0.22	3.87	6.52	2.52	2.52		2.12	2.20
16.5	0.22	-1.79	2.21	3.70	2.53	-1.57	2.53	7.70	3.70	3.70		3.19	3.19
17	0.23	-3.03	0.97	4.65	1.30	-2.80	2.20	8.65	4.65	4.65		4.05	4.05
17.5	0.25	-4.08	-0.08	5.33	0.27	-3.84	2.20	9.33	5.33	5.33		4.65	4.65
18	0.26	-4.87	-0.87	5.67	-0.49	-4.61	2.20	9.67	5.67	5.67		4.96	4.96
18.5	0.28	-5.35	-1.35	5.67	-0.95	-5.07	2.20	9.67	5.67	5.67		4.96	4.96
19	0.30	-5.49	-1.49	5.33	-1.06	-5.19	2.20	9.33	5.33	5.33		4.63	4.63
19.5	0.33	-5.28	-1.28	4.66	-0.81	-4.95	2.20	8.66	4.66	4.66		4.02	4.02
20	0.36	-4.74	-0.74	3.71	-0.22	-4.38	2.20	7.71	3.71	3.71		3.14	3.14
20.5	0.40	-3.89	0.11	2.55	0.68	-3.49	2.20	6.55	2.55	2.55		2.07	2.20
21	0.44	-2.79	1.21	1.24	1.84	-2.35	2.20	5.24	1.24	1.24		0.87	2.20
21.5	0.49	-1.52	2.48	-0.13	3.19	-1.03	3.19	3.87	-0.13	2.20		-0.39	2.20
22	0.56	-0.15	3.85	-1.47	4.66	0.41	4.66	2.53	-1.47	2.20		-1.63	2.20
22.5	0.66	1.23	5.23	-2.70	6.18	1.89	6.18	2.20	-2.70	2.20		-2.76	2.20
23	0.79	2.53	6.53	-3.73	7.66	3.32	7.66	2.20	-3.73	2.20		-3.72	2.20
23.5	0.98	3.67	7.67	-4.49	9.08	4.65	9.08	2.20	-4.49	2.20		-4.43	2.20
24	1.28	4.58	8.58	-4.95	10.42	5.86	10.42	2.20	-4.95	2.20		-4.87	2.20
24.5	1.78	5.19	9.19	-5.06	11.75	6.97	11.75	2.20	-5.06	2.20		-5.00	2.20
25	**2.10**	5.48	9.48	-4.81	12.50	7.58	12.50	2.20	-4.81	2.20		-4.81	2.20
25.5	2.06	5.41	9.41	-4.22	12.38	7.48	12.38	2.20	-4.22	2.20		-4.31	2.20
26	1.82	5.01	9.01	-3.32	11.62	6.82	11.62	2.20	-3.32	2.20		-3.54	2.20
26.5	1.55	4.28	8.28	-2.16	10.50	5.83	10.50	2.20	-2.16	2.20		-2.54	2.20
27	1.33	3.28	7.28	-0.81	9.19	4.61	9.19	3.19	-0.81	2.20		-1.38	2.20
27.5	1.16	2.07	6.07	0.66	7.74	3.23	7.74	4.66	0.66	2.20		-0.14	2.20
28	1.02	0.73	4.73	2.18	6.20	1.75	6.20	6.18	2.18	2.18		1.12	2.20
28.5	0.91	-0.65	3.35	3.66	4.66	0.26	4.66	7.66	3.66	3.66		2.30	2.30
29	0.83	-2.00	2.00	5.08	3.19	-1.17	3.19	9.08	5.08	5.08		3.34	3.34
29.5	0.75	-3.22	0.78	6.42	1.87	-2.46	2.20	10.42	6.42	6.42		4.16	4.16
30	0.69	-4.23	-0.23	7.75	0.77	-3.54	2.20	11.75	7.75	7.75		4.72	4.72
30.5	0.64	-4.97	-0.97	8.50	-0.05	-4.33	2.20	12.50	8.50	8.50		4.98	4.98
31	0.60	-5.40	-1.40	8.38	-0.54	-4.80	2.20	12.38	8.38	8.38		4.93	4.93
31.5	0.56	-5.48	-1.48	7.62	-0.68	-4.93	2.20	11.62	7.62	7.62		4.55	4.55
32	0.52	-5.22	-1.22	6.50	-0.47	-4.70	2.20	10.50	6.50	6.50		3.89	3.89
32.5	0.49	-4.62	-0.62	5.19	0.09	-4.13	2.20	9.19	5.19	5.19		2.98	2.98
33	0.46	-3.73	0.27	3.74	0.94	-3.26	2.20	7.74	3.74	3.74		1.89	2.20
33.5	0.44	-2.60	1.40	2.20	2.03	-2.16	2.20	6.20	2.20	2.20		0.67	2.20
34	0.42	-1.31	2.69	0.66	3.30	-0.89	3.30	4.66	0.66	2.20		-0.59	2.20
34.5	0.40	0.07	4.07	-0.81	4.64	0.47	4.64	3.19	-0.81	2.20		-1.82	2.20
35	0.38	1.44	5.44	-2.13	5.99	1.82	5.99	2.20	-2.13	2.20		-2.93	2.20
35.5	0.36	2.72	6.72	-3.23	7.25	3.09	7.25	2.20	-3.23	2.20		-3.85	2.20
36	0.35	3.83	7.83	-4.05	8.33	4.18	8.33	2.20	-4.05	2.20		-4.52	2.20
36.5	0.34	4.70	8.70	-4.54	9.18	5.03	9.18	2.20	-4.54	2.20		-4.91	2.20
37	0.32	5.26	9.26	-4.68	9.72	5.58	9.72	2.20	-4.68	2.20		-4.99	2.20
37.5	0.31	5.49	9.49	-4.47	9.94	5.80	9.94	2.20	-4.47	2.20		-4.75	2.20
38	0.30	5.37	9.37	-3.91	9.80	5.67	9.80	2.20	-3.91	2.20		-4.20	2.20
38.5	0.29	4.91	8.91	-3.06	9.33	5.20	9.33	2.20	-3.06	2.20		-3.39	2.20
39	0.28	4.14	8.14	-1.97	8.54	4.42	8.54	2.20	-1.97	2.20		-2.37	2.20
39.5	0.27	3.10	7.10	-0.70	7.49	3.37	7.49	3.30	-0.70	2.20		-1.19	2.20
40	0.26	1.87	5.87	0.64	6.24	2.13	6.24	4.64	0.64	2.20		0.06	2.20
40.5	0.25	0.51	4.51	1.99	4.88	0.77	4.88	5.99	1.99	1.99		1.31	2.20
41	0.25	-0.87	3.13	3.25	3.48	-0.63	3.48	7.25	3.25	3.25		2.48	2.48
41.5	0.24	-2.20	1.80	4.33	2.14	-1.96	2.20	8.33	4.33	4.33		3.49	3.49
42	0.23	-3.39	0.61	5.18	0.94	-3.16	2.20	9.18	5.18	5.18		4.27	4.27
42.5	0.23	-4.37	-0.37	5.72	-0.04	-4.14	2.20	9.72	5.72	5.72		4.79	4.79
43	0.22	-5.06	-1.06	5.94	-0.74	-4.84	2.20	9.94	5.94	5.94		5.00	5.00
43.5	0.22	-5.44	-1.44	5.80	-1.13	-5.22	2.20	9.80	5.80	5.80		4.89	4.89
44	0.21	-5.46	-1.46	5.33	-1.16	-5.25	2.20	9.33	5.33	5.33		4.47	4.47
44.5	0.20	-5.14	-1.14	4.54	-0.85	-4.94	2.20	8.54	4.54	4.54		3.76	3.76
45	0.20	-4.50	-0.50	3.49	-0.21	-4.30	2.20	7.49	3.49	3.49		2.82	2.82
45.5	0.20	-3.56	0.44	2.24	0.72	-3.37	2.20	6.24	2.24	2.24		1.70	2.20
46	0.19	-2.40	1.60	0.88	1.87	-2.21	2.20	4.88	0.88	2.20		0.47	2.20
46.5	0.19	-1.09	2.91	-0.52	3.18	-0.90	3.18	3.48	-0.52	2.20		-0.79	2.20
47	0.18	0.29	4.29	-1.86	4.55	0.47	4.55	2.20	-1.86	2.20		-2.00	2.20
47.5	0.18	1.66	5.66	-3.06	5.91	1.83	5.91	2.20	-3.06	2.20		-3.09	2.20
48	0.17	2.91	6.91	-4.04	7.17	3.09	7.17	2.20	-4.04	2.20		-3.97	2.20
48.5	0.17	3.99	7.99	-4.74	8.23	4.16	8.23	2.20	-4.74	2.20		-4.61	2.20
49	0.17	4.81	8.81	-5.13	9.05	4.97	9.05	2.20	-5.13	2.20		-4.95	2.20
49.5	0.16	5.32	9.32	-5.16	9.56	5.48	9.56	2.20	-5.16	2.20		-4.97	2.20
50	0.16	5.50	9.50	-4.85	9.73	5.66	9.73	2.20	-4.85	2.20		-4.68	2.20
				-4.21				2.20	-4.21	2.20		-4.09	2.20
				-3.28				2.20	-3.28	2.20		-3.24	2.20
				-2.13				2.20	-2.13	2.20		-2.19	2.20
				-0.82				3.18	-0.82	2.20		-0.99	2.20
				0.55				4.55	0.55	2.20		0.27	2.20
				1.91				5.91	1.91	1.91		1.51	2.20
				3.17				7.17	3.17	3.17		2.65	2.65
				4.23				8.23	4.23	4.23		3.63	3.63
				5.05				9.05	5.05	5.05		4.37	4.37
				5.56				9.56	5.56	5.56		4.84	4.84
				5.73				9.73	5.73	5.73		5.00	5.00

5.423813	2.2
5.471863	2.2
5.171696	2.2
4.542415	2.2
3.624065	2.2
2.475088	2.2
1.168602	2.2
-0.21225	2.331517
-1.5796	3.502538
-2.84642	4.450666
-3.9321	5.115564
-4.76756	5.42
-5.29962	5.47
-5.49442	5.17
-5.33957	4.54
-4.84492	3.62
-4.04196	2.48
-2.98177	2.20
-1.73183	2.20
-0.37168	2.20
1.012123	2.20
2.331517	2.20
3.502538	2.20
4.450666	2.20
5.115564	2.20
5.454919	2.20
5.447136	2.20
5.09271	2.20
4.414196	2.20
3.454772	2.20
2.275495	2.20
0.951411	2.20
-0.43322	2.33
-1.79028	3.50
-3.03341	4.45
-4.0835	5.12
-4.87373	5.45
-5.35381	5.45
-5.49318	5.09
-5.28298	4.41
-4.73658	3.45
-3.88875	2.28
-2.79346	2.20
-1.5204	2.20
-0.15058	2.20
1.228822	2.20
2.530023	2.20
3.670219	2.20
4.576851	2.20
5.192223	2.20
5.477174	2.20
5.413571	2.20
5.00546	2.20
4.278814	2.20
3.279874	2.20
2.07221	2.20
0.732676	2.20
-0.65348	2.53
-1.99806	3.67
-3.21548	4.58
-4.22828	5.19
-4.972	5.48
-5.39931	5.41
-5.48302	5.01
-5.21781	4.28
-4.62054	3.28
-3.72924	2.20
-2.60062	2.20
-1.3065	2.20
0.070766	2.20
1.443526	2.20
2.724423	2.20
3.831944	2.20
4.69561	2.20
5.260457	2.20
5.490542	2.20
5.371221	2.20
4.910088	2.20
4.136489	2.20
3.099653	2.20
1.865562	2.20
0.512752	2.20
-0.87269	2.72
-2.20259	3.83
-3.39233	4.70
-4.36619	5.26
-5.06219	5.49
-5.43605	5.37
-5.46397	4.91
-5.14417	4.14
-4.49702	3.10
-3.56368	2.20
-2.40356	2.20
-1.09048	2.20
0.291996	2.20
1.655887	2.20
2.914402	2.20
3.987452	2.20
4.806749	2.20
5.320156	2.20
5.495	2.20
	2.20
	2.20
	2.20
	2.20
	2.20
	2.20
	2.91
	3.99
	4.81
	5.32
	5.50
	2.20
	2.20
	2.20
	2.20
	2.20
	2.20
	2.20
	2.20
	2.20
	2.20
	2.20

NOTES

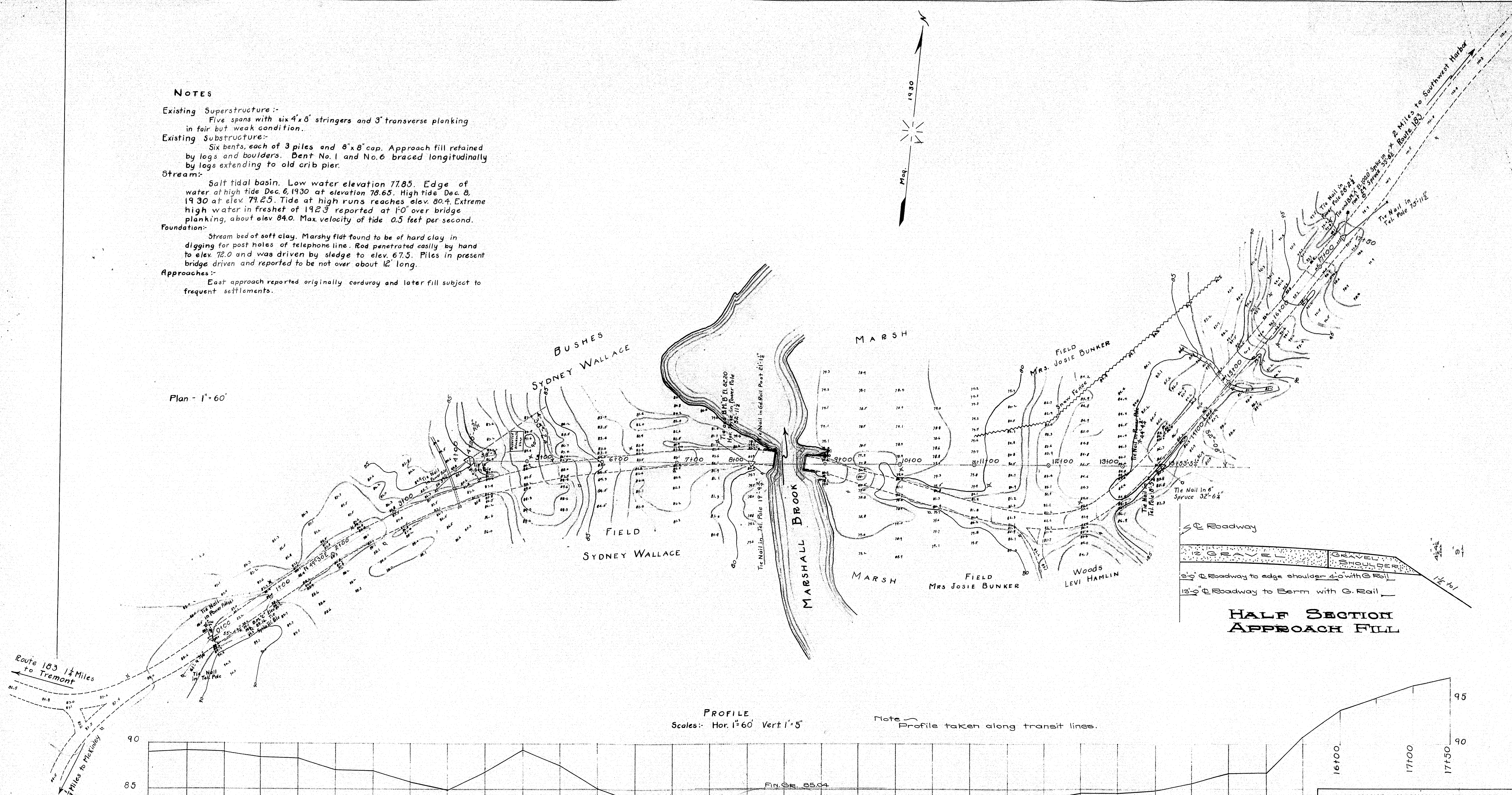
Existing Superstructure:-
Five spans with six 4"x 8" stringers and 3" transverse planking in fair but weak condition.

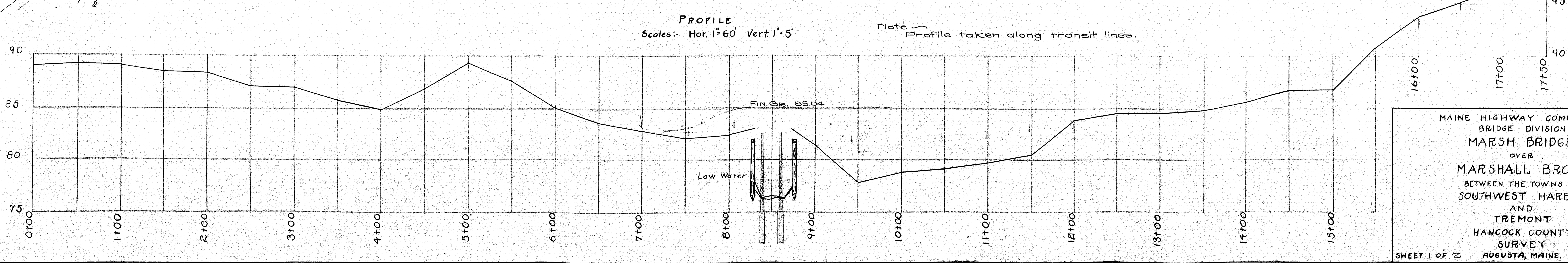
Existing Substructure:-
Six bents, each of 3 piles and 8"x 8" cap. Approach fill retained by logs and boulders. Bent No. 1 and No. 6 braced longitudinally by logs extending to old crib pier.

Stream:-
Salt tidal basin. Low water elevation 77.85. Edge of water at high tide Dec. 6, 1930 at elevation 78.65. High tide Dec. 8, 1930 at elev. 79.25. Tide at high runs reaches elev. 80.4. Extreme high water in freshet of 1923 reported at 1'-0" over bridge planking, about elev 84.0. Max. velocity of tide 0.5 feet per second.

Foundation:-
Stream bed of soft clay. Marshy flat found to be of hard clay in digging for post holes of telephone line. Rod penetrated easily by hand to elev. 72.0 and was driven by sledge to elev. 67.5. Piles in present bridge driven and reported to be not over about 12' long.

Approaches:-
East approach reported originally corduroy and later fill subject to frequent settlements.





SURVEY - BECKMAN
PLOTTED - BATES

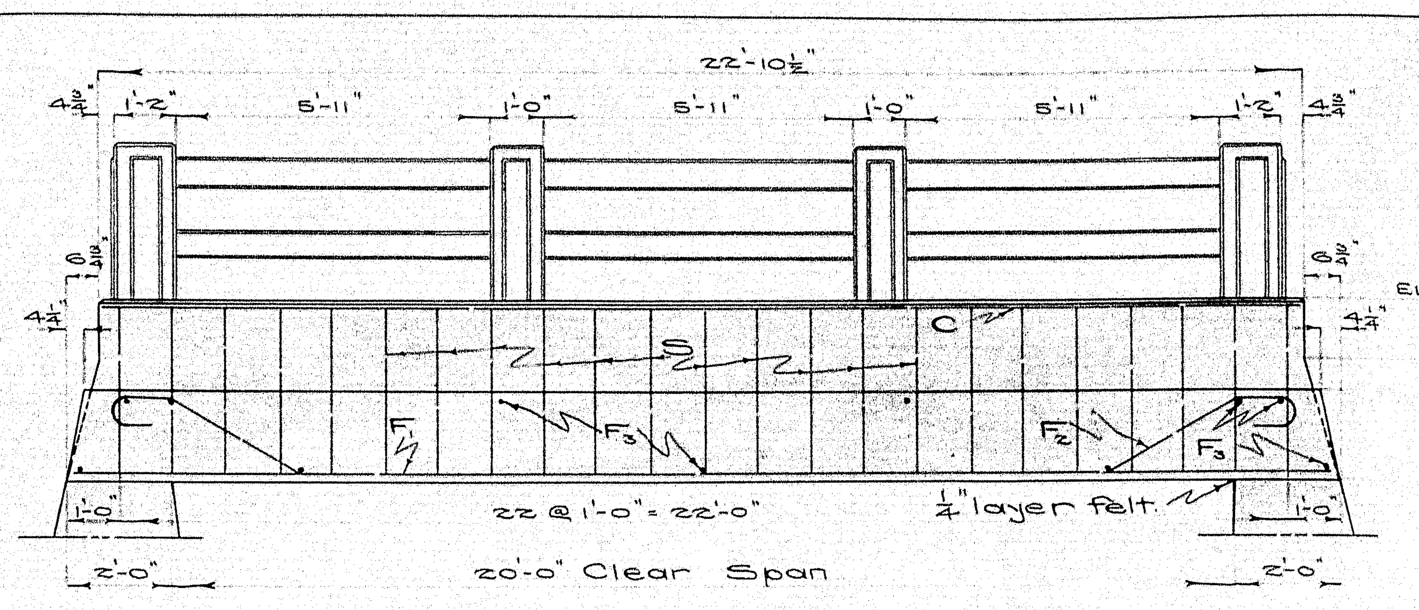
MAINE HIGHWAY COMMISSION
BRIDGE DIVISION
MARSH BRIDGE
OVER
MARSHALL BROOK
BETWEEN THE TOWNS OF
SOUTHWEST HARBOR
AND
TREMONT
HANCOCK COUNTY
SURVEY

SHEET 1 OF 2 AUGUSTA, MAINE. FEB. 5, 1931.

12-25

0 1 2 3 4 5 INCHES

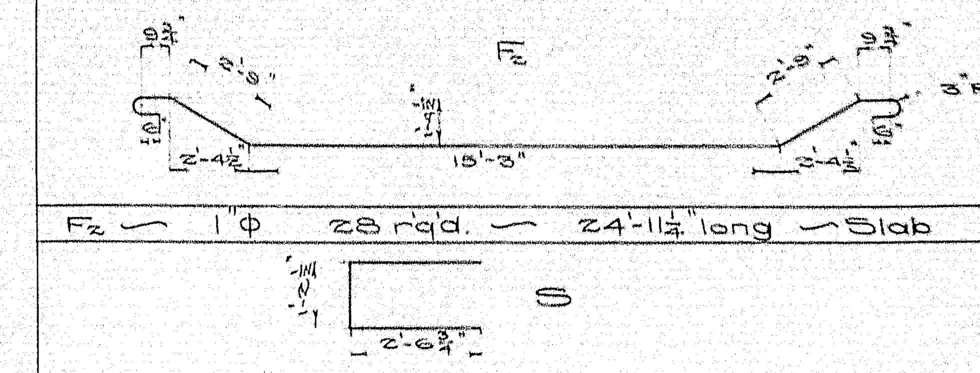
Note — S-bars 12" on ctrs.



Longitudinal Section

Note — Cover the ½" vertical slots between the superstructure and the wing walls on the back side with two layers of heavy roofing felt. Coat surface of concrete and back side of each layer as applied with hot tar or asphalt. Felt to be 10" wide. The area to be covered by the felt is to be recessed ¼" by nailing thin strips to the forms before the concrete is placed.

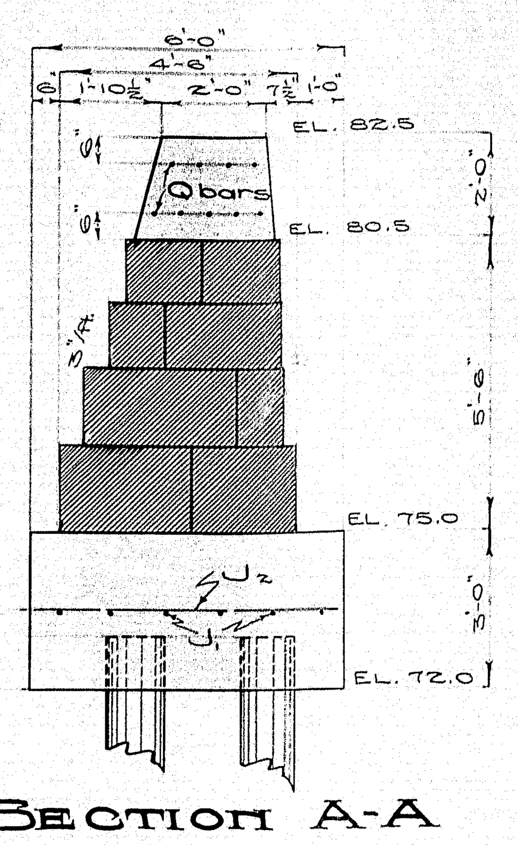
Steel Schedule



F2 — 1"φ 28 rq'd. — 24'-11¼" long — Slab

Mark	Size	No. Rq'd.	Length	Location
S	½"φ	46	6'-4"	Curbs
F1	1"φ	27	22'-11½"	Slab. Str.
F3	½"φ	11	24'-8"	" "
Q	¾"φ	36	24'-8"	Abuts.
J1	¾"φ	12	28'-0"	Abut Footings
J2	¾"φ	58	5'-8"	" "
J3	¾"φ	24	10'-0"	" "
J4	¾"φ	12	3'-8"	" "
J5	¾"φ	16	4'-6"	" "
J6	¾"φ	16	4'-9"	" "
P	¾"φ	32	4'-0"	Posts
R	⅝"φ	24	6'-2"	Rail Bars
C	½"φ	4	22'-7"	Curbs

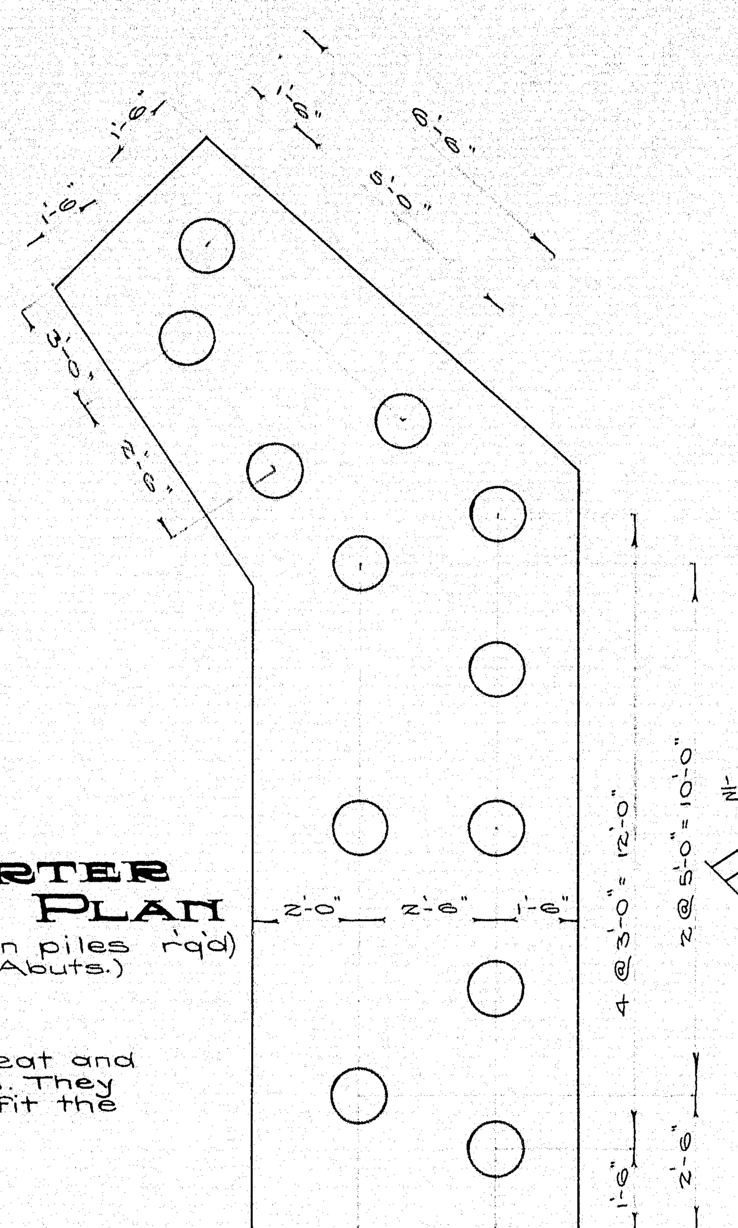
Note — All steel to be plain bars of structural grade. All dimensions are to centers of bars.



Section A-A

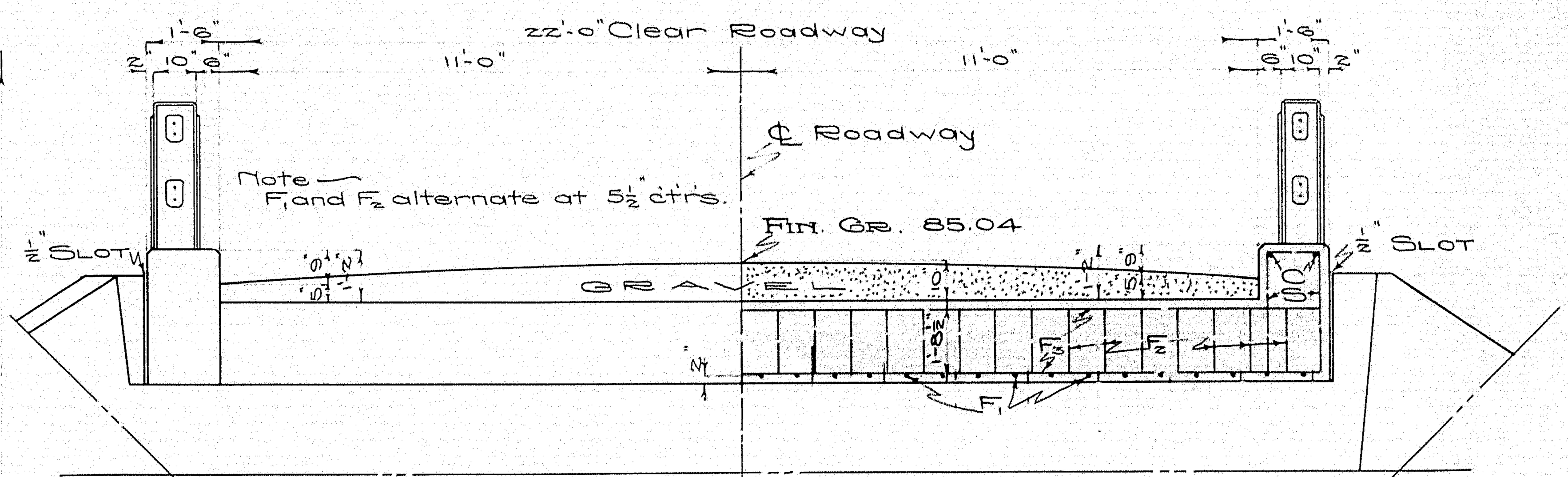
Note — Q-bars to be placed 6" below the bridge seat and 6" above the masonry spaced 6" on centers. They are to be lapped and bent in the field to fit the forms.

Abutments symmetrical about ℄



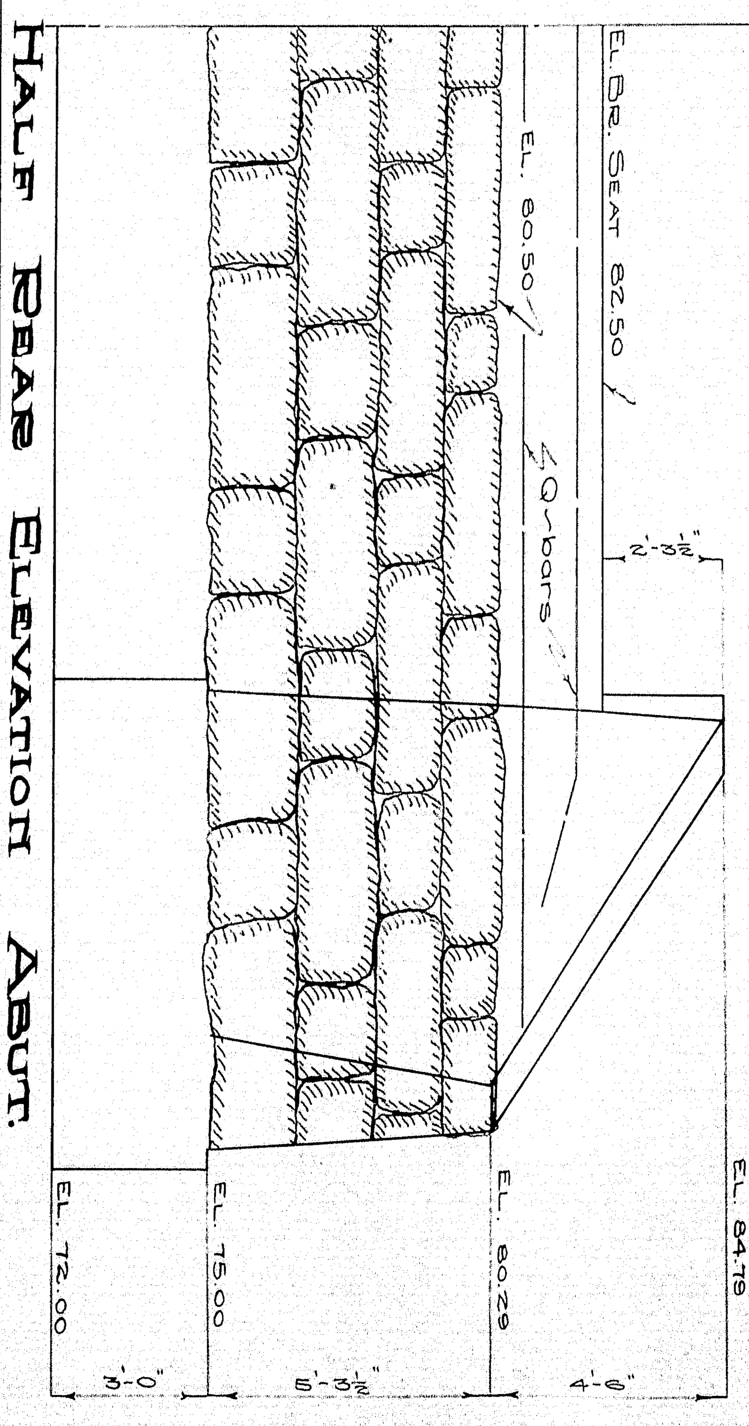
Quarter Pile Plan

(48 - 12 ton piles rq'd)
(Both Abuts.)

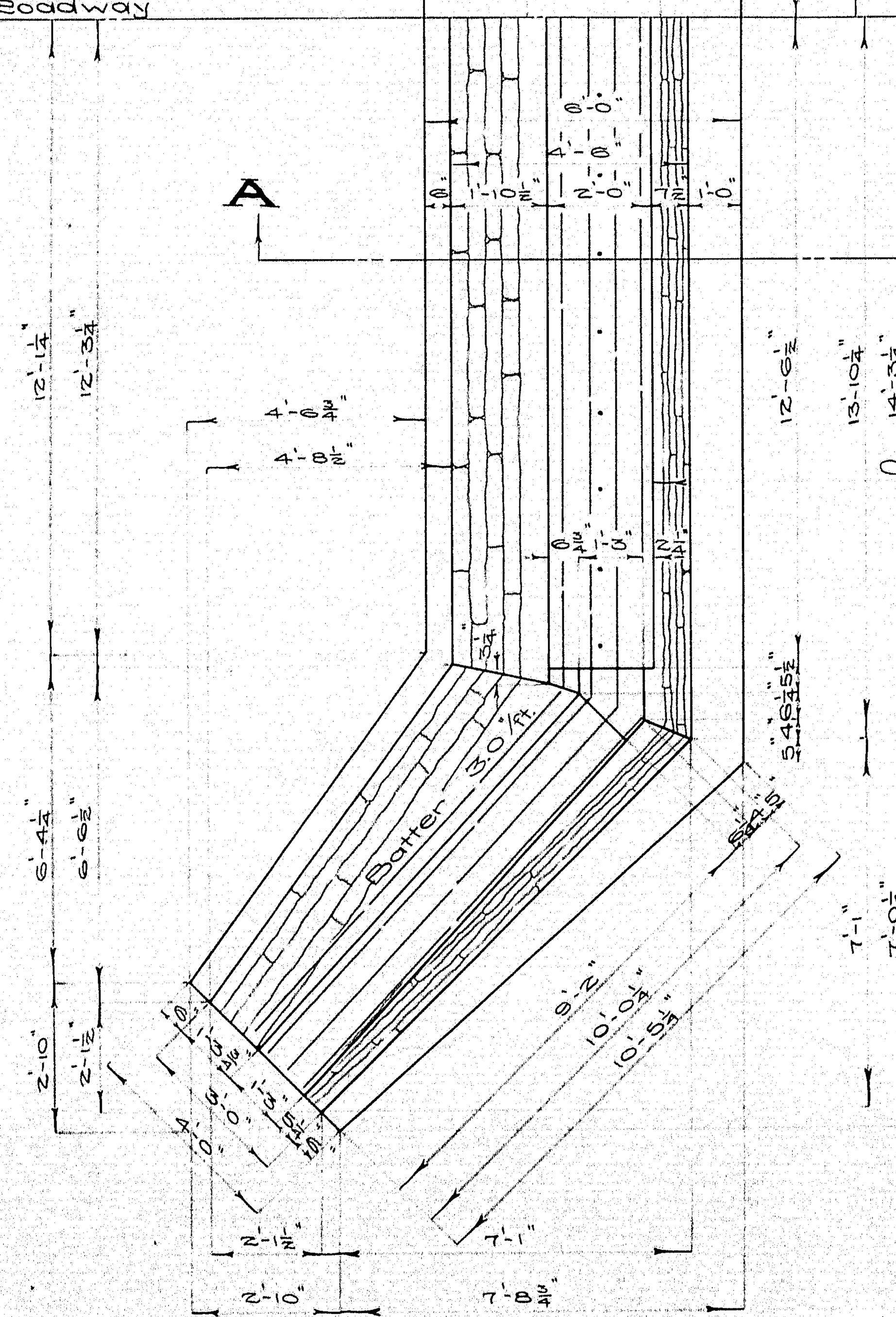


Half End Elev. Superstructure

Half Transverse Sect. Superstructure

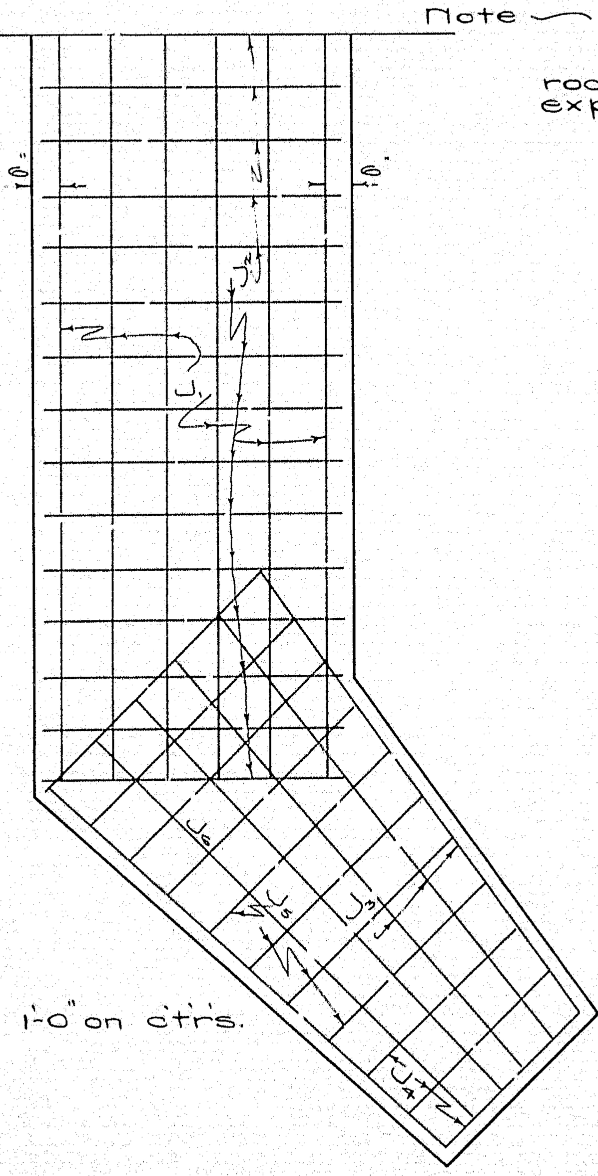


Half Rear Elevation Abut.



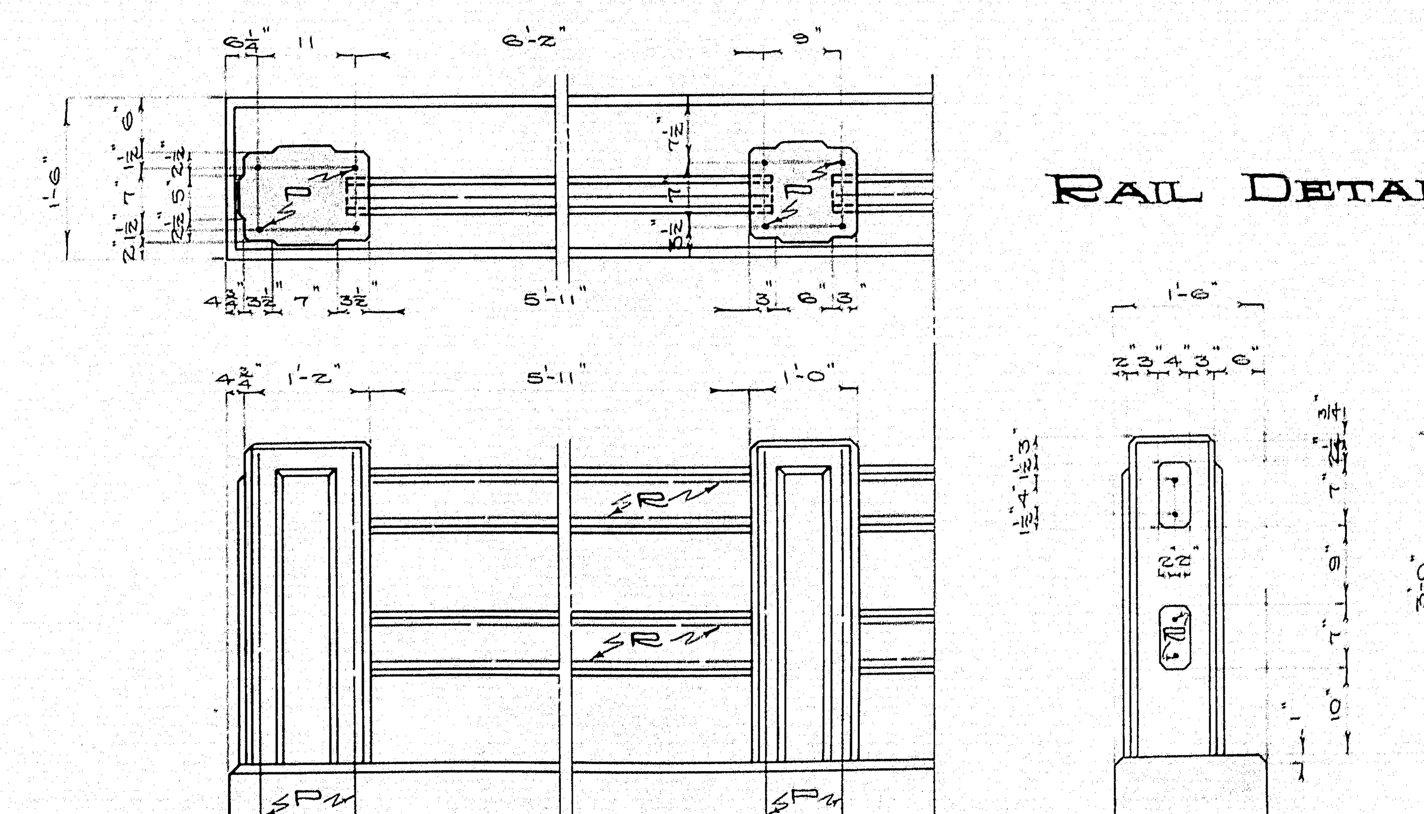
Quarter Plan Abut.

Note — Place a ¼" layer of heavy roofing felt on bridge seat for expansion joint. One abut. only.



Note — J-bars 1'-0" on ctrs.

Quarter Plan Footing Steel



Rail Details

Note — Curb and slab to be cast together. Steel for posts to be set in curb. Precast rail bars in lengths of 6'-4". Place rail bars in position with ends projecting into post forms 2½". Wrap end 6" with two thicknesses of light roofing felt. Fold in ends and when post forms are removed cut away all felt exposed. Panels on posts to be ⅞" thick. Chamfer all exposed edges of concrete ½" unless otherwise indicated.

Design by —
Traced by —
Checked by —

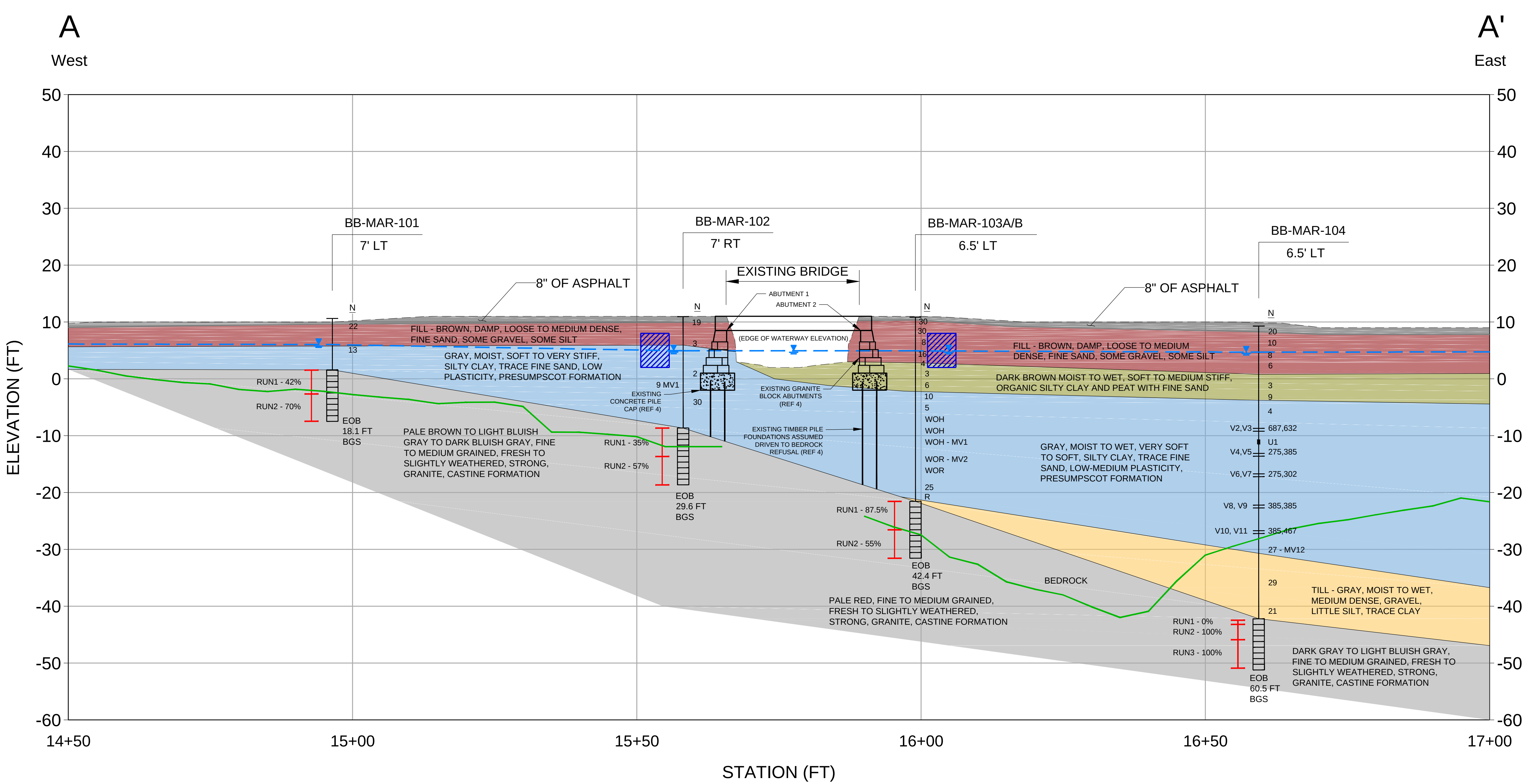
MAINE HIGHWAY COMMISSION
BRIDGE DIVISION

MARSH BRIDGE
OVER
MARSHALL BROOK
BETWEEN THE TOWNS OF
SOUTHWEST HARBOR
AND
TREMONT
HANCOCK COUNTY

Sheet 2 of 2 Augusta, Me. 7-28-31.

12-26

0 1 2 3 4 5 INCHES



LEGEND

BB-MAR-101 7FT RT	BORING LOCATION I.D. OFFSET
WOH	WEIGHT OF HAMMER
WOR	WEIGHT OF RODS
MV1	MISSED VANE
10	SPT : N - VALUE
V2,V3 687,632	FIELD VANE SHEAR TEST LOCATION AND UNDRAINED SHEAR STRENGTH (PSF)
	GROUNDWATER ELEVATION (FT)
RUN1 - 42%	ROCK CORE RUN NUMBER AND RQD
EOB 18.1 FT BGS	END OF BORING
	ASPHALT
	FILL
	ORGANIC SILTY CLAYS AND PEAT
	PRESUMPSCOT FORMATION
	GLACIAL TILL
	GRANITE, CASTINE FORMATION
	ESTIMATED BEDROCK SURFACE FROM SEISMIC SURVEY HAGER-RICHTER MAY 2017
	ESTIMATED LOCATION OF TIMBER CRIB FROM HAGER-RICHTER SURVEY MAY 2017 & 1931 HISTORICAL DRAWINGS

NOTES

1. THE WATER TABLE IS TIDALLY INFLUENCED. THE WATER TABLE SHOWN IN THIS FIGURE IS APPROXIMATE AND ACTUAL FIELD CONDITIONS WILL VARY.
2. THE BORING LOCATIONS SHOWN IN THIS FIGURE WERE SURVEYED BY MAINEDOT AND RECEIVED BY GOLDER ON MAY 19, 2017.
3. SEE BORING LOGS FOR DETAILED LITHOLOGIC DESCRIPTIONS.
4. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED, AND HAVE BEEN DEVELOPED BY INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS OF SAMPLES. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO EXPLORATION LOGS.
5. SEISMIC SURVEY WAS COMPLETED BY HAGER-RICHTER ON MAY 4, 2017 AND WAS SUMMARIZED IN A REPORT TO GOLDER ASSOCIATES ON JUNE 7, 2017.

REFERENCES

1. BASEMAP ELEMENTS FROM VHB DRAWING TITLED "3DTopo_13Dec2016.dgn" DATED ON DECEMBER 13, 2016. RECEIVED BY GOLDER ON APRIL 27, 2017.
2. BORINGS WERE LOCATED AND OBSERVED BY GOLDER AND DRILLED BY NEW ENGLAND BORING CONTRACTORS OF HERMON, MAINE FROM MAY 8-11, 2017.
3. SEISMIC SURVEY DATA PROVIDED IN DRAWING TITLED "Figure 4.dwg" BY HAGER-RICHTER DATED JUNE 7, 2017.
4. EXISTING STRUCTURES ARE APPROXIMATE AND TAKEN FROM MAINE HIGHWAY COMMISSION, MARSH BRIDGE OVER MARSHALL BROOK, SOUTHWEST HARBOR & TREATMENT, FEBRUARY 1931.

DRAFT

0 10 20
1" = 20' FEET

CLIENT
VANASSE HANGEN BRUSTLIN, INC.
500 SOUTHBOROUGH DRIVE, SUITE 105B
BEDFORD, NEW HAMPSHIRE 03110 - 6532

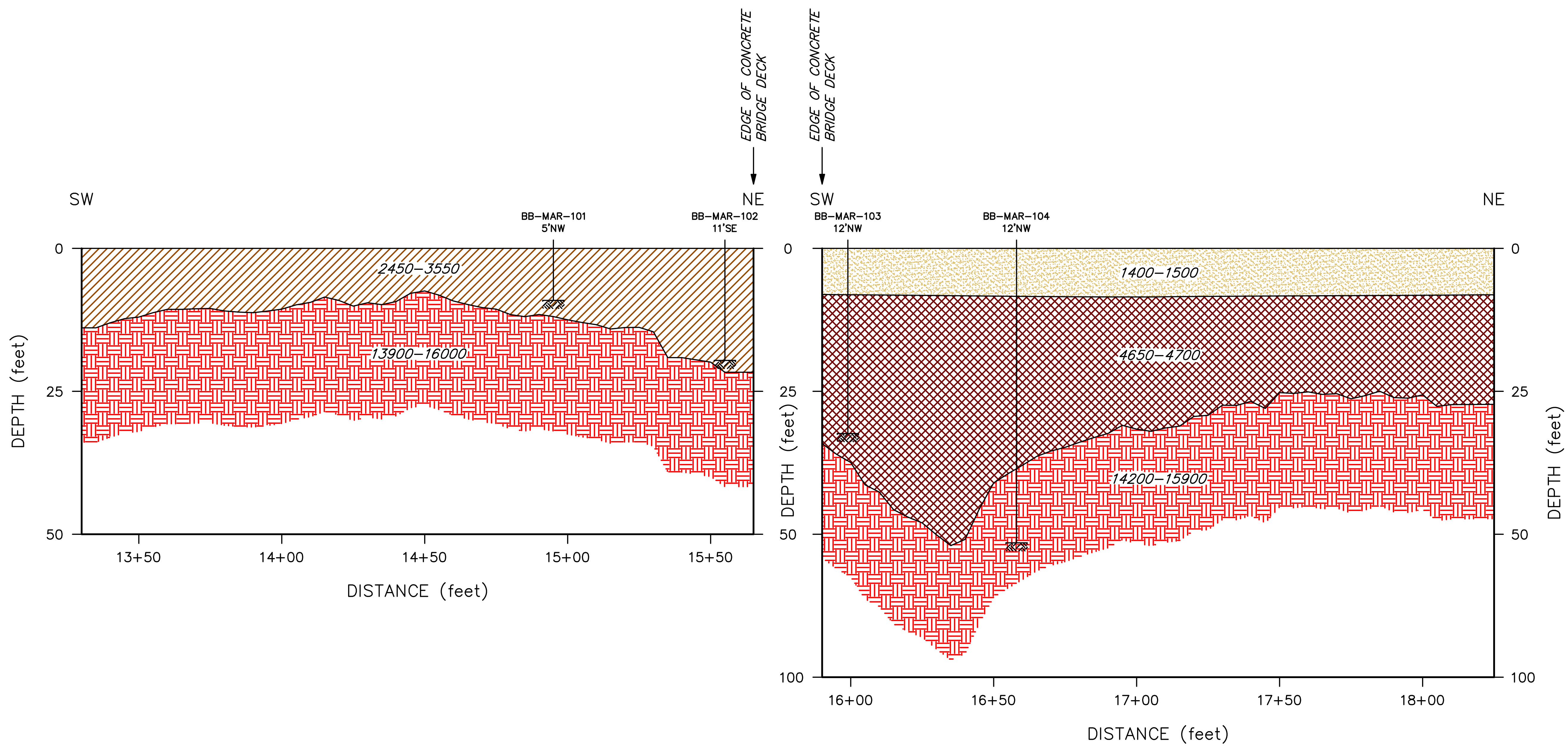
CONSULTANT
Golder Associates

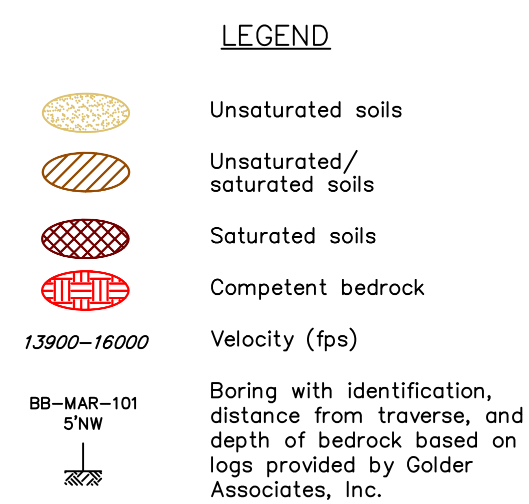
YYYY-MM-DD	2017-05-31
DESIGNED	LLM
PREPARED	RWC
REVIEWED	
APPROVED	

PROJECT
MARSH BRIDGE REPLACEMENT
TREMONT AND SOUTHWEST HARBOR, MAINE
MAINEDOT WIN 21702.00

TITLE
INTERPRETED SUBSURFACE PROFILE A-A'

PROJECT NO.	SUBTITLE	REV.	FIGURE
166-8741	A	0	3





NOTES:

1. Estimated standard deviation of depth of bedrock is ±10% or 2 feet, whichever is greater.
2. The depths determined for bedrock are depths of competent rock; weathered and/or fractured bedrock might occur at shallower depths.
3. Data were analyzed using the Generalized Reciprocal Method.

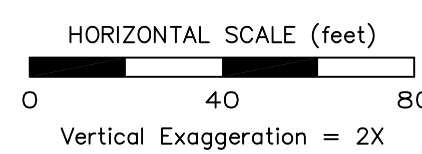


Figure 4
Seismic Lines 1 & 2
Marsh Bridge Replacement Project
Tremont, Maine

File 17MH08	June, 2017

HAGER-RICHTER
Salem, NH | Fords, NJ

Long Term Aggradation/Degradation

Bridge Plans

Estimated bottom elev = 2.7'

Current base = 2.0'

Clearwater Scour

$$y_2 = \left[\frac{K_u Q^2}{D_m^{2/3} W^2}\right]^{3/7}$$

y_2 = ave depth in contracted section after scour

$y_s = y_2 - y_0$

Q = discharge @ Bridge

D_m - diameter of smallest nontransportable particle in bed material

$= 1.25\, D_{50}$

say $D_{50} = .008$ ft ?

$D_m = .01$ ft

W = bottom width of contracted section

$K_u = .0077$

y_0 = ave depth in contracted section

$$y_2 = \left[\frac{.0077 \times 90^2}{(.01)^{2/3}\ 22^2}\right]^{3/7}$$

$$= \left[\frac{2.6}{484}\right]^{.43}$$

$= 0.1$

Marsh Bridge Abutment Scour

Froechlich
ys/ya = 2.27 K1 K2 (L'/ya)^0.43*Fr^0.61+1

K1=coeff for abutmt shape
K2 = coeff for angle of embankment to flow
K2= (theta/90)^1/3 (see fig 8.5)
theta < 90 if embankment points downstream
theta > 90 if embankment points upstream
L' = length of active flow obstructed by the embankment (ft)
Ae = Flow area of the approach cross section obstructed by the embankment, ft2
Fr = Froude No. of approach flow upstream of the abutment = Ve/(gya)^1/2
Ve = Qe/Ae (ft/s)
Qe = flow obstructed by the abutment and approach embankment fps
ya= averaage depth of flow on the floodplain (Ae/L), ft
L = Length of embankment projected normal to the flow, ft
Ys = scour depth, ft

see HIRE equation if ration of abutment length (L) to flow depth, y1 is > 25.

Ys/Y1 = 4 FR^.33 (K1/0.55) K2

y1 = Depth of flow at the abutment on the overbank or in the main channel
Fr = froude number based on velocity and depth adjacent to and upstream of the abutment
K1 = abutment shape coeff
K12 = skew angle coeff.

K1 Shape coefficients	K1		
vertical wall abutment			1
vertical wall abutment with wingwalls			0.82
spill-through abutment			0.55

entered variables
intermediate computed variables

		L	R
K1	1		
theta	90		
K2	1		
L'		22	45
Ae		60	142
Ve		0.6	0.6
Fr	#DIV/0!		
Qe		30	74
ya		3	3.5
L'		22	45
YS	#DIV/0!		

Table 8.1. Abutment Shape Coefficients.

Description	K_1
Vertical-wall abutment	1.00
Vertical-wall abutment with wing walls	0.82
Spill-through abutment	0.55

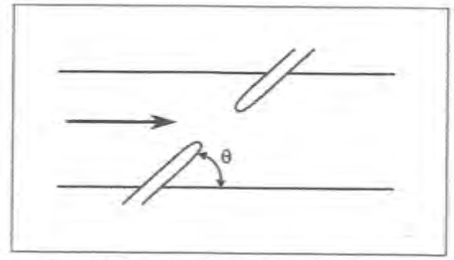


Figure 8.5. Orientation of embankment angle, 2, to the flow.

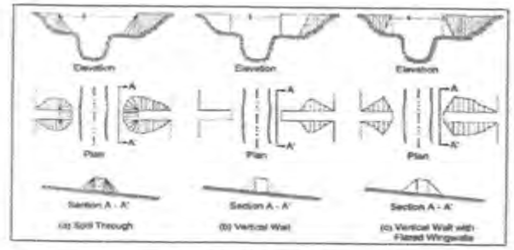


Figure 8.6. Abutment shape.

plan	geometry	flow file	time	L'Left	L'Right	Ae	Ve	Fr	Qe	ya	Ys	ys, hecras
			Q500, T1									
.p31	.g04	.u11	29jan0736- not likely good va	22		60	0.6	0.061047	30	3	3.913942	
			section 1975		45	142	0.6	0.056518	74	3.5	5.129158	
.p11	.go4	.u03	Q1T100	20	35	75	0.4	0.070491	32	1	3.076518	
.p31	.g04	.u11	30jan0348	22		70	0.4	0.033605	32	4.4	3.518507	
			Q500, T1		45	230	0.4	0.032515	78	4.7	4.486372	
							0.43	0.036543	137	4.3	1	4.9
							0.43	0.036976	130	4.2	1	4.3
							0.5	0.03864	184	5.2	1	6
							0.5	0.039017	175	5.1	1	4.9
							0.5	0.037572	200	5.5	1	6.4
							0.5	0.037918	190	5.4	1	5.3

Marsh Bridge

Contraction Scour

filled in variables
key computed variables
Critical Velocity in fps

Vc = Ku * y^(1/6) * D ^(1/3)

	english	m
Ku	11.17	6.19
D50 ft, mm	0.000197	0.06
D50 M	0.000197	0.00006
y, ft	4.7	1.432927
Y^/167	1.294912	1.061914
D^.333	0.058337	0.039276
Vc = Ku * y^(1/6) * D ^(1/3)		
VC	0.843803	0.258169

ave depth in us section

Slope
0.0007

		V*/T<.5	V*/T>.5<2	V*/T>2
k1		0.59	0.64	0.69
V*=(gyS1)^.5	100		0.325481182	
	500		0	
T, fig 6.8	mps		0.008	
	fps		0.02624	
V*/T	100		12.40400847	
	500		0	
K1			0.64	
			0.69	

D50- fine silt clay -

contraction scour

plan	geometry	flow file	time	hyd depth y1 depth US	Q2 flow BR	W2 width BR	Q1 flow US	W1 width US	y2 final BR depth	K1	Y0 ex depth in BR	Ys scour in BR	HECRAS ys
.p31	Proposed	Q500T1	29jan0736	3.7	213	20	164	82	12.25572	0.69	3.6	8.655723	not legit model time
													6.8
.p11	PRO	Q1T100	30jan0906	1	32	19	32	75	1	0	1.1	-0.1	
.p31	Proposed	Q500T1	30jan0348	4.7	223	20	223	82	12.44282	0.69	4.7	7.742817	6.1

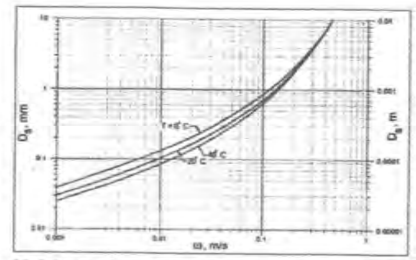
Live Bed Scour
- y1,y — ave depth in US channel
- y2 — ave depth in contracted section after scour
- y0 — existing depth in contracted section
- Q1 — flow in US channel section
- Q2 — flow in contracted channel section
- W1 — bottom width of US main channel transporting bed material
- W2 — bottom width of main channel in contracted section
- Ys — scour depth

D=particle size in ft/m
D50=particles size 50%smaller, ft, m

y2/y1 = (Q2/Q1)^(6/7) * (W1/W2)^k1

100	500
#DIV/0!	#DIV/0!
#DIV/0!	#DIV/0!

	(W1/W2)^k1		
	500	100	500
(Q2/Q1)^(6	#DIV/0!	#DIV/0!	#DIV/0!
100			
#DIV/0!			



re 6.8 Fall velocity of sand-sized particles with specific gravity of 2.65 in metric units.

From boring logs, preliminary design
- B101 — grey, wet loose, fine to medium sand
  - D50 fine to med sand = 0.43-2.0 mm
  - -14 ft to -41 ft
- B102 — brown wet dense gravelly sand
  - D50 med sand to gravel = 2-20 mm
  - -16' to -32'

Q500 T1 30Jan0348

Contraction Scour

Input Data		Left	Channel	Right
	Average Depth (ft):	1.58	4.69	2.28
	Approach Velocity (ft/s):	0.12	0.40	0.13
	Br Average Depth (ft):		4.70	
	BR Opening Flow (cfs):		223.43	
	BR Top WD (ft):		19.56	
	Grain Size D50 (mm):	0.06	0.06	0.06
	Approach Flow (cfs):	17.88	153.25	52.40
	Approach Top WD (ft):	98.37	81.94	172.02
	K1 Coefficient:	0.640	0.690	0.690
Results				
	Scour Depth Ys (ft):		6.10	
	Critical Velocity (ft/s):		0.84	HAND COMPS
	Equation:		Clear	7.7'

Abutment Scour

Input Data		Left	Right
	Station at Toe (ft):	19.40	38.22
	Toe Sta at appr (ft):	34.70	66.32
	Abutment Length (ft):	22	45
	Depth at Toe (ft):	4.82	4.67
	K1 Shape Coef:	1.00 - Vertical abutment	
	Degree of Skew (degrees):	90.00	90.00
	K2 Skew Coef:	1.00	1.00
	Projected Length L' (ft):	22	45
	Avg Depth Obstructed Ya (ft):	4.4	4.7
	Flow Obstructed Qe (cfs):	32	78
	Area Obstructed Ae (sq ft):	70	230
Results			
	Scour Depth Ys (ft):	7.13	7.85
	Qe/Ae = Ve:	0.46	0.34
	Froude #:	0.04	0.03
	Equation:	Froehlich	Froehlich

Combined Scour Depths

Left abutment scour + contraction scour (ft):	13.23
Right abutment scour + contraction scour (ft):	13.95