Reference: MaineDOT Stride Bridge – Rehab and Replacement Options

The Machias River is tidally influenced immediately seaward from Dike Bridge; and Tidal stage parameters for the Machias River were developed for this study using data collected by Maine DOT; these statistics are presented in Table 1.

Table 2: Tidal Statistics for Machias River

Tidal Data (ft, NAVD88)						
Max.	MHHW	MHW	Average	MLW	MLLW	Min.
11.7	9.3	8.4	2.0	-4.5	-4.8	-5.5

Tidal stage data collected by Maine DOT in the Middle River immediately upstream (landward) from Dyke Bridge indicates that the normal tidal range is from elevation -0.5 (normal high tide) to elevation -2.0 (normal low tide).

Backwater effects associated with the existing tide gate system at Dyke Bridge result in persistent backwater effects in the upstream reach of the Middle River and minimum water surface elevations (approximately elevation -2.0 ft) that are above the invert of the Stride Bridge culvert.

BRIDGE REHABILITATION OPTIONS

As requested by Maine DOT, the evaluated rehabilitation options for the Stride Bridge are invert lining and sliplining.

The top half of existing culvert appears to be in good condition and the bottom half is corroding so invert lining could be appropriate for this structure. There have been several MaineDOT invert lining projects in the past several years and they generally consist of a 5 to 6 inch reinforced slab cast against the lower half of the corrugated metal pipe (CMP) with shear studs welded along the sides of the pipe to transfer load from the existing CMP to the new concrete invert lining. The exposed steel portion could also be coated or painted to help prolong the life of the structure. Invert lining would maintain the structural integrity of the original design as the lower portion continues to corrode and the MaineDOT Bridge Design Guide (BDG) estimates that it would extend the life of the structure for 25 years or more. The structural capacity would need to be evaluated further for this alternative, as the current bridge rating is below current AASHTO design loads.

Sliplining would be a longer term rehabilitation option where a slightly smaller pipe would be placed inside the existing and the space between would be filled with grout. The estimated life span of a sliplining, according to the BDG would be 75 years, as it is a complete replacement with a new pipe.

The main concerns with these rehabilitation alternatives are the following:

- The existing roadway width is only 23' wide and sliplining or invert lining would not allow for any roadway widening;
- The hydraulic opening would be reduced;
- Fish passage may not be adequate.

Reference: MaineDOT Stride Bridge – Rehab and Replacement Options

BRIDGE REPLACEMENT OPTIONS

Replacement bridge alternatives for the Stride Bridge will depend on the actual subsurface information at the site and depth to bedrock. If bedrock is shallow, tall cantilever abutments bearing directly on bedrock could be used with a short superstructure just long enough to provide bankfull width plus the design safety factor. If the bedrock is very deep, integral or spill-through abutments with riprap protection sloping towards the channel would likely be needed and the superstructure would be a much longer span.

The Maine Geological Survey website has surficial geology maps available of the site which show "Qp" soils at the surface with bedrock outcrops (shown hatched) nearby, see Figure 1. The "Qp" designation indicates that Stride Bridge is on a silt and clay deposit, so the longer span integral or spill-through abutment alternative is the likely alternative, however site specific borings would be required to confirm how deep this layer is.

http://www.maine.gov/dacf/mgs/pubs/online/surficial/surficial.htm

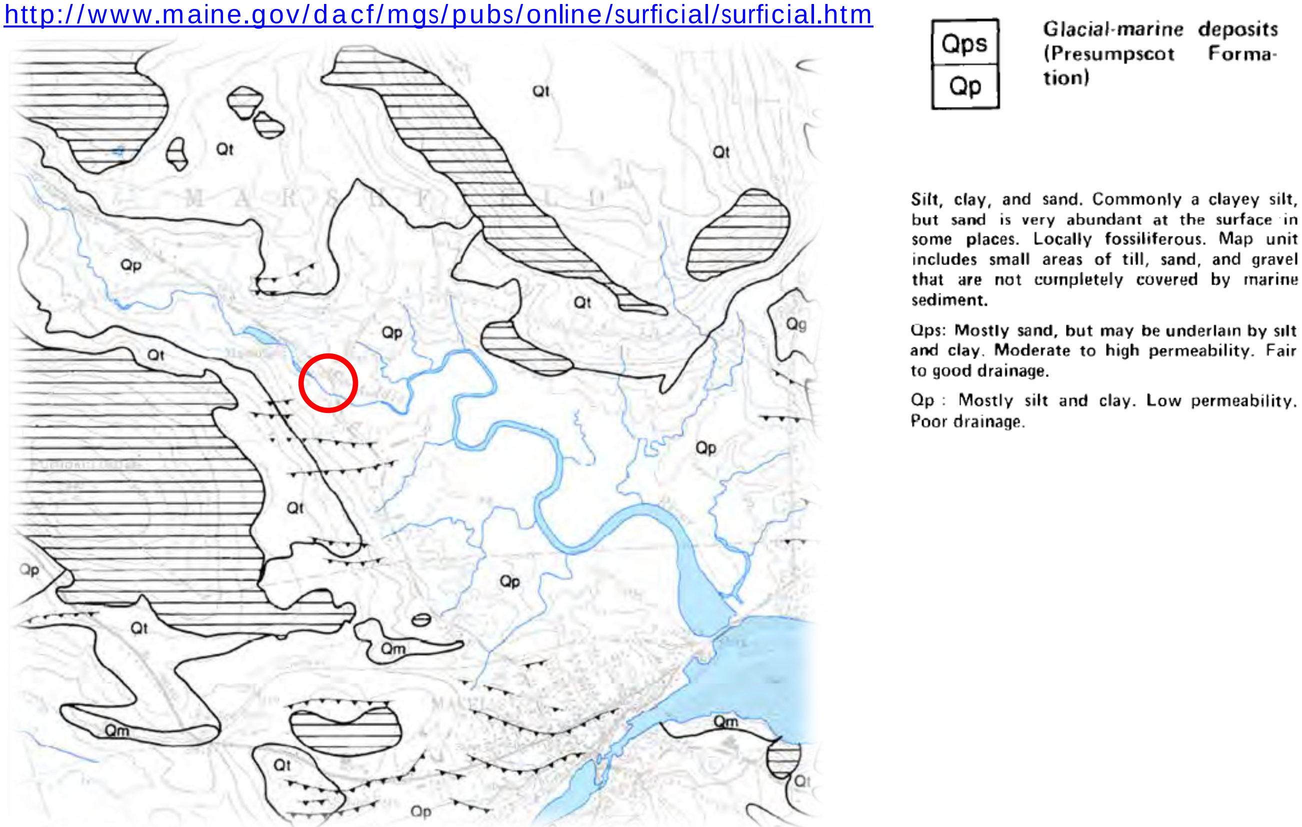

Figure 1 Clip from Maine Geological Survey's *Reconnaissance Surficial Geology of the Machias Quadrangle, Maine* by Harold Borns, Jr. 1974.

The following are conceptual bridge replacement options for two different subsurface conditions:

Reference: MaineDOT Stride Bridge – Rehab and Replacement Options

1. **Shallow Bedrock @ 1.2x Bankfull Width with Vertical Abutments**: Full-height cantilever abutments at 1.2-times bankfull width (37' face-to-face). The superstructure would likely be 21" voided slabs with a varying leveling slab up to 6", spanning 40' bearing-to-bearing, similar to Fryeburg WIN 17872.00. The structure depth at the center of road would be about 30". The low chord of the bridge should have a minimum 2' freeboard from the Q10 water surface elevation (based on MHW) including wave heights, as described in the BDG.

    a. A precast concrete arch, such as a Conspan ®, could also be used with full-height abutments, but are not recommended due to the smaller hydraulic opening.

2. **Deep Foundation @ 1.2x Bankfull Width with Sloped Abutments:** Integral or spill-through abutments with sloping riprap (1.5H:1V) protection towards the channel. If the toe of riprap is at the edge of 1.2-times bankfull width and a 2'-6" shelf is provided in front of the abutment the span would be at least 76' (73' face-to-face abutments). NEXT beams or butted box beams would be the likely beam type for spans in this range. 36" NEXT F-beams with an 8" deck and 3" wearing surface would put the structure depth around 52", accounting for cross-slope. Similar to the first alternative 2' of freeboard should be provided over the Q10, which may require a significant profile raise.

3. **Deep Foundation @ 1.0x Bankfull Width with Sloped Abutments:** Similar to alternative 2, but starting the toe of riprap at bankfull width, since the sloping riprap provides much more hydraulic opening over the full-height cantilever abutment alternative. It would drop the span to around 70' and would likely reduce the structure depth to 48", by using a 32" NEXT beam vs. 36".

Based on the available information it has been assumed that no underground utilities exist in the immediate vicinity of Stride Bridge.

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Maine Department of Transportation

Memo

To: Kristen Chamberlain, Eric Ham, Julie Senk

From: Charles Hebson

CC: David Gardner

Date: 2021 October 21

Re: 16714 Machias – Potential Racetrack Inundation Due to Tidal Restoration

---

Executive Summary

The frequency of racetrack inundation under Alternative 10 (tidal transparency) has been evaluated using 2011 data, 2021 data and modeling results provided by Stantec. The following discussion pertains to “normal” (i.e., non-storm) tides. Most generally, under Alternative 10 the track will see water twice daily, on every high tide. Using a racetrack elevation of 3-ft NAVD88 as the threshold for flooding, the data show that we can expect “flooding” about 33% of the time. This is somewhat conservative, since it assumes that the entire track is instantaneously covered with water as soon as the tide exceeds 3-ft. Mean High Water (MHW) is estimated at 6.40-ft from the 2021 data set, further confirming that the track will be inundated on a twice-daily basis if tidal transparency is established. Under the Alternative 4M model simulation (culverts allowing some tidal exchange), landward water levels never exceed 3-ft under “normal”, non-storm conditions. There may be localized areas in the track domain below 3-ft with drainage connectivity to the Middle River that will flood at water levels less that 3-ft. The 4M simulated landward water levels (not measured data) are very similar to the August 2021 data period corresponding to a leaky flapper gate. Once the gate was repaired in late August, the subsequent 2021 landward levels reverted to 2011 conditions.

Discussion

Alternative 10 consists of an opening large enough so that tidal hydrology is restored landward (upstream) of the causeway. This has been referred to as “tidal transparency”. The type of hydraulic structure (culvert or span) is immaterial, though to date Alternative 10 has been treated as a span. The idea is that the structure has no effect on tidal flow moving in and out of the Middle River. Under this scenario we can assume that the tides as measured seaward of the causeway in the Machias River will be duplicated landward (upstream) in the Middle River.

Figure 1 shows one complete tidal cycle spanning 31 July 2011. This is a “normal” spring tide, “normal” indicating “not a storm event”; the spring tides are the high tides that occur monthly. The tidal period is 24.83 hours; the water level exceeds 3-ft NAVD88 for (4.87 + 4.35) = 9.22 hours. This gives a water level exceedance duration of 37% above 3-ft for this cycle. The duration would be somewhat smaller for average and lower neap tides. Under Alternative 4M (culverts allowing some tidal exchange) high tides never exceed 3-ft. The tidal datums (MHW and MHHW) were calculated using the NOAA Tidal Datum Calculator and the 8/12 – 10/06/2021 data set used for Figure 2.

Figure 2 shows the Machias River tidal stage frequency distribution, based on the 8/12 – 10/06/2021 data set. As described above, we assume that this data is representative of what would result in the Middle River under Alternative 10. Since this data record covers a full range of tides, the calculated exceedance frequency is somewhat lower than for a single spring tide (35% vs. 37%) as in Figure 1.

Figure 3 shows the 2021 landward tidal data collected in the impoundment upstream of the causeway. The tides are significantly higher than the 2011 and the post-August 2021 landward data; the range is also larger (-0.75 to 1.25 ft; 2-ft range). This was due to a leaky flapper gate. These elevated water levels are consistent with aerial photos taken in the July 2021 drone flight, observations in the course of project field work prior to repair of the faulty gate, and anecdotal comments from local residents.

Model simulation results for Alternative 4M (two 10S x 5R culverts with flappers, one 10S x 5R open culvert) for a 2011 model period are superimposed on the 2021 data segment in Figure 4. The measured 2021 leaky hydrology is remarkably similar to the model results, particularly the peak water levels. Thus, the actual landward tidal experience through August 2021 gives a good idea of what Alternative 4M would be like if constructed. The gate was repaired around August 30 and the hydrology reverted almost immediately to what was seen in the 2011 data set. In Figure 5, 2011 measured landward water levels are superimposed over 2021 measurements. The post-repair water levels are essentially identical to what was measured in 2011 and indicates only a small amount of leakage.

Figure 1. Racetrack Inundation Illustrated Using 7/31/2011 Tidal Cycle

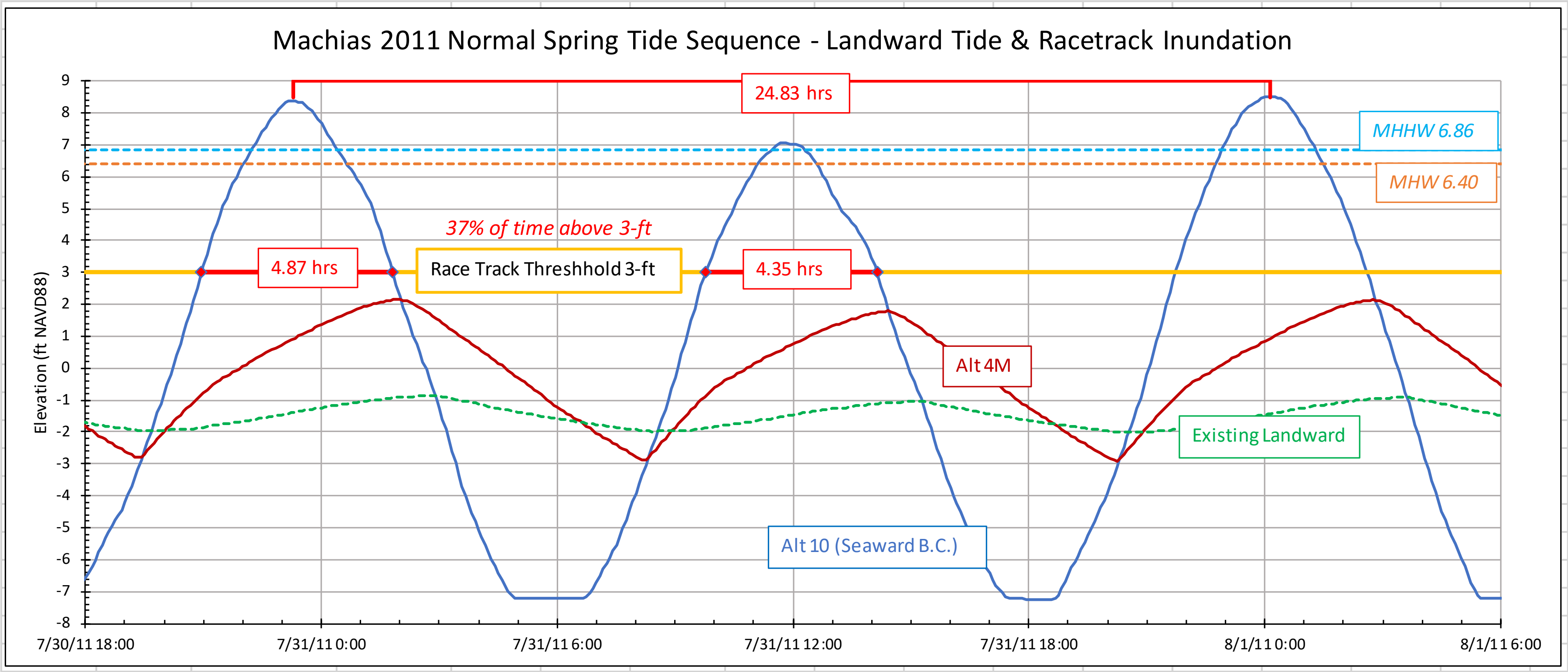


Figure 2. Machias River Tidal Stage Frequency Distribution

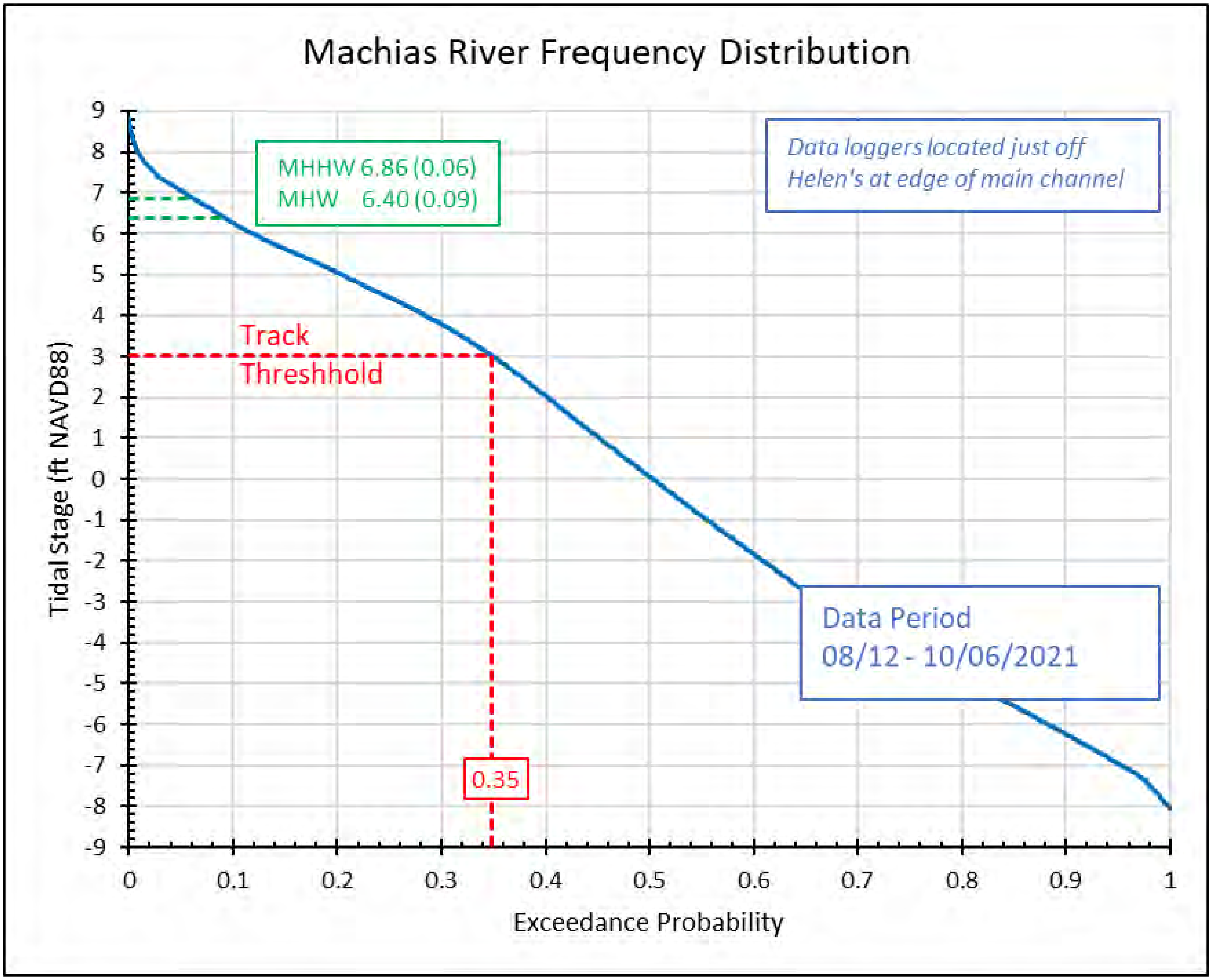


Figure 3. 2021 Landward Tide Data

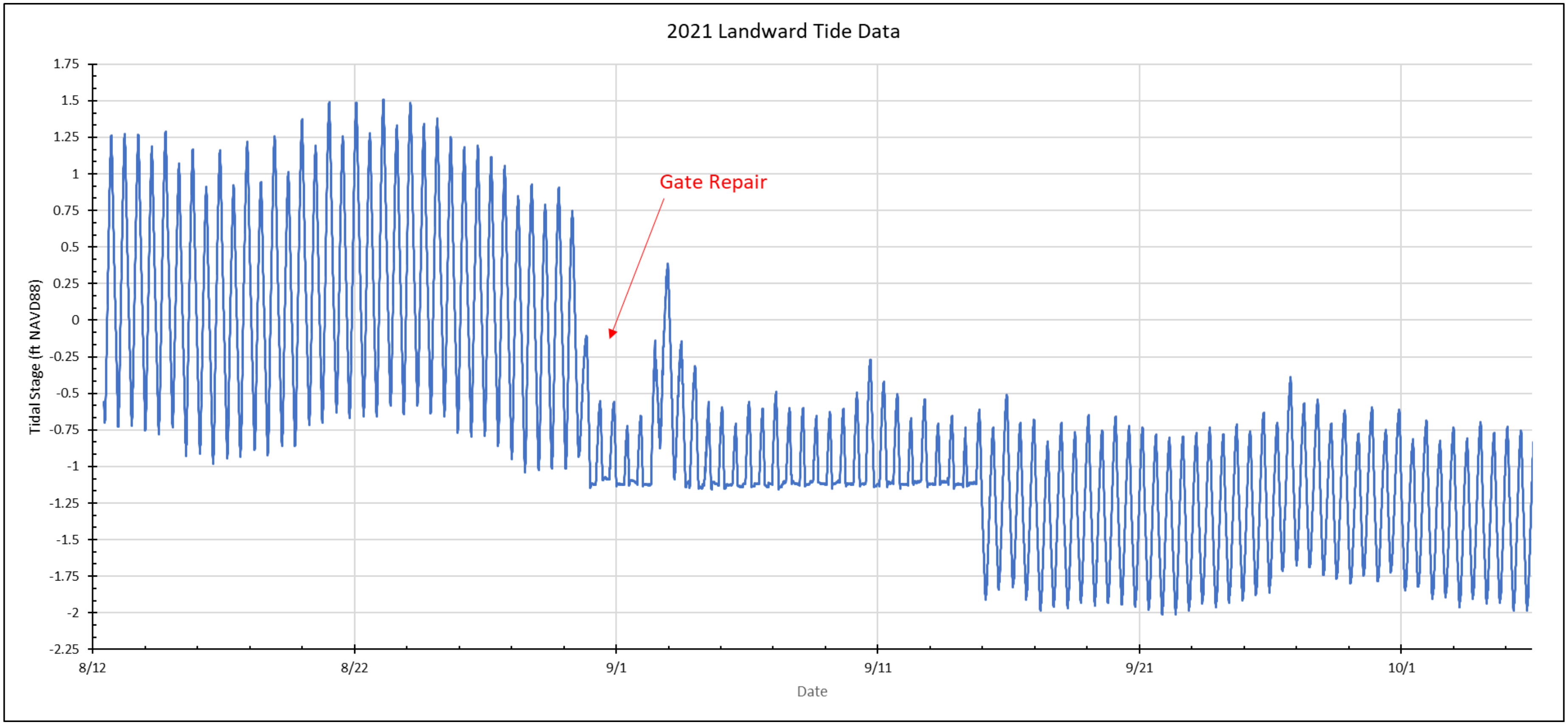


Figure 4. 2021 Tide Data Before Gate Repair

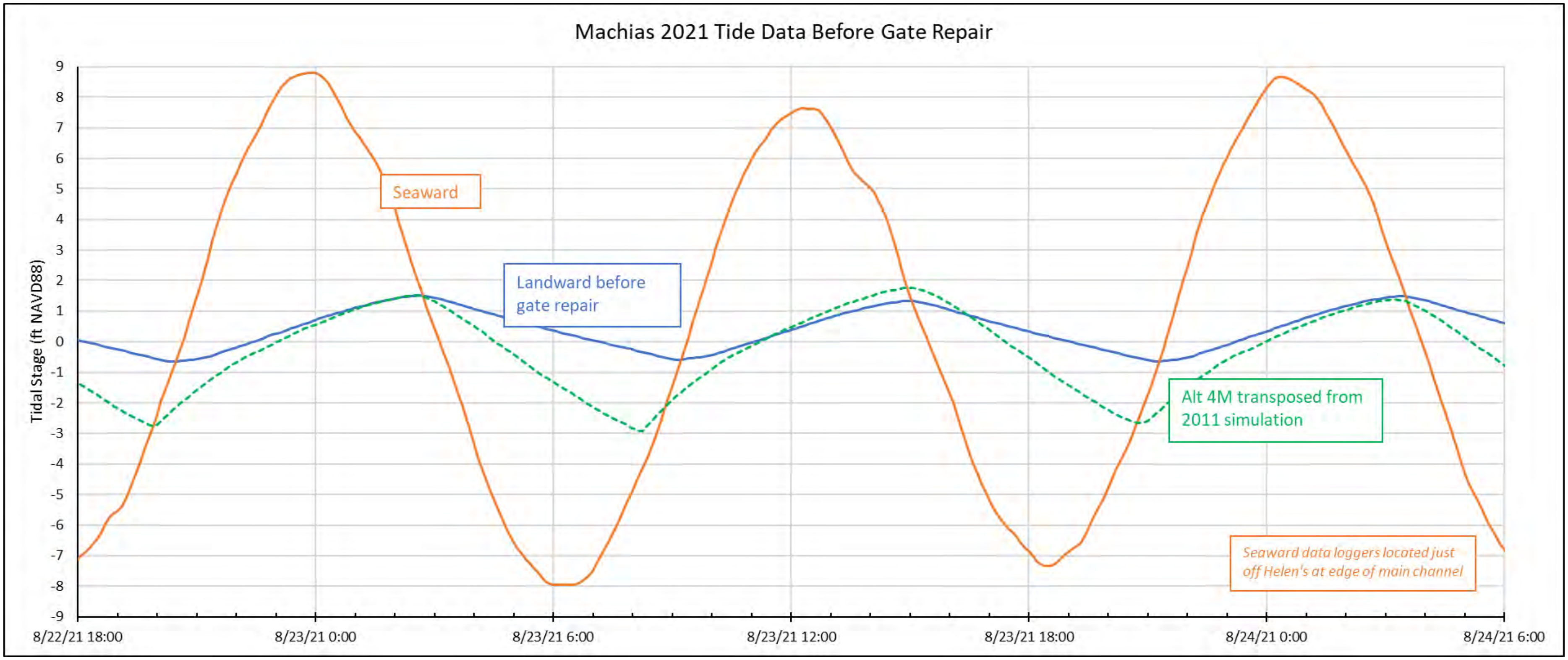
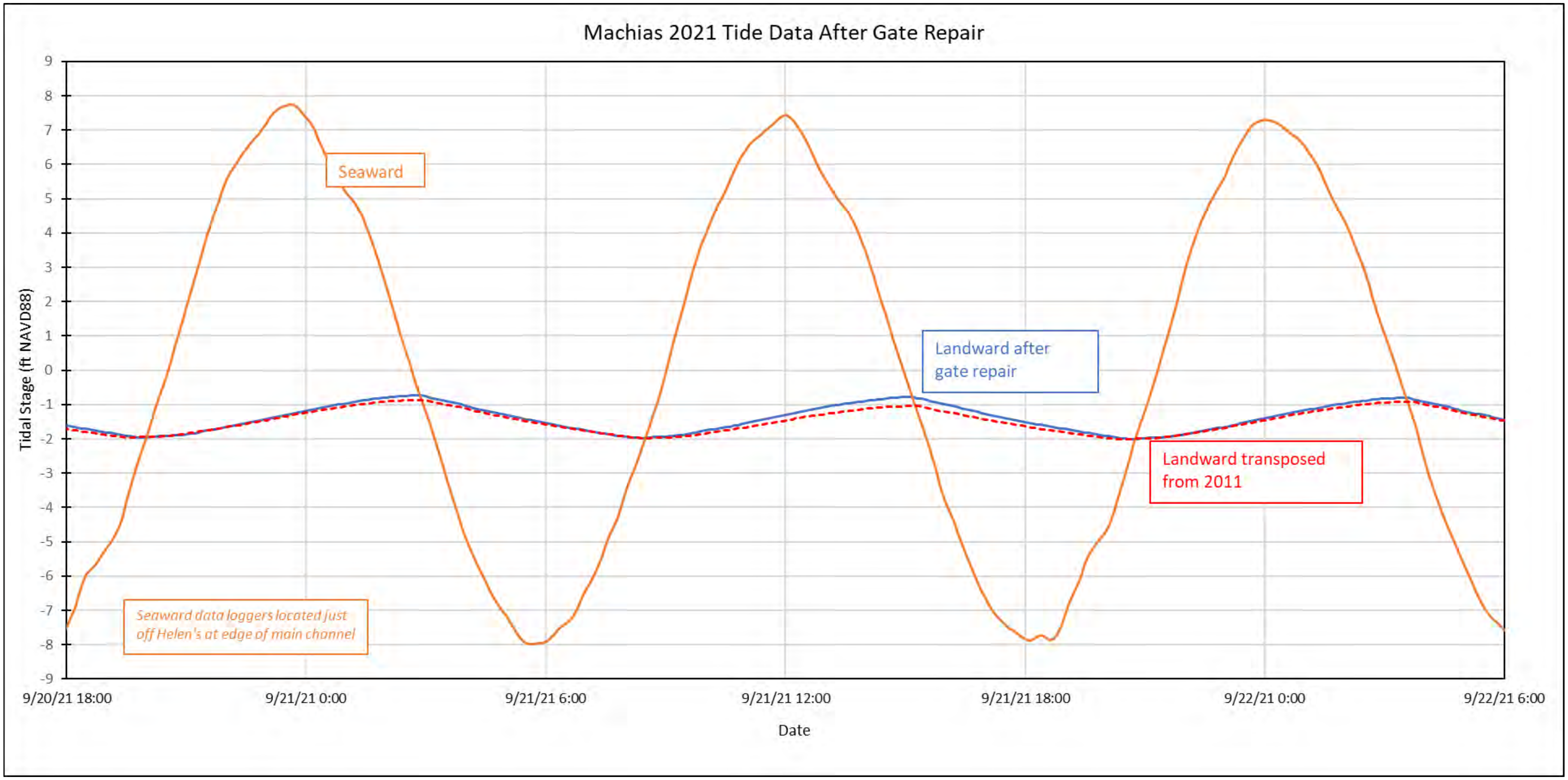


Figure 5. 2021 Tide Data After Gate Repair



Appendix A. Output from NOAA Tidal Datum Calculator

Run Time: 2021-10-19 16:58:15
Using DS-WL-for-Datum-Calc.csv
Time Zone = EDT-UTC4
13256 data points loaded.
Interval: 0:06:00
FEET

All calculations and results are in Feet

Gulf/East coast station:
Using Modified Range Ratio Method

Sampling Rate: 240.0 per day. Using cutoff frequency of 4.0 per day
107 highs 106 lows
Data Start: 2021-08-12 10:30:00
Data End : 2021-10-06 16:00:00
Mean Water Level: 0.10
Highest Water Level: 8.80
Lowest Water Level: -8.04
Duration: 55 days, 5:30:00
High Tides Found: 107
Low Tides Found : 106
Tides per day: 3.9
Semi-Diurnal - Using EXHL
54 Highs
53 Higher Highs
53 Lows
53 Lower Lows

3 Monthly plots generated
Control Datums for: 8411060

MHHW, MHW, DTL, MTL, MSL, MLW, MLLW
20.03 19.58 12.75 12.72 12.66 5.87 5.47
GT, MN, DHQ, DLQ, NAVD, LWI, HWI
14.56 13.71 0.45 0.40 12.99 9.51 3.25

SUBORDINATE MONTHLY MEANS:
9 / 2021 :
HWL = 8.33
MHHW = 7.10
MHW = 6.66
MSL = 0.09
MLW = -6.49
MLLW = -6.81
LWL = -7.94

TIDAL DATUMS BY Monthly Means Simultaneous Comparison:
Using Cutler Farris ref station

From 9 / 2021 to 9 / 2021
1 Months of control station means retrieved.
1 months in the analysis

Mean_Diff_MSL = -12.99
Mean Diff MTL = -13.04
Mean_Diff_DTL = -13.03
Mean_Ratio_MN = 0.98
Mean Ratio GT = 0.98
Mean_Diff_MHHW = -13.17
Mean_Diff_MHW = -13.17
Mean_Diff_MLW = -12.90
Mean_Diff_MLLW = -12.90

Corrected values for MN, GT, MTL, DTL
13.44 14.29 -0.31 -0.29
Corrected values for MHHW, MHW, MLW, MLLW
6.86 6.41 -7.04 -7.44

Datums by Monthly Means Simultaneous Comparison (MMSC):
HWL = 8.83 (2021/08/22 23:48)
MHHW = 6.86
MHW = 6.40
DTL = -0.29
MTL = -0.31
MSL = -0.32
MLW = -7.03
MLLW = -7.43
DHQ = 0.46
DLQ = 0.40
GT = 14.29
MN = 13.44
LWL = -8.08 (2021/08/22 05:30)

Feet

That is all.

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Maine Department of Transportation

Memo

To: Kristen Chamberlain

From: Charles Hebson

CC: Joyce Taylor, David Gardner, Eric Ham

Date: 2023 September 6

Re: 16714 Machias Dyke Bridge #2246 – Encroachment Determination

---

Executive Summary

Dyke Bridge (#2246) in Machias ME carries U.S. Route 1 over the Middle River just above its confluence with the Machias River. The bridge consists of a long causeway embankment structure with four 5'x5' timber box culverts fitted with outlet flap gates. The embankment has a length of approximately 1,000 feet (ft) and is constructed of timber cribbing with rubble and earthen fill. The culverts have deteriorated to the point that the overlying roadway is failing. One of the alternatives under consideration is a hydraulically equivalent replacement-in-kind culvert assemblage.

Along with replacing the culverts it is anticipated that the roadway will be raised to protect against sea level rise (SLR). Raising the road will involve placing fill on top as well as along the embankments and toes of the causeway. *Raising the causeway is the only practicable alternative for protecting Middle River upstream against expected Sea Level Rise.* But this raises the question, does placing fill along the causeway constitute a "significant encroachment". Based on a simple analysis of the required fill volume, it is reasonable to conclude that a culvert replacement/road raising alternative does not constitute a "significant encroachment".

A separate memo (MaineDOT, 9/6/23), discusses the history of Dyke Bridge and whether it should be viewed as a flood control structure. Our conclusion is that it is not a flood control structure in the modern sense of the term. That memo should be referenced for additional information and complements this discussion.

Discussion

Dyke Bridge has been a feature on the landscape since 1868. It was built to serve two purposes:

1. agricultural land reclamation by keeping tidal (saline) flow out of Middle River, and
2. providing a roadway across the top of the dike.

The culverts that constitute Dyke Bridge have reached the end of useful life and have started to fail. The seaward (downstream) side of Dyke Bridge is exposed to the tidal portion of the Machias River. In addition to inland riverine flow the tidal Machias River experiences a normal tide range of 10 – 12 ft. The Middle River approaches Dyke Bridge on the landward (upstream) side. Flap gates at the outlet prevent tidal flow into Middle River (except for some leakage).

Broadly speaking, there are three alternative approaches for dealing with the failing culverts:

1. *No action*. This choice is unacceptable since the causeway would eventually have to be closed and US-1 rerouted.

2. *Some variant of replace-in-kind (RIK) with culverts*. This option is most consistent with the existing structure and would continue to prevent tidal flow into Middle River, something the local population has come to assume and expect.

3. *An open span*. This would allow for full tidal flow into Middle River, subjecting land that is currently dry, accessible, and possibly suitable for agricultural usage to regular tidal inundation.

This discussion is limited to Alternative 2 (culvert option), assuming in addition that the roadway elevation will be raised by 4-ft.

The current Dyke Bridge is directly exposed to tides and is subject to Sea Level Rise (SLR). Typical causeway elevation is 11-ft (all elevations NAVD88) and MHHW in the Machias River at the bridge is 6.9-ft. The causeway overtops or comes close to overtopping on a regular (annual or biannual) basis; see the complementary memo for photos and tabulated tidal data. These storm tides will only get higher with SLR. The Maine Governor's Office and State Legislature have adopted 4-ft SLR by 2100 as the "prepare to manage" target. Therefore, MaineDOT has decided to build protection against SLR into the culvert alternative by raising the causeway 4-ft. This will entail placing fill along the embankment and into the adjoining waterbody, as well as on top of the roadway.

Alternative (2) – RIK – in conjunction with raising the road is the only practicable approach for protecting Middle River upstream from SLR, both normal tides as well as surge. "No Action" leaves the causeway at its current elevation, increasingly subject to overtopping and upstream inundation. "Open Span" would immediately subject upstream to the full range of tides as well as SLR and surge, losing the protection and attenuation provided by causeway.

Placement of fill in turn raises the question of whether this constitutes a "significant encroachment" on adjacent mapped floodplains. As described here, MaineDOT concludes that raising the causeway by augmenting the embankment slopes is not a significant encroachment.

<u>FHWA Policy and Guidance</u>

The Federal-Aid Policy Guide ("the Guide"; 1994; 23 CFR 650A) lays out policy and guidance for hydraulic design in flood plains. Prior to the date of the Guide, the Gordon-Clackley memo (4/2/85) explains in detail how a significant encroachment may be determined, particularly with regard to vital transportation facilities.

Selected Definitions: According to definitions in the Guide, Alternative 2 would constitute an "action". Furthermore, it would be an "encroachment", as the action would occur within the limits of the mapped base flood plain.

The definition for "significant encroachment" will be stated in full:

(q) "Significant encroachment" shall mean a highway encroachment and any direct support of likely base flood-plain development that would involve one or more of the following construction- or flood-related impacts:

(1) A significant potential for interruption or termination of a transportation facility which is needed for emergency vehicles or provides a community's only evacuation route.

(2) A significant risk, or

(3) A significant adverse impact in natural or beneficial flood-plain values

Selected Policies: pertinent policies addressed here include

(a) NFIP maps …. shall be used to determine whether a highway location alternative will include an encroachment

(b) To avoid longitudinal encroachments, where practicable

(c) To avoid significant encroachments, where practicable

<u>Culvert/Raising Road Alternative (#2) Checked Against Policy</u>

As noted, Alternative 2 (culverts) is an "action". Since it takes place in a mapped flood plain, it is also an "encroachment".

Policy (a): The FEMA map is shown in Figure 1. Middle River is an AE zone at BFE 11-ft; Machias River is an AE zone at BFE 10.7-ft. The Machias River Flood Insurance Study (FIS) profile is shown in Figure 2. The BFE in the Machias River is due to storm surge / tidal flooding at the point where Middle River joins the Machias. If the causeway were not present, or if there were an open span, this tidal flooding would move into the Middle River. The Middle River BFE is 11-ft and essentially reflects the Machias tidal flooding boundary condition at the outlet of the Middle River; details of the FIS modeling were not available. Estimated BFE rises are 0.01-ft in the Middle River and 0.20-ft in the Machias River (see Appendix A). These are well within a "no rise" limit of 1-ft.

Policy (b): More than anything, the horizontal alignment is fixed and cannot be modified in any practicable way. The causeway is transverse to flow in the Middle River, not longitudinal with the river, so placing fill on the landward side of the causeway is consistent with policy. The causeway is approximately longitudinal to flow in the Machias River, located back from an outside bend.

Policy (c): As demonstrated in Appendix A, fill placement to raise the causeway will not create a significant encroachment on the floodplain. This conclusion is amplified by considering the items under definition of "significant encroachment" copied above.

(1) *"… termination of a transportation facility …"*: There are only two crossings of the Middle River, at Dyke Bridge and well upstream at Stride Bridge. Both bridges are MaineDOT structures. The proposed action will place the Dyke Bridge roadway well above BFE (15-ft vs. 11-ft) and addresses an existing and anticipated future problem. The current roadway over Stride Bridge (12.5'D CMP; invert -2.5-ft approx.) is at about 11.5-ft. The estimated BFE rise is 0.01-ft, indicating that placing fill at the causeway will not impact Stride Bridge. The estimated BFE rise in the Machias River is 0.2-ft; this is conservative and actual rise is likely less. There are no transportation facilities that will be impacted on the Machias River. The only road across the river, ME92, is set back and well above the river. We conclude that there is no termination of transportation facilities associated with this action.

(2) *" a significant risk":* for all practical purposes, a rise of 0.01-ft (0.12-in) in the Middle River BFE cannot be measured and is effectively zero. As a calculation, this is well within reasonable accepted error bounds. It follows that there is no significant risk associated with placing fill on the Middle River embankment. The same holds true for an estimated 0.20-ft (2.4-in) rise in Machias River BFE.

(3) "*a significant adverse impact on natural or beneficial flood-plain values*": the toes will be extended out laterally about 25-ft on each side, converting from muddy silt bottom to riprap. These portions of the mapped flood plains are always submerged. Given the great areal expanse of mudflat bottoms upstream and downstream, this is a minor impact and cannot be characterized as "adverse".

References

FEMA, 7/18/2017. Flood Insurance Study, No. 23029CV000A, Washington County, Maine. https://map1.msc.fema.gov/data/23/S/PDF/23029CV000A.pdf?LOC=46f89f3ed1540c23ba99b01769fa9809

FHWA, 12/7/1994. Federal-Aid Policy Guide, 23 CFR 650A, Subchapter G – Engineering and Traffic Operations, Part 650 – Bridges, Structures, and Hydraulics, Subpart A – Location and Hydraulic Design of Encroachments on Flood Plans

FHWA, 4/2/1985. "Significant Encroachments", memo from S. Gordon to E. Clackley

MaineDOT, 9/6/23. Memo: "16714 Machias Dyke Bridge #2246 – Flood Control", Hebson to Chamberlain et al.

Figure 1. Location Map

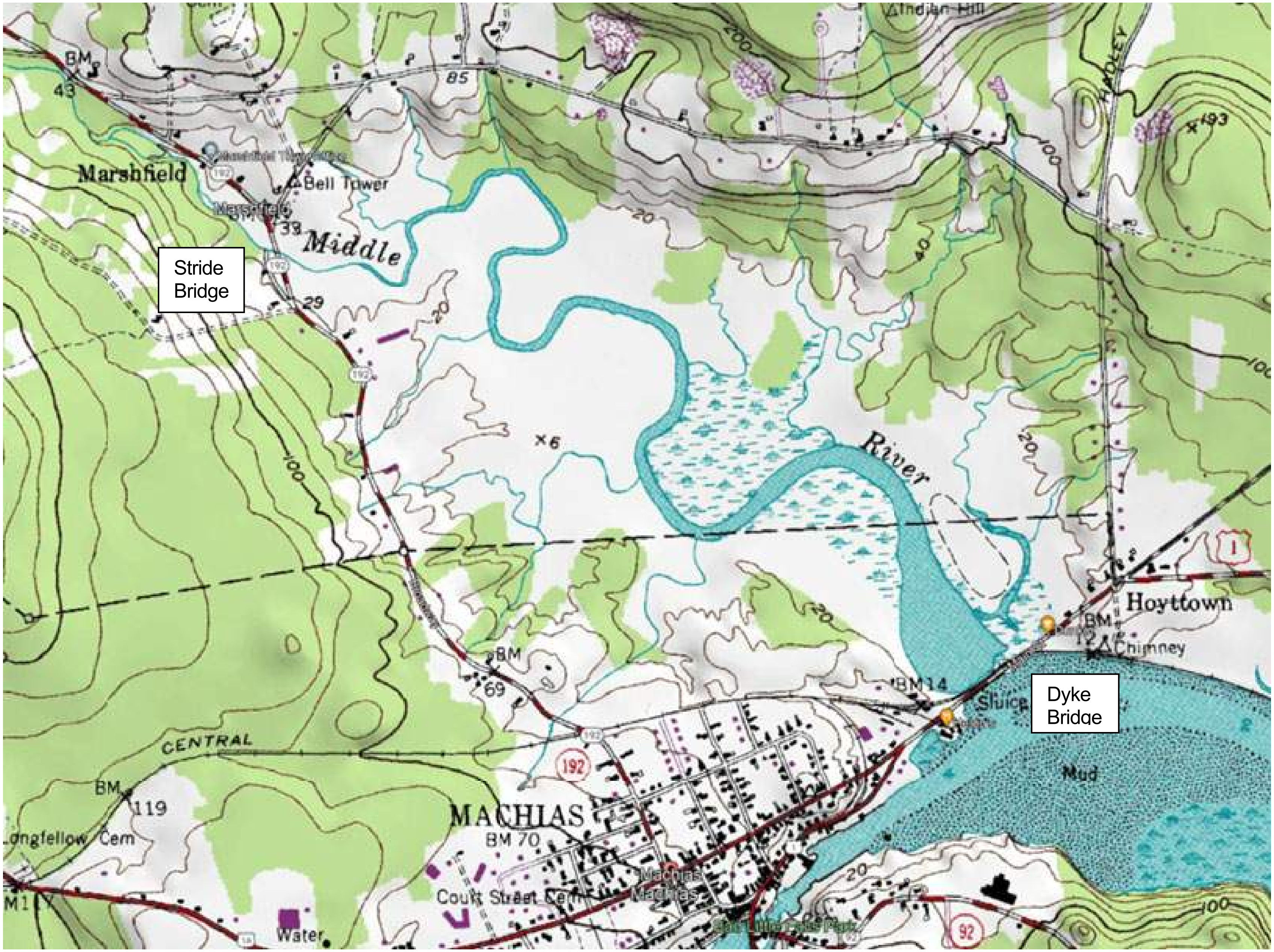


Figure 2. FEMA Flood Plain Map

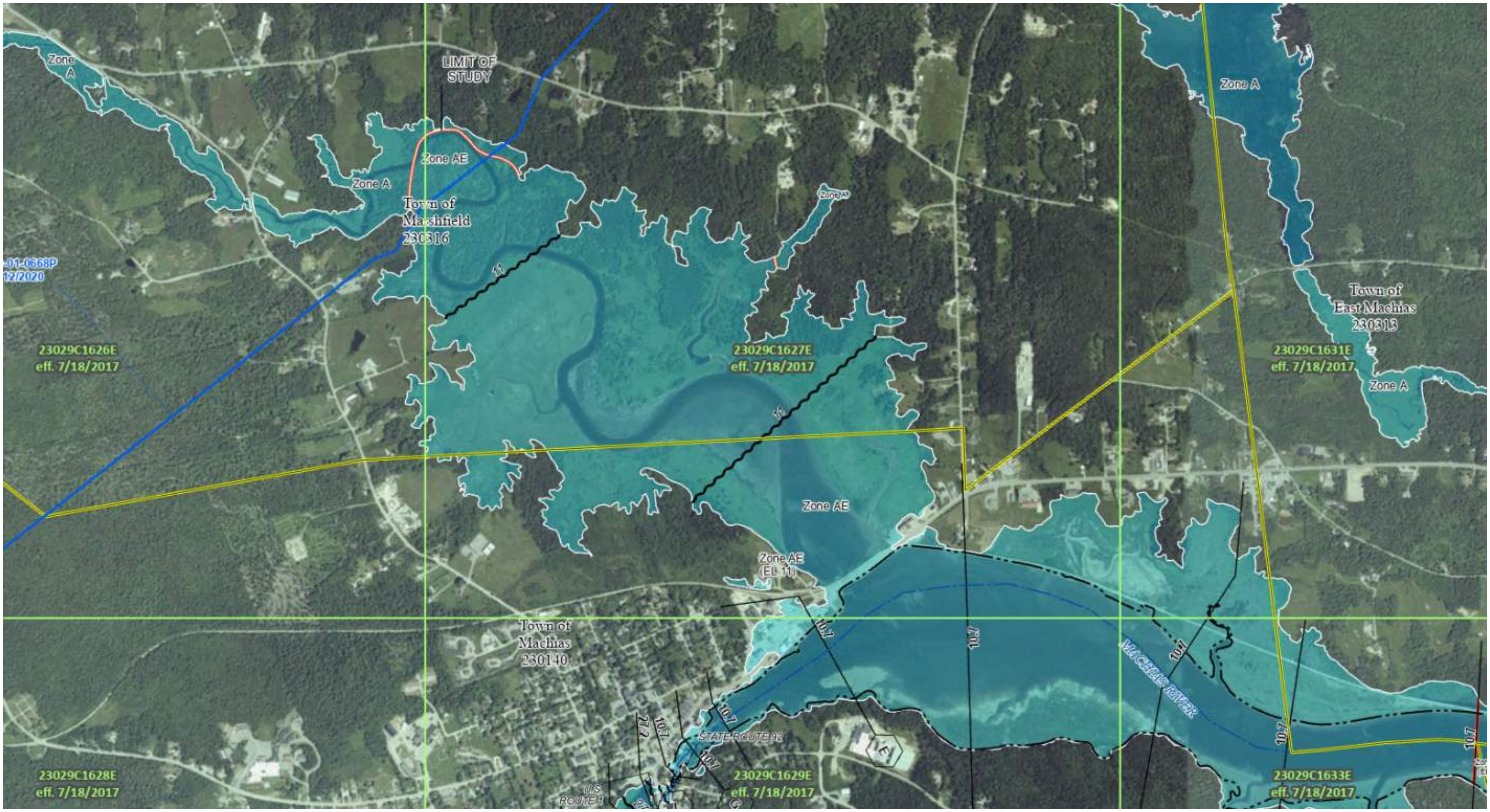
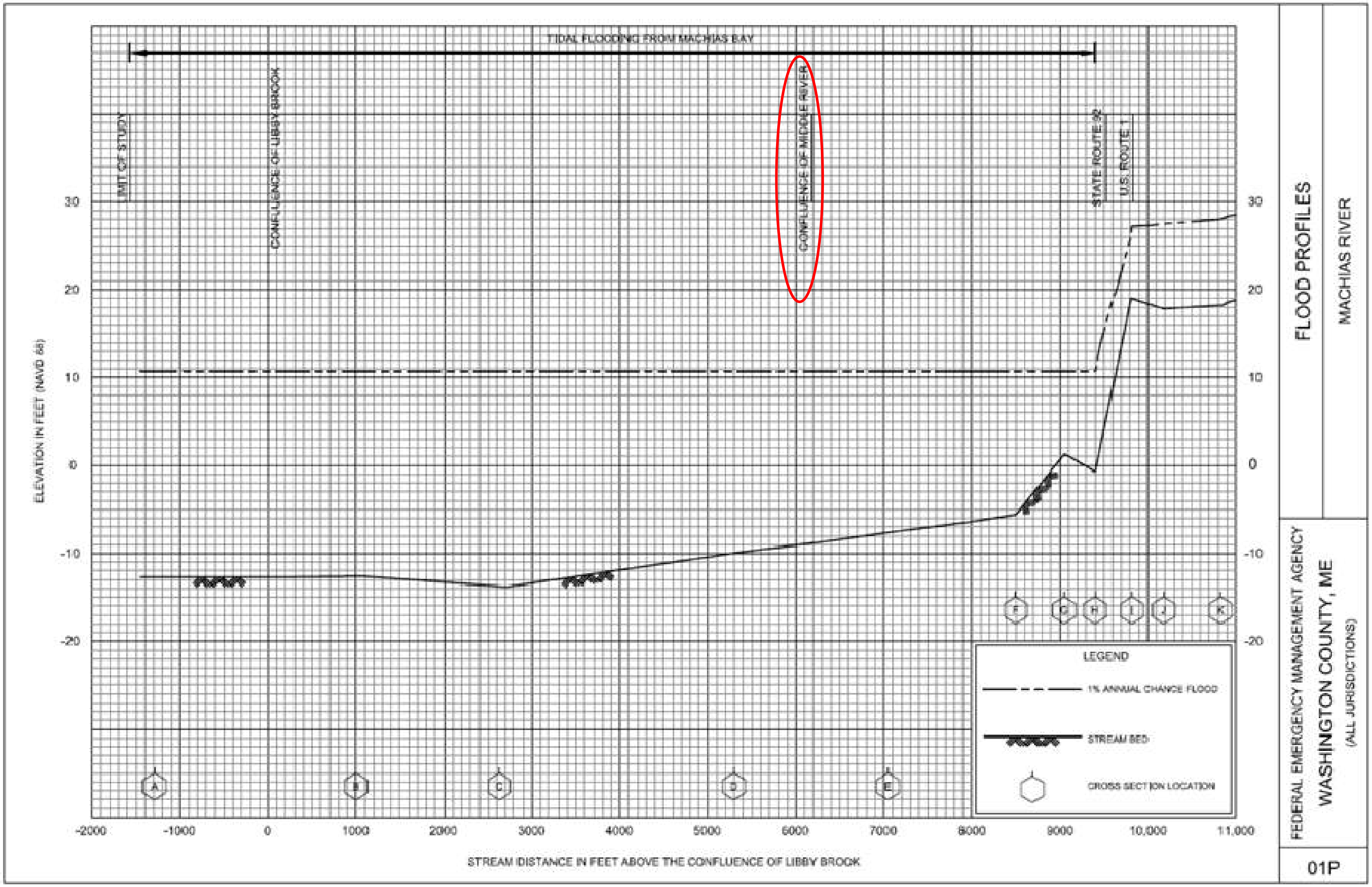


Figure 3. Flood Insurance Study Profile – Machias River at Confluence with Middle River (direction reversed from FIRM)



Appendix A

Simple Analysis of Potential Rise in BFE Due to Fill Placement

The Middle and Machias Rivers have mapped AE flood plains, determined with engineering methods. The causeway crosses the Middle River transversely at a right angle while it crosses the Machias flood plain somewhat obliquely. MaineDOT anticipates raising the causeway by 4-ft in order to address Sea Level Rise. This will entail placing fill along the embankments, onto the river bottoms at toe of slope, and on top of the roadway. The Middle River BFE is 11-ft; the Machias River BFE is 10.7-ft. This simplified analysis addresses the question of whether fill placement beneath the BFE will have a significant effect on the BFE.

This assessment is based on simple displacement: given a volume of fill placed beneath BFE, imagine spreading it over the surface water area at BFE. How thick would the layer of fill be? This gives an approximate idea how much BFE will rise.

Figure A1 shows causeway contours in the vicinity of the culverts. Figure A2 shows the section through the existing causeway and the same section simply raised by 4-ft. This is a simple approximation, assuming these sections are uniform along the 1000-ft long embankment. Design sections may vary along the embankment, as would the difference between the design and actual sections. The area between the blue and red lines is the fill volume (per linear foot) below 11-ft BFE. Figure A3 shows the fill volume as a function of station for the two embankments; Figure A4 shows fill volume as a function of elevation. Fill volume per linear foot is 275 ft^3/ft on the Middle River embankment and 216 ft^3/ft on the Machias River embankment.

The total fill volumes for the 1000-ft causeway are 1000 x 275 = 275,000 ft^3 on the Middle River side and 1000 x 216 = 216,000 ft^3 on the Machias River side. Table A1 gives the water surface area – elevation table (analogous to a hypsometric curve) for the Middle River. At BFE = 11-ft the water surface area is approximately 22,500,000 ft^2. If the total fill volume on the Middle River side were spread over this area, the depth would be

Fill depth (BFE rise) = 275,000 ft^3 / 22,500,000 ft^2 = 0.012 ft = 0.15 in

An area-depth table is not available for the Machias River. It is further complicated by the fact that the BFE is not described by a closed polygon since the river opens up downstream. The assumed effected area is shown in Figure A5. The shoreline boundaries correspond to the FEMA map. The BFE in the Machias River is reported as 10.7-ft; for simplicity here it was taken as 11-ft. The fill depth spread over the assumed area is

Fill depth (BFE rise) = 216,000 ft^3 / 1,100,000 ft^2 = 0.20 ft = 2.4 in

This is likely a conservative assumption about the extent of where the BFE might rise. Larger areas will lower the effective depth. Based on this simple geometric analysis, we conclude that fill placement is well withing a “no rise” result and will not create a significant encroachment.

Figure A1. Topo/Bathy Contours Near Culverts with Section Line

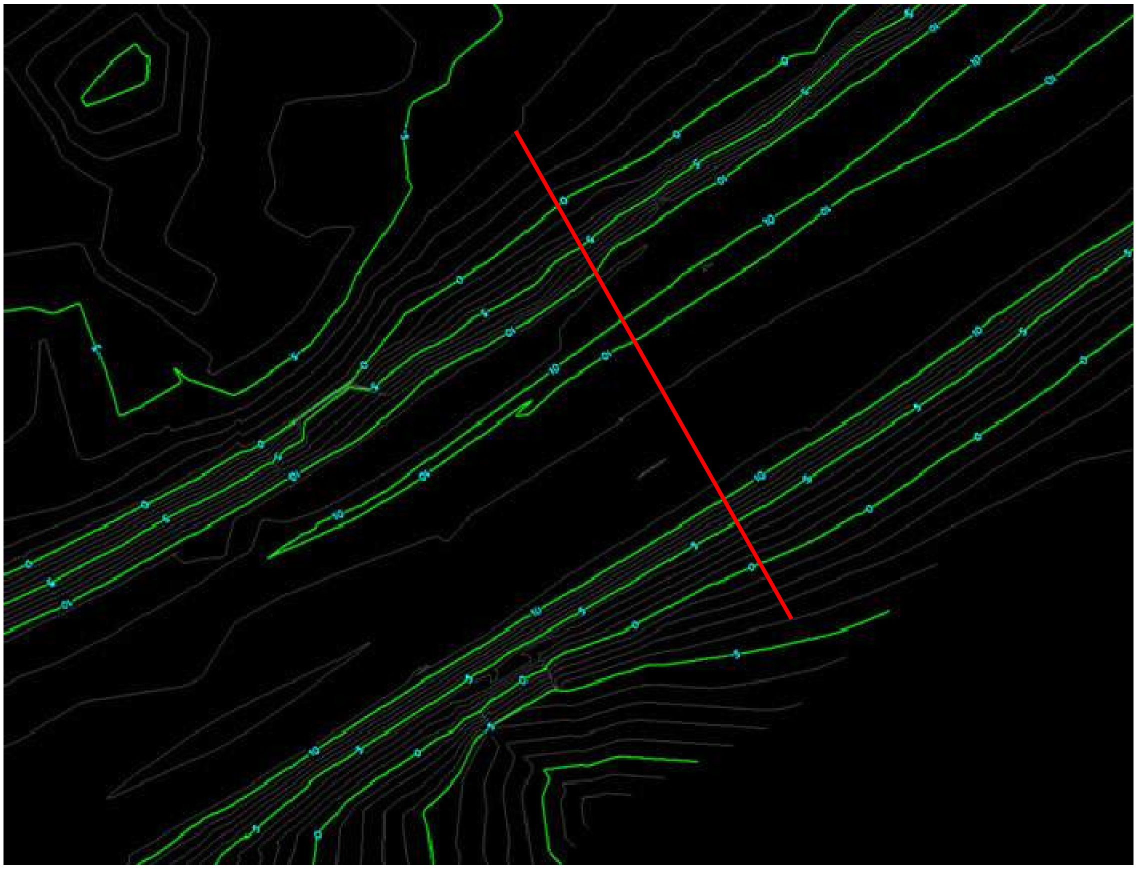


Figure A2. Causeway Section Just North of Culverts

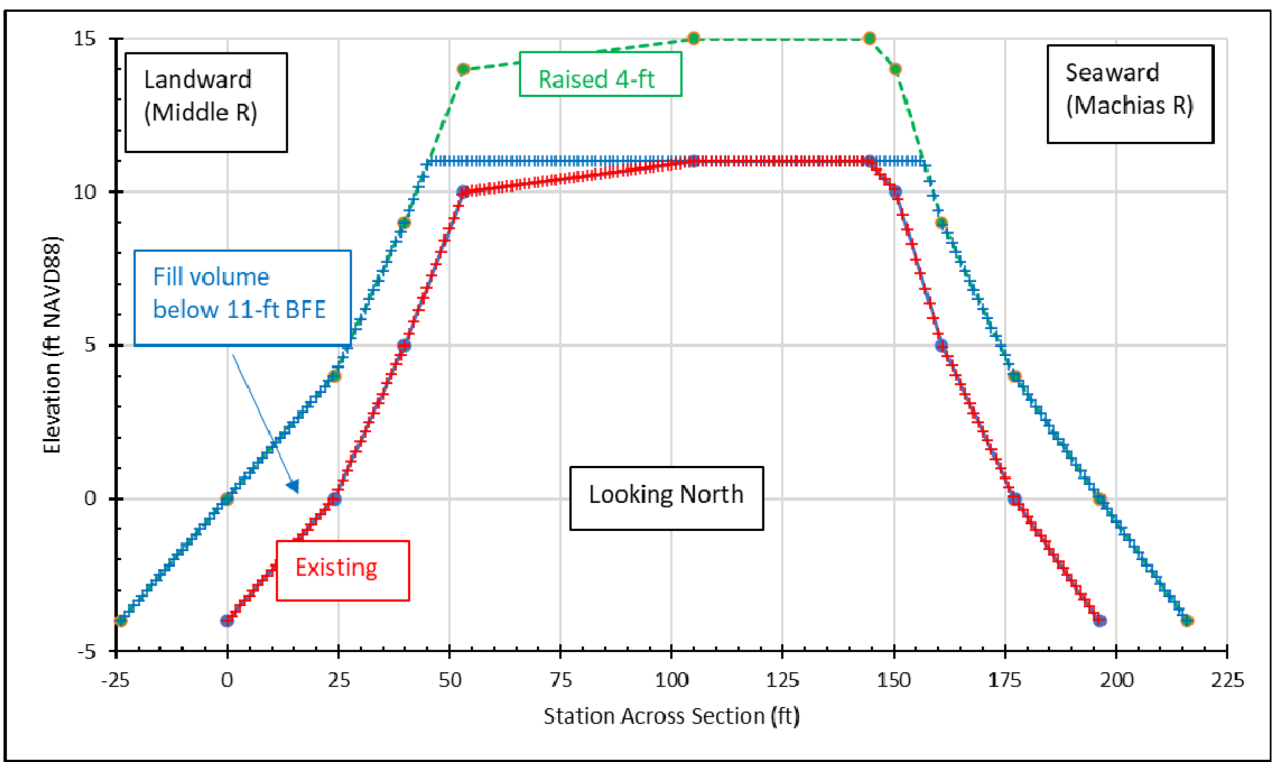


Figure A3. Fill Volume Across Section

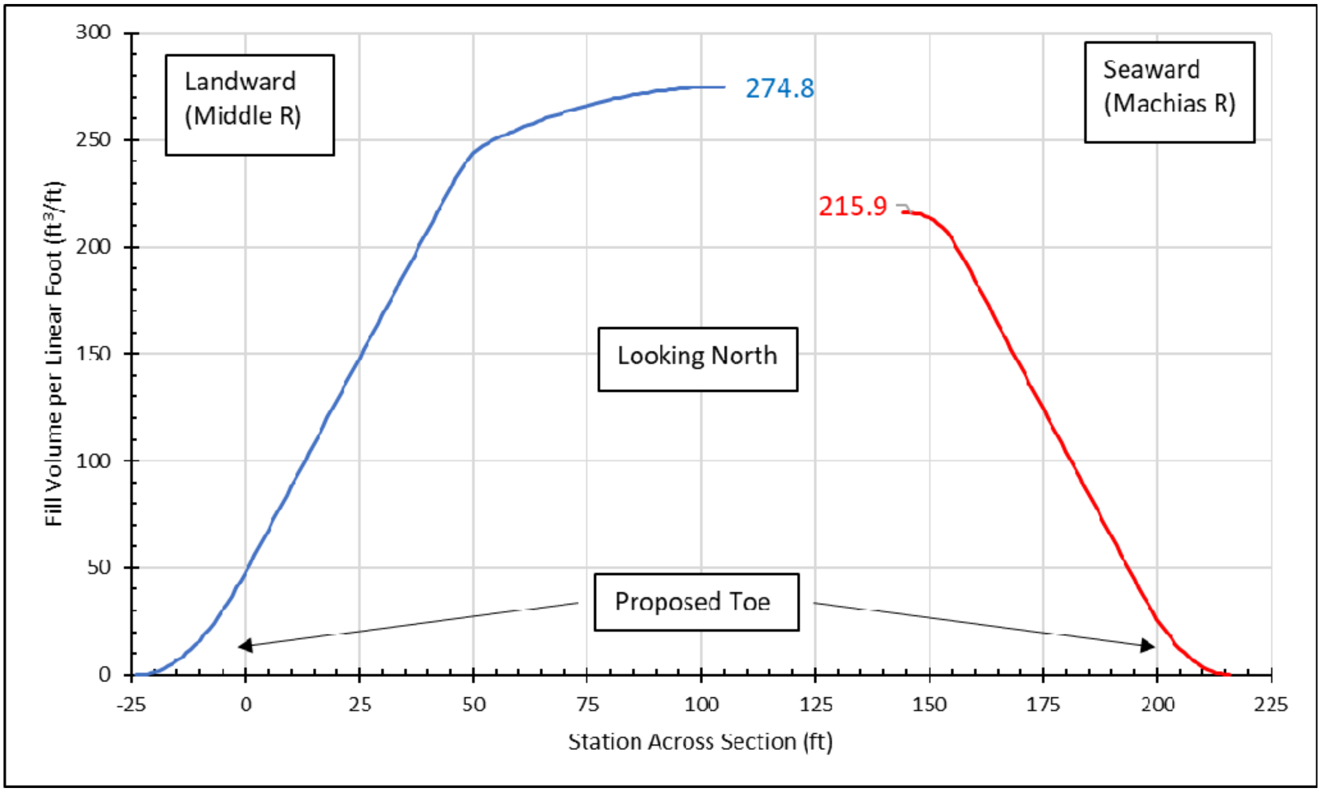


Figure A4. Fill Volume vs Elevation

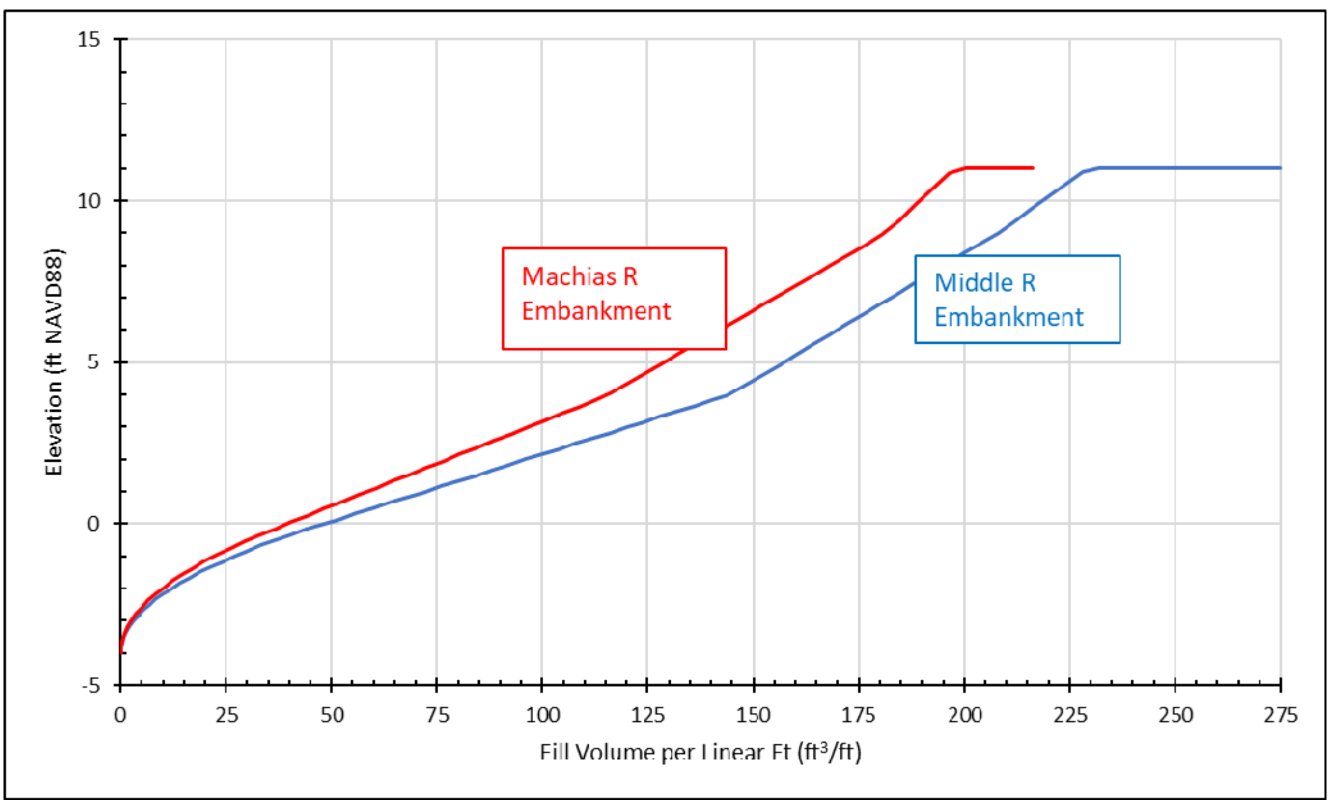
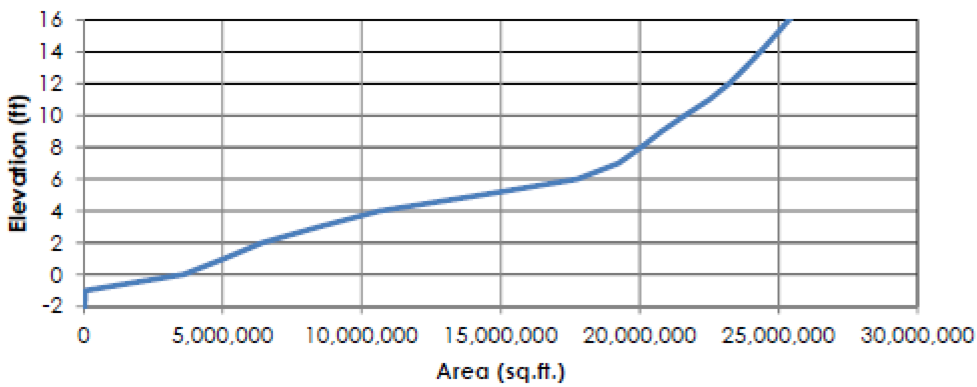


Table A1. Middle River Hypsometric Curve

Appendix B: ELEVATION-AREA INFORMATION, MIDDLE RIVER LANDWARD FROM DYKE BRIDGE

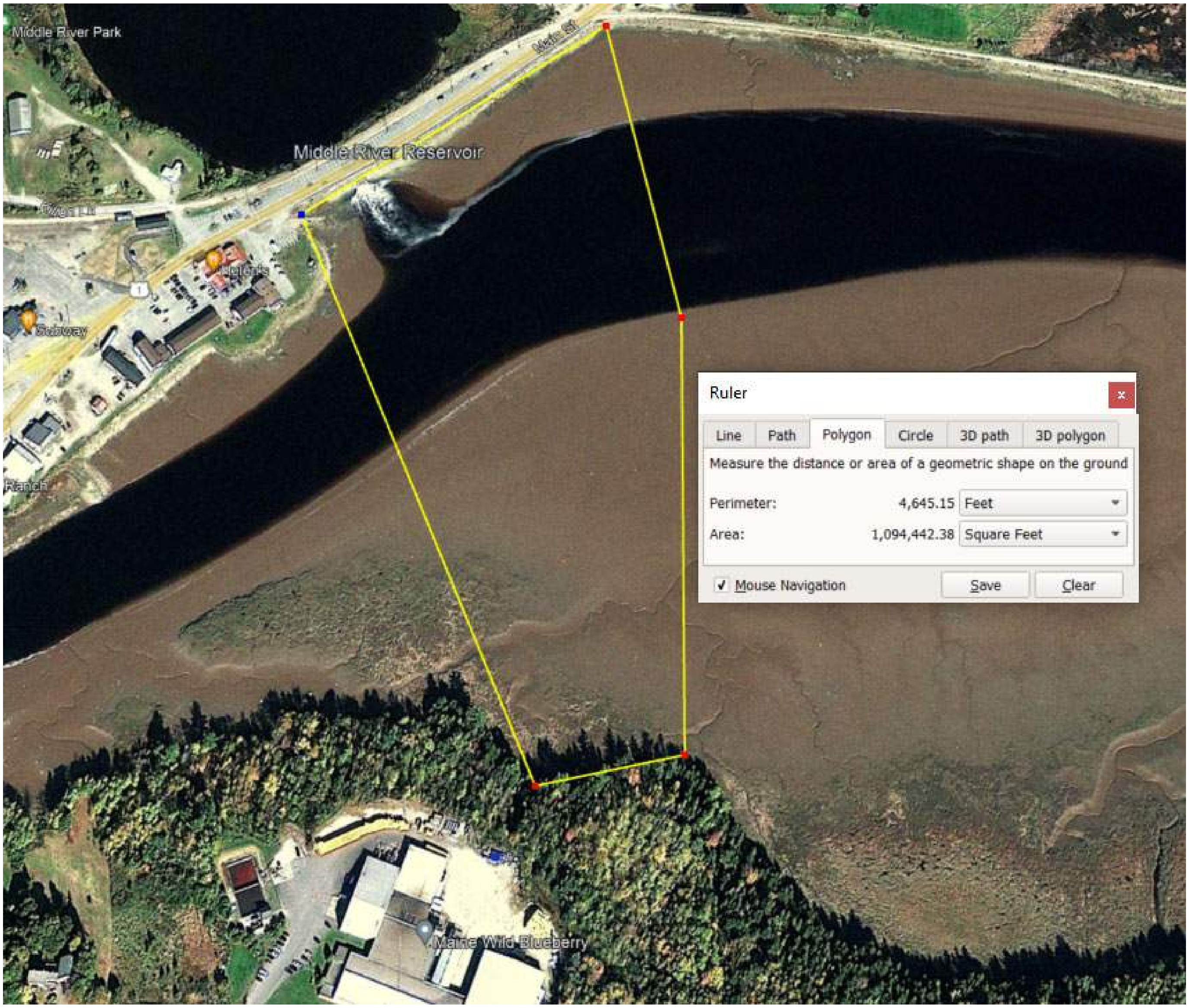
Plot of Elevation-Area Data



Tabular Elevation-Area Data

Elevation (ft NAVD88)	Area (sq. ft)	Area (acres)
-1	62,361	1.43
0	3,584,172	82.3
1	5,052,564	116
2	6,426,034	148
3	8,469,801	194
4	10,661,151	245
5	14,323,379	329
6	17,742,072	407
7	19,237,352	442
8	20,052,345	460
9	20,780,224	477
10	21,623,345	496
11	22,513,513	517
12	23,220,294	533
13	23,796,594	546
14	24,328,877	559
15	24,853,485	571
16	25,366,834	582

Figure A5. Effected Area in Machias River (assumed)



SUBCHAPTER G - ENGINEERING AND TRAFFIC OPERATIONS

PART 650 - BRIDGES, STRUCTURES, AND HYDRAULICS

Subpart A - Location and Hydraulic Design of Encroachments on Flood Plains

Sec.

Authority:23 U.S.C. 109 (a) and (h), 144, 151, 315, and 319; 23 CFR 1.32; 49 CFR 1.48(b), E.O. 11988 (3 CFR, 1977 Comp. p. 117); Department of Transportation Order 5650.2 dated April 23, 1979 (44 FR 24678); section 161 of Public Law 97-424, 96 Stat. 2097, 3135; section 4(b) of Public Law 97-134,95 Stat. 1699; and 33 U.S.C. 401, 491 et seq., 511 et seq.; and section 1057 of Public Law 102-240, 105 Stat. 2002.

[59 FR 37935, July 26, 1994]

Source:44 FR 67580, Nov. 26, 1979, unless otherwise noted.

Sec. 650.101 Purpose.

To prescribe Federal Highway Administration (FHWA) policies and procedures for the location and hydraulic design of highway encroachments on flood plains, including direct Federal highway projects administered by the FHWA.

Sec. 650.103 Policy.

It is the policy of the FHWA:

(a) To encourage a broad and unified effort to prevent uneconomic, hazardous or incompatible use and development of the Nation's flood plains,

(b) To avoid longitudinal encroachments, where practicable,

(C) To avoid significant encroachments, where practicable,

(d) To minimize impacts of highway agency actions which adversely affect base flood plains,

(e) To restore and preserve the natural and beneficial flood-plain values that are adversely impacted by highway agency actions,

(f) To avoid support of incompatible flood-plain development,

(g) To be consistent with the intent of the Standards and Criteria of the National Flood Insurance Program, where appropriate, and

(h) To incorporate "A Unified National Program for Floodplain Management" of the Water Resources Council into FHWA procedures.

Sec. 650.105 Definitions.

(a) "Action" shall mean any highway construction, reconstruction, rehabilitation, repair, or improvement undertaken with Federal or Federal-aid highway funds or FHWA approval.

(b) "Base flood" shall mean the flood or tide having a 1 percent chance of being exceeded in any given year.

(c) "Base flood plain" shall mean the area subject to flooding by the base flood.

(d) "Design Flood" shall mean the peak discharge, volume if appropriate, stage or wave crest elevation of the flood associated with the probability of exceedance selected for the design of a highway encroachmcnt. By definition, the highway will not be inundated from the stage of the design flood.

(e) "Encroachment" shall mean an action within the limits of the base flood plain.

(f) "Floodproof" shall mean to design and construct individual buildings, facilities, and their sites to protect against structural failure, to keep water out or to reduce the effects of water entry.

(g) "Freeboard" shall mean the vertical clearance of the lowest structural member of the bridge superstructure above the water surface elevation of the overtopping flood.

(h) "Minimize" shall mean to reduce to the smallest practicable amount or degree.

(i) "Natural and beneficial flood-plain values" shall include but are not limited to fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge.

(j) "Overtopping flood" shall mean the flood described by the probability of exceedance and water surface elevation at which flow occurs over the highway, over the watershed divide, or through structure(s) provided for emergency relief.

(k) "Practicable" shall mean capable of being done within reasonable natural, social, or economic constraints.

(l) "Preserve" shall mean to avoid modification to the functions of the natural flood-plain environment or to maintain it as closely as practicable in its natural state.

(m) "Regulatory floodway" shall mean the flood-plain area that is reserved in an open manner by Federal, State or local requirements, i.e., unconfined or unobstructed either horizontally or vertically, to provide for the discharge of the base flood so that the cumulative increase in water surface elevation is no more than a designated amount (not to exceed 1 foot as established by the Federal Emergency Management Agency (FEMA) for administering the National Flood Insurance Program).

(n) "Restore" shall mean to reestablish a setting or environment in which the functions of the natural and beneficial flood-plain values adversely impaeted by the highway agency action can again operate.

(o) "Risk" shall mean the consequences associated with the probability of flooding attributable to an encroachment. It shall include the potential for property loss and hazard to life during the service life of the highway.

(p) "Risk analysis" shall mean an economic comparison of design alternatives using expected total costs (construction costs plus risk eosts) to determine the alternative with the least total expected cost to the public. It shall include probable flood-related costs during the service life of the facility for highway operation, maintenance, and repair, for highway-aggravated flood damage to other property, and for additional or interrupted highway travel.

(q) "Significant encroachment" shall mean a highway encroachment and any direct support of likely base flood-plain development that would involve one or more of the following construction-or flood-related impacts:

(1) A significant potential for interruption or termination of a transportation facility which is needed for emergency vehicles or provides a community's only evacuation route.

(2) A significant risk, or

(3) A significant adverse impact on natural and beneficial flood-plain values.

(r) "Support base flood-plain development" shall mean to encourage, allow, serve, or otherwise facilitate additional base flood-plain development. Direct support results from an encroachment, while indirect support results from an action out of the base flood plain.

Sec. 650.107 Applicability.

(a) The provisions of this regulation shall apply to all encroachments and to all actions which affect base flood plains, except for repairs made with emergency funds (23 CFR Part 668) during or immediately following a disaster.

(b) The provisions of this regulation shall not apply to or alter approvals or authorizations which were given by FHWA pursuant to regulations or directives in effect before the effective date of this regulation.

Sec. 650.109 Public involvement.

Procedures which have been established to meet the public involvement requirements of 23 CFR Part 771 shall be used to provide opportunity for early public review and comment on alternatives which contain encroachments.

[53 FR 11065, Apr. 5, 1988]

Sec. 650.111 Location hydraulic studies.

(a) National Flood Insurance Program (NFIP) maps or information developed by the highway agency, if NFIP maps are not available, shall be used to determine whether a highway location alternative will include an encroachment.

(b) Location studies shall include evaluation and discussion of the practicability of alternatives to any longitudinal encroachments.

(c) Location studies shall include discussion of the following items, commensurate with the significance of the risk or environmental impact, for all alternatives containing encroachments and for those actions which would support base flood-plain development:

(1) The risks associated with implementation of the action,

(2) The impacts on natural and beneficial flood-plain values,

(3) The support of probable incompatible flood-plain development,

(4) The measures to minimize flood-plain impacts associated with the action, and

(5) The measures to restore and preserve the natural and beneficial flood-plain values impacted by the action.

(d) Location studies shall include evaluation and discussion of the practicability of alternatives to any significant encroachments or any support of incompatible flood-plain development.

(e) The studies required by Sec. 650.111 (c) and (d) shall be summarized in environmental review documents prepared pursuant to 23 CFR Part 771.

(f) Local, State, and Federal water resources and flood-plain management agencies should be consulted to determine if the proposed highway action is consistent with existing watershed and flood-plain management programs and to obtain current information on development and proposed actions in the affected watersheds.

Sec. 650.113 Only practicable alternative finding.

(a) A proposed action which includes a significant encroachment shall not be approved unless the FHWA finds that the proposed significant encroachment is the only practicable alternative. This finding shall be included in the final environmental document (final environmental impact statement or finding of no significant impact) and shall be supported by the following information:

(1) The reasons why the proposed action must be located in the flood plain,

(2) The alternatives considered and why they were not practicable, and

(3) A statement indicating whether the action conforms to applicable State or local flood-plain protection standards.

[44 FR 67580, Nov. 26, 1979, as amended at 48 FR 29274, June 24, 1983]

Sec. 650.115 Design standards.

(a) The design selected for an encroachment shall be supported by analyses of design alternatives with consideration given to capital costs and risks, and to other economic, engineering, social and environmental concerns.

(1) Consideration of capital costs and risks shall include, as appropriate, a risk analysis or assessment which includes:

(i) The overtopping flood or the base flood, whichever is greater, or

(ii) The greatest flood which must flow through the highway drainage structure(s), where overtopping is not practicable. The greatest flood used in the analysis is subject to state-of-the-art capability to estimate the exceedance probability.

(2) The design flood for encroachments by through lanes of Interstate highways shall not be less than the flood with a 2 percent chance of being exceeded in any given year. No minimum design flood is specified for Interstate highway ramps and frontage roads or for other highways.

(3) Freeboard shall be provided, where practicable, to protect bridge structures from debris- and scour-related failure.

(4) The effect of existing flood control channels, levees, and reservoirs shall be eonsidered inestimating the peak discharge and stage for all floods considered in the design.

(5) The design of encroachments shall be consistent with standards established by the FEMA, State, and local governmental agencies for the administration of the National Flood Insurance Program for:

(i) All direct Federal highway actions, unless the standards are demonstrably inappropriate, and

(ii) Federal-aid highway actions where a regulatory floodway has been designated or where studies are underway to establish a regulatory floodway.

(b) Rest area buildings and related water supply and waste treatment facilities shall be located outside the base flood plain, where practicable. Rest area buildings which are located on the base flood plain shall be floodproofed against damage from the base flood.

(c) Where highway fills are to be used as dams to permanently impound water more than 50 acre-feet ($6.17X10^4$ cubic metres) in volume or 25 feet (7.6 metres) deep, the hydrologic, hydraulic, and structural design of the fill and appurtenant spillways shall have the approval of the State or Federal agency responsible for the safety of dams or like structures within the State, prior to authorization by the Division Administrator to advertise for bids for construction.

Sec. 650.117 Content of design studies.

(a) The detail of studies shall be commensurate with the risk associated with the encroachment and with other economic, engineering, social or environmental concerns.

(b) Studies by highway agencies shall contain:

(1) The hydrologic and hydraulic data and design computations,

(2) The analysis required by Sec. 650.115(a), and

(3) For proposed direct Federal highway actions, the reasons, when applicable, why FEMA criteria (44 CFR 60.3, formerly 24 CFR 1910.3) are demonstrably inappropriate.

(c) For encroachment locations, project plans shall show:

(1) The magnitude, approximate probability of exceedance and, at appropriate locations, the water surface elevations associated with the overtopping flood or the flood of Sec. 650.115(a)(1) (ii), and

(2) The magnitude and water surface elevation of the base flood, if larger than the overtopping flood.

Form FHWA-881 (Rev. 11-67)

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
MINUTE - MEMO

Use this form in lieu of transmittal slips within Dept. of Trans. when message comment is to be retained as file material. Do not prepare carbons. Not to be used in lieu of Form FHWA-121 for informal correspondence.

SUBJECT

Significant Encroachments

TO	MESSAGE/COMMENT	FROM/DATE
E. Cleckley HEV-10	The following guidance is provided regarding the determination of a significant encroachment as defined in FHPM 6-7-3-2:	S. Gordon HNG-31 4/2/85

A significant encroachment is a Federal Action within the base flood plain (or any direct support of likely flood plain development) that would involve one of the following:

(1) significant potential for interruption or termination of a transportation facility which is needed for emergency vehicles or which provides a community's only evacuation route,

(2) a significant risk, or

(3) a significant adverse impact on natural and beneficial flood plain values.

In items 1 thru 3 above, the term significant is defined in the same manner as is used in environmental review procedures - i.e., a project with a significant encroachment must be processed with an EIS. This type of determination for items (2) and (3) above is made in a manner similar to any other type of impact and has generally been handled by FHWA and the States without problems in interpretation. Item (1), on the other hand, has caused problems in interpretation and is therefore explained in further detail.

If a planned Federal action would result in a significant potential for interruption or termination of the type of transportation facility described in (1) above, it shall be termed a significant encroachment. Engineering judgment is required in evaluating the site conditions to decide whether the Federal action should be classified as a significant encroachment, taking into consideration:

(1) extent and frequency of overtopping of the facility by floodwaters,

(2) consequences of overtopping - anticipated damages and effect on the community served, and

(3) other relevant factors that may have some bearing on the case such as amount of traffic using the facility, number of people in the community, general elevation of the community as compared with the overtopping elevation, anticipated time for advance warning, etc.

Form FHWA-881 (Rev. 11-67)

U.S. DEPARTMENT OF TRANSPORTATION
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MINUTE - MEMO

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SUBJECT

TO	MESSAGE/COMMENT	FROM/DATE

The determination of a significant encroachment is based on the proposed Federal action rather than on the existing transportation facility; therefore, an improvement proposed for construction on an existing alignment that alleviates or does not worsen the existing flood hazard would not normally be considered as a significant encroachment. In planning this type of project, consideration should be given to the need to minimize the flooding hazard for the entire section of the highway facility in the base flood plain. Where it is not practical to accomplish this objective, the project records should support the basis for the design selected, and there should be reasonable public notification of the proposed design.

It is our view that incorporation of the type of significant encroachment described above (resulting from a significant potential for interruption of a transportation facility) is rarely justified for Federal-aid highway projects on new location. Where the evaluation of site conditions for such facilities indicates substantial risks, we would encourage raising the transportation facility to an elevation (normally the 100-year flood or tide elevation) that would minimize the risk and avoid the significant encroachment.

Stantec

Memo

To:	Maine Department of Transportation Augusta, Maine	From:	Lori Benoit, Michael Chelminski Northampton MA Office
File:	197450347	Date:	November 8, 2021

Reference: Estimated Elevation Ranges of Intertidal Habitats for Middle River / Dyke Bridge Alternatives

In support of the Dyke Bridge Replacement Project (Project) located on the Middle River in Machias, Maine, Stantec was tasked with estimating the extent of tidal wetland habitats for two previously vetted alternatives (4m and 10) for replacing existing flap gates at Dyke Bridge. Stantec reviewed existing background information and data on tidal hydrology and vegetation elevations and distribution in the following documents:

- Technical Report: Middle River Hydrologic and Alternatives Analysis, Stantec 2015
- Memo: Draft Phase 1 Hydraulic Analysis for Machias Dyke Bridge (#2246) Planning Phase Support Services, September 2, 2021, Stantec to MaineDOT (Stantec 2021)
- Data: SchoppeeMarsh_TidalRestrictionAssessment_Draft_Hydrodata.xls. Schoppee Marsh Tide Gate Removal Project hydrology, elevation, and vegetation data from BB USFWS GOMP/ DSF.

SIMULATED TIDAL STAGE STATISTICS

Stantec 2021 presents information obtained from the preliminary, unsteady-state numerical hydraulic model study for a range of potential alternatives for the Project, including simulated water surface elevations in the Middle River for Alternatives 4m and 10. Tidal statistics were generated for the two noted alternatives based on a hydraulic model simulation period of 34 days. Boundary conditions for the unsteady-state simulations included a constant inflow of 13.7 cubic feet per second representing a typical discharge of the Middle River and a time-varying water surface elevation at downstream boundary condition based on tidal stage data collected in the Machias River by MaineDOT in 2011.

Tidal stage statistics were developed based on the simulated water surface elevations in the Middle River landward (upstream) from Dyke Bridge using the National Oceanic and Atmospheric Administration online Tidal Analysis Datum Calculator tool[1]. Calculated tidal statistics are presented in Table 1.

Table 1. Estimated Tide Statistics for the Middle River for Alternatives 4m and 10

	Estimated Tide Statistics (ft, NAVD88)	
	Alt4m	**Alt10**
Mean Higher High Water	2.01	7.39
Mean High Water	1.87	6.87
Mean Tide level	-0.41	0.21
Mean Low Water	-2.68	-6.46
Mean Lower Low Water	-2.73	-6.66

[1] CO-OPS Datum Calculator (noaa.gov)

Reference: Estimated Elevation Ranges of Intertidal Habitats for Middle River / Dyke Bridge Alternatives

ESTIMATED SALTMARSH RANGES

Based on this review, Stantec estimated potential elevation ranges for three habitat types of high marsh, low marsh, and unvegetated intertidal areas, and present the estimates in Table 1 with elevations referenced to the North American Vertical Datum of 1988 (NAVD88).

Table 2: Estimated Potential Saltmarsh Habitat Ranges

	Estimated Saltmarsh Habitat Ranges (ft, NAVD88)			
	Alternative 4m		**Alternative 10**	
Estimated Habitat	Low Range	High Range	Low Range	High Range
High Marsh	1.9	2.0	6.9	7.4
Low Marsh	0.8	1.9	3.8	6.9
Unvegetated intertidal/subtidal	-	0.8	-	3.8

The attached figures depict the estimated areas of high marsh, low marsh, and unvegetated intertidal and subtidal habitats based on the elevation ranges in Table 1 using a digital terrain model developed using LiDAR data. These figures include estimated areas for the evaluated habitat types. The estimated habitat areas were developed based on the assumption that salinities in the Middle River landward from Dyke Bridge would be similar to salinities in the Machias River seaward from the bridge.

Unvegetated intertidal habitat is a distinct habitat type but here has been temporarily lumped with subtidal habitat until updated bathymetric data becomes available. Predicted elevations for saltmarsh habitats may be revised as additional information becomes available. The estimated elevations and descriptions for intertidal habitats landward of Dyke Bridge under two alternatives are based also on the following assumptions:

1) High marsh formation is predicted at elevations between mean high water (MHW) and mean higher high water (MHHW), which are areas typically inundated with salt water during only the highest tides of the month.

2) High marsh is typically dominated by saltmeadow cordgrass (*Spartina patens*). Black grass (*Juncus gerardii*) may be found at the highest elevations/upper border of the high marsh. Saltwater cordgrass (*Spartina alterniflora*) may be found in the high marsh in slight depressions on the marsh surface (high saline pannes) along with glasswort species (*Salicornia* spp.)

3) Low marsh has the potential to establish from MHW to the approximate elevation of the mean tide level (MTL). In actuality, *S. alterniflora* often is not found at elevations as low as the mean tide level (MTL). Data for the unrestricted portion of Machias River does not show low marsh close to the “Diurnal Tide Level” in the Machias River at an elevation (El.) of 0.47 ft (see “Assessment Notes” tab of Schoppee Marsh Excel file) and which Stantec assumes approximates the MTL. At the seaward side (no restriction) of the Machias River, the data gathered by DSF shows low marsh at El. 4.99 ft. Based on this data point, approximately 5 ft above the MTL appears to not be vegetated. However, this one data point for unrestricted low marsh is insufficient information to assess the overall elevation distribution of low marsh in the tidal wetland with unrestricted flows. Also, the start of downstream (presumably downstream of tide gate in unrestricted flow Machias River) low marsh is shown at

approximately EL. 3.6 ft in the Schoppee Marsh Excel file . In this case, approximately 50% of the tide range between MTL and MHHW is unvegetated. This data is consistent with previously published findings indicating that ice scour may limit the lower extent of low marsh in northern New England salt marshes (Hardwick-Witman 1986) and this may explain lack of Spartina alterniflora at or near the MTL. Therefore, the lower limit of low marsh for both alternatives 4m and 10 was roughly estimated as the MHHW el. minus 50% of the tide range between the MTL and the MHHW.

4) *S. alterniflora* is the dominant, monotypic plant species of the low marsh.

5) Unvegetated intertidal areas (encompasses habitat called “mud flat”) are expected in the range from MTL to mean lower low water. Erosion caused by ice scour of mid-range intertidal areas may limit the lower extent of vegetated intertidal areas. Increased height of tidal flooding may inhibit *S. alterniflora* growth in the intertidal region below MHW particularly in locations such as the Gulf of Maine that experiences extreme tidal ranges.

6) At individual tidal sites, variations in microtopography and flood/drainage patterns, including those due to disturbances such as culverts and tide gates that cause tidal restrictions, may alter the elevations and predicted patterns at which high marsh, low marsh, and unvegetated tidal areas are established.

7) Estimated ranges of intertidal habitats for Alternative 10 were adjusted based on field-collected data at unrestricted Machias River intertidal sites. Notably, the extreme tide heights, and duration, and ice scour may preclude low marsh/ *S. alterniflora* establishment in a significant portion of the intertidal zone below MHW.

8) Under the Alternative 4m scenario, it was assumed that high marsh may become established in a narrow elevation range that will not be flooded daily but only on the highest predicted tides each month and based on restricted flow through the culverts that will limit the higher tidal heights.

MIDDLE RIVER STAGE-AREA CURVE

A stage-area (hypsometric) curve was developed from a digital terrain model (DTM) of land adjacent to the Middle River upstream from Dyke Bridge to the vicinity of Stride Bridge. The DTM was developed using existing LiDAR and was initially compiled for development of the project hydraulic model study program.

Figure 1 depicts the stage-area curve along with the estimated High Marsh and Low Marsh habitat elevation ranges for Alternatives 4m and 10 that are presented in Table 2. Table 3 presents the stage-area data in tabular format.

The stage-area data does not include areas for elevations below Elevation 0.0 ft which are largely in the current area that is inundated during normal tidal conditions in the Middle River upstream from Dyke Bridge. The estimated saltmarsh habitat ranges presented in Table 2 and in Figure 1 indicate that areas below Elevation 0.0 would be unvegetated intertidal/subtidal habitat for Alternative 4m and that areas below Elevation 4.5 ft would be unvegetated intertidal/subtidal habitat for Alternative 10.

Reference: **Estimated Elevation Ranges of Intertidal Habitats for Middle River / Dyke Bridge Alternatives**

Figure 1. Stage-Area Curve

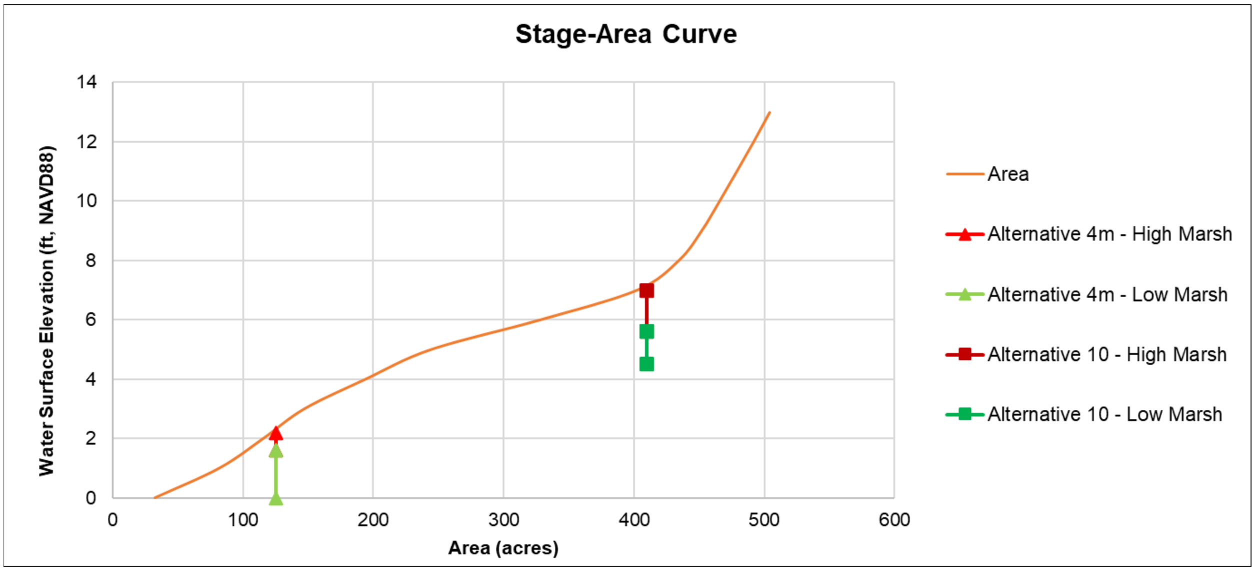

Table 3. Stage-Area Curve Data from Figure 1 for Middle River Upstream from Dyke Bridge

WSEL (ft, NAVD88)	Area (acres)
0	33
1	82
2	116
3	147
4	194
5	244
6	328
7	402
8	434
9	452
10	465
11	478
12	491
13	504

Reference: Estimated Elevation Ranges of Intertidal Habitats for Middle River / Dyke Bridge Alternatives

DATA LIMITATIONS AND CAVEATS

The methodology for collection of vegetation data by DSF is not provided. Using a series of transects from below MTL to the upland is a standard method for vegetation assessment. Identifying plants and community types on the fly in the field and taking vegetation and elevation data would not be recommended as this approach could introduce selection bias.

We are not able to determine from the DSF plant community and elevation data exactly which data applies to the Eastern Schoppee Marsh. That location has a partial tidal restriction (does not drain fully at low tide and does not reach full tidal height compared to the unrestricted Machias River) and could be skewing the data if it is grouped with the "unrestricted" data. Based on the presentation of three sets of tidal data (Machias River, Schoppee Marsh Restricted, and Schoppee Marsh Eastern), we would expect three sets of vegetation data that reflect the tidal regime in each location. However, plant community and elevation data is shown only as restricted vs. unrestricted. Are there any vegetation and elevation data specifically for the Eastern Schoppee Marsh? Of the three locations, the Eastern Schoppee Marsh may be most similar to the alternative 4m.

Elevations of vegetation community called "Low hypersaline panne – restricted" does not make sense given the elevations of the high marsh. Hypersaline pannes are embedded within the high marsh zone and are typically only a few millimeters lower in elevation than the surrounding S. patens-dominated high marsh. The elevation data for the pannes appear to be lower by a foot or more in elevation compared to the high marsh. It is possible that these areas are stunted and dying S. alterniflora areas caused by excessive duration of flooding upstream of the Schoppee tide gate.

The data assessment appears to be in the draft stage. Note comment by "WBennett" regarding the vegetation community classification: "Need to further evaluate the classification of different communities. Many irregularities exist and overlap." We suggest proceeding with caution on using and interpreting the existing data for predicting locations/areas of salt marsh habitats for the different design alternatives. We may want to discuss the data with DSF, and additional data collection may be warranted.

Please contact Stantec with questions or comments regarding the information presented in this memo.

Stantec Consulting Services Inc.

for K B T 11/08/2021

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11/8/2021

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Attachment: Figure 1: Alternative 4m, Estimated Saltmarsh Habitat
Figure 2: Alternative 10, Estimated Saltmarsh Habitat

c. Tim Merritt, Stantec

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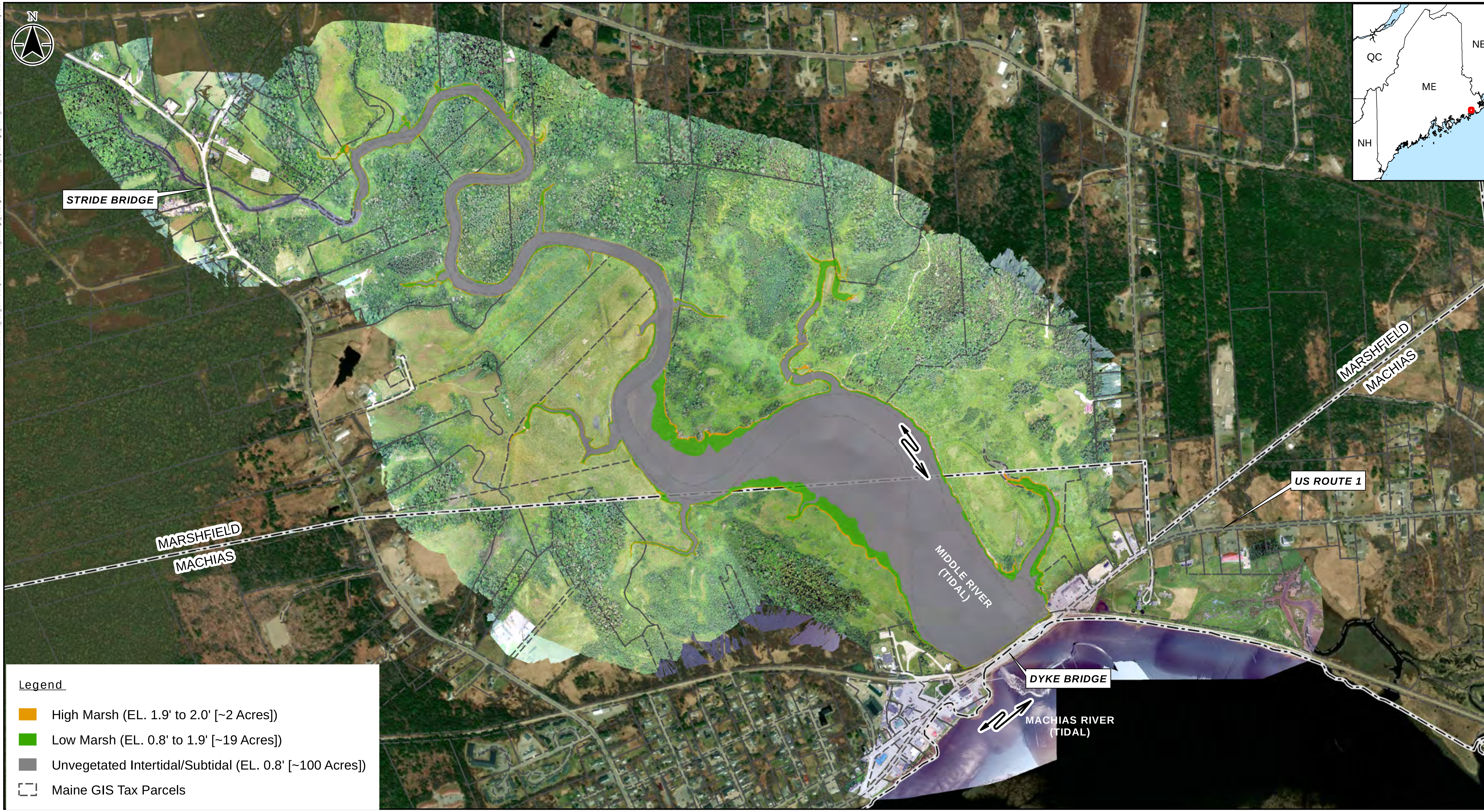

179450347

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Prepared by EPL on 2021-08-09
Reviewed by MRC on 2021-08-09

50347_DykeBridge_Alt4m_marshes.mxd

Notes

1. Approximate water surface elevations (WSEL) for proposed alternatives are based on the 2021 Phase 1 hydraulics analysis using tidal stage data collected by MaineDOT in 2011.
2. Coordinate System: NAD 1983 UTM Zone 19N FT
3. Vertical Datum: NAVD88
4. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
5. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
6. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

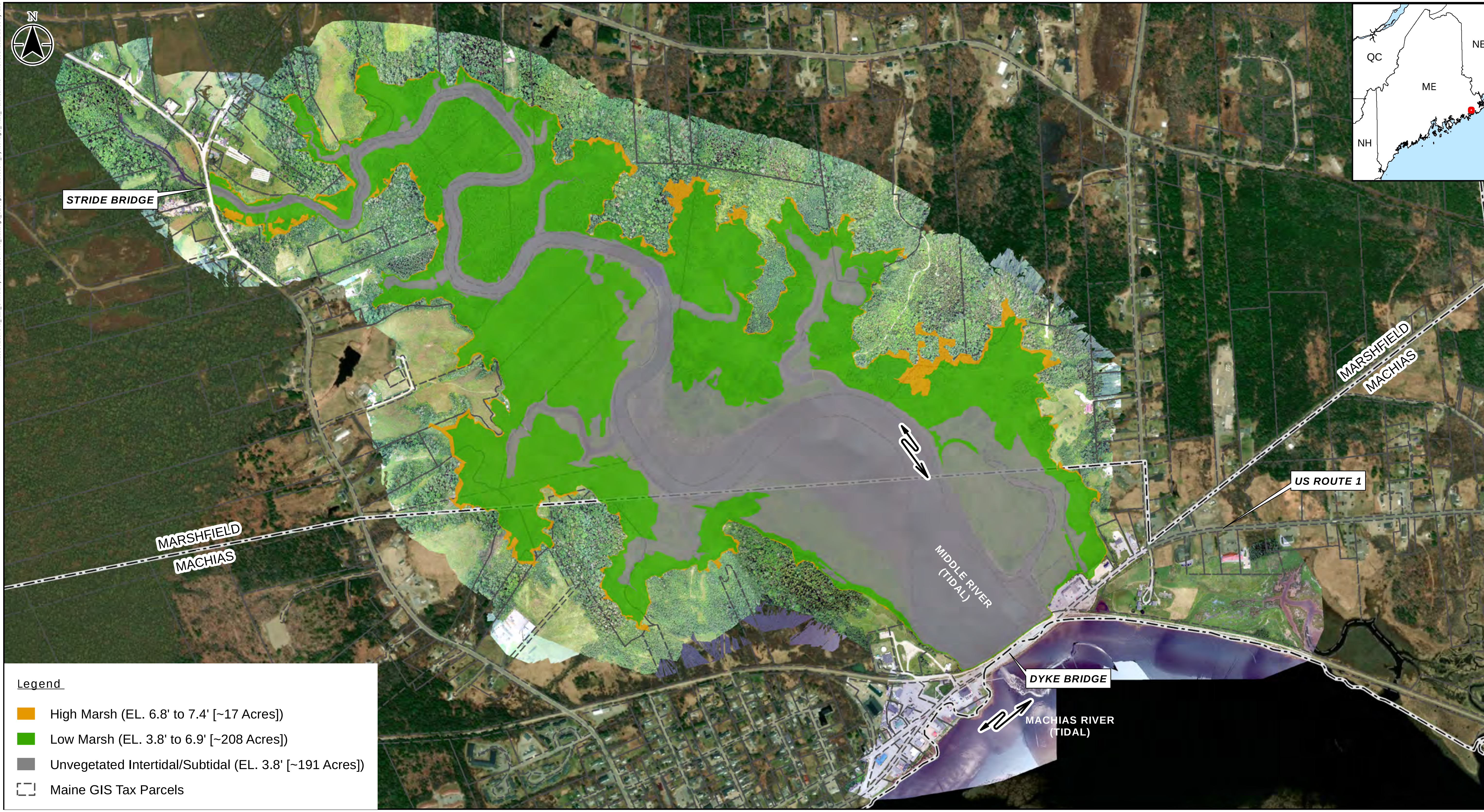
0 800 Feet
1 inch = 833 feet (At page size of 11"x17")

Client/Project
Maine DOT
Dyke Bridge
Machias, Maine

Figure No.
1

Title Alternative 4m
Estimated Saltmarsh Habitat

11/9/2021



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Prepared by EPL on 2021-08-09
Reviewed by MRC on 2021-08-09

50347_DykeBridge_Alt10_marshes.mxd

Notes

1. Approximate water surface elevations (WSEL) for proposed alternatives are based on the 2021 Phase 1 hydraulics analysis using tidal stage data collected by MaineDOT in 2011.
2. Coordinate System: NAD 1983 UTM Zone 19N FT
3. Vertical Datum: NAVD88
4. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
5. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
6. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

Client/Project
Maine DOT
Dyke Bridge
Machias, Maine

Figure No.
2

Title Alternative 10
Estimated Saltmarsh Habitat

11/9/2021

APPENDIX 6 – LANDFILL IMPACTS

1. Overview: Machias Landfill Investigation
2. November 2022 Report: Machias Landfill Investigation, Machias Dyke Bridge, MaineDOT WIN 16714.00, Machias, Maine
3. 8/26/2022 Memo: DRAFT Preliminary Municipal Landfill Impact Evaluation; Machias – Dike Bridge (#2246) Planning Phase Support Services Amendment #2

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

Janet T. Mills
GOVERNOR

Bruce A. Van Note
COMMISSIONER

OVERVIEW

MACHIAS LANDFILL INVESTIGATION

BACKGROUND: MaineDOT has completed an environmental and geotechnical assessment of subsurface conditions at the closed Machias Landfill. The primary objectives of this assessment focused on defining the existing stability of the landfill and current groundwater quality conditions. Additionally, based on findings, an evaluation was performed relative to potential impacts to the landfill associated with rising surface water levels in adjacent wetlands and the nearby Middle River.

ASSESSMENT: Work at the closed Machias Landfill included a subsurface investigation, groundwater monitoring, laboratory testing, and hydrogeologic and geotechnical evaluations. Eight subsurface test borings were drilled around and through the Landfill; groundwater observation wells were installed in five of the eight borings. Geologic and geotechnical samples were collected from the borings.

Groundwater levels and water quality samples were collected from the observation wells.

Geotechnical and water quality samples were sent to certified laboratories for testing. Information on the engineering properties of soils and the chemistry of groundwater near the Landfill was obtained.

Information captured in the field and from testing was used to perform engineering and hydrogeologic evaluations of conditions at the Landfill. Standard industry practices, aided with computer-assisted modeling, served as the basis for the evaluations.

FINDINGS: Groundwater at the Landfill flows generally from west to east with discharge into the adjacent wetland. Laboratory testing of groundwater samples suggest the Landfill has caused some impact on existing water quality; the most notable concerns are inorganic compounds (dissolved metals) and PFAS compounds. Barium, cadmium, iron, and manganese were found to exceed Maine Department of Environmental Protection (MDEP) Maximum Exposure Guidelines (MEGs) for drinking water.

PFAS compounds also exceeded Maine Drinking Water standards. The Maine Center for Disease Control (CDC) has implemented an interim drinking water standard of 20 ng/L-parts per trillion (ppt; alone or in combination) for the six regulated PFAS contaminants that include: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS), perfluorononanoic acid (PFNA), perfluoroheptanoic acid (PFHpA) and perfluorodecanoic acid (PFDA). Total PFAS (6) results ranged from 26.5 ng/L to 181 ng/L with all samples exceeding the CDC 20 ng/L standard.

Engineering calculations and computer modelling indicate the Landfill is currently stable. Underlying soil and groundwater conditions are favorable to support the Landfill. The calculated "Factor of Safety" values (a geotechnical measure of how stable a slope is given underlying soil characteristics and geometry of the slope) exceed recommended levels. Even under extreme structural forces such as an earthquake, engineering calculations indicate the Landfill exceeds the "pseudo-static seismic load" factor of safety threshold.

Further technical evaluations to determine the sensitivity of the Landfill's global stability relative to increasing surface and groundwater levels were performed. Results of these evaluations indicate that elevated water levels outside the landfill (i.e., at the toe of the landfill slope) would not negatively impact global stability factors of safety. Elevated water levels within the landfill (i.e., inboard of the landfill toe) were found to have a slight negative impact on the factor of safety, but the levels would need to be raised considerably (i.e., up to approximately elevation 31, about 30 feet above the current river level and 11 feet above measured stabilized groundwater levels within the landfill) to cause an unsatisfactory factor of safety.

Calculations indicate that increasing water levels in the Middle River estuary system associated with MaineDOT's proposed Machias Dike alternatives will not adversely impact the Machias Landfill. Depending on the proposed alternative, surface water levels in the Middle River are anticipated to increase upwards of 14 plus feet; as discussed previously, any anticipated rise in surface water levels associated with the Machias Dike alternatives will not adversely impact the Landfill.

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REPORT ON

MACHIAS LANDFILL INVESTIGATION
MACHIAS DIKE BRIDGE
MAINEDOT WIN 16714.00
MACHIAS, MAINE

by
Haley & Aldrich, Inc.
Portland, Maine

for
Maine Department of Transportation
Augusta, Maine

File No. 0130749-009
November 2022

HALEY & ALDRICH, INC.
75 Washington Avenue
Suite 1A
Portland, ME 04101
207.482.4600

9 November 2022
File No. 0130749-009

Maine Department of Transportation
16 State House Station
Augusta, Maine 04333-0016

Attention: Dwight Doughty, Jr., C.G.

Subject: Report on Machias Landfill Investigation
Machias Dike Bridge
MaineDOT WIN 16714.00
Machias, Maine

Ladies and Gentlemen:

We are pleased to submit herewith our report entitled, "Report on Machias Landfill Investigation, Machias Dike Bridge, MaineDOT WIN 16714.00, Machias Maine." This report has been prepared in accordance with our mutually agreed upon work scope and in accordance with the scope outlined in our Assignment Letter #8, dated 14 June 2022, under our environmental MultiWIN contract number 20170626000000000824 dated 22 June 2017.

Introduction

This report presents the results of the subsurface investigation and laboratory testing programs, groundwater monitoring program, and geotechnical evaluations conducted by Haley & Aldrich, Inc. (Haley & Aldrich) on behalf of the Maine Department of Transportation (MaineDOT) for the proposed Machias Dike Bridge project at the Machias Landfill in Machias, Maine (see Figure 1, Project Locus).

HORIZONTAL COORDINATE SYSTEM AND ELEVATION DATUM

Plan locations of test borings are reported as northing and easting coordinates relative to the Maine State Plane Coordinate System, North American Datum of 1983 (NAD 83), Maine 2000 East Zone.

The project elevation datum and elevations referenced herein are in feet and reference the North American Vertical Datum of 1988 (NAVD 88).

PROJECT LOCATION AND EXISTING SITE CONDITIONS

The project site is located at an existing, grass-covered, closed landfill, with natural site grades around the landfill ranging from approximately El. 10 northeast of the landfill to approximately El. 55 southwest of the landfill. The maximum ground surface elevation within the existing landfill footprint is at approximately El. 69. A two-lane road and residential homes are located to the south and west of the landfill. The area to the north and east of the landfill is generally undeveloped and occupied by wooded areas and grassed fields.

A series of timber box culverts are currently located below US Route 1 at the mouth of the Middle River. The culvert conveys water flow between the Machias and Middle Rivers during tide cycles, with a current inundation level of approximately El. -1.0.

PROPOSED IMPROVEMENTS

We understand that MaineDOT is currently considering replacing the existing culvert with a single-span bridge at the mouth of the Middle River. The bridge is proposed to have a larger hydraulic opening than the existing culvert and would result in higher water inundation levels on the upstream (west) side of the proposed replacement bridge. Inundation levels up to approximately El. 14.7 (including sea level rise) were used in the evaluations below. It is our understanding, based on discussions with MaineDOT, that this elevation is the highest water level between proposed “Alternative 10” and the “do nothing” condition. The larger water inundation area will extend up to the eastern edge of the existing landfill.

Subsurface Exploration Program

Haley & Aldrich completed an initial subsurface exploration program in association with the subject project consisting of five test borings designated HA22-1/HA22-1B, HA22-2, and HA22-5 through HA22-7, that were drilled at the site from 27 June to 1 July 2022. Test borings HA22-3 and HA22-4 were laid out in the field and planned to be drilled depending on conditions encountered and available time. These two borings were not drilled. The purpose of the subsurface exploration program was to characterize the general subsurface conditions in the area of the existing landfill that could be impacted by the larger inundation area.

Haley & Aldrich completed a supplemental subsurface exploration program consisting of three test borings designated HA22-8 through HA22-10, that were drilled at the site from 25 to 26 July 2022. The purpose of the supplemental program was to install additional wells to monitor groundwater levels and to collect groundwater samples for analytical testing.

The test boring locations were laid out in the field by Haley & Aldrich by taping distances from existing site features prior to the start of drilling. “As-drilled” boring locations and ground surface elevations at boring locations were determined in the field by MaineDOT using GPS survey equipment upon completion of drilling. The plan location data of the borings are summarized in Table I and are provided on the individual boring logs in Appendix A. Boring locations are shown on Figure 2.

The initial test borings were drilled by New England Boring Contractors (NEBC) of Hermon, Maine using a Mobile Drill B-53 track-mounted drill rig and the supplemental test borings were drilled by S.W. Cole Explorations, LLC (SWC) of Bangor, Maine using a Diedrich D-50 track-mounted drill rig. Test borings were advanced using cased wash drilling methods to depths ranging from approximately 6.0 to 44.0 ft below existing ground surface (BGS) using 4-in. (HW-size) inside diameter (ID) steel casing. At three locations (HA22-1/HA22-1B, HA22-2, and HA22-5), the borings were drilled to bedrock and each sampled 5 ft of rock core. Soil samples were generally collected continuously through fill soils and at standard, 5-ft intervals thereafter, by driving a 1-3/8-in. inside diameter (ID) split-spoon sampler with a 140-lb hammer dropped from a height of 30 in., as indicated on the test boring logs. The number of hammer blows required to advance the sampler through each 6-in. interval was recorded and is provided on the boring logs. The uncorrected SPT N-value (N-uncorrected) is defined as the total number of blows required to advance the sampler through the middle 12 in. of the 24-in. sampling interval.

The drill rigs were equipped with calibrated automatic hammers. Based on the calibration information provided by NEBC and SWC, a theoretical hammer efficiency factor of 0.863 and 0.91 were used for the automatic hammers. The energy-corrected SPT N-value (N60) is equal to the uncorrected SPT N-value multiplied by the hammer efficiency factor (0.863 or 0.91) divided by 0.6 (i.e., 60 percent calculated hammer efficiency). Both the raw blow count (uncorrected N-values) and the corrected N-values are shown on the boring logs.

All soil and bedrock samples were collected and preserved in glass jars and wooden boxes, respectively. The samples that were not submitted for laboratory testing are available for review upon request. The available soil and bedrock samples are currently being stored at the Haley & Aldrich storage facility in Portland, Maine.

Five observation wells were installed in the completed boreholes HA22-1B, HA22-2, and HA22-8 through HA22-10 to provide information on the variability of static groundwater levels at the site and to collect samples for groundwater testing. The observation wells consisted of 2-in. ID, machine-slotted PVC pipe and solid PVC riser pipe extending approximately 2.4 to 3.1 ft above existing ground surface. The observation wells were outfitted with steel guard pipes and lock/cap assemblies. The observation well installation and groundwater monitoring reports are provided in Appendix B.

All drilling and sampling operations were performed in accordance with MaineDOT specifications.

Generalized Subsurface Conditions

SOIL CONDITIONS

The subsurface conditions encountered at the site during the recent subsurface exploration programs completed by Haley & Aldrich generally consist of the following geologic units presented in order of increasing depth below ground surface: fill, clay cap, landfill waste and cover, marine deposit (reworked), tidal marsh deposit, marine deposit (natural), fluvial deposit, glacial till, and bedrock. Refer to Table II for a summary of the soil units and encountered thicknesses at each test boring location. A general description of each soil/bedrock unit is provided separately, below. Detailed soil and bedrock descriptions are provided on the boring logs included in Appendix A.

Soil Unit	Approximate Range in Encountered Thickness (ft)	Generalized Description
Fill	4	Silty fine to medium SAND, trace coarse sand and gravel *(only encountered in test boring HA22-8, located at the edge of the public works storage area, outside the landfill footprint)*
Clay Cap	1 to 4	Medium stiff to very stiff silty CLAY, trace coarse gravel *(encountered in test borings HA22-1/1B, HA22-2, HA22-5, and HA22-6; the clay cap may be present at the location of HA22-7, however was not encountered likely due to sampling frequency)*
Landfill Waste and Cover	5 to 22	Medium stiff to hard silty CLAY, trace fine to coarse sand and gravel; loose to very dense fine to coarse SAND, trace silt; contains occasional cobble pieces, ash layers, and approximately trace to 40% waste consisting of newspaper, plastic bag, wood, glass, metal, wire, plastic netting, and insulation *(encountered in test borings HA22-1/1B, HA22-5, HA22-7, and HA22-10)*
Marine Deposit (Reworked)	11 to 13	Very stiff to hard silty CLAY *(encountered in test borings HA22-1/1B and HA22-7 in the central portion of the landfill)*
Tidal Marsh Deposit	> 4.6	Very loose silty fine SAND, trace medium sand *(only encountered in test boring HA22-10 east of the landfill)*
Marine Deposit (Natural)	3 to > 21	Medium stiff to hard silty CLAY, layered depositional structure, occasional fine sand lenses *(encountered in test borings HA22-1/1B, HA22-2, HA22-5, HA22-6, HA22-8, and HA22-9)*
Fluvial Deposit	7	Medium dense fine to coarse SAND, little silt, trace gravel; contains cobbles and boulders *(only encountered in test boring HA22-5 along the northern edge of the landfill)*
Glacial Till	1 to 4	Dense to very dense fine to coarse SAND, trace silt, little gravel, loosely bonded; contains cobbles *(encountered in test borings HA22-1/1B, HA22-5, and HA22-7)*
Bedrock		Top of bedrock surface encountered at depths ranging from approximately 9.0 to 38.7 ft BGS (El. -5.1 to El. 8.0).

Please note that soil descriptions provided on the logs In Appendix A represent subsurface conditions at the specific boring locations. The subsurface conditions encountered between test boring locations may vary from those encountered in the borings.

BEDROCK CONDITIONS

As stated previously, approximately 5 ft of bedrock was cored in three of the test borings. The recovered bedrock samples generally consisted of the following:

- Very hard to hard, fresh to slightly weathered, dark gray, porphyritic BASALT with occasional 1-in. thick clasts. Primary joints dip horizontally and are moderately closely spaced, open.
- Very hard to hard, slightly weathered, dark gray and white, aphanitic to coarse-grained basaltic TUFF BRECCIA. Primary joints dip horizontal to low angles and are very close to moderately closely spaced, open.

Rock quality designation (RQD) is a common parameter that is used to help assess the competency of sampled bedrock. RQD is defined as the sum of pieces of recovered bedrock greater than 4 in. in length divided by the total length of the bedrock core run. RQD values for the BASALT encountered at the site ranged from 43 to 85 percent (average of 66 percent) indicating poor to good rock quality. RQD values for the TUFF BRECCIA encountered at the site was 78 percent indicating good rock quality.

Photographs of the sampled bedrock are provided for reference in Appendix A.

GROUNDWATER CONDITIONS

As discussed previously, an observation well was installed in completed boreholes HA22-1B, HA22-2, and HA22-8 through HA22-10 to provide information on the static groundwater levels at the site. The measured water levels during the period 28 June 2022 to 7 September 2022 ranged from approximately 0.1 ft above ground surface to 27.3 ft below ground surface (El. -0.9 to El. 62.1). In addition, water was encountered during drilling in borings HA22-1B, HA22-2, and HA22-8 through HA-22-10, at depths ranging from approximately 3.6 to 29.7 ft BGS (El. -3.3 to El. 59.1).

Groundwater flow directions in the overburden were evaluated based on water level measurements collected from the installed monitoring wells on 15 August 2022. Groundwater elevations ranged from El. 55.6 in HA22-8 to El. 10.2 in HA22-9. As anticipated, groundwater generally flows in an easterly direction towards the Middle River.

In general, water levels may fluctuate with season, precipitation and local soil/bedrock conditions. Therefore, water levels may vary from those summarized above, shown on the boring logs included in Appendix A and shown on the groundwater monitoring reports included in Appendix B.

Groundwater Analytical Testing Program

Groundwater samples were collected from select monitoring wells including HA22-8, an upgradient well located in the western portion of the site in the vicinity of the Machias Public Works facility, and monitoring wells HA22-2, HA22-9 and HA22-10 located at the landfill toe-of-slope (see Figure 2). Groundwater samples were collected for laboratory analysis for various parameters to assess potential groundwater impacts to areas downgradient of the landfill. Groundwater samples were collected from the monitoring wells on 15 and 16 August 2022.

Prior to sample collection, the wells were purged using dedicated polyethylene tubing and a variable-rate peristaltic pump. During the well purging, field measurements including pH, specific conductance, turbidity, dissolved oxygen, temperature, and oxidation-reduction potential (ORP) were monitored using a flow-through cell. Well evacuation continued until field parameters showed stable readings per the EPA low-flow sampling guidance. Copies of the low-flow sampling forms are included in Appendix D.

After the field parameters of the well discharge stabilized, groundwater samples were collected for laboratory analysis directly from the discharge of the pump tubing prior to the flow-through cell. The samples analyzed for dissolved metals were filtered in the field using disposable 0.45-micron filters. The samples were transferred directly to laboratory-supplied containers, labeled, and packaged in coolers with ice and chain of custody documentation for submission to the testing laboratory. The samples were submitted to Alpha Analytical Laboratories (Alpha) for analysis.

Based on discussions with MaineDOT and the Maine Department of Environmental Protection (MEDEP), groundwater samples from each of the four monitoring wells were sampled for the following parameters:

- Volatile Organic Compounds (VOCs) by Method 8260C
- Semi-Volatile Organic Compounds (SVOCs) by Method 8270D-SIM
- Pesticides by Method 8081B
- Herbicides by Method 8151A
- Dissolved Metals and Hardness
- Inorganics and Miscellaneous (Alkalinity, Nitrogen, Chemical Oxygen Demand, Total Organic Carbon, Bromide, Total Dissolved Solids, Nitrogen-Nitrates, Hexavalent Chromium, Chloride, Sulfate
- Perfluorinated Alkyl Acids (PFAS) by Alpha Method 134, LCMSMS-ID

The laboratory analytical results are summarized in Table III. Copies of the chain of custody documentation and the laboratory reports/analytical results are included in Appendix E.

ANALYTICAL RESULTS SUMMARY

Consistent with the MEDEP, the groundwater sample results collected in the vicinity of the landfill were compared to drinking water MEDEP Maximum Exposure Guidelines (MEGs) and EPA Maximum Contaminant Levels (MCLs) in addition to MEDEP Construction Worker Groundwater Remedial Action Guidelines (RAGs). For several parameters, including VOCs, SVOCs and herbicides, the laboratory detection limits exceeded the more stringent drinking water MEGs and MCLs for certain compounds as summarized below.

- **VOCs** – Various VOCs were detected in groundwater samples from each of the four wells. With the exception of naphthalene in HA22-8, all detected VOC concentrations were below the applicable MEG, MCL and RAGs criteria. The detected concentration of naphthalene in the groundwater sample from HA22-8 was 49 ug/L, which exceeded both the MEG (10 ug/L) and the RAG (19ug/L).

- **SVOCs** – No SVOCs were detected in HA22-2. Various SVOCs were detected in HA22-8, HA22-9 and HA22-10, however, none of the detected SVOCs exceeded the applicable MEGs, MCLs or RAGs criteria.
- **Inorganic Compounds (Dissolved Metals)** – Metals including arsenic, chromium, hexavalent chromium, copper, lead and mercury were not detected above laboratory detection limits in any of the groundwater samples. Barium was detected in all four samples but only the detected concentration in HA22-10 (2.18 mg/L) exceeded the MEG (1 mg/L) and the MCL (2 mg/L). The detected concentration of cadmium in HA22-9 (0.005 mg/L) exceeded the MEG (0.001 mg/L). Iron was detected in all samples at concentrations ranging from 0.168 mg/L (HA22-2) to 148 mg/L (HA22-8). The detected concentration of iron in HA22-9 and HA22-10 exceeded the MEG (5 mg/L) and the detected concentration of iron in HA22-8 exceeded both the MEG and the RAG. Manganese concentrations ranged from 0.396 mg/L (HA22-10) to 39.6 mg/L (HA22-9) and concentrations in HA22-2, HA22-8 and HA22-10 exceeded the MEG (0.3 mg/L) and detected concentrations in HA22-9 exceeded both the MEG and RAG (37 mg/L). Sodium concentrations ranged from 412 mg/L (HA22-2) to 2,380 mg/L (HA22-9). Detected sodium concentrations in each of the four monitoring wells exceeded the applicable MEG (20 mg/L). Calcium was detected in each of the samples at concentrations ranging from 98.3 mg/L (HA22-10) to 478 mg/L (HA22-9). Hardness ranged from 335 mg/L (HA22-10) to 2,010 mg/L (HA22-9). Magnesium was detected in each of the samples at concentrations ranging 21.7 mg/L (HA22-10) to 198 mg/L (HA22-9). Potassium was detected at concentrations ranging from 9.42 mg/L (HA22-8) to 29.3 mg/L (HA22-9). There are no applicable criteria for calcium, hardness, magnesium or potassium.
- **Dissolved Gases and Other Landfill Parameters –** Dissolved gas ethene was not detected in any of the samples. Ethane was detected in HA22-9 (0.51 ug/L) and HA22-10 (2.63 ug/L) and methane was detected at concentrations ranging from 32.6 ug/L (HA22-2) to 9,310 ug/L (HA22-8). There is no applicable criteria for ethene, ethane or methane. None of the detected concentrations of ammonia exceed the applicable MEG. Detected concentrations of both nitrate and nitrite were below the MEG, MCL and RAG criteria. Total dissolved solids (TDS) were detected at concentrations ranging from 1,700 mg/L (HA22-2) to 7,200 mg/L (HA22-9). Bicarbonate concentrations ranged from 64.2 mg/L (HA22-8) to 405 mg/L (HA22-2). Bromide concentrations ranged from 1.83 mg/L (HA22-2) to 9.39 mg/L (HA22-8). Detected concentrations of calcium carbonate ranged from 64.2 mg/L (HA22-8) to 405 mg/L (HA22-2). Chemical oxygen demand (COD) ranged from 47 mg/L (HA22-2) to 370 mg/L (HA22-9). Chloride concentrations ranged from 838 mg/L (HA22-2) to 4,190 mg/L (HA22-9). Total organic carbon (TOC) concentrations ranged from 3.31.mg/L (HA22-2) to 4.53 mg/L (HA22-10). There is no applicable criteria for TDS, bicarbonate, bromide, calcium carbonate, COD, chloride or TOC.
- **Herbicides and Pesticides** – No herbicides or pesticides were detected above the laboratory reporting limits.

- **PFAS** – Various PFAS compounds were detected in samples collected from each of the monitoring wells. Total PFAS ranged from 26.5 ng/L (HA22-8) to 181 ng/L (HA22-10). The detection of PFOS in HA22-10 (72 ng/L) exceeded the MEG (70 ng/L) and the detection of PFOA in both HA22-2 (84 ng/L) and HA22-10 (71.2 ng/L) exceed the MEG criteria (70 ng/L).

  The Maine Center for Disease Control (CDC) has implemented an interim drinking water standard of 20 ng/L-parts per trillion (ppt; alone or in combination) for the six regulated PFAS contaminants that include: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS), perfluorononanoic acid (PFNA), perfluoroheptanoic acid (PFHpA) and perfluorodecanoic acid (PFDA). Total PFAS (6) results ranged from 26.5 ng/L (HA22-8) to 181 ng/L (HA22-10) with all samples exceeding the CDC 20 ng/L standard. Total PFAS (6) results for the remaining samples from downgradient wells HA22-2 and HA22-9 were detected at 173 ng/L and 123 ng/L, respectively. Based on the comparison of the Total PFAS (6) results from the upgradient well (HA22-8) to the three downgradient landfill wells (HA22-2, HA22-9 and HA22-10), it appears that the landfill debris is contributing to the increased concentrations of Total PFAS (6).

Based on the comparison to the drinking water MEGs and MCLs of the groundwater sample analytical results collected from monitoring wells located along the toe of the existing landfill slope, it does not appear that groundwater beneath the landfill would have a significant environmental impact to downgradient surface water quality associated with the Middle River east of the landfill.

Geotechnical Laboratory Testing Program

A geotechnical laboratory testing program was undertaken by Haley & Aldrich on representative soil samples collected during the subsurface exploration program to aid in soil classification and determination of engineering soil properties. All laboratory testing was performed in accordance with applicable American Society for Testing Materials (ASTM) testing procedures by GeoTesting Express, Inc. (GTX) of Acton, Massachusetts. Laboratory test results are provided in Appendix C and are shown on boring logs in Appendix A. A summary of laboratory test results is provided below.

Laboratory Test	ASTM Test Designation	Soil Unit	No. of Completed Tests	Range in Test Results[1]
Atterberg Limits	ASTM D 4318	Marine Deposit	3	38 < LL < 45 20 < PL < 23 18 < PI < 22

Notes:
[1] LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index

Geotechnical Evaluations

Geotechnical analyses were completed to evaluate global stability of the landfill under current and future water level conditions as described below. Engineering calculations that support the evaluations outlined in this section are provided for reference in Appendix F.

Static and pseudo-static seismic stability evaluations were conducted at two critical sections in the northeast and southeast edges of the existing landfill. These areas were identified as being “critical” from a geotechnical standpoint as they had the steepest slopes and were closest to the potential new, higher inundation area. A series of computer-assisted, two-dimensional global stability evaluations were performed using the computer program Slide2 Version 9 to evaluate the likelihood of global stability failures at the site.

A typical soil profile was developed based on the subsurface conditions encountered in the test borings at each cross section. The following physical and strength properties were used to complete the global stability evaluations:

Material	Unit Weight (pcf)	Friction Angle (degrees)	Undrained Shear Strength (psf)
Clay Cap	120	-	775
Landfill Waste and Cover	120	28 OR	550
Marine Deposit (reworked)	120	-	3,000
Marine Deposit (natural)	120	-	1,500
Fluvial	120	35	-
Glacial Till	130	38	-
Bedrock	infinite strength		

The landfill waste and cover material sampled in borings included both cohesive and cohesionless soils. As shown in the table below, modeling the landfill waste and cover layer stratum with cohesive properties yielded more conservative results at Section A-A, therefore the cohesive properties were used for the remainder of our evaluations.

Two groundwater conditions were modeled at each section. A model with current groundwater levels was run at each cross section based on conditions observed in observation wells during the recent subsurface exploration program. A model with groundwater level equal to high tide plus storm surge plus sea level rise water level of El. 14.7 was also run at each section. This higher elevation was provided to us by MaineDOT.

The calculated global stability factors of safety (FoS) values at sections A-A and B-B are summarized below.

Section	Landfill Waste and Cover Properties	Calculated FoS	
		Static	Seismic
SE Landfill Section A-A (Current Groundwater Level; El. 12.1)	cohesive	1.53	1.24
SE Landfill Section A-A (Current Groundwater Level; El. 12.1)	cohesionless	2.04	1.66
SE Landfill Section A-A (Future High Tide/Storm/SLR; El. 14.7)	cohesive	1.53	1.24
NE Landfill Section B-B (Current Groundwater Level; El. 11.0)	cohesive	1.86	1.36
NE Landfill Section B-B (Future High Tide/Storm/SLR; El. 14.7)	cohesive	1.86	1.36

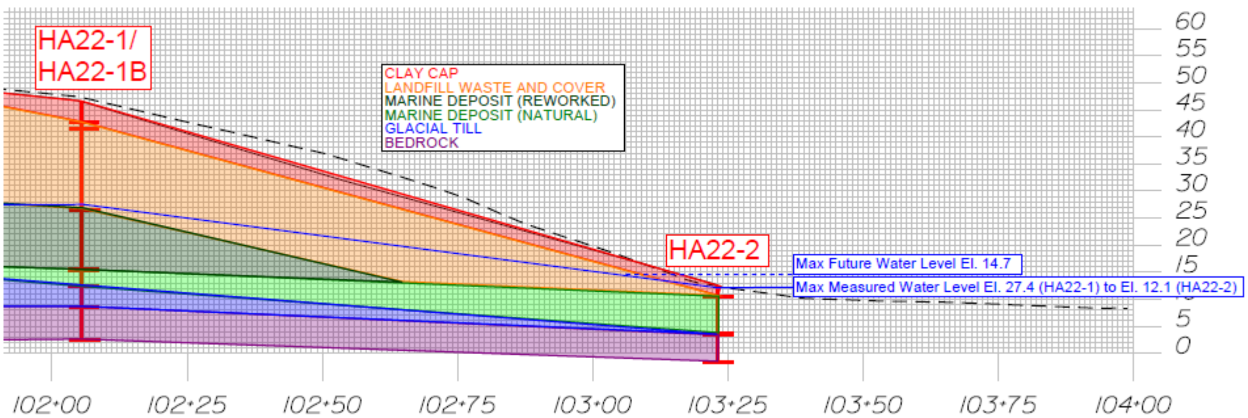
The factor of safety for pseudo-static seismic load cases was calculated using a horizontal acceleration coefficient, k_h, of 0.06g (i.e., one half of the acceleration coefficient, As). A value of As/2 was selected in accordance with AASHTO LRFD guidance in Section 11.6.5.2.2; the reduction from As is due to soil slope flexibility and the fact that the peak ground acceleration during an earthquake lasts only for a very short period of time.

The minimum required factor of safety as specified by both AASHTO LRFD and the MaineDOT BDG for embankments under static conditions which do not support structures is 1.3. The minimum required factor of safety for landfills under static conditions is typically 1.5. The minimum required factor of safety for embankments subjected to pseudo-static seismic loading is 1.1 (FHWA GEC No. 3).

The results indicate that the current and future conditions meet the required minimum acceptable factors of safety. Note that the increase in groundwater level did not impact the factors of safety. Although the water level at the toe of the landfill is expected to increase, the water level within the landfill where the critical failure surfaces are located is currently above El. 14.7, and is not expected to change significantly, as illustrated in the sketch below.

Per your request, we completed additional technical evaluations to determine the sensitivity of increased groundwater levels on the global stability results. The results of the evaluations indicate that elevated water levels outside the landfill (i.e., at and outboard of the toe of the landfill slope) would not negatively impact global stability factors of safety. Elevated water levels within the landfill (i.e., inboard of the landfill toe) were found to have a slight negative impact on the factor of safety, but the levels would need to be raised considerably (i.e., up to approx. El. 31, about 16 ft above maximum inundation flood level and 11 ft above measured stabilized water levels within the landfill) to cause an unsatisfactory factor of safety.

In our evaluations we assumed that no changes would be made to the landfill and adjacent ground surface. We also assumed that since the groundwater sample analytical results came back favorably, it would not be necessary to remove any of the waste (i.e., no excavation into the landfill). Note that based on the subsurface conditions encountered in the borings, the majority of the waste seems to be located above the future water level (El. 14.7). Based on interpolation between borings, there may be a small area of waste present below the future water level at the toe of slope at Section A-A (bottom interpolated at approximately El. 10.6), as shown in the sketch below.



Note that although increased water levels are not anticipated to cause global stability problems, they may cause surficial erosion/scour at the toe of the landfill. To protect against erosion/scour, we recommend placing a 3 ft-thick layer of plain riprap on the slopes from the existing toe of slope up to El. 15 (slightly above the maximum inundation water level). Refer to MaineDOT standard detail for "Stone Scour Protection, 610(02)" for additional information.

Conclusions

- Based on the comparison to the drinking water MEGs and MCLs of the groundwater sample analytical results collected from monitoring wells located along the toe of the existing landfill slope, it does not appear that groundwater beneath the landfill would have a significant environmental impact to downgradient surface water quality associated with the Middle River east of the landfill.

- The results of the geotechnical evaluations indicate that the current and future conditions meet the required minimum acceptable factors of safety. Evaluations indicate that the global stability factor of safety is not sensitive to changes in water level.

Limitations

This report is prepared for the exclusive use of MaineDOT relative to the subject project. There are no intended beneficiaries other than MaineDOT. Haley & Aldrich shall owe no duty whatsoever to any other person or entity on account of the Agreement or the report. Use of this report by any person or entity other than MaineDOT for any purpose whatsoever is expressly forbidden unless such other person or entity obtains written authorization from MaineDOT and Haley & Aldrich. Use of this report by such other person or entity without the written authorization of MaineDOT and Haley & Aldrich shall be at such other person's or entities sole risk and shall be without legal exposure or liability to Haley & Aldrich.

Use of this report by any person or entity, including by MaineDOT, for a purpose other than relative to the subject project is expressly prohibited unless such person or entity obtains written authorization from Haley & Aldrich indicating that the report is adequate for such other use. Use of this report by any other person or entity for such other purpose without written authorization by Haley & Aldrich shall be at such person's or entities sole risk and shall be without legal exposure or liability to Haley & Aldrich.

The information provided herein is based, in part, upon the data obtained from the referenced subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations then appear, it may be necessary to reevaluate the recommendations of this report.

Closure

We appreciate the opportunity to continue to provide MaineDOT services on this project. Please do not hesitate to call if you have any questions or comments.

Sincerely yours,
HALEY & ALDRICH, INC.

Erin A. Force, P.E. Senior Geotechnical Engineer	David A. Dearden Senior Environmental Geologist

Wayne A. Chadbourne, P.E.
Lead Quality Control Engineer

STATE OF MAINE
ERIN A. FORCE
No. 12207
LICENSED
PROFESSIONAL ENGINEER

Enclosures:

Table I –	Subsurface Exploration Location Data
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TABLES

TABLE I
Subsurface Exploration Location Data
Machias Landfill Investigation
Machias Dike Bridge
MaineDOT WIN 16714.00
Machias, Maine

Haley & Aldrich, Inc. File No.: 0130749-009

Test Boring No.[1,5]	Ground Surface Elevation (ft)[2,3]	Coordinates[4]	
		Northing	Easting
HA22-1	46.7	324,629	2,402,438
HA22-1B	46.7	324,629	2,402,438
HA22-2	12.6	324,616	2,402,555
HA22-5	26.4	324,780	2,402,399
HA22-6	17.0	324,827	2,402,414
HA22-7	52.5	324,632	2,402,378
HA22-8	64.5	324,623	2,401,655
HA22-9	17.5	324,821	2,402,411
HA22-10	19.2	324,502	2,402,502

Notes:
1 Test boring locations are shown on Figure 2, Site and Subsurface Exploration Location Plan.
2 Ground surface elevations at test boring locations were determined in the field by MaineDOT using GPS survey equipment.
3 Elevations are measured in feet and reference the North American Vertical Datum of 1988 (NAVD 88).
4 As-drilled coordinates of test borings were determined by MaineDOT using GPS survey equipment, are measured in feet and reference NAD83, Maine 2000 East Zone coordinate system.
5 Test boring HA22-3 and HA22-4 were laid out in the field as alternate boring locations, to be drilled depending on conditions encountered and available time. These two test borings were not drilled.

	Individual	Date
Prepared By:	EMS	10/4/2022
Checked By:	EAF	10/18/2022
Reviewed By:	WAC	10/20/2022

TABLE II
Subsurface Exploration Subsurface Data
Machias Landfill Investigation
Machias Dike Bridge
MaineDOT WIN 16714.00
Machias, Maine

Haley & Aldrich, Inc. File No.: 0130749-009

Test Boring No.[1,8]	Ground Surface Elevation (ft)[2,3]	Total Exploration Depth (ft)	El. Bottom of Exploration	Fill[4]			Clay Cap[4]			Landfill Waste and Cover[4]			Marine Deposit (Reworked)[4]			Tidal Marsh Deposit[4]			Marine Deposit (Natural)[4,5]			Fluvial[4,5]			Glacial Till[4,5]			Bedrock[4,5]	
				Depth to Top	El. of Top[2,3]	Thickness	Depth to Top	El. of Top[2,3]	Thickness	Depth to Top	El. of Top[2,3]	Thickness	Depth to Top	El. of Top[2,3]	Thickness	Depth to Top	El. of Top[2,3]	Thickness[6]	Depth to Top	El. of Top[2,3]	Thickness[6]	Depth to Top	El. of Top[2,3]	Thickness	Depth to Top	El. of Top[2,3]	Thickness[6]	Depth to Top	El. of Top[2,3]
				(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
HA22-1 / HA22-1B	46.7	44.0	2.7	NE	NE	NE	0.0	46.7	4.0	4.0	42.7	16.3	20.3	26.4	11.2	NE	NE	NE	31.5	15.2	3.1	NE	NE	NE	34.6	12.1	4.1	38.7	8.0
HA22-2	12.6	15.3	-2.7	NE	NE	NE	0.0	12.6	2.0	NE	NE	NE	NE	NE	NE	NE	NE	NE	2.0	10.6	7.0	NE	NE	NE	NE	NE	NE	9.0	3.6
HA22-5	26.4	37.5	-11.1	NE	NE	NE	0.0	26.4	2.0	2.0	24.4	5.7	NE	NE	NE	NE	NE	NE	7.7	18.7	16.0	23.7	2.7	6.8	30.5	-4.1	1.0	31.5	-5.1
HA22-6	17.0	6.0	11.0	NE	NE	NE	0.0	17.0	1.0	NE	NE	NE	NE	NE	NE	NE	NE	NE	1.0	16.0	> 5.0	--	--	--	--	--	--	--	--
HA22-7	52.5	35.6	16.9	NE	NE	NE	NE[9]	NE	NE	0.0	52.5	22.0	22.0	30.5	13.0	NE	NE	NE	NE	NE	NE	NE	NE	NE	35.0	17.5	> 0.6	--	--
HA22-8[7]	64.5	17.6	46.9	0.0	64.5	4.0	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	4.0	60.5	> 13.6	--	--	--	--	--	--	--	--
HA22-9[7]	17.5	21.4	-3.9	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.0	17.5	> 21.4	--	--	--	--	--	--	--	--
HA22-10[7]	19.2	9.6	9.6	NE	NE	NE	NE	NE	NE	0.0	19.2	5.0	NE	NE	NE	5.0	14.2	> 4.6	--	--	--	--	--	--	--	--	--	--	--

Notes:
[1] Test boring locations are shown on Figure 2, Site and Subsurface Exploration Location Plan.
[2] Ground surface elevations at test boring locations were determined in the field by MaineDOT using GPS survey equipment.
[3] Elevations are measured in feet and reference the North American Vertical Datum of 1988 (NAVD 88).
[4] "NE" indicates stratum was not encountered in test boring.
[5] "--" indicates test boring was not drilled deep enough to determine presence of stratum.
[6] "> 32.8" indicates test boring was not drilled deep enough to determine entire stratum thickness. Actual total stratum thickness greater than value shown.
[7] HA22-8 through HA22-10 were drilled to install wells for groundwater sampling. Minimal soil sample data was collected. Soil and strata descriptions determined from drilling cutting observations.
[8] Test boring HA22-3 and HA22-4 were laid out in the field as alternate boring locations, to be drilled depending on conditions encountered and available time. These two test borings were not drilled.
[9] Clay cap not encountered in HA22-8 likely due to sampling frequency.

	Individual	Date
Prepared By:	EMS	10/4/2022
Checked By:	EAF	10/18/2022
Reviewed By:	WAC	10/20/2022

TABLE III
Summary of Groundwater Analytical Results
Machias Landfill Investigation
Machias Dike Bridge
MaineDOT WIN 16714.00
Machias, Maine

	Aug-22				MEGs for Drinking Water	Maximum Contaminant Level (MCLs)	Construction Worker Groundwater RAGs
Location Name	HA22-2(OW)	HA22-8(OW)	HA22-9(OW)	HA22-10(OW)			
Lab Sample ID	L2244025-01 L2244025-05	L2244025-02 L2244025-06	L2244025-03 L2244025-07	L2244025-04 L2244025-08			
Volatile Organic Compounds (ug/L)							
1,1,1,2-Tetrachloroethane	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	10	NA	620
1,1,1-Trichloroethane	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	10000	200	29000
1,1,2,2-Tetrachloroethane	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	2	NA	90
1,1,2-Trichloroethane	ND (0.75)	ND (0.75)	ND (0.75)	ND (0.75)	6	5	12
1,1-Dichloroethane	**1.6**	ND (0.75)	ND (0.75)	**1.3**	60	NA	2200
1,1-Dichloroethene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	40	7	960
1,1-Dichloropropene	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	NA
1,2,3-Trichlorobenzene	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	2900
1,2,3-Trichloropropane	ND (1) [A]	ND (1) [A]	ND (1) [A]	ND (1) [A]	0.01	NA	2.1
1,2,4-Trichlorobenzene	ND (1)	ND (1)	ND (1)	ND (1)	70	70	140
1,2,4-Trimethylbenzene	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	1000
1,2-Dibromo-3-chloropropane (DBCP)	ND (1) [AB]	ND (1) [AB]	ND (1) [AB]	ND (1) [AB]	0.4	0.2	1.2
1,2-Dibromoethane (Ethylene Dibromide)	ND (1) [AB]	ND (1) [AB]	ND (1) [AB]	ND (1) [AB]	0.2	0.05	8.7
1,2-Dichlorobenzene	ND (1)	ND (1)	ND (1)	ND (1)	200	600	12000
1,2-Dichloroethane	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	4	5	140
1,2-Dichloropropane	ND (1)	ND (1)	ND (1)	ND (1)	10	5	22
1,3,5-Trichlorobenzene	ND (1)	ND (1)	ND (1)	ND (1)	40	NA	NA
1,3,5-Trimethylbenzene	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	1100
1,3-Dichlorobenzene	ND (1)	ND (1)	ND (1)	ND (1)	1	NA	6200
1,3-Dichloropropane	ND (1)	ND (1)	ND (1)	ND (1)	100	NA	100000
1,4-Dichlorobenzene	ND (1)	ND (1)	ND (1)	ND (1)	70	75	400
2,2-Dichloropropane	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	NA
2-Butanone (Methyl Ethyl Ketone)	ND (5)	ND (5)	ND (5)	ND (5)	4000	NA	9000
2-Chlorotoluene	ND (1)	ND (1)	ND (1)	ND (1)	100	NA	3300
2-Hexanone (Methyl Butyl Ketone)	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	240
2-Phenylbutane (sec-Butylbenzene)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	NA	NA	100000
4-Chlorotoluene	ND (1)	ND (1)	ND (1)	ND (1)	500	NA	100000
4-Methyl-2-Pentanone (Methyl Isobutyl Ketone)	ND (5)	ND (5)	ND (5)	ND (5)	500	NA	5800
Acetone	ND (5)	ND (5)	ND (5)	ND (5)	6000	NA	100000
Acrylonitrile	ND (5) [A]	ND (5) [A]	ND (5) [A]	ND (5) [A]	0.6	NA	11
Benzene	ND (0.5)	ND (0.5)	**0.55**	**0.56**	4	5	350
Bromobenzene	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	1200
Bromodichloromethane	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	6	80	130
Bromoform	ND (1)	ND (1)	ND (1)	ND (1)	40	80	5500
Bromomethane (Methyl Bromide)	ND (1)	ND (1)	ND (1)	ND (1)	10	NA	490
Carbon disulfide	ND (1)	ND (1)	ND (1)	ND (1)	600	NA	3100
Carbon tetrachloride	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	5	5	700
Chlorobenzene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	100	100	2600
Chlorobromomethane	ND (1)	ND (1)	ND (1)	ND (1)	100	NA	600
Chloroethane	**2.2**	ND (1)	**1.2**	**4**	7	NA	16000
Chloroform (Trichloromethane)	ND (0.75)	ND (0.75)	ND (0.75)	ND (0.75)	70	80	170
Chloromethane (Methyl Chloride)	ND (2)	ND (2)	ND (2)	ND (2)	20	NA	11000
cis-1,2-Dichloroethene	ND (0.5)	ND (0.5)	**0.64**	ND (0.5)	10	70	3700
cis-1,3-Dichloropropene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	NA	NA	NA
Cymene (p-Isopropyltoluene)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	70	NA	NA
Dibromochloromethane	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	4	80	53000
Dibromomethane	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	280
Dichlorodifluoromethane (CFC-12)	ND (2)	ND (2)	ND (2)	ND (2)	1000	NA	5400
Diisopropyl ether (DIPE)	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	3700
Ethyl Ether	**2**	ND (1)	**19**	**1.9**	NA	NA	14000
Ethylbenzene	ND (0.5)	**0.82**	ND (0.5)	ND (0.5)	30	700	1400
Hexachlorobutadiene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	4	NA	230
Iodomethane	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	NA
Isopropylbenzene (Cumene)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	NA	NA	500
Methyl Tert Butyl Ether (MTBE)	ND (1)	ND (1)	ND (1)	ND (1)	35	NA	13000
Methylene chloride (Dichloromethane)	ND (3)	ND (3)	ND (3)	ND (3)	40	5	4900
Naphthalene	ND (1)	**49 [AC]**	ND (1)	ND (1)	10	NA	19
n-Butylbenzene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	NA	NA	100000
n-Propylbenzene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	NA	NA	4900
Styrene	ND (1)	ND (1)	ND (1)	ND (1)	100	100	15000
Tert-Amyl Methyl Ether (TAME)	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	NA
Tert-Butyl Alcohol (tert-Butanol)	ND (10)	ND (10)	**15**	ND (10)	NA	NA	NA
Tert-Butyl Ethyl Ether (ETBE)	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	NA
tert-Butylbenzene	ND (1)	ND (1)	ND (1)	ND (1)	NA	NA	25000
Tetrachloroethene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	40	5	250
Tetrahydrofuran	**2.7**	ND (2)	**15**	**2.6**	600	NA	16000
Toluene	ND (0.75)	ND (0.75)	ND (0.75)	ND (0.75)	600	1000	24000
trans-1,2-Dichloroethene	ND (0.75)	ND (0.75)	ND (0.75)	ND (0.75)	100	100	3900
trans-1,3-Dichloropropene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	NA	NA	NA
trans-1,4-Dichloro-2-butene	ND (2.5) [C]	ND (2.5) [C]	ND (2.5) [C]	ND (2.5) [C]	NA	NA	1
Trichloroethene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	4	5	12
Trichlorofluoromethane (CFC-11)	ND (1)	ND (1)	ND (1)	ND (1)	2000	NA	5900
Vinyl acetate	ND (5)	ND (5)	ND (5)	ND (5)	7000	NA	180
Vinyl chloride	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	0.2	2	0.22
Xylene (total)	ND (1)	ND (1)	ND (1)	ND (1)	1000	10000	2100

TABLE III
Summary of Groundwater Analytical Results
Machias Landfill Investigation
Machias Dike Bridge
MaineDOT WIN 16714.00
Machias, Maine

	Aug-22				MEGs for Drinking Water	Maximum Contaminant Level (MCLs)	Construction Worker Groundwater RAGs
Location Name	HA22-2(OW)	HA22-8(OW)	HA22-9(OW)	HA22-10(OW)			
Lab Sample ID	L2244025-01 L2244025-05	L2244025-02 L2244025-06	L2244025-03 L2244025-07	L2244025-04 L2244025-08			
Semi-Volatile Organic Compounds (ug/L)							
1,2,4-Trichlorobenzene	ND (5)	ND (5)	ND (5)	ND (5)	70	70	140
1,2-Dichlorobenzene	ND (2)	ND (2)	ND (2)	ND (2)	200	600	12000
1,3-Dichlorobenzene	ND (2) [A]	ND (2) [A]	ND (2) [A]	ND (2) [A]	1	NA	6200
1,4-Dichlorobenzene	ND (2)	ND (2)	ND (2)	ND (2)	70	75	400
2,2'-oxybis(1-Chloropropane)	ND (2)	ND (2)	ND (2)	ND (2)	300	NA	NA
2,4,5-Trichlorophenol	ND (5)	ND (5)	ND (5)	ND (5)	700	NA	100000
2,4,6-Trichlorophenol	ND (5)	ND (5)	ND (5)	ND (5)	7	NA	690
2,4-Dichlorophenol	ND (5)	ND (5)	ND (5)	ND (5)	20	NA	27000
2,4-Dimethylphenol	ND (5)	ND (5)	ND (5)	ND (5)	100	NA	100000
2,4-Dinitrophenol	ND (20) [A]	ND (20) [A]	ND (20) [A]	ND (20) [A]	10	NA	100000
2,4-Dinitrotoluene	ND (5) [A]	ND (5) [A]	ND (5) [A]	ND (5) [A]	1	NA	15000
2,6-Dinitrotoluene	ND (5) [A]	ND (5) [A]	ND (5) [A]	ND (5) [A]	0.5	NA	2700
2-Chlorophenol	ND (2)	ND (2)	ND (2)	ND (2)	40	NA	29000
2-Methylphenol (o-Cresol)	ND (5)	ND (5)	ND (5)	ND (5)	40	NA	100000
2-Nitroaniline	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	NA
2-Nitrophenol	ND (10)	ND (10)	ND (10)	ND (10)	NA	NA	NA
3&4-Methylphenol	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	NA
3,3'-Dichlorobenzidine	ND (5) [A]	ND (5) [A]	ND (5) [A]	ND (5) [A]	0.8	NA	2000
3-Nitroaniline	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	NA
4,6-Dinitro-2-methylphenol	ND (10)	ND (10)	ND (10)	ND (10)	NA	NA	NA
4-Bromophenyl phenyl ether	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	NA
4-Chloro-3-methylphenol	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	100000
4-Chloroaniline	ND (5) [A]	ND (5) [A]	ND (5) [A]	ND (5) [A]	2	NA	2700
4-Chlorophenyl phenyl ether	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	NA
4-Nitroaniline	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	100000
4-Nitrophenol	ND (10)	ND (10)	ND (10)	ND (10)	60	NA	NA
Aniline	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	86000
Azobenzene	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	NA
Benzidine	ND (20)	ND (20)	ND (20)	ND (20)	NA	NA	NA
Benzoic acid	ND (50)	ND (50)	ND (50)	ND (50)	30000	NA	100000
Benzyl Alcohol	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	100000
Biphenyl	ND (2)	ND (2)	ND (2)	ND (2)	400	NA	29
bis(2-Chloroethoxy)methane	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	NA
bis(2-Chloroethyl)ether	ND (2) [A]	ND (2) [A]	ND (2) [A]	ND (2) [A]	0.3	NA	54
bis(2-Ethylhexyl)phthalate	ND (3)	ND (3)	**5.6**	ND (3)	30	6	100000
Butyl benzylphthalate	ND (5)	ND (5)	ND (5)	ND (5)	200	NA	100000
Carbazole	ND (2)	ND (2)	ND (2)	**2.1**	NA	NA	13000
Dibenzofuran	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	1200
Diethyl phthalate	ND (5)	ND (5)	ND (5)	ND (5)	6000	NA	100000
Dimethyl phthalate	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	NA
Di-n-butylphthalate	ND (5)	ND (5)	ND (5)	ND (5)	700	NA	100000
Di-n-octyl phthalate	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	100000
Hexachlorocyclopentadiene	ND (20)	ND (20)	ND (20)	ND (20)	40	50	NA
Isophorone	ND (5)	ND (5)	ND (5)	ND (5)	400	NA	100000
Nitrobenzene	ND (2) [A]	ND (2) [A]	ND (2) [A]	ND (2) [A]	1	NA	NA
N-Nitrosodimethylamine	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	NA
N-Nitrosodi-n-propylamine	ND (5)	ND (5)	ND (5)	ND (5)	NA	NA	NA
N-Nitrosodiphenylamine	ND (2)	ND (2)	ND (2)	ND (2)	NA	NA	100000
Phenol	ND (5)	ND (5)	ND (5)	ND (5)	2000	NA	100000
Pyridine	ND (3.5)	ND (3.5)	ND (3.5)	ND (3.5)	NA	NA	NA
Semi-Volatile Organic Compounds (SIM) (ug/L)							
1-Methylnaphthalene	ND (0.1)	**3.1**	ND (0.1)	ND (0.1)	NA	NA	8800
2-Chloronaphthalene	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	NA	NA	81000
2-Methylnaphthalene	ND (0.1)	**1.6**	**0.12**	ND (0.1)	30	NA	1500
Acenaphthene	ND (0.1)	**1.6**	ND (0.1)	ND (0.1)	400	NA	74000
Acenaphthylene	ND (0.1)	**0.2**	ND (0.1)	ND (0.1)	NA	NA	71000
Anthracene	ND (0.1)	**0.2**	ND (0.1)	ND (0.1)	2000	NA	100000
Benzo(a)anthracene	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.5	NA	470
Benzo(a)pyrene	ND (0.1) [A]	ND (0.1) [A]	ND (0.1) [A]	ND (0.1) [A]	0.05	0.2	11000
Benzo(b)fluoranthene	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.5	NA	100000
Benzo(g,h,i)perylene	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	NA	NA	100000
Benzo(k)fluoranthene	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	5	NA	100000
Chrysene	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	50	NA	100000
Dibenz(a,h)anthracene	ND (0.1) [A]	ND (0.1) [A]	ND (0.1) [A]	ND (0.1) [A]	0.05	NA	26000
Fluoranthene	ND (0.1)	**0.19**	ND (0.1)	ND (0.1)	300	NA	100000
Fluorene	ND (0.1)	**1.4**	ND (0.1)	ND (0.1)	300	NA	100000
Hexachlorobenzene	ND (0.8) [A]	ND (0.8) [A]	ND (0.8) [A]	ND (0.8) [A]	0.2	1	13
Hexachlorobutadiene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	4	NA	230
Hexachloroethane	ND (0.8)	ND (0.8)	ND (0.8)	ND (0.8)	5	NA	470
Indeno(1,2,3-cd)pyrene	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.5	NA	100000
Naphthalene	ND (0.1)	**5.9**	**0.29**	ND (0.1)	10	NA	19
Pentachlorophenol	ND (0.8)	ND (0.8)	ND (0.8)	ND (0.8)	0.9	1	140
Phenanthrene	ND (0.1)	**1.2**	ND (0.1)	ND (0.1)	NA	NA	58000
Pyrene	ND (0.1)	**0.18**	ND (0.1)	ND (0.1)	200	NA	36000

TABLE III
Summary of Groundwater Analytical Results
Machias Landfill Investigation
Machias Dike Bridge
MaineDOT WIN 16714.00
Machias, Maine

	Aug-22				MEGs for Drinking Water	Maximum Contaminant Level (MCLs)	Construction Worker Groundwater RAGs
Location Name	HA22-2(OW)	HA22-8(OW)	HA22-9(OW)	HA22-10(OW)			
Lab Sample ID	L2244025-01 L2244025-05	L2244025-02 L2244025-06	L2244025-03 L2244025-07	L2244025-04 L2244025-08			
Inorganic Compounds (mg/L)							
Arsenic, Dissolved	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	0.01	0.01	5.8
Barium, Dissolved	**0.161**	**0.314**	**0.739**	**2.18** [AB]	1	2	100
Cadmium, Dissolved	ND (0.005) [A]	ND (0.005) [A]	**0.005** [A]	ND (0.005) [A]	0.001	0.005	0.94
Calcium, Dissolved	**122**	**165**	**478**	**98.3**	NA	NA	NA
Chromium, Dissolved	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.02	0.1	NA
Chromium VI (Hexavalent), Dissolved	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.02	NA	0.69
Copper, Dissolved	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.5	1.3	100
Hardness, Dissolved	**624**	**680**	**2010**	**335**	NA	NA	NA
Iron, Dissolved	**0.168**	**148** [AC]	**5.65** [A]	**96.6** [A]	5	NA	100
Lead, Dissolved	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.01	0.015	NA
Magnesium, Dissolved	**77.6**	**65**	**198**	**21.7**	NA	NA	NA
Manganese, Dissolved	**4.07** [A]	**35.9** [A]	**39.6** [AC]	**0.396** [A]	0.3	NA	37
Mercury, Dissolved	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	NA	0.002	0.0021
Potassium, Dissolved	**14.5**	**9.42**	**29.3**	**25.6**	NA	NA	NA
Sodium, Dissolved	**412** [A]	**1870** [A]	**2380** [A]	**500** [A]	20	NA	NA
Dissolved Gases (ug/L)							
Ethane	ND (0.5)	ND (0.5)	**0.51**	**2.63**	NA	NA	NA
Ethene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	NA	NA	NA
Methane	**32.6**	**9310**	**1030**	**4090**	NA	NA	NA
Other							
Total Dissolved Solids (TDS) (mg/L)	**1700**	**5500**	**7200**	**1800**	NA	NA	NA
Ammonia, Total (mg/L)	**0.803**	**5.89**	**0.15**	**8.95**	30	NA	NA
Bicarbonate (as CaCO3), Total (mg/L)	**405**	**64.2**	**380**	**318**	NA	NA	NA
Bromide, Total (mg/L)	**1.83**	**9.39**	**6.06**	**4.78**	NA	NA	NA
Calcium Carbonate, Total (mg/L)	**405**	**64.2**	**380**	**318**	NA	NA	NA
Chemical Oxygen Demand (COD), Total (mg/L)	**47**	**250**	**370**	**64**	NA	NA	NA
Chloride, Total (mg/L)	**838**	**3250**	**4190**	**859**	NA	NA	NA
Nitrate (as N), Total (mg/L)	ND (0.05)	**0.537**	**0.166**	ND (0.05)	10	10	100
Nitrite (as N), Total (mg/L)	ND (0.05)	**0.057**	ND (0.05)	**0.05**	1	1	100
Sulfate, Total (mg/L)	**26.8**	ND (1)	**24.7**	**1.07**	NA	NA	NA
Total Organic Carbon (TOC) (mg/L)	**3.31**	**4.14**	**3.62**	**4.53**	NA	NA	NA
Herbicides (ug/L)							
2-(2-Methyl-4-chlorophenoxy)-propionic acid (MCPP)	ND (500)	ND (500)	ND (500)	ND (500)	NA	NA	16000
2,4,5-T	ND (2)	ND (2)	ND (2)	ND (2)	70	NA	100000
2,4,5-TP (Silvex)	ND (2)	ND (2)	ND (2)	ND (2)	60	50	8400
2,4-DB	ND (10)	ND (10)	ND (10)	ND (10)	NA	NA	NA
2,4-Dichlorophenoxyacetic acid (2,4-D)	ND (10)	ND (10)	ND (10)	ND (10)	70	70	NA
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	ND (63.2) [A]	ND (63.2) [A]	ND (63.2) [A]	ND (63.2) [A]	4	NA	680
2-sec-butyl-4,6-dinitrophenol (Dinoseb)	ND (5)	ND (5)	ND (5)	ND (5)	7	7	1200
Dalapon	ND (20)	ND (20)	ND (20)	ND (20)	200	200	100000
Dicamba	ND (1)	ND (1)	ND (1)	ND (1)	200	NA	NA
Dichloroprop	ND (10)	ND (10)	ND (10)	ND (10)	NA	NA	NA
Pesticides (ug/L)							
4,4'-DDD	ND (0.029)	ND (0.029)	ND (0.029)	ND (0.029)	1	NA	1.7
4,4'-DDE	ND (0.029)	ND (0.029)	ND (0.029)	ND (0.029)	1	NA	140
4,4'-DDT	ND (0.029)	ND (0.029)	ND (0.029)	ND (0.029)	1	NA	19000
Aldrin	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	0.02	NA	2.9
alpha-BHC	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	0.06	NA	80
alpha-Chlordane	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	NA	NA	NA
beta-BHC	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	0.2	NA	280
Chlordane	ND (0.143)	ND (0.143)	ND (0.143)	ND (0.143)	NA	NA	NA
delta-BHC	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	NA	NA	NA
Dieldrin	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	0.02	NA	13
Endosulfan I	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	NA	NA	NA
Endosulfan II	ND (0.029)	ND (0.029)	ND (0.029)	ND (0.029)	NA	NA	NA
Endosulfan sulfate	ND (0.029)	ND (0.029)	ND (0.029)	ND (0.029)	NA	NA	NA
Endrin	ND (0.029)	ND (0.029)	ND (0.029)	ND (0.029)	2	2	87
Endrin aldehyde	ND (0.029)	ND (0.029)	ND (0.029)	ND (0.029)	NA	NA	NA
Endrin ketone	ND (0.029)	ND (0.029)	ND (0.029)	ND (0.029)	NA	NA	NA
gamma-BHC (Lindane)	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	0.03	0.2	7.2
gamma-Chlordane	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	NA	NA	NA
Heptachlor	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	0.07	0.4	3.9
Heptachlor epoxide	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	0.04	0.2	5.5
Methoxychlor	ND (0.143)	ND (0.143)	ND (0.143)	ND (0.143)	40	40	1400
Toxaphene	ND (0.143)	ND (0.143)	ND (0.143)	ND (0.143)	0.3	3	NA

TABLE III
Summary of Groundwater Analytical Results
Machias Landfill Investigation
Machias Dike Bridge
MaineDOT WIN 16714.00
Machias, Maine

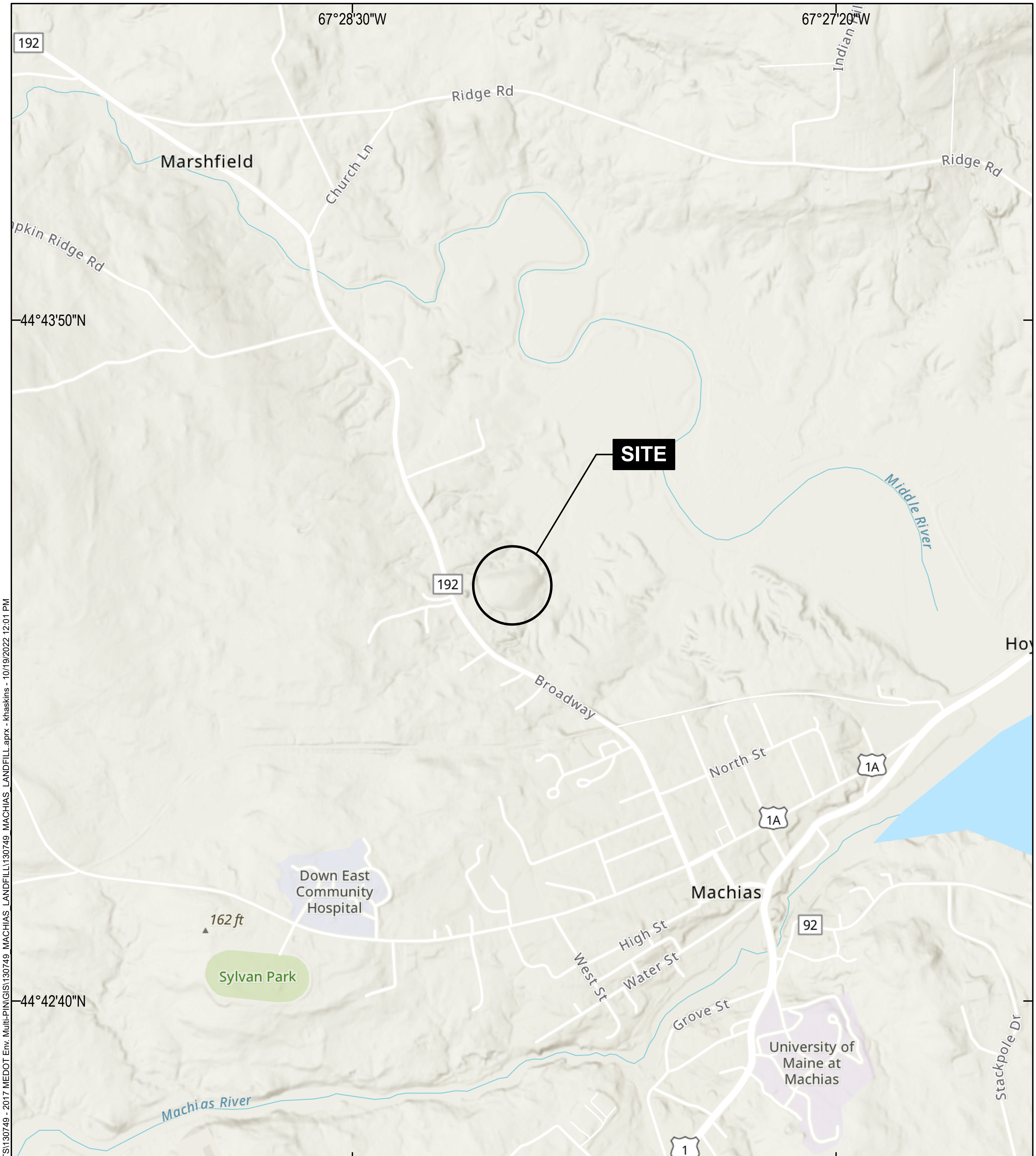
	Aug-22				MEGs for Drinking Water	Maximum Contaminant Level (MCLs)	Construction Worker Groundwater RAGs
Location Name	HA22-2(OW)	HA22-8(OW)	HA22-9(OW)	HA22-10(OW)			
	L2244025-01	L2244025-02	L2244025-03	L2244025-04			
Lab Sample ID	L2244025-05	L2244025-06	L2244025-07	L2244025-08			
PFAS (ng/L)							
4,8-Dioxa-3H-Perfluorononanoic Acid (ADONA)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	**3.29**	**3.46**	**5.39**	**5.49**	NA	NA	NA
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	ND (1.83)	ND (1.87)	ND (1.86)	**4.75**	NA	NA	NA
N-Methyl Perfluorooctanesulfonamidoacetic Acid (MeFOSAA)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluoro-2-propoxypropanoic acid (PFPrOPrA)(GenX) (HFPO-DA)	ND (45.7)	ND (46.7)	ND (46.4)	ND (46.1)	NA	NA	NA
Perfluorobutanesulfonic acid (PFBS)	**2.67**	ND (1.87)	**3.24**	**2.01**	NA	NA	1.00E+08
Perfluorobutanoic acid (PFBA)	**9.19**	ND (1.87)	**16.1**	**6.28**	NA	NA	NA
Perfluorodecanesulfonic acid (PFDS)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluorodecanoic acid (PFDA)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluorododecanoic acid (PFDoDA)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluoroheptanesulfonic acid (PFHpS)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluoroheptanoic acid (PFHpA)	**22.5** [D]	ND (1.87)	**26.2** [D]	**14.5**	NA	NA	NA
Perfluorohexadecanoic acid (PFHxDA)	ND (3.66)	ND (3.74)	ND (3.71)	ND (3.69)	NA	NA	NA
Perfluorohexanesulfonic acid (PFHxS)	**26.8** [D]	**16.3**	**28.9** [D]	**19.1**	NA	NA	NA
Perfluorohexanoic acid (PFHxA)	**23.1**	ND (1.87)	**33**	**13.9**	NA	NA	NA
Perfluorononane sulfonic acid (PFNS)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluorononanoic acid (PFNA)	**3.57**	ND (1.87)	ND (1.86)	**4.6**	NA	NA	NA
Perfluorooctadecanoic acid (PFOcDA)	ND (3.66)	ND (3.74)	ND (3.71)	ND (3.69)	NA	NA	NA
Perfluorooctane sulfonamide (PFOSA)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluorooctanesulfonic acid (PFOS)	**35.7** [D]	**8.02**	**8.27**	**72** [AD]	70	NA	750000
Perfluorooctanoic acid (PFOA)	**84** [AD]	**2.18**	**59.9** [D]	**71.2** [AD]	70	NA	750000
Perfluoropentanesulfonic acid (PFPeS)	**2.17**	ND (1.87)	**2.24**	ND (1.84)	NA	NA	NA
Perfluoropentanoic acid (PFPeA)	**13.3**	ND (1.87)	**16.7**	**8.83**	NA	NA	NA
Perfluorotetradecanoic acid (PFTeDA)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluorotridecanoic acid (PFTrDA)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Perfluoroundecanoic acid (PFUnDA)	ND (1.83)	ND (1.87)	ND (1.86)	ND (1.84)	NA	NA	NA
Total PFAS (6): PFOA, PFOS, PFNA, PFHxS, PFHpA, PFDA	**173** [D]	**26.5** [D]	**123** [D]	**181** [D]	NA	NA	NA

ABBREVIATIONS AND NOTES:
NA: Not Applicable
ND (2.5): Not detected, number in parentheses is the method detection limit
MEGs: Maximum Exposure Guidelines
RAGs: Maine Remedial Action Guidelines
ug/L: microgram per liter
-: Not Analyzed

- Volatile Organic analytes detected in at least one sample are reported herein. For a complete list of analytes see the laboratory data sheets.
- Highlighted values indicate an exceedances of at least one of the listed screening levels.
  - A - Maximum Exposure Guidelines for Drinking Water, 2016
  - B - Maximum Contaminant Level (MCLs)
  - C - Construction Worker Groundwater ME RAGs, May 2021
  - D - Maine Center for Disease Control interim drinking water standard of 20 ng/L (alone or in combination) for the six regulated PFAS contaminants that include PFOA, PFAS, PFHxS, PFNA, PFHpA, and PFDA.

	Individual	Date
Prepared By:	KJC	9/8/2022
Checked By:	DAD	9/8/2022
Reviewed By:	EAF	10/20/2022

FIGURES



MAP SOURCE: ESRI
SITE COORDINATES: 44°43'22"N, 67°28'07"W

HALEY ALDRICH

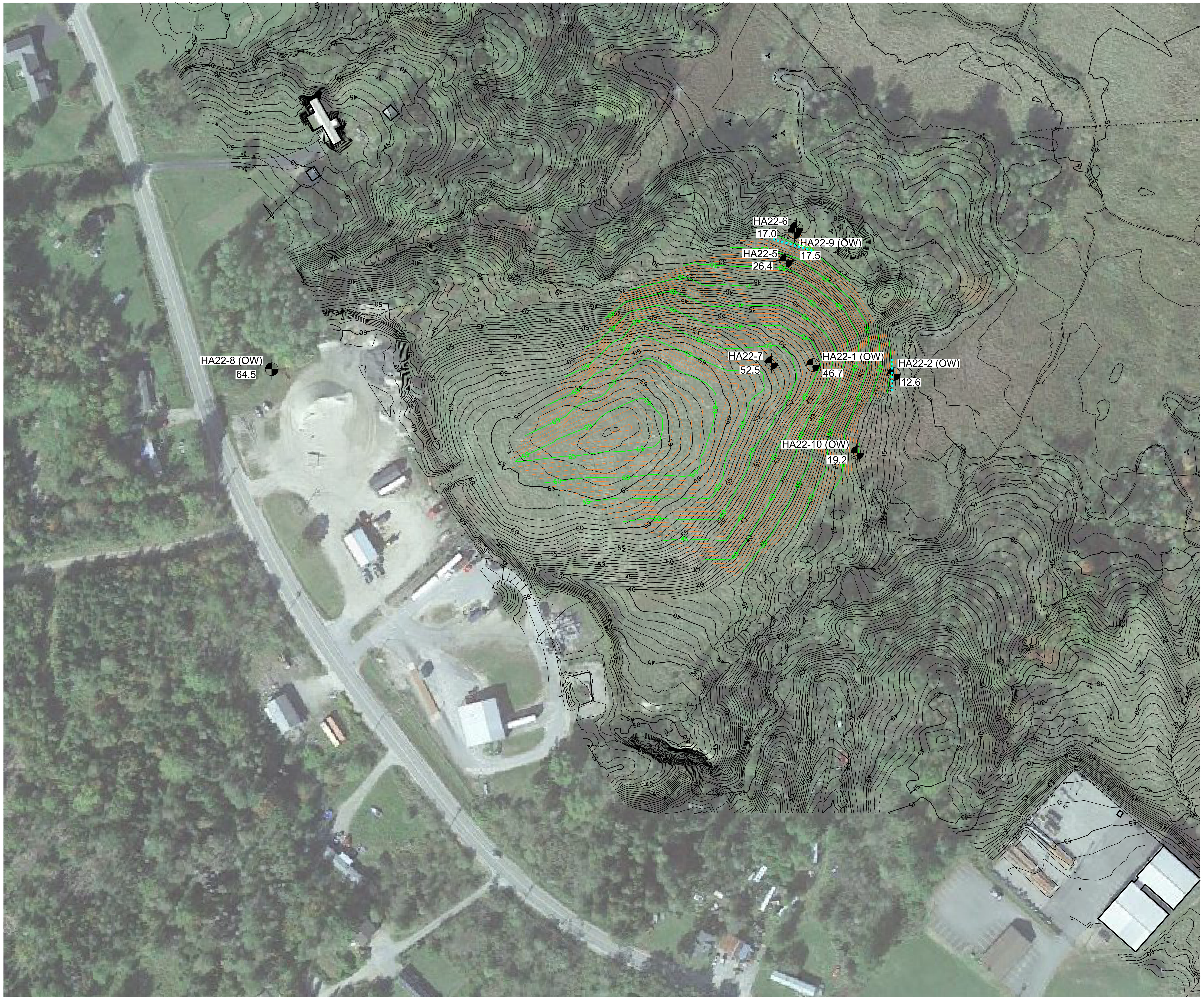
MACHIAS LANDFILL INVESTIGATION
MACHIAS DIKE BRIDGE
MAINEDOT WIN 16714.00
MACHIAS, MAINE

PROJECT LOCUS

APPROXIMATE SCALE: 1 IN = 2000 FT
NOVEMBER 2022

FIGURE 1

GIS: \\haleyaldrich.com\share\POR_common\PROJECTS\130749 - 2017 MEDOT Env. Multi-PIN\GIS\130749_MACHIAS_LANDFILL\130749_MACHIAS_LANDFILL.aprx - khaskins - 10/19/2022 12:01 PM



LEGEND

HA22-1 46.7 — DESIGNATION, AS-DRILLED LOCATION AND GROUND SURFACE ELEVATION OF BORING DRILLED BY NEW ENGLAND BORING CONTRACTORS OF HERMON, MAINE (HA22-1 THROUGH HA22-7) AND S.W. COLE ENGINEERING OF GRAY, MAINE (HA22-8 THROUGH HA22-10) UNDER THE DIRECTION OF HALEY & ALDRICH IN JUNE AND JULY 2022

(OW) — DESIGNATES WELL INSTALLED IN COMPLETED BOREHOLE

55 — EXISTING GROUND SURFACE ELEVATION CONTOUR BASED ON LIDAR SURVEY

60 — EXISTING GROUND SURFACE ELEVATION CONTOUR BASED ON SURVEY PERFORMED BY MAINE DEPARTMENT OF TRANSPORTATION (5-FT INTERVAL)

EXISTING GROUND SURFACE ELEVATION CONTOUR BASED ON SURVEY PERFORMED BY MAINE DEPARTMENT OF TRANSPORTATION (1-FT. INTERVAL)

APPROXIMATE LOCATION OF EDGE OF LANDFILL WASTE/ COVER BASED ON TEST BORING INFORMATION

NOTES:

1. EXISTING SITE CONDITIONS AND TOPOGRAPHY ARE TAKEN FROM ELECTRONIC MICROSTATION FILES PROVIDED BY STANTEC CONSULTING SERVICES INC. ON 12 SEPTEMBER 2022.
2. THE PLAN LOCATIONS OF AND GROUND SURFACE ELEVATIONS AT TEST BORINGS SHOWN WERE DETERMINED UPON THE COMPLETION OF DRILLING BY THE MAINE DEPARTMENT OF TRANSPORTATION USING GPS SURVEY EQUIPMENT.
3. ELEVATIONS ARE IN FEET AND REFERENCE THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
4. HORIZONTALL DATUM: MAINE 2000 EAST NAD 83 (FT).
5. TEST BORINGS WERE MONITORED IN THE FIELD BY A HALEY & ALDRICH, INC. GEOLOGIST.
6. REFER TO APPENDIX A FOR TEST BORING LOGS AND ROCK CORE PHOTOGRAPHS AND APPENDIX B FOR OBSERVATION WELL INSTALLATION AND GROUNDWATER MONITORING REPORTS.
7. BACKGROUND IMAGE TAKEN FROM GOOGLE EARTH PRO DATED 28 SEPTEMBER 2019.
8. TEST BORING HA22-3 AND HA22-4 WERE LAID OUT IN THE FIELD AS ALTERNATE BORING LOCATIONS, TO BE DRILLED DEPENDING ON CONDITIONS ENCOUNTERED AND AVAILABLE TIME. THESE TWO BORINGS WERE NOT DRILLED.

N

0 75 150

HALEY ALDRICH

MACHIAS LANDFILL INVESTIGATION
MACHIAS DIKE BRIDGE
MAINEDOT WIN 16714.00
MACHIAS, MAINE

SITE AND SUBSURFACE EXPLORATION LOCATION PLAN

SCALE: AS SHOWN
NOVEMBER 2022

FIGURE 2

Saved by: KPOSTOLOWSKI Printed: ---- Sheet: MODEL
Z:\POR_COMMON\PROJECTS\130749 - 2017 MEDOT ENV. MULTI-PIN\CAD\130749_001_BORING PLAN.DGN

APPENDIX A
Test Boring Logs and
Rock Core Photographs

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill
Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-1
WIN: 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	46.7	**Auger ID/OD:**	
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 3.0 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30;HW-300#/16
Date Start/Finish:	6-29-2022/6-29-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	NQ-2.0 in. ID
Boring Location:	N324629; E2402438	**Casing ID/OD:**	HW-4.0 in. ID/NW-3.0 in. ID	**Water Level*:**	29.7 ft
Hammer Efficiency Factor: 0.863		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/12	0.0 - 2.0	3/8/8/7	16	23				Brown, slightly moist, very stiff, Silty CLAY, trace coarse gravel -CLAY CAP-(CL) PID Readings=Not Detected MgM=CH4=OK	
	2D	24/10	2.0 - 4.0	3/7/2/29	9	13				Similar to above, except stiff, cobble pieces -CLAY CAP-(CL) PID Readings=Not Detected MgM=CH4=2.6	
								42.7		4.0 Cobble layer from 4 to 5 ft	
5	3D	24/16	5.0 - 7.0	40/57/8/10	65	93		41.7		5.0 Dark grey, slightly moist, hard, Silty CLAY, trace fine to coarse sand, trace gravel, cobble pieces, approximately 30% waste of newspaper, trash plastic bag, fine plastic netting -LANDFILL WASTE AND COVER-(CL) PID Readings=Not Detected MgM=CH4=0.2 Note: Driller moved rig approximately 3 ft to avoid obstruction at approximately 6 ft.	
								40.7		6.0 **Bottom of Exploration at 6.0 feet below ground surface.** Note: Boring moved approximately 3 ft to avoid obstruction at approximately 6 ft depth. See Test Boring Report HA22-1B for soil description of continued boring.	
10											
15											
20											
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill
Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-1B(OW)
WIN: 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	46.7	**Auger ID/OD:**	
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 3.0 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30;HW-300#/16
Date Start/Finish:	6-29-2022/6-30-2022	**Drilling Method:**	SSA/HW/NW Drive	**Core Barrel:**	NQ-2.0 in. ID
Boring Location:	N324629; E2402438	**Casing ID/OD:**	HW-4.0 in. ID/NW-3.0 in. ID	**Water Level*:**	29.7 ft
Hammer Efficiency Factor:	0.863	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0										Driller moved rig approximately 3 ft to avoid obstruction at approximately 6 ft depth at boring location HA22-1. See Test Boring Report HA22-1 for soil description for 0 to 6 ft depth.	
5								40.7		6.0	
	4D	24/12	6.0 - 8.0	4/3/4/5	7	10				Dark grey, slightly moist, stiff, Silty CLAY, trace sand, some cobble pieces -LANDFILL WASTE AND COVER-(CL) PID Readings=Not Detected MgM=OK	
	5D	24/12	8.0 - 10.0	4/3/4/5	7	10				Similar to 4D, except trace gravel, approximately 0.5-in. thick layer of black ash, approximately 30% waste of newspaper, wood, plastic bags, glass, metal -LANDFILL WASTE AND COVER-(CL)	
10								36.7		10.0	
	6D	24/3	10.0 - 12.0	19/34/60/35	94	135				Grey, moist, very dense, granitic piece of COBBLE, trace metal, rag, poor recovery, waste approximately 20% -LANDFILL WASTE AND COVER-(CL)	
								34.7		12.0	
	7D	24/12	12.0 - 14.0	11/19/22/14	41	59				Grey, wet, very dense, fine to coarse SAND, little silt, trace gravel, poorly-graded, approximately 40% waste of newspaper, plastic bags, approximately 3-in. black ash layer beneath waste -LANDFILL WASTE AND COVER-(SP)	
								32.7		14.0	
	8D	24/4	14.0 - 16.0	8/4/2/2	6	9				Brown, wet, loose, fine to coarse SAND, trace silt, well-graded, washed soil -LANDFILL WASTE AND COVER-(SW)	
15	9D	24/3	16.0 - 18.0	2/3/6/8	9	13				Similar to 8D, except medium dense and trace glass, plastic -LANDFILL WASTE AND COVER-(SW)	
	10D	24/8	18.0 - 20.0	5/3/3/2	6	9		28.4		Dark brown, wet, loose, fine to coarse SAND, trace silt, well-graded, trace glass (approximately 10%) -LANDFILL WASTE AND COVER-(SW-SM)	
										18.3	
20								26.7		Dark grey, wet, loose, Silty SAND -LANDFILL WASTE AND COVER-(SM)	
								26.4		20.0	
	11D	24/14	20.0 - 22.0	20/42/42/46	84	121				Grey, slightly moist, hard, Silty CLAY, trace nail -LANDFILL WASTE AND COVER-(CL)	
										20.3	
	12D	24/20	22.0 - 24.0	9/20/22/24	42	60				Brown and grey mottled, slightly moist, hard, Silty CLAY -MARINE DEPOSIT-(REWORKED) (CL) Similar to 11D -MARINE DEPOSIT-(REWORKED) (CL)	
25	13D	24/22	24.0 - 26.0	9/10/14/14	24	35				Brown and grey mottled, slightly moist, hard, Silty CLAY -MARINE DEPOSIT-(REWORKED) (CL)	

Remarks:

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Boring No.: HA22-1B(OW)

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-1B(OW)
WIN: 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	46.7	**Auger ID/OD:**	
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 3.0 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30;HW-300#/16
Date Start/Finish:	6-29-2022/6-30-2022	**Drilling Method:**	SSA/HW/NW Drive	**Core Barrel:**	NQ-2.0 in. ID
Boring Location:	N324629; E2402438	**Casing ID/OD:**	HW-4.0 in. ID/NW-3.0 in. ID	**Water Level*:**	29.7 ft
Hammer Efficiency Factor: 0.863		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	14D	24/24	26.0 - 28.0	13/15/16/20	31	45				Similar to 13D -MARINE DEPOSIT-(REWORKED) (CL)	
	15D	24/24	28.0 - 30.0	6/8/12/14	20	29		18.2		Similar to 13D, except very stiff -MARINE DEPOSIT-(REWORKED) (CL) 28.5	
30										Grey-brown,slightly moist, very stiff, Silty CLAY -MARINE DEPOSIT-(REWORKED) (CL)	
	16D	24/24	30.0 - 32.0	5/9/10/12	19	27				Grey-brown, slightly moist, very stiff, Silty CLAY -MARINE DEPOSIT-(REWORKED) (CL)	
								15.2		31.5 Grey, slightly moist, very stiff, Silty CLAY, layered depositional structure -MARINE DEPOSIT-(CL)	
								12.1		34.6	
35	17D	24/20	35.0 - 37.0	20/20/27/29	47	68				Grey-brown, slightly moist, very dense, fine to coarse SAND, trace silt, little gravel, loosely bonded -GLACIAL TILL-(SP)	
								8.7		38.0 COBBLES	
							RC	8.0		38.7	
	R1	60/51	39.0 - 44.0	RQD = 85%			NQ Core			Top of Bedrock El. 8.0 Note: Advanced roller bit to 39.0 ft and begin NQ rock core. R1: Dark grey, porphyritic BASALT with occasional 1-in. thick clasts, very hard, fresh, massive, solid core stem. Rock Quality=Good -DENNYS FORMATION- Recovery=85% R1 Core Times (min:sec): 39.0-40.0' (3:30); 40.0-41.0' (3:00); 41.0-42.0' (2:30); 42.0-43.0' (2:00); 43.0-44.0' (2:30)	
40											
								2.7		44.0 **Bottom of Exploration at 44.0 feet below ground surface.** Note: Installed Observation Well. See Observation Well Report HA22-1(OW) for details.	
45											
50											

Remarks:

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Boring No.: HA22-1B(OW)

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill
Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-2(OW)
WIN: 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	12.6	**Auger ID/OD:**	
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 3.0 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30;HW-300#/16
Date Start/Finish:	6-27-2022/6-28-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	NQ-2.0 in. ID
Boring Location:	N324616; E2402555	**Casing ID/OD:**	HW-4.0 in. ID/NW-3.0 in. ID	**Water Level*:**	3.6 ft
Hammer Efficiency Factor:	0.863	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/18	0.0 - 2.0	2/2/5/8	7	10				Brown grading to grey-brown, slightly moist, stiff, Silty CLAY, reworked -CLAY CAP-(CL) PID Readings=1.7 ppm MgM=OK	
	2D	24/20	2.0 - 4.0	2/7/8/11	15	22		10.6		2.0 Grey-brown, slightly moist, very stiff, Silty CLAY, layered depositional structure -MARINE DEPOSIT-(CL) PID Reading=1.0 ppm MgM=OK	
5	3D	24/20	4.0 - 6.0	4/7/9/10	16	23				Grey-brown mottled, slightly moist to moist, very stiff, Silty CLAY, fissures of wet grey clay -MARINE DEPOSIT-(CL) PID Readings=0.7 ppm MgM=OK	WC=30 LL=45 PL=23 PI=22 CL
	4D	24/22	6.0 - 8.0	4/6/9/12	15	22				Grey-brown, slightly moist, very stiff, Silty CLAY, layered depositional structure, occasional fine sand partings -MARINE DEPOSIT-(CL) PID Readings=0.2 ppm MgM=OK Note: Advanced NW 3-in. casing to 9.0 ft.	
							RC	3.6		9.0	
10	R1	20/18	10.3 - 12.0	RQD = 70%			NQ Core			Top of Bedrock El. 3.6 Note: Advanced roller bit to 10.0 ft and begin NQ rock coring. R1: Dark grey, porphyritic BASALT, very hard to hard, fresh to slightly weathered. Primary joints dipping horizontally, spaced moderately close, open. Joint surfaces moderately weathered with iron staining. Joint infilled with approximately 0.5 in. grey fine to coarse silty sand. Secondary joints dipping at moderate angles, smooth, planar. Rock Quality=Fair -DENNYS FORMATION- Recovery=90% R1 Core Times (min:sec): 10.3-11.0' (5:00); 11.0-12.0' (4:00)	
	R2	39.6/23	12.0 - 15.3	RQD = 43%						R2: Similar to R1. Rock Quality=Poor -DENNYS FORMATION- Recovery=58% R2 Core Times (min:sec): 12.0-13.0' (4:00); 13.0-14.0' (3:00); 14.0-15.3' (4:00)	
15								-2.7		15.3 **Bottom of Exploration at 15.3 feet below ground surface.** Note: Installed Observation Well. See Observation Well Report HA22-2(OW) for details.	
20											
25											

Remarks:

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Boring No.: HA22-2(OW)

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill
Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-5

WIN: 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	26.4	**Auger ID/OD:**	
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 1.375 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30;HW-300#/16
Date Start/Finish:	6-28-2022/6-29-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	NQ-2.0 in. ID
Boring Location:	N324780; E2402399	**Casing ID/OD:**	HW-4.0 in. ID/NW-3.0 in. ID	**Water Level*:**	--
Hammer Efficiency Factor: 0.863		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/18	0.0 - 2.0	1/3/4/3	7	10				Grey and brown, slightly moist, stiff, Silty CLAY, poorly-graded sand layer approximately 0.5-in. thick, no odor -CLAY CAP-(CL) PID Readings=7.8 ppm MgM=OK	
								24.4		2.0	
	2D	24/16	2.0 - 4.0	2/2/3/3	5	7				Grey, moist, medium stiff, Silty CLAY, few 0.5-in. thick sand layers, trace ash seam, few layers of plastic sheeting, septic-like odor -LANDFILL WASTE-(CL) PID Readings=0.8 ppm MgM=OK	
	3D	24/6	4.0 - 6.0	1/2/2/2	4	6					
5											
	4D	24/16	6.0 - 8.0	1/2/6/6	8	12				Similar to 2D, except wet, trace fine sand, thin seam of blue plastic sheeting, thin seam of newspaper, few sand seams approximately 0.5-in. spaced approximately 3 to 4 in. -LANDFILL WASTE-(CL) PID Readings=0.2 ppm MgM=0.8 CH4	
								18.7			
	5D	24/20	8.0 - 10.0	4/7/9/11	16	23				Grey, wet, stiff, Silty CLAY, few black ash layers, trace metal, glass pieces, plastic sheeting, insulation pieces, no odor -LANDFILL WASTE-(CL) PID Readings=0.0 ppm MgM=1.1 CH4	
10										7.7	
	6D	24/20	10.0 - 12.0	3/7/8/11	15	22				Brown, slightly moist, stiff, Silty CLAY, layered depositional structure -MARINE DEPOSIT-(CL)	
										Grey-brown mottled, slightly moist, very stiff, Silty CLAY, layered depositional structure -MARINE DEPOSIT-(CL)	
										Similar to 5D -MARINE DEPOSIT-(CL)	
15	7D	24/24	15.0 - 17.0	3/4/5/7	9	13				Grey-brown, slightly moist, stiff, Silty CLAY -MARINE DEPOSIT-(CL)	
20	8D	24/24	20.0 - 22.0	WOH/WOH/3/3	3	4				Grey, slightly moist, medium stiff, Silty CLAY -MARINE DEPOSIT-(CL)	WC=29 LL=38 PL=20 PI=18 CL
								2.7		23.7	
								1.9		Note: Drilling change noted while advancing casing. Casing refusal at 24.8 ft.	
25											

Remarks:

3.0-in. diameter split-spoon used to sample 1D to 6D.

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Machias Landfill Machias Dike Bridge **Location:** Machias, Maine	**Boring No.:** HA22-5 **WIN:** 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	26.4	**Auger ID/OD:**	
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 1.375 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30;HW-300#/16
Date Start/Finish:	6-28-2022/6-29-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	NQ-2.0 in. ID
Boring Location:	N324780; E2402399	**Casing ID/OD:**	HW-4.0 in. ID/NW-3.0 in. ID	**Water Level*:**	--
Hammer Efficiency Factor: 0.863		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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T_v = Pocket Torvane Shear Strength (psf)
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LL = Liquid Limit
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PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										24.5 Cobbles	
	9D	24/12	26.0 - 28.0	16/10/11/11	21	30		0.4		26.0 Grey, wet, medium dense, fine to coarse SAND, little silt, trace gravel, poorly-graded, one silt laminae -FLUVIAL DEPOSIT-(SM)	
								-2.4		Note: Rollerbit to 28.8 ft and cored from 28.8 to 30.5 ft.	
										28.8 Boulder and Cobbles	
30	10D	12/6	30.5 - 31.5	20/30				-4.1		30.5 Grey-brown, wet, dense to very dense, fine to coarse SAND, trace silt, little gravel, well-graded, loosely bonded -GLACIAL TILL-(SW)	
							RC	-5.1			
	R1	60/57	32.5 - 37.5	RQD = 78%			NQ			31.5 Top of Bedrock El. -5.1 Note: Advance roller bit to 32.5 ft and begin NQ rock coring. R1: Dark grey, white, aphanitic to coarse-grained, basaltic TUFF-BRECCIA, very hard to hard, slightly weathered. Primary joints dipping at horizontal to low angles, spaced very close to moderately close, open. No infilling. Joint surfaces slightly iron-stained, calcite coatings. Rock Mass=Good -DENNYS FORMATION- Recovery=95% R1 Core Times (min:sec): 32.5-33.5' (3:00); 33.5-34.5' (2:00); 34.5-35.5' (3:00); 35.5-36.5' (3:00); 36.5-37.5' (2:00)	
							Core				
35											
								-11.1		37.5	
										Bottom of Exploration at 37.5 feet below ground surface.	
40											
45											
50											

Remarks:

3.0-in. diameter split-spoon used to sample 1D to 6D.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill, Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-6
WIN: 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	17.0	**Auger ID/OD:**	--
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 3.0 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30
Date Start/Finish:	6-29-2022/6-29-2022	**Drilling Method:**	SSA Drive	**Core Barrel:**	--
Boring Location:	N324827; E2402414	**Casing ID/OD:**	--	**Water Level*:**	--
Hammer Efficiency Factor: 0.863		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/18	0.0 - 2.0	WOH/2/2/7	4	6		16.0		Grey and brown, slightly moist, medium stiff, silty CLAY, trace plastic bag, reworked structure to approximately 1 ft -CLAY CAP-(CL) 1.0	
	2D	24/22	2.0 - 4.0	10/23/36/38	59	85				Grey-brown mottled, slightly moist, hard, Silty CLAY, layered depositional structure -MARINE DEPOSIT-(CL)	
	3D	24/24	4.0 - 6.0	7/10/11/13	21	30				Similar to 2D, except very stiff	WC=26 LL=40 PL=22 PI=18 CL
5								11.0		6.0	
										Bottom of Exploration at 6.0 feet below ground surface.	
										No Refusal	
10											
15											
20											
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill
Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-7

WIN: 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	52.5	**Auger ID/OD:**	--
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 1.375 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30
Date Start/Finish:	7-01-2022/7-01-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	--
Boring Location:	N324632; E2402378	**Casing ID/OD:**	HW-4.0 in. ID	**Water Level*:**	--
Hammer Efficiency Factor:	0.863	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0											
5											
10	1D	24/14	10.0 - 12.0	2/2/3/4	5	7				Grey-brown, slightly moist, medium stiff, silty CLAY, trace fine sand, trace gravel, approximately 10% waste of plastic bags -LANDFILL WASTE AND COVER-(CL)	
15											
20	2D	24/10	20.0 - 22.0	6/4/4/4	8	12				Grey, wet, stiff, Silty CLAY, trace fine to coarse sand, trace gravel, approximately 30% waste of plastic, glass and wire -LANDFILL WASTE AND COVER-(CL)	
								30.5		22.0	
	3D	24/16	22.0 - 24.0	17/30/37/44	67	96				Brown, slightly moist, hard, Silty CLAY, reworked -MARINE DEPOSIT (REWORKED)-(CL)	
25											

Remarks:

3.0-in. diameter split-spoon used to sample 1D.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-7
WIN: 16714.00

Driller:	New England Boring Co., Inc.	**Elevation (ft.)**	52.5	**Auger ID/OD:**	--
Operator:	T. Schaeffer	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 1.375 in. ID
Logged By:	H. Hollauer	**Rig Type:**	B53 Mobile Drill	**Hammer Wt./Fall:**	SS-140#/30
Date Start/Finish:	7-01-2022/7-01-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	--
Boring Location:	N324632; E2402378	**Casing ID/OD:**	HW-4.0 in. ID	**Water Level*:**	--
Hammer Efficiency Factor:	0.863	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										Note: Probe advanced to bottom of clay/glacial till interface.	
30											
										Note: Drill action indicates cobbles and gravel at 35.0 ft.	
35								17.5		-PROBABLE GLACIAL TILL- 35.0	
								16.9		35.6 **Bottom of Exploration at 35.6 feet below ground surface.**	
40											
45											
50											

Remarks:

3.0-in. diameter split-spoon used to sample 1D.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Machias Landfill
Machias Dike Bridge
Location: Machias, Maine

Boring No.: HA22-8(OW)
WIN: 16714.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	64.5	**Auger ID/OD:**	--
Operator:	K. Hanscom	**Datum:**	NAVD 88	**Sampler:**	--
Logged By:	H. Hollauer	**Rig Type:**	Diedrich 50 Track	**Hammer Wt./Fall:**	HW-300#/16
Date Start/Finish:	7-25-2022/7-25-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	--
Boring Location:	N324623; E2401655	**Casing ID/OD:**	HW-4.0 in. ID	**Water Level*:**	5.4 ft
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0										Note: No soil samples collected. SSA used to determine refusal depth and approximate depth to water. Soil descriptions determined from drill cutting observations. Brown, dry, Silty fine to medium SAND, trace coarse sand, trace coarse gravel -FILL-(SM)	
								60.5		4.0	
5										Brown grading to grey, moist, Silty CLAY -MARINE DEPOSIT-(CL)	
10											
15											
								46.9		Auger refusal at 17.6 ft 17.6	
										Bottom of Exploration at 17.6 feet below ground surface.	
										Note: Installed observation well - see Observation Well Installation Report HA22-8(OW) for details.	
20											
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: HA22-8(OW)

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Machias Landfill Machias Dike Bridge			**Boring No.:**	HA22-9(OW)
Location:	Machias, Maine			**WIN:**	16714.00
Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	17.5	**Auger ID/OD:**	--
Operator:	K. Hanscom	**Datum:**	NAVD 88	**Sampler:**	--
Logged By:	H. Hollauer	**Rig Type:**	Diedrich 50 Track	**Hammer Wt./Fall:**	HW-300#/16
Date Start/Finish:	7-25-2022/7-25-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	--
Boring Location:	N324821; E2402411	**Casing ID/OD:**	HW-4.0 in. ID	**Water Level*:**	20.8 ft
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0										Note: No soil samples collected. SSA used to determine refusal depth and approximate depth to water. Soil descriptions determined from drill cutting observations. Brown grading to grey, slightly moist, Silty CLAY, trace fine sand -MARINE DEPOSIT-(CL)	
5											
10											
15											
20											
								-3.8		21.3	
								-3.9		Grey, Silty CLAY, trace medium sand in wash water at 21.3 ft -MARINE DEPOSIT-(CL) Casing refusal at 21.4 ft	
										21.4	
										Bottom of Exploration at 21.4 feet below ground surface. Note: Installed observation well - see Observation Well Installation Report HA22-9(OW) for details.	
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Machias Landfill Machias Dike Bridge Location: Machias, Maine	Boring No.: HA22-10(OW) WIN: 16714.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	19.2	**Auger ID/OD:**	--
Operator:	K. Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon 1.375 in. ID
Logged By:	H. Hollauer	**Rig Type:**	Diedrich 50 Track	**Hammer Wt./Fall:**	SS-140#/30
Date Start/Finish:	7-26-2022/7-26-2022	**Drilling Method:**	SSA/HW Drive	**Core Barrel:**	--
Boring Location:	N324502; E2402502	**Casing ID/OD:**	HW-4.0 in. ID	**Water Level*:**	4.9 ft
Hammer Efficiency Factor: 0.91		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0										Note: No soil samples collected in upper 5 ft. SSA used to determine refusal depth and approximate depth to water. Strata descriptions determined from drill cutting observations. -LANDFILL WASTE AND COVER-	
5	1D	24/20	5.0 - 7.0	1/1/1/1	2	3		14.2		5.0 Dark grey to black, wet, very loose, Silty fine SAND, trace medium sand -TIDAL MARSH DEPOSIT-(SM)	
								9.6		Refusal at 9.6 ft on probable bedrock 9.6	
10										**Bottom of Exploration at 9.6 feet below ground surface.** Note: Installed observation well - see Observation Well Installation Report HA22-10(OW) for details.	
15											
20											
25											

Remarks:

Note: Auger refusal at multiple locations at 5.2 ft, 3.2 ft, 3.5 ft, 6.9 ft below ground surface. Auger cuttings indicate LANDFILL WASTE AND COVER.

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Boring No.: HA22-10(OW)

ROCK CORE PHOTOGRAPHS
MACHIAS LANDFILL INVESTIGATION
MACHIAS, MAINE
FILE NO. 0130749-009

Top Row: HA22-2, Run No. C1 10.3 (left) to 12.0 (middle-left); Run No. C2 12.0 (middle-left) to 15.3 (right)
Top Middle Row: HA22-5, Run No. C1 32.5 (left) to 37.5 (right)
Bottom Middle Row: HA22-1, Run No. C1 39.0 (left) to 44.0 (right)
Bottom Row: empty

APPENDIX B
Observation Well Installation and Groundwater Monitoring Reports

OBSERVATION WELL INSTALLATION REPORT

HALEY ALDRICH

Well No. HA22-1 (OW)
Boring No. HA22-1

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	New England Boring Contractors, Inc.	**DATE INSTALLED**	6/30/2022
DRILLER	T. Schaeffer	**WATER LEVEL**	19.4 ft (below ground surface)

Ground El. 46.7 ft **Location** See Plan
El. Datum NAVD 88

☑ **Guard Pipe**
☐ **Roadway Box**

SOIL/ROCK CONDITIONS	BOREHOLE BACKFILL
CLAY CAP	BENTONITE
4.0 ft	
LANDFILL WASTE AND COVER	
20.3 ft	
REWORKED MARINE DEPOSIT (CLAY)	
31.5 ft	
NATIVE MARINE DEPOSIT (CLAY)	32.0 ft
34.6 ft	FILTER SAND
GLACIAL TILL	
38.0 ft	
COBBLES	38.5 ft
38.7 ft	BENTONITE
BEDROCK	
44.0	**44.0**

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)

Type of protective cover/lock	Lockable Cap	
Height of top of guard pipe/roadway box above ground surface	3.2	**ft**
Height of top of riser pipe above ground surface	3.1	**ft**
Type of protective casing:	Steel Guard Pipe	
Length	5.3	**ft**
Inside Diameter	4.0	**in**
Depth of bottom of guard pipe/roadway box	2.2	**ft**

Type of Seals	Top of Seal (ft)	Thickness (ft)
Bentonite Seal	0.0	32.0
Bentonite Seal	38.5	5.5

Type of riser pipe:	Sch. 40 PVC	
Inside diameter of riser pipe	2.0	**in**
Type of backfill around riser	Filter Sand/Bentonite	
Diameter of borehole	4.0	**in**
Depth to top of well screen	34.0	**ft**
Type of screen	Sch. 40 PVC	
Screen gauge or size of openings	0.010	**in**
Diameter of screen	2.0	**in**
Type of backfill around screen	Filter Sand	
Depth of bottom of well screen	39.0	**ft**
Bottom of Silt trap	39.0	**ft**
Depth of bottom of borehole	44.0	**ft**

L1

L2

L3

(Not to Scale)

37.0 ft + 5.0 ft + 0.0 ft = 42.0 ft
Riser Pay Length (L1) + Length of screen (L2) + Length of silt trap (L3) = Pay length

COMMENTS:

\\haleyaldrich.com\share\por_common\PROJECTS\130749 - 2017 MEDOT Env. Multi-PIN\009 - Machias Landfill\Field

Form 2007

OBSERVATION WELL INSTALLATION REPORT

HALEY ALDRICH

Well No. HA22-2 (OW)
Boring No. HA22-2

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	New England Boring Contractors, Inc.	**DATE INSTALLED**	6/28/2022
DRILLER	T. Schaeffer	**WATER LEVEL**	0.5 ft (below ground surface)

Ground El. 12.6 ft **Location** See Plan ☑ **Guard Pipe**
El. Datum NAVD 88 ☐ **Roadway Box**

SOIL/ROCK CONDITIONS	BOREHOLE BACKFILL
CLAY CAP	
2.0 ft	
MARINE DEPOSIT (CLAY)	BENTONITE
	3.0 ft
	FILTER SAND
9.0 ft	9.0 ft
BEDROCK	BENTONITE SEAL
15.3	15.3

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)

L1 L2 L3

Type of protective cover/lock	Lockable Cap	
Height of top of guard pipe/roadway box above ground surface	3.3	ft
Height of top of riser pipe above ground surface	3.1	ft
Type of protective casing:	Steel Guard Pipe	
Length	5.3	ft
Inside Diameter	4.0	in
Depth of bottom of guard pipe/roadway box	2.4	ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Bentonite Seal	0.0	3.0
Bentonite Seal	9.0	6.3

Type of riser pipe:	Sch. 40 PVC	
Inside diameter of riser pipe	2.0	in
Type of backfill around riser	Filter Sand/Bentonite	
Diameter of borehole	4.0	in
Depth to top of well screen	4.0	ft
Type of screen	Sch. 40 PVC	
Screen gauge or size of openings	0.010	in
Diameter of screen	2.0	in
Type of backfill around screen	Filter Sand	
Depth of bottom of well screen	9.0	ft
Bottom of Silt trap	9.0	ft
Depth of bottom of borehole	15.3	ft

(Not to Scale)

6.7 ft + 5.0 ft + 0.0 ft = 11.7 ft
Riser Pay Length (L1) + Length of screen (L2) + Length of silt trap (L3) = Pay length

COMMENTS:

\\haleyaldrich.com\share\por_common\PROJECTS\130749 - 2017 MEDOT Env. Multi-PIN\009 - Machias Landfill\Field

Form 2007

OBSERVATION WELL INSTALLATION REPORT

HALEY ALDRICH

Well No.	HA22-8 (OW)
Boring No.	HA22-8 (OW)

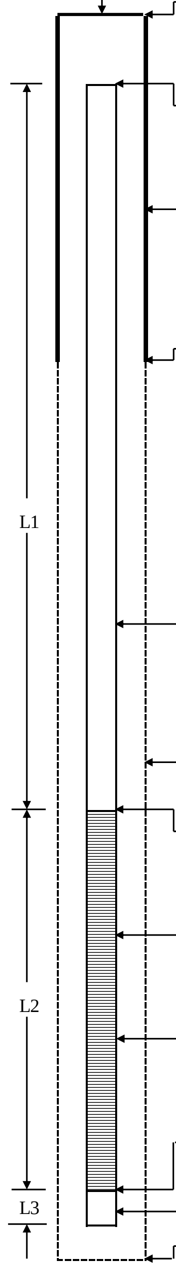
PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	SW Cole Explorations	**DATE INSTALLED**	7/25/2022
DRILLER	K. Hanscom	**WATER LEVEL**	2.4 ft (below ground surface)

Ground El.	64.5 ft	**Location**	See Plan
El. Datum	NAVD 88		**North side of salt pile along tree line**

☑ **Guard Pipe**
☐ **Roadway Box**

SOIL/ROCK CONDITIONS	BOREHOLE BACKFILL
FILL	BENTONITE
	1.0 ft
~4.0 ft	FILTER SAND
MARINE DEPOSIT	
17.6	17.6

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)



Type of protective cover/lock	N/A	
Height of top of guard pipe/roadway box above ground surface	3.2	ft
Height of top of riser pipe above ground surface	3.0	ft
Type of protective casing:	4-in. dia. Steel Guard Pipe	
Length	5.4	ft
Inside Diameter	4.0	in
Depth of bottom of guard pipe/roadway box	2.4	ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Bentonite	0.0	1.0

Type of riser pipe:	Sch. 40 PVC	
Inside diameter of riser pipe	2.0	in
Type of backfill around riser	Filter Sand	
Diameter of borehole	4.0	in
Depth to top of well screen	1.3	ft
Type of screen	Sch. 40 PVC	
Screen gauge or size of openings	0.010	in
Diameter of screen	2.0	in
Type of backfill around screen	Filter Sand	
Depth of bottom of well screen	16.3	ft
Bottom of Silt trap	16.3	ft
Depth of bottom of borehole	17.6	ft

(Not to Scale)

Riser Pay Length (L1)		Length of screen (L2)		Length of silt trap (L3)		Pay length
4.1 ft	+	15.0 ft	+	0.0 ft	=	19.1 ft

COMMENTS: Soil conditions determined from drill cutting observations.

\\haleyaldrich.com\share\por_common\PROJECTS\130749 - 2017 MEDOT Env. Multi-PIN\009 - Machias Landfill\Field

Form 2007

OBSERVATION WELL INSTALLATION REPORT

HALEY ALDRICH

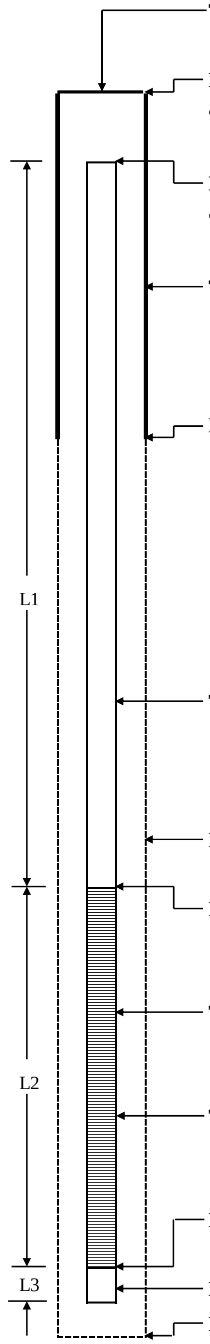
Well No.	HA22-9 (OW)
Boring No.	HA22-9 (OW)

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	SW Cole Explorations	**DATE INSTALLED**	7/25/2022
DRILLER	K. Hanscom	**WATER LEVEL**	18.4 ft (below ground surface)

Ground El.	**17.5** ft	**Location**	See Plan	☑ **Guard Pipe**
El. Datum	**NAVD 88**		Approx. 7 ft west of HA22-6	☐ **Roadway Box**

SOIL/ROCK CONDITIONS	**BOREHOLE BACKFILL**
	SAND
	1.0 ft
	BENTONITE
	2.0 ft
	FILTER SAND
MARINE DEPOSIT	
	20.8 ft
	FILTER SAND
21.4	**21.4**

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)



Type of protective cover/lock	N/A	
Height of top of guard pipe/roadway box above ground surface	3.1	**ft**
Height of top of riser pipe above ground surface	2.4	**ft**
Type of protective casing:	4-in. dia. Steel Guard Pipe	
Length	5.4	**ft**
Inside Diameter	4.0	**in**
Depth of bottom of guard pipe/roadway box	2.4	**ft**

Type of Seals	**Top of Seal (ft)**	**Thickness (ft)**
Bentonite	1.0	1.0

Type of riser pipe:	Sch. 40 PVC	
Inside diameter of riser pipe	2.0	**in**
Type of backfill around riser	Filter Sand	
Diameter of borehole	4.0	**in**
Depth to top of well screen	4.5	**ft**
Type of screen	Sch. 40 PVC	
Screen gauge or size of openings	0.010	**in**
Diameter of screen	2.0	**in**
Type of backfill around screen	Filter Sand	
Depth of bottom of well screen	19.5	**ft**
Bottom of Silt trap	19.5	**ft**
Depth of bottom of borehole	21.4	**ft**

(Not to Scale)

Riser Pay Length (L1)		Length of screen (L2)		Length of silt trap (L3)		Pay length
6.8 ft	+	15.0 ft	+	0.0 ft	=	21.8 ft

COMMENTS: Soil conditions determined from drill cutting observations.

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Form 2007

OBSERVATION WELL INSTALLATION REPORT

HALEY ALDRICH

Well No.	HA22-10 (OW)
Boring No.	HA22-10 (OW)

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	SW Cole Explorations	**DATE INSTALLED**	7/26/2022
DRILLER	K. Hanscom	**WATER LEVEL**	2.0 ft (below ground surface)

Ground El. 19.2 ft **Location** See Plan
El. Datum NAVD 88 **South side of landfill at toe of slope**

☑ **Guard Pipe**
☐ **Roadway Box**

SOIL/ROCK CONDITIONS	**BOREHOLE BACKFILL**
LANDFILL WASTE AND COVER	BENTONITE
5.0 ft	2.0 ft
TIDAL MARSH DEPOSIT	FILTER SAND
	9.4 ft
	FILTER SAND
9.6	9.6

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)

L1
L2
L3

Type of protective cover/lock	N/A	
Height of top of guard pipe/roadway box above ground surface	3.2	ft
Height of top of riser pipe above ground surface	2.9	ft
Type of protective casing:	4-in. dia. Steel Guard Pipe	
Length	5.4	ft
Inside Diameter	4.0	in
Depth of bottom of guard pipe/roadway box	2.7	ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Bentonite	0.0	2.0

Type of riser pipe:	Sch. 40 PVC	
Inside diameter of riser pipe	2.0	in
Type of backfill around riser	Filter Sand	
Diameter of borehole	4.0	in
Depth to top of well screen	2.6	ft
Type of screen	Sch. 40 PVC	
Screen gauge or size of openings	0.010	in
Diameter of screen	2.0	in
Type of backfill around screen	Filter Sand	
Depth of bottom of well screen	9.6	ft
Bottom of Silt trap	9.6	ft
Depth of bottom of borehole	9.6	ft

(Not to Scale)

Riser Pay Length (L1)		Length of screen (L2)		Length of silt trap (L3)		Pay length
5.0 ft	+	7.0 ft	+	0.0 ft	=	12.0 ft

COMMENTS:

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Form 2007

GROUNDWATER MONITORING REPORT

OW/PZ NUMBER
HA22-1
Page **of**

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	New England Boring Contractors, Inc.	**DATE**	6/30/2022

ELEVATION OF REFERENCE POINT 49.8 **REFERENCE POINT:** **Ground Surface** ☐ **PVC** ☑ **Other** ☐

Date	Time	Elapsed Time (days)	Depth of Water from Reference Point	Elevation of Water	Remarks	Read By
6/30/2022		0	22.5	27.4		HH
7/1/2022	8:00	1	29.7	20.1		HH
7/26/2022		26	30.3	19.5		HH
9/7/2022	13:45	69	30.4	19.4		JI

GROUNDWATER MONITORING REPORT

HALEY ALDRICH

OW/PZ NUMBER **HA22-2**

Page of

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	New England Boring Contractors, Inc.	**DATE**	6/28/2022

ELEVATION OF REFERENCE POINT 15.7 **REFERENCE POINT:** **Ground Surface** ☐ **PVC** ☑ **Other** ☐

Date	Time	Elapsed Time (days)	Depth of Water from Reference Point	Elevation of Water	Remarks	Read By
6/28/2022	8:30	0	3.6	12.1		HH
6/28/2022	14:00	0	3.7	12.0		HH
6/29/2022	7:00	1	3.7	12.0		HH
6/30/2022	7:30	2	3.8	11.9		HH
7/25/2022		27	4.1	11.6		HH
7/26/2022	8:40	28	4.1	11.6		HH
8/15/2022	14:00	48	4.6	11.2		HH
9/7/2022	13:35	71	4.0	11.7		JI

HALEY ALDRICH

GROUNDWATER MONITORING REPORT

OW/PZ NUMBER **HA22-8**

Page of

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	New England Boring Contractors, Inc.	**DATE**	7/25/2022

ELEVATION OF REFERENCE POINT 67.5 **REFERENCE POINT: Ground Surface** ☐ **PVC** ☑ **Other** ☐

Date	Time	Elapsed Time (days)	Depth of Water from Reference Point	Elevation of Water	Remarks	Read By
7/25/2022	12:30	0	5.4	62.1		HH
7/25/2022	16:30	0	9.8	57.7		HH
8/15/2022	11:00	21	11.9	55.6		HH
9/7/2022	14:30	44	10.8	56.7		JI

GROUNDWATER MONITORING REPORT

HALEY ALDRICH

OW/PZ NUMBER **HA22-9**

Page of

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	New England Boring Contractors, Inc.	**DATE**	7/25/2022

ELEVATION OF REFERENCE POINT 19.9 **REFERENCE POINT:** **Ground Surface** ☐ **PVC** ☑ **Other** ☐

Date	Time	Elapsed Time (days)	Depth of Water from Reference Point	Elevation of Water	Remarks	Read By
7/25/2022	16:30	0	20.8	-0.9		HH
7/26/2022	6:50	1	8.9	11.0		HH
8/15/2022	12:35	21	9.7	10.2		HH
9/7/2022	14:15	44	9.3	10.6		JI

HALEY ALDRICH

GROUNDWATER MONITORING REPORT

OW/PZ NUMBER
HA22-10
Page **of**

PROJECT	Machias Landfill Investigation, Machias Dike Bridge	**H&A FILE NO.**	130749-009
LOCATION	Machias, Maine	**PROJECT MGR.**	D. Dearden
CLIENT	Maine Department of Transportation	**FIELD REP.**	H. Hollauer
CONTRACTOR	New England Boring Contractors, Inc.	**DATE**	7/26/2022

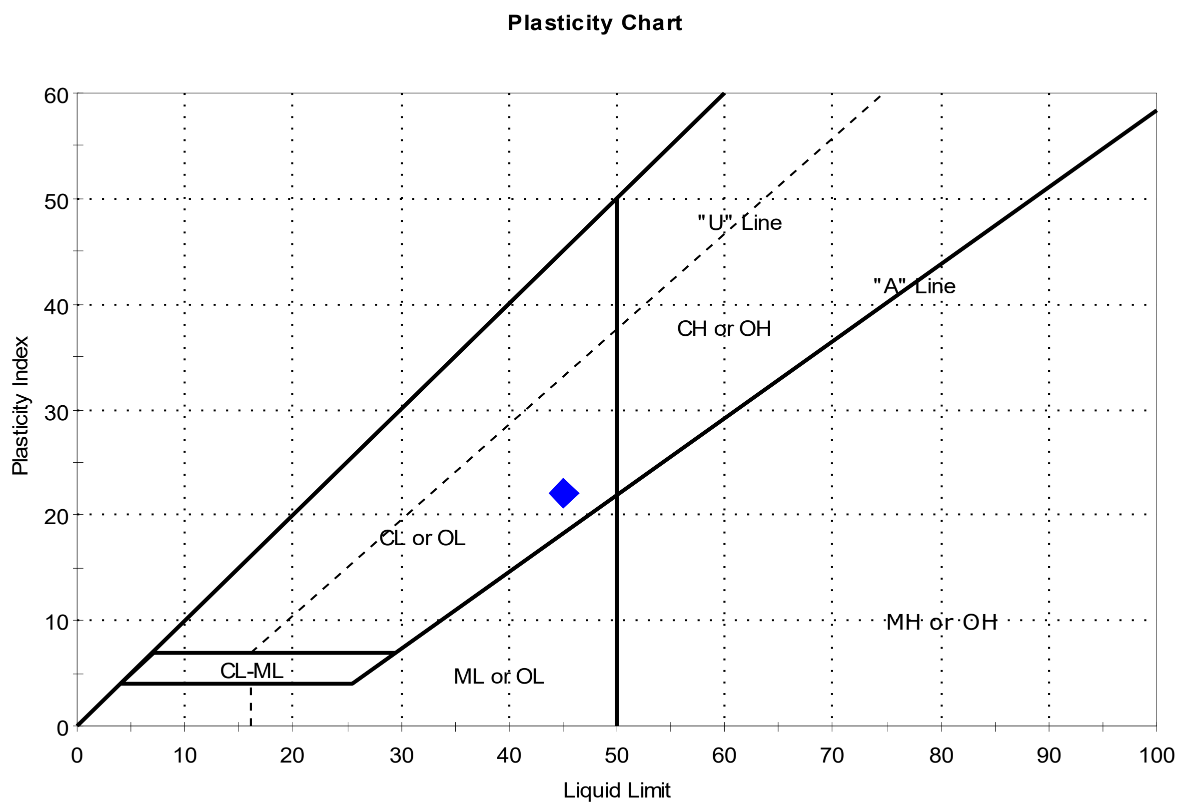
ELEVATION OF REFERENCE POINT 22.1 **REFERENCE POINT: Ground Surface** ☐ **PVC** ☑ **Other** ☐

Date	Time	Elapsed Time (days)	Depth of Water from Reference Point	Elevation of Water	Remarks	Read By
7/26/2022		0	4.9	17.2		HH
7/26/2022	9:45	0	5.2	17.0		HH
8/15/2022	15:15	20	3.1	19.0		HH
9/7/2022	13:25	43	2.8	19.3		JI

APPENDIX C
Geotechnical Laboratory Test Results

Client:	Haley & Aldrich, Inc.				
Project:	Machias Landfill				
Location:	Machias, ME			Project No:	GTX-315911
Boring ID:	HA22-2	Sample Type:	bag	Tested By:	cam
Sample ID:	S3	Test Date:	08/16/22	Checked By:	bfs
Depth :	4-6'	Test Id:	682011		
Test Comment:	---				
Visual Description:	Moist, light olive brown clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S3	HA22-2	4-6'	30	45	23	22	0.3	

Sample Prepared using the WET method

Dry Strength: VERY HIGH

Dilatancy: SLOW

Toughness: LOW

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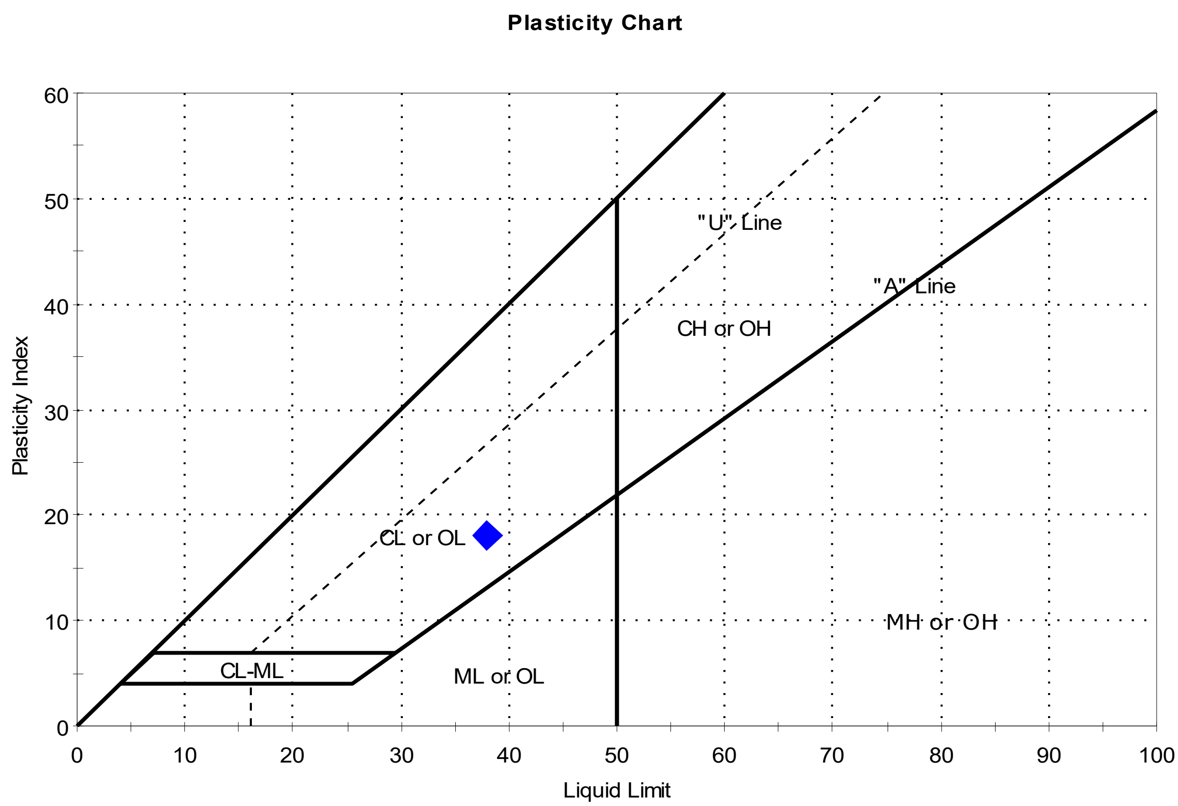
Client:	Haley & Aldrich, Inc.		
Project:	Machias Landfill		
Location:	Machias, ME	Project No:	GTX-315911
Boring ID: HA22-5	Sample Type: bag	Tested By:	cam
Sample ID: S8	Test Date: 08/16/22	Checked By:	bfs
Depth : 20-22'	Test Id: 682012		
Test Comment:	---		
Visual Description:	Moist, gray clay		
Sample Comment:	---		

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S8	HA22-5	20-22'	29	38	20	18	0.5	

Sample Prepared using the WET method

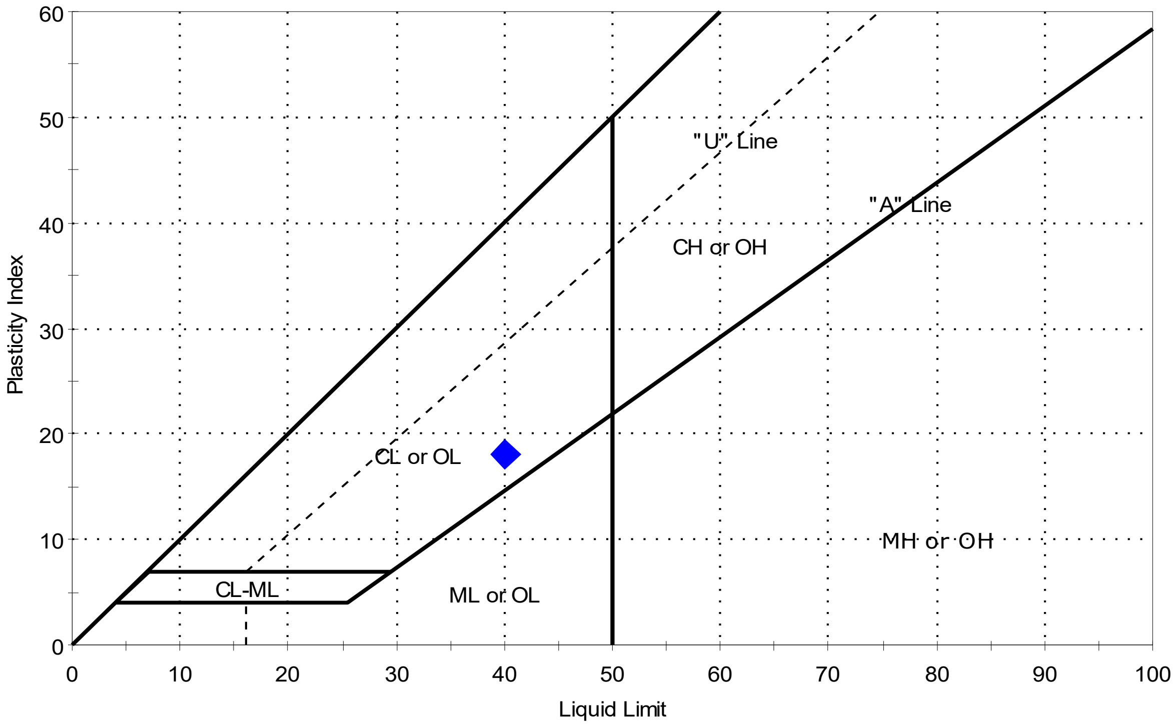
Dry Strength: VERY HIGH

Dilatancy: SLOW

Toughness: LOW

Client:	Haley & Aldrich, Inc.
Project:	Machias Landfill
Location:	Machias, ME
Project No:	GTX-315911
Boring ID:	HA22-6
Sample Type:	bag
Tested By:	cam
Sample ID:	S3
Test Date:	08/16/22
Checked By:	bfs
Depth :	4-6'
Test Id:	682013
Test Comment:	---
Visual Description:	Moist, brown clay
Sample Comment:	---

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S3	HA22-6	4-6'	26	40	22	18	0.2	

Sample Prepared using the WET method

Dry Strength: VERY HIGH
Dilatancy: SLOW
Toughness: LOW

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APPENDIX D
Low Flow Field Sampling Forms

HALEY ALDRICH

LOW FLOW/MNA FIELD SAMPLING FORM

PROJECT	MDOT Machias Landfill	H&A FILE NO.	130749
LOCATION	Machias, Maine	PROJECT MGR.	D. Dearden
CLIENT	Maine DOT	FIELD REP.	H. Hollauer
CONTRACTOR	None	DATE INSTALLED	6/28/2022
DRILLER		WATER LEVEL	4.55

Sampling Data: 15 Aug. 2022

Well ID:	HA22-2(OW)	Well Depth:	9.0 ft	Initial Depth To Water:	4.55 ft	Purging Device:	Geotech peristaltic pump
Start time:	1400	Depth To Top Of Screen:	4.0 ft	Depth Of Pump Intake:	~8.0 ft	Tubing Present In Well:	Yes X No
Finish Time:	1510	Depth To Bottom Of Screen:	9.0 ft	Pump started 1410		Tubing Type:	Silicone and LDPE

Elapsed Time (24 hour)	Depth To Water From Casing (ft)	Pump Setting (ml/min) or (gal/min)	Purge Rate (ml/min) or (gal/min)	Cumulative Purge Vol. (liters) or (gal)	Temperature (°F) or (°C) +/-__%	pH +/-__	Conductivity (us/cm) +/-__%	Dissolved Oxygen (mg/L) +/-__%	Turbidity (NTU) <__NTU	ORP/eH (mv) +/-__mv	Comments
1415	5.68		~300		19.41	6.45	3.00	1.42	28.3	146	Clear, no odor
1420	6.30				19.10	6.43	2.93	0.76	22.8	146	
1425	6.82				18.99	6.42	2.87	0.48	17.1	138	
1430	7.00				18.80	6.41	2.85	0.33	14.9	136	
1435	7.25			~1.0	18.65	6.41	2.85	0.19	11.7	135	
											Collected sample prior to full stabilization because well possibly may be pumped dry.
											DTW at end of sampling = 8.88
											The hole for the lock broke so unable to lock casing.
											Top PVC to Top casing = 0.15'

HexCr, etc. collected 8/16/22 @ 0800.

Sample Time 1440

PFAS Field Blank Taken Field Blank-1 @ 8/15 @ 1430

Form 3010

LOW FLOW/MNA FIELD SAMPLING FORM

HALEY ALDRICH

PROJECT	MDOT Machias Landfill	H&A FILE NO.	130749
LOCATION	Machias, Maine	PROJECT MGR.	D. Dearden
CLIENT	Maine DOT	FIELD REP.	H. Hollauer
CONTRACTOR	None	DATE INSTALLED	7/25/2022
DRILLER		WATER LEVEL	11.90

Sampling Data: 15 Aug. 2022

Well ID:	HA22-8(OW)	Well Depth:	16.3 ft	Initial Depth To Water:	11.90 ft	Purging Device:	Geotech peristaltic pump
Start time:	1100	Depth To Top Of Screen:	1.3 ft	Depth Of Pump Intake:	~15 ft	Tubing Present In Well:	Yes X No
Finish Time:	1230	Depth To Bottom Of Screen:	16.3 ft	Pump started 1110		Tubing Type:	Silicone and LDPE

Elapsed Time (24 hour)	Depth To Water From Casing (ft)	Pump Setting (ml/min) or (gal/min)	Purge Rate (ml/min) or (gal/min)	Cumulative Purge Vol. (liters) or (gal)	Temperature (°F) or (°C) +/-3%	pH +/-0.1	Conductivity mS/cm (us/cm) +/-3%	Dissolved Oxygen (mg/L) ≤0.5%	Turbidity (NTU) <10 NTU	ORP/eH (mv) +/-10 mv	Comments
1115	12.42		~300		16.71	6.15	12.1	1.05	18.1	-44	Clear, no odor
1120	12.65				16.31	6.10	11.6	1.13	17.3	-38	Changed pump head to slower
1125	12.70		~250		17.13	6.13	11.8	2.24	20.5	-22	RPM
1130	12.75				17.90	6.20	12.1	3.92	32.8	-13	
1135	12.92				17.33	6.10	11.3	0.69	26.5	-11	
1140	13.11				17.56	6.09	11.0	0.22	15.7	-12	
1145	13.13				17.45	6.08	10.9	0.02	11.8	-13	
1148	13.15				17.49	6.08	10.8	0.00	10.2	-13	
1153	13.18				17.49	6.08	10.7	0.00	9.4	-12	
1158	13.21			~1.5gal	17.49	6.08	10.6	0.00	9.3	-12	
											Top PVC to Top Casing = 0.15'

Sample time 1200

HexCr, etc collected 8/16/22 @0720

HALEY ALDRICH

LOW FLOW/MNA FIELD SAMPLING FORM

PROJECT: MDOT Machias Landfill
LOCATION: Machias, Maine
CLIENT: Maine DOT
CONTRACTOR: None
DRILLER:

H&A FILE NO: 130749
PROJECT MGR: D. Dearden
FIELD REP.: H. Hollauer
DATE INSTALLED: 7/25/2022
WATER LEVEL: 9.66

Sampling Data: 15 Aug. 2022

Well ID: HA22-9(ow) — Well Depth: 19.5 ft — Initial Depth To Water: 9.66 ft — Purging Device: Geotech peristaltic pump
Start time: 1235 — Depth To Top Of Screen: 4.5 ft — Depth Of Pump Intake: ~18 ft — Tubing Present In Well: Yes X No
Finish Time: 1415 — Depth To Bottom Of Screen: 19.5 ft — Pumping started 1240 — Tubing Type: Silicone and LDPE

Elapsed Time (24 hour)	Depth To Water From Casing (ft)	Pump Setting (ml/min) or (gal/min)	Purge Rate (ml/min) or (gal/min)	Cumulative Purge Vol. (liters) or (gal)	Temperature (°F) or (°C) +/- 3 %	pH +/- 0.1	Conductivity mS/cm (us/cm) +/- 3 %	Dissolved Oxygen (mg/L) <0.5 %	Turbidity (NTU) <10 NTU	ORP/eH (mv) +/- 10 mv	Comments
1245	9.66		~300		19.56	6.60	4.90	0.95	26.5	82	Clear, no odor
1250	10.42				17.37	6.59	5.09	0.28	43.7	93	
1255	10.52				16.69	6.60	5.19	0.08	54.2	81	
1300	10.72				15.64	6.59	5.43	0.00	56.2	63	
1305	10.80				14.97	6.57	5.68	0.00	25.8	62	
1310	10.82				14.62	6.57	5.91	0.00	4.7	66	
1315	10.90				14.34	6.47	6.30	0.00	2.5	75	
1320	11.08				14.34	6.49	6.35	0.00	3.8	80	
1325	11.18			~2.0	14.34	6.45	6.42	0.00	4.4	79	
											Top PVC to Top Casing = 0.15'

Sample time 1330

HexCr sampled 8/16/22 @ 0740

HALEY ALDRICH

LOW FLOW/MNA FIELD SAMPLING FORM

PROJECT	MDOT Machias Landfill	H&A FILE NO.	130749
LOCATION	Machias, Maine	PROJECT MGR.	D. Dearden
CLIENT	Maine DOT	FIELD REP.	H. Hollauer
CONTRACTOR	None	DATE INSTALLED	7/26/2022
DRILLER		WATER LEVEL	3.08

Sampling Data: 15 Aug. 2022

Well ID:	HA22-10(OW)	Well Depth:	9.6 ft	Initial Depth To Water:	3.08 ft	Purging Device:	Geotech peristaltic pump
Start time:	1515	Depth To Top Of Screen:	2.6 ft	Depth Of Pump Intake:	~8' ft	Tubing Present In Well:	Yes X No
Finish Time:	1630	Depth To Bottom Of Screen:	9.6 ft	Pump start	1530	Tubing Type:	Silicone and LDPE

Elapsed Time (24 hour)	Depth To Water From Casing (ft)	Pump Setting (ml/min) or (gal/min)	Purge Rate (ml/min) or (gal/min)	Cumulative Purge Vol. (liters) or (gal)	Temperature (°F) or (°C) +/- 3 %	pH +/- 0.1	Conductivity mS/cm (us/cm) +/- 3 %	Dissolved Oxygen (mg/L) <0.5 %	Turbidity (NTU) <10 NTU	ORP/eH (mv) +/- 10 mv	Comments
1530	3.22		~300		24.95	6.55	2.77	0.83	14.5	-88	Clear, organic odor
1535	3.22				22.01	6.53	2.87	0.26	17.3	-88	
1540	3.22				19.93	6.52	2.96	0.00	26.1	-88	
1545	3.22				19.71	6.52	2.97	0.00	25.5	-88	
1550	3.22				19.52	6.51	2.98	0.00	27.7	-88	
1555	3.22			~3/4	19.50	6.51	2.98	0.00	27.0	-88	
											Top PVC to Top casing = 0.27

Sample Time 1600

Hex Cr sampled 8/16/22 @ 0750

APPENDIX E
Groundwater Analytical Results

ANALYTICAL REPORT

Lab Number:	L2244025
Client:	Haley & Aldrich 75 Washington Avenue Suite 203 Portland, ME 04101-2617
ATTN:	Dave Dearden
Phone:	(207) 482-4600
Project Name:	MOOT MACHIAS LF
Project Number:	130749
Report Date:	08/25/22

Certifications & Approvals: MA (M-MA086), NH NELAP (2064), CT (PH-0574), IL (200077), ME (MA00086), MD (348), NJ (MA935), NY (11148), NC (25700/666), PA (68-03671), RI (LAO00065), TX (T104704476), VT (VT-0935), VA (460195), USDA (Permit #P330-17-00196).

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Alpha Sample ID	Client ID	Matrix	Sample Location	Collection Date/Time	Receive Date
L2244025-01	HA22-2(OW)	WATER	MACHIAS, ME	08/15/22 14:40	08/16/22
L2244025-02	HA22-8(OW)	WATER	MACHIAS, ME	08/15/22 12:00	08/16/22
L2244025-03	HA22-9(OW)	WATER	MACHIAS, ME	08/15/22 13:30	08/16/22
L2244025-04	HA22-10(OW)	WATER	MACHIAS, ME	08/15/22 16:00	08/16/22
L2244025-05	HA22-2(OW)	WATER	MACHIAS, ME	08/16/22 08:00	08/16/22
L2244025-06	HA22-8(OW)	WATER	MACHIAS, ME	08/16/22 07:20	08/16/22
L2244025-07	HA22-9(OW)	WATER	MACHIAS, ME	08/16/22 07:40	08/16/22
L2244025-08	HA22-10(OW)	WATER	MACHIAS, ME	08/16/22 07:50	08/16/22
L2244025-09	FIELD BLANK	WATER	MACHIAS, ME	08/15/22 14:30	08/16/22

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet NELAP requirements for all NELAP accredited parameters unless otherwise noted in the following narrative. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. Tentatively Identified Compounds (TICs), if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively.

When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances, the specific failure is not narrated but noted in the associated QC Outlier Summary Report, located directly after the Case Narrative. QC information is also incorporated in the Data Usability Assessment table (Format 11) of our Data Merger tool, where it can be reviewed in conjunction with the sample result, associated regulatory criteria and any associated data usability implications.

Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

HOLD POLICY - For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Alpha Project Manager and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Project Management at 800-624-9220 with any questions.

Case Narrative (continued)

Sample Receipt

L2244025-09: A sample identified as "FIELD BLANK" was received, but not listed on the Chain of Custody. At the client's request, this sample was not analyzed.

Semivolatile Organics

The WG1677442-2/-3 LCS/LCSD recoveries, associated with L2244025-01 through -04, are below the acceptance criteria for benzidine (6%/4%) and benzoic acid (0%/0%); however, it has been identified as a "difficult" analyte. The results of the associated samples are reported.

Semivolatile Organics by SIM

The WG1677444-1 Method Blank, associated with L2244025-01 through -04, has a concentration above the reporting limit for naphthalene. Since the concentrations in L2244025-01, -02, and -04 are non-detect for this target analyte, no corrective action is required. L2244025-03 was re-extracted and the associated Method Blank had a concentration above the reporting limit for naphthalene. The results of the original analysis are reported and are qualified with a "B".

Perfluorinated Alkyl Acids by Isotope Dilution

L2244025-01 through -04: Extracted Internal Standard recoveries were outside the acceptance criteria for individual analytes. Please refer to the surrogate section of the report for details.

L2244025-04: The sample was centrifuged and decanted prior to extraction due to sample matrix.

Anions by Ion Chromatography

The WG1676555-3 MS recoveries, performed on L2244025-08, are outside the acceptance criteria for chloride (122%), nitrogen, nitrate (75%), and sulfate (81%); however, the associated LCS recoveries are within criteria. No further action was taken.

The WG1677498-3 MS recovery, performed on L2244025-04, is outside the acceptance criteria for bromide (128%); however, the associated LCS recovery is within criteria. No further action was taken.

Case Narrative (continued)

The WG1676555-4 Laboratory Duplicate RPD for performed on L2244025-08, is above the acceptance criteria for sulfate; however, the sample and duplicate results are less than five times the reporting limit. Therefore, the RPD is valid.

Alkalinity, Total
The WG1678011-4 MS recovery, performed on L2244025-04, is outside the acceptance criteria for alkalinity, total (49%); however, the associated LCS recovery is within criteria. No further action was taken.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Kelly Stenstrom

Title: Technical Director/Representative Date: 08/25/22

ORGANICS

VOLATILES

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-01	Date Collected:	08/15/22 14:40
Client ID:	HA22-2(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8260C
Analytical Date: 08/17/22 19:46
Analyst: MV

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	3.0	--	1
1,1-Dichloroethane	1.6		ug/l	0.75	--	1
Chloroform	ND		ug/l	0.75	--	1
Carbon tetrachloride	ND		ug/l	0.50	--	1
1,2-Dichloropropane	ND		ug/l	1.0	--	1
Dibromochloromethane	ND		ug/l	0.50	--	1
1,1,2-Trichloroethane	ND		ug/l	0.75	--	1
Tetrachloroethene	ND		ug/l	0.50	--	1
Chlorobenzene	ND		ug/l	0.50	--	1
Trichlorofluoromethane	ND		ug/l	1.0	--	1
1,2-Dichloroethane	ND		ug/l	0.50	--	1
1,1,1-Trichloroethane	ND		ug/l	0.50	--	1
Bromodichloromethane	ND		ug/l	0.50	--	1
trans-1,3-Dichloropropene	ND		ug/l	0.50	--	1
cis-1,3-Dichloropropene	ND		ug/l	0.50	--	1
1,1-Dichloropropene	ND		ug/l	1.0	--	1
Bromoform	ND		ug/l	1.0	--	1
1,1,2,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Benzene	ND		ug/l	0.50	--	1
Toluene	ND		ug/l	0.75	--	1
Ethylbenzene	ND		ug/l	0.50	--	1
Chloromethane	ND		ug/l	2.0	--	1
Bromomethane	ND		ug/l	1.0	--	1
Vinyl chloride	ND		ug/l	0.20	--	1
Chloroethane	2.2		ug/l	1.0	--	1
1,1-Dichloroethene	ND		ug/l	0.50	--	1
trans-1,2-Dichloroethene	ND		ug/l	0.75	--	1
1,2-Dichloroethene, Total	ND		ug/l	0.50	--	1

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025
Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-01	Date Collected:	08/15/22 14:40
Client ID:	HA22-2(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Trichloroethene	ND		ug/l	0.50	--	1
1,2-Dichlorobenzene	ND		ug/l	1.0	--	1
1,3-Dichlorobenzene	ND		ug/l	1.0	--	1
1,4-Dichlorobenzene	ND		ug/l	1.0	--	1
Methyl tert butyl ether	ND		ug/l	1.0	--	1
p/m-Xylene	ND		ug/l	1.0	--	1
o-Xylene	ND		ug/l	1.0	--	1
Xylenes, Total	ND		ug/l	1.0	--	1
cis-1,2-Dichloroethene	ND		ug/l	0.50	--	1
Dibromomethane	ND		ug/l	1.0	--	1
Iodomethane	ND		ug/l	5.0	--	1
1,2,3-Trichloropropane	ND		ug/l	1.0	--	1
Styrene	ND		ug/l	1.0	--	1
Dichlorodifluoromethane	ND		ug/l	2.0	--	1
Acetone	ND		ug/l	5.0	--	1
Carbon disulfide	ND		ug/l	1.0	--	1
2-Butanone	ND		ug/l	5.0	--	1
Vinyl acetate	ND		ug/l	5.0	--	1
4-Methyl-2-pentanone	ND		ug/l	5.0	--	1
2-Hexanone	ND		ug/l	5.0	--	1
Acrylonitrile	ND		ug/l	5.0	--	1
Bromochloromethane	ND		ug/l	1.0	--	1
Tetrahydrofuran	2.7		ug/l	2.0	--	1
2,2-Dichloropropane	ND		ug/l	1.0	--	1
1,2-Dibromoethane	ND		ug/l	1.0	--	1
1,3-Dichloropropane	ND		ug/l	1.0	--	1
1,1,1,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Bromobenzene	ND		ug/l	1.0	--	1
n-Butylbenzene	ND		ug/l	0.50	--	1
sec-Butylbenzene	ND		ug/l	0.50	--	1
tert-Butylbenzene	ND		ug/l	1.0	--	1
o-Chlorotoluene	ND		ug/l	1.0	--	1
p-Chlorotoluene	ND		ug/l	1.0	--	1
1,2-Dibromo-3-chloropropane	ND		ug/l	1.0	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Isopropylbenzene	ND		ug/l	0.50	--	1
p-Isopropyltoluene	ND		ug/l	0.50	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-01	Date Collected:	08/15/22 14:40
Client ID:	HA22-2(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Naphthalene	ND		ug/l	1.0	--	1
n-Propylbenzene	ND		ug/l	0.50	--	1
1,2,3-Trichlorobenzene	ND		ug/l	1.0	--	1
1,2,4-Trichlorobenzene	ND		ug/l	1.0	--	1
1,3,5-Trimethylbenzene	ND		ug/l	1.0	--	1
1,3,5-Trichlorobenzene	ND		ug/l	1.0	--	1
1,2,4-Trimethylbenzene	ND		ug/l	1.0	--	1
trans-1,4-Dichloro-2-butene	ND		ug/l	2.5	--	1
Ethyl ether	2.0		ug/l	1.0	--	1
Diisopropyl Ether	ND		ug/l	1.0	--	1
Tert-Butyl Alcohol	ND		ug/l	10	--	1
Ethyl-Tert-Butyl-Ether	ND		ug/l	1.0	--	1
Tertiary-Amyl Methyl Ether	ND		ug/l	1.0	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	116		70-130
Toluene-d8	97		70-130
4-Bromofluorobenzene	98		70-130
Dibromofluoromethane	102		70-130

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-01	Date Collected:	08/15/22 14:40
Client ID:	HA22-2(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Matrix: Water

Analytical Method: 117,-

Analytical Date: 08/18/22 13:25

Analyst: BB

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Dissolved Gases by GC - Mansfield Lab							
Methane	32.6		ug/l	2.00	--	1	A
Ethene	ND		ug/l	0.500	--	1	A
Ethane	ND		ug/l	0.500	--	1	A

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-02 Date Collected: 08/15/22 12:00
Client ID: HA22-8(OW) Date Received: 08/16/22
Sample Location: MACHIAS, ME Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8260C
Analytical Date: 08/17/22 20:07
Analyst: MV

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	3.0	--	1
1,1-Dichloroethane	ND		ug/l	0.75	--	1
Chloroform	ND		ug/l	0.75	--	1
Carbon tetrachloride	ND		ug/l	0.50	--	1
1,2-Dichloropropane	ND		ug/l	1.0	--	1
Dibromochloromethane	ND		ug/l	0.50	--	1
1,1,2-Trichloroethane	ND		ug/l	0.75	--	1
Tetrachloroethene	ND		ug/l	0.50	--	1
Chlorobenzene	ND		ug/l	0.50	--	1
Trichlorofluoromethane	ND		ug/l	1.0	--	1
1,2-Dichloroethane	ND		ug/l	0.50	--	1
1,1,1-Trichloroethane	ND		ug/l	0.50	--	1
Bromodichloromethane	ND		ug/l	0.50	--	1
trans-1,3-Dichloropropene	ND		ug/l	0.50	--	1
cis-1,3-Dichloropropene	ND		ug/l	0.50	--	1
1,1-Dichloropropene	ND		ug/l	1.0	--	1
Bromoform	ND		ug/l	1.0	--	1
1,1,2,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Benzene	ND		ug/l	0.50	--	1
Toluene	ND		ug/l	0.75	--	1
Ethylbenzene	0.82		ug/l	0.50	--	1
Chloromethane	ND		ug/l	2.0	--	1
Bromomethane	ND		ug/l	1.0	--	1
Vinyl chloride	ND		ug/l	0.20	--	1
Chloroethane	ND		ug/l	1.0	--	1
1,1-Dichloroethene	ND		ug/l	0.50	--	1
trans-1,2-Dichloroethene	ND		ug/l	0.75	--	1
1,2-Dichloroethene, Total	ND		ug/l	0.50	--	1

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025
Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-02 | Date Collected: 08/15/22 12:00
Client ID: HA22-8(OW) | Date Received: 08/16/22
Sample Location: MACHIAS, ME | Field Prep: Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Trichloroethene	ND		ug/l	0.50	--	1
1,2-Dichlorobenzene	ND		ug/l	1.0	--	1
1,3-Dichlorobenzene	ND		ug/l	1.0	--	1
1,4-Dichlorobenzene	ND		ug/l	1.0	--	1
Methyl tert butyl ether	ND		ug/l	1.0	--	1
p/m-Xylene	ND		ug/l	1.0	--	1
o-Xylene	ND		ug/l	1.0	--	1
Xylenes, Total	ND		ug/l	1.0	--	1
cis-1,2-Dichloroethene	ND		ug/l	0.50	--	1
Dibromomethane	ND		ug/l	1.0	--	1
Iodomethane	ND		ug/l	5.0	--	1
1,2,3-Trichloropropane	ND		ug/l	1.0	--	1
Styrene	ND		ug/l	1.0	--	1
Dichlorodifluoromethane	ND		ug/l	2.0	--	1
Acetone	ND		ug/l	5.0	--	1
Carbon disulfide	ND		ug/l	1.0	--	1
2-Butanone	ND		ug/l	5.0	--	1
Vinyl acetate	ND		ug/l	5.0	--	1
4-Methyl-2-pentanone	ND		ug/l	5.0	--	1
2-Hexanone	ND		ug/l	5.0	--	1
Acrylonitrile	ND		ug/l	5.0	--	1
Bromochloromethane	ND		ug/l	1.0	--	1
Tetrahydrofuran	ND		ug/l	2.0	--	1
2,2-Dichloropropane	ND		ug/l	1.0	--	1
1,2-Dibromoethane	ND		ug/l	1.0	--	1
1,3-Dichloropropane	ND		ug/l	1.0	--	1
1,1,1,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Bromobenzene	ND		ug/l	1.0	--	1
n-Butylbenzene	ND		ug/l	0.50	--	1
sec-Butylbenzene	ND		ug/l	0.50	--	1
tert-Butylbenzene	ND		ug/l	1.0	--	1
o-Chlorotoluene	ND		ug/l	1.0	--	1
p-Chlorotoluene	ND		ug/l	1.0	--	1
1,2-Dibromo-3-chloropropane	ND		ug/l	1.0	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Isopropylbenzene	ND		ug/l	0.50	--	1
p-Isopropyltoluene	ND		ug/l	0.50	--	1

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-02	Date Collected:	08/15/22 12:00
Client ID:	HA22-8(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Naphthalene	49		ug/l	1.0	--	1
n-Propylbenzene	ND		ug/l	0.50	--	1
1,2,3-Trichlorobenzene	ND		ug/l	1.0	--	1
1,2,4-Trichlorobenzene	ND		ug/l	1.0	--	1
1,3,5-Trimethylbenzene	ND		ug/l	1.0	--	1
1,3,5-Trichlorobenzene	ND		ug/l	1.0	--	1
1,2,4-Trimethylbenzene	ND		ug/l	1.0	--	1
trans-1,4-Dichloro-2-butene	ND		ug/l	2.5	--	1
Ethyl ether	ND		ug/l	1.0	--	1
Diisopropyl Ether	ND		ug/l	1.0	--	1
Tert-Butyl Alcohol	ND		ug/l	10	--	1
Ethyl-Tert-Butyl-Ether	ND		ug/l	1.0	--	1
Tertiary-Amyl Methyl Ether	ND		ug/l	1.0	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	116		70-130
Toluene-d8	101		70-130
4-Bromofluorobenzene	97		70-130
Dibromofluoromethane	101		70-130

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-02	Date Collected:	08/15/22 12:00
Client ID:	HA22-8(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 117,-
Analytical Date: 08/18/22 13:43
Analyst: BB

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Dissolved Gases by GC - Mansfield Lab							
Methane	9310		ug/l	2.00	--	1	A
Ethene	ND		ug/l	0.500	--	1	A
Ethane	ND		ug/l	0.500	--	1	A

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-03	Date Collected:	08/15/22 13:30
Client ID:	HA22-9(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8260C
Analytical Date: 08/17/22 20:29
Analyst: MV

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	3.0	--	1
1,1-Dichloroethane	ND		ug/l	0.75	--	1
Chloroform	ND		ug/l	0.75	--	1
Carbon tetrachloride	ND		ug/l	0.50	--	1
1,2-Dichloropropane	ND		ug/l	1.0	--	1
Dibromochloromethane	ND		ug/l	0.50	--	1
1,1,2-Trichloroethane	ND		ug/l	0.75	--	1
Tetrachloroethene	ND		ug/l	0.50	--	1
Chlorobenzene	ND		ug/l	0.50	--	1
Trichlorofluoromethane	ND		ug/l	1.0	--	1
1,2-Dichloroethane	ND		ug/l	0.50	--	1
1,1,1-Trichloroethane	ND		ug/l	0.50	--	1
Bromodichloromethane	ND		ug/l	0.50	--	1
trans-1,3-Dichloropropene	ND		ug/l	0.50	--	1
cis-1,3-Dichloropropene	ND		ug/l	0.50	--	1
1,1-Dichloropropene	ND		ug/l	1.0	--	1
Bromoform	ND		ug/l	1.0	--	1
1,1,2,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Benzene	0.55		ug/l	0.50	--	1
Toluene	ND		ug/l	0.75	--	1
Ethylbenzene	ND		ug/l	0.50	--	1
Chloromethane	ND		ug/l	2.0	--	1
Bromomethane	ND		ug/l	1.0	--	1
Vinyl chloride	ND		ug/l	0.20	--	1
Chloroethane	1.2		ug/l	1.0	--	1
1,1-Dichloroethene	ND		ug/l	0.50	--	1
trans-1,2-Dichloroethene	ND		ug/l	0.75	--	1
1,2-Dichloroethene, Total	0.64		ug/l	0.50	--	1

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-03
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 13:30
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Trichloroethene	ND		ug/l	0.50	--	1
1,2-Dichlorobenzene	ND		ug/l	1.0	--	1
1,3-Dichlorobenzene	ND		ug/l	1.0	--	1
1,4-Dichlorobenzene	ND		ug/l	1.0	--	1
Methyl tert butyl ether	ND		ug/l	1.0	--	1
p/m-Xylene	ND		ug/l	1.0	--	1
o-Xylene	ND		ug/l	1.0	--	1
Xylenes, Total	ND		ug/l	1.0	--	1
cis-1,2-Dichloroethene	0.64		ug/l	0.50	--	1
Dibromomethane	ND		ug/l	1.0	--	1
Iodomethane	ND		ug/l	5.0	--	1
1,2,3-Trichloropropane	ND		ug/l	1.0	--	1
Styrene	ND		ug/l	1.0	--	1
Dichlorodifluoromethane	ND		ug/l	2.0	--	1
Acetone	ND		ug/l	5.0	--	1
Carbon disulfide	ND		ug/l	1.0	--	1
2-Butanone	ND		ug/l	5.0	--	1
Vinyl acetate	ND		ug/l	5.0	--	1
4-Methyl-2-pentanone	ND		ug/l	5.0	--	1
2-Hexanone	ND		ug/l	5.0	--	1
Acrylonitrile	ND		ug/l	5.0	--	1
Bromochloromethane	ND		ug/l	1.0	--	1
Tetrahydrofuran	15		ug/l	2.0	--	1
2,2-Dichloropropane	ND		ug/l	1.0	--	1
1,2-Dibromoethane	ND		ug/l	1.0	--	1
1,3-Dichloropropane	ND		ug/l	1.0	--	1
1,1,1,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Bromobenzene	ND		ug/l	1.0	--	1
n-Butylbenzene	ND		ug/l	0.50	--	1
sec-Butylbenzene	ND		ug/l	0.50	--	1
tert-Butylbenzene	ND		ug/l	1.0	--	1
o-Chlorotoluene	ND		ug/l	1.0	--	1
p-Chlorotoluene	ND		ug/l	1.0	--	1
1,2-Dibromo-3-chloropropane	ND		ug/l	1.0	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Isopropylbenzene	ND		ug/l	0.50	--	1
p-Isopropyltoluene	ND		ug/l	0.50	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-03	Date Collected:	08/15/22 13:30
Client ID:	HA22-9(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Naphthalene	ND		ug/l	1.0	--	1
n-Propylbenzene	ND		ug/l	0.50	--	1
1,2,3-Trichlorobenzene	ND		ug/l	1.0	--	1
1,2,4-Trichlorobenzene	ND		ug/l	1.0	--	1
1,3,5-Trimethylbenzene	ND		ug/l	1.0	--	1
1,3,5-Trichlorobenzene	ND		ug/l	1.0	--	1
1,2,4-Trimethylbenzene	ND		ug/l	1.0	--	1
trans-1,4-Dichloro-2-butene	ND		ug/l	2.5	--	1
Ethyl ether	19		ug/l	1.0	--	1
Diisopropyl Ether	ND		ug/l	1.0	--	1
Tert-Butyl Alcohol	15		ug/l	10	--	1
Ethyl-Tert-Butyl-Ether	ND		ug/l	1.0	--	1
Tertiary-Amyl Methyl Ether	ND		ug/l	1.0	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	124		70-130
Toluene-d8	97		70-130
4-Bromofluorobenzene	101		70-130
Dibromofluoromethane	107		70-130

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-03
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME
Date Collected: 08/15/22 13:30
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 117,-
Analytical Date: 08/18/22 14:01
Analyst: BB

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Dissolved Gases by GC - Mansfield Lab							
Methane	1030		ug/l	2.00	--	1	A
Ethene	ND		ug/l	0.500	--	1	A
Ethane	0.510		ug/l	0.500	--	1	A

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8260C
Analytical Date: 08/17/22 20:50
Analyst: MV

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	3.0	--	1
1,1-Dichloroethane	1.3		ug/l	0.75	--	1
Chloroform	ND		ug/l	0.75	--	1
Carbon tetrachloride	ND		ug/l	0.50	--	1
1,2-Dichloropropane	ND		ug/l	1.0	--	1
Dibromochloromethane	ND		ug/l	0.50	--	1
1,1,2-Trichloroethane	ND		ug/l	0.75	--	1
Tetrachloroethene	ND		ug/l	0.50	--	1
Chlorobenzene	ND		ug/l	0.50	--	1
Trichlorofluoromethane	ND		ug/l	1.0	--	1
1,2-Dichloroethane	ND		ug/l	0.50	--	1
1,1,1-Trichloroethane	ND		ug/l	0.50	--	1
Bromodichloromethane	ND		ug/l	0.50	--	1
trans-1,3-Dichloropropene	ND		ug/l	0.50	--	1
cis-1,3-Dichloropropene	ND		ug/l	0.50	--	1
1,1-Dichloropropene	ND		ug/l	1.0	--	1
Bromoform	ND		ug/l	1.0	--	1
1,1,2,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Benzene	0.56		ug/l	0.50	--	1
Toluene	ND		ug/l	0.75	--	1
Ethylbenzene	ND		ug/l	0.50	--	1
Chloromethane	ND		ug/l	2.0	--	1
Bromomethane	ND		ug/l	1.0	--	1
Vinyl chloride	ND		ug/l	0.20	--	1
Chloroethane	4.0		ug/l	1.0	--	1
1,1-Dichloroethene	ND		ug/l	0.50	--	1
trans-1,2-Dichloroethene	ND		ug/l	0.75	--	1
1,2-Dichloroethene, Total	ND		ug/l	0.50	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Trichloroethene	ND		ug/l	0.50	--	1
1,2-Dichlorobenzene	ND		ug/l	1.0	--	1
1,3-Dichlorobenzene	ND		ug/l	1.0	--	1
1,4-Dichlorobenzene	ND		ug/l	1.0	--	1
Methyl tert butyl ether	ND		ug/l	1.0	--	1
p/m-Xylene	ND		ug/l	1.0	--	1
o-Xylene	ND		ug/l	1.0	--	1
Xylenes, Total	ND		ug/l	1.0	--	1
cis-1,2-Dichloroethene	ND		ug/l	0.50	--	1
Dibromomethane	ND		ug/l	1.0	--	1
Iodomethane	ND		ug/l	5.0	--	1
1,2,3-Trichloropropane	ND		ug/l	1.0	--	1
Styrene	ND		ug/l	1.0	--	1
Dichlorodifluoromethane	ND		ug/l	2.0	--	1
Acetone	ND		ug/l	5.0	--	1
Carbon disulfide	ND		ug/l	1.0	--	1
2-Butanone	ND		ug/l	5.0	--	1
Vinyl acetate	ND		ug/l	5.0	--	1
4-Methyl-2-pentanone	ND		ug/l	5.0	--	1
2-Hexanone	ND		ug/l	5.0	--	1
Acrylonitrile	ND		ug/l	5.0	--	1
Bromochloromethane	ND		ug/l	1.0	--	1
Tetrahydrofuran	2.6		ug/l	2.0	--	1
2,2-Dichloropropane	ND		ug/l	1.0	--	1
1,2-Dibromoethane	ND		ug/l	1.0	--	1
1,3-Dichloropropane	ND		ug/l	1.0	--	1
1,1,1,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Bromobenzene	ND		ug/l	1.0	--	1
n-Butylbenzene	ND		ug/l	0.50	--	1
sec-Butylbenzene	ND		ug/l	0.50	--	1
tert-Butylbenzene	ND		ug/l	1.0	--	1
o-Chlorotoluene	ND		ug/l	1.0	--	1
p-Chlorotoluene	ND		ug/l	1.0	--	1
1,2-Dibromo-3-chloropropane	ND		ug/l	1.0	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Isopropylbenzene	ND		ug/l	0.50	--	1
p-Isopropyltoluene	ND		ug/l	0.50	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Naphthalene	ND		ug/l	1.0	--	1
n-Propylbenzene	ND		ug/l	0.50	--	1
1,2,3-Trichlorobenzene	ND		ug/l	1.0	--	1
1,2,4-Trichlorobenzene	ND		ug/l	1.0	--	1
1,3,5-Trimethylbenzene	ND		ug/l	1.0	--	1
1,3,5-Trichlorobenzene	ND		ug/l	1.0	--	1
1,2,4-Trimethylbenzene	ND		ug/l	1.0	--	1
trans-1,4-Dichloro-2-butene	ND		ug/l	2.5	--	1
Ethyl ether	1.9		ug/l	1.0	--	1
Diisopropyl Ether	ND		ug/l	1.0	--	1
Tert-Butyl Alcohol	ND		ug/l	10	--	1
Ethyl-Tert-Butyl-Ether	ND		ug/l	1.0	--	1
Tertiary-Amyl Methyl Ether	ND		ug/l	1.0	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	115		70-130
Toluene-d8	98		70-130
4-Bromofluorobenzene	102		70-130
Dibromofluoromethane	102		70-130

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025

Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-04
Client ID: HA22-10(OW)
Sample Location: MACHIAS, ME
Date Collected: 08/15/22 16:00
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 117,-
Analytical Date: 08/18/22 15:38
Analyst: BB

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Dissolved Gases by GC - Mansfield Lab							
Methane	4090		ug/l	2.00	--	1	A
Ethene	ND		ug/l	0.500	--	1	A
Ethane	2.63		ug/l	0.500	--	1	A

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 117,-
Analytical Date: 08/18/22 09:30
Analyst: BB

Parameter	Result	Qualifier	Units	RL	MDL	
Dissolved Gases by GC - Mansfield Lab for sample(s): 01-04 Batch: WG1676908-3						
Methane	ND		ug/l	2.00	--	A
Ethene	ND		ug/l	0.500	--	A
Ethane	ND		ug/l	0.500	--	A

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8260C
Analytical Date: 08/17/22 18:43
Analyst: LAC

Parameter	Result	Qualifier	Units	RL	MDL
Volatile Organics by GC/MS - Westborough Lab for sample(s): 01-04 Batch: WG1677231-5					
Methylene chloride	ND		ug/l	3.0	--
1,1-Dichloroethane	ND		ug/l	0.75	--
Chloroform	ND		ug/l	0.75	--
Carbon tetrachloride	ND		ug/l	0.50	--
1,2-Dichloropropane	ND		ug/l	1.0	--
Dibromochloromethane	ND		ug/l	0.50	--
1,1,2-Trichloroethane	ND		ug/l	0.75	--
Tetrachloroethene	ND		ug/l	0.50	--
Chlorobenzene	ND		ug/l	0.50	--
Trichlorofluoromethane	ND		ug/l	1.0	--
1,2-Dichloroethane	ND		ug/l	0.50	--
1,1,1-Trichloroethane	ND		ug/l	0.50	--
Bromodichloromethane	ND		ug/l	0.50	--
trans-1,3-Dichloropropene	ND		ug/l	0.50	--
cis-1,3-Dichloropropene	ND		ug/l	0.50	--
1,1-Dichloropropene	ND		ug/l	1.0	--
Bromoform	ND		ug/l	1.0	--
1,1,2,2-Tetrachloroethane	ND		ug/l	0.50	--
Benzene	ND		ug/l	0.50	--
Toluene	ND		ug/l	0.75	--
Ethylbenzene	ND		ug/l	0.50	--
Chloromethane	ND		ug/l	2.0	--
Bromomethane	ND		ug/l	1.0	--
Vinyl chloride	ND		ug/l	0.20	--
Chloroethane	ND		ug/l	1.0	--
1,1-Dichloroethene	ND		ug/l	0.50	--
trans-1,2-Dichloroethene	ND		ug/l	0.75	--
1,2-Dichloroethene, Total	ND		ug/l	0.50	--
Trichloroethene	ND		ug/l	0.50	--

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8260C
Analytical Date: 08/17/22 18:43
Analyst: LAC

Parameter	Result	Qualifier	Units	RL	MDL
Volatile Organics by GC/MS - Westborough Lab for sample(s): 01-04 Batch: WG1677231-5					
1,2-Dichlorobenzene	ND		ug/l	1.0	--
1,3-Dichlorobenzene	ND		ug/l	1.0	--
1,4-Dichlorobenzene	ND		ug/l	1.0	--
Methyl tert butyl ether	ND		ug/l	1.0	--
p/m-Xylene	ND		ug/l	1.0	--
o-Xylene	ND		ug/l	1.0	--
Xylenes, Total	ND		ug/l	1.0	--
cis-1,2-Dichloroethene	ND		ug/l	0.50	--
Dibromomethane	ND		ug/l	1.0	--
Iodomethane	ND		ug/l	5.0	--
1,2,3-Trichloropropane	ND		ug/l	1.0	--
Styrene	ND		ug/l	1.0	--
Dichlorodifluoromethane	ND		ug/l	2.0	--
Acetone	ND		ug/l	5.0	--
Carbon disulfide	ND		ug/l	1.0	--
2-Butanone	ND		ug/l	5.0	--
Vinyl acetate	ND		ug/l	5.0	--
4-Methyl-2-pentanone	ND		ug/l	5.0	--
2-Hexanone	ND		ug/l	5.0	--
Acrylonitrile	ND		ug/l	5.0	--
Bromochloromethane	ND		ug/l	1.0	--
Tetrahydrofuran	ND		ug/l	2.0	--
2,2-Dichloropropane	ND		ug/l	1.0	--
1,2-Dibromoethane	ND		ug/l	1.0	--
1,3-Dichloropropane	ND		ug/l	1.0	--
1,1,1,2-Tetrachloroethane	ND		ug/l	0.50	--
Bromobenzene	ND		ug/l	1.0	--
n-Butylbenzene	ND		ug/l	0.50	--
sec-Butylbenzene	ND		ug/l	0.50	--

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025
Project Number: 130749 | **Report Date:** 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8260C
Analytical Date: 08/17/22 18:43
Analyst: LAC

Parameter	Result	Qualifier	Units	RL	MDL
Volatile Organics by GC/MS - Westborough Lab for sample(s): 01-04 Batch: WG1677231-5					
tert-Butylbenzene	ND		ug/l	1.0	--
o-Chlorotoluene	ND		ug/l	1.0	--
p-Chlorotoluene	ND		ug/l	1.0	--
1,2-Dibromo-3-chloropropane	ND		ug/l	1.0	--
Hexachlorobutadiene	ND		ug/l	0.50	--
Isopropylbenzene	ND		ug/l	0.50	--
p-Isopropyltoluene	ND		ug/l	0.50	--
Naphthalene	ND		ug/l	1.0	--
n-Propylbenzene	ND		ug/l	0.50	--
1,2,3-Trichlorobenzene	ND		ug/l	1.0	--
1,2,4-Trichlorobenzene	ND		ug/l	1.0	--
1,3,5-Trimethylbenzene	ND		ug/l	1.0	--
1,3,5-Trichlorobenzene	ND		ug/l	1.0	--
1,2,4-Trimethylbenzene	ND		ug/l	1.0	--
trans-1,4-Dichloro-2-butene	ND		ug/l	2.5	--
Ethyl ether	ND		ug/l	1.0	--
Diisopropyl Ether	ND		ug/l	1.0	--
Tert-Butyl Alcohol	ND		ug/l	10	--
Ethyl-Tert-Butyl-Ether	ND		ug/l	1.0	--
Tertiary-Amyl Methyl Ether	ND		ug/l	1.0	--

Surrogate	%Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	111		70-130
Toluene-d8	101		70-130
4-Bromofluorobenzene	105		70-130
Dibromofluoromethane	101		70-130

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits	Column
Dissolved Gases by GC - Mansfield Lab Associated sample(s): 01-04 Batch: WG1676908-2									
Methane	102		-		80-120	-		25	A
Ethene	98		-		80-120	-		25	A
Ethane	96		-		80-120	-		25	A

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF

Project Number: 130749

Lab Number: L2244025

Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Volatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-04 Batch: WG1677231-3 WG1677231-4								
Methylene chloride	90		86		70-130	5		20
1,1-Dichloroethane	100		97		70-130	3		20
Chloroform	94		89		70-130	5		20
Carbon tetrachloride	90		86		63-132	5		20
1,2-Dichloropropane	95		90		70-130	5		20
Dibromochloromethane	88		84		63-130	5		20
1,1,2-Trichloroethane	98		94		70-130	4		20
Tetrachloroethene	110		98		70-130	12		20
Chlorobenzene	97		89		75-130	9		25
Trichlorofluoromethane	120		110		62-150	9		20
1,2-Dichloroethane	100		100		70-130	0		20
1,1,1-Trichloroethane	94		88		67-130	7		20
Bromodichloromethane	87		82		67-130	6		20
trans-1,3-Dichloropropene	83		75		70-130	10		20
cis-1,3-Dichloropropene	74		71		70-130	4		20
1,1-Dichloropropene	100		97		70-130	3		20
Bromoform	81		74		54-136	9		20
1,1,2,2-Tetrachloroethane	98		89		67-130	10		20
Benzene	95		90		70-130	5		25
Toluene	96		88		70-130	9		25
Ethylbenzene	95		88		70-130	8		20
Chloromethane	110		110		64-130	0		20
Bromomethane	91		87		39-139	4		20

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Volatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-04 Batch: WG1677231-3 WG1677231-4								
Vinyl chloride	120		110		55-140	9		20
Chloroethane	110		100		55-138	10		20
1,1-Dichloroethene	100		97		61-145	3		25
trans-1,2-Dichloroethene	97		95		70-130	2		20
Trichloroethene	95		92		70-130	3		25
1,2-Dichlorobenzene	95		86		70-130	10		20
1,3-Dichlorobenzene	100		88		70-130	13		20
1,4-Dichlorobenzene	97		87		70-130	11		20
Methyl tert butyl ether	84		82		63-130	2		20
p/m-Xylene	100		90		70-130	11		20
o-Xylene	95		85		70-130	11		20
cis-1,2-Dichloroethene	91		88		70-130	3		20
Dibromomethane	90		85		70-130	6		20
Iodomethane	**52**	Q	**48**	Q	70-130	8		20
1,2,3-Trichloropropane	97		92		64-130	5		20
Styrene	95		90		70-130	5		20
Dichlorodifluoromethane	100		100		36-147	0		20
Acetone	110		120		58-148	9		20
Carbon disulfide	100		100		51-130	0		20
2-Butanone	100		110		63-138	10		20
Vinyl acetate	98		98		70-130	0		20
4-Methyl-2-pentanone	88		87		59-130	1		20
2-Hexanone	81		79		57-130	3		20

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749
Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Volatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-04 Batch: WG1677231-3 WG1677231-4								
Acrylonitrile	94		96		70-130	2		20
Bromochloromethane	92		89		70-130	3		20
Tetrahydrofuran	130		130		58-130	0		20
2,2-Dichloropropane	89		80		63-133	11		20
1,2-Dibromoethane	98		94		70-130	4		20
1,3-Dichloropropane	98		92		70-130	6		20
1,1,1,2-Tetrachloroethane	94		88		64-130	7		20
Bromobenzene	97		86		70-130	12		20
n-Butylbenzene	100		89		53-136	12		20
sec-Butylbenzene	98		87		70-130	12		20
tert-Butylbenzene	94		82		70-130	14		20
o-Chlorotoluene	100		88		70-130	13		20
p-Chlorotoluene	98		87		70-130	12		20
1,2-Dibromo-3-chloropropane	76		71		41-144	7		20
Hexachlorobutadiene	96		83		63-130	15		20
Isopropylbenzene	94		82		70-130	14		20
p-Isopropyltoluene	93		83		70-130	11		20
Naphthalene	80		73		70-130	9		20
n-Propylbenzene	100		90		69-130	11		20
1,2,3-Trichlorobenzene	95		86		70-130	10		20
1,2,4-Trichlorobenzene	89		79		70-130	12		20
1,3,5-Trimethylbenzene	98		86		64-130	13		20
1,3,5-Trichlorobenzene	96		87		70-130	10		20

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Volatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-04 Batch: WG1677231-3 WG1677231-4								
1,2,4-Trimethylbenzene	93		82		70-130	13		20
trans-1,4-Dichloro-2-butene	94		85		70-130	10		20
Ethyl ether	93		88		59-134	6		20
Diisopropyl Ether	96		94		70-130	2		20
Tert-Butyl Alcohol	90		90		70-130	0		20
Ethyl-Tert-Butyl-Ether	88		85		70-130	3		20
Tertiary-Amyl Methyl Ether	77		76		66-130	1		20

Surrogate	LCS %Recovery	Qual	LCSD %Recovery	Qual	Acceptance Criteria
1,2-Dichloroethane-d4	114		110		70-130
Toluene-d8	101		100		70-130
4-Bromofluorobenzene	105		102		70-130
Dibromofluoromethane	101		98		70-130

Lab Duplicate Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits	
Dissolved Gases by GC - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676908-4 QC Sample: L2244025-02 Client ID: HA22-8(OW)							
Methane	9310	9610	ug/l	3		25	A
Ethene	ND	ND	ug/l	NC		25	A
Ethane	ND	ND	ug/l	NC		25	A

SEMIVOLATILES

Project Name: MOOT MACHIAS LF

Project Number: 130749

Lab Number: L2244025

Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-01
Client ID: HA22-2(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 14:40
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8270D
Analytical Date: 08/20/22 19:04
Analyst: EK

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:58

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS - Westborough Lab						
Benzidine	ND		ug/l	20	--	1
1,2,4-Trichlorobenzene	ND		ug/l	5.0	--	1
Bis(2-chloroethyl)ether	ND		ug/l	2.0	--	1
1,2-Dichlorobenzene	ND		ug/l	2.0	--	1
1,3-Dichlorobenzene	ND		ug/l	2.0	--	1
1,4-Dichlorobenzene	ND		ug/l	2.0	--	1
3,3'-Dichlorobenzidine	ND		ug/l	5.0	--	1
2,4-Dinitrotoluene	ND		ug/l	5.0	--	1
2,6-Dinitrotoluene	ND		ug/l	5.0	--	1
Azobenzene	ND		ug/l	2.0	--	1
4-Chlorophenyl phenyl ether	ND		ug/l	2.0	--	1
4-Bromophenyl phenyl ether	ND		ug/l	2.0	--	1
Bis(2-chloroisopropyl)ether	ND		ug/l	2.0	--	1
Bis(2-chloroethoxy)methane	ND		ug/l	5.0	--	1
Hexachlorocyclopentadiene	ND		ug/l	20	--	1
Isophorone	ND		ug/l	5.0	--	1
Nitrobenzene	ND		ug/l	2.0	--	1
NDPA/DPA	ND		ug/l	2.0	--	1
n-Nitrosodi-n-propylamine	ND		ug/l	5.0	--	1
Bis(2-ethylhexyl)phthalate	ND		ug/l	3.0	--	1
Butyl benzyl phthalate	ND		ug/l	5.0	--	1
Di-n-butylphthalate	ND		ug/l	5.0	--	1
Di-n-octylphthalate	ND		ug/l	5.0	--	1
Diethyl phthalate	ND		ug/l	5.0	--	1
Dimethyl phthalate	ND		ug/l	5.0	--	1
Biphenyl	ND		ug/l	2.0	--	1
Aniline	ND		ug/l	2.0	--	1
4-Chloroaniline	ND		ug/l	5.0	--	1

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-01	Date Collected:	08/15/22 14:40
Client ID:	HA22-2(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS - Westborough Lab						
2-Nitroaniline	ND		ug/l	5.0	--	1
3-Nitroaniline	ND		ug/l	5.0	--	1
4-Nitroaniline	ND		ug/l	5.0	--	1
Dibenzofuran	ND		ug/l	2.0	--	1
n-Nitrosodimethylamine	ND		ug/l	2.0	--	1
2,4,6-Trichlorophenol	ND		ug/l	5.0	--	1
p-Chloro-m-cresol	ND		ug/l	2.0	--	1
2-Chlorophenol	ND		ug/l	2.0	--	1
2,4-Dichlorophenol	ND		ug/l	5.0	--	1
2,4-Dimethylphenol	ND		ug/l	5.0	--	1
2-Nitrophenol	ND		ug/l	10	--	1
4-Nitrophenol	ND		ug/l	10	--	1
2,4-Dinitrophenol	ND		ug/l	20	--	1
4,6-Dinitro-o-cresol	ND		ug/l	10	--	1
Phenol	ND		ug/l	5.0	--	1
2-Methylphenol	ND		ug/l	5.0	--	1
3-Methylphenol/4-Methylphenol	ND		ug/l	5.0	--	1
2,4,5-Trichlorophenol	ND		ug/l	5.0	--	1
Benzoic Acid	ND		ug/l	50	--	1
Benzyl Alcohol	ND		ug/l	2.0	--	1
Carbazole	ND		ug/l	2.0	--	1
Pyridine	ND		ug/l	3.5	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	51		21-120
Phenol-d6	43		10-120
Nitrobenzene-d5	58		23-120
2-Fluorobiphenyl	60		15-120
2,4,6-Tribromophenol	93		10-120
4-Terphenyl-d14	68		41-149

Project Name: MOOT MACHIAS LF

Project Number: 130749

Lab Number: L2244025

Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-01
Client ID: HA22-2(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 14:40
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8270D-SIM
Analytical Date: 08/20/22 20:17
Analyst: DV

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:58

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS-SIM - Westborough Lab						
Acenaphthene	ND		ug/l	0.10	--	1
2-Chloronaphthalene	ND		ug/l	0.20	--	1
Fluoranthene	ND		ug/l	0.10	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Naphthalene	ND		ug/l	0.10	--	1
Benzo(a)anthracene	ND		ug/l	0.10	--	1
Benzo(a)pyrene	ND		ug/l	0.10	--	1
Benzo(b)fluoranthene	ND		ug/l	0.10	--	1
Benzo(k)fluoranthene	ND		ug/l	0.10	--	1
Chrysene	ND		ug/l	0.10	--	1
Acenaphthylene	ND		ug/l	0.10	--	1
Anthracene	ND		ug/l	0.10	--	1
Benzo(ghi)perylene	ND		ug/l	0.10	--	1
Fluorene	ND		ug/l	0.10	--	1
Phenanthrene	ND		ug/l	0.10	--	1
Dibenzo(a,h)anthracene	ND		ug/l	0.10	--	1
Indeno(1,2,3-cd)pyrene	ND		ug/l	0.10	--	1
Pyrene	ND		ug/l	0.10	--	1
1-Methylnaphthalene	ND		ug/l	0.10	--	1
2-Methylnaphthalene	ND		ug/l	0.10	--	1
Pentachlorophenol	ND		ug/l	0.80	--	1
Hexachlorobenzene	ND		ug/l	0.80	--	1
Hexachloroethane	ND		ug/l	0.80	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-01	Date Collected:	08/15/22 14:40
Client ID:	HA22-2(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS-SIM - Westborough Lab						

Surrogate	% Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	58		21-120
Phenol-d6	47		10-120
Nitrobenzene-d5	70		23-120
2-Fluorobiphenyl	67		15-120
2,4,6-Tribromophenol	107		10-120
4-Terphenyl-d14	67		41-149

Project Name: MOOT MACHIAS LF
Lab Number: L2244025
Project Number: 130749
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-01
Client ID: HA22-2(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 14:40
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 134,LCMSMS-ID
Analytical Date: 08/18/22 15:44
Analyst: MP

Extraction Method: ALPHA 23528
Extraction Date: 08/17/22 17:51

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab						
Perfluorobutanoic Acid (PFBA)	9.19		ng/l	1.83	--	1
Perfluoropentanoic Acid (PFPeA)	13.3		ng/l	1.83	--	1
Perfluorobutanesulfonic Acid (PFBS)	2.67		ng/l	1.83	--	1
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	ND		ng/l	1.83	--	1
Perfluorohexanoic Acid (PFHxA)	23.1		ng/l	1.83	--	1
Perfluoropentanesulfonic Acid (PFPeS)	2.17		ng/l	1.83	--	1
Perfluoroheptanoic Acid (PFHpA)	22.5		ng/l	1.83	--	1
Perfluorohexanesulfonic Acid (PFHxS)	26.8		ng/l	1.83	--	1
Perfluorooctanoic Acid (PFOA)	84.0		ng/l	1.83	--	1
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	3.29		ng/l	1.83	--	1
Perfluoroheptanesulfonic Acid (PFHpS)	ND		ng/l	1.83	--	1
Perfluorononanoic Acid (PFNA)	3.57		ng/l	1.83	--	1
Perfluorooctanesulfonic Acid (PFOS)	35.7		ng/l	1.83	--	1
Perfluorodecanoic Acid (PFDA)	ND		ng/l	1.83	--	1
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	ND		ng/l	1.83	--	1
Perfluorononanesulfonic Acid (PFNS)	ND		ng/l	1.83	--	1
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	ND		ng/l	1.83	--	1
Perfluoroundecanoic Acid (PFUnA)	ND		ng/l	1.83	--	1
Perfluorodecanesulfonic Acid (PFDS)	ND		ng/l	1.83	--	1
Perfluorooctanesulfonamide (FOSA)	ND		ng/l	1.83	--	1
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	ND		ng/l	1.83	--	1
Perfluorododecanoic Acid (PFDoA)	ND		ng/l	1.83	--	1
Perfluorotridecanoic Acid (PFTrDA)	ND		ng/l	1.83	--	1
Perfluorotetradecanoic Acid (PFTA)	ND		ng/l	1.83	--	1
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-Propanoic Acid (HFPO-DA)	ND		ng/l	45.7	--	1
4,8-Dioxa-3h-Perfluorononanoic Acid (ADONA)	ND		ng/l	1.83	--	1
Perfluorohexadecanoic Acid (PFHxDA)	ND		ng/l	3.66	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-01	Date Collected:	08/15/22 14:40
Client ID:	HA22-2(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab						
Perfluorooctadecanoic Acid (PFODA)	ND		ng/l	3.66	--	1
PFAS, Total (6)	173		ng/l	1.83	--	1

Surrogate (Extracted Internal Standard)	% Recovery	Qualifier	Acceptance Criteria
Perfluoro[13C4]Butanoic Acid (MPFBA)	89		58-132
Perfluoro[13C5]Pentanoic Acid (M5PFPEA)	91		62-163
Perfluoro[2,3,4-13C3]Butanesulfonic Acid (M3PFBS)	89		70-131
1H,1H,2H,2H-Perfluoro[1,2-13C2]Hexanesulfonic Acid (M2-4:2FTS)	**230**	Q	12-142
Perfluoro[1,2,3,4,6-13C5]Hexanoic Acid (M5PFHxA)	73		57-129
Perfluoro[1,2,3,4-13C4]Heptanoic Acid (M4PFHpA)	76		60-129
Perfluoro[1,2,3-13C3]Hexanesulfonic Acid (M3PFHxS)	86		71-134
Perfluoro[13C8]Octanoic Acid (M8PFOA)	92		62-129
1H,1H,2H,2H-Perfluoro[1,2-13C2]Octanesulfonic Acid (M2-6:2FTS)	**199**	Q	14-147
Perfluoro[13C9]Nonanoic Acid (M9PFNA)	104		59-139
Perfluoro[13C8]Octanesulfonic Acid (M8PFOS)	104		69-131
Perfluoro[1,2,3,4,5,6-13C6]Decanoic Acid (M6PFDA)	89		62-124
1H,1H,2H,2H-Perfluoro[1,2-13C2]Decanesulfonic Acid (M2-8:2FTS)	144		10-162
N-Deuteriomethylperfluoro-1-octanesulfonamidoacetic Acid (d3-NMeFOSAA)	62		24-116
Perfluoro[1,2,3,4,5,6,7-13C7]Undecanoic Acid (M7-PFUDA)	73		55-137
Perfluoro[13C8]Octanesulfonamide (M8FOSA)	18		5-112
N-Deuterioethylperfluoro-1-octanesulfonamidoacetic Acid (d5-NEtFOSAA)	54		27-126
Perfluoro[1,2-13C2]Dodecanoic Acid (MPFDOA)	62		48-131
Perfluoro[1,2-13C2]Tetradecanoic Acid (M2PFTEDA)	79		22-136
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-13C3-Propanoic Acid (M3HFPO-DA)	94		10-165
Perfluoro[13C2]Hexadecanoic Acid (M2PFHxDA)	52		10-206

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-02
Client ID: HA22-8(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 12:00
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8270D
Analytical Date: 08/20/22 19:27
Analyst: EK

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:58

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS - Westborough Lab						
Benzidine	ND		ug/l	20	--	1
1,2,4-Trichlorobenzene	ND		ug/l	5.0	--	1
Bis(2-chloroethyl)ether	ND		ug/l	2.0	--	1
1,2-Dichlorobenzene	ND		ug/l	2.0	--	1
1,3-Dichlorobenzene	ND		ug/l	2.0	--	1
1,4-Dichlorobenzene	ND		ug/l	2.0	--	1
3,3'-Dichlorobenzidine	ND		ug/l	5.0	--	1
2,4-Dinitrotoluene	ND		ug/l	5.0	--	1
2,6-Dinitrotoluene	ND		ug/l	5.0	--	1
Azobenzene	ND		ug/l	2.0	--	1
4-Chlorophenyl phenyl ether	ND		ug/l	2.0	--	1
4-Bromophenyl phenyl ether	ND		ug/l	2.0	--	1
Bis(2-chloroisopropyl)ether	ND		ug/l	2.0	--	1
Bis(2-chloroethoxy)methane	ND		ug/l	5.0	--	1
Hexachlorocyclopentadiene	ND		ug/l	20	--	1
Isophorone	ND		ug/l	5.0	--	1
Nitrobenzene	ND		ug/l	2.0	--	1
NDPA/DPA	ND		ug/l	2.0	--	1
n-Nitrosodi-n-propylamine	ND		ug/l	5.0	--	1
Bis(2-ethylhexyl)phthalate	ND		ug/l	3.0	--	1
Butyl benzyl phthalate	ND		ug/l	5.0	--	1
Di-n-butylphthalate	ND		ug/l	5.0	--	1
Di-n-octylphthalate	ND		ug/l	5.0	--	1
Diethyl phthalate	ND		ug/l	5.0	--	1
Dimethyl phthalate	ND		ug/l	5.0	--	1
Biphenyl	ND		ug/l	2.0	--	1
Aniline	ND		ug/l	2.0	--	1
4-Chloroaniline	ND		ug/l	5.0	--	1

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-02	Date Collected:	08/15/22 12:00
Client ID:	HA22-8(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS - Westborough Lab						
2-Nitroaniline	ND		ug/l	5.0	--	1
3-Nitroaniline	ND		ug/l	5.0	--	1
4-Nitroaniline	ND		ug/l	5.0	--	1
Dibenzofuran	ND		ug/l	2.0	--	1
n-Nitrosodimethylamine	ND		ug/l	2.0	--	1
2,4,6-Trichlorophenol	ND		ug/l	5.0	--	1
p-Chloro-m-cresol	ND		ug/l	2.0	--	1
2-Chlorophenol	ND		ug/l	2.0	--	1
2,4-Dichlorophenol	ND		ug/l	5.0	--	1
2,4-Dimethylphenol	ND		ug/l	5.0	--	1
2-Nitrophenol	ND		ug/l	10	--	1
4-Nitrophenol	ND		ug/l	10	--	1
2,4-Dinitrophenol	ND		ug/l	20	--	1
4,6-Dinitro-o-cresol	ND		ug/l	10	--	1
Phenol	ND		ug/l	5.0	--	1
2-Methylphenol	ND		ug/l	5.0	--	1
3-Methylphenol/4-Methylphenol	ND		ug/l	5.0	--	1
2,4,5-Trichlorophenol	ND		ug/l	5.0	--	1
Benzoic Acid	ND		ug/l	50	--	1
Benzyl Alcohol	ND		ug/l	2.0	--	1
Carbazole	ND		ug/l	2.0	--	1
Pyridine	ND		ug/l	3.5	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	58		21-120
Phenol-d6	48		10-120
Nitrobenzene-d5	68		23-120
2-Fluorobiphenyl	73		15-120
2,4,6-Tribromophenol	90		10-120
4-Terphenyl-d14	80		41-149

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-02
Client ID: HA22-8(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 12:00
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8270D-SIM
Analytical Date: 08/20/22 20:33
Analyst: DV

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:58

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS-SIM - Westborough Lab						
Acenaphthene	1.6		ug/l	0.10	--	1
2-Chloronaphthalene	ND		ug/l	0.20	--	1
Fluoranthene	0.19		ug/l	0.10	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Naphthalene	5.9		ug/l	0.10	--	1
Benzo(a)anthracene	ND		ug/l	0.10	--	1
Benzo(a)pyrene	ND		ug/l	0.10	--	1
Benzo(b)fluoranthene	ND		ug/l	0.10	--	1
Benzo(k)fluoranthene	ND		ug/l	0.10	--	1
Chrysene	ND		ug/l	0.10	--	1
Acenaphthylene	0.20		ug/l	0.10	--	1
Anthracene	0.20		ug/l	0.10	--	1
Benzo(ghi)perylene	ND		ug/l	0.10	--	1
Fluorene	1.4		ug/l	0.10	--	1
Phenanthrene	1.2		ug/l	0.10	--	1
Dibenzo(a,h)anthracene	ND		ug/l	0.10	--	1
Indeno(1,2,3-cd)pyrene	ND		ug/l	0.10	--	1
Pyrene	0.18		ug/l	0.10	--	1
1-Methylnaphthalene	3.1		ug/l	0.10	--	1
2-Methylnaphthalene	1.6		ug/l	0.10	--	1
Pentachlorophenol	ND		ug/l	0.80	--	1
Hexachlorobenzene	ND		ug/l	0.80	--	1
Hexachloroethane	ND		ug/l	0.80	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-02	Date Collected:	08/15/22 12:00
Client ID:	HA22-8(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor

Semivolatile Organics by GC/MS-SIM - Westborough Lab

Surrogate	% Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	58		21-120
Phenol-d6	49		10-120
Nitrobenzene-d5	71		23-120
2-Fluorobiphenyl	69		15-120
2,4,6-Tribromophenol	111		10-120
4-Terphenyl-d14	69		41-149

Project Name: MOOT MACHIAS LF
Lab Number: L2244025
Project Number: 130749
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-02
Client ID: HA22-8(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 12:00
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 134,LCMSMS-ID
Analytical Date: 08/18/22 16:00
Analyst: MP

Extraction Method: ALPHA 23528
Extraction Date: 08/17/22 17:51

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab						
Perfluorobutanoic Acid (PFBA)	ND		ng/l	1.87	--	1
Perfluoropentanoic Acid (PFPeA)	ND		ng/l	1.87	--	1
Perfluorobutanesulfonic Acid (PFBS)	ND		ng/l	1.87	--	1
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	ND		ng/l	1.87	--	1
Perfluorohexanoic Acid (PFHxA)	ND		ng/l	1.87	--	1
Perfluoropentanesulfonic Acid (PFPeS)	ND		ng/l	1.87	--	1
Perfluoroheptanoic Acid (PFHpA)	ND		ng/l	1.87	--	1
Perfluorohexanesulfonic Acid (PFHxS)	16.3		ng/l	1.87	--	1
Perfluorooctanoic Acid (PFOA)	2.18		ng/l	1.87	--	1
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	3.46		ng/l	1.87	--	1
Perfluoroheptanesulfonic Acid (PFHpS)	ND		ng/l	1.87	--	1
Perfluorononanoic Acid (PFNA)	ND		ng/l	1.87	--	1
Perfluorooctanesulfonic Acid (PFOS)	8.02		ng/l	1.87	--	1
Perfluorodecanoic Acid (PFDA)	ND		ng/l	1.87	--	1
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	ND		ng/l	1.87	--	1
Perfluorononanesulfonic Acid (PFNS)	ND		ng/l	1.87	--	1
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	ND		ng/l	1.87	--	1
Perfluoroundecanoic Acid (PFUnA)	ND		ng/l	1.87	--	1
Perfluorodecanesulfonic Acid (PFDS)	ND		ng/l	1.87	--	1
Perfluorooctanesulfonamide (FOSA)	ND		ng/l	1.87	--	1
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	ND		ng/l	1.87	--	1
Perfluorododecanoic Acid (PFDoA)	ND		ng/l	1.87	--	1
Perfluorotridecanoic Acid (PFTrDA)	ND		ng/l	1.87	--	1
Perfluorotetradecanoic Acid (PFTA)	ND		ng/l	1.87	--	1
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-Propanoic Acid (HFPO-DA)	ND		ng/l	46.7	--	1
4,8-Dioxa-3h-Perfluorononanoic Acid (ADONA)	ND		ng/l	1.87	--	1
Perfluorohexadecanoic Acid (PFHxDA)	ND		ng/l	3.74	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-02	Date Collected:	08/15/22 12:00
Client ID:	HA22-8(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab						
Perfluorooctadecanoic Acid (PFODA)	ND		ng/l	3.74	--	1
PFAS, Total (6)	26.5		ng/l	1.87	--	1

Surrogate (Extracted Internal Standard)	% Recovery	Qualifier	Acceptance Criteria
Perfluoro[13C4]Butanoic Acid (MPFBA)	90		58-132
Perfluoro[13C5]Pentanoic Acid (M5PFPEA)	112		62-163
Perfluoro[2,3,4-13C3]Butanesulfonic Acid (M3PFBS)	99		70-131
1H,1H,2H,2H-Perfluoro[1,2-13C2]Hexanesulfonic Acid (M2-4:2FTS)	**234**	Q	12-142
Perfluoro[1,2,3,4,6-13C5]Hexanoic Acid (M5PFHxA)	81		57-129
Perfluoro[1,2,3,4-13C4]Heptanoic Acid (M4PFHpA)	84		60-129
Perfluoro[1,2,3-13C3]Hexanesulfonic Acid (M3PFHxS)	95		71-134
Perfluoro[13C8]Octanoic Acid (M8PFOA)	95		62-129
1H,1H,2H,2H-Perfluoro[1,2-13C2]Octanesulfonic Acid (M2-6:2FTS)	**179**	Q	14-147
Perfluoro[13C9]Nonanoic Acid (M9PFNA)	108		59-139
Perfluoro[13C8]Octanesulfonic Acid (M8PFOS)	112		69-131
Perfluoro[1,2,3,4,5,6-13C6]Decanoic Acid (M6PFDA)	94		62-124
1H,1H,2H,2H-Perfluoro[1,2-13C2]Decanesulfonic Acid (M2-8:2FTS)	119		10-162
N-Deuteriomethylperfluoro-1-octanesulfonamidoacetic Acid (d3-NMeFOSAA)	73		24-116
Perfluoro[1,2,3,4,5,6,7-13C7]Undecanoic Acid (M7-PFUDA)	75		55-137
Perfluoro[13C8]Octanesulfonamide (M8FOSA)	16		5-112
N-Deuterioethylperfluoro-1-octanesulfonamidoacetic Acid (d5-NEtFOSAA)	66		27-126
Perfluoro[1,2-13C2]Dodecanoic Acid (MPFDOA)	65		48-131
Perfluoro[1,2-13C2]Tetradecanoic Acid (M2PFTEDA)	83		22-136
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-13C3-Propanoic Acid (M3HFPO-DA)	103		10-165
Perfluoro[13C2]Hexadecanoic Acid (M2PFHxDA)	48		10-206

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025
Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-03
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 13:30
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8270D
Analytical Date: 08/20/22 19:49
Analyst: EK

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:58

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS - Westborough Lab						
Benzidine	ND		ug/l	20	--	1
1,2,4-Trichlorobenzene	ND		ug/l	5.0	--	1
Bis(2-chloroethyl)ether	ND		ug/l	2.0	--	1
1,2-Dichlorobenzene	ND		ug/l	2.0	--	1
1,3-Dichlorobenzene	ND		ug/l	2.0	--	1
1,4-Dichlorobenzene	ND		ug/l	2.0	--	1
3,3'-Dichlorobenzidine	ND		ug/l	5.0	--	1
2,4-Dinitrotoluene	ND		ug/l	5.0	--	1
2,6-Dinitrotoluene	ND		ug/l	5.0	--	1
Azobenzene	ND		ug/l	2.0	--	1
4-Chlorophenyl phenyl ether	ND		ug/l	2.0	--	1
4-Bromophenyl phenyl ether	ND		ug/l	2.0	--	1
Bis(2-chloroisopropyl)ether	ND		ug/l	2.0	--	1
Bis(2-chloroethoxy)methane	ND		ug/l	5.0	--	1
Hexachlorocyclopentadiene	ND		ug/l	20	--	1
Isophorone	ND		ug/l	5.0	--	1
Nitrobenzene	ND		ug/l	2.0	--	1
NDPA/DPA	ND		ug/l	2.0	--	1
n-Nitrosodi-n-propylamine	ND		ug/l	5.0	--	1
Bis(2-ethylhexyl)phthalate	5.6		ug/l	3.0	--	1
Butyl benzyl phthalate	ND		ug/l	5.0	--	1
Di-n-butylphthalate	ND		ug/l	5.0	--	1
Di-n-octylphthalate	ND		ug/l	5.0	--	1
Diethyl phthalate	ND		ug/l	5.0	--	1
Dimethyl phthalate	ND		ug/l	5.0	--	1
Biphenyl	ND		ug/l	2.0	--	1
Aniline	ND		ug/l	2.0	--	1
4-Chloroaniline	ND		ug/l	5.0	--	1

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-03
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME
Date Collected: 08/15/22 13:30
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS - Westborough Lab						
2-Nitroaniline	ND		ug/l	5.0	--	1
3-Nitroaniline	ND		ug/l	5.0	--	1
4-Nitroaniline	ND		ug/l	5.0	--	1
Dibenzofuran	ND		ug/l	2.0	--	1
n-Nitrosodimethylamine	ND		ug/l	2.0	--	1
2,4,6-Trichlorophenol	ND		ug/l	5.0	--	1
p-Chloro-m-cresol	ND		ug/l	2.0	--	1
2-Chlorophenol	ND		ug/l	2.0	--	1
2,4-Dichlorophenol	ND		ug/l	5.0	--	1
2,4-Dimethylphenol	ND		ug/l	5.0	--	1
2-Nitrophenol	ND		ug/l	10	--	1
4-Nitrophenol	ND		ug/l	10	--	1
2,4-Dinitrophenol	ND		ug/l	20	--	1
4,6-Dinitro-o-cresol	ND		ug/l	10	--	1
Phenol	ND		ug/l	5.0	--	1
2-Methylphenol	ND		ug/l	5.0	--	1
3-Methylphenol/4-Methylphenol	ND		ug/l	5.0	--	1
2,4,5-Trichlorophenol	ND		ug/l	5.0	--	1
Benzoic Acid	ND		ug/l	50	--	1
Benzyl Alcohol	ND		ug/l	2.0	--	1
Carbazole	ND		ug/l	2.0	--	1
Pyridine	ND		ug/l	3.5	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	55		21-120
Phenol-d6	46		10-120
Nitrobenzene-d5	63		23-120
2-Fluorobiphenyl	66		15-120
2,4,6-Tribromophenol	90		10-120
4-Terphenyl-d14	66		41-149

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025
Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-03
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME
Date Collected: 08/15/22 13:30
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8270D-SIM
Analytical Date: 08/20/22 20:49
Analyst: AH
Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:58

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS-SIM - Westborough Lab						
Acenaphthene	ND		ug/l	0.10	--	1
2-Chloronaphthalene	ND		ug/l	0.20	--	1
Fluoranthene	ND		ug/l	0.10	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Naphthalene	0.29	B	ug/l	0.10	--	1
Benzo(a)anthracene	ND		ug/l	0.10	--	1
Benzo(a)pyrene	ND		ug/l	0.10	--	1
Benzo(b)fluoranthene	ND		ug/l	0.10	--	1
Benzo(k)fluoranthene	ND		ug/l	0.10	--	1
Chrysene	ND		ug/l	0.10	--	1
Acenaphthylene	ND		ug/l	0.10	--	1
Anthracene	ND		ug/l	0.10	--	1
Benzo(ghi)perylene	ND		ug/l	0.10	--	1
Fluorene	ND		ug/l	0.10	--	1
Phenanthrene	ND		ug/l	0.10	--	1
Dibenzo(a,h)anthracene	ND		ug/l	0.10	--	1
Indeno(1,2,3-cd)pyrene	ND		ug/l	0.10	--	1
Pyrene	ND		ug/l	0.10	--	1
1-Methylnaphthalene	ND		ug/l	0.10	--	1
2-Methylnaphthalene	0.12		ug/l	0.10	--	1
Pentachlorophenol	ND		ug/l	0.80	--	1
Hexachlorobenzene	ND		ug/l	0.80	--	1
Hexachloroethane	ND		ug/l	0.80	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-03	Date Collected:	08/15/22 13:30
Client ID:	HA22-9(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor

Semivolatile Organics by GC/MS-SIM - Westborough Lab

Surrogate	% Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	61		21-120
Phenol-d6	51		10-120
Nitrobenzene-d5	77		23-120
2-Fluorobiphenyl	73		15-120
2,4,6-Tribromophenol	**126**	Q	10-120
4-Terphenyl-d14	74		41-149

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-03	Date Collected:	08/15/22 13:30
Client ID:	HA22-9(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water	Extraction Method:	ALPHA 23528
Analytical Method:	134,LCMSMS-ID	Extraction Date:	08/17/22 17:51
Analytical Date:	08/18/22 16:17		
Analyst:	MP		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab						
Perfluorobutanoic Acid (PFBA)	16.1		ng/l	1.86	--	1
Perfluoropentanoic Acid (PFPeA)	16.7		ng/l	1.86	--	1
Perfluorobutanesulfonic Acid (PFBS)	3.24		ng/l	1.86	--	1
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	ND		ng/l	1.86	--	1
Perfluorohexanoic Acid (PFHxA)	33.0		ng/l	1.86	--	1
Perfluoropentanesulfonic Acid (PFPeS)	2.24		ng/l	1.86	--	1
Perfluoroheptanoic Acid (PFHpA)	26.2		ng/l	1.86	--	1
Perfluorohexanesulfonic Acid (PFHxS)	28.9		ng/l	1.86	--	1
Perfluorooctanoic Acid (PFOA)	59.9		ng/l	1.86	--	1
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	5.39		ng/l	1.86	--	1
Perfluoroheptanesulfonic Acid (PFHpS)	ND		ng/l	1.86	--	1
Perfluorononanoic Acid (PFNA)	ND		ng/l	1.86	--	1
Perfluorooctanesulfonic Acid (PFOS)	8.27	F	ng/l	1.86	--	1
Perfluorodecanoic Acid (PFDA)	ND		ng/l	1.86	--	1
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	ND		ng/l	1.86	--	1
Perfluorononanesulfonic Acid (PFNS)	ND		ng/l	1.86	--	1
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	ND		ng/l	1.86	--	1
Perfluoroundecanoic Acid (PFUnA)	ND		ng/l	1.86	--	1
Perfluorodecanesulfonic Acid (PFDS)	ND		ng/l	1.86	--	1
Perfluorooctanesulfonamide (FOSA)	ND		ng/l	1.86	--	1
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	ND		ng/l	1.86	--	1
Perfluorododecanoic Acid (PFDoA)	ND		ng/l	1.86	--	1
Perfluorotridecanoic Acid (PFTrDA)	ND		ng/l	1.86	--	1
Perfluorotetradecanoic Acid (PFTA)	ND		ng/l	1.86	--	1
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-Propanoic Acid (HFPO-DA)	ND		ng/l	46.4	--	1
4,8-Dioxa-3h-Perfluorononanoic Acid (ADONA)	ND		ng/l	1.86	--	1
Perfluorohexadecanoic Acid (PFHxDA)	ND		ng/l	3.71	--	1

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-03
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 13:30
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab						
Perfluorooctadecanoic Acid (PFODA)	ND		ng/l	3.71	--	1
PFAS, Total (6)	123		ng/l	1.86	--	1

Surrogate (Extracted Internal Standard)	% Recovery	Qualifier	Acceptance Criteria
Perfluoro[13C4]Butanoic Acid (MPFBA)	96		58-132
Perfluoro[13C5]Pentanoic Acid (M5PFPEA)	90		62-163
Perfluoro[2,3,4-13C3]Butanesulfonic Acid (M3PFBS)	97		70-131
1H,1H,2H,2H-Perfluoro[1,2-13C2]Hexanesulfonic Acid (M2-4:2FTS)	**275**	Q	12-142
Perfluoro[1,2,3,4,6-13C5]Hexanoic Acid (M5PFHxA)	76		57-129
Perfluoro[1,2,3,4-13C4]Heptanoic Acid (M4PFHpA)	81		60-129
Perfluoro[1,2,3-13C3]Hexanesulfonic Acid (M3PFHxS)	96		71-134
Perfluoro[13C8]Octanoic Acid (M8PFOA)	98		62-129
1H,1H,2H,2H-Perfluoro[1,2-13C2]Octanesulfonic Acid (M2-6:2FTS)	**282**	Q	14-147
Perfluoro[13C9]Nonanoic Acid (M9PFNA)	115		59-139
Perfluoro[13C8]Octanesulfonic Acid (M8PFOS)	105		69-131
Perfluoro[1,2,3,4,5,6-13C6]Decanoic Acid (M6PFDA)	88		62-124
1H,1H,2H,2H-Perfluoro[1,2-13C2]Decanesulfonic Acid (M2-8:2FTS)	**233**	Q	10-162
N-Deuteriomethylperfluoro-1-octanesulfonamidoacetic Acid (d3-NMeFOSAA)	69		24-116
Perfluoro[1,2,3,4,5,6,7-13C7]Undecanoic Acid (M7-PFUDA)	69		55-137
Perfluoro[13C8]Octanesulfonamide (M8FOSA)	24		5-112
N-Deuterioethylperfluoro-1-octanesulfonamidoacetic Acid (d5-NEtFOSAA)	66		27-126
Perfluoro[1,2-13C2]Dodecanoic Acid (MPFDOA)	55		48-131
Perfluoro[1,2-13C2]Tetradecanoic Acid (M2PFTEDA)	78		22-136
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-13C3-Propanoic Acid (M3HFPO-DA)	119		10-165
Perfluoro[13C2]Hexadecanoic Acid (M2PFHxDA)	48		10-206

Project Name: MOOT MACHIAS LF
Lab Number: L2244025
Project Number: 130749
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water	Extraction Method:	EPA 3510C
Analytical Method:	1,8270D	Extraction Date:	08/19/22 15:58
Analytical Date:	08/20/22 20:12		
Analyst:	EK		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS - Westborough Lab						
Benzidine	ND		ug/l	20	--	1
1,2,4-Trichlorobenzene	ND		ug/l	5.0	--	1
Bis(2-chloroethyl)ether	ND		ug/l	2.0	--	1
1,2-Dichlorobenzene	ND		ug/l	2.0	--	1
1,3-Dichlorobenzene	ND		ug/l	2.0	--	1
1,4-Dichlorobenzene	ND		ug/l	2.0	--	1
3,3'-Dichlorobenzidine	ND		ug/l	5.0	--	1
2,4-Dinitrotoluene	ND		ug/l	5.0	--	1
2,6-Dinitrotoluene	ND		ug/l	5.0	--	1
Azobenzene	ND		ug/l	2.0	--	1
4-Chlorophenyl phenyl ether	ND		ug/l	2.0	--	1
4-Bromophenyl phenyl ether	ND		ug/l	2.0	--	1
Bis(2-chloroisopropyl)ether	ND		ug/l	2.0	--	1
Bis(2-chloroethoxy)methane	ND		ug/l	5.0	--	1
Hexachlorocyclopentadiene	ND		ug/l	20	--	1
Isophorone	ND		ug/l	5.0	--	1
Nitrobenzene	ND		ug/l	2.0	--	1
NDPA/DPA	ND		ug/l	2.0	--	1
n-Nitrosodi-n-propylamine	ND		ug/l	5.0	--	1
Bis(2-ethylhexyl)phthalate	ND		ug/l	3.0	--	1
Butyl benzyl phthalate	ND		ug/l	5.0	--	1
Di-n-butylphthalate	ND		ug/l	5.0	--	1
Di-n-octylphthalate	ND		ug/l	5.0	--	1
Diethyl phthalate	ND		ug/l	5.0	--	1
Dimethyl phthalate	ND		ug/l	5.0	--	1
Biphenyl	ND		ug/l	2.0	--	1
Aniline	ND		ug/l	2.0	--	1
4-Chloroaniline	ND		ug/l	5.0	--	1

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS - Westborough Lab						
2-Nitroaniline	ND		ug/l	5.0	--	1
3-Nitroaniline	ND		ug/l	5.0	--	1
4-Nitroaniline	ND		ug/l	5.0	--	1
Dibenzofuran	ND		ug/l	2.0	--	1
n-Nitrosodimethylamine	ND		ug/l	2.0	--	1
2,4,6-Trichlorophenol	ND		ug/l	5.0	--	1
p-Chloro-m-cresol	ND		ug/l	2.0	--	1
2-Chlorophenol	ND		ug/l	2.0	--	1
2,4-Dichlorophenol	ND		ug/l	5.0	--	1
2,4-Dimethylphenol	ND		ug/l	5.0	--	1
2-Nitrophenol	ND		ug/l	10	--	1
4-Nitrophenol	ND		ug/l	10	--	1
2,4-Dinitrophenol	ND		ug/l	20	--	1
4,6-Dinitro-o-cresol	ND		ug/l	10	--	1
Phenol	ND		ug/l	5.0	--	1
2-Methylphenol	ND		ug/l	5.0	--	1
3-Methylphenol/4-Methylphenol	ND		ug/l	5.0	--	1
2,4,5-Trichlorophenol	ND		ug/l	5.0	--	1
Benzoic Acid	ND		ug/l	50	--	1
Benzyl Alcohol	ND		ug/l	2.0	--	1
Carbazole	2.1		ug/l	2.0	--	1
Pyridine	ND		ug/l	3.5	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	53		21-120
Phenol-d6	45		10-120
Nitrobenzene-d5	62		23-120
2-Fluorobiphenyl	64		15-120
2,4,6-Tribromophenol	97		10-120
4-Terphenyl-d14	71		41-149

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025

Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-04
Client ID: HA22-10(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 16:00
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8270D-SIM
Analytical Date: 08/20/22 21:05
Analyst: DV

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:58

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Semivolatile Organics by GC/MS-SIM - Westborough Lab						
Acenaphthene	ND		ug/l	0.10	--	1
2-Chloronaphthalene	ND		ug/l	0.20	--	1
Fluoranthene	ND		ug/l	0.10	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Naphthalene	ND		ug/l	0.10	--	1
Benzo(a)anthracene	ND		ug/l	0.10	--	1
Benzo(a)pyrene	ND		ug/l	0.10	--	1
Benzo(b)fluoranthene	ND		ug/l	0.10	--	1
Benzo(k)fluoranthene	ND		ug/l	0.10	--	1
Chrysene	ND		ug/l	0.10	--	1
Acenaphthylene	ND		ug/l	0.10	--	1
Anthracene	ND		ug/l	0.10	--	1
Benzo(ghi)perylene	ND		ug/l	0.10	--	1
Fluorene	ND		ug/l	0.10	--	1
Phenanthrene	ND		ug/l	0.10	--	1
Dibenzo(a,h)anthracene	ND		ug/l	0.10	--	1
Indeno(1,2,3-cd)pyrene	ND		ug/l	0.10	--	1
Pyrene	ND		ug/l	0.10	--	1
1-Methylnaphthalene	ND		ug/l	0.10	--	1
2-Methylnaphthalene	ND		ug/l	0.10	--	1
Pentachlorophenol	ND		ug/l	0.80	--	1
Hexachlorobenzene	ND		ug/l	0.80	--	1
Hexachloroethane	ND		ug/l	0.80	--	1

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor

Semivolatile Organics by GC/MS-SIM - Westborough Lab

Surrogate	% Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	47		21-120
Phenol-d6	39		10-120
Nitrobenzene-d5	57		23-120
2-Fluorobiphenyl	55		15-120
2,4,6-Tribromophenol	90		10-120
4-Terphenyl-d14	55		41-149

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water	Extraction Method:	ALPHA 23528
Analytical Method:	134,LCMSMS-ID	Extraction Date:	08/17/22 17:51
Analytical Date:	08/18/22 16:33		
Analyst:	MP		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab						
Perfluorobutanoic Acid (PFBA)	6.28		ng/l	1.84	--	1
Perfluoropentanoic Acid (PFPeA)	8.83		ng/l	1.84	--	1
Perfluorobutanesulfonic Acid (PFBS)	2.01		ng/l	1.84	--	1
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	ND		ng/l	1.84	--	1
Perfluorohexanoic Acid (PFHxA)	13.9		ng/l	1.84	--	1
Perfluoropentanesulfonic Acid (PFPeS)	ND		ng/l	1.84	--	1
Perfluoroheptanoic Acid (PFHpA)	14.5		ng/l	1.84	--	1
Perfluorohexanesulfonic Acid (PFHxS)	19.1	F	ng/l	1.84	--	1
Perfluorooctanoic Acid (PFOA)	71.2		ng/l	1.84	--	1
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	5.49		ng/l	1.84	--	1
Perfluoroheptanesulfonic Acid (PFHpS)	ND		ng/l	1.84	--	1
Perfluorononanoic Acid (PFNA)	4.60		ng/l	1.84	--	1
Perfluorooctanesulfonic Acid (PFOS)	72.0		ng/l	1.84	--	1
Perfluorodecanoic Acid (PFDA)	ND		ng/l	1.84	--	1
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	ND		ng/l	1.84	--	1
Perfluorononanesulfonic Acid (PFNS)	ND		ng/l	1.84	--	1
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	ND		ng/l	1.84	--	1
Perfluoroundecanoic Acid (PFUnA)	ND		ng/l	1.84	--	1
Perfluorodecanesulfonic Acid (PFDS)	ND		ng/l	1.84	--	1
Perfluorooctanesulfonamide (FOSA)	ND		ng/l	1.84	--	1
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	4.75		ng/l	1.84	--	1
Perfluorododecanoic Acid (PFDoA)	ND		ng/l	1.84	--	1
Perfluorotridecanoic Acid (PFTrDA)	ND		ng/l	1.84	--	1
Perfluorotetradecanoic Acid (PFTA)	ND		ng/l	1.84	--	1
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-Propanoic Acid (HFPO-DA)	ND		ng/l	46.1	--	1
4,8-Dioxa-3h-Perfluorononanoic Acid (ADONA)	ND		ng/l	1.84	--	1
Perfluorohexadecanoic Acid (PFHxDA)	ND		ng/l	3.69	--	1

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab						
Perfluorooctadecanoic Acid (PFODA)	ND		ng/l	3.69	--	1
PFAS, Total (6)	181		ng/l	1.84	--	1

Surrogate (Extracted Internal Standard)	% Recovery	Qualifier	Acceptance Criteria
Perfluoro[13C4]Butanoic Acid (MPFBA)	96		58-132
Perfluoro[13C5]Pentanoic Acid (M5PFPEA)	103		62-163
Perfluoro[2,3,4-13C3]Butanesulfonic Acid (M3PFBS)	96		70-131
1H,1H,2H,2H-Perfluoro[1,2-13C2]Hexanesulfonic Acid (M2-4:2FTS)	**250**	Q	12-142
Perfluoro[1,2,3,4,6-13C5]Hexanoic Acid (M5PFHxA)	74		57-129
Perfluoro[1,2,3,4-13C4]Heptanoic Acid (M4PFHpA)	82		60-129
Perfluoro[1,2,3-13C3]Hexanesulfonic Acid (M3PFHxS)	97		71-134
Perfluoro[13C8]Octanoic Acid (M8PFOA)	99		62-129
1H,1H,2H,2H-Perfluoro[1,2-13C2]Octanesulfonic Acid (M2-6:2FTS)	**267**	Q	14-147
Perfluoro[13C9]Nonanoic Acid (M9PFNA)	119		59-139
Perfluoro[13C8]Octanesulfonic Acid (M8PFOS)	109		69-131
Perfluoro[1,2,3,4,5,6-13C6]Decanoic Acid (M6PFDA)	93		62-124
1H,1H,2H,2H-Perfluoro[1,2-13C2]Decanesulfonic Acid (M2-8:2FTS)	**204**	Q	10-162
N-Deuteriomethylperfluoro-1-octanesulfonamidoacetic Acid (d3-NMeFOSAA)	75		24-116
Perfluoro[1,2,3,4,5,6,7-13C7]Undecanoic Acid (M7-PFUDA)	78		55-137
Perfluoro[13C8]Octanesulfonamide (M8FOSA)	21		5-112
N-Deuterioethylperfluoro-1-octanesulfonamidoacetic Acid (d5-NEtFOSAA)	64		27-126
Perfluoro[1,2-13C2]Dodecanoic Acid (MPFDOA)	62		48-131
Perfluoro[1,2-13C2]Tetradecanoic Acid (M2PFTEDA)	85		22-136
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-13C3-Propanoic Acid (M3HFPO-DA)	120		10-165
Perfluoro[13C2]Hexadecanoic Acid (M2PFHxDA)	49		10-206

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 134,LCMSMS-ID
Analytical Date: 08/18/22 13:48
Analyst: MP

Extraction Method: ALPHA 23528
Extraction Date: 08/17/22 17:51

Parameter	Result	Qualifier	Units	RL	MDL
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab for sample(s): 01-04 Batch: WG1676461-1					
Perfluorobutanoic Acid (PFBA)	ND		ng/l	2.00	--
Perfluoropentanoic Acid (PFPeA)	ND		ng/l	2.00	--
Perfluorobutanesulfonic Acid (PFBS)	ND		ng/l	2.00	--
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	ND		ng/l	2.00	--
Perfluorohexanoic Acid (PFHxA)	ND		ng/l	2.00	--
Perfluoropentanesulfonic Acid (PFPeS)	ND		ng/l	2.00	--
Perfluoroheptanoic Acid (PFHpA)	ND		ng/l	2.00	--
Perfluorohexanesulfonic Acid (PFHxS)	ND		ng/l	2.00	--
Perfluorooctanoic Acid (PFOA)	ND		ng/l	2.00	--
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	ND		ng/l	2.00	--
Perfluoroheptanesulfonic Acid (PFHpS)	ND		ng/l	2.00	--
Perfluorononanoic Acid (PFNA)	ND		ng/l	2.00	--
Perfluorooctanesulfonic Acid (PFOS)	ND		ng/l	2.00	--
Perfluorodecanoic Acid (PFDA)	ND		ng/l	2.00	--
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	ND		ng/l	2.00	--
Perfluorononanesulfonic Acid (PFNS)	ND		ng/l	2.00	--
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	ND		ng/l	2.00	--
Perfluoroundecanoic Acid (PFUnA)	ND		ng/l	2.00	--
Perfluorodecanesulfonic Acid (PFDS)	ND		ng/l	2.00	--
Perfluorooctanesulfonamide (FOSA)	ND		ng/l	2.00	--
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	ND		ng/l	2.00	--
Perfluorododecanoic Acid (PFDoA)	ND		ng/l	2.00	--
Perfluorotridecanoic Acid (PFTrDA)	ND		ng/l	2.00	--
Perfluorotetradecanoic Acid (PFTA)	ND		ng/l	2.00	--
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-Propanoic Acid (HFPO-DA)	ND		ng/l	50.0	--
4,8-Dioxa-3h-Perfluorononanoic Acid (ADONA)	ND		ng/l	2.00	--

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method:	134,LCMSMS-ID	Extraction Method:	ALPHA 23528
Analytical Date:	08/18/22 13:48	Extraction Date:	08/17/22 17:51
Analyst:	MP		

Parameter	Result	Qualifier	Units	RL	MDL
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab for sample(s): 01-04 Batch: WG1676461-1					
Perfluorohexadecanoic Acid (PFHxDA)	ND		ng/l	4.00	--
Perfluorooctadecanoic Acid (PFODA)	ND		ng/l	4.00	--
PFAS, Total (6)	ND		ng/l	2.00	--

Surrogate (Extracted Internal Standard)	%Recovery	Qualifier	Acceptance Criteria
Perfluoro[13C4]Butanoic Acid (MPFBA)	107		58-132
Perfluoro[13C5]Pentanoic Acid (M5PFPEA)	135		62-163
Perfluoro[2,3,4-13C3]Butanesulfonic Acid (M3PFBS)	108		70-131
1H,1H,2H,2H-Perfluoro[1,2-13C2]Hexanesulfonic Acid (M2-4:2FTS)	85		12-142
Perfluoro[1,2,3,4,6-13C5]Hexanoic Acid (M5PFHxA)	105		57-129
Perfluoro[1,2,3,4-13C4]Heptanoic Acid (M4PFHpA)	103		60-129
Perfluoro[1,2,3-13C3]Hexanesulfonic Acid (M3PFHxS)	100		71-134
Perfluoro[13C8]Octanoic Acid (M8PFOA)	110		62-129
1H,1H,2H,2H-Perfluoro[1,2-13C2]Octanesulfonic Acid (M2-6:2FTS)	83		14-147
Perfluoro[13C9]Nonanoic Acid (M9PFNA)	120		59-139
Perfluoro[13C8]Octanesulfonic Acid (M8PFOS)	122		69-131
Perfluoro[1,2,3,4,5,6-13C6]Decanoic Acid (M6PFDA)	104		62-124
1H,1H,2H,2H-Perfluoro[1,2-13C2]Decanesulfonic Acid (M2-8:2FTS)	86		10-162
N-Deuteriomethylperfluoro-1-octanesulfonamidoacetic Acid (d3-NMeFOSAA)	71		24-116
Perfluoro[1,2,3,4,5,6,7-13C7]Undecanoic Acid (M7-PFUDA)	101		55-137
Perfluoro[13C8]Octanesulfonamide (M8FOSA)	40		5-112
N-Deuterioethylperfluoro-1-octanesulfonamidoacetic Acid (d5-NEtFOSAA)	74		27-126
Perfluoro[1,2-13C2]Dodecanoic Acid (MPFDOA)	89		48-131
Perfluoro[1,2-13C2]Tetradecanoic Acid (M2PFTEDA)	108		22-136
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-13C3-Propanoic Acid (M3HFPO-DA)	143		10-165
Perfluoro[13C2]Hexadecanoic Acid (M2PFHxDA)	68		10-206

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method:	1,8270D	Extraction Method:	EPA 3510C
Analytical Date:	08/20/22 14:10	Extraction Date:	08/19/22 15:44
Analyst:	CMM		

Parameter	Result	Qualifier	Units	RL	MDL
Semivolatile Organics by GC/MS - Westborough Lab for sample(s): 01-04 Batch: WG1677442-1					
Acenaphthene	ND		ug/l	2.0	--
Benzidine	ND		ug/l	20	--
1,2,4-Trichlorobenzene	ND		ug/l	5.0	--
Hexachlorobenzene	ND		ug/l	2.0	--
Bis(2-chloroethyl)ether	ND		ug/l	2.0	--
2-Chloronaphthalene	ND		ug/l	2.0	--
1,2-Dichlorobenzene	ND		ug/l	2.0	--
1,3-Dichlorobenzene	ND		ug/l	2.0	--
1,4-Dichlorobenzene	ND		ug/l	2.0	--
3,3'-Dichlorobenzidine	ND		ug/l	5.0	--
2,4-Dinitrotoluene	ND		ug/l	5.0	--
2,6-Dinitrotoluene	ND		ug/l	5.0	--
Azobenzene	ND		ug/l	2.0	--
Fluoranthene	ND		ug/l	2.0	--
4-Chlorophenyl phenyl ether	ND		ug/l	2.0	--
4-Bromophenyl phenyl ether	ND		ug/l	2.0	--
Bis(2-chloroisopropyl)ether	ND		ug/l	2.0	--
Bis(2-chloroethoxy)methane	ND		ug/l	5.0	--
Hexachlorobutadiene	ND		ug/l	2.0	--
Hexachlorocyclopentadiene	ND		ug/l	20	--
Hexachloroethane	ND		ug/l	2.0	--
Isophorone	ND		ug/l	5.0	--
Naphthalene	ND		ug/l	2.0	--
Nitrobenzene	ND		ug/l	2.0	--
NDPA/DPA	ND		ug/l	2.0	--
n-Nitrosodi-n-propylamine	ND		ug/l	5.0	--
Bis(2-ethylhexyl)phthalate	ND		ug/l	3.0	--
Butyl benzyl phthalate	ND		ug/l	5.0	--
Di-n-butylphthalate	ND		ug/l	5.0	--

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8270D
Analytical Date: 08/20/22 14:10
Analyst: CMM

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:44

Parameter	Result	Qualifier	Units	RL	MDL
Semivolatile Organics by GC/MS - Westborough Lab for sample(s): 01-04 Batch: WG1677442-1					
Di-n-octylphthalate	ND		ug/l	5.0	--
Diethyl phthalate	ND		ug/l	5.0	--
Dimethyl phthalate	ND		ug/l	5.0	--
Benzo(a)anthracene	ND		ug/l	2.0	--
Benzo(a)pyrene	ND		ug/l	2.0	--
Benzo(b)fluoranthene	ND		ug/l	2.0	--
Benzo(k)fluoranthene	ND		ug/l	2.0	--
Chrysene	ND		ug/l	2.0	--
Acenaphthylene	ND		ug/l	2.0	--
Anthracene	ND		ug/l	2.0	--
Benzo(ghi)perylene	ND		ug/l	2.0	--
Fluorene	ND		ug/l	2.0	--
Phenanthrene	ND		ug/l	2.0	--
Dibenzo(a,h)anthracene	ND		ug/l	2.0	--
Indeno(1,2,3-cd)pyrene	ND		ug/l	2.0	--
Pyrene	ND		ug/l	2.0	--
Biphenyl	ND		ug/l	2.0	--
Aniline	ND		ug/l	2.0	--
4-Chloroaniline	ND		ug/l	5.0	--
1-Methylnaphthalene	ND		ug/l	2.0	--
2-Nitroaniline	ND		ug/l	5.0	--
3-Nitroaniline	ND		ug/l	5.0	--
4-Nitroaniline	ND		ug/l	5.0	--
Dibenzofuran	ND		ug/l	2.0	--
2-Methylnaphthalene	ND		ug/l	2.0	--
n-Nitrosodimethylamine	ND		ug/l	2.0	--
2,4,6-Trichlorophenol	ND		ug/l	5.0	--
p-Chloro-m-cresol	ND		ug/l	2.0	--
2-Chlorophenol	ND		ug/l	2.0	--

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8270D
Analytical Date: 08/20/22 14:10
Analyst: CMM

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:44

Parameter	Result	Qualifier	Units	RL	MDL
Semivolatile Organics by GC/MS - Westborough Lab for sample(s): 01-04 Batch: WG1677442-1					
2,4-Dichlorophenol	ND		ug/l	5.0	--
2,4-Dimethylphenol	ND		ug/l	5.0	--
2-Nitrophenol	ND		ug/l	10	--
4-Nitrophenol	ND		ug/l	10	--
2,4-Dinitrophenol	ND		ug/l	20	--
4,6-Dinitro-o-cresol	ND		ug/l	10	--
Pentachlorophenol	ND		ug/l	10	--
Phenol	ND		ug/l	5.0	--
2-Methylphenol	ND		ug/l	5.0	--
3-Methylphenol/4-Methylphenol	ND		ug/l	5.0	--
2,4,5-Trichlorophenol	ND		ug/l	5.0	--
Benzoic Acid	ND		ug/l	50	--
Benzyl Alcohol	ND		ug/l	2.0	--
Carbazole	ND		ug/l	2.0	--
Pyridine	ND		ug/l	3.5	--

Surrogate	%Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	54		21-120
Phenol-d6	40		10-120
Nitrobenzene-d5	61		23-120
2-Fluorobiphenyl	64		15-120
2,4,6-Tribromophenol	82		10-120
4-Terphenyl-d14	65		41-149

Project Name: MOOT MACHIAS LF
Lab Number: L2244025
Project Number: 130749
Report Date: 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8270D-SIM
Analytical Date: 08/21/22 11:38
Analyst: JJW

Extraction Method: EPA 3510C
Extraction Date: 08/19/22 15:43

Parameter	Result	Qualifier	Units	RL	MDL
Semivolatile Organics by GC/MS-SIM - Westborough Lab for sample(s): 01-04 Batch: WG1677444-1					
Acenaphthene	ND		ug/l	0.10	--
2-Chloronaphthalene	ND		ug/l	0.20	--
Fluoranthene	ND		ug/l	0.10	--
Hexachlorobutadiene	ND		ug/l	0.50	--
Naphthalene	0.25		ug/l	0.10	--
Benzo(a)anthracene	ND		ug/l	0.10	--
Benzo(a)pyrene	ND		ug/l	0.10	--
Benzo(b)fluoranthene	ND		ug/l	0.10	--
Benzo(k)fluoranthene	ND		ug/l	0.10	--
Chrysene	ND		ug/l	0.10	--
Acenaphthylene	ND		ug/l	0.10	--
Anthracene	ND		ug/l	0.10	--
Benzo(ghi)perylene	ND		ug/l	0.10	--
Fluorene	ND		ug/l	0.10	--
Phenanthrene	ND		ug/l	0.10	--
Dibenzo(a,h)anthracene	ND		ug/l	0.10	--
Indeno(1,2,3-cd)pyrene	ND		ug/l	0.10	--
Pyrene	ND		ug/l	0.10	--
1-Methylnaphthalene	ND		ug/l	0.10	--
2-Methylnaphthalene	ND		ug/l	0.10	--
Pentachlorophenol	ND		ug/l	0.80	--
Hexachlorobenzene	ND		ug/l	0.80	--
Hexachloroethane	ND		ug/l	0.80	--

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method:	1,8270D-SIM	Extraction Method:	EPA 3510C
Analytical Date:	08/21/22 11:38	Extraction Date:	08/19/22 15:43
Analyst:	JJW		

Parameter	Result	Qualifier	Units	RL	MDL
Semivolatile Organics by GC/MS-SIM - Westborough Lab for sample(s): 01-04 Batch: WG1677444-1					

Surrogate	%Recovery	Qualifier	Acceptance Criteria
2-Fluorophenol	25		21-120
Phenol-d6	19		10-120
Nitrobenzene-d5	31		23-120
2-Fluorobiphenyl	30		15-120
2,4,6-Tribromophenol	41		10-120
4-Terphenyl-d14	**26**	Q	41-149

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab Associated sample(s): 01-04 Batch: WG1676461-2								
Perfluorobutanoic Acid (PFBA)	91		-		67-148	-		30
Perfluoropentanoic Acid (PFPeA)	93		-		63-161	-		30
Perfluorobutanesulfonic Acid (PFBS)	95		-		65-157	-		30
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	104		-		37-219	-		30
Perfluorohexanoic Acid (PFHxA)	91		-		69-168	-		30
Perfluoropentanesulfonic Acid (PFPeS)	97		-		52-156	-		30
Perfluoroheptanoic Acid (PFHpA)	93		-		58-159	-		30
Perfluorohexanesulfonic Acid (PFHxS)	112		-		69-177	-		30
Perfluorooctanoic Acid (PFOA)	90		-		63-159	-		30
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	105		-		49-187	-		30
Perfluoroheptanesulfonic Acid (PFHpS)	84		-		61-179	-		30
Perfluorononanoic Acid (PFNA)	79		-		68-171	-		30
Perfluorooctanesulfonic Acid (PFOS)	85		-		52-151	-		30
Perfluorodecanoic Acid (PFDA)	88		-		63-171	-		30
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	132		-		56-173	-		30
Perfluorononanesulfonic Acid (PFNS)	84		-		48-150	-		30
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	102		-		60-166	-		30
Perfluoroundecanoic Acid (PFUnA)	117		-		60-153	-		30
Perfluorodecanesulfonic Acid (PFDS)	85		-		38-156	-		30
Perfluorooctanesulfonamide (FOSA)	91		-		46-170	-		30
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	91		-		45-170	-		30
Perfluorododecanoic Acid (PFDoA)	96		-		67-153	-		30

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749
Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab Associated sample(s): 01-04 Batch: WG1676461-2								
Perfluorotridecanoic Acid (PFTrDA)	92		-		48-158	-		30
Perfluorotetradecanoic Acid (PFTA)	79		-		59-182	-		30
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-Propanoic Acid (HFPO-DA)	83		-		57-162	-		30
4,8-Dioxa-3h-Perfluorononanoic Acid (ADONA)	86		-		69-143	-		30
Perfluorohexadecanoic Acid (PFHxDA)	105		-		40-167	-		30
Perfluorooctadecanoic Acid (PFODA)	19		-		10-119	-		30

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF

Project Number: 130749

Lab Number: L2244025

Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab Associated sample(s): 01-04 Batch: WG1676461-2								

Surrogate (Extracted Internal Standard)	LCS %Recovery	Qual	LCSD %Recovery	Qual	Acceptance Criteria
Perfluoro[13C4]Butanoic Acid (MPFBA)	106				58-132
Perfluoro[13C5]Pentanoic Acid (M5PFPEA)	128				62-163
Perfluoro[2,3,4-13C3]Butanesulfonic Acid (M3PFBS)	105				70-131
1H,1H,2H,2H-Perfluoro[1,2-13C2]Hexanesulfonic Acid (M2-4:2FTS)	86				12-142
Perfluoro[1,2,3,4,6-13C5]Hexanoic Acid (M5PFHxA)	105				57-129
Perfluoro[1,2,3,4-13C4]Heptanoic Acid (M4PFHpA)	101				60-129
Perfluoro[1,2,3-13C3]Hexanesulfonic Acid (M3PFHxS)	100				71-134
Perfluoro[13C8]Octanoic Acid (M8PFOA)	111				62-129
1H,1H,2H,2H-Perfluoro[1,2-13C2]Octanesulfonic Acid (M2-6:2FTS)	89				14-147
Perfluoro[13C9]Nonanoic Acid (M9PFNA)	122				59-139
Perfluoro[13C8]Octanesulfonic Acid (M8PFOS)	120				69-131
Perfluoro[1,2,3,4,5,6-13C6]Decanoic Acid (M6PFDA)	111				62-124
1H,1H,2H,2H-Perfluoro[1,2-13C2]Decanesulfonic Acid (M2-8:2FTS)	91				10-162
N-Deuteriomethylperfluoro-1-octanesulfonamidoacetic Acid (d3-NMeFOSAA)	68				24-116
Perfluoro[1,2,3,4,5,6,7-13C7]Undecanoic Acid (M7-PFUDA)	96				55-137
Perfluoro[13C8]Octanesulfonamide (M8FOSA)	44				5-112
N-Deuterioethylperfluoro-1-octanesulfonamidoacetic Acid (d5-NEtFOSAA)	67				27-126
Perfluoro[1,2-13C2]Dodecanoic Acid (MPFDOA)	90				48-131
Perfluoro[1,2-13C2]Tetradecanoic Acid (M2PFTEDA)	108				22-136
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-13C3-Propanoic Acid (M3HFPO-DA)	138				10-165
Perfluoro[13C2]Hexadecanoic Acid (M2PFHxDA)	71				10-206

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749
Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Semivolatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-04 Batch: WG1677442-2 WG1677442-3								
Acenaphthene	83		76		37-111	9		30
Benzidine	**6**	Q	**4**	Q	10-75	**42**	Q	30
1,2,4-Trichlorobenzene	81		73		39-98	10		30
Hexachlorobenzene	96		93		40-140	3		30
Bis(2-chloroethyl)ether	71		65		40-140	9		30
2-Chloronaphthalene	79		75		40-140	5		30
1,2-Dichlorobenzene	77		71		40-140	8		30
1,3-Dichlorobenzene	75		72		40-140	4		30
1,4-Dichlorobenzene	75		70		36-97	7		30
3,3'-Dichlorobenzidine	77		68		40-140	12		30
2,4-Dinitrotoluene	78		74		48-143	5		30
2,6-Dinitrotoluene	78		75		40-140	4		30
Azobenzene	97		87		40-140	11		30
Fluoranthene	80		79		40-140	1		30
4-Chlorophenyl phenyl ether	84		80		40-140	5		30
4-Bromophenyl phenyl ether	92		85		40-140	8		30
Bis(2-chloroisopropyl)ether	67		62		40-140	8		30
Bis(2-chloroethoxy)methane	74		69		40-140	7		30
Hexachlorobutadiene	88		83		40-140	6		30
Hexachlorocyclopentadiene	91		83		40-140	9		30
Hexachloroethane	82		81		40-140	1		30
Isophorone	75		67		40-140	11		30
Naphthalene	100		73		40-140	**31**	Q	30

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF

Project Number: 130749

Lab Number: L2244025

Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Semivolatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-04 Batch: WG1677442-2 WG1677442-3								
Nitrobenzene	78		75		40-140	4		30
NDPA/DPA	84		81		40-140	4		30
n-Nitrosodi-n-propylamine	75		75		29-132	0		30
Bis(2-ethylhexyl)phthalate	101		100		40-140	1		30
Butyl benzyl phthalate	88		92		40-140	4		30
Di-n-butylphthalate	89		86		40-140	3		30
Di-n-octylphthalate	100		98		40-140	2		30
Diethyl phthalate	90		86		40-140	5		30
Dimethyl phthalate	80		77		40-140	4		30
Benzo(a)anthracene	89		84		40-140	6		30
Benzo(a)pyrene	93		86		40-140	8		30
Benzo(b)fluoranthene	91		82		40-140	10		30
Benzo(k)fluoranthene	91		84		40-140	8		30
Chrysene	82		78		40-140	5		30
Acenaphthylene	81		77		45-123	5		30
Anthracene	80		78		40-140	3		30
Benzo(ghi)perylene	80		74		40-140	8		30
Fluorene	84		79		40-140	6		30
Phenanthrene	80		74		40-140	8		30
Dibenzo(a,h)anthracene	78		74		40-140	5		30
Indeno(1,2,3-cd)pyrene	89		84		40-140	6		30
Pyrene	80		78		26-127	3		30
Biphenyl	82		78		40-140	5		30

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749
Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Semivolatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-04 Batch: WG1677442-2 WG1677442-3								
Aniline	40		**36**	Q	40-140	11		30
4-Chloroaniline	77		85		40-140	10		30
1-Methylnaphthalene	94		82		41-103	14		30
2-Nitroaniline	77		79		52-143	3		30
3-Nitroaniline	75		70		25-145	7		30
4-Nitroaniline	80		79		51-143	1		30
Dibenzofuran	84		81		40-140	4		30
2-Methylnaphthalene	120		109		40-140	10		30
n-Nitrosodimethylamine	51		51		22-74	0		30
2,4,6-Trichlorophenol	89		89		30-130	0		30
p-Chloro-m-cresol	90		86		23-97	5		30
2-Chlorophenol	78		75		27-123	4		30
2,4-Dichlorophenol	85		79		30-130	7		30
2,4-Dimethylphenol	74		75		30-130	1		30
2-Nitrophenol	79		75		30-130	5		30
4-Nitrophenol	73		71		10-80	3		30
2,4-Dinitrophenol	68		75		20-130	10		30
4,6-Dinitro-o-cresol	74		71		20-164	4		30
Pentachlorophenol	85		92		9-103	8		30
Phenol	56		54		12-110	4		30
2-Methylphenol	75		71		30-130	5		30
3-Methylphenol/4-Methylphenol	77		69		30-130	11		30
2,4,5-Trichlorophenol	89		89		30-130	0		30

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Semivolatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-04 Batch: WG1677442-2 WG1677442-3								
Benzoic Acid	**0**	Q	**0**	Q	10-164	NC		30
Benzyl Alcohol	80		74		26-116	8		30
Carbazole	85		82		55-144	4		30
Pyridine	22		18		10-66	20		30

Surrogate	LCS %Recovery	Qual	LCSD %Recovery	Qual	Acceptance Criteria
2-Fluorophenol	72		67		21-120
Phenol-d6	66		59		10-120
Nitrobenzene-d5	85		76		23-120
2-Fluorobiphenyl	83		79		15-120
2,4,6-Tribromophenol	120		115		10-120
4-Terphenyl-d14	86		87		41-149

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Semivolatile Organics by GC/MS-SIM - Westborough Lab Associated sample(s): 01-04 Batch: WG1677444-2 WG1677444-3								
Acenaphthene	72		67		40-140	7		40
2-Chloronaphthalene	66		61		40-140	8		40
Fluoranthene	67		69		40-140	3		40
Hexachlorobutadiene	76		67		40-140	13		40
Naphthalene	**173**	Q	62		40-140	**94**	Q	40
Benzo(a)anthracene	72		75		40-140	4		40
Benzo(a)pyrene	66		68		40-140	3		40
Benzo(b)fluoranthene	77		76		40-140	1		40
Benzo(k)fluoranthene	77		81		40-140	5		40
Chrysene	80		76		40-140	5		40
Acenaphthylene	62		57		40-140	8		40
Anthracene	68		66		40-140	3		40
Benzo(ghi)perylene	82		82		40-140	0		40
Fluorene	71		69		40-140	3		40
Phenanthrene	70		68		40-140	3		40
Dibenzo(a,h)anthracene	85		86		40-140	1		40
Indeno(1,2,3-cd)pyrene	86		89		40-140	3		40
Pyrene	67		69		40-140	3		40
1-Methylnaphthalene	67		60		40-140	11		40
2-Methylnaphthalene	72		60		40-140	18		40
Pentachlorophenol	87		86		40-140	1		40
Hexachlorobenzene	86		80		40-140	7		40
Hexachloroethane	65		57		40-140	13		40

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF

Project Number: 130749

Lab Number: L2244025

Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits

Semivolatile Organics by GC/MS-SIM - Westborough Lab Associated sample(s): 01-04 Batch: WG1677444-2 WG1677444-3

Surrogate	LCS %Recovery	Qual	LCSD %Recovery	Qual	Acceptance Criteria
2-Fluorophenol	58		53		21-120
Phenol-d6	48		45		10-120
Nitrobenzene-d5	69		65		23-120
2-Fluorobiphenyl	67		64		15-120
2,4,6-Tribromophenol	98		101		10-120
4-Terphenyl-d14	60		63		41-149

Matrix Spike Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676461-3 QC Sample: L2243218-01 Client ID: MS Sample												
Perfluorobutanoic Acid (PFBA)	15.4	37.8	50.1	92		-	-		67-148	-		30
Perfluoropentanoic Acid (PFPeA)	23.8	37.8	57.8	90		-	-		63-161	-		30
Perfluorobutanesulfonic Acid (PFBS)	26.4	33.6	58.3	95		-	-		65-157	-		30
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	ND	35.5	38.4	108		-	-		37-219	-		30
Perfluorohexanoic Acid (PFHxA)	38.4	37.8	73.2	92		-	-		69-168	-		30
Perfluoropentanesulfonic Acid (PFPeS)	ND	35.6	36.1	101		-	-		52-156	-		30
Perfluoroheptanoic Acid (PFHpA)	66.2	37.8	101	92		-	-		58-159	-		30
Perfluorohexanesulfonic Acid (PFHxS)	ND	34.6	40.0	112		-	-		69-177	-		30
Perfluorooctanoic Acid (PFOA)	161	37.8	197	95		-	-		63-159	-		30
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	ND	36	39.2	109		-	-		49-187	-		30
Perfluoroheptanesulfonic Acid (PFHpS)	ND	36.1	33.9	94		-	-		61-179	-		30
Perfluorononanoic Acid (PFNA)	ND	37.8	30.2	79		-	-		68-171	-		30
Perfluorooctanesulfonic Acid (PFOS)	ND	35.1	34.2	94		-	-		52-151	-		30
Perfluorodecanoic Acid (PFDA)	ND	37.8	33.2	88		-	-		63-171	-		30
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	ND	36.3	45.4	125		-	-		56-173	-		30
Perfluorononanesulfonic Acid (PFNS)	ND	36.4	31.7	87		-	-		48-150	-		30
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	ND	37.8	36.8	97		-	-		60-166	-		30
Perfluoroundecanoic Acid (PFUnA)	ND	37.8	43.3	114		-	-		60-153	-		30
Perfluorodecanesulfonic Acid (PFDS)	ND	36.5	33.0	90		-	-		38-156	-		30
Perfluorooctanesulfonamide (FOSA)	ND	37.8	35.4	94		-	-		46-170	-		30
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	ND	37.8	37.2	98		-	-		45-170	-		30
Perfluorododecanoic Acid (PFDoA)	ND	37.8	37.0	98		-	-		67-153	-		30

Matrix Spike Analysis
Batch Quality Control

Project Name:	MOOT MACHIAS LF	***Lab Number:***	L2244025
Project Number:	130749	***Report Date:***	08/25/22

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676461-3 QC Sample: L2243218-01 Client ID: MS Sample												
Perfluorotridecanoic Acid (PFTrDA)	ND	37.8	36.1	95		-	-		48-158	-		30
Perfluorotetradecanoic Acid (PFTA)	ND	37.8	31.0	82		-	-		59-182	-		30

Surrogate (Extracted Internal Standard)	MS % Recovery	MS Qualifier	MSD % Recovery	MSD Qualifier	Acceptance Criteria
1H,1H,2H,2H-Perfluoro[1,2-13C2]Decanesulfonic Acid (M2-8:2FTS)	89				10-162
1H,1H,2H,2H-Perfluoro[1,2-13C2]Hexanesulfonic Acid (M2-4:2FTS)	108				12-142
1H,1H,2H,2H-Perfluoro[1,2-13C2]Octanesulfonic Acid (M2-6:2FTS)	82				14-147
N-Deuterioethylperfluoro-1-octanesulfonamidoacetic Acid (d5-NEtFOSAA)	46				27-126
N-Deuteriomethylperfluoro-1-octanesulfonamidoacetic Acid (d3-NMeFOSAA)	46				24-116
Perfluoro[1,2,3,4,5,6,7-13C7]Undecanoic Acid (M7-PFUDA)	74				55-137
Perfluoro[1,2,3,4,5,6-13C6]Decanoic Acid (M6PFDA)	80				62-124
Perfluoro[1,2,3,4,6-13C5]Hexanoic Acid (M5PFHxA)	71				57-129
Perfluoro[1,2,3,4-13C4]Heptanoic Acid (M4PFHpA)	69				60-129
Perfluoro[1,2,3-13C3]Hexanesulfonic Acid (M3PFHxS)	100				71-134
Perfluoro[1,2-13C2]Dodecanoic Acid (MPFDOA)	71				48-131
Perfluoro[1,2-13C2]Tetradecanoic Acid (M2PFTEDA)	95				22-136
Perfluoro[13C4]Butanoic Acid (MPFBA)	69				58-132
Perfluoro[13C5]Pentanoic Acid (M5PFPEA)	83				62-163
Perfluoro[13C8]Octanesulfonamide (M8FOSA)	9				5-112
Perfluoro[13C8]Octanesulfonic Acid (M8PFOS)	106				69-131
Perfluoro[13C8]Octanoic Acid (M8PFOA)	72				62-129
Perfluoro[13C9]Nonanoic Acid (M9PFNA)	90				59-139
Perfluoro[2,3,4-13C3]Butanesulfonic Acid (M3PFBS)	103				70-131

Lab Duplicate Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676461-4 QC Sample: L2243218-02 Client ID: DUP Sample						
Perfluorobutanoic Acid (PFBA)	12.5	12.6	ng/l	1		30
Perfluoropentanoic Acid (PFPeA)	21.1	21.1	ng/l	0		30
Perfluorobutanesulfonic Acid (PFBS)	26.4	26.9	ng/l	2		30
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	ND	ND	ng/l	NC		30
Perfluorohexanoic Acid (PFHxA)	33.9	35.4	ng/l	4		30
Perfluoropentanesulfonic Acid (PFPeS)	ND	ND	ng/l	NC		30
Perfluoroheptanoic Acid (PFHpA)	58.8	59.9	ng/l	2		30
Perfluorohexanesulfonic Acid (PFHxS)	ND	ND	ng/l	NC		30
Perfluorooctanoic Acid (PFOA)	112	118	ng/l	5		30
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	ND	ND	ng/l	NC		30
Perfluoroheptanesulfonic Acid (PFHpS)	ND	ND	ng/l	NC		30
Perfluorononanoic Acid (PFNA)	ND	ND	ng/l	NC		30
Perfluorooctanesulfonic Acid (PFOS)	ND	ND	ng/l	NC		30
Perfluorodecanoic Acid (PFDA)	ND	ND	ng/l	NC		30
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	ND	ND	ng/l	NC		30
Perfluorononanesulfonic Acid (PFNS)	ND	ND	ng/l	NC		30
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	ND	ND	ng/l	NC		30
Perfluoroundecanoic Acid (PFUnA)	ND	ND	ng/l	NC		30
Perfluorodecanesulfonic Acid (PFDS)	ND	ND	ng/l	NC		30
Perfluorooctanesulfonamide (FOSA)	ND	ND	ng/l	NC		30

Lab Duplicate Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749
Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676461-4 QC Sample: L2243218-02 Client ID: DUP Sample						
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	ND	ND	ng/l	NC		30
Perfluorododecanoic Acid (PFDoA)	ND	ND	ng/l	NC		30
Perfluorotridecanoic Acid (PFTrDA)	ND	ND	ng/l	NC		30
Perfluorotetradecanoic Acid (PFTA)	ND	ND	ng/l	NC		30

Surrogate (Extracted Internal Standard)	%Recovery	Qualifier	%Recovery	Qualifier	Acceptance Criteria
Perfluoro[13C4]Butanoic Acid (MPFBA)	61		64		58-132
Perfluoro[13C5]Pentanoic Acid (M5PFPEA)	74		78		62-163
Perfluoro[2,3,4-13C3]Butanesulfonic Acid (M3PFBS)	111		94		70-131
1H,1H,2H,2H-Perfluoro[1,2-13C2]Hexanesulfonic Acid (M2-4:2FTS)	99		82		12-142
Perfluoro[1,2,3,4,6-13C5]Hexanoic Acid (M5PFHxA)	58		61		57-129
Perfluoro[1,2,3,4-13C4]Heptanoic Acid (M4PFHpA)	**58**	Q	60		60-129
Perfluoro[1,2,3-13C3]Hexanesulfonic Acid (M3PFHxS)	107		91		71-134
Perfluoro[13C8]Octanoic Acid (M8PFOA)	62		66		62-129
1H,1H,2H,2H-Perfluoro[1,2-13C2]Octanesulfonic Acid (M2-6:2FTS)	81		69		14-147
Perfluoro[13C9]Nonanoic Acid (M9PFNA)	74		76		59-139
Perfluoro[13C8]Octanesulfonic Acid (M8PFOS)	110		112		69-131
Perfluoro[1,2,3,4,5,6-13C6]Decanoic Acid (M6PFDA)	73		71		62-124
1H,1H,2H,2H-Perfluoro[1,2-13C2]Decanesulfonic Acid (M2-8:2FTS)	93		79		10-162
N-Deuteriomethylperfluoro-1-octanesulfonamidoacetic Acid (d3-NMeFOSAA)	40		41		24-116
Perfluoro[1,2,3,4,5,6,7-13C7]Undecanoic Acid (M7-PFUDA)	71		70		55-137
Perfluoro[13C8]Octanesulfonamide (M8FOSA)	6		7		5-112
N-Deuterioethylperfluoro-1-octanesulfonamidoacetic Acid (d5-NEtFOSAA)	34		42		27-126
Perfluoro[1,2-13C2]Dodecanoic Acid (MPFDOA)	69		70		48-131

Lab Duplicate Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
Perfluorinated Alkyl Acids by Isotope Dilution - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676461-4 QC Sample: L2243218-02 Client ID: DUP Sample						

Surrogate (Extracted Internal Standard)	%Recovery	Qualifier	%Recovery	Qualifier	Acceptance Criteria
Perfluoro[1,2-13C2]Tetradecanoic Acid (M2PFTEDA)	91		92		22-136

PESTICIDES

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-01
Client ID: HA22-2(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 14:40
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8081B
Analytical Date: 08/22/22 12:59
Analyst: AKM

Extraction Method: EPA 3510C
Extraction Date: 08/21/22 17:30

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Pesticides by GC - Westborough Lab							
Delta-BHC	ND		ug/l	0.014	--	1	A
Lindane	ND		ug/l	0.014	--	1	A
Alpha-BHC	ND		ug/l	0.014	--	1	A
Beta-BHC	ND		ug/l	0.014	--	1	A
Heptachlor	ND		ug/l	0.014	--	1	A
Aldrin	ND		ug/l	0.014	--	1	A
Heptachlor epoxide	ND		ug/l	0.014	--	1	A
Endrin	ND		ug/l	0.029	--	1	A
Endrin aldehyde	ND		ug/l	0.029	--	1	A
Endrin ketone	ND		ug/l	0.029	--	1	A
Dieldrin	ND		ug/l	0.029	--	1	A
4,4'-DDE	ND		ug/l	0.029	--	1	A
4,4'-DDD	ND		ug/l	0.029	--	1	A
4,4'-DDT	ND		ug/l	0.029	--	1	A
Endosulfan I	ND		ug/l	0.014	--	1	A
Endosulfan II	ND		ug/l	0.029	--	1	A
Endosulfan sulfate	ND		ug/l	0.029	--	1	A
Methoxychlor	ND		ug/l	0.143	--	1	A
Toxaphene	ND		ug/l	0.143	--	1	A
Chlordane	ND		ug/l	0.143	--	1	A
cis-Chlordane	ND		ug/l	0.014	--	1	A
trans-Chlordane	ND		ug/l	0.014	--	1	A

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-01 Date Collected: 08/15/22 14:40
Client ID: HA22-2(OW) Date Received: 08/16/22
Sample Location: MACHIAS, ME Field Prep: Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Pesticides by GC - Westborough Lab							

Surrogate	% Recovery	Qualifier	Acceptance Criteria	Column
2,4,5,6-Tetrachloro-m-xylene	74		30-150	A
Decachlorobiphenyl	72		30-150	A
2,4,5,6-Tetrachloro-m-xylene	78		30-150	B
Decachlorobiphenyl	81		30-150	B

Project Name: MOOT MACHIAS LF
Lab Number: L2244025
Project Number: 130749
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-01
Client ID: HA22-2(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 14:40
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8151A
Analytical Date: 08/20/22 22:43
Analyst: EJL

Extraction Method: EPA 8151A
Extraction Date: 08/19/22 14:02

Methylation Date: 08/20/22 09:59

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Chlorinated Herbicides by GC - Westborough Lab							
MCPP	ND		ug/l	500	--	1	A
MCPA	ND		ug/l	500	--	1	A
Dalapon	ND		ug/l	20.0	--	1	A
Dicamba	ND		ug/l	1.00	--	1	A
Dichloroprop	ND		ug/l	10.0	--	1	A
2,4-D	ND		ug/l	10.0	--	1	A
2,4-DB	ND		ug/l	10.0	--	1	A
2,4,5-T	ND		ug/l	2.00	--	1	A
2,4,5-TP (Silvex)	ND		ug/l	2.00	--	1	A
Dinoseb	ND		ug/l	5.00	--	1	A

Surrogate	% Recovery	Qualifier	Acceptance Criteria	Column
DCAA	126		30-150	A
DCAA	124		30-150	B

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025
Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-02	Date Collected:	08/15/22 12:00
Client ID:	HA22-8(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water	Extraction Method:	EPA 3510C
Analytical Method:	1,8081B	Extraction Date:	08/21/22 17:30
Analytical Date:	08/22/22 13:10		
Analyst:	AKM		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Pesticides by GC - Westborough Lab							
Delta-BHC	ND		ug/l	0.014	--	1	A
Lindane	ND		ug/l	0.014	--	1	A
Alpha-BHC	ND		ug/l	0.014	--	1	A
Beta-BHC	ND		ug/l	0.014	--	1	A
Heptachlor	ND		ug/l	0.014	--	1	A
Aldrin	ND		ug/l	0.014	--	1	A
Heptachlor epoxide	ND		ug/l	0.014	--	1	A
Endrin	ND		ug/l	0.029	--	1	A
Endrin aldehyde	ND		ug/l	0.029	--	1	A
Endrin ketone	ND		ug/l	0.029	--	1	A
Dieldrin	ND		ug/l	0.029	--	1	A
4,4'-DDE	ND		ug/l	0.029	--	1	A
4,4'-DDD	ND		ug/l	0.029	--	1	A
4,4'-DDT	ND		ug/l	0.029	--	1	A
Endosulfan I	ND		ug/l	0.014	--	1	A
Endosulfan II	ND		ug/l	0.029	--	1	A
Endosulfan sulfate	ND		ug/l	0.029	--	1	A
Methoxychlor	ND		ug/l	0.143	--	1	A
Toxaphene	ND		ug/l	0.143	--	1	A
Chlordane	ND		ug/l	0.143	--	1	A
cis-Chlordane	ND		ug/l	0.014	--	1	A
trans-Chlordane	ND		ug/l	0.014	--	1	A

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025

Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-02	Date Collected:	08/15/22 12:00
Client ID:	HA22-8(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Pesticides by GC - Westborough Lab							

Surrogate	% Recovery	Qualifier	Acceptance Criteria	Column
2,4,5,6-Tetrachloro-m-xylene	67		30-150	A
Decachlorobiphenyl	58		30-150	A
2,4,5,6-Tetrachloro-m-xylene	61		30-150	B
Decachlorobiphenyl	63		30-150	B

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025
Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-02
Client ID: HA22-8(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 12:00
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8151A
Analytical Date: 08/20/22 23:01
Analyst: EJL

Extraction Method: EPA 8151A
Extraction Date: 08/19/22 14:02

Methylation Date: 08/20/22 09:59

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Chlorinated Herbicides by GC - Westborough Lab							
MCPP	ND		ug/l	500	--	1	A
MCPA	ND		ug/l	500	--	1	A
Dalapon	ND		ug/l	20.0	--	1	A
Dicamba	ND		ug/l	1.00	--	1	A
Dichloroprop	ND		ug/l	10.0	--	1	A
2,4-D	ND		ug/l	10.0	--	1	A
2,4-DB	ND		ug/l	10.0	--	1	A
2,4,5-T	ND		ug/l	2.00	--	1	A
2,4,5-TP (Silvex)	ND		ug/l	2.00	--	1	A
Dinoseb	ND		ug/l	5.00	--	1	A

Surrogate	% Recovery	Qualifier	Acceptance Criteria	Column
DCAA	123		30-150	A
DCAA	131		30-150	B

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-03
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 13:30
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8081B
Analytical Date: 08/22/22 13:22
Analyst: AKM

Extraction Method: EPA 3510C
Extraction Date: 08/21/22 17:30

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Pesticides by GC - Westborough Lab							
Delta-BHC	ND		ug/l	0.014	--	1	A
Lindane	ND		ug/l	0.014	--	1	A
Alpha-BHC	ND		ug/l	0.014	--	1	A
Beta-BHC	ND		ug/l	0.014	--	1	A
Heptachlor	ND		ug/l	0.014	--	1	A
Aldrin	ND		ug/l	0.014	--	1	A
Heptachlor epoxide	ND		ug/l	0.014	--	1	A
Endrin	ND		ug/l	0.029	--	1	A
Endrin aldehyde	ND		ug/l	0.029	--	1	A
Endrin ketone	ND		ug/l	0.029	--	1	A
Dieldrin	ND		ug/l	0.029	--	1	A
4,4'-DDE	ND		ug/l	0.029	--	1	A
4,4'-DDD	ND		ug/l	0.029	--	1	A
4,4'-DDT	ND		ug/l	0.029	--	1	A
Endosulfan I	ND		ug/l	0.014	--	1	A
Endosulfan II	ND		ug/l	0.029	--	1	A
Endosulfan sulfate	ND		ug/l	0.029	--	1	A
Methoxychlor	ND		ug/l	0.143	--	1	A
Toxaphene	ND		ug/l	0.143	--	1	A
Chlordane	ND		ug/l	0.143	--	1	A
cis-Chlordane	ND		ug/l	0.014	--	1	A
trans-Chlordane	ND		ug/l	0.014	--	1	A

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025

Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-03	Date Collected:	08/15/22 13:30
Client ID:	HA22-9(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Pesticides by GC - Westborough Lab							

Surrogate	% Recovery	Qualifier	Acceptance Criteria	Column
2,4,5,6-Tetrachloro-m-xylene	80		30-150	A
Decachlorobiphenyl	80		30-150	A
2,4,5,6-Tetrachloro-m-xylene	80		30-150	B
Decachlorobiphenyl	87		30-150	B

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-03	Date Collected:	08/15/22 13:30
Client ID:	HA22-9(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water	Extraction Method:	EPA 8151A
Analytical Method:	1,8151A	Extraction Date:	08/19/22 14:02
Analytical Date:	08/20/22 23:20		
Analyst:	EJL		

Methylation Date: 08/20/22 09:59

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Chlorinated Herbicides by GC - Westborough Lab							
MCPP	ND		ug/l	500	--	1	A
MCPA	ND		ug/l	500	--	1	A
Dalapon	ND		ug/l	20.0	--	1	A
Dicamba	ND		ug/l	1.00	--	1	A
Dichloroprop	ND		ug/l	10.0	--	1	A
2,4-D	ND		ug/l	10.0	--	1	A
2,4-DB	ND		ug/l	10.0	--	1	A
2,4,5-T	ND		ug/l	2.00	--	1	A
2,4,5-TP (Silvex)	ND		ug/l	2.00	--	1	A
Dinoseb	ND		ug/l	5.00	--	1	A

Surrogate	% Recovery	Qualifier	Acceptance Criteria	Column
DCAA	118		30-150	A
DCAA	123		30-150	B

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-04
Client ID: HA22-10(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 16:00
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water
Analytical Method: 1,8081B
Analytical Date: 08/22/22 13:33
Analyst: AKM

Extraction Method: EPA 3510C
Extraction Date: 08/21/22 17:30

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Pesticides by GC - Westborough Lab							
Delta-BHC	ND		ug/l	0.014	--	1	A
Lindane	ND		ug/l	0.014	--	1	A
Alpha-BHC	ND		ug/l	0.014	--	1	A
Beta-BHC	ND		ug/l	0.014	--	1	A
Heptachlor	ND		ug/l	0.014	--	1	A
Aldrin	ND		ug/l	0.014	--	1	A
Heptachlor epoxide	ND		ug/l	0.014	--	1	A
Endrin	ND		ug/l	0.029	--	1	A
Endrin aldehyde	ND		ug/l	0.029	--	1	A
Endrin ketone	ND		ug/l	0.029	--	1	A
Dieldrin	ND		ug/l	0.029	--	1	A
4,4'-DDE	ND		ug/l	0.029	--	1	A
4,4'-DDD	ND		ug/l	0.029	--	1	A
4,4'-DDT	ND		ug/l	0.029	--	1	A
Endosulfan I	ND		ug/l	0.014	--	1	A
Endosulfan II	ND		ug/l	0.029	--	1	A
Endosulfan sulfate	ND		ug/l	0.029	--	1	A
Methoxychlor	ND		ug/l	0.143	--	1	A
Toxaphene	ND		ug/l	0.143	--	1	A
Chlordane	ND		ug/l	0.143	--	1	A
cis-Chlordane	ND		ug/l	0.014	--	1	A
trans-Chlordane	ND		ug/l	0.014	--	1	A

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC

Sample Depth:

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Pesticides by GC - Westborough Lab							

Surrogate	% Recovery	Qualifier	Acceptance Criteria	Column
2,4,5,6-Tetrachloro-m-xylene	79		30-150	A
Decachlorobiphenyl	74		30-150	A
2,4,5,6-Tetrachloro-m-xylene	75		30-150	B
Decachlorobiphenyl	81		30-150	B

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water	Extraction Method:	EPA 8151A
Analytical Method:	1,8151A	Extraction Date:	08/19/22 14:02
Analytical Date:	08/20/22 23:38		
Analyst:	EJL		

Methylation Date: 08/20/22 09:59

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Column
Chlorinated Herbicides by GC - Westborough Lab							
MCPP	ND		ug/l	500	--	1	A
MCPA	ND		ug/l	500	--	1	A
Dalapon	ND		ug/l	20.0	--	1	A
Dicamba	ND		ug/l	1.00	--	1	A
Dichloroprop	ND		ug/l	10.0	--	1	A
2,4-D	ND		ug/l	10.0	--	1	A
2,4-DB	ND		ug/l	10.0	--	1	A
2,4,5-T	ND		ug/l	2.00	--	1	A
2,4,5-TP (Silvex)	ND		ug/l	2.00	--	1	A
Dinoseb	ND		ug/l	5.00	--	1	A

Surrogate	% Recovery	Qualifier	Acceptance Criteria	Column
DCAA	126		30-150	A
DCAA	122		30-150	B

Project Name: MOOT MACHIAS LF
Project Number: 130749
Lab Number: L2244025
Report Date: 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8151A
Analytical Date: 08/20/22 20:35
Analyst: EJL

Extraction Method: EPA 8151A
Extraction Date: 08/19/22 14:02

Methylation Date: 08/20/22 09:59

Parameter	Result	Qualifier	Units	RL	MDL	Column
Chlorinated Herbicides by GC - Westborough Lab for sample(s): 01-04 Batch: WG1677401-1						
MCPP	ND		ug/l	500	--	A
MCPA	ND		ug/l	500	--	A
Dalapon	ND		ug/l	20.0	--	A
Dicamba	ND		ug/l	1.00	--	A
Dichloroprop	ND		ug/l	10.0	--	A
2,4-D	ND		ug/l	10.0	--	A
2,4-DB	ND		ug/l	10.0	--	A
2,4,5-T	ND		ug/l	2.00	--	A
2,4,5-TP (Silvex)	ND		ug/l	2.00	--	A
Dinoseb	ND		ug/l	5.00	--	A

Surrogate	%Recovery	Qualifier	Acceptance Criteria	Column
DCAA	116		30-150	A
DCAA	99		30-150	B

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8081B Extraction Method: EPA 3510C
Analytical Date: 08/22/22 12:25 Extraction Date: 08/21/22 17:30
Analyst: AKM

Parameter	Result	Qualifier	Units	RL	MDL	Column
Pesticides by GC - Westborough Lab for sample(s): 01-04 Batch: WG1677901-1						
Delta-BHC	ND		ug/l	0.014	--	A
Lindane	ND		ug/l	0.014	--	A
Alpha-BHC	ND		ug/l	0.014	--	A
Beta-BHC	ND		ug/l	0.014	--	A
Heptachlor	ND		ug/l	0.014	--	A
Aldrin	ND		ug/l	0.014	--	A
Heptachlor epoxide	ND		ug/l	0.014	--	A
Endrin	ND		ug/l	0.029	--	A
Endrin aldehyde	ND		ug/l	0.029	--	A
Endrin ketone	ND		ug/l	0.029	--	A
Dieldrin	ND		ug/l	0.029	--	A
4,4'-DDE	ND		ug/l	0.029	--	A
4,4'-DDD	ND		ug/l	0.029	--	A
4,4'-DDT	ND		ug/l	0.029	--	A
Endosulfan I	ND		ug/l	0.014	--	A
Endosulfan II	ND		ug/l	0.029	--	A
Endosulfan sulfate	ND		ug/l	0.029	--	A
Methoxychlor	ND		ug/l	0.143	--	A
Toxaphene	ND		ug/l	0.143	--	A
Chlordane	ND		ug/l	0.143	--	A
cis-Chlordane	ND		ug/l	0.014	--	A
trans-Chlordane	ND		ug/l	0.014	--	A

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8081B
Analytical Date: 08/22/22 12:25
Analyst: AKM

Extraction Method: EPA 3510C
Extraction Date: 08/21/22 17:30

Parameter	Result	Qualifier	Units	RL	MDL	Column
Pesticides by GC - Westborough Lab for sample(s): 01-04 Batch: WG1677901-1						

Surrogate	%Recovery	Qualifier	Acceptance Criteria	Column
2,4,5,6-Tetrachloro-m-xylene	88		30-150	A
Decachlorobiphenyl	85		30-150	A
2,4,5,6-Tetrachloro-m-xylene	81		30-150	B
Decachlorobiphenyl	95		30-150	B

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits	Column
Chlorinated Herbicides by GC - Westborough Lab Associated sample(s): 01-04 Batch: WG1677401-2 WG1677401-3									
MCPP	**318**	Q	**304**	Q	30-150	5		25	A
MCPA	**200**	Q	**190**	Q	30-150	5		25	A
Dalapon	117		108		30-150	8		25	A
Dicamba	106		99		30-150	7		25	A
Dichloroprop	130		123		30-150	6		25	A
2,4-D	120		112		30-150	7		25	A
2,4-DB	99		97		30-150	2		25	A
2,4,5-T	129		118		30-150	9		25	A
2,4,5-TP (Silvex)	114		107		30-150	6		25	A
Dinoseb	75		70		30-150	7		25	A

Surrogate	LCS %Recovery	Qual	LCSD %Recovery	Qual	Acceptance Criteria	Column
DCAA	126		118		30-150	A
DCAA	131		123		30-150	B

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits	Column
Pesticides by GC - Westborough Lab Associated sample(s): 01-04 Batch: WG1677901-2 WG1677901-3									
Delta-BHC	65		67		30-150	3		20	A
Lindane	81		78		30-150	4		20	A
Alpha-BHC	84		81		30-150	4		20	A
Beta-BHC	78		74		30-150	6		20	A
Heptachlor	81		78		30-150	4		20	A
Aldrin	86		82		30-150	5		20	A
Heptachlor epoxide	83		80		30-150	5		20	A
Endrin	83		80		30-150	4		20	A
Endrin aldehyde	67		68		30-150	2		20	A
Endrin ketone	82		81		30-150	1		20	A
Dieldrin	96		92		30-150	4		20	A
4,4'-DDE	88		84		30-150	4		20	A
4,4'-DDD	93		88		30-150	6		20	A
4,4'-DDT	90		85		30-150	5		20	A
Endosulfan I	91		83		30-150	9		20	A
Endosulfan II	80		82		30-150	2		20	A
Endosulfan sulfate	74		76		30-150	3		20	A
Methoxychlor	92		86		30-150	7		20	A
cis-Chlordane	79		76		30-150	4		20	A
trans-Chlordane	108		101		30-150	7		20	A

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF

Project Number: 130749

Lab Number: L2244025

Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits

Pesticides by GC - Westborough Lab Associated sample(s): 01-04 Batch: WG1677901-2 WG1677901-3

Surrogate	LCS %Recovery	Qual	LCSD %Recovery	Qual	Acceptance Criteria	Column
2,4,5,6-Tetrachloro-m-xylene	77		80		30-150	A
Decachlorobiphenyl	79		75		30-150	A
2,4,5,6-Tetrachloro-m-xylene	72		76		30-150	B
Decachlorobiphenyl	88		87		30-150	B

METALS

Project Name: MOOT MACHIAS LF
Lab Number: L2244025
Project Number: 130749
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-01
Date Collected: 08/15/22 14:40
Client ID: HA22-2(OW)
Date Received: 08/16/22
Sample Location: MACHIAS, ME
Field Prep: Refer to COC

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
Dissolved Metals - Mansfield Lab											
Arsenic, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Barium, Dissolved	0.161		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Cadmium, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Calcium, Dissolved	122		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Chromium, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Copper, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Iron, Dissolved	0.168		mg/l	0.050	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Lead, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Magnesium, Dissolved	77.6		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Manganese, Dissolved	4.07		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Mercury, Dissolved	ND		mg/l	0.00020	--	1	08/17/22 17:24	08/21/22 16:17	EPA 7470A	1,7470A	AW
Potassium, Dissolved	14.5		mg/l	2.50	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Sodium, Dissolved	412		mg/l	2.00	--	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF
Dissolved Hardness by SM 2340B - Mansfield Lab											
Hardness	624		mg/l	0.660	NA	1	08/17/22 17:03	08/25/22 14:48	EPA 3005A	1,6010D	JF

Project Name: MOOT MACHIAS LF | **Lab Number:** L2244025
Project Number: 130749 | **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-02 | Date Collected: 08/15/22 12:00
Client ID: HA22-8(OW) | Date Received: 08/16/22
Sample Location: MACHIAS, ME | Field Prep: Refer to COC

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
Dissolved Metals - Mansfield Lab											
Arsenic, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Barium, Dissolved	0.314		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Cadmium, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Calcium, Dissolved	165		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Chromium, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Copper, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Iron, Dissolved	148		mg/l	0.050	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Lead, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Magnesium, Dissolved	65.0		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Manganese, Dissolved	35.9		mg/l	0.100	--	10	08/17/22 17:03	08/25/22 15:40	EPA 3005A	1,6010D	JF
Mercury, Dissolved	ND		mg/l	0.00020	--	1	08/17/22 17:24	08/21/22 16:04	EPA 7470A	1,7470A	AW
Potassium, Dissolved	9.42		mg/l	2.50	--	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF
Sodium, Dissolved	1870		mg/l	20.0	--	10	08/17/22 17:03	08/25/22 15:40	EPA 3005A	1,6010D	JF
Dissolved Hardness by SM 2340B - Mansfield Lab											
Hardness	680		mg/l	0.660	NA	1	08/17/22 17:03	08/25/22 14:33	EPA 3005A	1,6010D	JF

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-03	Date Collected:	08/15/22 13:30
Client ID:	HA22-9(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
Dissolved Metals - Mansfield Lab											
Arsenic, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Barium, Dissolved	0.739		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Cadmium, Dissolved	0.005		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Calcium, Dissolved	478		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Chromium, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Copper, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Iron, Dissolved	5.65		mg/l	0.050	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Lead, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Magnesium, Dissolved	198		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Manganese, Dissolved	39.6		mg/l	0.100	--	10	08/17/22 17:03	08/25/22 15:45	EPA 3005A	1,6010D	JF
Mercury, Dissolved	ND		mg/l	0.00020	--	1	08/17/22 17:24	08/21/22 16:49	EPA 7470A	1,7470A	AW
Potassium, Dissolved	29.3		mg/l	2.50	--	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF
Sodium, Dissolved	2380		mg/l	20.0	--	10	08/17/22 17:03	08/25/22 15:45	EPA 3005A	1,6010D	JF
Dissolved Hardness by SM 2340B - Mansfield Lab											
Hardness	2010		mg/l	0.660	NA	1	08/17/22 17:03	08/25/22 14:37	EPA 3005A	1,6010D	JF

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-04	Date Collected:	08/15/22 16:00
Client ID:	HA22-10(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
Dissolved Metals - Mansfield Lab											
Arsenic, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Barium, Dissolved	2.18		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Cadmium, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Calcium, Dissolved	98.3		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Chromium, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Copper, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Iron, Dissolved	96.6		mg/l	0.050	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Lead, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Magnesium, Dissolved	21.7		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Manganese, Dissolved	0.396		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Mercury, Dissolved	ND		mg/l	0.00020	--	1	08/17/22 17:24	08/21/22 16:53	EPA 7470A	1,7470A	AW
Potassium, Dissolved	25.6		mg/l	2.50	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Sodium, Dissolved	500		mg/l	2.00	--	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF
Dissolved Hardness by SM 2340B - Mansfield Lab											
Hardness	335		mg/l	0.660	NA	1	08/17/22 17:03	08/25/22 14:43	EPA 3005A	1,6010D	JF

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Dissolved Metals - Mansfield Lab for sample(s): 01-04 Batch: WG1676235-1										
Arsenic, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Barium, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Cadmium, Dissolved	ND		mg/l	0.005	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Calcium, Dissolved	ND		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Chromium, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Copper, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Iron, Dissolved	ND		mg/l	0.050	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Lead, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Magnesium, Dissolved	ND		mg/l	0.100	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Manganese, Dissolved	ND		mg/l	0.010	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Potassium, Dissolved	ND		mg/l	2.50	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF
Sodium, Dissolved	ND		mg/l	2.00	--	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF

Prep Information

Digestion Method: EPA 3005A

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Dissolved Hardness by SM 2340B - Mansfield Lab for sample(s): 01-04 Batch: WG1676235-1										
Hardness	ND		mg/l	0.660	NA	1	08/17/22 17:03	08/25/22 14:23	1,6010D	JF

Prep Information

Digestion Method: EPA 3005A

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Dissolved Metals - Mansfield Lab for sample(s): 01-04 Batch: WG1676237-1										
Mercury, Dissolved	ND		mg/l	0.00020	--	1	08/17/22 17:24	08/21/22 15:57	1,7470A	AW

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

Method Blank Analysis
Batch Quality Control

Prep Information

Digestion Method: EPA 7470A

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Dissolved Metals - Mansfield Lab Associated sample(s): 01-04 Batch: WG1676235-2								
Arsenic, Dissolved	102		-		80-120	-		
Barium, Dissolved	97		-		80-120	-		
Cadmium, Dissolved	96		-		80-120	-		
Calcium, Dissolved	99		-		80-120	-		
Chromium, Dissolved	94		-		80-120	-		
Copper, Dissolved	98		-		80-120	-		
Iron, Dissolved	98		-		80-120	-		
Lead, Dissolved	98		-		80-120	-		
Magnesium, Dissolved	103		-		80-120	-		
Manganese, Dissolved	95		-		80-120	-		
Potassium, Dissolved	101		-		80-120	-		
Sodium, Dissolved	94		-		80-120	-		
Dissolved Hardness by SM 2340B - Mansfield Lab Associated sample(s): 01-04 Batch: WG1676235-2								
Hardness	102		-		80-120	-		
Dissolved Metals - Mansfield Lab Associated sample(s): 01-04 Batch: WG1676237-2								
Mercury, Dissolved	107		-		80-120	-		

Matrix Spike Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
Dissolved Metals - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676235-3 QC Sample: L2244025-01 Client ID: HA22-2(OW)												
Arsenic, Dissolved	ND	0.12	0.128	107		-	-		75-125	-		20
Barium, Dissolved	0.161	2	2.03	93		-	-		75-125	-		20
Cadmium, Dissolved	ND	0.053	0.049	92		-	-		75-125	-		20
Calcium, Dissolved	122	10	130	80		-	-		75-125	-		20
Chromium, Dissolved	ND	0.2	0.180	90		-	-		75-125	-		20
Copper, Dissolved	ND	0.25	0.252	101		-	-		75-125	-		20
Iron, Dissolved	0.168	1	0.995	83		-	-		75-125	-		20
Lead, Dissolved	ND	0.53	0.490	92		-	-		75-125	-		20
Magnesium, Dissolved	77.6	10	88.3	107		-	-		75-125	-		20
Manganese, Dissolved	4.07	0.5	4.45	76		-	-		75-125	-		20
Potassium, Dissolved	14.5	10	25.2	107		-	-		75-125	-		20
Sodium, Dissolved	412	10	421	90		-	-		75-125	-		20
Dissolved Hardness by SM 2340B - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676235-3 QC Sample: L2244025-01 Client ID: HA22-2(OW)												
Hardness	624	66.2	687	95		-	-		75-125	-		20
Dissolved Metals - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676237-3 QC Sample: L2244025-02 Client ID: HA22-8(OW)												
Mercury, Dissolved	ND	0.005	0.00511	102		-	-		75-125	-		20

Lab Duplicate Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
Dissolved Metals - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676235-4 QC Sample: L2244025-01 Client ID: HA22-2(OW)						
Arsenic, Dissolved	ND	ND	mg/l	NC		20
Barium, Dissolved	0.161	0.155	mg/l	4		20
Cadmium, Dissolved	ND	ND	mg/l	NC		20
Calcium, Dissolved	122	119	mg/l	2		20
Chromium, Dissolved	ND	ND	mg/l	NC		20
Copper, Dissolved	ND	ND	mg/l	NC		20
Iron, Dissolved	0.168	ND	mg/l	NC		20
Lead, Dissolved	ND	ND	mg/l	NC		20
Magnesium, Dissolved	77.6	77.0	mg/l	1		20
Manganese, Dissolved	4.07	3.97	mg/l	2		20
Potassium, Dissolved	14.5	14.0	mg/l	4		20
Sodium, Dissolved	412	400	mg/l	3		20
Dissolved Hardness by SM 2340B - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676235-4 QC Sample: L2244025-01 Client ID: HA22-2(OW)						
Hardness	624	614	mg/l	2		20
Dissolved Metals - Mansfield Lab Associated sample(s): 01-04 QC Batch ID: WG1676237-4 QC Sample: L2244025-02 Client ID: HA22-8(OW)						
Mercury, Dissolved	ND	ND	mg/l	NC		20

INORGANICS
&
MISCELLANEOUS

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

SAMPLE RESULTS

Lab ID:	L2244025-01	Date Collected:	08/15/22 14:40
Client ID:	HA22-2(OW)	Date Received:	08/16/22
Sample Location:	MACHIAS, ME	Field Prep:	Refer to COC
Sample Depth:			
Matrix:	Water		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Alkalinity, Total	405.		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
Alkalinity, Bicarbonate	405.		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
Nitrogen, Ammonia	0.803		mg/l	0.075	--	1	08/22/22 13:50	08/22/22 20:10	121,4500NH3-BH	AT
Chemical Oxygen Demand	47.		mg/l	20	--	1	08/17/22 09:00	08/17/22 12:08	121,5220D	CN
Total Organic Carbon	3.31		mg/l	1.00	--	2	-	08/17/22 10:01	121,5310C	DW
Anions by Ion Chromatography - Westborough Lab										
Bromide	1.83		mg/l	0.050	--	1	-	08/19/22 17:13	44,300.0	AT

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-02 Date Collected: 08/15/22 12:00
Client ID: HA22-8(OW) Date Received: 08/16/22
Sample Location: MACHIAS, ME Field Prep: Refer to COC

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Alkalinity, Total	64.2		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
Alkalinity, Bicarbonate	64.2		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
Nitrogen, Ammonia	5.89		mg/l	0.075	--	1	08/22/22 13:50	08/22/22 20:13	121,4500NH3-BH	AT
Chemical Oxygen Demand	250		mg/l	20	--	1	08/17/22 09:00	08/17/22 12:08	121,5220D	CN
Total Organic Carbon	4.14		mg/l	2.00	--	4	-	08/17/22 10:23	121,5310C	DW
Anions by Ion Chromatography - Westborough Lab										
Bromide	9.39		mg/l	1.25	--	25	-	08/19/22 21:02	44,300.0	AT

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-03
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 13:30
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Alkalinity, Total	380.		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
Alkalinity, Bicarbonate	380.		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
Nitrogen, Ammonia	0.150		mg/l	0.075	--	1	08/22/22 13:50	08/22/22 20:17	121,4500NH3-BH	AT
Chemical Oxygen Demand	370		mg/l	20	--	1	08/17/22 09:00	08/17/22 12:16	121,5220D	CN
Total Organic Carbon	3.62		mg/l	2.00	--	4	-	08/17/22 12:08	121,5310C	DW
Anions by Ion Chromatography - Westborough Lab										
Bromide	6.06		mg/l	2.50	--	50	-	08/19/22 20:51	44,300.0	AT

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-04
Client ID: HA22-10(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/15/22 16:00
Date Received: 08/16/22
Field Prep: Refer to COC

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Alkalinity, Total	318.		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
Alkalinity, Bicarbonate	318.		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
Nitrogen, Ammonia	8.95		mg/l	0.075	--	1	08/22/22 13:50	08/22/22 20:18	121,4500NH3-BH	AT
Chemical Oxygen Demand	64.		mg/l	20	--	1	08/17/22 09:00	08/17/22 12:16	121,5220D	CN
Total Organic Carbon	4.53		mg/l	1.00	--	2	-	08/17/22 11:06	121,5310C	DW
Anions by Ion Chromatography - Westborough Lab										
Bromide	4.78		mg/l	1.25	--	25	-	08/19/22 21:35	44,300.0	AT

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-05
Client ID: HA22-2(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/16/22 08:00
Date Received: 08/16/22
Field Prep: Not Specified

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Solids, Total Dissolved	1700		mg/l	10	--	1	-	08/17/22 09:10	121,2540C	DW
Nitrogen, Nitrite	ND		mg/l	0.050	--	1	-	08/17/22 05:36	44,353.2	KA
Chromium, Hexavalent	ND		mg/l	0.010	--	1	08/17/22 06:05	08/17/22 06:19	1,7196A	KA
Anions by Ion Chromatography - Westborough Lab										
Chloride	838.		mg/l	12.5	--	25	-	08/17/22 20:35	44,300.0	AT
Nitrogen, Nitrate	ND		mg/l	0.050	--	1	-	08/17/22 16:57	44,300.0	AT
Sulfate	26.8		mg/l	1.00	--	1	-	08/17/22 16:57	44,300.0	AT

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-06
Client ID: HA22-8(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/16/22 07:20
Date Received: 08/16/22
Field Prep: Not Specified

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Solids, Total Dissolved	5500		mg/l	20	--	2	-	08/17/22 09:10	121,2540C	DW
Nitrogen, Nitrite	0.057		mg/l	0.050	--	1	-	08/17/22 05:44	44,353.2	KA
Chromium, Hexavalent	ND		mg/l	0.010	--	1	08/17/22 06:05	08/17/22 06:19	1,7196A	KA
Anions by Ion Chromatography - Westborough Lab										
Chloride	3250		mg/l	250	--	500	-	08/17/22 20:46	44,300.0	AT
Nitrogen, Nitrate	0.537		mg/l	0.050	--	1	-	08/17/22 17:08	44,300.0	AT
Sulfate	ND		mg/l	1.00	--	1	-	08/17/22 17:08	44,300.0	AT

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-07
Client ID: HA22-9(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/16/22 07:40
Date Received: 08/16/22
Field Prep: Not Specified

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Solids, Total Dissolved	7200		mg/l	20	--	2	-	08/17/22 09:10	121,2540C	DW
Nitrogen, Nitrite	ND		mg/l	0.050	--	1	-	08/17/22 05:45	44,353.2	KA
Chromium, Hexavalent	ND		mg/l	0.010	--	1	08/17/22 06:05	08/17/22 06:20	1,7196A	KA
Anions by Ion Chromatography - Westborough Lab										
Chloride	4190		mg/l	250	--	500	-	08/17/22 20:57	44,300.0	AT
Nitrogen, Nitrate	0.166		mg/l	0.050	--	1	-	08/17/22 17:19	44,300.0	AT
Sulfate	24.7		mg/l	1.00	--	1	-	08/17/22 17:19	44,300.0	AT

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

SAMPLE RESULTS

Lab ID: L2244025-08
Client ID: HA22-10(OW)
Sample Location: MACHIAS, ME

Date Collected: 08/16/22 07:50
Date Received: 08/16/22
Field Prep: Not Specified

Sample Depth:
Matrix: Water

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Solids, Total Dissolved	1800		mg/l	20	--	2	-	08/17/22 09:10	121,2540C	DW
Nitrogen, Nitrite	0.050		mg/l	0.050	--	1	-	08/17/22 05:47	44,353.2	KA
Chromium, Hexavalent	ND		mg/l	0.010	--	1	08/17/22 06:05	08/17/22 06:20	1,7196A	KA
Anions by Ion Chromatography - Westborough Lab										
Chloride	859.		mg/l	12.5	--	25	-	08/17/22 20:02	44,300.0	AT
Nitrogen, Nitrate	ND		mg/l	0.050	--	1	-	08/17/22 17:30	44,300.0	AT
Sulfate	1.07		mg/l	1.00	--	1	-	08/17/22 17:30	44,300.0	AT

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab for sample(s): 05-08 Batch: WG1676050-1										
Nitrogen, Nitrite	ND		mg/l	0.050	--	1	-	08/17/22 03:21	44,353.2	KA
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG1676086-1										
Total Organic Carbon	ND		mg/l	0.500	--	1	-	08/17/22 05:15	121,5310C	DW
General Chemistry - Westborough Lab for sample(s): 05-08 Batch: WG1676114-1										
Chromium, Hexavalent	ND		mg/l	0.010	--	1	08/17/22 06:05	08/17/22 06:18	1,7196A	KA
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG1676163-1										
Chemical Oxygen Demand	ND		mg/l	20	--	1	08/17/22 09:00	08/17/22 12:05	121,5220D	CN
General Chemistry - Westborough Lab for sample(s): 05-08 Batch: WG1676175-1										
Solids, Total Dissolved	ND		mg/l	10	--	1	-	08/17/22 09:10	121,2540C	DW
Anions by Ion Chromatography - Westborough Lab for sample(s): 05-08 Batch: WG1676555-1										
Chloride	ND		mg/l	0.500	--	1	-	08/17/22 16:35	44,300.0	AT
Nitrogen, Nitrate	ND		mg/l	0.050	--	1	-	08/17/22 16:35	44,300.0	AT
Sulfate	ND		mg/l	1.00	--	1	-	08/17/22 16:35	44,300.0	AT
Anions by Ion Chromatography - Westborough Lab for sample(s): 01-04 Batch: WG1677498-1										
Bromide	ND		mg/l	0.050	--	1	-	08/19/22 16:51	44,300.0	AT
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG1678011-1										
Alkalinity, Total	ND		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG1678013-1										
Alkalinity, Bicarbonate	ND		mg CaCO3/L	2.00	NA	1	-	08/22/22 08:44	121,2320B	MT
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG1678048-1										
Nitrogen, Ammonia	ND		mg/l	0.075	--	1	08/22/22 13:50	08/22/22 20:05	121,4500NH3-BH	AT

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 05-08 Batch: WG1676050-2								
Nitrogen, Nitrite	94		-		90-110	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-04 Batch: WG1676086-2								
Total Organic Carbon	98		-		90-110	-		
General Chemistry - Westborough Lab Associated sample(s): 05-08 Batch: WG1676114-2								
Chromium, Hexavalent	102		-		85-115	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-04 Batch: WG1676163-2								
Chemical Oxygen Demand	100		-		90-110	-		
General Chemistry - Westborough Lab Associated sample(s): 05-08 Batch: WG1676175-2								
Solids, Total Dissolved	100		-		80-120	-		
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 05-08 Batch: WG1676555-2								
Chloride	104		-		90-110	-		
Nitrogen, Nitrate	92		-		90-110	-		
Sulfate	103		-		90-110	-		

Lab Control Sample Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749
Lab Number: L2244025
Report Date: 08/25/22

Parameter	LCS %Recovery	LCSD %Recovery	%Recovery Limits	RPD	RPD Limits
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 01-04 Batch: WG1677498-2					
Bromide	109	-	90-110	-	
General Chemistry - Westborough Lab Associated sample(s): 01-04 Batch: WG1678011-2					
Alkalinity, Total	108	-	90-110	-	10
General Chemistry - Westborough Lab Associated sample(s): 01-04 Batch: WG1678048-2					
Nitrogen, Ammonia	90	-	80-120	-	20

Matrix Spike Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749
Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 05-08 QC Batch ID: WG1676050-4 QC Sample: L2244025-05 Client ID: HA22-2(OW)												
Nitrogen, Nitrite	ND	4	3.9	98		-	-		80-120	-		20
General Chemistry - Westborough Lab Associated sample(s): 05-08 QC Batch ID: WG1676114-4 QC Sample: L2244025-06 Client ID: HA22-8(OW)												
Chromium, Hexavalent	ND	0.1	0.098	98		-	-		85-115	-		20
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 05-08 QC Batch ID: WG1676555-3 QC Sample: L2244025-08 Client ID: HA22-10(OW)												
Chloride	859	100	981	**122**	Q	-	-		90-110	-		18
Nitrogen, Nitrate	ND	0.4	0.292	**75**	Q	-	-		90-110	-		15
Sulfate	1.07	8	8.00	**81**	Q	-	-		90-110	-		20
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG1677498-3 QC Sample: L2244025-04 Client ID: HA22-10(OW)												
Bromide	4.78	10	17.5	**128**	Q	-	-		90-110	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG1678011-4 QC Sample: L2244025-04 Client ID: HA22-10(OW)												
Alkalinity, Total	318	100	367	**49**	Q	-	-		86-116	-		10
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG1678048-4 QC Sample: L2244025-01 Client ID: HA22-2(OW)												
Nitrogen, Ammonia	0.803	4	4.64	96		-	-		80-120	-		20

Lab Duplicate Analysis
Batch Quality Control

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 05-08 QC Batch ID: WG1676050-3 QC Sample: L2244025-05 Client ID: HA22-2(OW)						
Nitrogen, Nitrite	ND	ND	mg/l	NC		20
General Chemistry - Westborough Lab Associated sample(s): 05-08 QC Batch ID: WG1676114-3 QC Sample: L2244025-05 Client ID: HA22-2(OW)						
Chromium, Hexavalent	ND	ND	mg/l	NC		20
General Chemistry - Westborough Lab Associated sample(s): 05-08 QC Batch ID: WG1676175-3 QC Sample: L2244025-05 Client ID: HA22-2(OW)						
Solids, Total Dissolved	1700	1700	mg/l	0		10
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 05-08 QC Batch ID: WG1676555-4 QC Sample: L2244025-08 Client ID: HA22-10(OW)						
Nitrogen, Nitrate	ND	ND	mg/l	NC		15
Sulfate	1.07	ND	mg/l	NC		20
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 05-08 QC Batch ID: WG1676555-4 QC Sample: L2244025-08 Client ID: HA22-10(OW)						
Chloride	859	867	mg/l	1		18
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG1677498-4 QC Sample: L2244025-04 Client ID: HA22-10(OW)						
Bromide	4.78	4.77	mg/l	0		20
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG1678011-3 QC Sample: L2244025-04 Client ID: HA22-10(OW)						
Alkalinity, Total	318	317	mg CaCO3/L	0		10
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG1678013-2 QC Sample: L2244025-04 Client ID: HA22-10(OW)						
Alkalinity, Bicarbonate	318	317	mg CaCO3/L	0		9

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Duplicate Analysis
Batch Quality Control

Lab Number: L2244025
Report Date: 08/25/22

Parameter	Native Sample	Duplicate Sample	Units	RPD	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG1678048-3 QC Sample: L2244025-01 Client ID: HA22-2(OW)					
Nitrogen, Ammonia	0.803	0.846	mg/l	5	20

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Cooler Information

Cooler	*Custody Seal*
A	Absent
B	Absent
C	Absent
D	Absent
E	Absent

Container Information

Container ID	*Container Type*	*Cooler*	*Initial pH*	*Final pH*	*Temp deg C*	*Pres*	*Seal*	*Frozen Date/Time*	*Analysis(*)*
L2244025-01A	Plastic 250ml unpreserved	C	NA		2.9	Y	Absent		ME-8260(7),BR-300(28)
L2244025-01B	Vial HCl preserved	C	NA		2.9	Y	Absent		ME-8260(7)
L2244025-01C	Vial HCl preserved	C	NA		2.9	Y	Absent		ME-8260(7)
L2244025-01D	Vial H2SO4 preserved	C	NA		2.9	Y	Absent		TOC-5310(28)
L2244025-01E	Vial H2SO4 preserved	C	NA		2.9	Y	Absent		TOC-5310(28)
L2244025-01F	20ml Vial HCl preserved	C	NA		2.9	Y	Absent		DISSGAS(14)
L2244025-01G	20ml Vial HCl preserved	A	NA		2.8	Y	Absent		DISSGAS(14)
L2244025-01H	Plastic 250ml unpreserved	A	NA		2.8	Y	Absent		A2-ME-537ISOTOPE-28+(14)
L2244025-01I	Plastic 250ml unpreserved	C	NA		2.9	Y	Absent		A2-ME-537ISOTOPE-28+(14)
L2244025-01J	Plastic 250ml unpreserved/No Headspace	C	NA		2.9	Y	Absent		ALK-T-2320(14),ALK-HCO3-2320(14)
L2244025-01K	Plastic 250ml HNO3 preserved	C	<2	<2	2.9	Y	Absent		PB-SI(180),FE-SI(180),BA-SI(180),AS-SI(180),CU-SI(180),NA-SI(180),MN-SI(180),CD-SI(180),HARDS(180),K-SI(180),MG-SI(180),CR-SI(180),CA-SI(180),HG-S(28)
L2244025-01L	Amber 120ml unpreserved	C	7	7	2.9	Y	Absent		PEST-8081(7)
L2244025-01M	Amber 120ml unpreserved	C	7	7	2.9	Y	Absent		PEST-8081(7)
L2244025-01N	Amber 250ml unpreserved	C	7	7	2.9	Y	Absent		8270TCL-LVI(7),8270TCL-SIM-LVI(7)
L2244025-01O	Amber 250ml unpreserved	C	7	7	2.9	Y	Absent		8270TCL-LVI(7),8270TCL-SIM-LVI(7)
L2244025-01P	Plastic 500ml H2SO4 preserved	C	<2	<2	2.9	Y	Absent		COD-5220(28),NH3-4500(28)
L2244025-01Q	Amber 1000ml unpreserved	C	7	7	2.9	Y	Absent		HERB-8151(7)

*Values in parentheses indicate holding time in days

Container Information

Container ID	Container Type	Cooler	Initial pH	Final pH	Temp deg C	Pres	Seal	Frozen Date/Time	Analysis(*)
L2244025-01R	Amber 1000ml unpreserved	C	7	7	2.9	Y	Absent		HERB-8151(7)
L2244025-02A	Plastic 250ml unpreserved	B	NA		2.8	Y	Absent		ME-8260(7),BR-300(28)
L2244025-02B	Vial HCl preserved	B	NA		2.8	Y	Absent		ME-8260(7)
L2244025-02C	Vial HCl preserved	B	NA		2.8	Y	Absent		ME-8260(7)
L2244025-02D	Vial H2SO4 preserved	B	NA		2.8	Y	Absent		TOC-5310(28)
L2244025-02E	Vial H2SO4 preserved	B	NA		2.8	Y	Absent		TOC-5310(28)
L2244025-02F	20ml Vial HCl preserved	B	NA		2.8	Y	Absent		DISSGAS(14)
L2244025-02G	20ml Vial HCl preserved	A	NA		2.8	Y	Absent		DISSGAS(14)
L2244025-02H	Plastic 250ml unpreserved	A	NA		2.8	Y	Absent		A2-ME-537ISOTOPE-28+(14)
L2244025-02I	Plastic 250ml unpreserved	B	NA		2.8	Y	Absent		A2-ME-537ISOTOPE-28+(14)
L2244025-02J	Plastic 250ml unpreserved/No Headspace	B	NA		2.8	Y	Absent		ALK-T-2320(14),ALK-HCO3-2320(14)
L2244025-02K	Plastic 250ml HNO3 preserved	B	<2	<2	2.8	Y	Absent		PB-SI(180),FE-SI(180),BA-SI(180),NA-SI(180),AS-SI(180),CU-SI(180),MN-SI(180),CD-SI(180),HARDS(180),K-SI(180),MG-SI(180),CR-SI(180),CA-SI(180),HG-S(28)
L2244025-02L	Amber 120ml unpreserved	B	7	7	2.8	Y	Absent		PEST-8081(7)
L2244025-02M	Amber 120ml unpreserved	B	7	7	2.8	Y	Absent		PEST-8081(7)
L2244025-02N	Amber 250ml unpreserved	B	7	7	2.8	Y	Absent		8270TCL-LVI(7),8270TCL-SIM-LVI(7)
L2244025-02O	Amber 250ml unpreserved	B	7	7	2.8	Y	Absent		8270TCL-LVI(7),8270TCL-SIM-LVI(7)
L2244025-02P	Plastic 500ml H2SO4 preserved	B	<2	<2	2.8	Y	Absent		COD-5220(28),NH3-4500(28)
L2244025-02Q	Amber 1000ml unpreserved	B	7	7	2.8	Y	Absent		HERB-8151(7)
L2244025-02R	Amber 1000ml unpreserved	B	7	7	2.8	Y	Absent		HERB-8151(7)
L2244025-03A	Plastic 250ml unpreserved	E	NA		2.8	Y	Absent		ME-8260(7),BR-300(28)
L2244025-03B	Vial HCl preserved	E	NA		2.8	Y	Absent		ME-8260(7)
L2244025-03C	Vial HCl preserved	E	NA		2.8	Y	Absent		ME-8260(7)
L2244025-03D	Vial H2SO4 preserved	E	NA		2.8	Y	Absent		TOC-5310(28)
L2244025-03E	Vial H2SO4 preserved	E	NA		2.8	Y	Absent		TOC-5310(28)
L2244025-03F	20ml Vial HCl preserved	E	NA		2.8	Y	Absent		DISSGAS(14)
L2244025-03G	20ml Vial HCl preserved	A	NA		2.8	Y	Absent		DISSGAS(14)

*Values in parentheses indicate holding time in days

Project Name: MOOT MACHIAS LF
Project Number: 130749

Lab Number: L2244025
Report Date: 08/25/22

Container Information

Container ID	Container Type	Cooler	Initial pH	Final pH	Temp deg C	Pres	Seal	Frozen Date/Time	Analysis(*)
L2244025-03H	Plastic 250ml unpreserved	A	NA		2.8	Y	Absent		A2-ME-537ISOTOPE-28+(14)
L2244025-03I	Plastic 250ml unpreserved	E	NA		2.8	Y	Absent		A2-ME-537ISOTOPE-28+(14)
L2244025-03J	Plastic 250ml unpreserved/No Headspace	E	NA		2.8	Y	Absent		ALK-T-2320(14),ALK-HCO3-2320(14)
L2244025-03K	Plastic 250ml HNO3 preserved	E	<2	<2	2.8	Y	Absent		PB-SI(180),FE-SI(180),BA-SI(180),NA-SI(180),AS-SI(180),MN-SI(180),CU-SI(180),CD-SI(180),HARDS(180),CR-SI(180),MG-SI(180),K-SI(180),HG-S(28),CA-SI(180)
L2244025-03L	Amber 120ml unpreserved	E	7	7	2.8	Y	Absent		PEST-8081(7)
L2244025-03M	Amber 120ml unpreserved	E	7	7	2.8	Y	Absent		PEST-8081(7)
L2244025-03N	Amber 250ml unpreserved	E	7	7	2.8	Y	Absent		8270TCL-LVI(7),8270TCL-SIM-LVI(7)
L2244025-03O	Amber 250ml unpreserved	E	7	7	2.8	Y	Absent		8270TCL-LVI(7),8270TCL-SIM-LVI(7)
L2244025-03P	Plastic 500ml H2SO4 preserved	E	<2	<2	2.8	Y	Absent		COD-5220(28),NH3-4500(28)
L2244025-03Q	Amber 1000ml unpreserved	E	7	7	2.8	Y	Absent		HERB-8151(7)
L2244025-03R	Amber 1000ml unpreserved	E	7	7	2.8	Y	Absent		HERB-8151(7)
L2244025-04A	Plastic 250ml unpreserved	D	NA		2.4	Y	Absent		ME-8260(7),BR-300(28)
L2244025-04B	Vial HCl preserved	D	NA		2.4	Y	Absent		ME-8260(7)
L2244025-04C	Vial HCl preserved	D	NA		2.4	Y	Absent		ME-8260(7)
L2244025-04D	Vial H2SO4 preserved	D	NA		2.4	Y	Absent		TOC-5310(28)
L2244025-04E	Vial H2SO4 preserved	D	NA		2.4	Y	Absent		TOC-5310(28)
L2244025-04F	20ml Vial HCl preserved	D	NA		2.4	Y	Absent		DISSGAS(14)
L2244025-04G	20ml Vial HCl preserved	A	NA		2.8	Y	Absent		DISSGAS(14)
L2244025-04H	Plastic 250ml unpreserved	A	NA		2.8	Y	Absent		A2-ME-537ISOTOPE-28+(14)
L2244025-04I	Plastic 250ml unpreserved	D	NA		2.4	Y	Absent		A2-ME-537ISOTOPE-28+(14)
L2244025-04J	Plastic 250ml unpreserved/No Headspace	D	NA		2.4	Y	Absent		ALK-T-2320(14),ALK-HCO3-2320(14)
L2244025-04K	Plastic 250ml HNO3 preserved	D	<2	<2	2.4	Y	Absent		PB-SI(180),FE-SI(180),BA-SI(180),MN-SI(180),CU-SI(180),NA-SI(180),AS-SI(180),CD-SI(180),HARDS(180),CR-SI(180),MG-SI(180),K-SI(180),CA-SI(180),HG-S(28)
L2244025-04L	Amber 120ml unpreserved	D	7	7	2.4	Y	Absent		PEST-8081(7)
L2244025-04M	Amber 120ml unpreserved	D	7	7	2.4	Y	Absent		PEST-8081(7)
L2244025-04N	Amber 250ml unpreserved	D	7	7	2.4	Y	Absent		8270TCL-LVI(7),8270TCL-SIM-LVI(7)

*Values in parentheses indicate holding time in days

Project Name: MOOT MACHIAS LF

Project Number: 130749

Lab Number: L2244025

Report Date: 08/25/22

Container Information

Container ID	Container Type	Cooler	Initial pH	Final pH	Temp deg C	Pres	Seal	Frozen Date/Time	Analysis(*)
L2244025-04O	Amber 250ml unpreserved	D	7	7	2.4	Y	Absent		8270TCL-LVI(7),8270TCL-SIM-LVI(7)
L2244025-04P	Plastic 500ml H2SO4 preserved	D	<2	<2	2.4	Y	Absent		COD-5220(28),NH3-4500(28)
L2244025-04Q	Amber 1000ml unpreserved	D	7	7	2.4	Y	Absent		HERB-8151(7)
L2244025-04R	Amber 1000ml unpreserved	D	7	7	2.4	Y	Absent		HERB-8151(7)
L2244025-05A	Plastic 950ml unpreserved	C	7	7	2.9	Y	Absent		SO4-300(28),HEXCR-7196(1),CL-300(28),NO2-353(2),NO3-300(2),TDS-2540(7)
L2244025-06A	Plastic 950ml unpreserved	B	7	7	2.8	Y	Absent		SO4-300(28),CL-300(28),HEXCR-7196(1),NO2-353(2),NO3-300(2),TDS-2540(7)
L2244025-07A	Plastic 950ml unpreserved	E	7	7	2.8	Y	Absent		SO4-300(28),HEXCR-7196(1),CL-300(28),NO3-300(2),NO2-353(2),TDS-2540(7)
L2244025-08A	Plastic 950ml unpreserved	D	7	7	2.4	Y	Absent		SO4-300(28),HEXCR-7196(1),CL-300(28),NO2-353(2),NO3-300(2),TDS-2540(7)
L2244025-09A	Plastic 250ml unpreserved	A	NA		2.8	Y	Absent		HOLD-537(14)

*Values in parentheses indicate holding time in days

PFAS PARAMETER SUMMARY

Parameter	Acronym	CAS Number
PERFLUOROALKYL CARBOXYLIC ACIDS (PFCAs)		
Perfluorooctadecanoic Acid	PFODA	16517-11-6
Perfluorohexadecanoic Acid	PFHxDA	67905-19-5
Perfluorotetradecanoic Acid	PFTA	376-06-7
Perfluorotridecanoic Acid	PFTrDA	72629-94-8
Perfluorododecanoic Acid	PFDoA	307-55-1
Perfluoroundecanoic Acid	PFUnA	2058-94-8
Perfluorodecanoic Acid	PFDA	335-76-2
Perfluorononanoic Acid	PFNA	375-95-1
Perfluorooctanoic Acid	PFOA	335-67-1
Perfluoroheptanoic Acid	PFHpA	375-85-9
Perfluorohexanoic Acid	PFHxA	307-24-4
Perfluoropentanoic Acid	PFPeA	2706-90-3
Perfluorobutanoic Acid	PFBA	375-22-4
PERFLUOROALKYL SULFONIC ACIDS (PFSAs)		
Perfluorododecanesulfonic Acid	PFDoDS	79780-39-5
Perfluorodecanesulfonic Acid	PFDS	335-77-3
Perfluorononanesulfonic Acid	PFNS	68259-12-1
Perfluorooctanesulfonic Acid	PFOS	1763-23-1
Perfluoroheptanesulfonic Acid	PFHpS	375-92-8
Perfluorohexanesulfonic Acid	PFHxS	355-46-4
Perfluoropentanesulfonic Acid	PFPeS	2706-91-4
Perfluorobutanesulfonic Acid	PFBS	375-73-5
FLUOROTELOMERS		
1H,1H,2H,2H-Perfluorododecanesulfonic Acid	10:2FTS	120226-60-0
1H,1H,2H,2H-Perfluorodecanesulfonic Acid	8:2FTS	39108-34-4
1H,1H,2H,2H-Perfluorooctanesulfonic Acid	6:2FTS	27619-97-2
1H,1H,2H,2H-Perfluorohexanesulfonic Acid	4:2FTS	757124-72-4
PERFLUOROALKANE SULFONAMIDES (FASAs)		
Perfluorooctanesulfonamide	FOSA	754-91-6
N-Ethyl Perfluorooctane Sulfonamide	NEtFOSA	4151-50-2
N-Methyl Perfluorooctane Sulfonamide	NMeFOSA	31506-32-8
PERFLUOROALKANE SULFONYL SUBSTANCES		
N-Ethyl Perfluorooctanesulfonamido Ethanol	NEtFOSE	1691-99-2
N-Methyl Perfluorooctanesulfonamido Ethanol	NMeFOSE	24448-09-7
N-Ethyl Perfluorooctanesulfonamidoacetic Acid	NEtFOSAA	2991-50-6
N-Methyl Perfluorooctanesulfonamidoacetic Acid	NMeFOSAA	2355-31-9
PER- and POLYFLUOROALKYL ETHER CARBOXYLIC ACIDS		
2,3,3,3-Tetrafluoro-2-[1,1,2,2,3,3,3-Heptafluoropropoxy]-Propanoic Acid	HFPO-DA	13252-13-6
4,8-Dioxa-3h-Perfluorononanoic Acid	ADONA	919005-14-4
CHLORO-PERFLUOROALKYL SULFONIC ACIDS		
11-Chloroeicosafluoro-3-Oxaundecane-1-Sulfonic Acid	11Cl-PF3OUdS	763051-92-9
9-Chlorohexadecafluoro-3-Oxanone-1-Sulfonic Acid	9Cl-PF3ONS	756426-58-1
PERFLUOROETHER SULFONIC ACIDS (PFESAs)		
Perfluoro(2-Ethoxyethane)Sulfonic Acid	PFEESA	113507-82-7
PERFLUOROETHER/POLYETHER CARBOXYLIC ACIDS (PFPCAs)		
Perfluoro-3-Methoxypropanoic Acid	PFMPA	377-73-1
Perfluoro-4-Methoxybutanoic Acid	PFMBA	863090-89-5
Nonafluoro-3,6-Dioxaheptanoic Acid	NFDHA	151772-58-6

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

GLOSSARY

Acronyms

DL	- Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the limit of quantitation (LOQ). The DL includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)
EDL	- Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).
EMPC	- Estimated Maximum Possible Concentration: The concentration that results from the signal present at the retention time of an analyte when the ions meet all of the identification criteria except the ion abundance ratio criteria. An EMPC is a worst-case estimate of the concentration.
EPA	- Environmental Protection Agency.
LCS	- Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
LCSD	- Laboratory Control Sample Duplicate: Refer to LCS.
LFB	- Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
LOD	- Limit of Detection: This value represents the level to which a target analyte can reliably be detected for a specific analyte in a specific matrix by a specific method. The LOD includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)
LOQ	- Limit of Quantitation: The value at which an instrument can accurately measure an analyte at a specific concentration. The LOQ includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.) Limit of Quantitation: The value at which an instrument can accurately measure an analyte at a specific concentration. The LOQ includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)
MDL	- Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
MS	- Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. For Method 332.0, the spike recovery is calculated using the native concentration, including estimated values.
MSD	- Matrix Spike Sample Duplicate: Refer to MS.
NA	- Not Applicable.
NC	- Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.
NDPA/DPA	- N-Nitrosodiphenylamine/Diphenylamine.
NI	- Not Ignitable.
NP	- Non-Plastic: Term is utilized for the analysis of Atterberg Limits in soil.
NR	- No Results: Term is utilized when 'No Target Compounds Requested' is reported for the analysis of Volatile or Semivolatile Organic TIC only requests.
RL	- Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
RPD	- Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.
SRM	- Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.
STLP	- Semi-dynamic Tank Leaching Procedure per EPA Method 1315.
TEF	- Toxic Equivalency Factors: The values assigned to each dioxin and furan to evaluate their toxicity relative to 2,3,7,8-TCDD.
TEQ	- Toxic Equivalent: The measure of a sample's toxicity derived by multiplying each dioxin and furan by its corresponding TEF and then summing the resulting values.
TIC	- Tentatively Identified Compound: A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations.

Report Format: Data Usability Report

Project Name: MOOT MACHIAS LF **Lab Number:** L2244025
Project Number: 130749 **Report Date:** 08/25/22

Footnotes

1 - The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Chlordane: The target compound Chlordane (CAS No. 57-74-9) is reported for GC ECD analyses. Per EPA,this compound "refers to a mixture of chlordane isomers, other chlorinated hydrocarbons and numerous other components." (Reference: USEPA Toxicological Review of Chlordane, In Support of Summary Information on the Integrated Risk Information System (IRIS), December 1997.)

Difference: With respect to Total Oxidizable Precursor (TOP) Assay analysis, the difference is defined as the Post-Treatment value minus the Pre-Treatment value.

Final pH: As it pertains to Sample Receipt & Container Information section of the report, Final pH reflects pH of container determined after adjustment at the laboratory, if applicable. If no adjustment required, value reflects Initial pH.

Frozen Date/Time: With respect to Volatile Organics in soil, Frozen Date/Time reflects the date/time at which associated Reagent Water-preserved vials were initially frozen. Note: If frozen date/time is beyond 48 hours from sample collection, value will be reflected in 'bold'.

Gasoline Range Organics (GRO): Gasoline Range Organics (GRO) results include all chromatographic peaks eluting from Methyl tert butyl ether through Naphthalene, with the exception of GRO analysis in support of State of Ohio programs, which includes all chromatographic peaks eluting from Hexane through Dodecane.

Initial pH: As it pertains to Sample Receipt & Container Information section of the report, Initial pH reflects pH of container determined upon receipt, if applicable.

PAH Total: With respect to Alkylated PAH analyses, the 'PAHs, Total' result is defined as the summation of results for all or a subset of the following compounds: Naphthalene, C1-C4 Naphthalenes, 2-Methylnaphthalene, 1-Methylnaphthalene, Biphenyl, Acenaphthylene, Acenaphthene, Fluorene, C1-C3 Fluorenes, Phenanthrene, C1-C4 Phenanthrenes/Anthracenes, Anthracene, Fluoranthene, Pyrene, C1-C4 Fluoranthenes/Pyrenes, Benz(a)anthracene, Chrysene, C1-C4 Chrysenes, Benzo(b)fluoranthene, Benzo(j)+(k)fluoranthene, Benzo(e)pyrene, Benzo(a)pyrene, Perylene, Indeno(1,2,3-cd)pyrene, Dibenz(ah)+(ac)anthracene, Benzo(g,h,i)perylene. If a 'Total' result is requested, the results of its individual components will also be reported.

PFAS Total: With respect to PFAS analyses, the 'PFAS, Total (5)' result is defined as the summation of results for: PFHpA, PFHxS, PFOA, PFNA and PFOS. In addition, the 'PFAS, Total (6)' result is defined as the summation of results for: PFHpA, PFHxS, PFOA, PFNA, PFDA and PFOS. For MassDEP DW compliance analysis only, the 'PFAS, Total (6)' result is defined as the summation of results at or above the RL. Note: If a 'Total' result is requested, the results of its individual components will also be reported.

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Data Qualifiers

A - Spectra identified as "Aldol Condensates" are byproducts of the extraction/concentration procedures when acetone is introduced in the process.

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone).

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

D - Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.

E - Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.

F - The ratio of quantifier ion response to qualifier ion response falls outside of the laboratory criteria. Results are considered to be an estimated maximum concentration.

G - The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.

H - The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.

I - The lower value for the two columns has been reported due to obvious interference.

J - Estimated value. This represents an estimated concentration for Tentatively Identified Compounds (TICs).

M - Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.

Report Format: Data Usability Report

Project Name:	MOOT MACHIAS LF	**Lab Number:**	L2244025
Project Number:	130749	**Report Date:**	08/25/22

Data Qualifiers

ND - Not detected at the reporting limit (RL) for the sample.

NJ - Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.

P - The RPD between the results for the two columns exceeds the method-specified criteria.

Q - The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)

R - Analytical results are from sample re-analysis.

RE - Analytical results are from sample re-extraction.

S - Analytical results are from modified screening analysis.

V - The surrogate associated with this target analyte has a recovery outside the QC acceptance limits. (Applicable to MassDEP DW Compliance samples only.)

Z - The batch matrix spike and/or duplicate associated with this target analyte has a recovery/RPD outside the QC acceptance limits. (Applicable to MassDEP DW Compliance samples only.)

REFERENCES

1 Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. EPA SW-846. Third Edition. Updates I - VI, 2018.

44 Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, August 1993.

117 Technical Guidance for the Natural Attenuation Indicators: Methane, Ethane, and Ethene, EPA-NE, Revision 1, February 21, 2002 and Sample Preparation & Calculations for Dissolved Gas Analysis in Water Samples using a GC Headspace Equilibration Technique, EPA RSKSOP-175, Revision 2, May 2004.

121 Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WEF. Standard Methods Online.

134 Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS) using Isotope Dilution. Alpha SOP 23528.

LIMITATION OF LIABILITIES

Alpha Analytical performs services with reasonable care and diligence normal to the analytical testing laboratory industry. In the event of an error, the sole and exclusive responsibility of Alpha Analytical shall be to re-perform the work at it's own expense. In no event shall Alpha Analytical be held liable for any incidental, consequential or special damages, including but not limited to, damages in any way connected with the use of, interpretation of, information or analysis provided by Alpha Analytical.

We strongly urge our clients to comply with EPA protocol regarding sample volume, preservation, cooling, containers, sampling procedures, holding time and splitting of samples in the field.

Certification Information

The following analytes are not included in our Primary NELAP Scope of Accreditation:

Westborough Facility
EPA 624/624.1: m/p-xylene, o-xylene, Naphthalene
EPA 625/625.1: alpha-Terpineol
EPA 8260C/8260D: NPW: 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene, Azobenzene; SCM: Iodomethane (methyl iodide), 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene.
EPA 8270D/8270E: NPW: Dimethylnaphthalene,1,4-Diphenylhydrazine, alpha-Terpineol; SCM: Dimethylnaphthalene,1,4-Diphenylhydrazine.
SM4500: NPW: Amenable Cyanide; SCM: Total Phosphorus, TKN, NO2, NO3.

Mansfield Facility
SM 2540D: TSS
EPA 8082A: NPW: PCB: 1, 5, 31, 87,101, 110, 141, 151, 153, 180, 183, 187.
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.
Biological Tissue Matrix: EPA 3050B

The following analytes are included in our Massachusetts DEP Scope of Accreditation

Westborough Facility:

Drinking Water
EPA 300.0: Chloride, Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B, SM4500NO2-B**
EPA 332: Perchlorate; **EPA 524.2:** THMs and VOCs; **EPA 504.1:** EDB, DBCP.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT,SM9222D**.

Non-Potable Water
SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2320B, SM4500CL-E, SM4500F-BC, SM4500NH3-BH: Ammonia-N and Kjeldahl-N, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **EPA 351.1, SM4500NO3-F, EPA 353.2**: Nitrate-N**, SM4500P-E, SM4500P-B, E, SM4500SO4-E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, EPA 420.1, SM4500-CN-CE, SM2540D, EPA 300: Chloride, Sulfate, Nitrate.**
EPA 624.1: Volatile Halocarbons & Aromatics,
EPA 608.3: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625.1: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9221E, EPA 1600, EPA 1603, SM9222D.**

Mansfield Facility:

Drinking Water
EPA 200.7: Al, Ba, Cd, Cr, Cu, Fe, Mn, Ni, Na, Ag, Ca, Zn. **EPA 200.8:** Al, Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Mn, Ni, Se, Ag, TL, Zn. **EPA 245.1** Hg.
EPA 522, EPA 537.1.

Non-Potable Water
EPA 200.7: Al, Sb, As, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Sr, TL, Ti, V, Zn.
EPA 200.8: Al, Sb, As, Be, Cd, Cr, Cu, Fe, Pb, Mn, Ni, K, Se, Ag, Na, TL, Zn.
EPA 245.1 Hg.
SM2340B

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

ALPHA ANALYTICAL

8 Walkup Drive
Westboro, MA 01581
Tel: 508-898-9220

320 Forbes Blvd
Mansfield, MA 02048
Tel: 508-822-9300

CHAIN OF COUSTODY

PAGE 1 OF 1

Date Rec'd in Lab: 8/16/22

ALPHA Job #: L2244025

Project Information

Project Name: MDOT Machias LF

Project Location: Machias, ME

Project #: 130749

Project Manager: D. Dearden

ALPHA Quote #:

Report Information - Data Deliverables

☐ ADEx ☒ EMAIL

Billing Information

☐ Same as Client info PO #:

Client Information

Client: Haley + Aldrich

Address: 75 Washington Ave, St#1 Portland, ME

Phone: 207-482-4606

Email: adearden@haleyaldrich.com

Regulatory Requirements & Project Information Requirements

☐ Yes ☐ No MA MCP Analytical Methods ☐ Yes ☐ No CT RCP Analytical Methods

☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)

☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)

☐ Yes ☐ No NPDES RGP

☐ Other State /Fed Program Maine DEP Landfill Criteria Parameters

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved)

Date Due:

Additional Project Information:

Dissolved metals are field filtered.
HexCr, etc was not filtered.
Dissolved metals parameters - contact Melissa Gulli

SAMPLE INFO

Filtration
☒ Field
☒ Lab to do

Preservation
☐ Lab to do

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	VOC: ☒ 8260 ☐ 624 ☐ 524.2	SVOC: ~~☐ ABN~~ ~~☐ PAH~~ 8270 TCL-SIM-LVI 8270	METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15	METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13 Dissolved	EPH: ☐ Ranges & Targets ☐ Ranges Only	VPH: ☐ Ranges & Targets ☐ Ranges Only	☐ PCB ☒ PEST, Herb 8151	TPH: ☐ Quant Only ☐ Fingerprint	NH3, COD	TOC	Dissolved gas	Alk, 2320, HCO3	PFOAS by 537	HexCr, TDS, SO4, Cl, NO3, NO2	Sample Comments	TOTAL # BOTTLES
44025 01	HA22-2(OW)	8/15/22	1440	GW	HMH	X	X		X			X		X	X	X	X	X			18
02	HA22-8(OW)	8/15/22	1200	GW	HMH	X	X		X			X		X	X	X	X	X		Some HNO3 spilled out	18
03	HA22-9(OW)	8/15/22	1330	GW	HMH	X	X		X			X		X	X	X	X	X			18
04	HA22-10(OW)	8/15/22	1600	GW	HMH	X	X		X			X		X	X	X	X	X			18
05	HA22-2(OW)	8/16/22	0800	GW	HMH														X		1
06	HA22-8(OW)	8/16/22	0720	GW	HMH														X		1
07	HA22-9(OW)	8/16/22	0740	GW	HMH														X		1
08	HA22-10(OW)	8/16/22	0750	GW	HMH														X		1
Container Type						V	A		P			A		P	V	V	P	P	P		
Preservative						B	A		C			A		D	D	B	A	A	A		

Container Type	Preservative
P= Plastic	A= None
A= Amber glass	B= HCl
V= Vial	C= HNO_3
G= Glass	D= H_2SO_4
B= Bacteria cup	E= NaOH
C= Cube	F= MeOH
O= Other	G= $NaHSO_4$
E= Encore	H = $Na_2S_2O_3$
D= BOD Bottle	I= Ascorbic Acid
	J = NH_4Cl
	K= Zn Acetate
	O= Other

Relinquished By:	Date/Time	Received By:	Date/Time
Melissa Holland	8/16/22 1030	[illegible]	8/16/22 1030
[illegible]		D. Dearden AAL	8/16/22 16:21
D. Dearden AAL	8/16/22 21:00	[illegible]	8/16/22 21:00

FORM NO: 01-01 (rev. 12-Mar-2012)

APPENDIX F
Geotechnical Design Calculations

HALEY ALDRICH	CALCULATIONS	File No.:	130749-009
		Sheet:	1 of 1
Client:	Maine Department of Transportation	Date:	18-Oct-2022
Project:	Machias Landfill, Dike Bridge Culvert Replacement	Computed by:	EMS
Subject:	Global Stability	Checked by:	EAF

PROBLEM STATEMENT AND OBJECTIVE

Calculate the global stability minimum factor of safety at the existing landfill.

REFERENCES

1. Slide2 version 9 by RocScience.

AVAILABLE INFORMATION

1. Topographic plan and cross sections AA' and BB' provided by MaineDOT.
2. Boring logs HA22-1, HA22-1B, HA22-2, and HA22-5 through HA22-10, and their associated observation wells.

ASSUMPTIONS

1. Water levels were modeled based on conditions observed in observation wells (OW-1 at AA' and BB' crest, OW-2 at AA' toe, and OW-9 at BB' toe).
2. High tide plus storm plus sea level rise water level (El. 14.7) was considered and had no effect on factors of safety.
3. Seismic cases will have a seismic force of As/2 (0.119 g/2) = 0.06 g based on the seismic site class calculations.
4. Soil properties were determined based on soil types and SPT N-values observed in the field.
5. The landfill waste and cover strata encountered both granular and cohesive soils. Cohesive properties were determined to be more conservative, therefore the landfill waste and cover is assumed to be cohesive in our final models.
6. Sections AA' and BB' were modeled to represent the "worst case scenario" steepest areas of the landfill slopes.

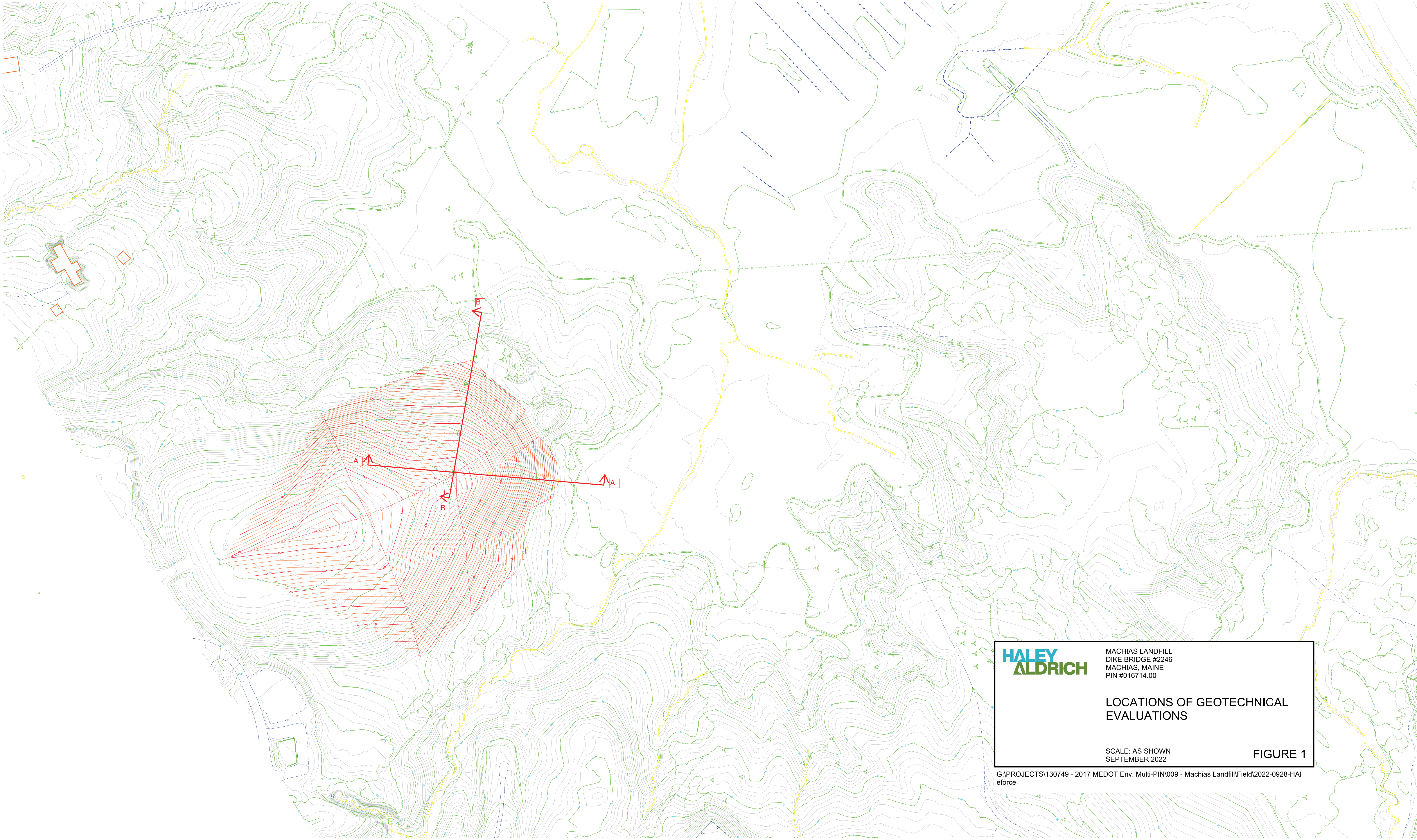
SOIL PROPERTIES

Material	Unit Weight (pcf)	Friction Angle (degrees)	Undrained Shear Strength (psf)
Clay Cap	120	-	775
Landfill Waste and Cover	120	28	550
Marine Deposit (reworked)	120	-	3000
Marine Deposit (natural)	120	-	1500
Fluvial	120	35	-
Glacial Till	130	38	-
Bedrock	130	infinite strength	

RESULTS AND CONCLUSIONS

Section	Landfill Waste and Cover Properties	F.S.	
		Static	Seismic
SE Landfill Section A-A (Current Groundwater Level; El. 12.1)	cohesive	1.53	1.24
SE Landfill Section A-A (Current Groundwater Level; El. 12.1)	cohesionless	2.04	1.66
SE Landfill Section A-A (Future High Tide/Storm/SLR; El. 14.7)	cohesive	1.53	1.24
NE Landfill Section B-B (Current Groundwater Level; El. 11.0)	cohesive	1.86	1.36
NE Landfill Section B-B (Future High Tide/Storm/SLR; El. 14.7)	cohesive	1.86	1.36

Based on AASHTO LRFD Section 11.6.3.7, an acceptable resistance factor for where the geotechnical parameters and subsurface stratigraphy are well defined is 0.75 (F.S. = 1/0.75 = 1.3).
Based on FHWA GEC No. 3, a minimum seismic factor of safety of 1.1 is acceptable for slope stability.



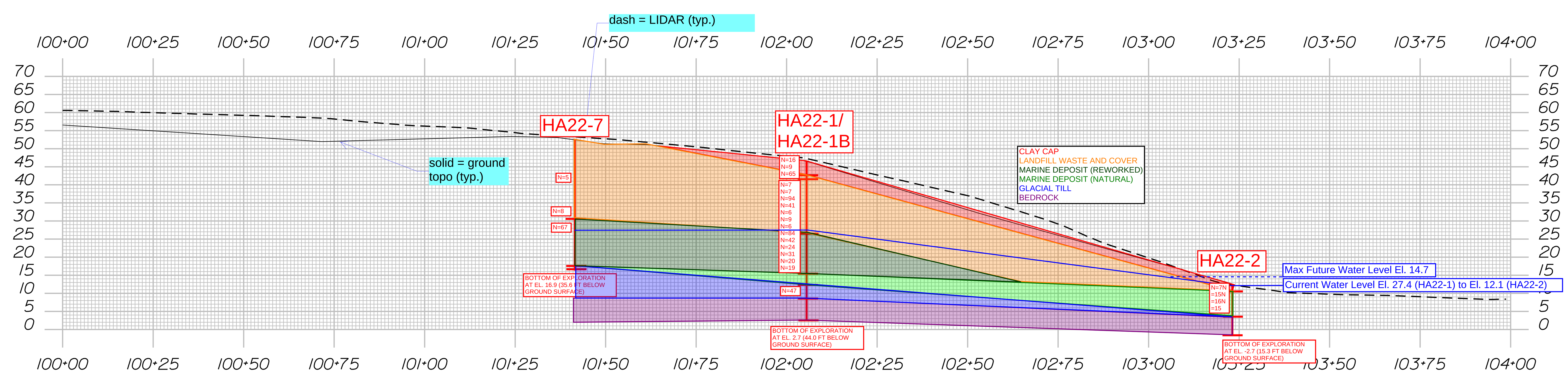
MACHIAS LANDFILL
DIKE BRIDGE #2246
MACHIAS, MAINE
PIN #016714.00

LOCATIONS OF GEOTECHNICAL EVALUATIONS

SCALE: AS SHOWN
SEPTEMBER 2022

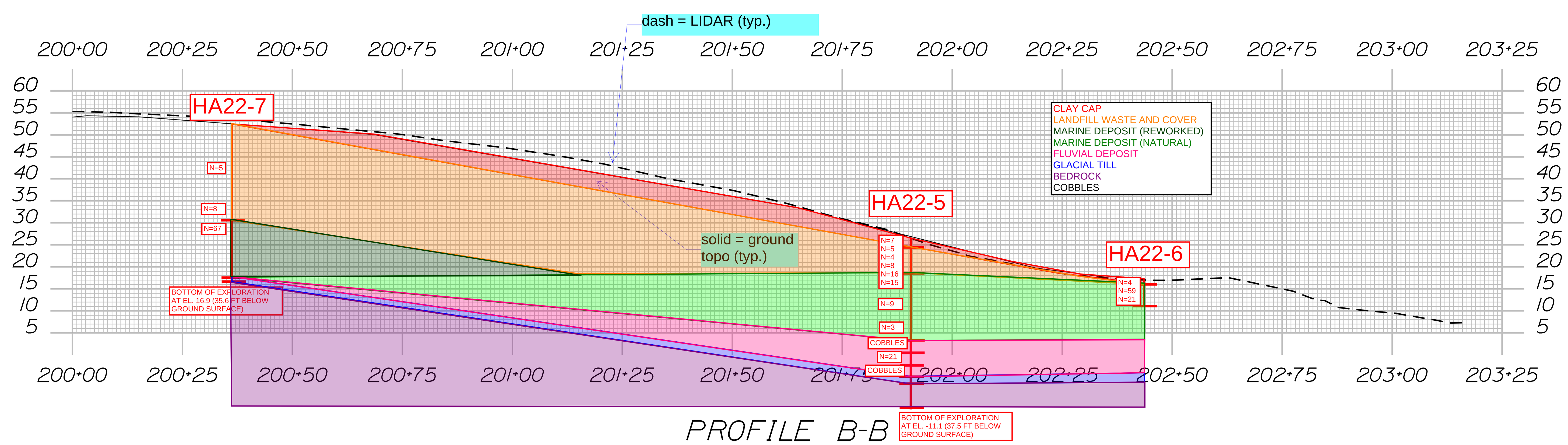
FIGURE 1

G:\PROJECTS\130749 - 2017 MEDOT Env. Multi-PIN\009 - Machias Landfill\Field\2022-0928-HAI-eforce

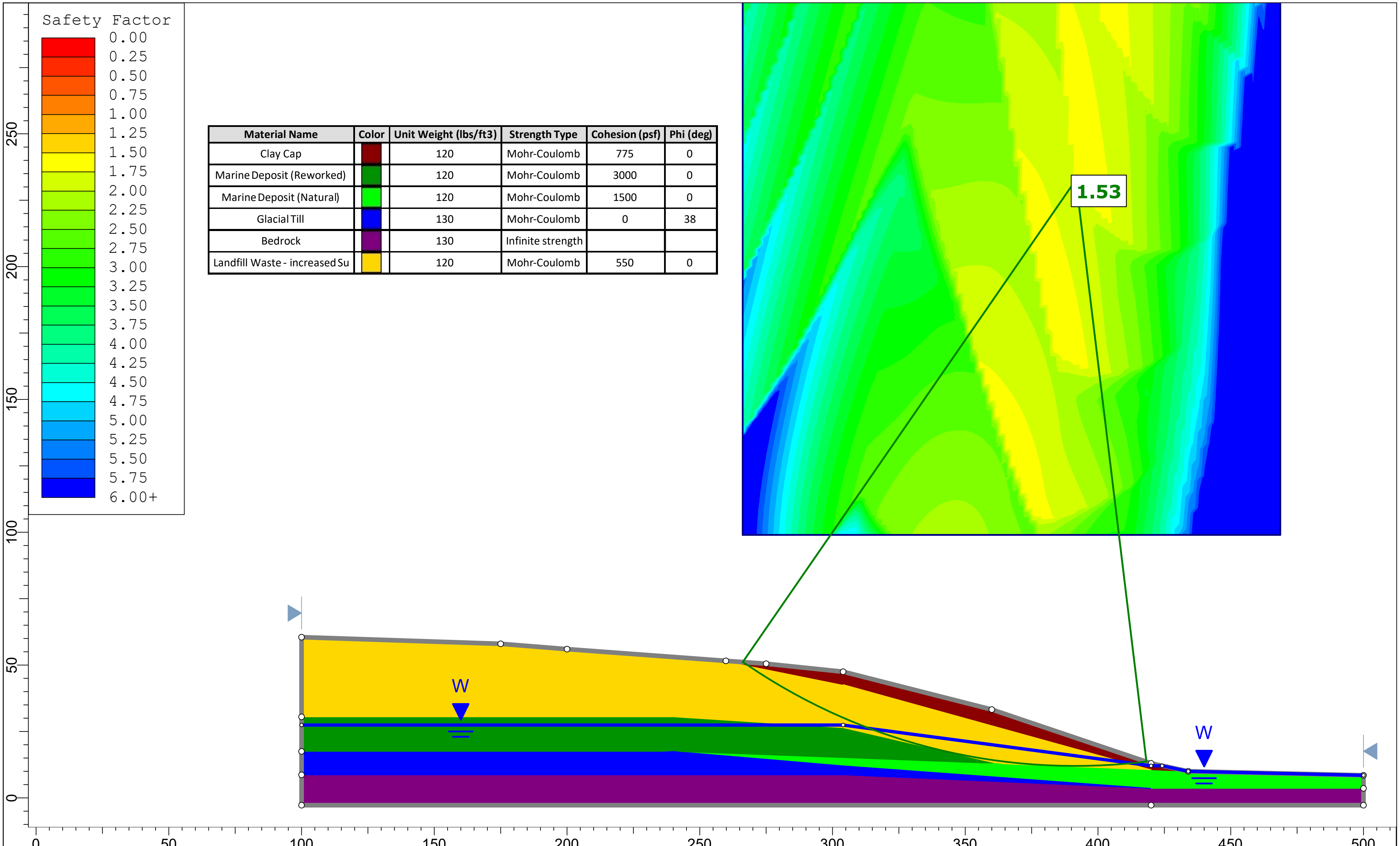


dash = LIDAR (typ.)
solid = ground topo (typ.)
HA22-7
HA22-1/ HA22-1B
HA22-2
N=5
N=8
N=67
BOTTOM OF EXPLORATION AT EL. 16.9 (35.6 FT BELOW GROUND SURFACE)
N=16 N=9 N=65
N=7 N=7 N=94 N=41 N=6 N=9 N=6 N=84 N=42 N=24 N=31 N=20 N=19
N=47
BOTTOM OF EXPLORATION AT EL. 2.7 (44.0 FT BELOW GROUND SURFACE)
N=7N =15N =16N =15
BOTTOM OF EXPLORATION AT EL. -2.7 (15.3 FT BELOW GROUND SURFACE)
CLAY CAP
LANDFILL WASTE AND COVER
MARINE DEPOSIT (REWORKED)
MARINE DEPOSIT (NATURAL)
GLACIAL TILL
BEDROCK
Max Future Water Level El. 14.7
Current Water Level El. 27.4 (HA22-1) to El. 12.1 (HA22-2)
100+00 100+25 100+50 100+75 101+00 101+25 101+50 101+75 102+00 102+25 102+50 102+75 103+00 103+25 103+50 103+75 104+00
70 65 60 55 50 45 40 35 30 25 20 15 10 5 0

PROFILE A-A


dash = LIDAR (typ.)
200+00
200+25
200+50
200+75
201+00
201+25
201+50
201+75
202+00
202+25
202+50
202+75
203+00
203+25
60
55
50
45
40
35
30
25
20
15
10
5
HA22-7
N=5
N=8
N=67
BOTTOM OF EXPLORATION AT EL. 16.9 (35.6 FT BELOW GROUND SURFACE)
solid = ground topo (typ.)
HA22-5
N=7
N=5
N=4
N=8
N=16
N=15
N=9
N=3
COBBLES
N=21
COBBLES
BOTTOM OF EXPLORATION AT EL. -11.1 (37.5 FT BELOW GROUND SURFACE)
HA22-6
N=4
N=59
N=21
CLAY CAP
LANDFILL WASTE AND COVER
MARINE DEPOSIT (REWORKED)
MARINE DEPOSIT (NATURAL)
FLUVIAL DEPOSIT
GLACIAL TILL
BEDROCK
COBBLES

PROFILE B-B

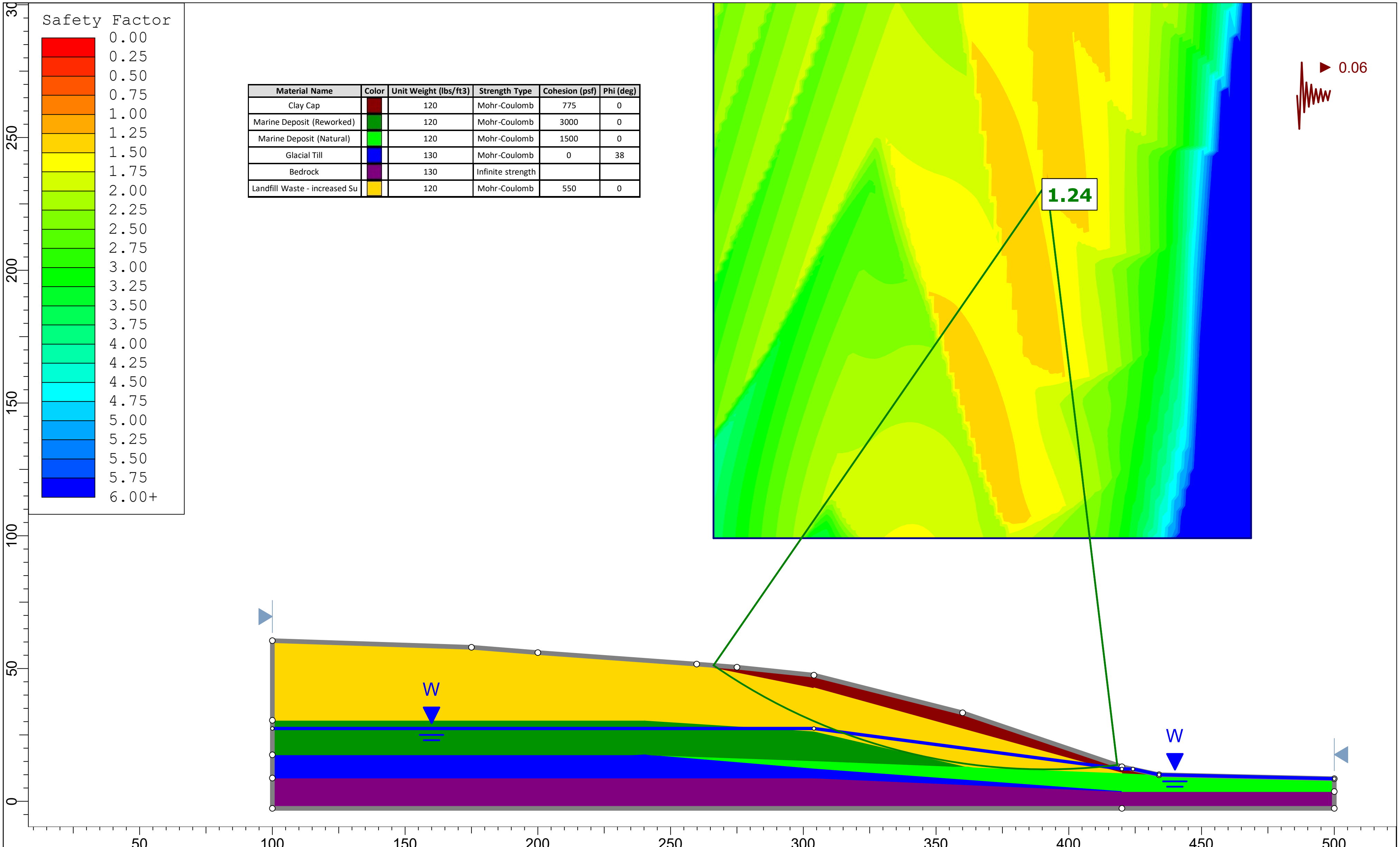


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay Cap		120	Mohr-Coulomb	775	0
Marine Deposit (Reworked)		120	Mohr-Coulomb	3000	0
Marine Deposit (Natural)		120	Mohr-Coulomb	1500	0
Glacial Till		130	Mohr-Coulomb	0	38
Bedrock		130	Infinite strength		
Landfill Waste - increased Su		120	Mohr-Coulomb	550	0

rocscience

SLIDEINTERPRET 9.023

Project	Slide2 - An Interactive Slope Stability Program		
Analysis Description	Section AA - Static		
Drawn By		*Company*	
Date	9/23/2022, 9:01:45 AM	*File Name*	2022-1018-Section AA Stability-DF.slmd

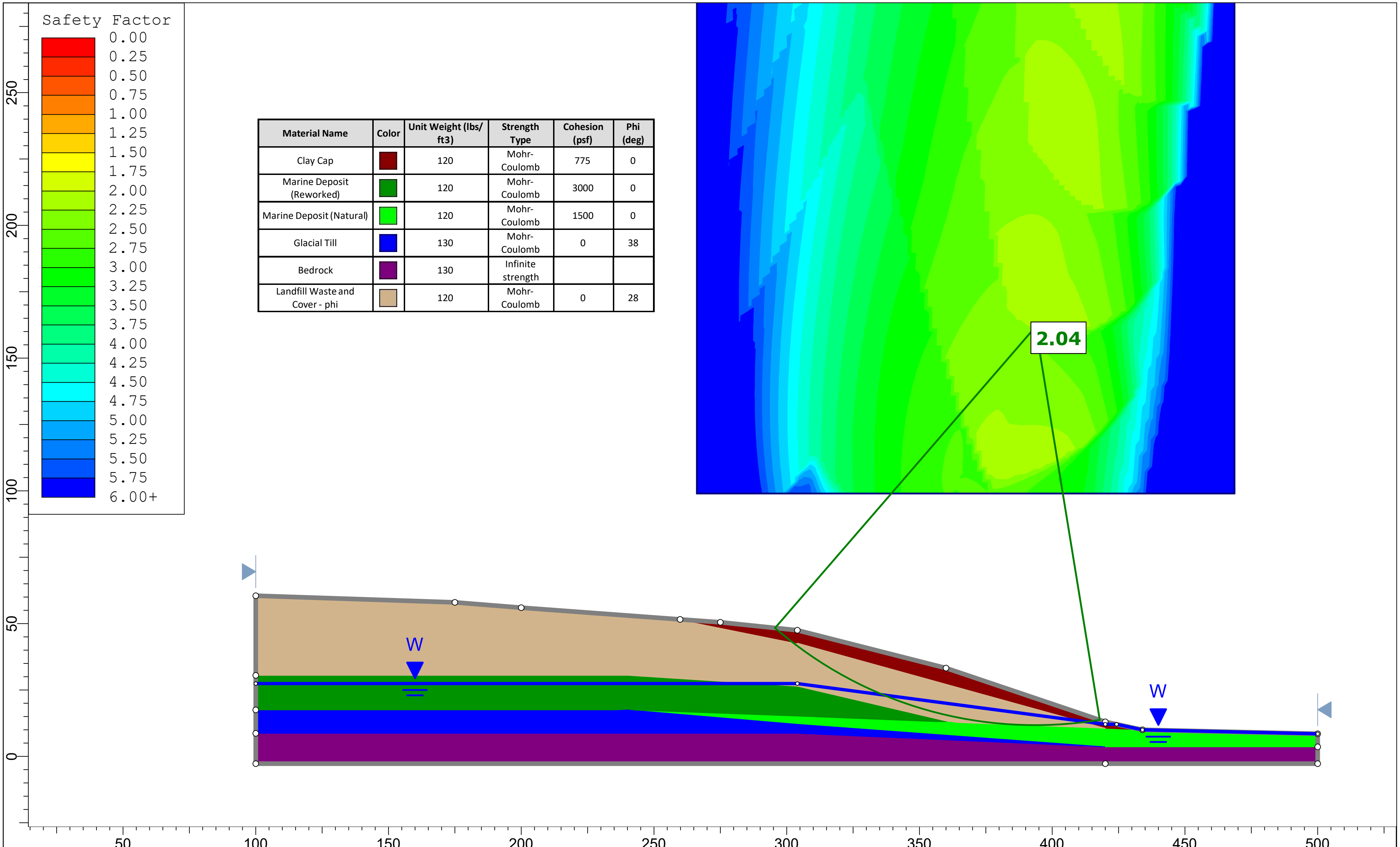


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay Cap		120	Mohr-Coulomb	775	0
Marine Deposit (Reworked)		120	Mohr-Coulomb	3000	0
Marine Deposit (Natural)		120	Mohr-Coulomb	1500	0
Glacial Till		130	Mohr-Coulomb	0	38
Bedrock		130	Infinite strength		
Landfill Waste - increased Su		120	Mohr-Coulomb	550	0

rocscience

SLIDEINTERPRET 9.023

Project	Slide2 - An Interactive Slope Stability Program
Analysis Description	Section AA - Seismic
Drawn By	*Company*
Date 9/23/2022, 9:01:45 AM	*File Name* 2022-1018-Section AA Stability-DF.slmd

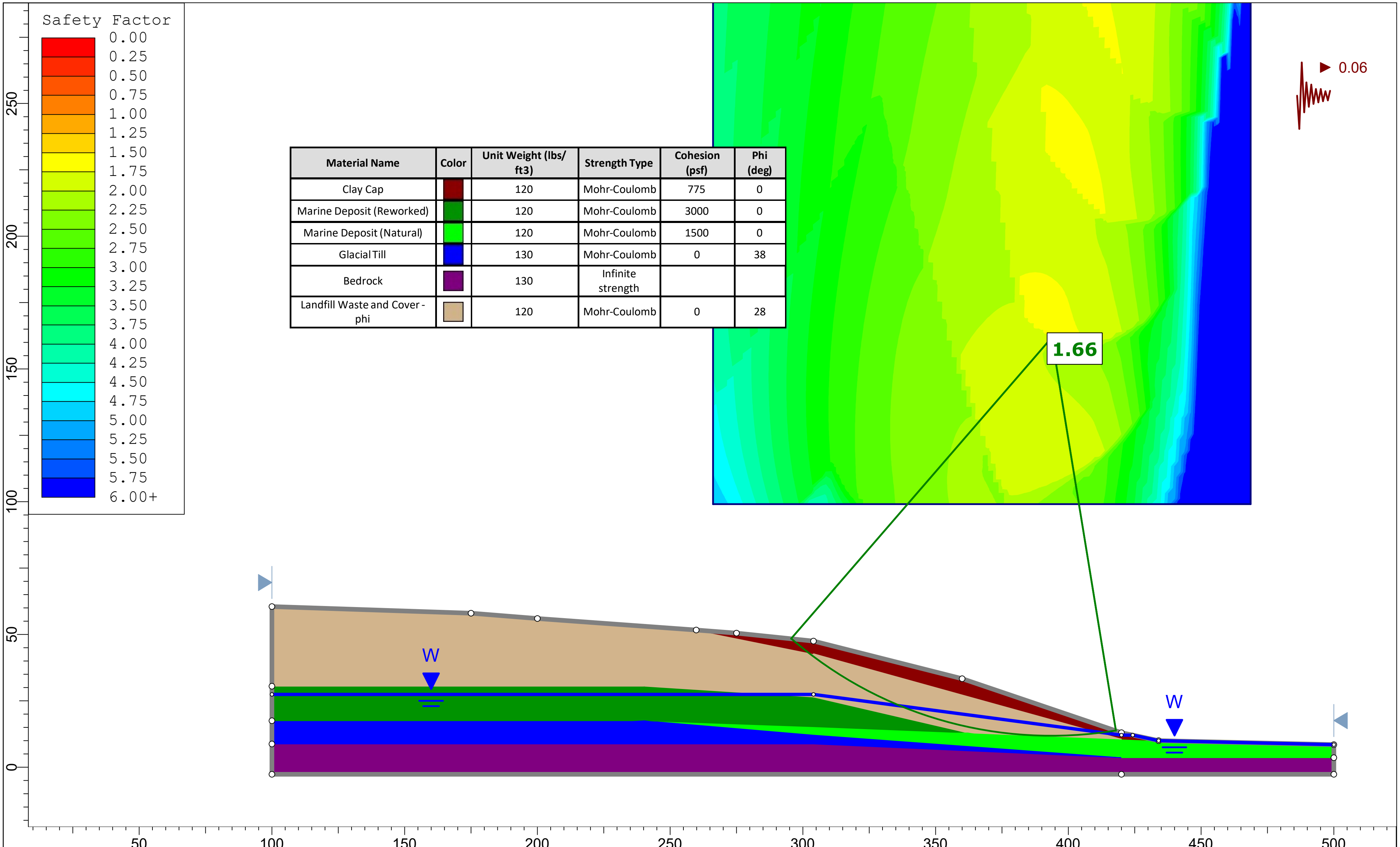


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay Cap		120	Mohr-Coulomb	775	0
Marine Deposit (Reworked)		120	Mohr-Coulomb	3000	0
Marine Deposit (Natural)		120	Mohr-Coulomb	1500	0
Glacial Till		130	Mohr-Coulomb	0	38
Bedrock		130	Infinite strength		
Landfill Waste and Cover - phi		120	Mohr-Coulomb	0	28

rocscience

SLIDEINTERPRET 9.023

Project	Slide2 - An Interactive Slope Stability Program
Analysis Description	Section AA - Static (Cohesionless Landfill Waste Properties)
Drawn By	*Company*
Date 9/23/2022, 9:01:45 AM	*File Name* 2022-0930-Section AA Stability-D3.slmd



Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay Cap		120	Mohr-Coulomb	775	0
Marine Deposit (Reworked)		120	Mohr-Coulomb	3000	0
Marine Deposit (Natural)		120	Mohr-Coulomb	1500	0
Glacial Till		130	Mohr-Coulomb	0	38
Bedrock		130	Infinite strength		
Landfill Waste and Cover - phi		120	Mohr-Coulomb	0	28

rocscience

SLIDEINTERPRET 9.023

Project

Slide2 - An Interactive Slope Stability Program

Analysis Description

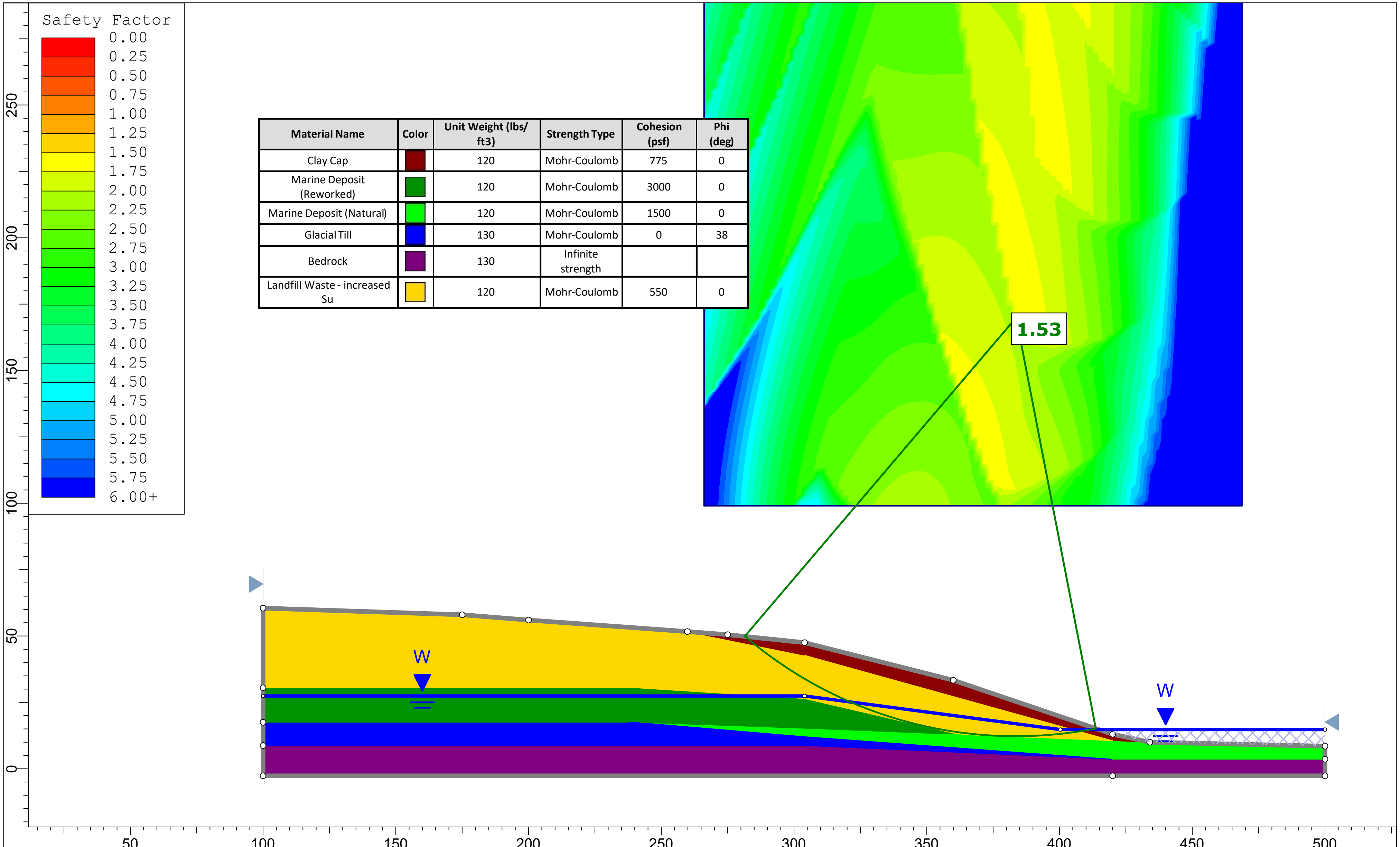
Section AA - Seismic (Cohesionless Landfill Waste Properties)

Drawn By

Company

Date 9/23/2022, 9:01:45 AM

File Name 2022-1018-Section AA Stability-DF.slmd

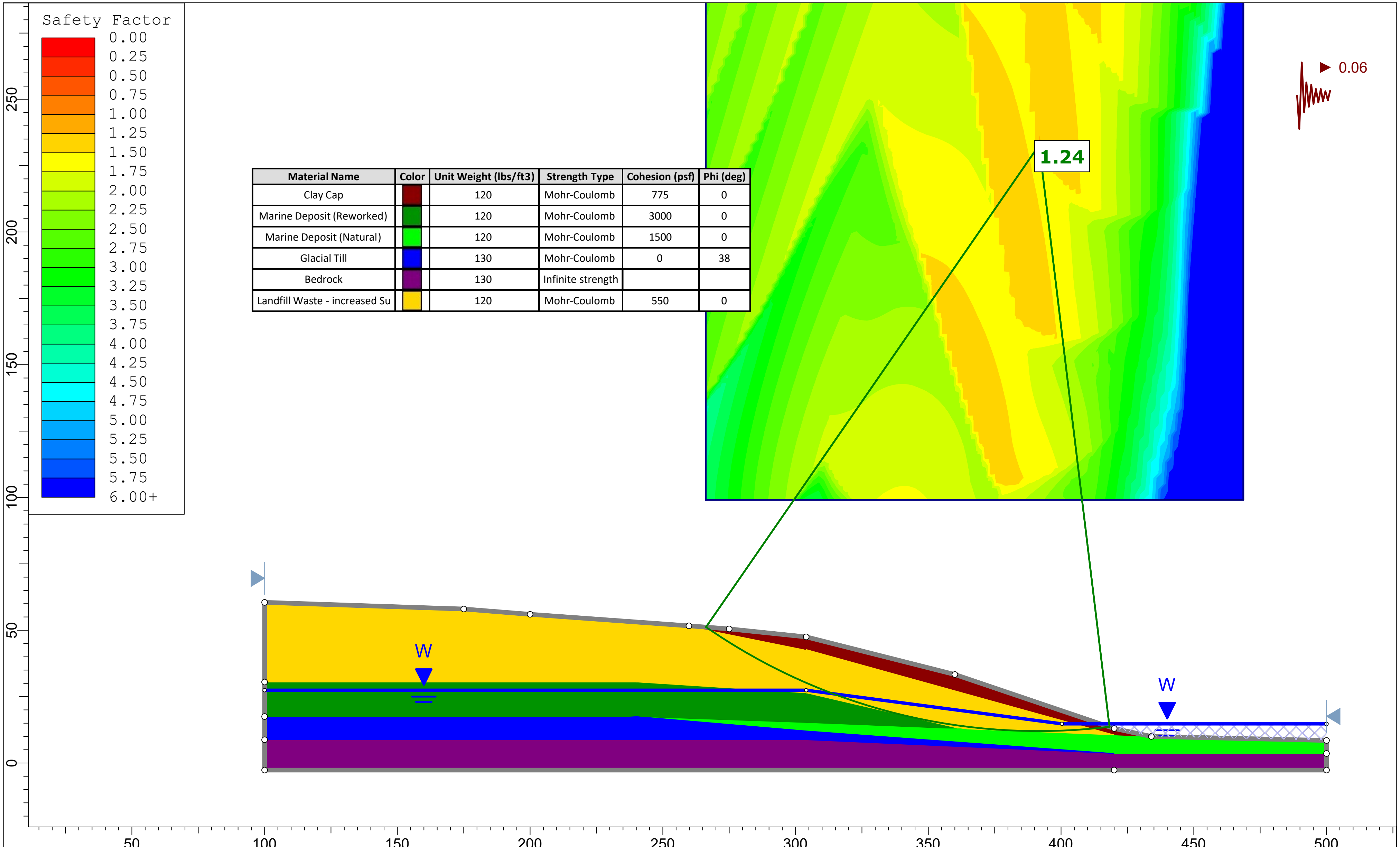


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay Cap		120	Mohr-Coulomb	775	0
Marine Deposit (Reworked)		120	Mohr-Coulomb	3000	0
Marine Deposit (Natural)		120	Mohr-Coulomb	1500	0
Glacial Till		130	Mohr-Coulomb	0	38
Bedrock		130	Infinite strength		
Landfill Waste - increased Su		120	Mohr-Coulomb	550	0

rocscience

SLIDEINTERPRET 9.023

Project	Slide2 - An Interactive Slope Stability Program
Analysis Description	Section AA - Static (High Water)
Drawn By	
Company	
Date	9/23/2022, 9:01:45 AM
File Name	2022-1018-Section AA Stability-DF.slmd



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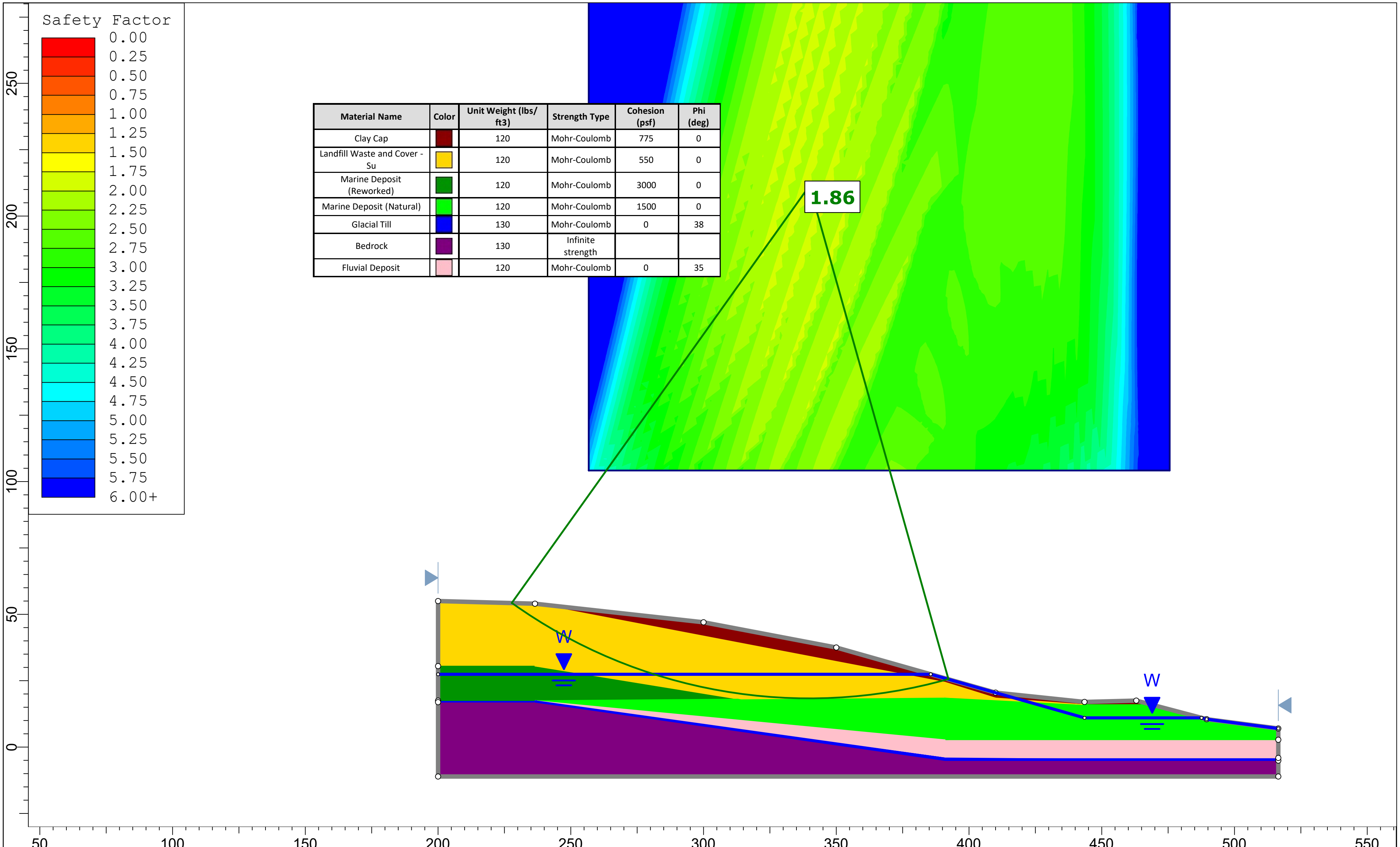
Marine Deposit (Reworked)		120	Mohr-Coulomb	3000	0
Marine Deposit (Natural)		120	Mohr-Coulomb	1500	0
Glacial Till		130	Mohr-Coulomb	0	38
Bedrock		130	Infinite strength		
Landfill Waste - increased Su		120	Mohr-Coulomb	550	0

rocscience

SLIDEINTERPRET 9.023

Project	Slide2 - An Interactive Slope Stability Program
Analysis Description	Section AA - Seismic (High Water)
Drawn By	*Company*
Date 9/23/2022, 9:01:45 AM	*File Name* 2022-1018-Section AA Stability-DF.slmd



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Landfill Waste and Cover - Su		120	Mohr-Coulomb	550	0
Marine Deposit (Reworked)		120	Mohr-Coulomb	3000	0
Marine Deposit (Natural)		120	Mohr-Coulomb	1500	0
Glacial Till		130	Mohr-Coulomb	0	38
Bedrock		130	Infinite strength		
Fluvial Deposit		120	Mohr-Coulomb	0	35

rocscience

SLIDEINTERPRET 9.023

Project

Slide2 - An Interactive Slope Stability Program

Analysis Description

Section BB - Static

Drawn By

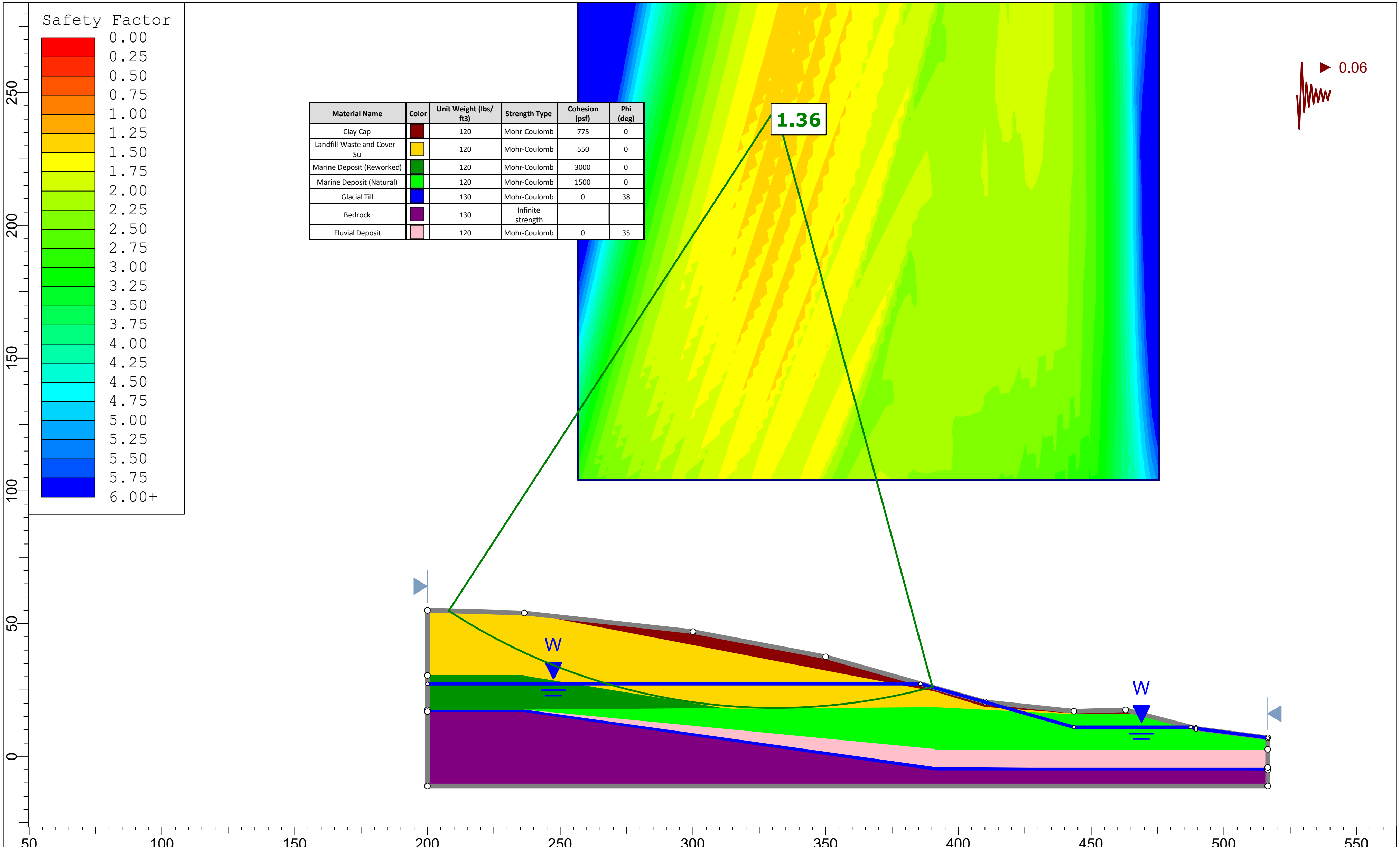
Company

Date

9/23/2022, 9:01:45 AM

File Name

2022-1018-Section BB Stability-DF.slmd



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Landfill Waste and Cover - Su		120	Mohr-Coulomb	550	0
Marine Deposit (Reworked)		120	Mohr-Coulomb	3000	0
Marine Deposit (Natural)		120	Mohr-Coulomb	1500	0
Glacial Till		130	Mohr-Coulomb	0	38
Bedrock		130	Infinite strength		
Fluvial Deposit		120	Mohr-Coulomb	0	35

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Project Slide2 - An Interactive Slope Stability Program

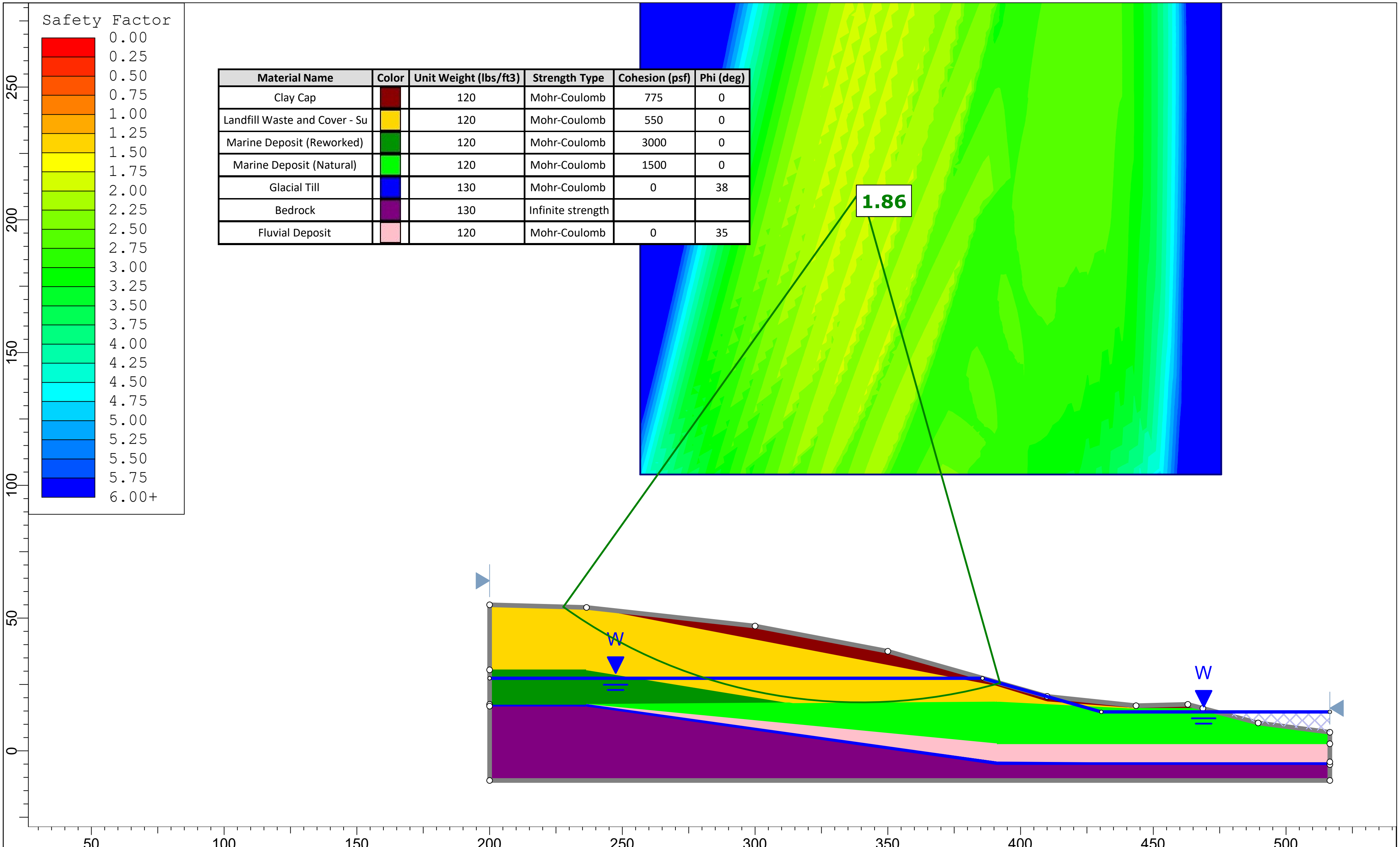
Analysis Description Section BB - Seismic

Drawn By

Company

Date 9/23/2022, 9:01:45 AM

File Name 2022-1018-Section BB Stability-DF.slmd



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Bedrock		130	Infinite strength		
Fluvial Deposit		120	Mohr-Coulomb	0	35

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SLIDEINTERPRET 9.023

Project
Slide2 - An Interactive Slope Stability Program

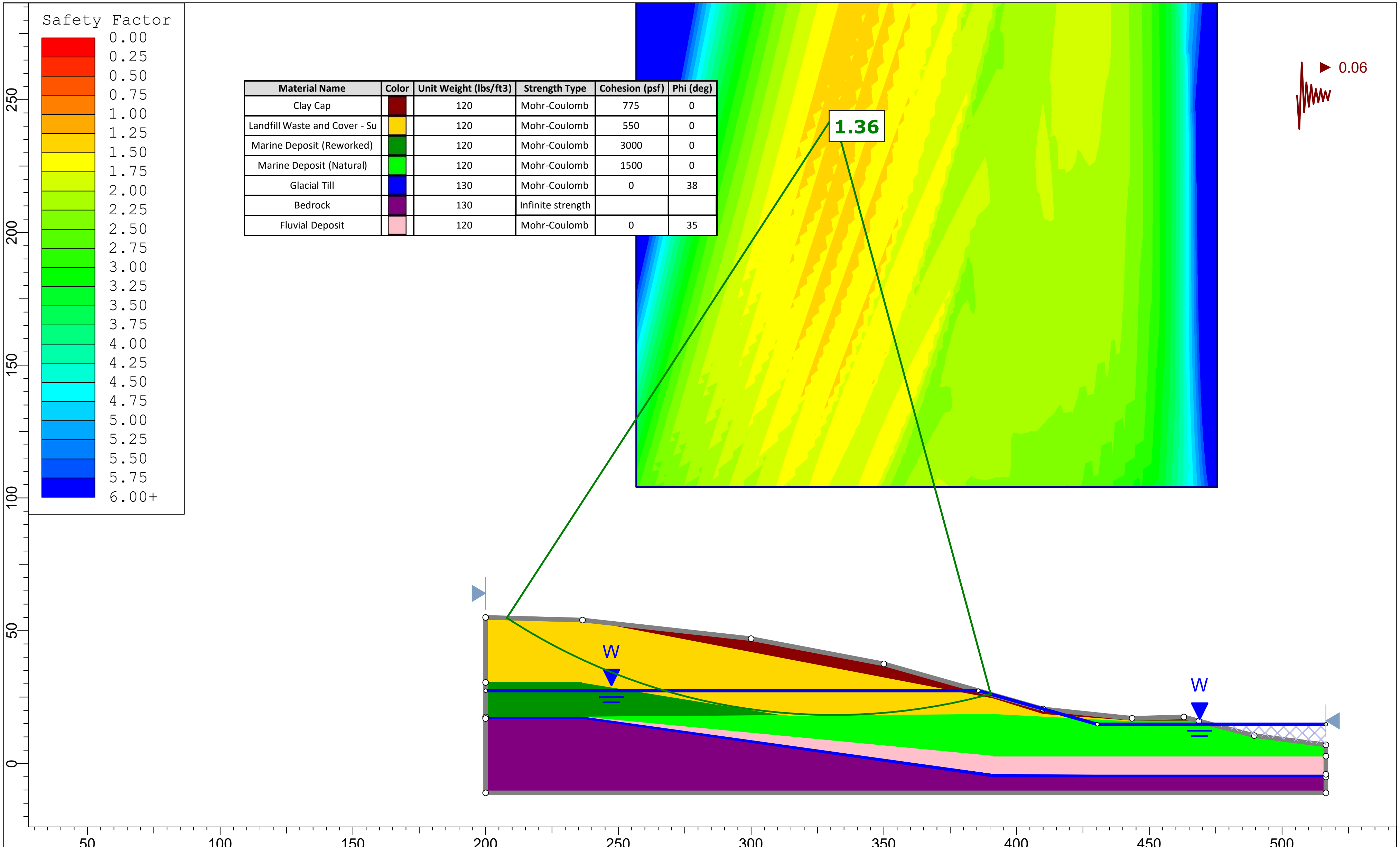
Analysis Description
Section BB - Static (High Water)

Drawn By

Company

Date
9/23/2022, 9:01:45 AM

File Name
2022-1018-Section BB Stability-DF.slmd



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SLIDEINTERPRET 9.023

Project	Slide2 - An Interactive Slope Stability Program
Analysis Description	Section BB - Seismic (High Water)
Drawn By	*Company*
Date 9/23/2022, 9:01:45 AM	*File Name* 2022-1018-Section BB Stability-DF.slmd

Stantec

Memo

To:	MaineDOT	From:	Gordon E. Clark Michael Chelminski, P.E.
File:	179450347	Date:	August 26, 2022

Reference: DRAFT Preliminary Municipal Landfill Impact Evaluation; Machias – Dike Bridge (#2246) Planning Phase Support Services Amendment #2

1 Introduction

This memo was prepared by Stantec Consulting Services Inc. (Stantec) under contract to the Maine Department of Transportation (MaineDOT) for Planning Phase Support Services (Planning Study) as part of the Dike Bridge Replacement Project (Project) located on the Middle River in Machias, Maine. MaineDOT is pursuing replacement of the existing infrastructure at Dike Bridge due to its poor condition with the objectives to provide adequate drainage from upland floods without overtopping the Route 1 roadway, provide adequate freeboard during tidal flood events, provide sea-level-rise resiliency, and accommodate fish passage to the extent practicable.

As part of this scope of services for the Planning Study, Stantec performed hydraulic analyses to assess hydraulic conditions associated with replacement alternatives for the Dike Bridge culvert. The first phase (Phase 1) of the hydraulic analyses included assessment of hydraulic conditions associated with five primary replacement alternatives for the Dike Bridge culvert, which is documented in the "Phase 1 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services" dated September 2021 (Phase 1 Study). The second phase (Phase 2) of the hydraulic analyses included evaluation of hydraulic performance across a wider range of conditions for two refined alternatives, including Alternative 4m and Alternative 10, which is documented in the "Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services" dated December 2021 (Phase 2 Study).

Following Phase 1 and Phase 2 of the Planning Study, additional concerns were voiced related to potential impacts of the proposed bridge replacement alternatives on the municipal landfill located upstream of Dike Bridge. To better understand these potential impacts, Stantec performed a preliminary evaluation to compare simulated hydraulic conditions upstream of Dike Bridge for the refined alternatives to existing conditions based on the Phase 2 Study model simulations. A summary of this preliminary evaluation of potential impacts to the municipal landfill are documented in this memo and includes a brief review of existing conditions for subject infrastructure, hydraulic conditions for existing and proposed alternatives, and recommended additional study and data collection. Attachment A contains a figure that shows the approximate wetland areas in the floodplain of the Middle River in the vicinity of the municipal landfill. Attachment B contains figures that depict mapped water surface elevations[1] (WSELs) along the Middle River landward from Dike Bridge for the proposed alternatives.

1.1 Goals and Objectives

This section presents goals and objectives of the preliminary evaluation as documented herein. The goal of the preliminary evaluation is to present anticipated hydraulic conditions that would occur landward of Dike

[1] Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88).

Bridge in the Middle River and potential impacts to the municipal landfill from the proposed alternatives based on results from the Phase 2 Study. The objective of the preliminary evaluation is twofold and includes the following:

1. Comparison of existing hydraulic conditions, including primarily water surface elevations and inundation areas, for existing and proposed alternatives adjacent to the municipal landfill across a range of different flow events including normal tide and riverine flow conditions and higher magnitude storm conditions; and

2. Evaluation of potential impacts based on the hydraulic simulation results on the municipal landfill.

1.2 Assumptions and Limitations

The preliminary evaluation presented in this memo is based on the following limitations and assumptions:

1. Hydraulic information used to compare existing conditions and the refined proposed conditions alternatives are based on the model prepared and documented as part of the Phase 2 Study, including the associated methodologies, assumptions, and limitations.

2. The character and location of the potential leachate-impacted groundwater/surface water interface is unknown.

3. Municipal landfill leachate contamination conditions, particularly fate and transport, have not been assessed or studied, and therefore it is unknown how proposed alternatives would alter the fate and transport of contamination from the municipal landfill.

4. The geotechnical stability of the existing landfill is unknown and information related to the geotechnical characteristics of the landfill were not reviewed as part of this preliminary evaluation.

5. Information from any existing municipal landfill site remedial and mitigation systems that are used to characterize potential exposure to contaminants as part of routine system monitoring, operation, and maintenance was not reviewed in preparation of this memo.

2 Existing Conditions Overview

The following sections present information on existing conditions relevant to the preliminary evaluation of potential impacts to the municipal landfill from replacement of Dike Bridge, including a brief summary of conditions of existing relevant infrastructure and a summary of existing hydraulic conditions landward from the bridge.

2.1 Subject Infrastructure

The following section presents information on the existing conditions at Dike Bridge and the municipal landfill.

2.1.1 DIKE BRIDGE

Dike Bridge (#2246) caries Route 1 over the Middle River in the Town of Machias. The existing conveyance structure at Dike Bridge is approximately 130 feet (ft) long and composed of four rectangular box culverts (approximately 6 ft wide by 5.5 ft high) constructed of timber and stone masonry. A buried concrete slab that was previously installed as a remedial repair is located over part of the culvert. There are top-hinged flap-gates installed on the seaward side of each of the four culverts, with at least one which does not seal and leaks landward during flood tides. The Dike Bridge culvert system needs improvement due to large spalls, heavy scaling, wide cracks, loss of and rotted timber members, poorly functioning tide gates, and the need for urgent and unscheduled repairs. The primary purpose and need for the Project are addressing the culvert structure's condition and the safety of the traveling public along US Route 1 and the adjacent Calais Branch Rail Corridor.

From a hydraulic perspective, there is no apparent flood history associated with the conveyance through the existing culvert or a need to increase the hydraulic opening. The proposed structure configuration and opening are being driven by the need to improve the upstream fish passage while mitigating potential landward flooding during the normal daily riverine and tidal conditions. In addition, the existing structure may also be inadequate under certain sea level rise (SLR) scenarios (see Section 3.1). Upstream fish passage, mitigation of landward flooding during normal daily riverine and tidal conditions, and resiliency due to sea-level rise are elements that represent some of the secondary purpose and needs for the Project.

2.1.2 MUNICIPAL LANDFILL

The municipal landfill is located approximately 3,800 ft west-northwest of Dike Bridge, and approximately 1,100 ft from the existing channel of the Middle River normal flow west (i.e., right[2]) bank about 0.84 river miles landward of Dike Bridge. It is adjacent to the current waste transfer station on Route 192. The municipal landfill is reportedly approximately 2.5 acres in size and is an unlined landfill. According to records from the Maine Department of Environmental Protection (MDEP), the landfill was capped in 1996 as part of the MDEP Landfill Closure and Remediation Program using what MDEP describes as a "reduced procedure" approach, which includes regrading the waste and capping with six inches of topsoil over 18 inches of glacial till over six inches of borrow.

The municipal landfill is located between two small unnamed channels that are classified as low-gradient riverine habitat by the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI), which drain the east side of the upland topography west of Route 192. The municipal landfill is directly adjacent to a persistent, freshwater emergent wetland, which is located in the lower gradient historic floodplain between the channel of the Middle River and the edge of the municipal landfill. See Attachment A Figure A.1 for a depiction of NWI wetlands in the vicinity of the municipal landfill.

Due to the unlined landfill design and the "reduced procedure" capping approach, routine monitoring, operation, and maintenance may be necessary at this site. Information related to the existing condition of the landfill cap, monitoring data for the site's remedial or mitigation systems for managing potential environmental contaminants, and groundwater/surface water leachate interface characteristics, and geotechnical stability are currently unknown and were not available for the preparation of this memo.

[2] Based on an observer facing downstream/seaward.

2.2 Hydraulics

Based on review of digital elevation model data available at the municipal landfill, the elevation[3] at the toe of the municipal landfill slope is estimated to be around 10 to 11 ft in the low-gradient area abutting the floodplain and noted wetlands. Based on review of the topography and data from the NWI, there appears to be potential for hydrologic connectivity between the unnamed tributaries, wetlands, and the Middle River, specifically on the east-southeast side of the municipal landfill.

Existing maximum water surface elevations for normal, annual peak flow, and the 10-year peak flow are -0.5 ft, 1.4 ft, and 5.2 ft, respectively. The Federal Emergency Management Agency (FEMA) 100-year event base flood elevation is at 11 ft and is therefore located at the toe of the municipal landfill under existing conditions. Although the water surface elevation of the Middle River near the municipal landfill is not near the municipal landfill on a daily basis, it remains a concern for higher flows based on the FEMA base flood elevation.

3 Proposed Alternative Conditions

The following section presents a summary of the hydraulic conditions for the proposed alternatives compared to existing conditions upstream of Dike Bridge in the Middle River adjacent to the municipal landfill as well as a summary of potential landfill impacts based on the assumptions and limitations of the Phase 2 Study methodology.

3.1 Hydraulics

Figure 1 is a graphical depiction of the range of peak upstream water surface elevations in a traditional box-and-whisker plot across different model simulations with normal tidal (i.e., without storm surge) seaward boundary conditions with and without SLR. Note that the estimated elevation of the toe of the municipal landfill slope is depicted in Figure 1 as the yellow area outlined with red around elevation 10 to 11 ft. The different model simulations include normal tidal conditions, 1.5 ft of SLR on normal tidal conditions, and 3.9 ft of SLR on normal tidal conditions, for riverine median, annual peak (Q1.1), and 10-year peak (Q10) flows. Reference the Phase 2 Study for additional information and descriptions related to these different model simulations.

There were some statistical outliers in the model runs over the simulation period, which are represented as points in Figure 1. Values were considered outliers if they were 1.5 times the interquartile range (IQR; the difference between the third quartile and the first quartile) larger than the third quartile or 1.5 times the IQR smaller than the first quartile. There were more outliers for the existing conditions simulations with the 3.9 ft of SLR tidal boundary condition due to what may be undeveloped or stable oscillation patterns in the numerical model as a result of overtopping of Dike Bridge, which is at elevation 11 ft, and the maximum tidal stage for the normal tide with 3.9 ft of SLR of 12.1 ft. Reference section 5.1 in the Phase 2 Study Memo for more discussion related to this SLR scenario.

[3] Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88)

Reference: DRAFT Preliminary Municipal Landfill Impact Evaluation; Machias – Dike Bridge (#2246) Planning Phase Support Services Amendment #2

Both Alternative 4m and 10 result in increased bi-directional flow across Dike Bridge. As a result, under normal riverine flow and tidal conditions, the upstream water surface elevation is both greater in magnitude and also results in a wider range of flows than for the existing conditions. Similar to existing conditions, the daily peak water surface elevations landward of Dike Bridge in the Middle River for the proposed alternatives coincide with the high tide cycles (i.e., the timing of the peak upstream flows relative to the normal tide cycles generally remain the same); however, the maximum water surface elevation on a daily basis would be greater than for existing conditions under both proposed alternatives as presented in Figure 1 and Alternative 10 would result in the largest change in maximum upstream water surface elevations

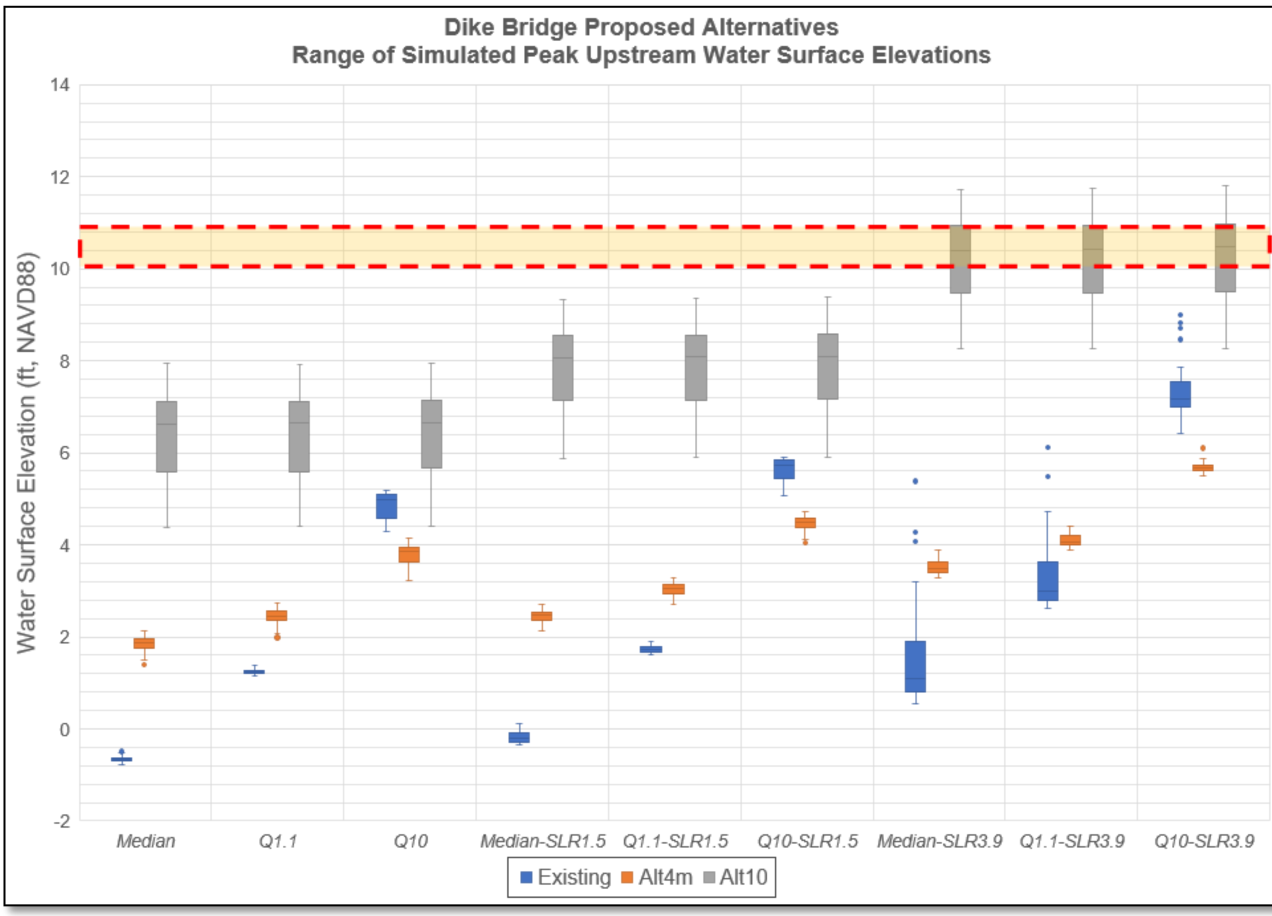


Figure 1. Summary of simulated peak landward water surface elevations in Middle River across a range of different riverine flows and downstream tidal boundary conditions; Note that the area highlighted in yellow and outlined in red represents the approximate elevation of the toe of the municipal landfill slope

While peak riverine flows such as the 1.1-year (~annual) peak flow and the 10-year peak flow are expected to occur relatively infrequently (e.g., 10% chance on an annual basis), the regular semi-diurnal tides result in approximately two occurrences of a high tide each day. Therefore, compared to peak flow conditions, typical

Reference: DRAFT Preliminary Municipal Landfill Impact Evaluation; Machias – Dike Bridge (#2246) Planning Phase Support Services Amendment #2

riverine and tidal conditions have a much more significant and frequent impact on the water surface elevations landward from Dike Bridge in the Middle River. Table 1 presents a summary of the range of peak landward water surface elevations under normal riverine flow and normal tidal conditions for existing and proposed alternatives. On a daily basis, Alternative 4m would result in an average increase in upstream water surface elevations of approximately 1.5 ft and Alternative 10 would result in an approximately 6 ft average increase compared to existing. Both proposed alternatives would result in increased peak water surface elevations compared to existing conditions. Alternative 10 results in the largest change in maximum upstream water surface elevations. The peak upstream water surface elevations for normal flows and normal tidal conditions under Alternative 10 are between 4.4 ft and 8 ft. This would come within two vertical feet of the toe of the municipal landfill slope. The peak upstream water surface elevations for normal flows and normal tidal conditions under Alternative 4m are between 1.4 and 2.1 ft, which would be approximately 8 vertical feet from the toe of the municipal landfill slope.

Table 1. Summary of the range of peak upstream water surface elevations under normal flow and normal tide conditions for existing and proposed alternatives.

	Existing	**Alternative 4m**	**Alternative 10**
Minimum	-0.8	1.4	4.4
Average	-0.6	1.8	6.4
Maximum	-0.5	2.1	7.9

Attachment B contains figures that depict the inundation extents for existing and proposed alternatives for various riverine and tidal conditions. In general, there is increased landward inundation under the proposed alternatives compared to existing conditions. The increased inundated area in Alternative 10 is a result of the more transparent tidal regime. The single bidirectional flow culvert used on one of the three culverts in Alternative 4m will also result in increased inundation relative to existing conditions, but not to the extent of Alternative 10.

Figure B.0 presents the maximum landward (i.e., upstream) water levels for typical tides and river flows. For normal tidal and riverine flow conditions, Alternatives 4m and 10 result in increased areas of inundation of approximately 86 acres and 398 acres, respectively. The spatial extents and inundation areas of the maximum landward water levels for typical tides and river flows for existing conditions and Alternatives 4m and 10 are presented and can be compared to the approximate location of the municipal landfill slope. For this tide and river flow scenario, Alternative 10 would result in landward water levels that are in relatively close proximity (i.e., approximately 250 ft) to the toe-of-slope of the municipal landfill compared to a distance of approximately 1,000 ft for existing conditions and Alternative 4m, which are approximately similar in distance.

Figure B.1 presents the landward water levels that represent the 100-year peak riverine flow and mean high water downstream boundary condition based on steady-state modeling methods. This figure shows that the inundation area for all three model geometries (i.e., existing conditions and both proposed conditions) are relatively similar for this simulation. Note that the FEMA base flood elevation (BFE) is also depicted in Figure B.1, and the inundation area aligns relatively closely to the simulation results from the model.

Figures B.2., B.3. and B.4 present the inundation extents for the simulated 1.1-year (~annual) peak flow riverine conditions with 100-year high tide surge downstream boundary conditions with 1.5 ft and 3.9 ft of SLR. In general, Alternative 10 has the greatest area of inundation and comes in closest proximity to the landfill compared to existing conditions and Alternative 4m, except for 3.9 ft of SLR where Dike bridge is overtopped under existing conditions.

3.2 Potential Landfill Impacts

Based on the results of the Phase 2 Study simulation results as presented in the Phase 2 Study Memo and in Section 3.1 of this memo, there are anticipated changes to the landward water surface elevations upstream of Dike Bridge from existing to proposed conditions for both Alternative 4m and Alterative 10. In general, there will be an increased magnitude in the maximum peak upstream water surface elevations for both alternatives with Alternative 10 resulting in the greatest increase due to the increased tidal transparency through the proposed bridge opening. The larger bridge opening in Alternative 10 will also result in a greater flux and exchange of water between the tidal area of the Middle River upstream of Dike Bridge and its confluence with the Machias River compared to both existing conditions and Alternative 4m. Due to the limited information and assumptions and limitations of the Phase 2 Study analyses, it is unknown whether this greater flux and resulting increased wetting at the toe-of-slope of the municipal landfill would result in conditions that would increase the likelihood of adverse impacts from contaminants at the municipal landfill (e.g., impacts to fate and transport of contaminants downstream).

The results from the Phase 2 Study and as presented in this memo suggest that the extent of daily inundation associated with regular, semi-diurnal tides are to be significantly more pronounced for Alternative 10 compared to Alternative 4m. This would result in a reduced wetland buffer between the municipal landfill and the Middle River on a daily basis. This would also result in the normal daily wetted area of the Middle River being in closer proximity to the toe of slope and the groundwater / surface water interface. Note that the characteristics of the groundwater / surface water interface are currently unknown (reference Section 1.2).

In addition, based on the steady-state simulation results for the 100-year riverine flow with mean high water downstream boundary conditions and the regulatory FEMA BFE of 11 ft, it appears as though the toe of the municipal landfill slope may be subject to inundation and flooding risk under existing conditions, which may potentially pose concerns for adverse impacts related to contaminants. Sea-level rise will also increase the likelihood for increased inundation in the future for both existing and proposed conditions. Existing potential acute effects and risk associated with a large pulse or slug of contamination from gross-failure of the municipal land fill slope at the wetland and floodplain interface may also be exacerbated by low-frequency storm events under both current sea-level and future sea-level rise conditions.

4 Recommended Additional Study and Data Collection

The following additional studies and data collection are recommended to further evaluate the potential impacts of the proposed alternatives on the municipal landfill:

1. Evaluate the conditions of the existing installed municipal landfill site remedial and mitigation systems used to prevent ongoing exposure to site contaminants as part of routine system monitoring, operation, and maintenance.

2. Evaluate the characteristics and location of the leachate groundwater / surface water interface.

3. Identify the primary leachate contaminate constituents.

4. If contaminants of concern are identified in the municipal landfill, evaluate the fate and transport of contaminants for both existing and proposed conditions downstream.

5. Evaluate geotechnical conditions including slope-stability at the municipal landfill for various hydraulic conditions for existing and proposed conditions at Dike Bridge. Various hydraulic conditions for consideration may include typical normal flows in Middle River with normal tidal boundary conditions, as well as for low-frequency storm flow events (e.g., 100-year riverine flow), and storm surge and SLR conditions .

5 Conclusion

A preliminary evaluation was performed to compare hydraulic conditions simulated upstream of Dike Bridge for the refined alternatives to existing conditions. A summary of this preliminary evaluation of potential impacts to the municipal landfill are documented in this memo and recommendations for additional study and data collection are provided. The following items summarize the findings from this preliminary evaluation:

1. Both Alternative 4m and Alternative 10 will result in increased landward water surface levels in the Middle River landward of Dike Bridge with Alternative 10 resulting in the largest increase due to the increased tidal transparency from the large bridge opening.

2. Alternative 10 would result in a significantly greater inundation area under typical tides and riverine flows compared to existing conditions and Alternative 4m.

3. Typical tides and riverine flows represent the hydraulic conditions that would occur most frequently in the Middle River landward from Dike Bridge.

4. Peak landward water surface elevations for normal flows in the Middle River and normal tidal conditions under Alternative 10 are between 4.4 ft and 8 ft. Water surface elevations in the range of 8 ft would be within two vertical feet of the toe of the municipal landfill slope.

5. Peak upstream water surface elevations for normal flows in the Middle River and normal tidal conditions under Alternative 4m are between 1.2 and 2.1 ft, which would be approximately eight vertical feet from the toe of the municipal landfill slope.

6. Alternative 10 would result in a significant change to the amount of wetland buffer in the floodplain between the municipal landfill and the Middle River under typical flow and tidal conditions. Alternative 4m and existing conditions are relatively similar under normal conditions. For example, the approximate distance between the normal maximum water line in the Middle River under Alternative 10 is 250 ft versus approximately 1,000 ft for Alternative 4m and existing conditions.

7. If a slope-stability issue was identified at the municipal landfill, then a slope failure of the municipal landfill could potentially result in increased risk of environmental contamination under existing and proposed conditions for both alternatives. However, the increased inundation characteristics and the

resulting potential for increased dispersal of material associated with Alterative 10 may make a remediation cleanup effort more challenging.

8. Low-frequency storm events, such as the regulatory 100-year FEMA BFE, may result in conditions that would place the inundation extent in close proximity to the municipal landfill under existing conditions as well.

9. SLR is also expected to increase the likelihood of increased inundation at the location of the municipal landfill under existing and proposed conditions.

10. Due primarily to the assumptions and limitations of the preliminary evaluation presented herein, it is unknown whether the increased inundation and greater flux of water at the location of the municipal landfill would result in conditions that would increase the likelihood of adverse impacts from contaminants at the municipal landfill (e.g., impacts to fate and transport of contaminants downstream).

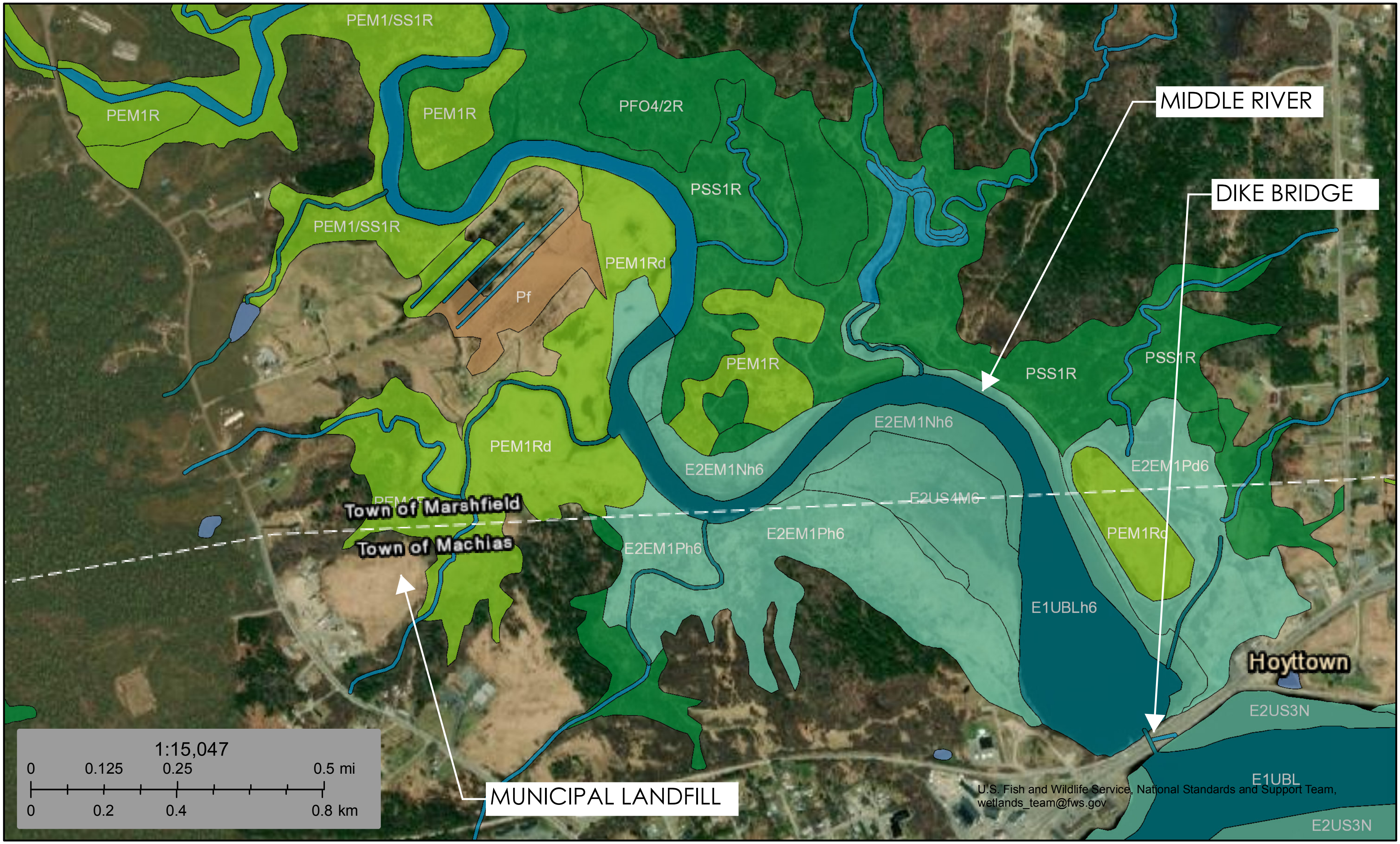
Attachment A

Wetland Figure

U.S. Fish and Wildlife Service

National Wetlands Inventory

Middle River, Machias, ME



August 17, 2022

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

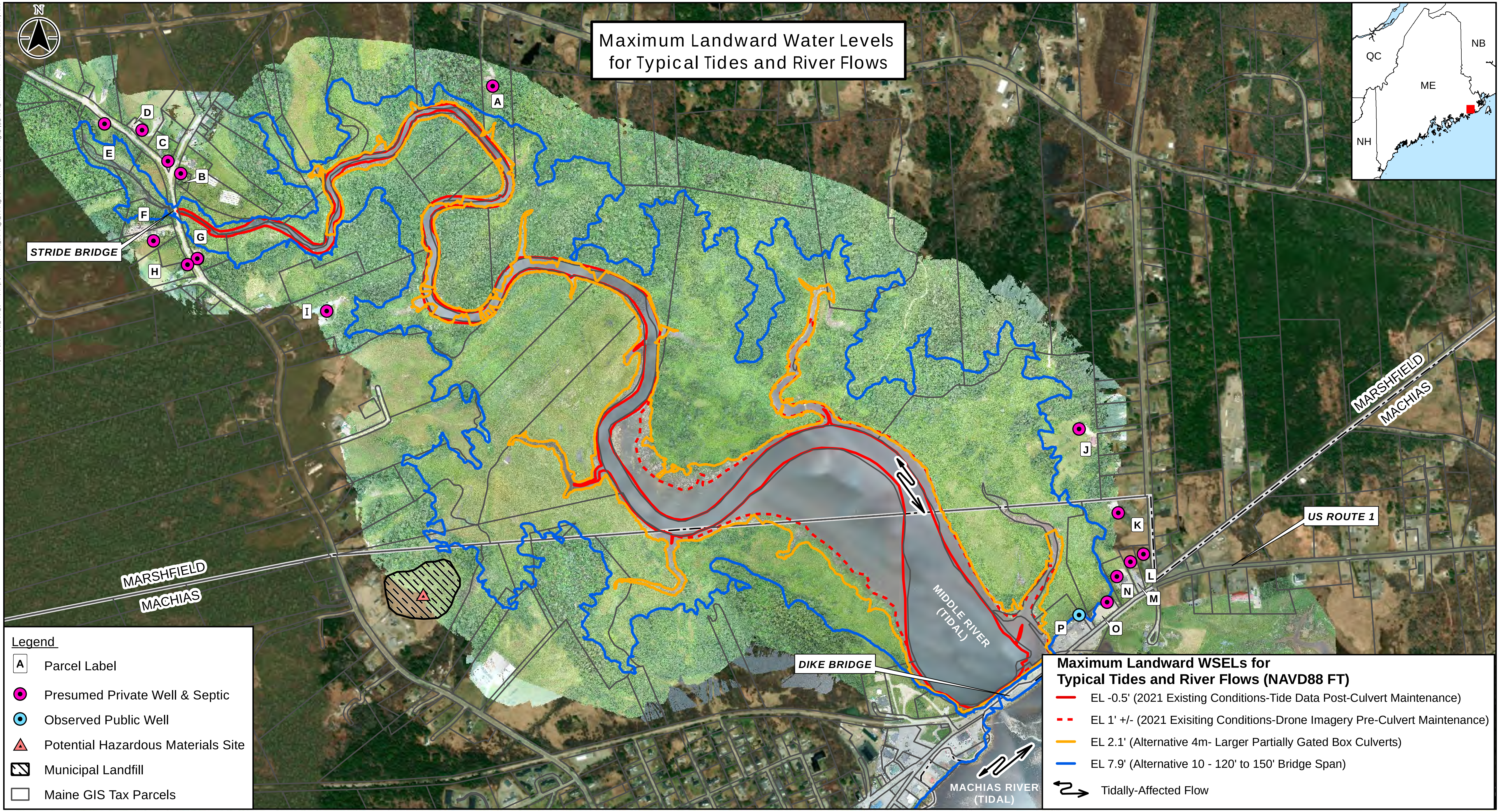
This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

FIGURE A.1

National Wetlands Inventory (NWI)
This page was produced by the NWI mapper

Attachment B

Inundation Figures



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Topsham, ME USA 04086
Phone (207) 729-1199

Prepared by EPL on 2022-08-26
Reviewed by TM on 2022-08-26
50347_DikeBridge_Typ_Tides_WSEL.mxd

Notes

1. Existing conditions are based on 2021 tidal stage data that was collected after leaking gates were fixed and 2021 drone imagery collected by MaineDOT before the leaking gates were fixed and represent a range of potential existing conditions.
2. Approximate water surface elevations (WSEL) depicted are based on unsteady-state methods as part of the 2021 Phase 1 and Phase 2 hydraulics analyses using tidal stage data collected by MaineDOT in 2021.
3. Coordinate System: NAD 1983 UTM Zone 19N FT
4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

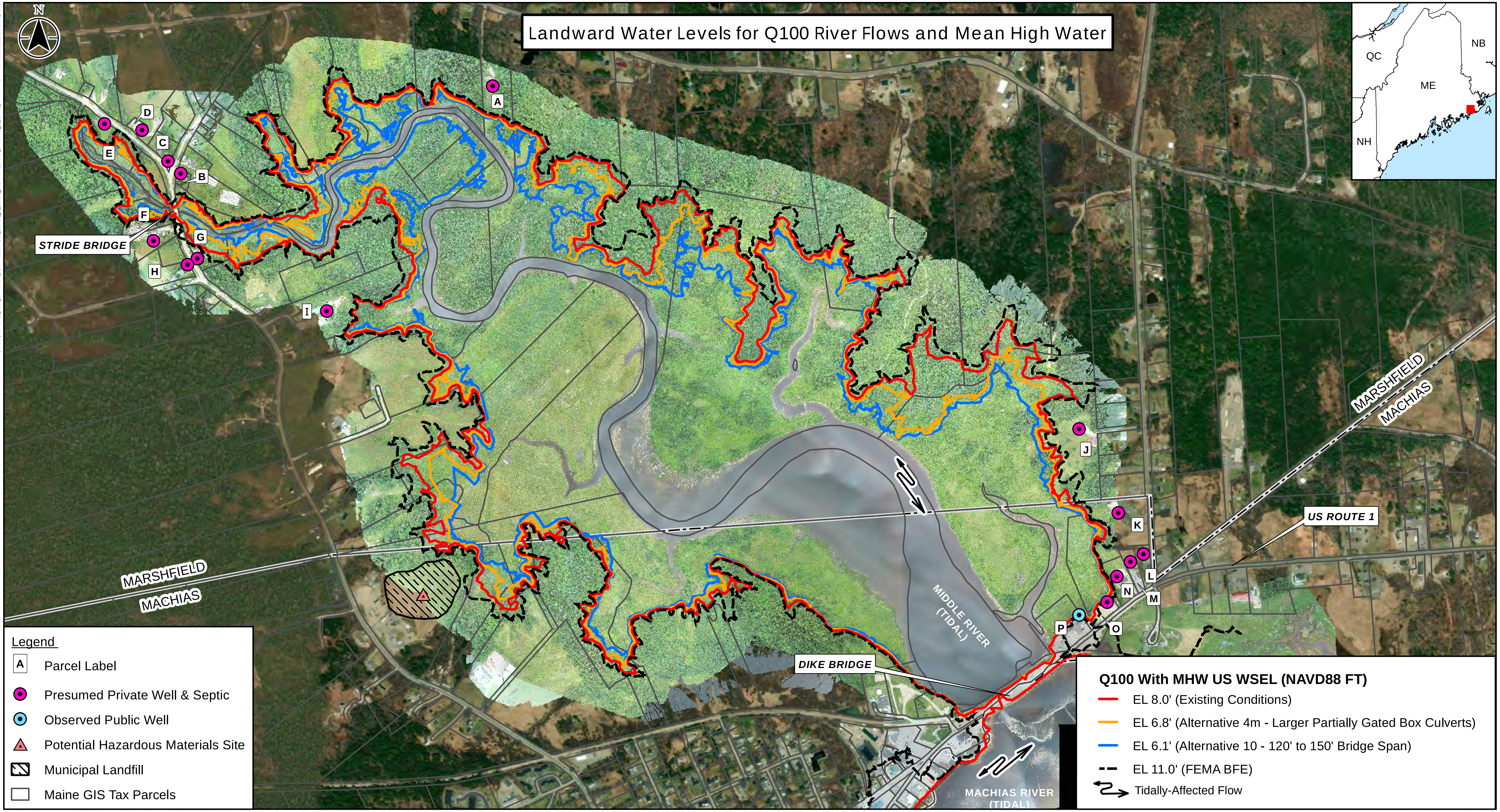
0 800 Feet
1 inch = 800 feet (At page size of 11"x17")

179450347

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.0

Title
Maximum Landward Water Levels
for Typical Tides and River Flows
8/26/2022



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Prepared by EPL on 2022-08-26
Reviewed by TM on 2022-08-26
50347_DikeBridge_Q100_MHW.mxd

Notes
1. 2021 drone imagery collected by MaineDOT before the leaking gates were fixed.
2. Approximate water surface elevations (WSEL) depicted are based on unsteady-state methods as part of the 2021 Phase 1 and Phase 2 hydraulics analyses using tidal stage data collected by MaineDOT in 2021.
3. Coordinate System: NAD 1983 UTM Zone 19N FT
4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

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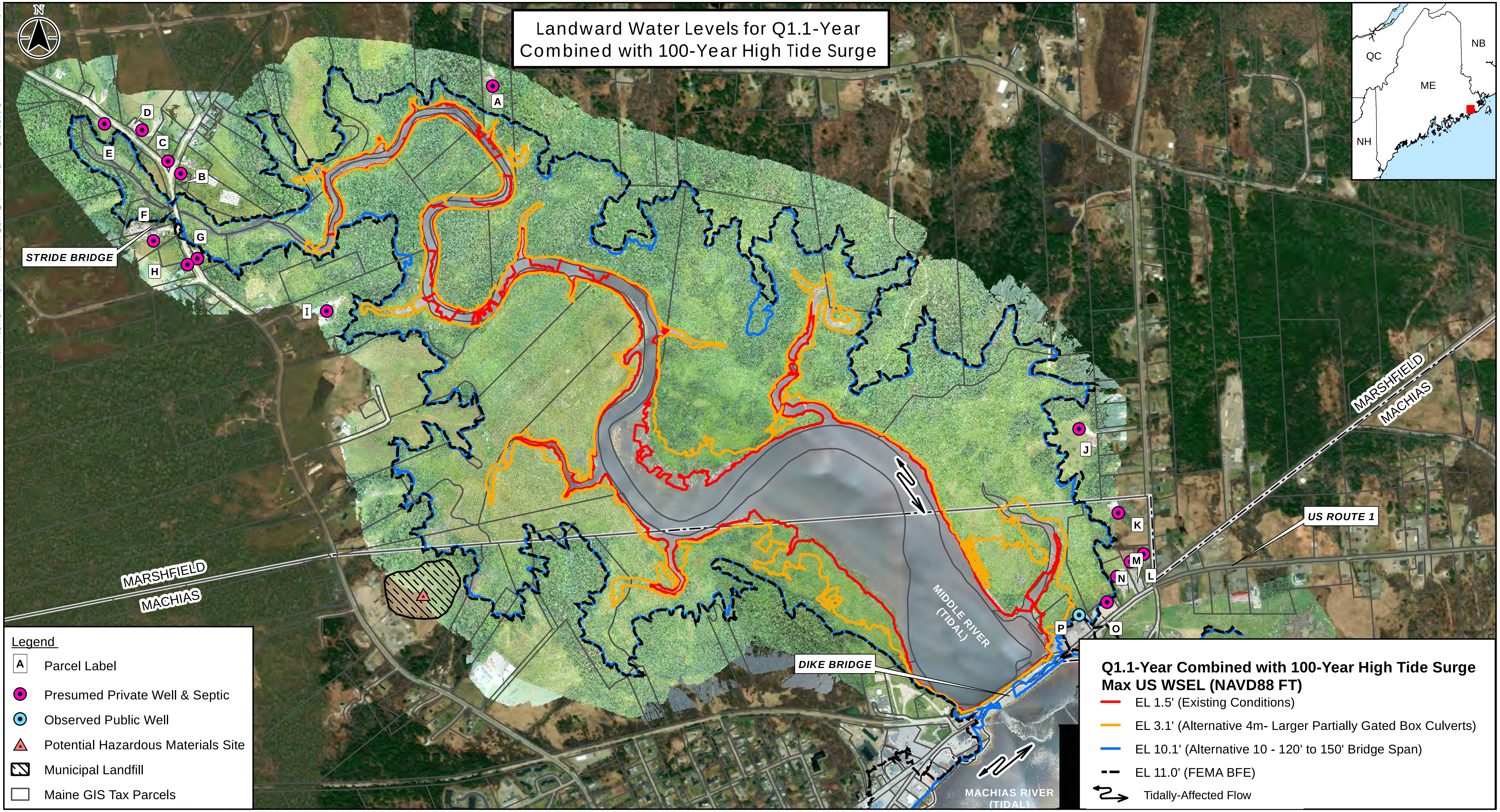
1 inch = 800 feet (At page size of 11"x17")

179450347

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.1

Title
Landward Water Levels for
Q100 River Flows and Mean High Water
8/26/2022



179450347

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Phone (207) 729-1199

Prepared by EPL on 2022-08-26
Reviewed by TM on 2022-08-26
50347_DikeBridge_100yr_Q1p1_norm.mxd

Notes
1. 2021 drone imagery collected by MaineDOT before the leaking gates were fixed.
2. Approximate water surface elevations (WSEL) depicted are based on unsteady-state methods as part of the 2021 Phase 1 and Phase 2 hydraulics analyses using tidal stage data collected by MaineDOT in 2021.
3. Coordinate System: NAD 1983 UTM Zone 19N FT
4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

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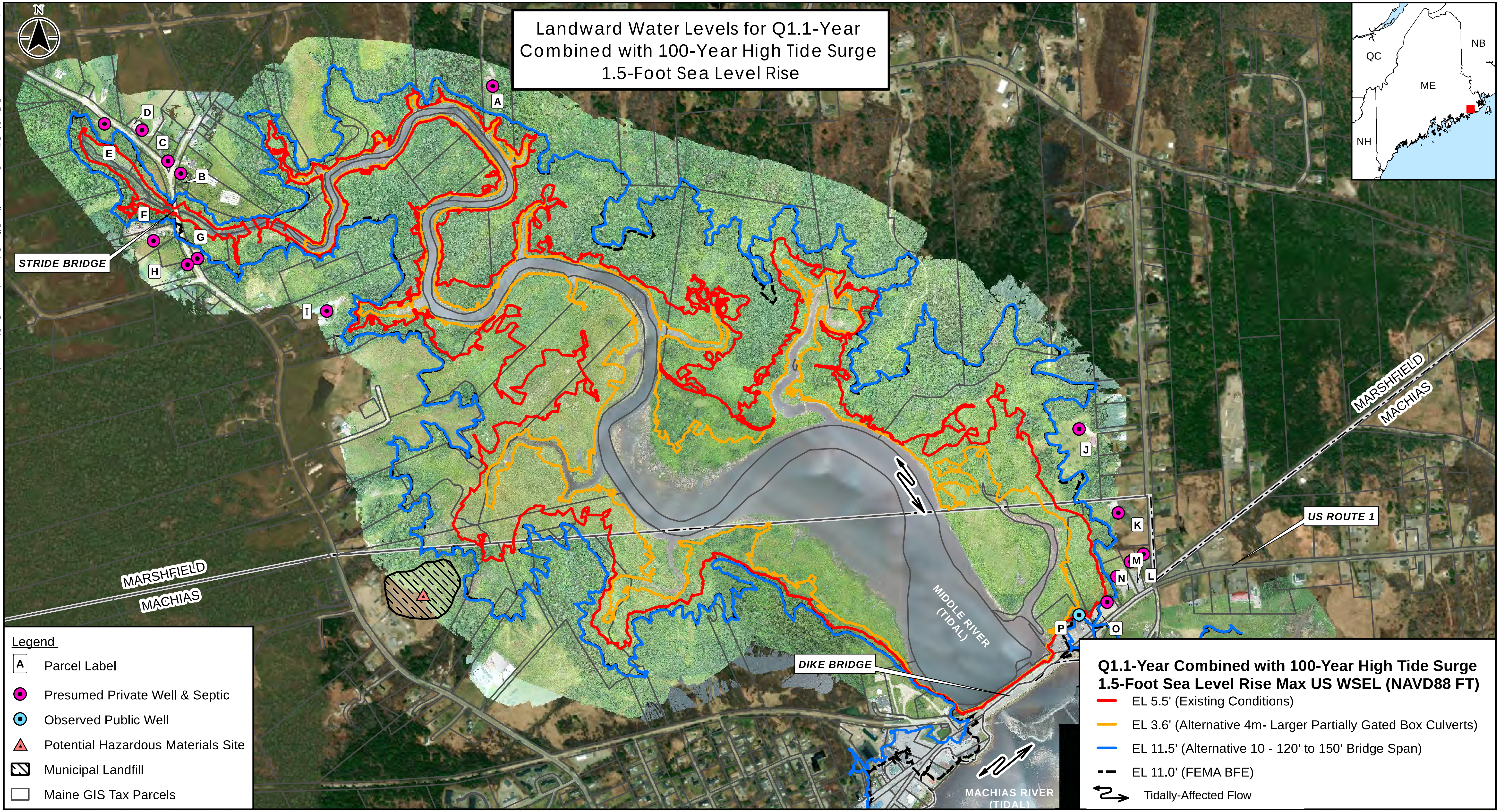
Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.2

Title
Landward Water Levels for Q1.1-Year Combined with 100-Year High Tide Surge

8/26/2022



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Reviewed by TM on 2022-08-26
50347_DikeBridge_100yr_Q1p_p5_SLR.mxd

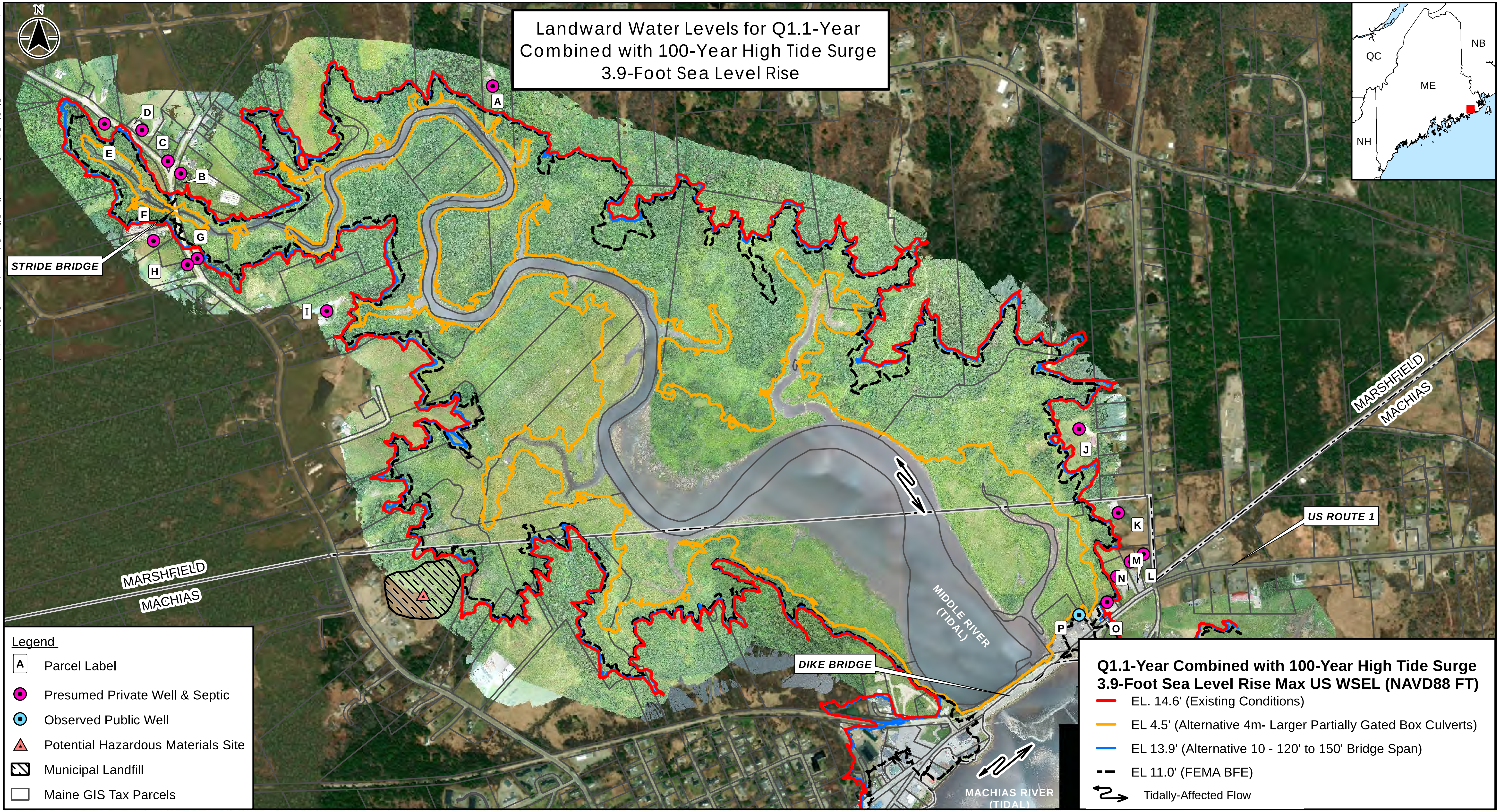
Notes
1. 2021 drone imagery collected by MaineDOT before the leaking gates were fixed.
2. Approximate water surface elevations (WSEL) depicted are based on unsteady-state methods as part of the 2021 Phase 1 and Phase 2 hydraulics analyses using tidal stage data collected by MaineDOT in 2021.
3. Coordinate System: NAD 1983 UTM Zone 19N FT
4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

0 800 Feet
1 inch = 800 feet (At page size of 11"x17")

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.3

Title
Landward Water Levels for Q1.1-Year
Combined with 100-Year High Tide Surge
1.5-Foot Sea Level Rise
8/26/2022



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Prepared by EPL on 2022-08-26
Reviewed by TM on 2022-08-26

50347_DikeBridge_100yr_Q1p_SLR.mxd

Notes
1. 2021 tidal stage data that was collected after leaking gates were fixed and 2021 drone imagery collected by MaineDOT before the leaking gates were fixed.
2. Approximate water surface elevations (WSEL) depicted are based on unsteady-state methods as part of the 2021 Phase 1 and Phase 2 hydraulics analyses using tidal stage data collected by MaineDOT in 2021.
3. Coordinate System: NAD 1983 UTM Zone 19N FT
4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

0 800 Feet
1 inch = 800 feet (At page size of 11"x17")

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.4

Title
Landward Water Levels for Q1.1-Year
Combined with 100-Year High Tide Surge
3.9-Foot Sea Level Rise
8/26/2022

APPENDIX 7 – Section 106 – Determination of Eligibility and Effects / Concurrence

1. 3/6/2023 Memo: Concurrence-Finding of Effects – All Alternatives
2. 2/7/2023 Memo: Additional Information Response for Finding of Effects
3. 12/28/2022 Memo: Response to Section 106 Request for Concurrence
4. 12/8/2022 Memo: Section 106 Request for Concurrence

STATE OF MAINE

MEMORANDUM

March 6, 2023

To: Julie Senk, ENV/Maine Department of Transportation

From: Kirk F. Mohney, State Historic Preservation Officer KFM

Subject: WIN 16714.00, Machias, Dyke Bridge Replacement; MHPC # 1269-08

In response to your recent request, I have reviewed the information received February 7, 2023 to continue consultation on the above referenced undertaking pursuant to the Maine Programmatic Agreement and Section 106 of the National Historic Preservation Act of 1966, as amended.

Finding of Effects
Based on the alternatives presented in the supplemental documentation for finding of effects, the Commission has reached the following conclusions:

No Build
The Commission concurs with MaineDOT that *no historic properties would be affected* under this alternative.

In-Kind Replacement (Alternative 1)
The Commission concurs with MaineDOT that *no historic properties would be affected* under this alternative.

Partially-Gated Culvert Replacement (Alternative 4)
The Commission concurs with MaineDOT that this alternative would have an *no adverse effect* on the Trotting Park. Under normal tides, this alternative would have *no effect* on the Railroad Station. However, when SLR and an astronomical high tide is taken into consideration, this alternative would have *no adverse effect* on the Railroad Station.

Partially-Gated Culvert Replacement (Alternative 4M)
The Commission concurs with MaineDOT that this alternative would have *no adverse effect* on the Trotting Park. Under normal tides, this alternative would have *no effect* on the Railroad Station. However, when SLR and an astronomical high tide is taken into consideration, this alternative would have *no adverse effect* on the Railroad Station.

Open Box Culvert Replacement (Alternative 9)
The Commission concurs with MaineDOT that this alternative would have an *adverse effect* on the Trotting Park. Under normal tides, this alternative would have *no effect* on the Railroad Station. However, when SLR and an astronomical high tide is taken into consideration, this alternative would have *no adverse effect* on the Railroad Station.

Bridge Replacement (Alternative 10)
The Commission concurs with MaineDOT that this alternative would have an *adverse effect* on the Trotting Park. Under normal tides, this alternative would have *no adverse effect* on the Railroad Station. However, when SLR and an astronomical high tide is taken into consideration, this alternative would have an *adverse effect* on the Railroad Station.

Please contact Megan M. Rideout of our office if we can be of further assistance in this matter.

STATE OF MAINE
Memorandum

Date: February 7, 2023

To: Kirk Mohney, MHPC
From: Julie Senk, Maine DOT/ENV
Subject: Section 106 Request for More Information
Project: Machias 16714.00, MHPC #1269-08

The Maine DOT has reviewed this project pursuant to the Maine Programmatic Agreement (PA) and Section 106 of the National Historic Preservation Act of 1966, as amended.

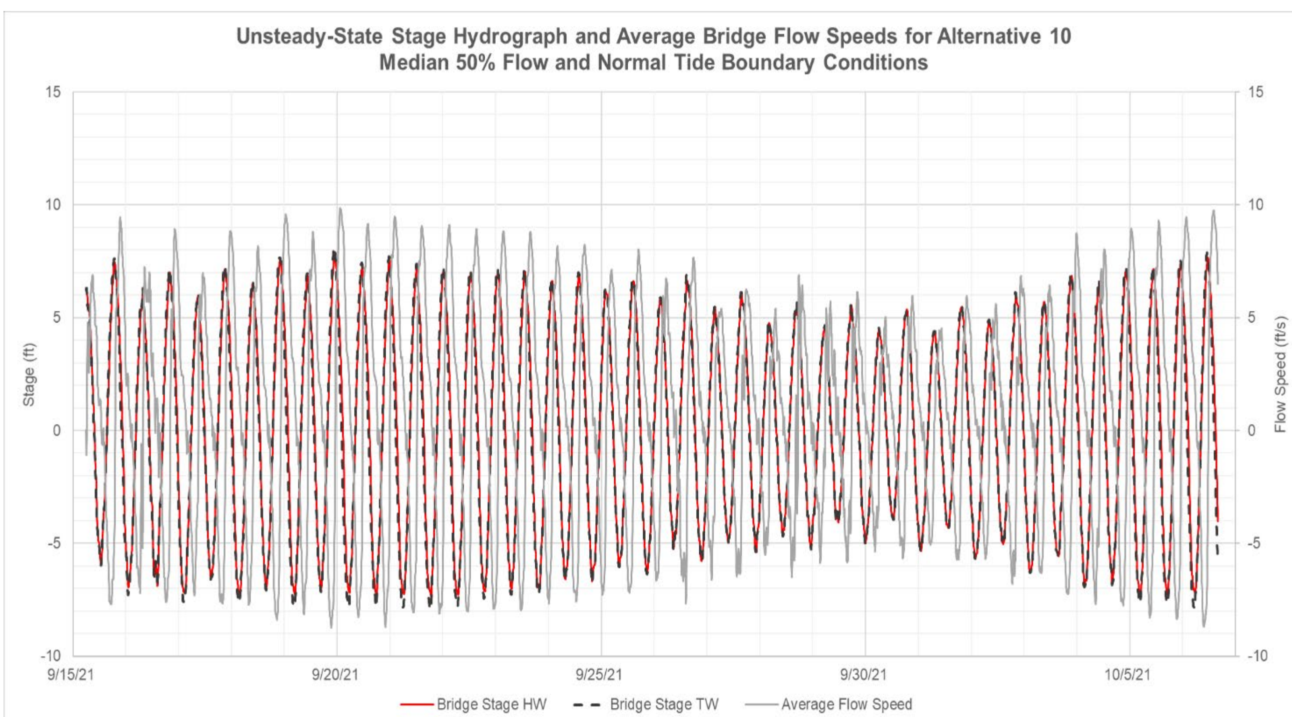
This memo is in response to the Maine Historic Preservation Commission's request for more information on the subject project, dated December 28, 2022. The MaineDOT consulted with Stantec, who provided this information in the December 21, 2021, memo from Stantec to MaineDOT ("Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services"). The report is attached to this memo for reference.

Q: What SLR scenarios were considered during the hydraulic study?

A: Unsteady-state modeling of conditions with 1.5 feet (ft) and 3.9 ft of SLR on the normal tide hydrograph based on the updated tidal stage data collected by MaineDOT in 2021 with the 50^{th} percentile (median), 1.1-year, and 10-year flows in the Middle River.

Q: Did the MaineDOT explore SLR scenarios with astronomical high tides for the existing structure and each of the proposed alternatives?

A: The two SLR scenarios (1.5 ft and 3.9 ft) were used to evaluate potential impacts of SLR with normal tides by linearly applying (adding elevation) the two SLR scenarios to tidal stage data collected by MaineDOT in 2021.



The dashed gray line in the graph above reflects the 2021 tidal stage data collected by MaineDOT that was used to force the hydraulic model and depicts a series of higher astronomical tides around 9/20/21 and 10/6/21. Note that the hydraulic model simulations were constrained to using actual tidal stage data collected by MaineDOT and did not attempt to identify the highest annual tide/highest astronomical tide.

Q: What is the water level difference between the existing high tides and expected high tides under the various alternatives?

A: Information relevant to this question is presented in Tables 6 (Current (2021) conditions, 7 (1.5 ft SLR) and 8 (3.9 ft SLR) in Stantec's 2021 report (page 13). The question has been addressed with and without SLR, but the table below specifically addresses SLR. The referenced tables provide information only on Existing Conditions, Alternative 4M, and Alternative 10. The table below provides a preliminary assessment based on the information provided above (positive values in the "difference" column are increased/higher water surface elevations). For reference, the representative elevation of the Trotting Track is approximately 3 ft.

	Current Conditions	**1.5 ft SLR**		**3.9 ft SLR**	
Middle River Flow	***Median Flow***	***Median Flow***		***Median Flow***	
Scenario	Max WSEL (ft, NAVD88)	Max WSEL (ft, NAVD88)	*Difference from Current Conditions (ft)*	Max WSEL (ft, NAVD88)	*Difference from Current Conditions (ft)*
Existing Conditions	-0.5	0.1	*0.6*	5.4	*5.9*
Alternative 4M	2.1	2.7	*0.6*	3.9	*1.8*
Difference from Current Conditions (ft)	***2.6***				
Alternative 10	7.9	9.3	*1.4*	11.7	*3.8*
Difference from Current Conditions (ft)	***8.4***				

Q: What is the existing water level difference at astronomical high tides with accounting for SLR?

A: This information is summarized in the table above and can be found in Tables 6, 7, and 8 in the attached Stantec report (page 13). For the simulation period from 9/20/21 and 10/6/21, Alternative 4M results in an increase in WSELs landward (upstream) from the Dike Bridge of 2.6 ft and Alternative 10 results in an increase in WSELs landward (upstream) from the Dike Bridge of 8.4 ft.

Q: Please confirm the proposed vertical alignment height for all alternatives, including the causeway.

A: The proposed conceptual profiles for the culvert and bridge alternatives are summarized for minimum and maximum SLR scenarios developed to date in the table below. Also included is the relative change compared to existing conditions at key locations along the causeway, (at the proposed structure, at the high-point or low-point for min/max SLR).

Alternative	Existing Causeway Elevation (ft)	Minimum Conceptual Sea-Level Rise Causeway Profile (EL in ft)	Maximum Conceptual Sea-Level Rise Causeway Profile (EL in ft)	Relative Elevation Change (current condition to conceptual profile)
Culverts (Alt 1, 4, 4M, 9)	~EL. 12.0 ft in existing timber culvert location (Elevation of causeway is relatively flat with finished grade varying between EL. 11.0 and 12.0 ft) and 13.0-13.5 ft just beyond the end of the causeway	Finished Grade ~EL. 14.5 at conceptual culvert location and high point at EL 15.6 near middle of causeway. The profile ties into existing grade (~EL. 12.0) near Helens on the West end of causeway and low point (EL. 13.2) near mini mall drive at the East end of the causeway.	Finished Grade ~EL. 17.0 at conceptual culvert location and high point at EL 18.2 near middle of causeway. The profile ties into existing grade (~EL. 12.0) near Helens on the West end of causeway and low point (EL. 15.7) near mini mall drive at the East end of the causeway.	At Conceptual Culvert = 2.5 ft with min SLR and 5 ft with max SLR Max = ~ 4.1 ft with min SLR and ~6.7 ft at high-point of profile (EL 18.2) At low point near mini mall – 0.2 ft with min SLR and ~2.3 ft with max SLR
Bridge (Alt 10)		Finished Grade EL. 19.0 at conceptual Bridge location. The profile ties into existing grade (EL 12.0) near Helens on the West end of causeway and low point (EL. 13.2) near mini mall drive at the East end of the causeway.	Finished Grade EL. 19.0 at conceptual Bridge location. The profile ties into existing grade (EL 12.0) near Helens on the West end of causeway and low point (EL. 15.7) near mini mall drive at the East end of the causeway.	At conceptual bridge location = 7 ft with min and max SLR At low point near mini mall – 0.2 ft with min SLR and ~1.0 ft with max SLR. At max SLR the causeway has a more consistent raise of ~5.0 ft

Please contact me at Julie.Senk@maine.gov or 592-3486 if you have any questions. Thank you.

cc: CPD e-file
enc: Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services (Stantec 2021)

Stantec

Memo

2/17/2022 MICHAEL R. CHELMINSKI No. 10320 STATE OF MAINE LICENSED PROFESSIONAL ENGINEER

PHASE 2 MEMO

To:	MaineDOT	From:	Michael R. Chelminski, P.E. Gordon E. Clark
Project/File:	179450347	Date:	December 20, 2021

Reference: Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services

1.0 INTRODUCTION

This memo was prepared by Stantec Consulting Services Inc. (Stantec) under contract to the Maine Department of Transportation (MaineDOT) for Planning Phase Support Services (2020-2021 Planning Study) as part of the Dike Bridge Replacement Project (Project) located on the Middle River in Machias, Maine. MaineDOT is pursuing replacement of the existing infrastructure at Dike Bridge due to its poor condition with the objectives to provide adequate drainage from upland floods without overtopping the Route 1 roadway, provide adequate freeboard during tidal flood events, provide sea-level-rise resiliency, and accommodate fish passage to the extent practicable.

As part of this scope of services for the 2020-2021 Planning Study, Stantec performed hydraulic analyses to assess hydraulic conditions associated with replacement alternatives for the Dike Bridge culvert. The first phase (Phase 1) of the hydraulic analyses included assessment of hydraulic conditions associated with five primary replacement alternatives for the Dike Bridge culvert, which is documented in the “Phase 1 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services” dated September 2021 (Phase 1 Study). Phase 2 of the hydraulic analyses builds on the previous work completed as part of Phase 1 and includes evaluation of hydraulic performance across a wider range of conditions for two refined alternatives (Alternative 4m - larger partially gated box culverts and Alternative 10 - 120 ft bridge). This memo documents the **second phase** (Phase 2) of the hydraulic analysis for the 2020-2021 Planning Study (Phase 2 Study), including the methodology and results of the hydraulic modeling for the primary replacement alternatives. Implications on upstream (landward) fish passage into the Middle River through the refined alternatives, preliminary recommendations for scour countermeasures, and evaluation of potential impacts and sediment management approaches related to development of a new channel in the landward area for the bridge alternative are discussed.

Appendix A contains the unsteady-state stage hydrograph simulation results from the hydraulic model. Appendix B contains figures that depict mapped water surface elevations[1] (WSELs) along the Middle River upstream from Dike Bridge for the refined alternatives. Appendix C contains a conceptual sketch of the anticipated channel in the landward embayment and in the expected footprint of the existing embankment of Dike Bridge for estimating impacts to regulated resources and construction costs. Appendix D contains figures depicting the U.S. Army Corps of Engineers (USACE) navigation channel bathymetry on the seaward side of Dike Bridge.

[1] Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88).

2.0 BACKGROUND[2]

The proposed hydraulic studies for the 2020-2021 Planning Study are focused on evaluating potential alternatives relative to regulatory agency request for improved upstream fish passage, and potential analysis and channel design needs for replacement of the existing culverts with a bridge structure. The Project hydraulic analyses include a two-phased hydraulic analysis approach. Phase 1 is presented in the September 2021 Phase 1 Study Memo. Phase 1 of the hydraulic analysis was performed for the five primary alternatives and simulated the following conditions:

1. Unsteady-state modeling of conditions with normal tide data as represented by tidal stage data collected by MaineDOT in 2011 with the 50th percentile (median) flow in the Middle River;
2. Unsteady-state modeling of conditions with normal tide data as represented by tidal stage data collected by MaineDOT in 2011 with the 1.1-year (Q1.1) and 10-year (Q10) riverine flow conditions for the bridge replacement alternative only (Alternative 10); and
3. Steady-state modeling of the 100-year (Q100) peak flow in the Middle River with mean high water (MHW) and mean low water (MLW) downstream boundary conditions.

The Phase 2 of the hydraulic analyses was performed for the two refined alternatives that were identified by MaineDOT following the Phase 1 Study. The Phase 2 hydraulic model simulations were developed for the following conditions:

1. Unsteady-state modeling of conditions with normal tide data as represented by updated tidal stage data collected by MaineDOT (2021) with the 50th percentile (median), 1.1-year, and 10-year flows in the Middle River;
2. Unsteady-state modeling of conditions with 1.5 feet (ft) and 3.9 ft of sea-level rise (SLR) on the normal tide hydrograph based on the updated tidal stage data collected by MaineDOT in 2021 with the 50th percentile (median), 1.1-year, and 10-year flows in the Middle River;
3. Unsteady-state modeling of conditions with the 100-year tidal surge for high tide with the 1.1-year and 10-year flows in the Middle River;
4. Unsteady-state modeling of conditions with 1.5 ft and 3.9 ft of SLR on the 100-year tidal surge for high tide with the 1.1-year and 10-year flows in the Middle River; and
5. Steady-state modeling of the 50-year (Q50) and 100-year peak flows in the Middle River with MHW and MLW downstream boundary conditions.

Phase 2 hydraulic analyses included updates to the normal tidal regime used for Phase 1, which was based on 2011 tidal data collected by MaineDOT, with tidal data collected by MaineDOT in 2021. The normal tidal regime data were used in both the Phase 1 Study and Phase 2 Study for establishing a baseline for existing conditions and for simulation of the evaluated alternatives. Interim repairs to the Dike Bridge culvert flap gates by MaineDOT in August 2021 prompted MaineDOT to collect updated tidal stage data in the Middle River upstream and in the Machias River downstream (seaward) from Dike Bridge. The tidal stage data collected by Maine DOT in 2021 were used to recalibrate the existing conditions Phase 2 hydraulic model (see Section 3.4) to establish baseline conditions across the simulation scenarios.

The objective of the Phase 2 hydraulic analyses is to build on the work completed as part of Phase 1 and include assessment of the refined alternatives for the following:

---

[2] For additional Project background information refer to Section 1.0 in the September 2021 Phase 1 Study Memo.

Reference: Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services

1. Potential improvements to upstream fish passage at Dike Bridge (e.g., duration of advective landward fish passage relative to existing conditions, typical flow speeds through structure opening, water depths at lower tides);
2. Changes in water surface elevations (WSELs) landward from Dike Bridge (e.g., areas of land that would be inundated if normal tidal exchange results in higher typical WSELs);
3. Hydraulic performance for the 100-year high tide surge scenario (e.g., overtopping, freeboard)
4. Changes in hydraulic characteristics and performance as a result of SLR (e.g., upstream fish passage criteria, changes in WSELs landward from Dike Bridge, overtopping and freeboard);
5. Preliminary scour countermeasure design (e.g., stable riprap sizing); and
6. Potential impacts and preliminary sediment management approaches related to development of a new channel in the landward area for the bridge alternative as well as considerations for the area immediately seaward of the proposed bridge location.

The Phase 2 Study includes evaluation of 1) existing conditions and 2) two refined alternatives. The two refined alternatives were identified following review of the work performed as part of Phase 1 and represent MaineDOT's two refined alternative approaches for a replacement structure at Dike Bridge. Stantec developed the 2020-2021 Alternatives Matrix (Matrix), which provides a comprehensive overview of replacement alternatives for the Project. For information related to how the refined alternatives align with the Matrix, refer to the September 2021 Phase 1 Study Memo. For details related to the parameterization of the geometries of the refined alternatives for the hydraulic model, refer to Section 3.2 in this memo.

3.0 METHODOLOGY

Hydraulic modeling simulations of existing conditions and the refined alternatives were performed using the numerical, hydraulic model that Stantec developed as part of Phase 1 of the 2020-2021 Planning Study and builds on previous work (refer to the September 2021 Phase 1 Study Memo for information related to previous methodologies). The Phase 2 Study included evaluations with steady- and unsteady-state flow regimes. The following sections document the development of the hydraulic model, including the geometric data, boundary conditions, flow regimes, and model scenarios.

3.1 HYDRAULIC MODEL

A one-dimensional, steady- and unsteady-state numerical hydraulic model (Model) was developed using HEC-RAS (v. 5.0.7) for the Phase 2 Study, which includes integration of automated flap-gate routines on culvert structures. Hydraulic studies performed prior to those as part of the 2020-2021 Planning Study used an earlier version of HEC-RAS, which did not include integration of automated flap-gate routines on culvert structures.

One shortcoming of the integrated flap-gate routines is the inability to assign individual culverts flap-gates within a group of culverts in an inline structure. The flap-gate routines can either be assigned to none of the culverts or all the culverts. Alternative 4m includes bidirectional flow (i.e., no flap-gate) on one culvert barrel with flap-gates on the remaining two culvert barrels. To apply the flap-gate routines in the Model, a "dummy reach" was developed that represented a cloned parallel reach that extends approximately 500 ft upstream and 200 ft downstream of Dike Bridge. Additional details related to this geometry modification are documented in Section 3.2 (Geometry Data) in this memo.

3.2 GEOMETRY DATA

Geometric data for the Phase 2 Study Model was developed using bathymetric and topographic data provided by MaineDOT, including a limited number of bathymetric transects surveyed by MaineDOT before 2014 and augmented with bathymetric data collected in the Middle River by MaineDOT in 2021 after substantial completion of the Phase 1 Study. In addition, minor modifications to geometry transects were incorporated in the Model to increase the numerical stability during unsteady-state simulations of low-flow conditions. Normal ineffective flow areas were parameterized along the approximate top of banks along the Middle River landward from Dike Bridge. Note that normal ineffective flow areas landward of Dike Bridge upstream of the recommended expansion/contraction ineffective flow areas (see HEC-RAS documentation) were not included in the Phase 1 Study hydraulic model, but were identified during the Phase 2 Study modeling as beneficial to improving model stability and accuracy and were included as part of the Phase 2 Study.

A "dummy-reach" (Dummy Reach) was inserted to connect upstream and downstream of Dike Bridge (bifurcated geometry). This created two parallel reaches, which provided the ability to model the bidirectional flow culvert as part of Alternative 4m while still using the integrated culvert flap-gate routines. Alternative 10 was evaluated using a single thread channel. For additional information related to the bifurcated geometry approach, including a schematic overview of the Model geometry with the parallel reaches at Dike Bridge, refer to the September 2021 Phase 1 Study Memo.

The following sections document the geometric data for the Phase 2 Study Model, representing a total of three different geometries that correspond to the existing condition geometry and the two refined alternative geometries. For information related to the development of the geometric data for the Model used in the rest of the domain, refer to the September 2021 Phase 1 Study Memo.

3.2.1 Existing

The existing conditions geometry ("ex"[3]) was based on the bifurcated geometry approach that includes the cloned, dummy reach. The bifurcated geometry approach was used primarily to facilitate model calibration and for consistency of approaches across the Model simulations, since Alternative 4m also was based on the bifurcated geometry approach. The roadway embankment was modeled as two inline structures, one on each parallel reach, with one box culvert fitted with a flap-gate on Parallel Reach 1 and three box culverts fitted with flap-gates on Parallel Reach 2. The four box culverts have top-hinged flap-gates installed on the seaward side of each of the four culverts. The existing culverts and flap-gates are deteriorated, which results in partial blockage of the culverts and leakage. The integrated flap-gate routines in HEC-RAS do not allow for leakage. To accommodate leakage, a 0.35 ft high by 17 ft wide opening with the invert at -4.1 ft was used in the Model with no flap-gate for the duration of the simulation. The geometry of this "leakage opening" was determined based on an iterative calibration process comparing the simulation data to the observed data (see Section 3.4) and varied slightly from the leakage opening that was 12 ft wide as part of the Phase 1 Study.

The existing conditions culverts were modeled with heights of 4 ft and widths of 5 ft, with the culvert inverts at elevation -3.1 ft. Culvert invert selection was based on review of survey data provided by MaineDOT, including elevations of the culvert inverts. The reduced culvert heights and invert elevations were used to address apparent blockages in the bottoms of the culverts (e.g., stone, debris) as determined from bridge inspection reports provided by MaineDOT and result in the Model's culvert inverts being approximately one foot higher than the average surveyed invert elevations of -4.05 ft. The existing culverts were modeled as 130 ft long with an entrance loss coefficient of 0.5 and an exit loss coefficient of 1. Manning's n values in the culvert were set at 0.018 to represent some of the debris and additional roughness within the culverts due to their existing condition. The culverts were modeled using the FHWA Chart #16 (corrugated metal box culvert) and Scale #1 (90-degree headwall), which was determined to be most representative of existing conditions. Ineffective flow

[3] Abbreviations in quotes are provided for clarity as they are combined in the HEC-RAS Plan file names that are depicted on graphics in this memo.

areas were defined within the upstream and downstream cross-sections adjacent to the bridge at an approximately one-to-one aspect ratio.

3.2.2 Alternative 4m

The Alternative 4m geometry ("alt04m") was based on the bifurcated geometry approach. The roadway embankment was modeled as two inline structures, one on each parallel reach, with one box culvert (no flap-gates) on Parallel Reach 1 and two box culverts fitted with flap-gates on Parallel Reach 2. The Alternative 4m culvert on Parallel Reach 1 was modeled with a height of 5 ft, width of 10 ft, and the invert of the culvert at elevation -6.05 ft. Alternative 4m culverts on Parallel Reach 2 were modeled with heights of 5 ft, widths of 10 ft, and the inverts at -4.05 ft.

Based on preliminary analysis results and discussion with MaineDOT on March 29, 2021, it was decided that the box culvert heights should be reduced from 10 ft to 5 ft to better match the overall opening to hydraulic conveyance needs (i.e., reduce landward flows during flood tides) and reduce landward water surface levels. The open culvert invert was lowered with the intent of further improving fish passage for a wider range of tidal flows and the 10-ft width was maintained to address fish injury concerns. The Manning's n for the culverts were assumed to be the same for the top and bottom at 0.012. A 130-ft culvert length was used with an entrance loss coefficient of 0.5 and an exit loss coefficient of 1. The culverts were modeled using the FHWA Chart #10 Scale #1 approach corresponding to 90-degree headwall with inlet edges chamfered three-quarters of an inch. Ineffective flow areas were defined within the upstream and downstream cross-sections adjacent to the bridge at an approximately one-to-one aspect ratio.

3.2.3 Alternative 10

The Alternative 10 geometry ("alt10") uses a single thread channel instead of the bifurcated geometry approach. The roadway embankment was modeled as a bridge structure with a deck/roadway. The Alternative 10 bridge was modeled with bridge span of 120 ft and a clear span of 116.5 ft and a low-chord elevation of 13.1 ft. Sloping, spill-through type abutments were defined at slopes of 1.75 horizontal to 1 vertical (1.75H:1V) and 2-ft-wide benches at elevations of 10.42 ft to provide access along each abutment adjacent to both bridge abutments. The channel elevation was set at -8.5 ft. The preliminary bridge low-chord elevation was selected to match the Town of Machias' "Phase 1" SLR protection plans to be above the highest astronomical tide (HAT) elevation of 9.8 ft and the Federal Emergency Management Agency (FEMA) Base Flood Elevation (BFE) of 10.7 ft plus a freeboard allowance for at least 1.5 ft of SLR. This results in a roadway grade raise of approximately 7 ft in the bridge area. Modeling of this alternative included changes to some of the HEC-RAS cross sections in the Middle River upstream (landward) from Dike Bridge to have a lower and more defined channel. These geometric changes were made to improve the numerical stability of the unsteady-state HEC-RAS model and reflect expected erosion of sediment in the Middle River if a bridge were installed at Dike Bridge. The bridge was modeled using the Energy (Standard Step) approach in the bridge routines. Ineffective flow areas were defined within the upstream and downstream cross-sections adjacent to the bridge at an approximately one-to-one aspect ratio.

3.3 BOUNDARY CONDITIONS

Boundary conditions for the Model included both steady- and unsteady-state regimes, which are documented in the following sections.

3.3.1 Steady-State Boundary Conditions

The upstream[4] boundary conditions for steady-state simulations as part of the 2020-2021 Planning Study included the 50- and 100-year peak flows. Peak flows were calculated and provided by MaineDOT and are referenced in previous studies (see the September 2021 Phase 1 Study Memo). Peak flows for steady-state boundary conditions at Dike Bridge and Stride Bridge[5] used in the Model are presented in Table 1. The steady-state upstream flows were input to the Model at locations landward of Stride Bridge and Dike Bridge. Under steady-state conditions, these upstream, inland flows are simulated as a constant flow value (e.g., not a hydrograph) with no attenuation due to potential storage in the Model domain.

Table 1. Drainage areas and peak upland flows for upstream steady-state boundary conditions at Dike Bridge and Stride Bridge

Location	Drainage Area (sq. mi.)	50-Year Return-Interval Event Peak Flow (cfs*)	100-Year Return-Interval Event Peak Flow (cfs)
Stride Bridge	9.41	787	912
Dike Bridge	13.22	832	958

*cfs - “cubic feet per second”

Note that the use of the bifurcated geometry approach resulted in the need to split flow between the two parallel reaches just upstream of Dike Bridge. The initial conditions flows at the upstream junction were divided equally in half for the steady-state modeling and then recombined at the junction downstream of Dike Bridge. Flow splits at the Model junctions were then calculated by the HEC-RAS model.

The downstream boundary conditions for the steady-state flow simulations were set at the downstream (seaward) limit of the Model assuming constant values of 6.1 ft for MHW and -6.6 ft for MLW. See the September 2021 Phase 1 Study Memo for additional information related to the basis for these downstream boundary conditions, including tidal statistics tables.

3.3.2 Unsteady-State Boundary Conditions

The following section documents the unsteady-state upstream and downstream boundary conditions for the Phase 2 Study.

3.3.2.1 Upstream Boundary Conditions

The upstream boundary conditions for the unsteady-state simulations included peak flow values for the annual median flow (i.e., 50% flow duration annual exceedance), 1-year peak flow (note the 1.1-year or the peak flow with an annual exceedance of 0.91 [91%] is used as representative of the 1-year peak flow), and the 10-year

[4] “Upstream” and “downstream” are used in this report to describe the HEC-RAS model boundary conditions for consistency with boundary condition references in the HEC-RAS documentation. For reference, upstream generally refers to the landward direction and downstream generally refers to seaward direction.
[5] Stride Bridge is located landward from Dike Bridge and is included in the project HEC-RAS model that was developed for a previous study of Dike Bridge. Alternatives at Stride Bridge were not evaluated as part of the 2020-2021 Planning Study.

peak flow (i.e., annual exceedance probability of 0.1 [10%]). Upstream boundary conditions are summarized in Table 2 below.

Table 2. Peak upland flows for upstream unsteady-state boundary conditions

Location	Return-Interval Event (Years) / Peak Flow (cfs)		
	50% Median Flow	**1.1**	**10**
Upstream Model Boundary	13.7	152	565

3.3.2.2 Downstream Boundary Conditions

Downstream boundary conditions for "normal tide" conditions used in the unsteady-state simulations included use of tidal stage data collected by MaineDOT at the Project site from mid-August to early October 2021. These data were used as the downstream boundary condition representing typical tidal conditions. The tidal stage data were collected at two locations using datalogging pressure transducers that recorded pressure at 5-minute intervals at locations landward and seaward from Dike Bridge in the Middle River and Machias River, respectively, and post-processed by MaineDOT to develop tidal stage and elevation data. A subset of these data (September 14 to October 6, 2021) were selected for the Phase 2 Study, which represents a range of tide levels typical of this location with high-tide elevations ranging from 4.4 ft to 8.2 ft and low-tide elevations ranging from -3.9 to -8.0 ft. Note that this is compared to 4.5 to 9.0 ft and -4.7 to -7.2 ft for high- and low-tides, respectively, from the 2011 MaineDOT tidal data used as part of the Phase 1 modeling. The data subset of the seaward datalogger tide values were used for the downstream boundary condition of the unsteady-state flow model as representing typical, normal tides.

Additional downstream boundary conditions included derivations of this MaineDOT 2021 tidal data set. A summary of downstream boundary condition data used for the Phase 2 Study includes:

1. A normal tidal stage hydrograph based on a selected set of MaineDOT recorded data from September and October 2021 used as "normal tide" boundary conditions;
2. Two future SLR tidal stage hydrographs developed by adding 1.5 and 3.9 ft to the 2021 MaineDOT normal tidal stage hydrograph data;
3. A 100-year high tide surge stage hydrograph based on a subset of the 2021 MaineDOT tidal stage hydrograph data (for additional details related to the development of the 100-year high tide surge stage hydrograph, refer to Section 3.3.2.3); and
4. Two future SLR, 100-year high tide surge stage hydrographs developed by adding 1.5 ft and 3.9 ft to the 100-year high tide surge stage hydrograph (see item (3) above).

See Table 3 for a summary of the maximum and minimum high tides and low tides across the six downstream boundary conditions.

Table 3. Summary of range of minimum and maximum high- and low-tide stage hydrograph values across the Phase 2 downstream boundary conditions

Downstream Boundary Condition Description	High Tide		Low Tide	
	Minimum	Maximum	Minimum	Maximum
Normal Tide	4.39	8.19	-8.04	-3.94
Normal Tide +1.5 ft SLR	5.89	9.69	-6.54	-2.44
Normal Tide +3.9 ft SLR	8.29	12.09	-4.14	-0.04
100-Year High Tide Surge	4.46	10.70	-7.97	-4.98
100-Year High Tide Surge +1.5 ft SLR	5.96	12.20	-6.47	-3.48
100-Year High Tide Surge +3.9 ft SLR	8.36	14.60	-4.07	-1.08

3.3.2.3 100-Year Tidal Surge Hydrograph Development

A 100-year tidal surge hydrograph was developed to evaluate potential flooding associated with a tidal surge storm event. The tidal surge hydrograph was developed using guidance from MaineDOT, information presented in the report "Technical Report: Middle River Hydrologic and Alternatives Analyses" dated June 30, 2015, that was prepared for MaineDOT by Stantec (Stantec 2015), and information obtained from the current FEMA Flood Insurance Study for the Project area.

Stantec 2015 included development of a 100-year tidal surge hydrograph with a duration of 50 hours and an amplitude of 2.5 ft. This hydrograph was mapped onto tidal stage data collected by MaineDOT in 2021 to generate a synthetic storm surge hydrograph with a maximum water surface elevation of 10.7 ft in the Machias River seaward from Dike Bridge. The basis for selection of a maximum water surface elevation of 10.7 ft is that this is the elevation of the existing FEMA BFE in the Machias River.

3.4 CALIBRATION

The Phase 1 Study hydraulic model was calibrated based on the 2011 MaineDOT tidal data. Due to the updated normal tide downstream boundary condition that uses the 2021 MaineDOT data (see Section 3.3.2.2), the Phase 2 Study Model required recalibration to provide an accurate baseline for the existing conditions scenarios.

The bidirectional "leakage gate" included in the existing conditions geometry (see Section 3.1) allows for landward flow during flood tides, which is apparent in visual observations and the tidal stage data collected by MaineDOT in the Middle River landward from Dike Bridge. Similar to previous calibration efforts, gate parameters within the inline gate editor in HEC-RAS were modified until a satisfactory calibration was achieved that accounted for leakage based on visual comparison of observed and simulated upstream WSELs. Leakage was accounted for in the existing conditions geometry through use of a gate opening with a height of 0.35 ft, a width of 17 ft, and an invert at -4.1 ft (see Section 3.2.1). Figure 1 presents the simulation results of the final calibrated Model for existing conditions with a normal tide and typical riverine flows (i.e., 50% Median Flow) compared to the observed landward data.

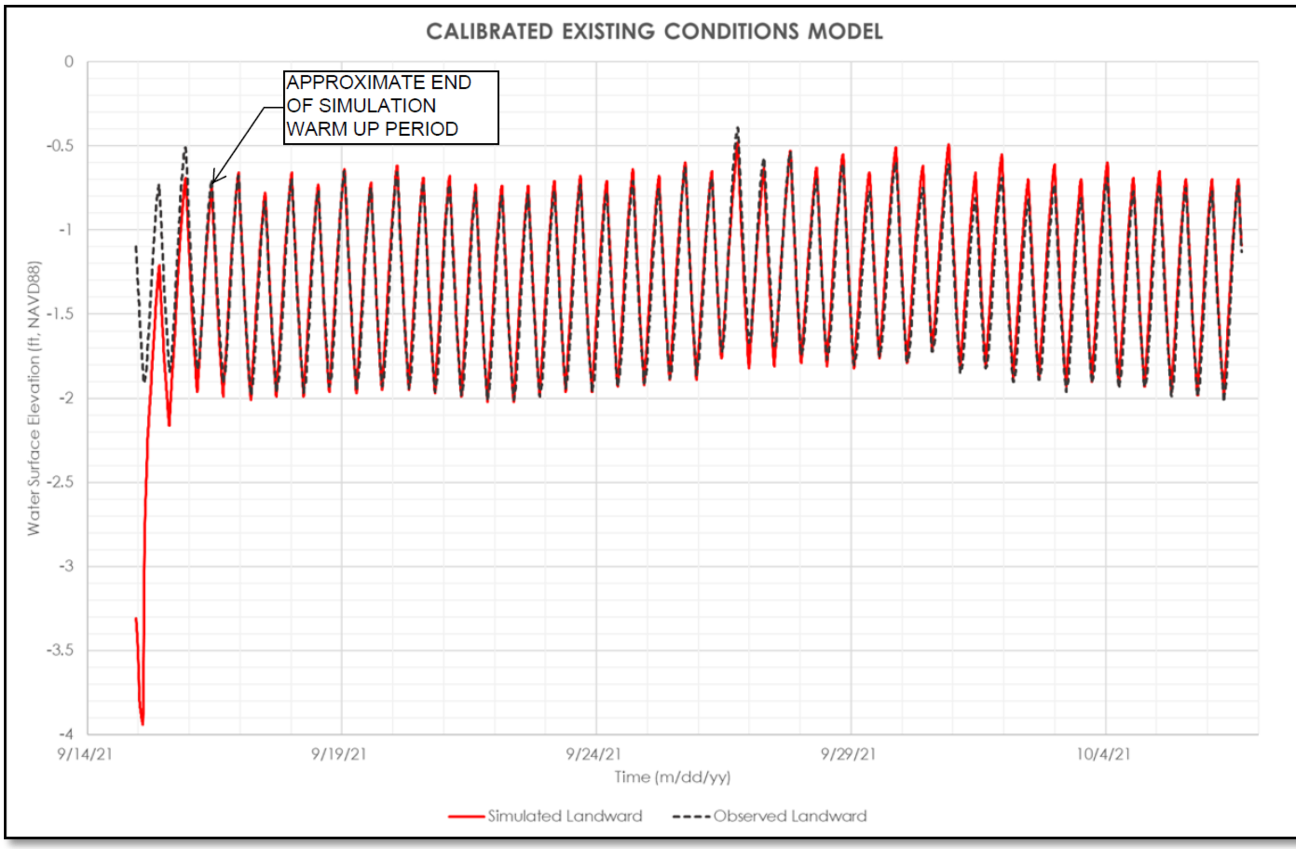


Figure 1. Final calibrated existing conditions Phase 2 Study simulation results compared to observed data

3.5 MODEL SCENARIOS

Hydraulic modeling efforts as part of the Phase 2 Study included 57 independent simulations (Model scenarios) that consisted of the unique geometries (see Section 3.2) and boundary conditions (see Section 3.3) combined together in HEC-RAS "plan" files. These simulations included 12 steady-state and 45 unsteady-state scenarios for a total of 57 plans. Table 4 presents a summary of the model scenarios used as part of the Phase 2 Study and presented in this report including the plan name, geometry name, flow name, and HEC-RAS file names.

Table 4. Summary of unique model scenarios performed as part of the Phase 2 Study

Simulation No.	ScenarioID	Plan Name	Plan File	Geom. Name	Geom. File	Flow Name	Flow File
1	ex_ss_q050_mlw	ex_ss_mlw	2021_machias_phs2.p04	ex	2021_machias_phs1.g01	ss_mlw	2021_machias_phs1.f01
2	ex_ss_q050_mhw	ex_ss_mhw	2021_machias_phs2.p02	ex	2021_machias_phs1.g01	ss_mhw	2021_machias_phs1.f02
3	ex_ss_q100_mlw	ex_ss_mlw	2021_machias_phs2.p04	ex	2021_machias_phs1.g01	ss_mlw	2021_machias_phs1.f01
4	ex_ss_q100_mhw	ex_ss_mhw	2021_machias_phs2.p02	ex	2021_machias_phs1.g01	ss_mhw	2021_machias_phs1.f02
5	alt04m_ss_q050_mlw	alt04m_ss_mlw	2021_machias_phs1.p49	alt04m	2021_machias_phs1.g04	ss_mlw	2021_machias_phs1.f01
6	alt04m_ss_q050_mhw	alt04m_ss_mhw	2021_machias_phs1.p50	alt04m	2021_machias_phs1.g04	ss_mhw	2021_machias_phs1.f02
7	alt04m_ss_q100_mlw	alt04m_ss_mlw	2021_machias_phs1.p49	alt04m	2021_machias_phs1.g04	ss_mlw	2021_machias_phs1.f01
8	alt04m_ss_q100_mhw	alt04m_ss_mhw	2021_machias_phs1.p50	alt04m	2021_machias_phs1.g04	ss_mhw	2021_machias_phs1.f02
9	alt10_ss_q050_mlw	alt10_ss_mlw	2021_machias_phs1.p51	alt10	2021_machias_phs1.g08	ss_mlw-singlethread	2021_machias_phs1.f03
10	alt10_ss_q050_mhw	alt10_ss_mhw	2021_machias_phs1.p52	alt10	2021_machias_phs1.g08	ss_mhw-singlethread	2021_machias_phs1.f04
11	alt10_ss_q100_mlw	alt10_ss_mlw	2021_machias_phs1.p51	alt10	2021_machias_phs1.g08	ss_mlw-singlethread	2021_machias_phs1.f03
12	alt10_ss_q100_mhw	alt10_ss_mhw	2021_machias_phs1.p52	alt10	2021_machias_phs1.g08	ss_mhw-singlethread	2021_machias_phs1.f04
13	ex_us_fd50per_normtide	ex_us_fd50per_normtide	2021_machias_phs2.p03	ex	2021_machias_phs2.g01	us_fd50per_normtide	2021_machias_phs2.u01
14	ex_us_q001_normtide	ex_us_q001_normtide	2021_machias_phs2.p05	ex	2021_machias_phs2.g01	us_q001_normtide	2021_machias_phs2.u02
15	ex_us_q010_normtide	ex_us_q010_normtide	2021_machias_phs2.p06	ex	2021_machias_phs2.g01	us_q010_normtide	2021_machias_phs2.u03
16	ex_us_fd50per_SLR1p5	ex_us_fd50per_SLR1p5	2021_machias_phs2.p09	ex	2021_machias_phs2.g01	us_fd50per_SLR1p5	2021_machias_phs2.u07
17	ex_us_q001_SLR1p5	ex_us_q001_SLR1p5	2021_machias_phs2.p16	ex	2021_machias_phs2.g01	us_q001_SLR1p5	2021_machias_phs2.u11
18	ex_us_q010_SLR1p5	ex_us_q010_SLR1p5	2021_machias_phs2.p25	ex	2021_machias_phs2.g01	us_q010_SLR1p5	2021_machias_phs2.u13
19	ex_us_fd50per_SLR3p9	ex_us_fd50per_SLR3p9	2021_machias_phs2.p10	ex	2021_machias_phs2.g01	us_fd50per_SLR3p9	2021_machias_phs2.u08
20	ex_us_q001_SLR3p9	ex_us_q001_SLR3p9	2021_machias_phs2.p17	ex	2021_machias_phs2.g01	us_q001_SLR3p9	2021_machias_phs2.u12
21	ex_us_q010_SLR3p9	ex_us_q010_SLR3p9	2021_machias_phs2.p26	ex	2021_machias_phs2.g01	us_q010_SLR3p9	2021_machias_phs2.u14
22	ex_us_q001_surge-high	ex_us_q001_surge-high	2021_machias_phs2.p31	ex	2021_machias_phs2.g01	us_q001_surge-high	2021_machias_phs2.u19
23	ex_us_q010_surge-high	ex_us_q010_surge-high	2021_machias_phs2.p32	ex	2021_machias_phs2.g01	us_q010_surge-high	2021_machias_phs2.u20
24	ex_us_q001_surgehigh-SLR1p5	ex_us_q001_surgehigh-SLR1p5	2021_machias_phs2.p37	ex	2021_machias_phs2.g01	us_q001_surgehigh-SLR1p5	2021_machias_phs2.u23
25	ex_us_q010_surgehigh-SLR1p5	ex_us_q010_surgehigh-SLR1p5	2021_machias_phs2.p39	ex	2021_machias_phs2.g01	us_q010_surgehigh-SLR1p5	2021_machias_phs2.u24
26	ex_us_q001_surgehigh-SLR3p9	ex_us_q001_surgehigh-SLR3p9	2021_machias_phs2.p43	ex	2021_machias_phs2.g01	us_q001_surgehigh-SLR3p9	2021_machias_phs2.u27
27	ex_us_q010_surgehigh-SLR3p9	ex_us_q010_surgehigh-SLR3p9	2021_machias_phs2.p46	ex	2021_machias_phs2.g01	us_q010_surgehigh-SLR3p9	2021_machias_phs2.u29
28	alt04m_us_fd50per_normtide	alt04m_us_fd50per_normtide	2021_machias_phs2.p12	alt04m	2021_machias_phs2.g04	us_fd50per_normtide	2021_machias_phs2.u01
29	alt04m_us_q001_normtide	alt04m_us_q001_normtide	2021_machias_phs2.p07	alt04m	2021_machias_phs2.g04	us_q001_normtide	2021_machias_phs2.u02
30	alt04m_us_q010_normtide	alt04m_us_q010_normtide	2021_machias_phs2.p08	alt04m	2021_machias_phs2.g04	us_q010_normtide	2021_machias_phs2.u03
31	alt04m_us_fd50per_SLR1p5	alt04m_us_fd50per_SLR1p5	2021_machias_phs2.p11	alt04m	2021_machias_phs2.g04	us_fd50per_SLR1p5	2021_machias_phs2.u07
32	alt04m_us_q001_SLR1p5	alt04m_us_q001_SLR1p5	2021_machias_phs2.p18	alt04m	2021_machias_phs2.g04	us_q001_SLR1p5	2021_machias_phs2.u11
33	alt04m_us_q010_SLR1p5	alt04m_us_q010_SLR1p5	2021_machias_phs2.p27	alt04m	2021_machias_phs2.g04	us_q010_SLR1p5	2021_machias_phs2.u13

Reference: **Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services**

Simulation No.	ScenarioID	Plan Name	Plan File	Geom. Name	Geom. File	Flow Name	Flow File
34	alt04m_us_fd50per_SLR3p9	alt04m_us_fd50per_SLR3p9	2021_machias_phs2.p13	alt04m	2021_machias_phs2.g04	us_fd50per_SLR3p9	2021_machias_phs2.u08
35	alt04m_us_q001_SLR3p9	alt04m_us_q001_SLR3p9	2021_machias_phs2.p19	alt04m	2021_machias_phs2.g04	us_q001_SLR3p9	2021_machias_phs2.u12
36	alt04m_us_q010_SLR3p9	alt04m_us_q010_SLR3p9	2021_machias_phs2.p28	alt04m	2021_machias_phs2.g04	us_q010_SLR3p9	2021_machias_phs2.u14
37	alt04m_us_q001_surge-high	alt04m_us_q001_surge-high	2021_machias_phs2.p33	alt04m	2021_machias_phs2.g04	us_q001_surge-high	2021_machias_phs2.u19
38	alt04m_us_q010_surge-high	alt04m_us_q010_surge-high	2021_machias_phs2.p34	alt04m	2021_machias_phs2.g04	us_q010_surge-high	2021_machias_phs2.u20
39	alt04m_us_q001_surgehigh-SLR1p5	alt04m_us_q001_surgehigh-SLR1p5	2021_machias_phs2.p38	alt04m	2021_machias_phs2.g04	us_q001_surgehigh-SLR1p5	2021_machias_phs2.u23
40	alt04m_us_q010_surgehigh-SLR1p5	alt04m_us_q010_surgehigh-SLR1p5	2021_machias_phs2.p40	alt04m	2021_machias_phs2.g04	us_q010_surgehigh-SLR1p5	2021_machias_phs2.u24
41	alt04m_us_q001_surgehigh-SLR3p9	alt04m_us_q001_surgehigh-SLR3p9	2021_machias_phs2.p44	alt04m	2021_machias_phs2.g04	us_q001_surgehigh-SLR3p9	2021_machias_phs2.u27
42	alt04m_us_q010_surgehigh-SLR3p9	alt04m_us_q010_surgehigh-SLR3p9	2021_machias_phs2.p47	alt04m	2021_machias_phs2.g04	us_q010_surgehigh-SLR3p9	2021_machias_phs2.u29
43	alt10_us_fd50per_normtide	alt10_us_fd50per_normtide	2021_machias_phs2.p22	alt10	2021_machias_phs2.g08	us_fd50per_normtide-singlethread	2021_machias_phs2.u04
44	alt10_us_q001_normtide	alt10_us_q001_normtide	2021_machias_phs2.p23	alt10	2021_machias_phs2.g08	us_q001_normtide-singlethread	2021_machias_phs2.u05
45	alt10_us_q010_normtide	alt10_us_q010_normtide	2021_machias_phs2.p24	alt10	2021_machias_phs2.g08	us_q010_normtide-singlethread	2021_machias_phs2.u06
46	alt10_us_fd50per_SLR1p5	alt10_us_fd50per_SLR1p5	2021_machias_phs2.p14	alt10	2021_machias_phs2.g08	us_fd50per_SLR1p5-singlethread	2021_machias_phs2.u09
47	alt10_us_q001_SLR1p5	alt10_us_q001_SLR1p5	2021_machias_phs2.p20	alt10	2021_machias_phs2.g08	us_q001_SLR1p5-singlethread	2021_machias_phs2.u15
48	alt10_us_q010_SLR1p5	alt10_us_q010_SLR1p5	2021_machias_phs2.p29	alt10	2021_machias_phs2.g08	us_q010_SLR1p5-singlethread	2021_machias_phs2.u17
49	alt10_us_fd50per_SLR3p9	alt10_us_fd50per_SLR3p9	2021_machias_phs2.p15	alt10	2021_machias_phs2.g08	us_fd50per_SLR3p9-singlethread	2021_machias_phs2.u10
50	alt10_us_q001_SLR3p9	alt10_us_q001_SLR3p9	2021_machias_phs2.p21	alt10	2021_machias_phs2.g08	us_q001_SLR3p9-singlethread	2021_machias_phs2.u16
51	alt10_us_q010_SLR3p9	alt10_us_q010_SLR3p9	2021_machias_phs2.p30	alt10	2021_machias_phs2.g08	us_q010_SLR3p9-singlethread	2021_machias_phs2.u18
52	alt10_us_q001_surge-high	alt10_us_q001_surge-high	2021_machias_phs2.p35	alt10	2021_machias_phs2.g08	us_q001_surge-high-singlethread	2021_machias_phs2.u21
53	alt10_us_q010_surge-high	alt10_us_q010_surge-high	2021_machias_phs2.p36	alt10	2021_machias_phs2.g08	us_q010_surge-high-singlethread	2021_machias_phs2.u22
54	alt10_us_q001_surgehigh-SLR1p5	alt10_us_q001_surgehigh-SLR1p5	2021_machias_phs2.p41	alt10	2021_machias_phs2.g08	us_q001_surgehigh-SLR1p5-singlethread	2021_machias_phs2.u25
55	alt10_us_q010_surgehigh-SLR1p5	alt10_us_q010_surgehigh-SLR1p5	2021_machias_phs2.p42	alt10	2021_machias_phs2.g08	us_q010_surgehigh-SLR1p5-singlethread	2021_machias_phs2.u26
56	alt10_us_q001_surgehigh-SLR3p9	alt10_us_q001_surgehigh-SLR3p9	2021_machias_phs2.p45	alt10	2021_machias_phs2.g08	us_q001_surgehigh-SLR3p9-singlethread	2021_machias_phs2.u28
57	alt10_us_q010_surgehigh-SLR3p9	alt10_us_q010_surgehigh-SLR3p9	2021_machias_phs2.p48	alt10	2021_machias_phs2.g08	us_q010_surgehigh-SLR3p9-singlethread	2021_machias_phs2.u30

4.0 RESULTS

The following sections summarize the hydraulic Model simulation results for the steady- and unsteady-state scenarios.

4.1 STEADY-STATE

A total of 12 steady-state simulations were performed as part of the Study. Table 5 presents a summary of results from the steady-state Model simulations. The results are presented based on the WSELs upstream (US) and downstream (DS) of Dike Bridge.

Table 5. Summary of upstream and downstream WSELs across steady-state simulations. Note that values in parenthesis are WSELs previously reported in the Phase 1 Study that changed as part of the Phase 2 Study*.

Alternative	Q50 with MLW		Q50 with MHW		Q100 with MLW		Q100 with MHW	
	US WSEL (ft)	DS WSEL (ft)	US WSEL (ft)	DS WSEL (ft)	US WSEL (ft)	DS WSEL (ft)	US WSEL (ft)	DS WSEL (ft)
Existing Conditions	1.6	-6.6	7.5	6.1	1.9 (5.9)	-6.6	8.0 (10.9)	6.1
Alternative 04m	0.1	-6.6	6.6	6.1	0.5 (0.8)	-6.6	6.8 (7.3)	6.1
Alternative 10	-4.9	-6.8	6.1	6.1	-4.6 (-5.0)	-6.7	6.1 (6.1)	6.1

*Note: Some values in this table were updated during the Phase 2 Study reporting and reflect some differences from the Phase 1 Study reporting.

Note that the Phase 1 Study included evaluation of the 100-year peak flow scenario for these three alternatives and reported values that varied from those reported herein. Apparent differences in reported values between the Phase 1 and Phase 2 modeling are due to 1) a recalibrated existing conditions model, 2) updated bathymetric data, and 3) more extensive use of ineffective flow areas landward of Dike Bridge along the Middle River identified during Phase 2 to improve model stability and accuracy.

4.2 UNSTEADY STATE

A total of 45 unsteady-state simulations were performed as part of the Phase 2 Study. Appendix A contains figures representing the stage hydrograph simulation outputs. The observed MaineDOT 2021 stage data landward of Dike Bridge was included in the flow stage hydrographs, with the exception of the scenarios that included the 100-year high tide surge downstream boundary condition with and without SLR, to compare differences between the exiting and proposed scenarios.

Maximum upstream and downstream WSELs and the total change between these values were calculated for each of the modeled scenarios. In addition, the percentage of time flow was being conveyed landward (i.e., flows moving from the sea [downstream] towards land [upstream]) at Dike Bridge were calculated based on the simulation results. The maximum WSELs in the Middle River and upstream WSEL range for the normal tide, normal tide with 1.5 ft of SLR, and normal tide with 3.9 ft of SLR downstream boundary conditions are presented in Tables 6, 7, and 8, respectively. A summary of maximum upstream WSELs from the unsteady-state simulations for the 100-year surge for high tide is presented in Table 9. Percentage of time of landward flow for the duration of the simulation are presented in Table 10. For discussion related to the results presented in this section, see Section 5.0.

Reference: **Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services**

Table 6. Summary of maximum, minimum, and maximum range of WSELs from the unsteady-state simulations for the normal tide downstream boundary conditions

Alternative	Median Flow			Q1.1-Year			Q10-Year		
	Max US WSEL	Min US WSEL	Range	Max US WSEL	Min US WSEL	Range	Max US WSEL	Min US WSEL	Range
Existing Conditions	-0.5	-2.0	1.5	1.4	-0.2	1.6	5.2	3.5	1.7
Alternative 4m	2.1	-3.2	5.3	2.7	-2.1	4.8	4.1	0.3	3.8
Alternative 10	7.9	-7.4	15.3	7.9	-6.9	14.8	8.0	-5.5	13.4

Table 7. Summary of maximum, minimum, and maximum range of WSELs from the unsteady-state simulations for the normal tide plus 1.5 ft of SLR downstream boundary conditions

Alternative	Median Flow			Q1.1-Year			Q10-Year		
	Max US WSEL	Min US WSEL	Range	Max US WSEL	Min US WSEL	Range	Max US WSEL	Min US WSEL	Range
Existing Conditions	0.1	-1.7	1.8	1.9	0.2	1.7	5.9	4.3	1.6
Alternative 4m	2.7	-2.2	4.9	3.3	-1.2	4.5	4.7	1.3	3.5
Alternative 10	9.3	-6.3	15.7	9.4	-6.2	15.5	9.4	-5.2	14.6

Table 8. Summary of maximum, minimum, and maximum range of WSELs from the unsteady-state simulations for the normal tide plus 3.9 ft of SLR downstream boundary conditions

Alternative	Median Flow			Q1.1-Year			Q10-Year		
	Max US WSEL	Min US WSEL	Range	Max US WSEL	Min US WSEL	Range	Max US WSEL	Min US WSEL	Range
Existing Conditions	5.4	-0.6	6.0	6.2	1.3	4.9	9.0	5.6	3.5
Alternative 4m	3.9	-0.5	4.4	4.4	0.4	4.0	6.1	3.1	3.0
Alternative 10	11.7	-3.9	15.6	11.7	-3.8	15.6	11.8	-3.5	15.2

Table 9. Summary of maximum upstream WSELs from the unsteady-state simulations for the 100-Year surge for high tide

Alternative	Q1.1-Year	Q10-Year	Q1.1-Year (1.5 ft SLR)	Q10-Year (1.5 ft SLR)	Q1.1-Year (3.9 ft SLR)	Q10-Year (3.9 ft SLR)
	Max US WSEL	Max US WSEL	Max US WSEL	Max US WSEL	Max US WSEL	Max US WSEL
Existing Conditions	1.5	5.5	5.5	7.8	14.6	14.6
Alternative 4m	3.1	4.5	3.6	5.1	4.5	6.1
Alternative 10	10.1	10.1	11.5	11.6	13.9	13.9

Table 10. Summary of percent landward flow for typical, median (50%) riverine flows and normal tide downstream boundary conditions

Alternative	Normal Tide	Normal Tide +1.5 ft SLR	Normal Tide +3.9 ft SLR
Existing Conditions	57%	63%	68%
Alternative 4m	53%	57%	62%
Alternative 10	44%	46%	48%

4.3 INUNDATED LAND FOR NORMAL TIDAL AND RIVER FLOW CONDITIONS

This section summarizes areas of inundated land upstream from Dike Bridge for the two refined alternatives based on 1) an elevation-area relationship (stage-area curve) and 2) the unsteady-state simulation results for the maximum WSELs during normal tidal and riverine flow conditions from the Phase 2 Study (see Table 6). Reference Appendix B for figures that depict WSEL contours for selected conditions for the Phase 2 Study alternatives in the area adjacent to the Middle River upstream from Dike Bridge.

The stage-area curve is presented in the September 2021 Phase 1 Study Memo and was developed using the existing terrain model that was compiled for the Phase 2 Study Model. Refer to the September 2021 Phase 1 Study memo for details related to the stage-area curve development.

Table 11 presents the maximum upstream WSELs for normal tidal and riverine flow conditions based on the stage-area curve relationships. The “Increased Inundation Area” in Table 11 reflects estimated inundated areas in the Middle River with normal tidal and riverine flow conditions upstream from Dike Bridge above elevation 0.0 ft and exclusive of the existing, regularly inundated area (~33 acres). Table 11 depicts an inundation area based on 1) tidal stage data in the Middle River collected by MaineDOT in 2021 and 2) additional bathymetric data collected by MaineDOT in 2021.

Table 11. Inundated areas and increased inundated areas for maximum upstream WSELs for normal tidal and riverine flow conditions

Alternative	Max US WSEL (ft)	Inundation Area (acres)	Increased Inundation Area (acres)
Existing Conditions	-0.5	32.7	n/a
Alternative 4m	2.1	119	86
Alternative 10	7.9	431	398

4.4 FISH PASSAGE

Hydraulic parameters related to fish passage, including flow speed and depth of flow, were evaluated for the bridge alternative (Alternative 10) based on the results of the model simulations. Results from this evaluation are presented in this section and are relevant to discussion of fish passage for the refined alternatives as part of the Project.

Flow speeds were calculated by dividing the discharge through the bridge with a representative (average) area through the prismatic, trapezoidal cross-sectional geometry at the bridge opening. Note that this approach results in a depth-averaged flow speed and does not account for variations in flow speed within the water column or laterally across the channel. Although more complex modeling approaches (e.g., two- or three-dimensional modeling) and/or physical modeling could assist in achieving a higher precision of flow distribution, the modeling approach used for this study with the accompanying assumptions and limitations was considered suitable for providing a general evaluation of bridge hydraulics that meet the needs of the Project.

The percent exceedance of average flow speeds for the modeled bridge alternatives are presented in Table 12 for the full tidal spectrum (i.e., All Flows), landward flows only (i.e., Landward), and seaward flows only (i.e., Seaward). In general, the flow speeds for the seaward flows were slightly greater than those for the landward flows, which is expected since the current is not working against the downstream riverine flows. However, the differences were very small and were not significantly different.

Table 12. Summary of average flow speed (feet per second [ft/s]) percent exceedance distributions through the Alternative 10 bridge opening for median (50%) riverine flows and normal tide boundary conditions for landward flows only, seaward flows only, and all flows for the simulation duration.

Percent Exceedance	Landward (ft/s)	Seaward (ft/s)	All Flows (ft/s)
95%	7.9	8.8	8.4
90%	7.5	8.1	7.8
75%	6.3	6.5	6.4
50%	4.2	4.1	4.1
25%	1.7	2.0	1.9
10%	0.5	0.8	0.6

Reference: Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services

Figure 2 graphically depicts the information in Table 12 for seaward flows, since these flows correspond with upstream fish passage conditions. Fish passage maximum swimming speed criteria[6] are also presented in Figure 2, which are based on general categories of strong, moderate, and weak swimming species with maximum flow speed criteria of 12 ft/s, 6 ft/s, and 3 ft/s, respectively. In addition, an all-species criterion of 0.75 ft/s as additionally suggested by Project stakeholders as part of the Project planning phase is included.

Figure 3 and Figure 4 present the unsteady-state stage hydrograph for the full simulation time frame as well as for a select two-day tidal cycle for Alternative 10 with bridge headwater (HW), tailwater (TW), and average flow speeds through the bridge span for median annual (i.e. 50% exceedance) riverine flows and normal tidal boundary conditions. The two-day tidal cycle presented in Figure 4 is useful for examining the relationship between headwater and tailwater with flow speed. Negative flow speeds represent flow landward (upstream) and positive flow speeds represent flow seaward (downstream). The greatest flow speeds for each tidal cycle occur during the ebb tide when the difference in headwater and tailwater are the greatest. Similarly, the second greatest flow speed occurs during the flood tide. This is also reflected in the differences in the 95% exceedance flows comparing seaward and landward flow speeds in Table 12, since the seaward flow speed is higher than the landward for these higher flows.

Flow depths in the bridge were calculated by taking the average of the headwater and tailwater WSELs and comparing to the proposed channel elevation through the bridge (-8.5 ft). A close up of typical depths of flow through the Alternative 10 bridge opening during the simulation with median (50%) riverine flows and normal tide boundary conditions are presented in Figure 5

For reference to simulated ambient flow speed conditions in the Middle River, Figure 5 presents simulated flow speeds at HEC-RAS cross-section 3028.072 in the Middle River approximately 2,500 ft upstream from Dike Bridge along with the general fish passage maximum flow speed criteria thresholds. Information presented in Figure 5 indicates that regular ebb tide (seaward) flow speeds typically exceed the all-species criterion of 0.75 ft/s and, at times, exceed a flow speed of 3 ft/s. A similar evaluation of minimum depths of water identifies that typical depths at this cross-section are approximately 1 ft except during higher low tides when depths approach up to approximately 2 ft.

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[6] Criteria are based on the values presented in the *Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes* by Turek, J., Haro, A., & Towler, B., and published in May 2016 by the National Marine Fisheries Service, the U.S. Geological Survey, and the U.S. Fish and Wildlife Service.

Reference: Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services

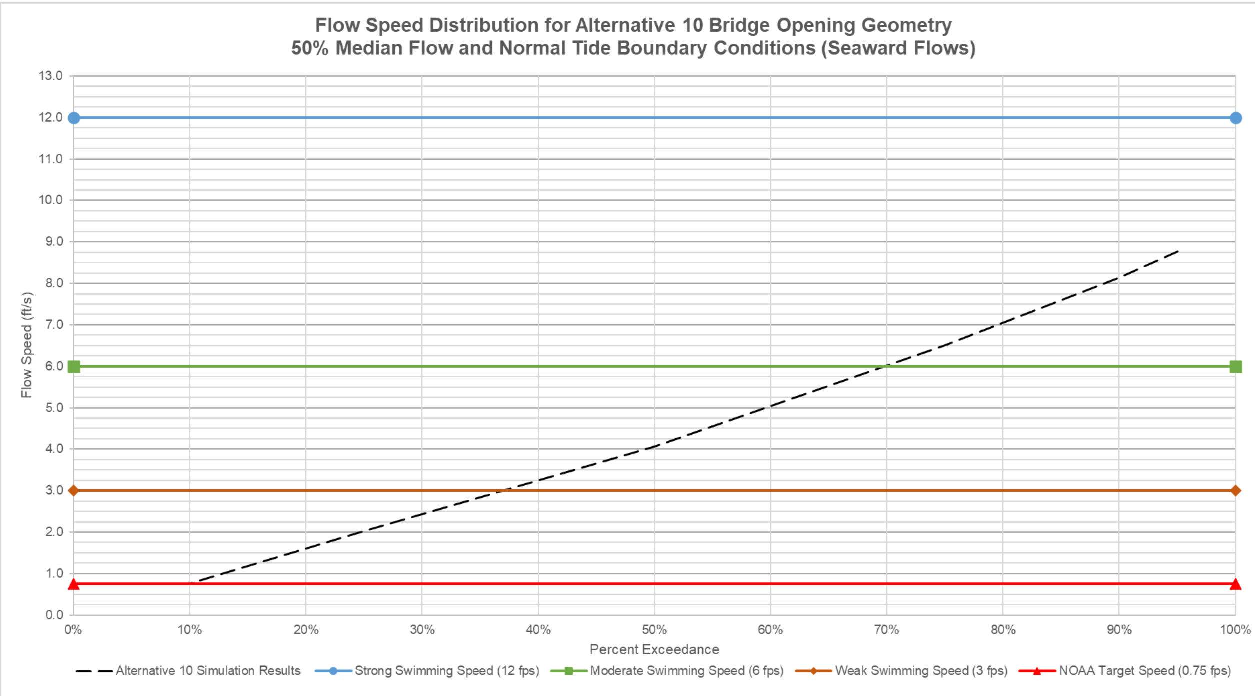

Figure 2. Flow speed distribution for the Alternative 10 bridge opening geometry for seaward flows only with fish passage flow speed criteria for ebb tide

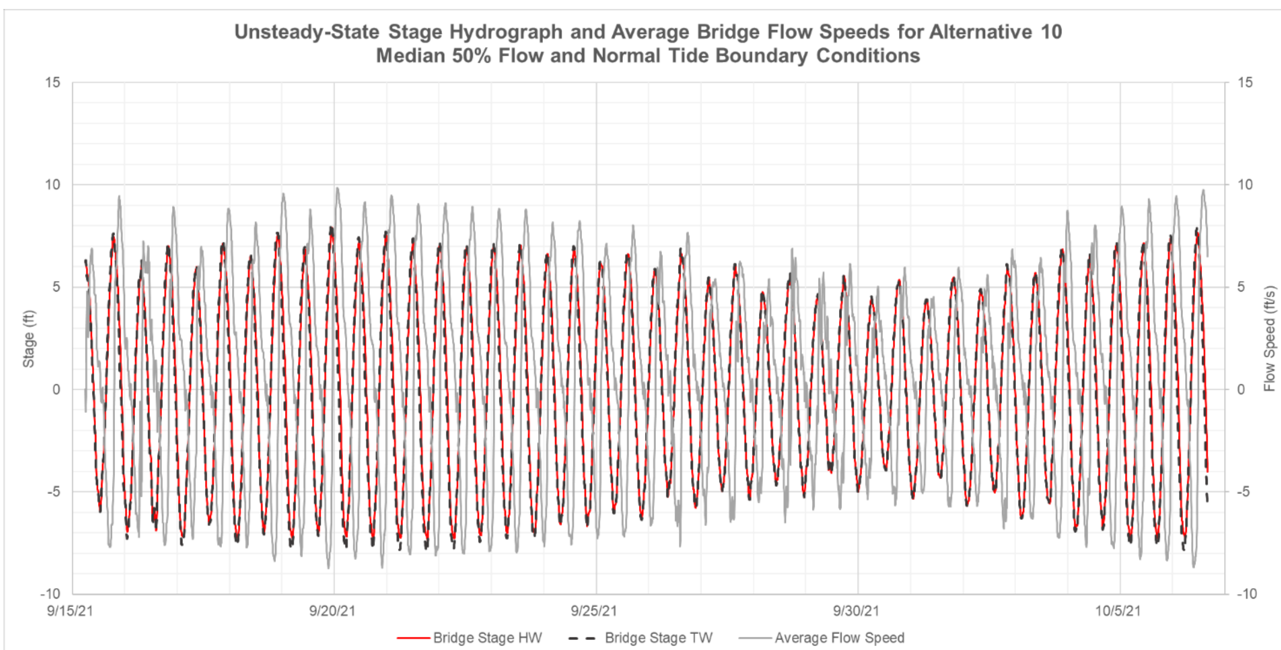

Figure 3. Unsteady-state stage hydrograph and average flow speeds through the bridge for Alternative 10 for median (50%) riverine flows and normal tide boundary conditions.

Reference: Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services

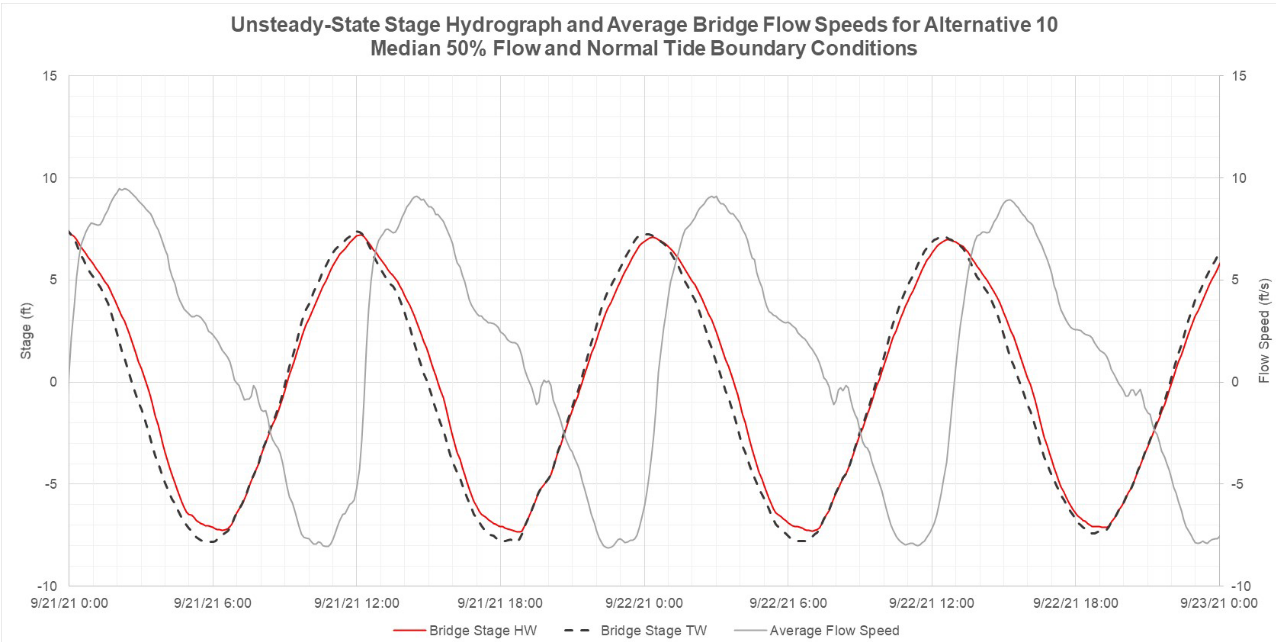

Figure 4. Close-up of typical unsteady-state stage hydrograph and average flow speeds through the bridge for Alternative 10 for median (50%) riverine flows and normal tide boundary conditions.

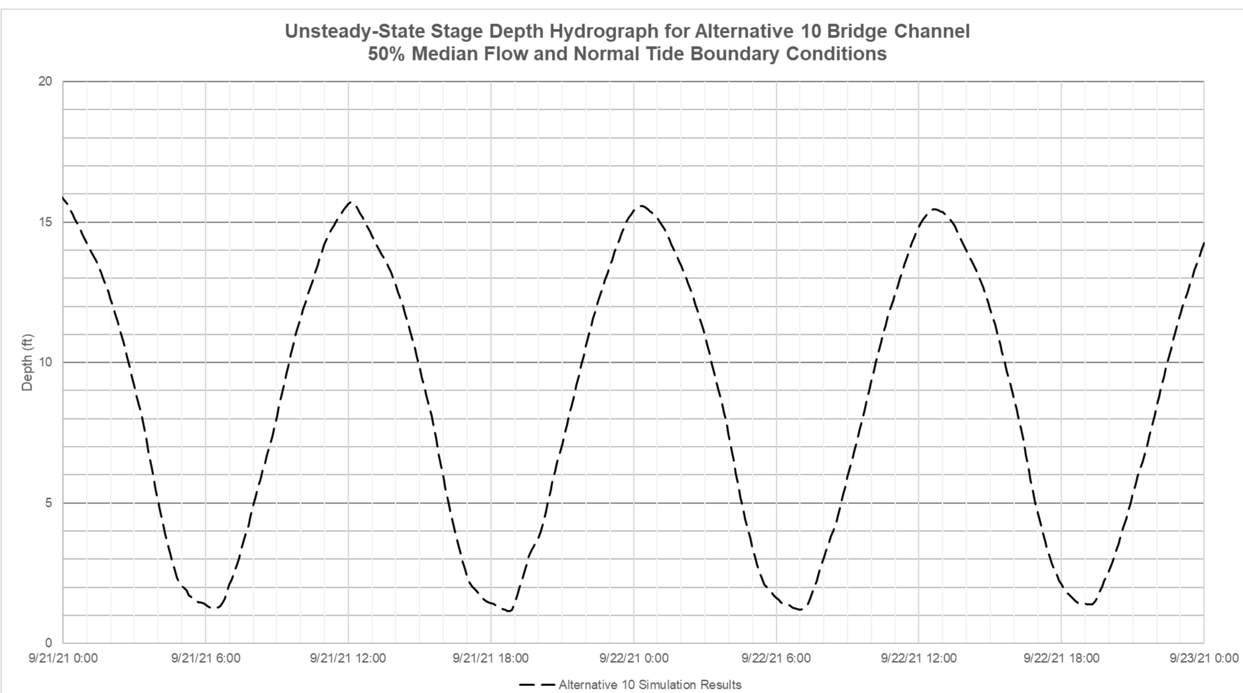

Figure 5. Close-up of the typical unsteady-state depth hydrograph for flow through the Alternative 10 bridge opening.

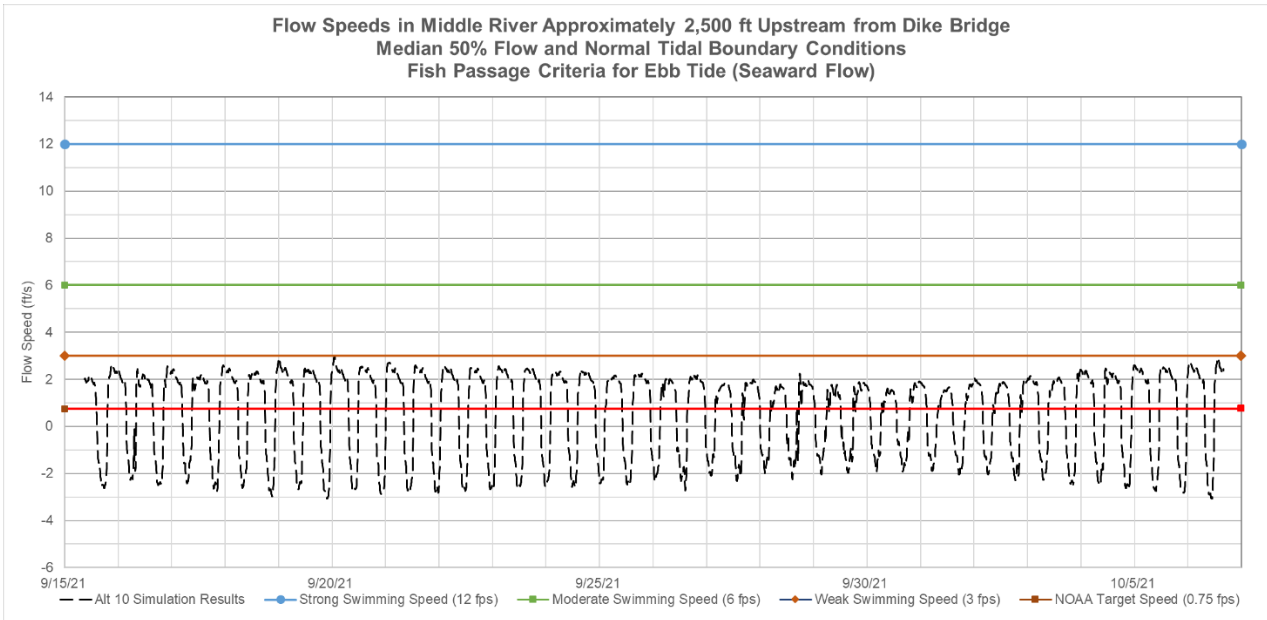

Figure 6. Overview of the Alternative 10 average bridge flow speeds for median (50%) riverine flow and normal tide boundary conditions with fish passage criteria for ebb tide.

4.5 PRELIMINARY SCOUR COUNTERMEASURE DESIGN

Scour countermeasure rock armor sizing was assessed from the model results using the method presented in the US Army Corps of Engineers (USACE) Engineering Manual EM-1110-2-1601 (Hydraulic Design of Flood Control Channels)[7]. The USACE approach is the method recommended in the National Cooperative Highway Research Program NCHRP 568 Report and as recommended in the Federal Highway Administration Hydraulic Engineering Circular No. 23 Design Guidelines #4 and #14.

Input parameters for calculation of the rock armor size were obtained from the Model and professional judgement. The D_{30} is determined and D_{50} is then calculated based on a uniformity ratio (D_{85}/D_{15}) of 2. Input parameters that were used to calculate the rock material D_{30} include depth of water and flow speed, a safety factor (Sf) of 1.1, a stability coefficient (CS) of 0.3 (corresponding to angular rock), a vertical velocity coefficient (CV) of 1.0 corresponding to a straight channel alignment, and a rock armor thickness coefficient (CT) of 1.3 corresponding to a rock armor thickness of more than two-times the material D_{50} or greater than the D_{100}. The side-slope correction factor (K1) was set at 0.9 based on an angle of repose of angular rock of 40 degrees and a maximum side slope of 3.5 horizontal: 1 vertical (approximately 16 degrees). The unit weight of water (Y_W) was set at 62.4 pounds per cubic foot (pcf) and the unit weight of the rock material (Y_S) was set as 156 pcf based on a specific gravity of 2.5. Note that this approach is limited to longitudinal (parallel to the direction of flow) channel bed slopes of less than 2% and that the ratio of the D_{30} to the channel depth at the design flow is greater than or equal to 0.02 (i.e., the depth of water is less than 50-times the D_{30}).

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[7] USACE. 1994. *Hydraulic design of flood control channels*. Engineer manual 1110-2-1601.

A stable rock size was calculated for the Alternative 10 bridge using the estimated average flow speed and depth of flow in the middle of the proposed bridge channel for the median, 1.1-, and 10-year flows. Seaward and landward flow directions were both used in the calculation. The median D_{50} rock size was determined to be approximately 2.47, 2.51, and 2.71 ft for the typical, median (50%) flow, and 1.1- and 10-year peak flows, respectively. These results suggest that the approximate size of stable rock armor material for scour countermeasures would need to have a nominal diameter of approximately 3 ft, which is consistent with MaineDOT's "Heavy Riprap" material specification. Note that the Phase 2 Study Model results indicate that maximum discharges for simulations with the median (50%) riverine flow and normal tide boundary conditions results in maximum discharges of approximately 10,000 cfs that are substantially greater than the evaluated peak flow riverine discharges (e.g., the 100-year peak flow in the Middle River at Dike Bridge is 958 cfs). Unlike typical riverine bridges, regular tidal conditions are therefore specifically relevant to design of scour countermeasures for Alternative 10.

5.0 DISCUSSION

This section presents discussion of the hydraulic model simulation results for the Phase 2 Study as part of the Project including discussion on WSELs landward of Dike Bridge, inundated land, fish passage, preliminary scour countermeasure design, and dredging and sediment transport considerations.

5.1 LANDWARD WATER SURFACE ELEVATIONS

There are minor variations between results presented in this memo compared to the results presented in the September 2021 Phase 1 Study Memo. These variations can be attributed to (1) updated downstream tide data that was collected in 2021 by MaineDOT and supersedes the previous 2011 tidal dataset, (2) updated bathymetric data, and (3) additional normal ineffective flow areas along the banks of the Middle River upstream of Dike Bridge, where identified and included during Phase 2 to improve Model stability and accuracy. In general, these variations are minor and do not appear to represent significant deviations from the Phase 1 Study findings.

Both Alternative 4m and Alternative 10 provide increases in the upstream tidal range across the range of scenarios modeled. Alternative 4m provides significantly less of a landward tidal range compared to Alternative 10 (e.g., 5.3 ft versus 15.3 ft during normal flows and normal tides, see Table 6). Alternative 10 provides a greater hydraulic conveyance capacity compared to existing conditions and Alternative 4m due to the larger effective, cross-sectional area and therefore was less sensitive to increases in maximum landward WSELs with increased flow. Overall, as the upstream inflows increase, maximum and minimum landward WSELs increase and the ranges (difference between maximum and minimum landward surface elevations during the simulation period) decrease.

SLR results in higher maximum and minimum WSELs landward from Dike Bridge (see Table 7 and Table 8). For the existing-conditions simulations, the maximum landward WSELs increases from approximately -0.5 ft to 0.1 ft, representing an increase in approximately 0.6 ft, for the 1.5-ft SLR increase to the normal tidal range under median flow conditions. Similarly, 1.5 ft of SLR under median flow conditions also results in approximately 0.6 ft of increase in the landward maximum WSELs for Alternative 4m. The Alternative 10 bridge approaches tidal transparency and consequently results in a comparatively greater increase in landward maximum WSELs as a result of SLR. For example, 1.5 ft of SLR results in an increase from a maximum landward WSEL of 7.9 ft to 9.3 ft (1.4-ft increase) for Alternative 10 under median riverine flow conditions.

Reference: Phase 2 Hydraulic Analysis for Machias Dike Bridge (#2246) Planning Phase Support Services

The maximum tidal stage for the normal tide with 3.9 ft of SLR was approximately 12.1 ft, which was above the top elevation of the existing Dike Bridge roadway (see Table 3). Therefore, under the existing conditions simulations, it is expected that the existing Dike Bridge would be overtopped and that landward WSELs and resulting flooding would occur under this SLR scenario. This is reflected in the dramatic increase in maximum landward WSEL under the existing conditions simulations for 3.9 ft of SLR (see Table 8). The variations in landward tidal amplitude, and specifically the peak high-tide stages, occurring during spring tides for the 3.9 ft of SLR downstream normal tide boundary condition appears to result in perturbations in the landward existing conditions scenario WSELs (see Figures A.13, A.19, A.25, A.37, and A.43 in Appendix A). The maximum elevation of the perturbations occur during the peak stage of the spring tide series and dampen as riverine flow increases (e.g., comparing Figures A.13 to A.25). The apparent cause of the perturbations is landward flow over Dike Bridge during spring tides with 3.9 ft of SLR, consequent surcharging in the Middle River, and limited seaward discharge on the ebb tide. Simulations for Alternative 4m do not result in similar perturbations and appear to reflect increased seaward discharge capacity with Alternative 4m as well as no overtopping. More refined modeling may be necessary to resolve the complex hydraulic occurring during these overtopping events within the vicinity of the bridge under existing conditions. However, it is unlikely that the existing configuration at Dike Bridge would be present under the 3.9-ft SLR scenario, which is based on potential end-of-century climate change scenarios and is rather included to provide approximately relative comparisons between alternatives. Note that the refined alternatives evaluated assume that the top of the roadway would be greater than the maximum tidal stage for SLR boundary conditions and no overtopping would occur.

5.2 INUNDATED AREA LANDWARD OF DIKE BRIDGE

Both alternatives will result in an increase in inundation area. Of the two refined alternatives, Alternative 10 will result in the largest increase in inundated area landward of Dike Bridge. The increased inundated land area is a result of the more transparent tidal regime as part of the Alternative 10 bridge. The single bidirectional flow culvert used on one of the three culverts in Alternative 4m will also result in increased inundation relative to existing conditions but not to the degree of Alternative 10.

5.3 UPSTREAM FISH PASSAGE

Upstream fish passage was preliminarily assessed for the refined alternatives, which are discussed and summarized in this section.

Alternative 4m includes two gated culverts that allow for seaward flow and a single, ungated culvert that allows for bi-directional flow to facilitate landward (upstream) fish passage at Dike Bridge. When the seaward tide WSEL is greater than the landward WSEL, there are opportunities for upstream fish passage via advection through the ungated culvert. Fish species interested in migrating upstream would benefit from the mass-movement of the flood tide through the ungated culvert and would be advected through the culvert upstream into the inundated area landward of Dike Bridge following which migrating fish species would either take refuge in the lower energy areas or continue traveling upstream along the Middle River. Based on analysis of percentage of time in which seaward flows would be occurring through the ungated culvert, it was determined that under normal riverine flows and normal (astronomical) tides, Alternative 4m offers upstream fish passage via advection for 53%, 57%, and 62% of the time for existing normal tides, 1.5-ft SLR, and 3.9-ft SLR, respectively.

Results from the flow speed evaluation through the Alternative 10 bridge opening provides an opportunity to assess typical flow and tidal conditions against fish passage criteria. Headwater and tailwater differentials and flow speed were evaluated. The objective of the flow speed evaluation was to identify flow speeds that may allow for volitional fish passage. Note that specific criteria for fish passage (e.g., target fish species, maximum allowable flow speed, designed range and tolerances for conditions suitable for volitional fish passage) have not been identified for the Project. Therefore, this memo presents information that is expected to assist in developing a general approach providing reasonably transparent tidal cycle conditions across a bridge alternative and thereby allow for volitional fish passage opportunities.

The evaluated bridge alternatives have the underlying channel at an elevation of -8.5 ft and therefore similar to the elevation of lower low tides. During low tides, depths of water in the channel are approximately 1 ft. Shallow flow at low tide could necessitate construction of a defined “low-flow” channel through the bridge opening to meet minimum depth criteria for upstream fish passage. A low-flow channel would need to extend well beyond the upstream limits of any proposed bridge near-field dredging and riprap apron in order to tie into the existing channel. Similarly, results identify the percentage of time in which certain flow speeds occur; however, in the absence of a defined target fish species and associated performance criteria, evaluation of volitional fish passage performance is not possible. It is recommended that these criteria (e.g., target fish species) be defined.

Information on fish passage criteria were provided by stakeholders and include a flow speed criterion of 0.75 ft/s. Information obtained from the HEC-RAS model in the Middle River at a cross-section approximately 2,500 ft upstream from Dike Bridge indicates that ebb tide (seaward) flows exceed this value and exceed 3 ft/s during regular tidal conditions. In addition, depths of water at this cross-section are approximately 1 ft except during higher low tides when depths approach up to approximately 2 ft.

5.4 SCOUR COUNTERMEASURES

Preliminary scour countermeasure design calculations suggest that stable rock armor sizes would have a nominal diameter of approximately 3 ft (heavy riprap). The relatively large size of this preliminary scour countermeasure rock size is due to periods during the tidal cycle where the depths of flow are shallow and the flow speeds are the greatest. The maximum seaward flow speed is greater than the maximum landward flow speed during the simulation period; therefore, the seaward flows govern the rock sizing for the scour countermeasure design. It is further recommended that the selected alternative include considerations for ice and debris loading in addition to the expected hydraulic loading effects.

5.5 DREDGING AND SEDIMENT TRANSPORT

Selection of a bridge replacement alternative for the Project would require consideration for “active”, or “passive” development of an upstream channel. Active channel development refers to the process of dredging a channel in the anticipated alignment in advance of installation of the bridge. Passive channel development refers to the process of near-field dredging within the vicinity of the proposed replacement structure (e.g., channel through the bridge and immediately upstream and downstream), and then relying on natural sediment transport processes to mobilize sediment downstream. The opportunities of active channel development primarily include (1) reduced transport of sediment downstream and (2) reduced likelihood of requiring dredging to address shoaling in the Machias River seaward from Dike Bridge following completion of the Project. The opportunities of passive channel development primarily include (1) reduced costs in the short-term associated with the Project and (2) eliminating risks associated with dredging upstream without a prior knowledge on where the channel may actually form. Note that in addition to the areas landward of Dike Bridge that may require dredging, dredging of the existing mud flat areas immediately downstream of the bridge would also likely be required.

Appendix C contains a figure that depicts the anticipated alignment and conceptual area where a channel would be anticipated to head-cut upstream after installation of a bridge (i.e., Alternative 10). Based on the bathymetric data, it is estimated that greater than 20,000 cubic yards (CY) of sediment would be displaced by this conceptual channel alignment. If no upstream dredging is proposed as part of the Project, it is anticipated that this volume of sediment would become mobilized in the near-term, shortly after completion of the bridge installation, which would all be relocated to the USACE navigation channel adjacent to the municipal boat launch on the Machias River adjacent to the southwest end of Dike Bridge. Appendix D contains figures that depict the USACE navigation channel in the areas immediately downstream of Dike Bridge in the Machias River.

Note that a utility (sewer) pipeline crosses the Middle River about 25 ft upstream of Dike Bridge. The vertical profile and horizontal location of the pipeline are not well defined. Additional information related to this utility infrastructure is required to better inform potential design solutions for the Project.

6.0 SUMMARY

The following is a bulleted summary of findings from the Phase 2 Study.

1. Both Alternative 4m and Alternative 10 will result in higher WSELs and increased land inundation upstream from Dike Bridge.

2. Alternative 10 would result in the greatest increase in inundation area upstream from Dike Bridge. Increased upstream WSELs may be an issue for property owners along the upstream reach of the Middle River.

3. Alternative 10 has the greatest tidal exchange and qualitatively appears to approach tidal transparency landward of Dike Bridge. Additional preliminary analysis of various bridge sizes suggests that increasing the bridge span beyond 120 ft provide relatively small (e.g., approximately 2%) increases in intertidal habitat acreage.

4. Alternative 10 has opportunities for volitional upstream fish passage. Results identify the percentage of time in which certain flow speeds occur; however, in the absence of a defined target fish species and associated performance criteria, evaluation of volitional fish passage performance was not possible. It is recommended that these criteria (e.g., target fish species) be defined. The results also identify that depths of flow through the bridge would be relatively shallow (e.g., less than 1.5 ft) at and near low tide.

5. Alternative 4m provides enhanced opportunities for fish passage compared to existing conditions due to the larger culvert opening and an ungated culvert. Fish passage would generally be through the process of advection through the bi-directional (i.e., ungated) culvert opening when the seaward WSELs are greater than landward WSELs.

6. Information on fish passage criteria were provided by stakeholders and include a flow speed criterion of 0.75 ft/s. Information obtained from the HEC-RAS model in the Middle River at a cross-section approximately 2,500 ft upstream from Dike Bridge indicates that ebb tide (seaward) flows exceed this value and exceed 3 ft/s during regular tidal conditions. This ambient condition suggests that the lower 0.75 ft/s criterion is too conservative and may be inappropriate for evaluating fish passage for Alternative 10.

7. Increased WSELs in the Middle River for the two refined alternatives may result in increased fish passage opportunities at Stride Bridge, either by upstream passage through advection during flood tides, or by increasing the tailwater elevation at Stride Bridge, which would lower velocities through the culvert barrel thereby facilitating passage.

8. Additional hydraulic evaluations at Stride Bridge are recommended to assess if hydraulic design criteria (e.g., freeboard) are adequate when coupled with the hydraulic changes to the Middle River reach from the replacement alternatives proposed at Dike Bridge.

9. Preliminary scour countermeasure design calculations suggest that stable riprap armor sizes would have a nominal diameter of approximately 3 ft (MaineDOT Heavy Riprap) for Alternative 10. The relatively large size of this preliminary scour countermeasure riprap size is due to periods during the tidal cycle where the depths of flow are shallow and the flow speeds are the greatest.

10. Alternative 4m would require energy dissipation on the seaward side of Dike Bridge. It is expected that boulders would need to be placed adjacent to the seaward side of the Alternative 4m culverts to control scour. Scour countermeasures would be required adjacent to the landward side of the Alternative 4m culverts but would be more limited (relative to the seaward side) due to a persistent backwater condition. The spatial extent of scour countermeasures on the landward side of the ungated Alternative 4m culvert would need to be larger than for the two gated culverts.

11. The spatial extent of scour countermeasures adjacent to the ends of the Alternative 4m culverts would be smaller than those for Alternative 10.

12. Alternative 10 would result in development of a larger channel morphology through the reach landward of the Dike Bridge in the Middle River due to the larger span and lower invert compared to Alternative 4m. Greater than 20,000 CY of sediment is estimated to be mobilized landward of the estimated near-field dredge and riprap apron area.

13. Upstream mobilization of sediment for Alternative 10 would likely have implications on the downstream USACE navigation channel in the Machias River where shoaling already exists adjacent to the boat launch. Additional investigation is recommended.

14. No increases in the FEMA BFE are anticipated for the refined alternatives that were modeled as part of the Phase 2 Study when considering the non-SLR flood events.

15. Alternative 4m results in the lowest WSELs in the Middle River during the 100-year high-tide surge and 1.1-year riverine peak flow with 1.5 ft and 3.9 ft SLR scenarios relative to the existing condition and Alternative 10 simulations.

16. The existing condition with the 100-year high tide surge and 1.1-year riverine peak flow with 3.9 ft of SLR results in overtopping of Dike Bridge and the highest WSELs in the Middle River. This condition results from no resiliency measures (e.g., seawalls) for the existing condition simulations.

17. Analyses as part of this study did not consider potential impacts to public safety or navigation.

APPENDIX A UNSTEADY-STAGE HYDROGRAPHS

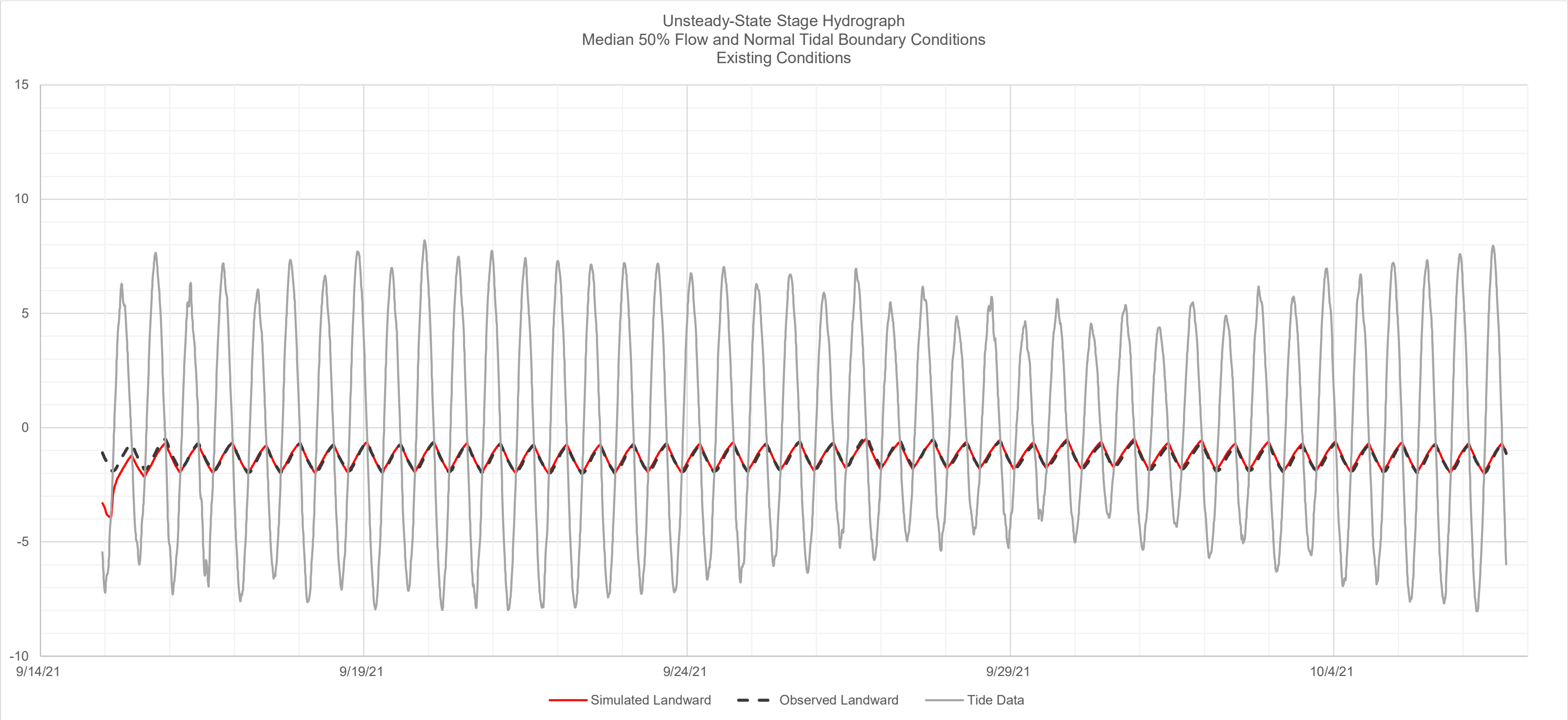


Figure A.1 - Unsteady-state stage hydrograph for median riverine flow and normal tide boundary conditions.

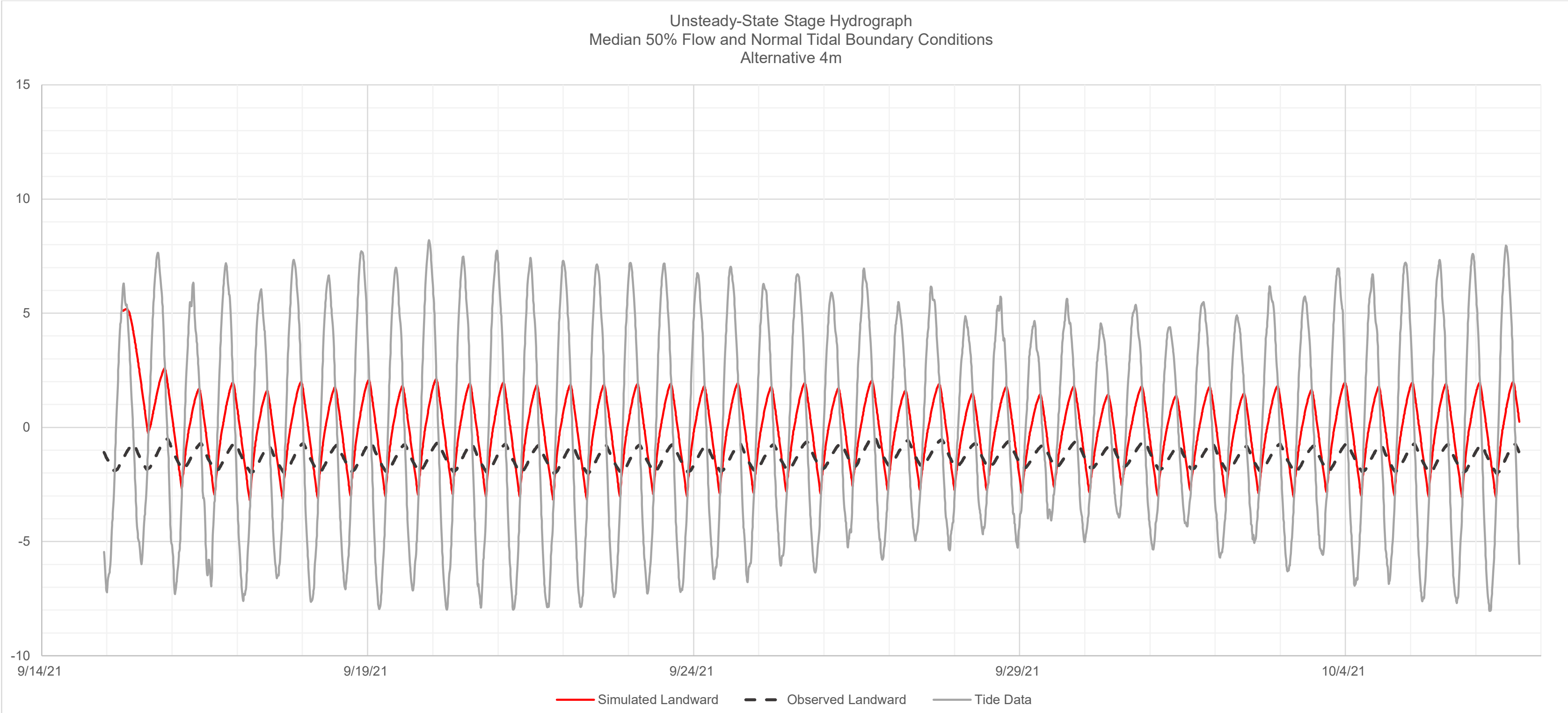


Figure A.2 - Unsteady-state stage hydrograph for median riverine flow and normal tide boundary conditions.

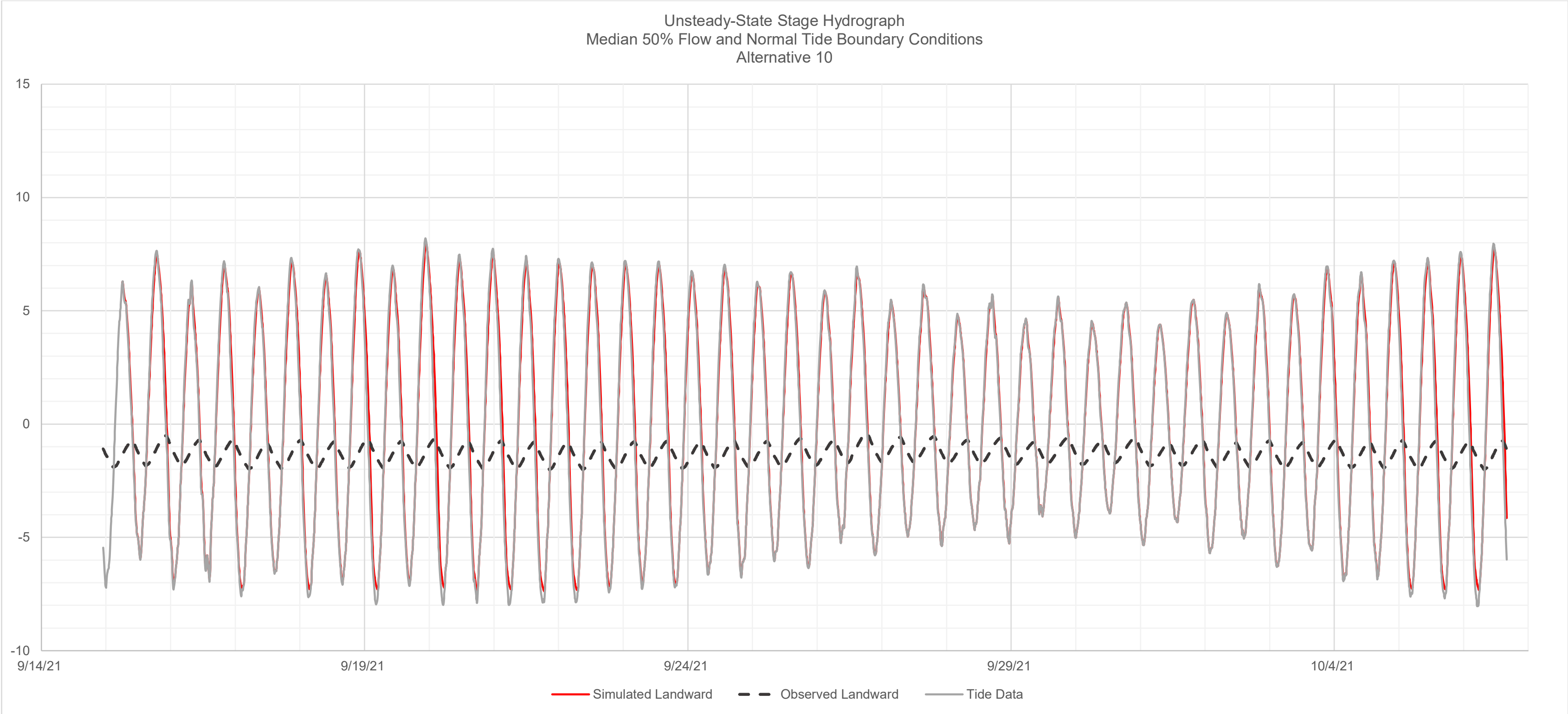


Figure A.3 - Unsteady-state stage hydrograph for median riverine flow and normal tide boundary conditions.

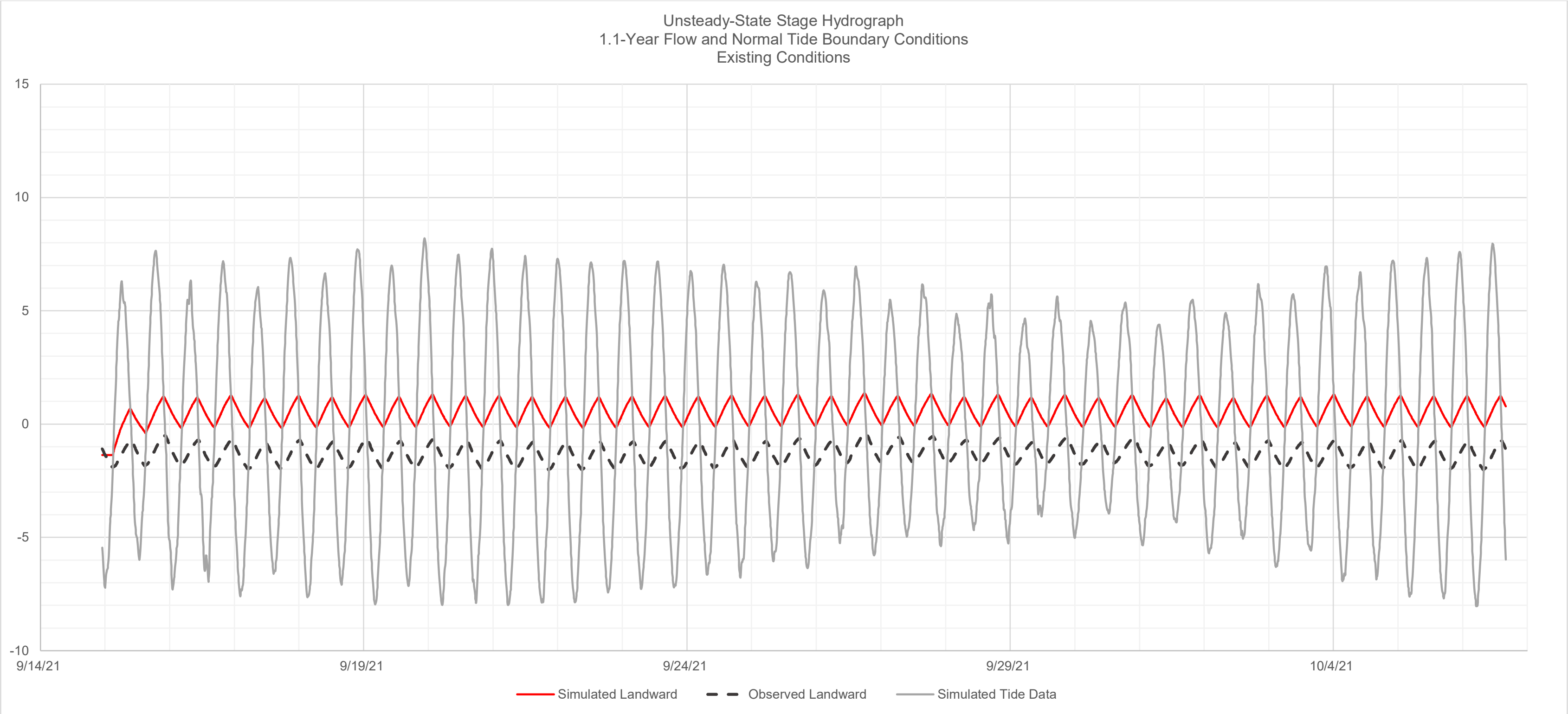


Figure A.4 - Unsteady-state stage hydrograph for 1.1-year riverine flow and normal tide boundary conditions.

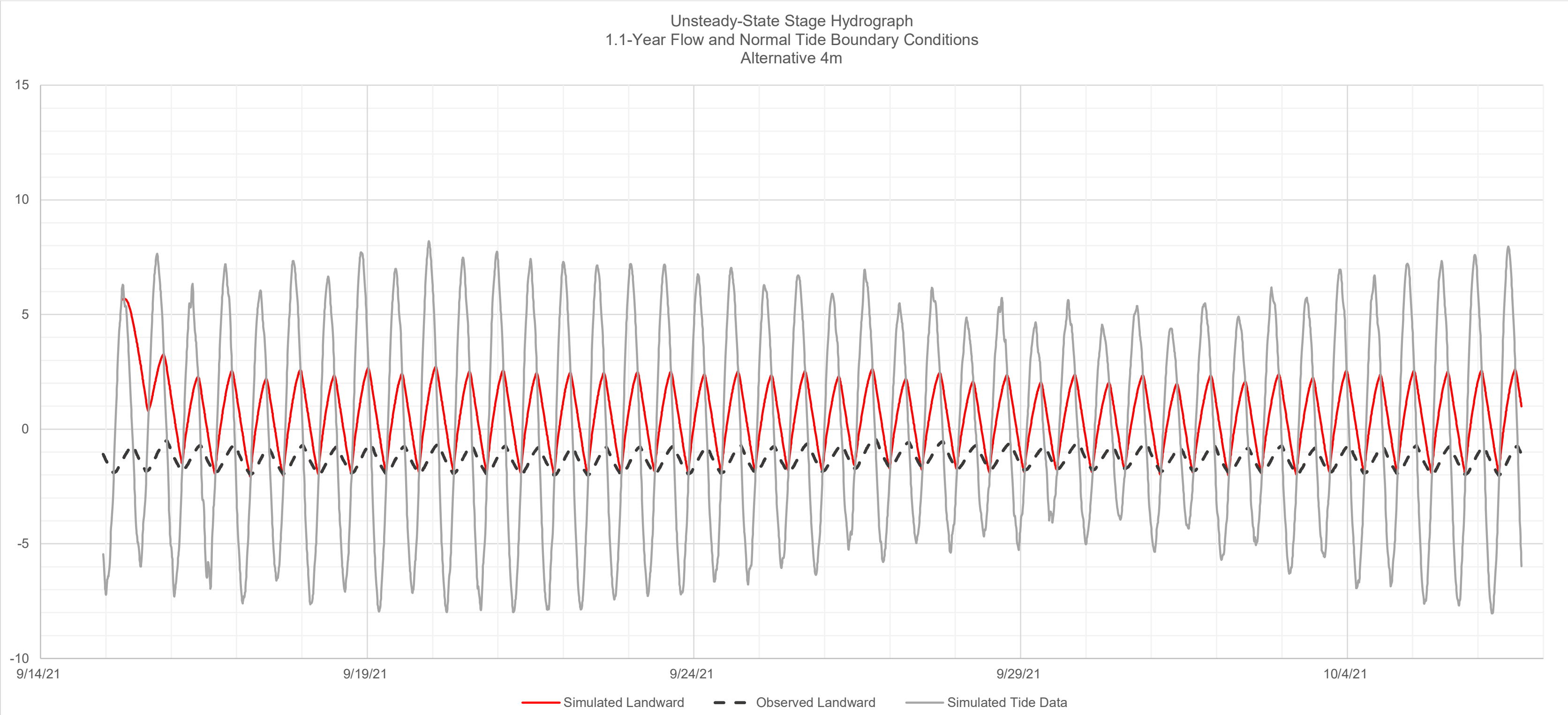


Figure A.5 - Unsteady-state stage hydrograph for 1.1-year riverine flow and normal tide boundary conditions.

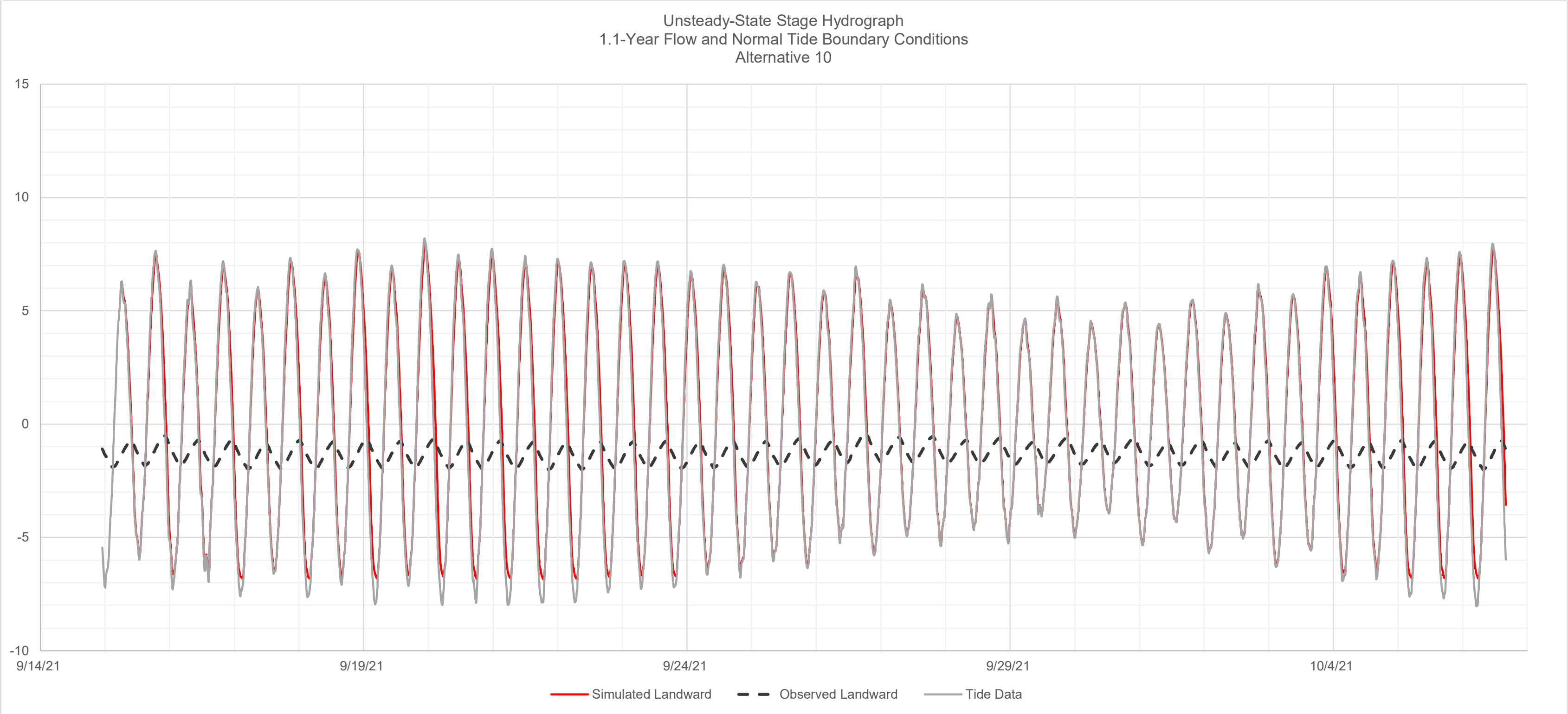


Figure A.6 - Unsteady-state stage hydrograph for 1.1-year riverine flow and normal tide boundary conditions.

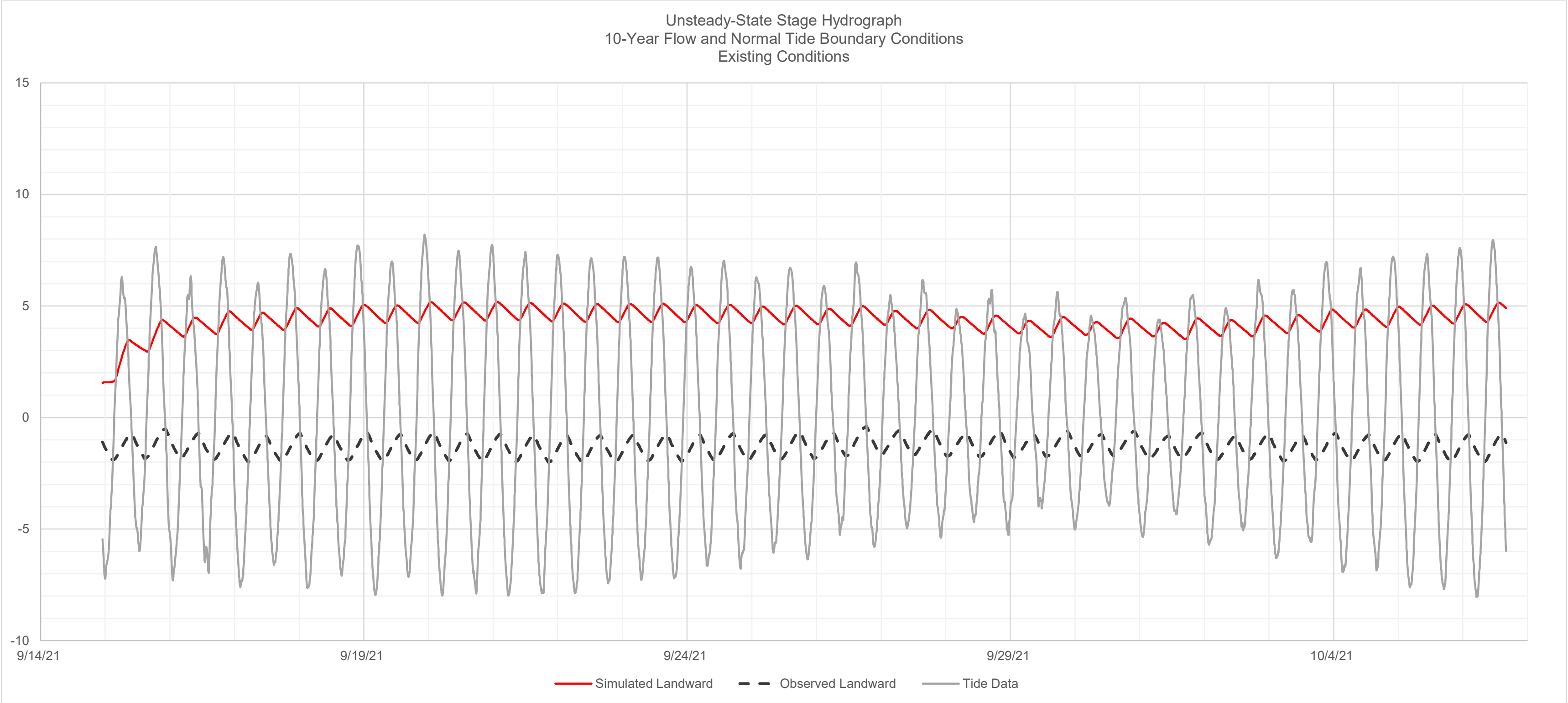


Figure A.7 - Unsteady-state stage hydrograph for 10-year riverine flow and normal tide boundary conditions.

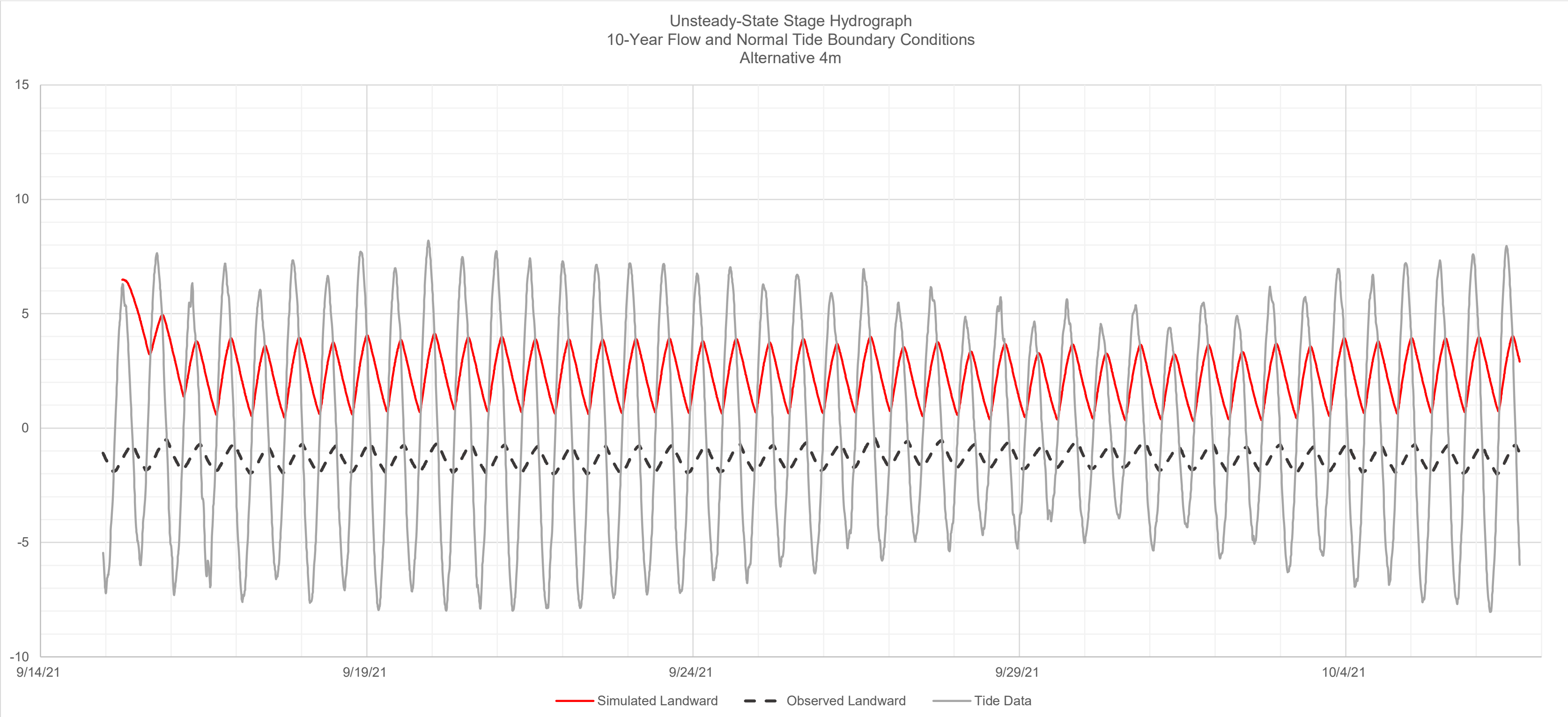


Figure A.8 - Unsteady-state stage hydrograph for 10-year riverine flow and normal tide boundary conditions.

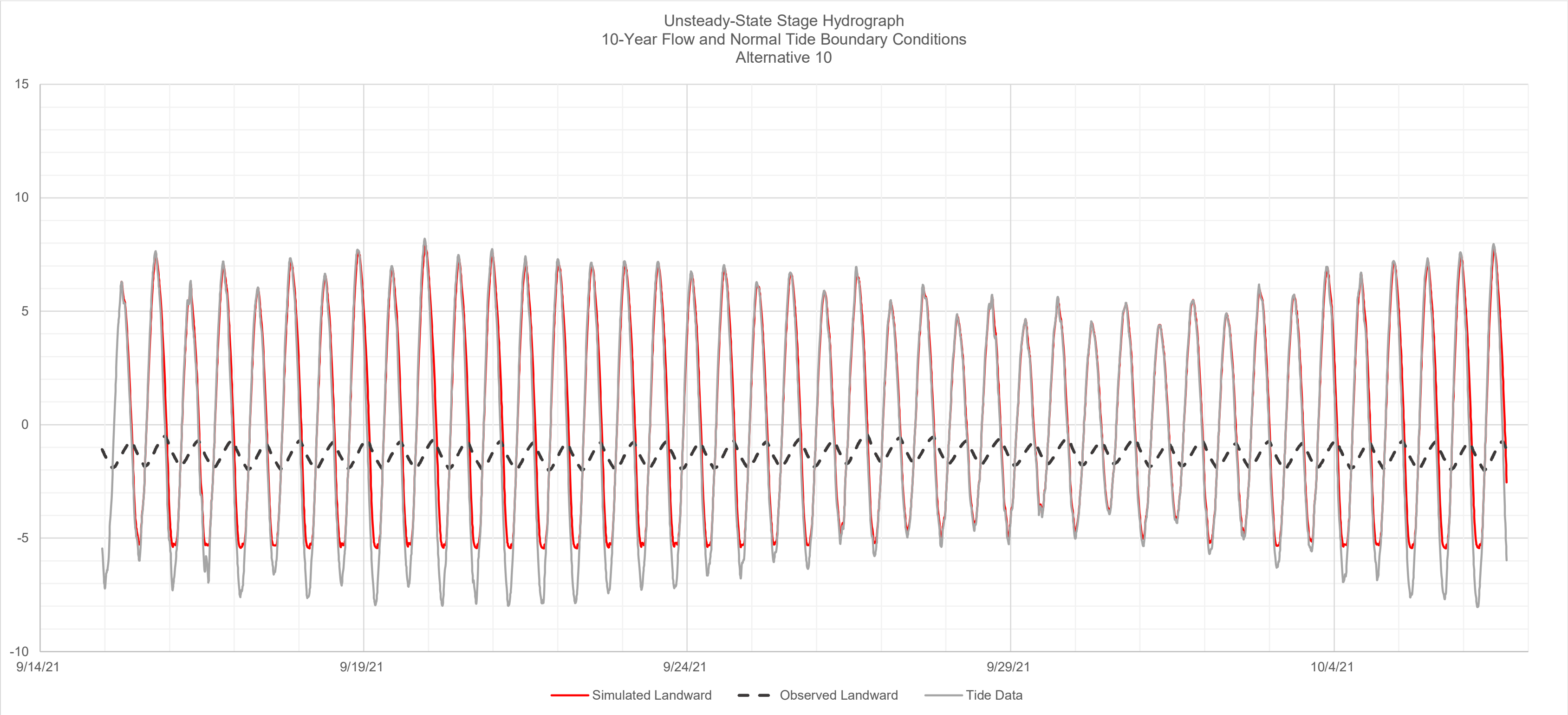


Figure A.9 - Unsteady-state stage hydrograph for 10-year riverine flow and normal tide boundary conditions.

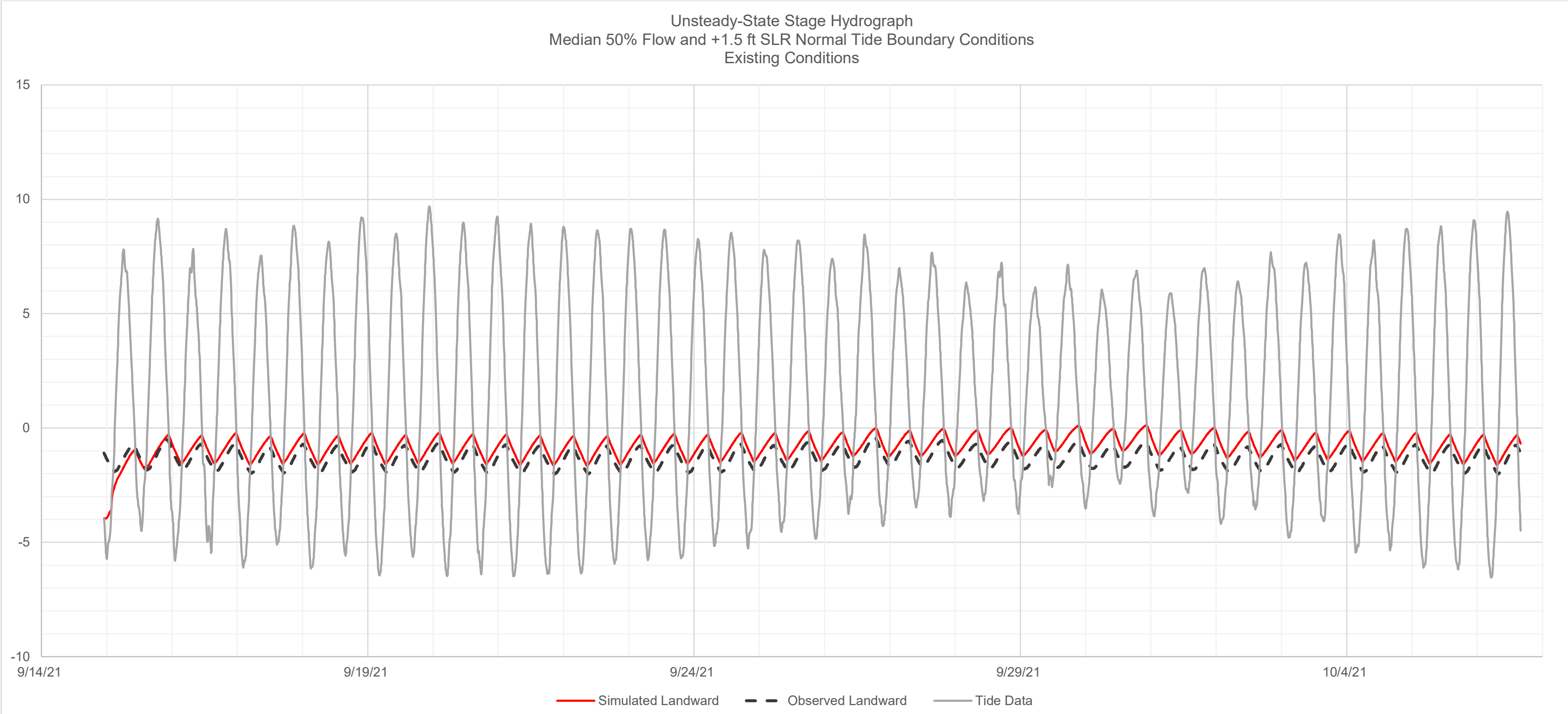


Figure A.10 - Unsteady-state stage hydrograph for median riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

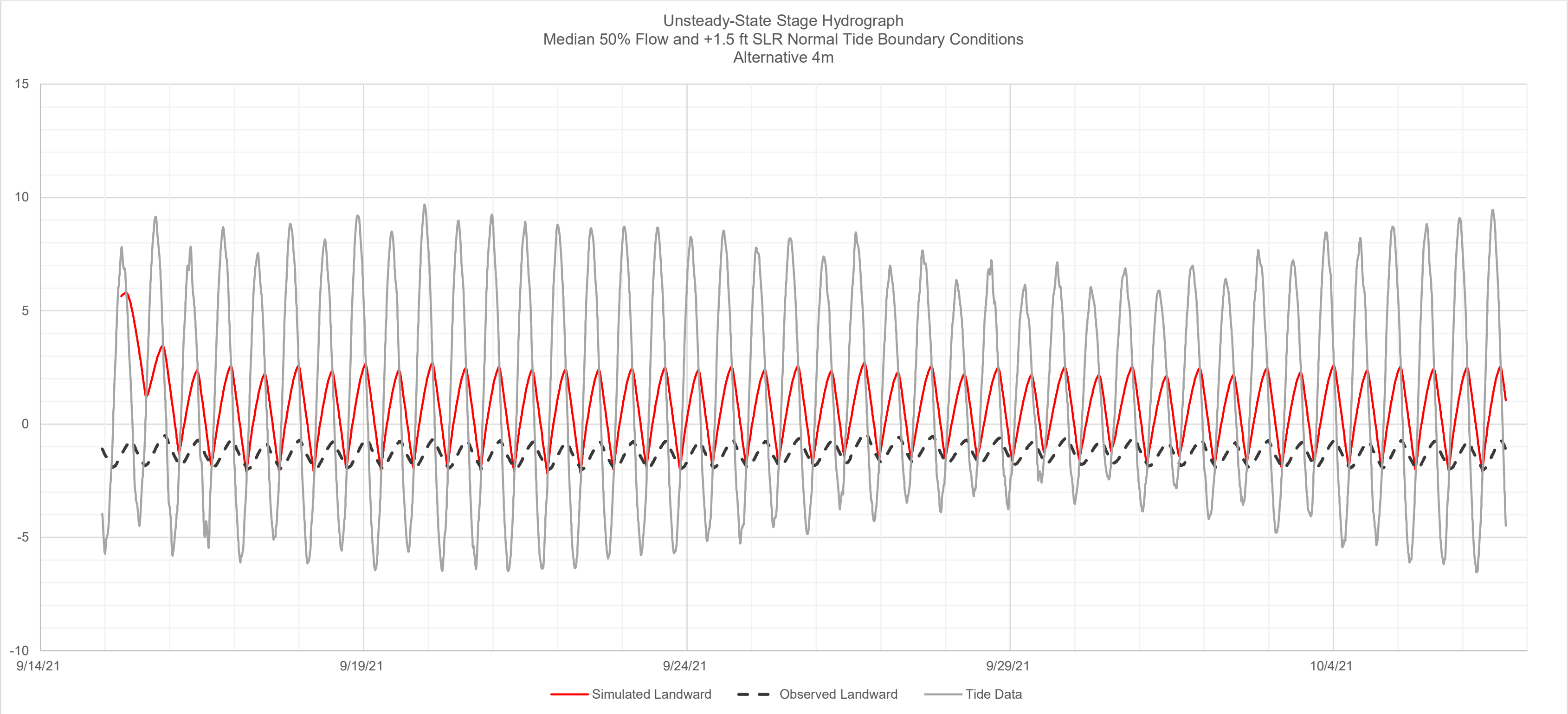


Figure A.11 - Unsteady-state stage hydrograph for median riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

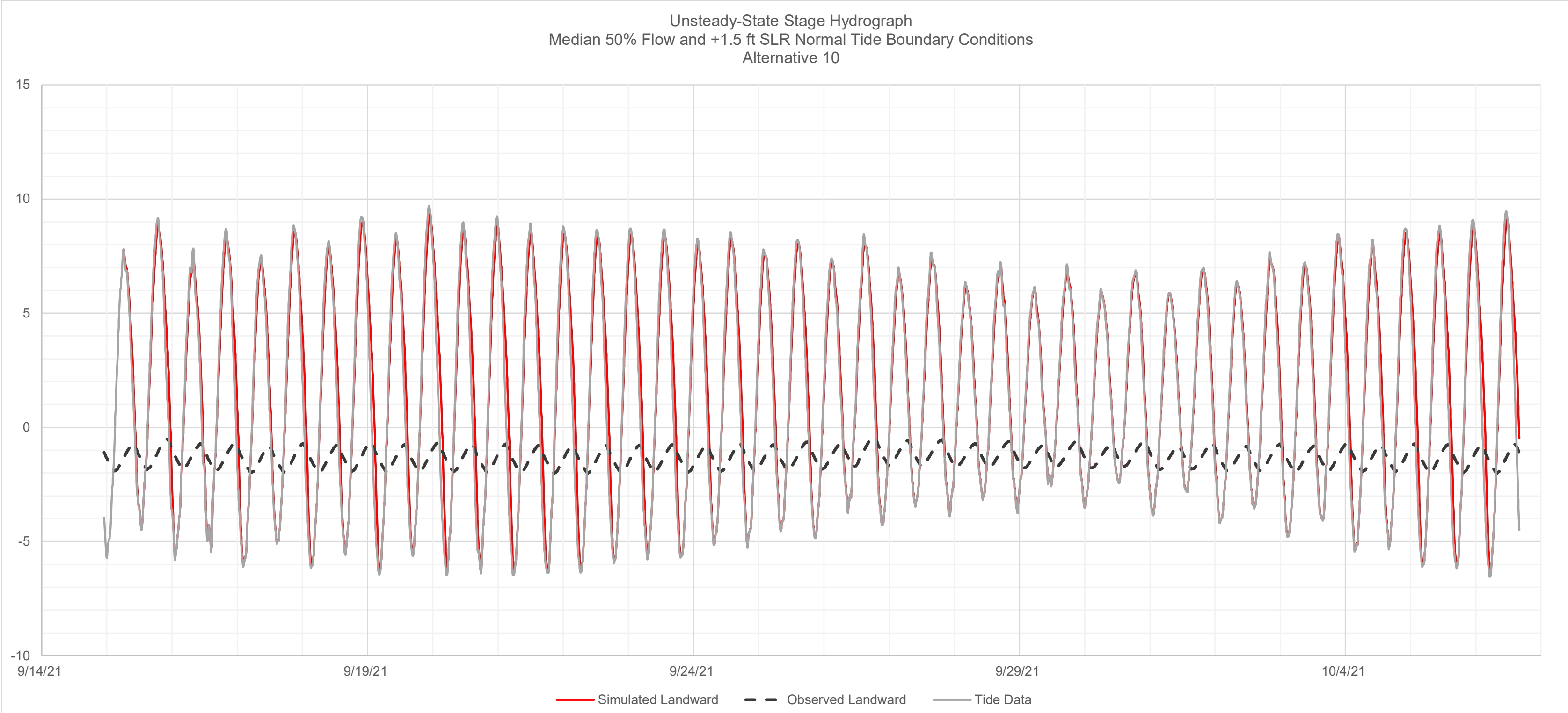


Figure A.12 - Unsteady-state stage hydrograph for median riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

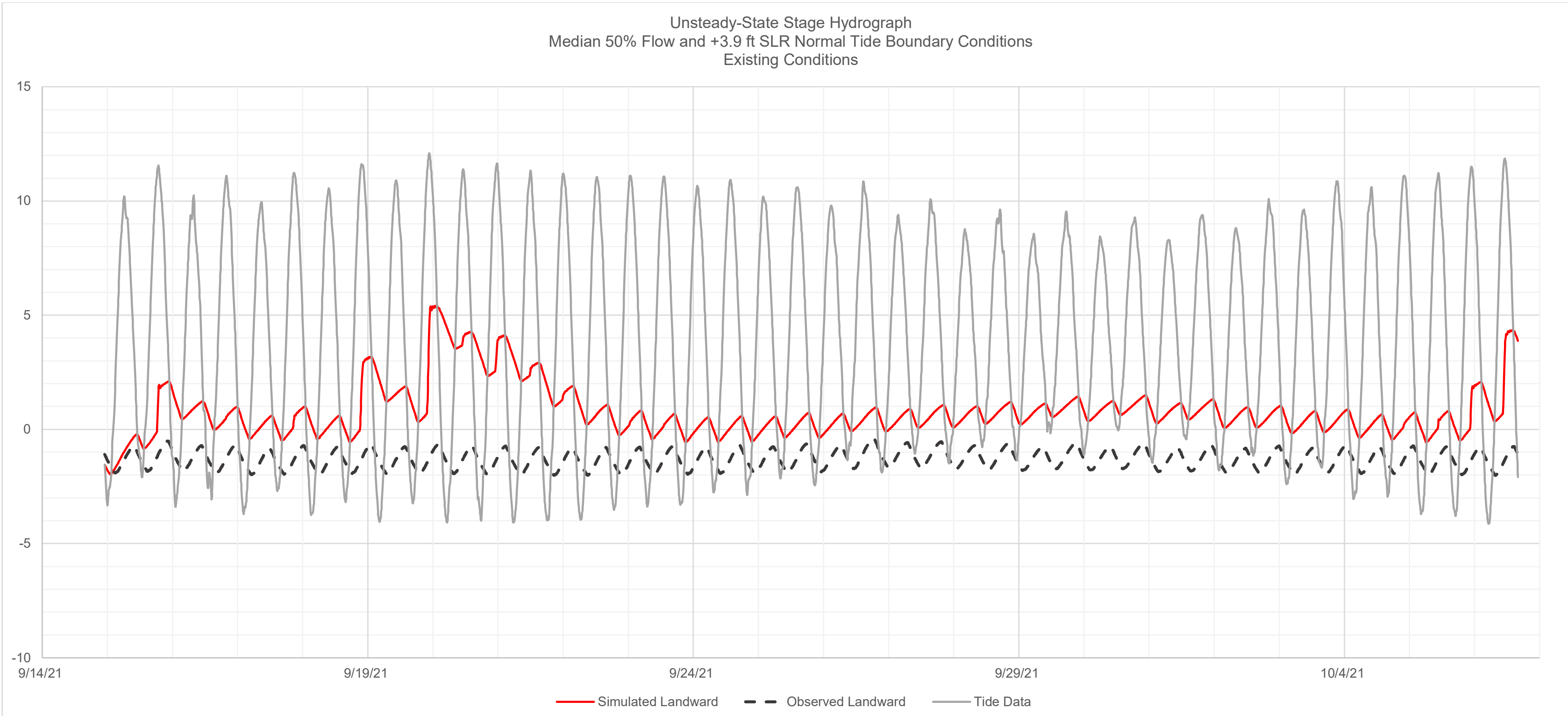


Figure A.13 - Unsteady-state stage hydrograph for median riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

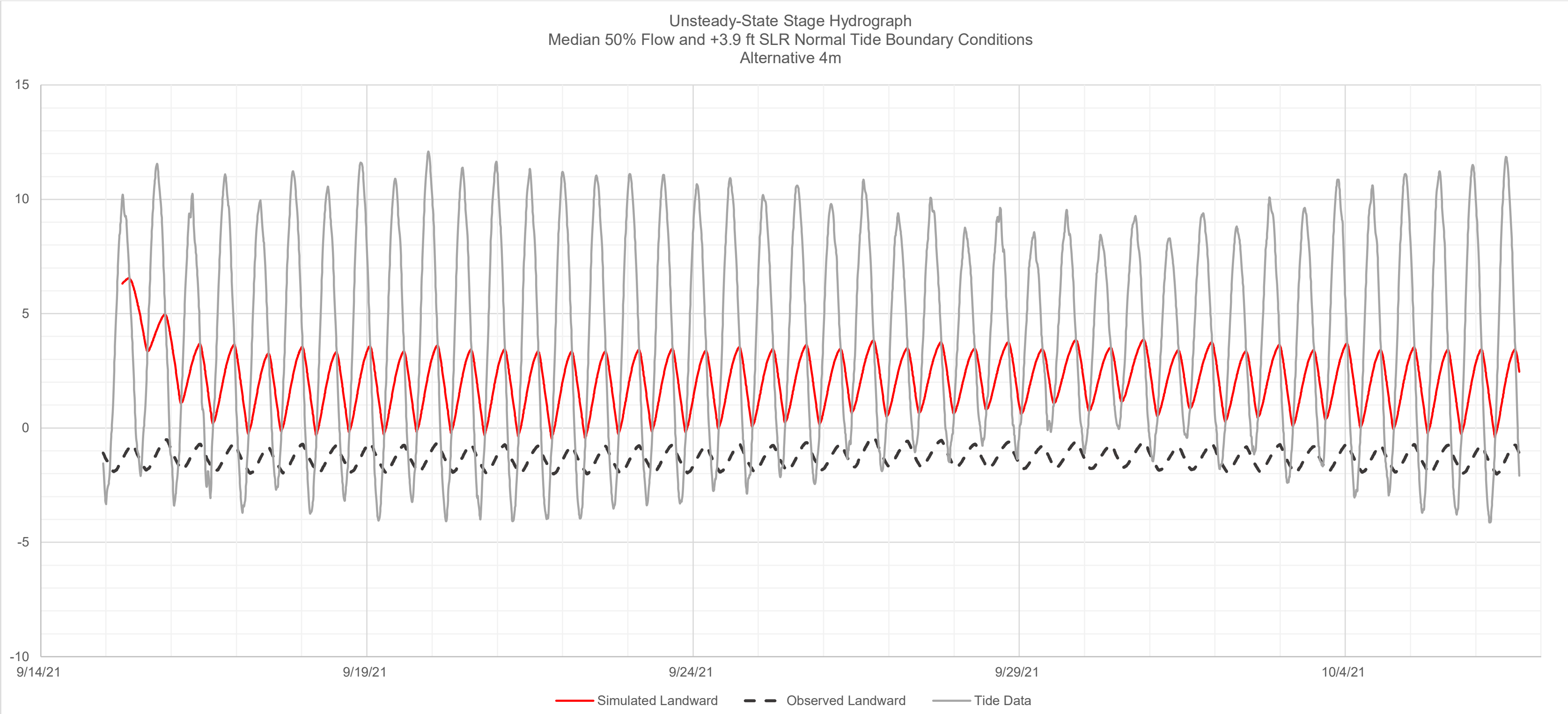


Figure A.14 - Unsteady-state stage hydrograph for median riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

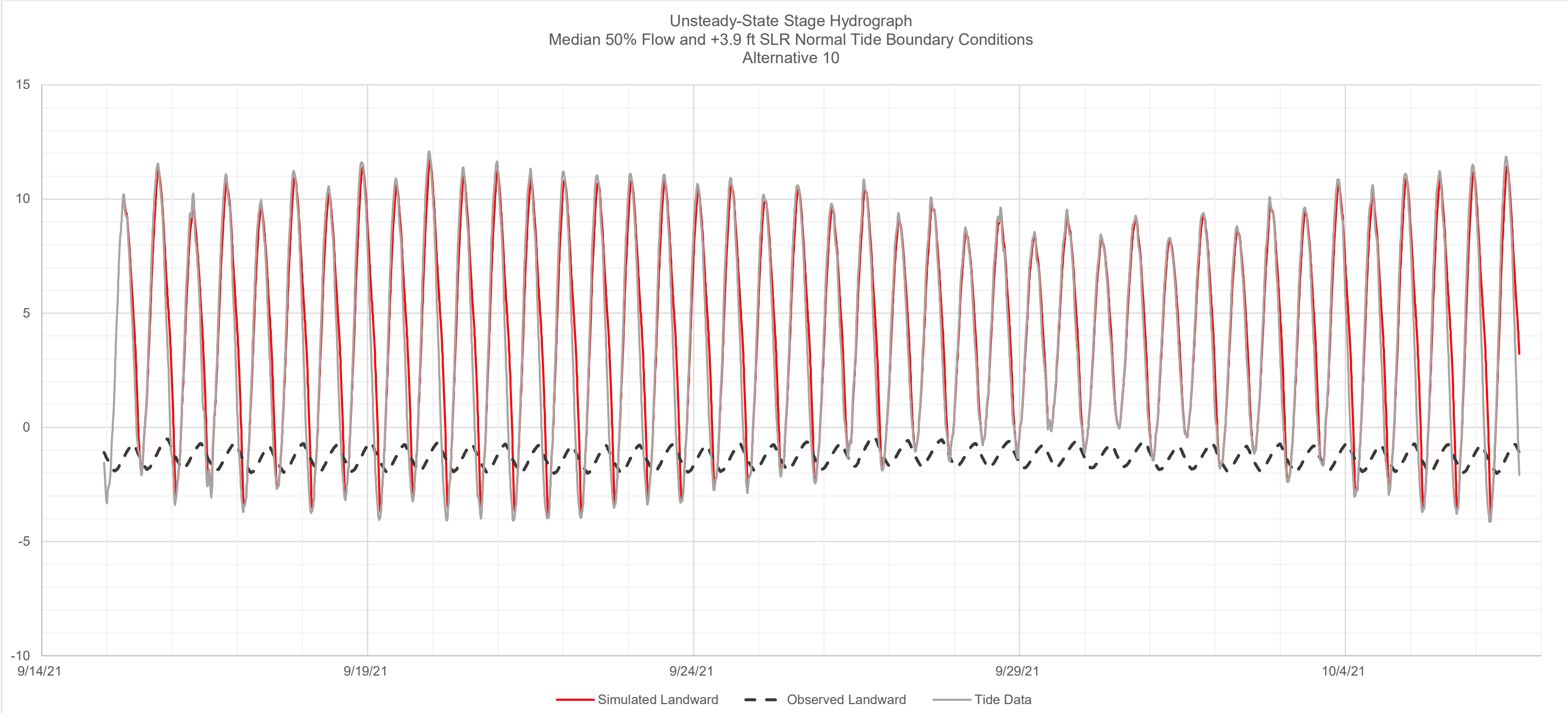


Figure A.15 - Unsteady-state stage hydrograph for median riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

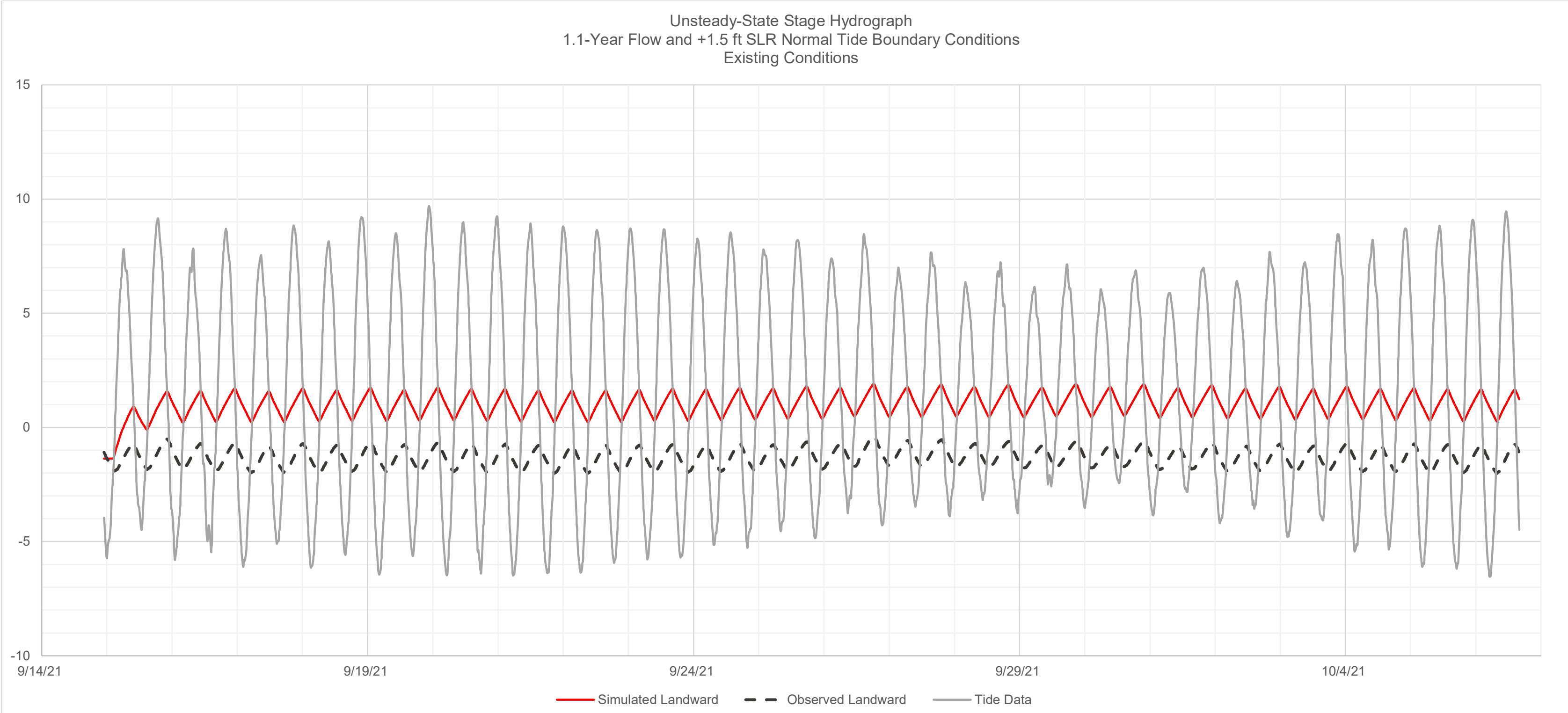


Figure A.16 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

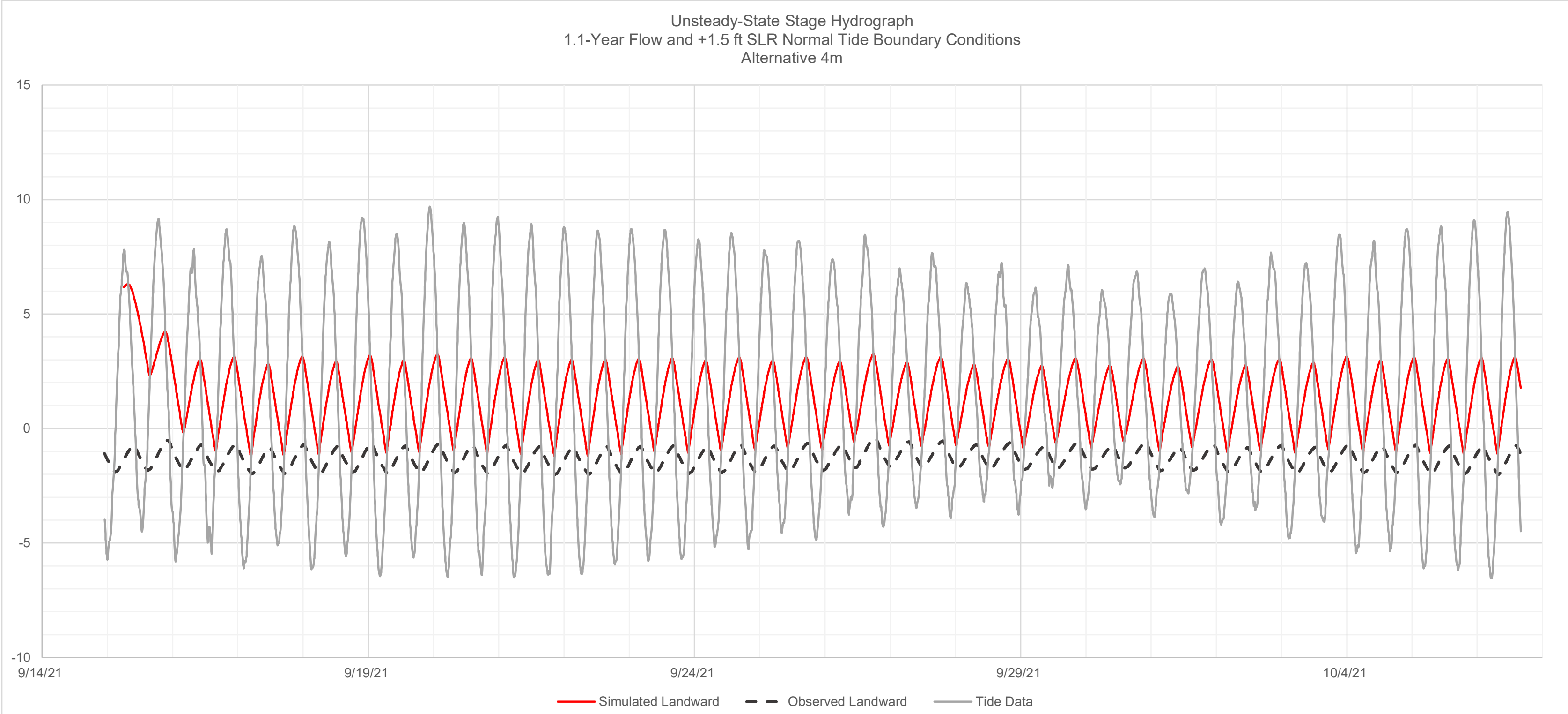


Figure A.17 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

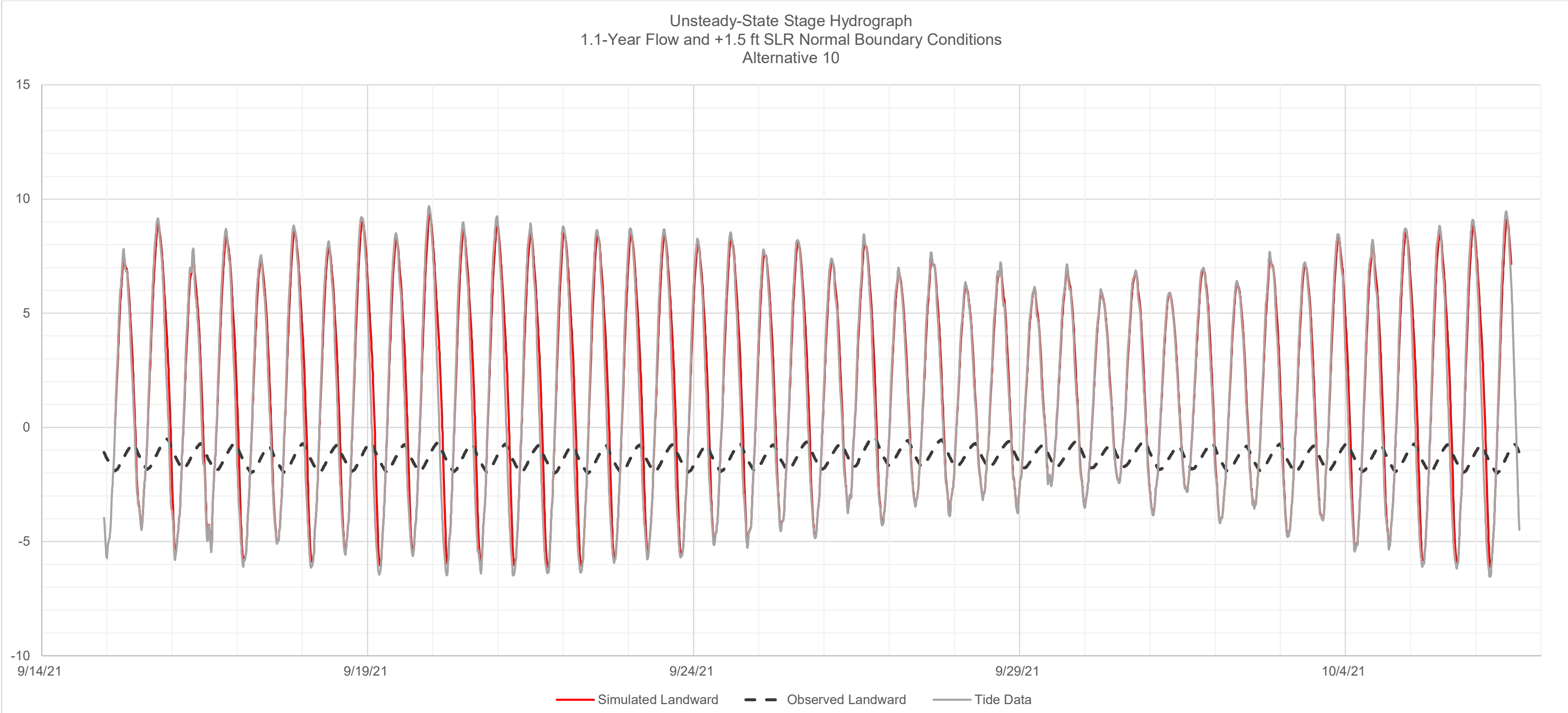


Figure A.18 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

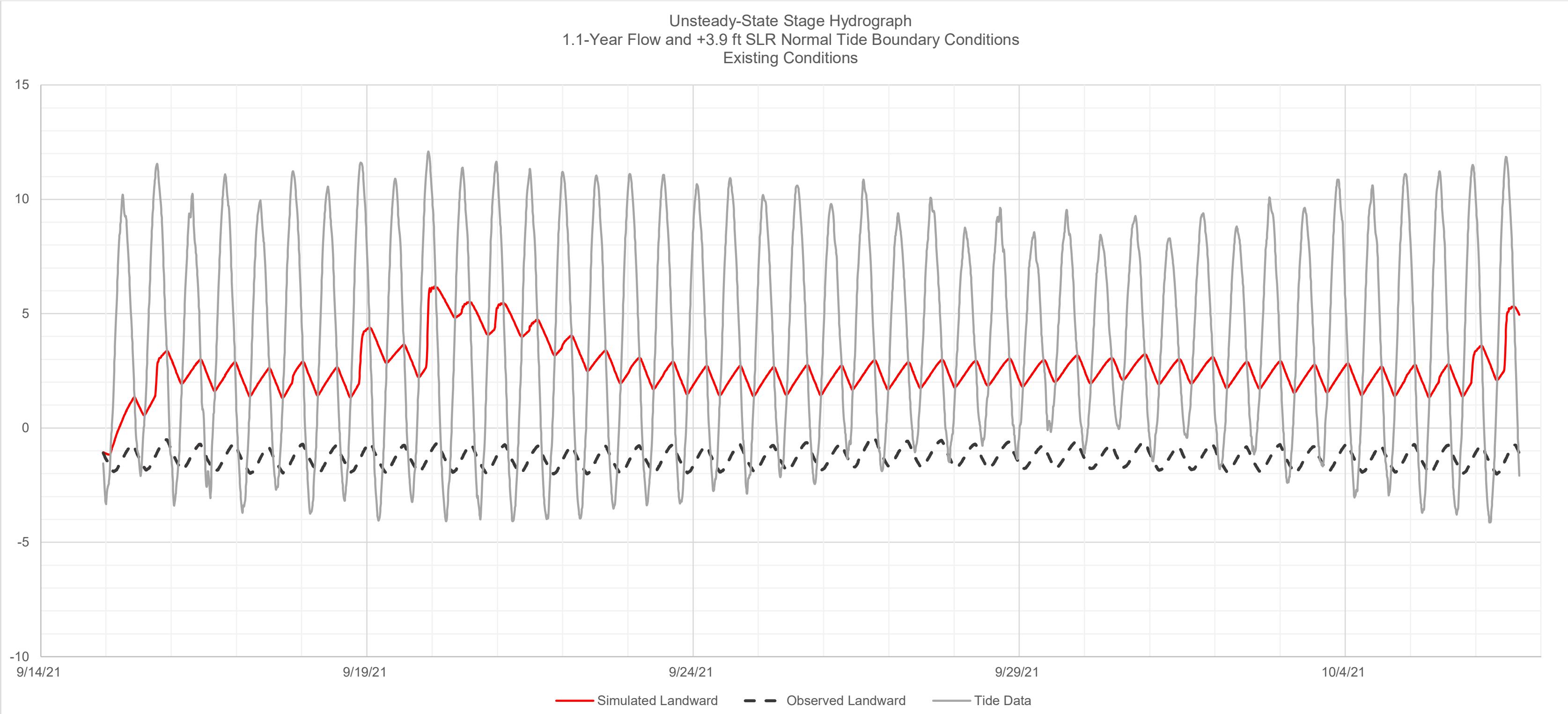


Figure A.19 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

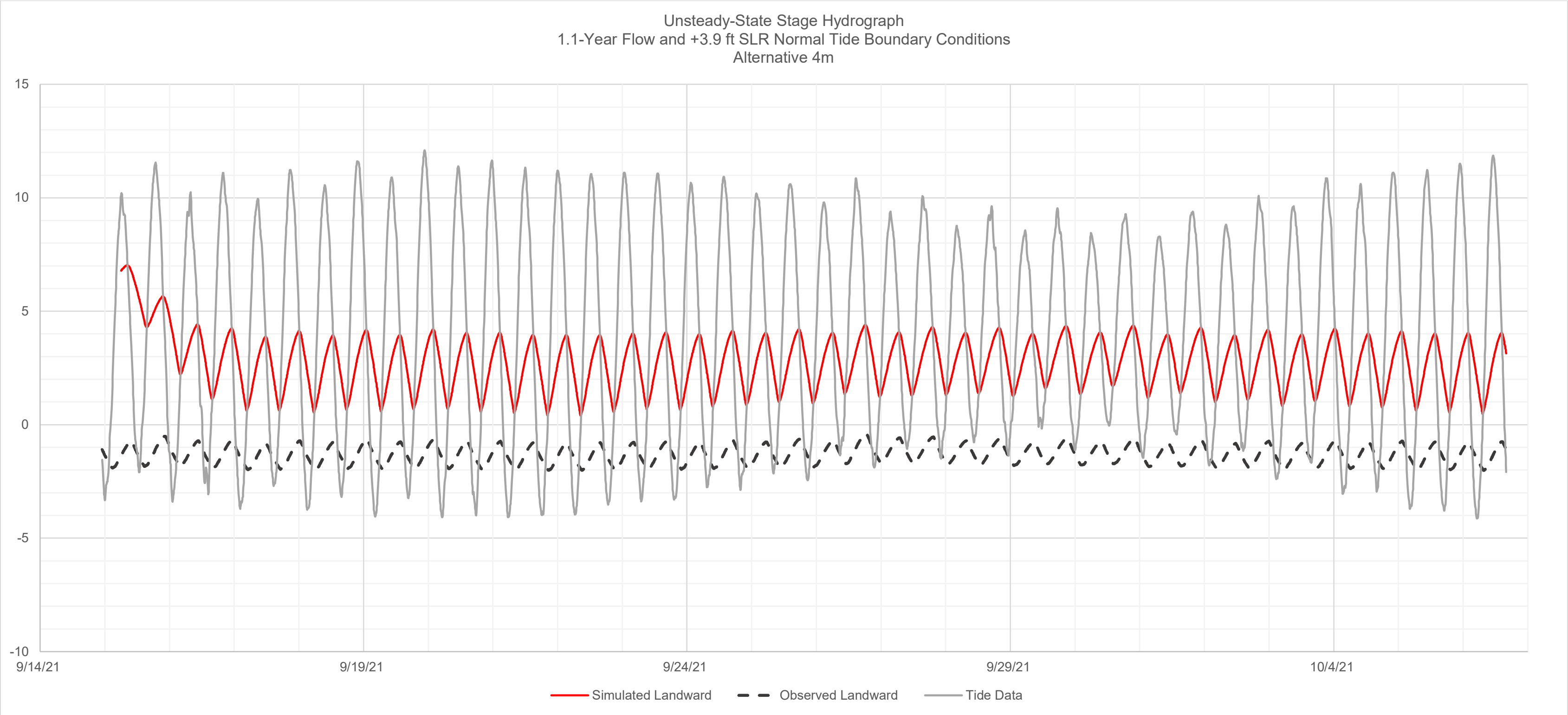


Figure A.20 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

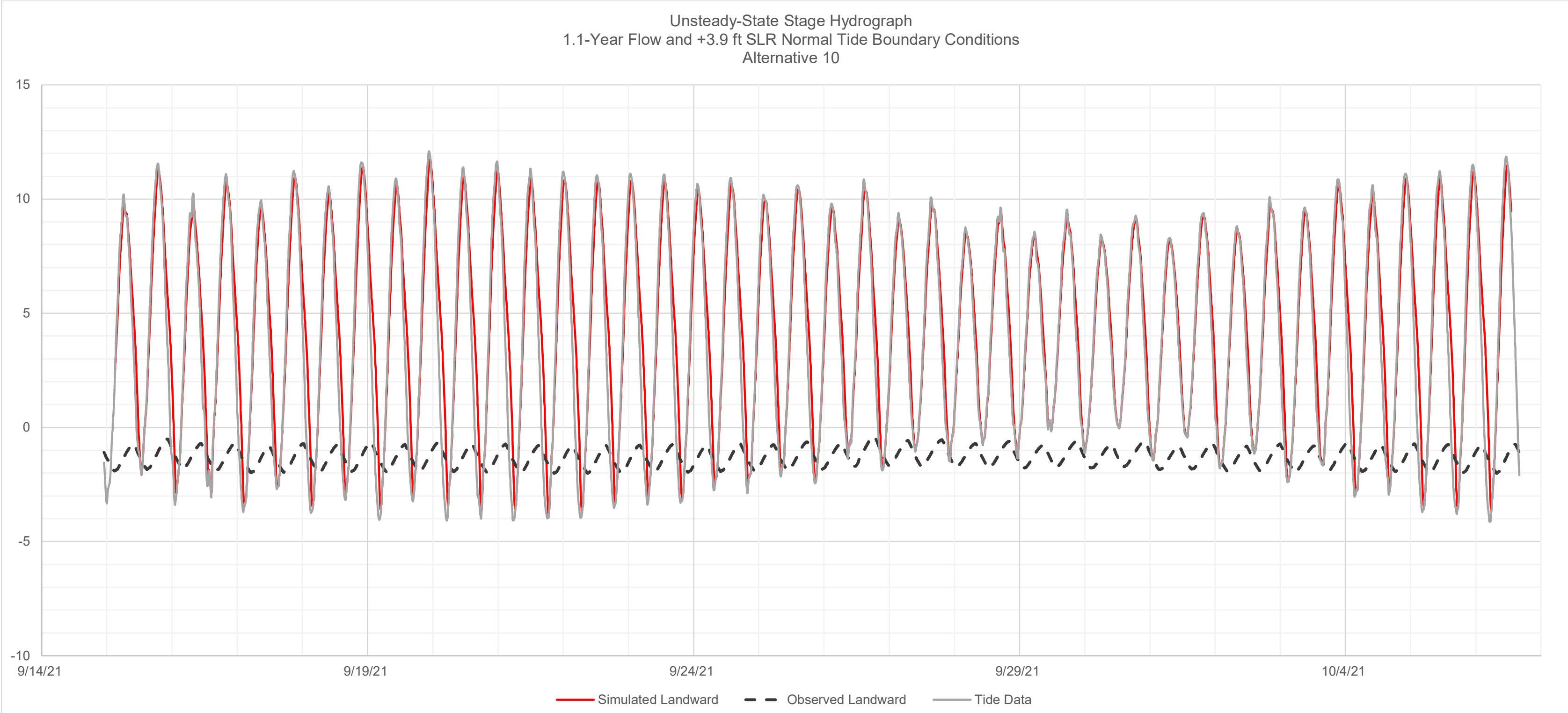


Figure A.21 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

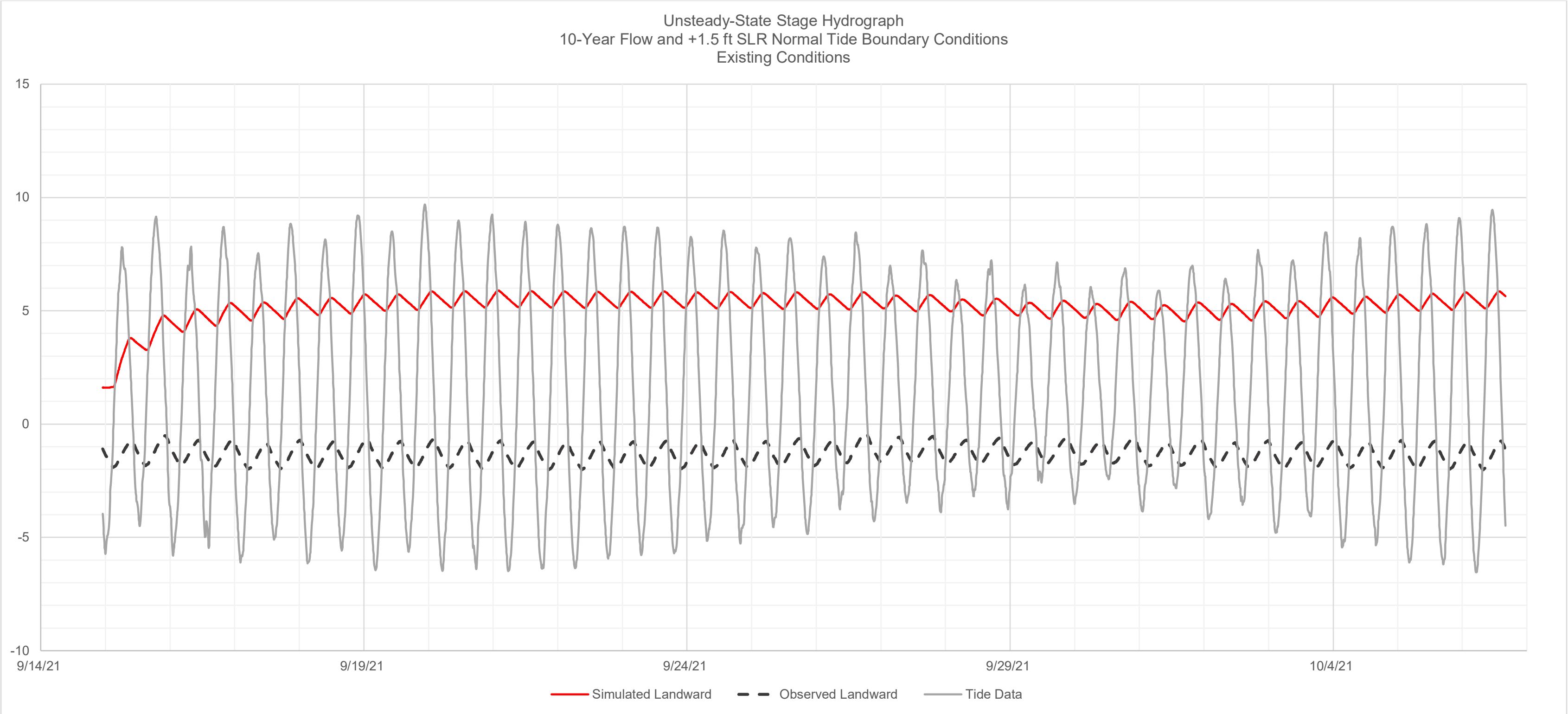


Figure A.22 - Unsteady-state stage hydrograph for 10-year riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

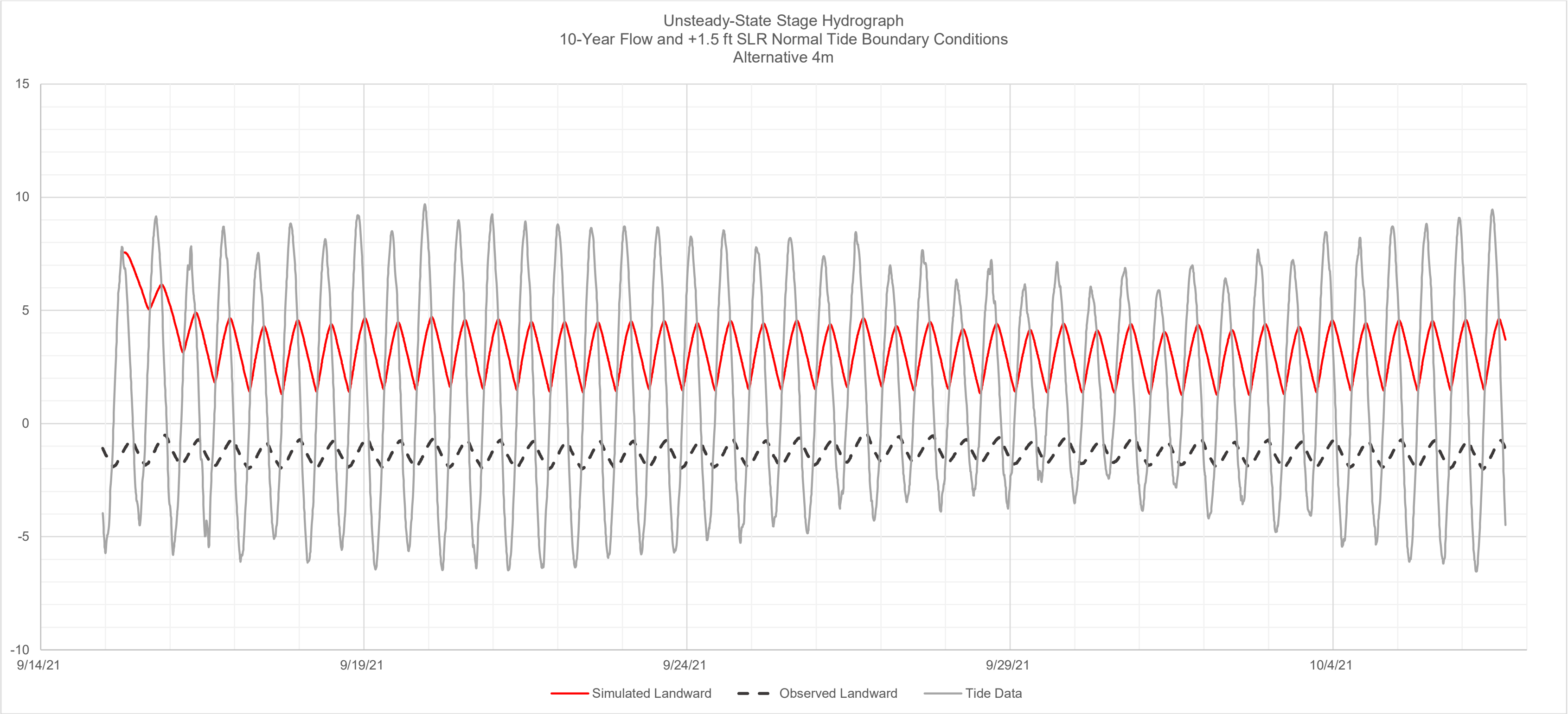


Figure A.23 - Unsteady-state stage hydrograph for 10-year riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

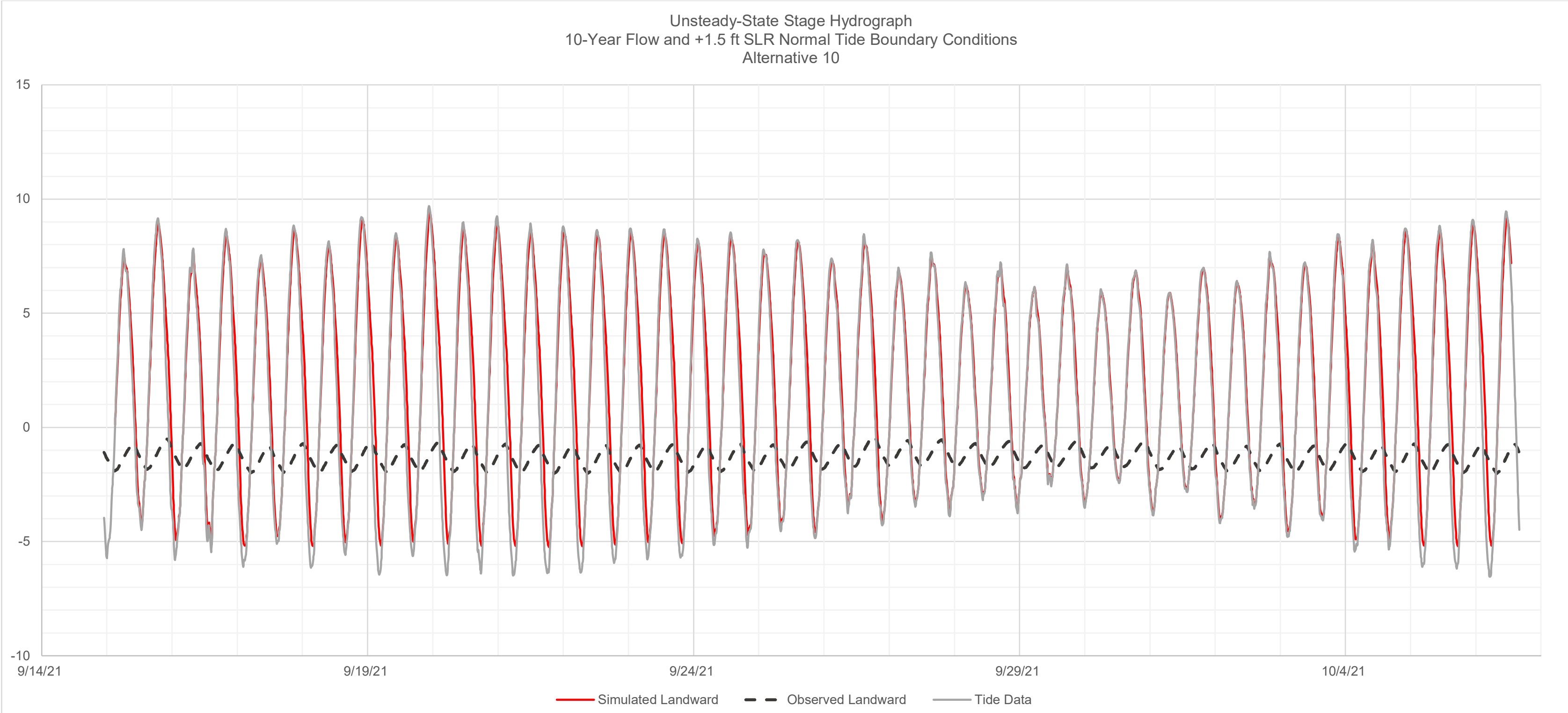


Figure A.24 - Unsteady-state stage hydrograph for 10-year riverine flow and +1.5 ft sea-level rise normal tide boundary conditions.

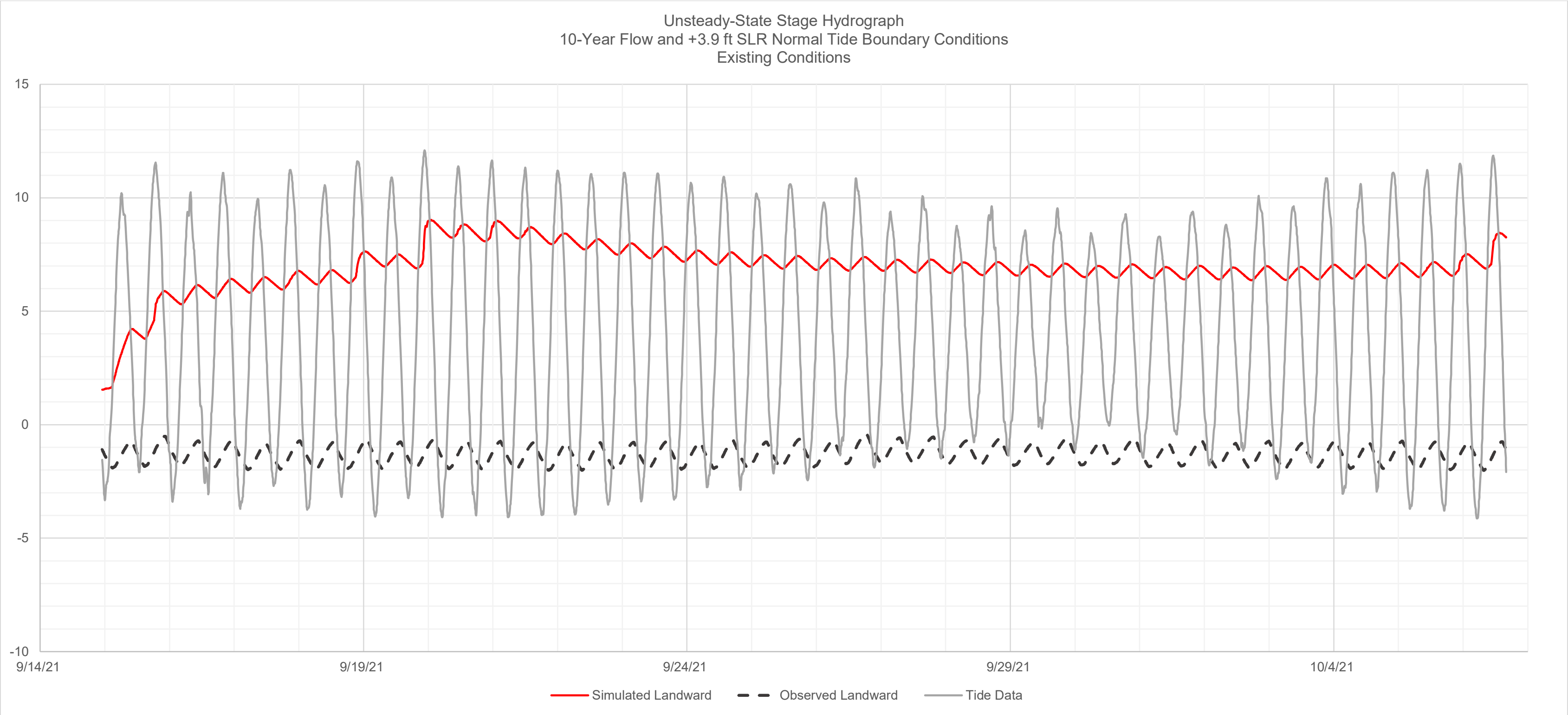


Figure A.25 - Unsteady-state stage hydrograph for 10-year riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

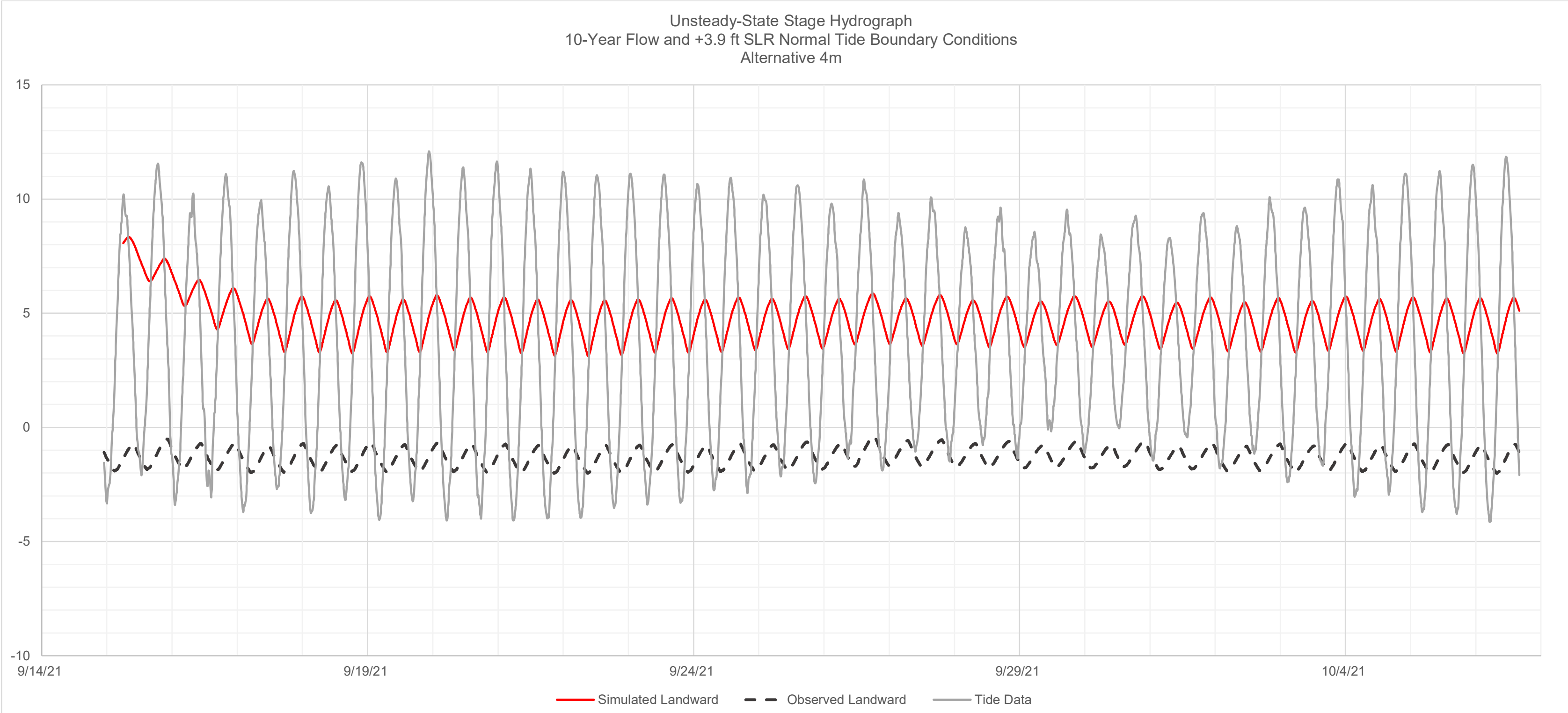


Figure A.26 - Unsteady-state stage hydrograph for 10-year riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

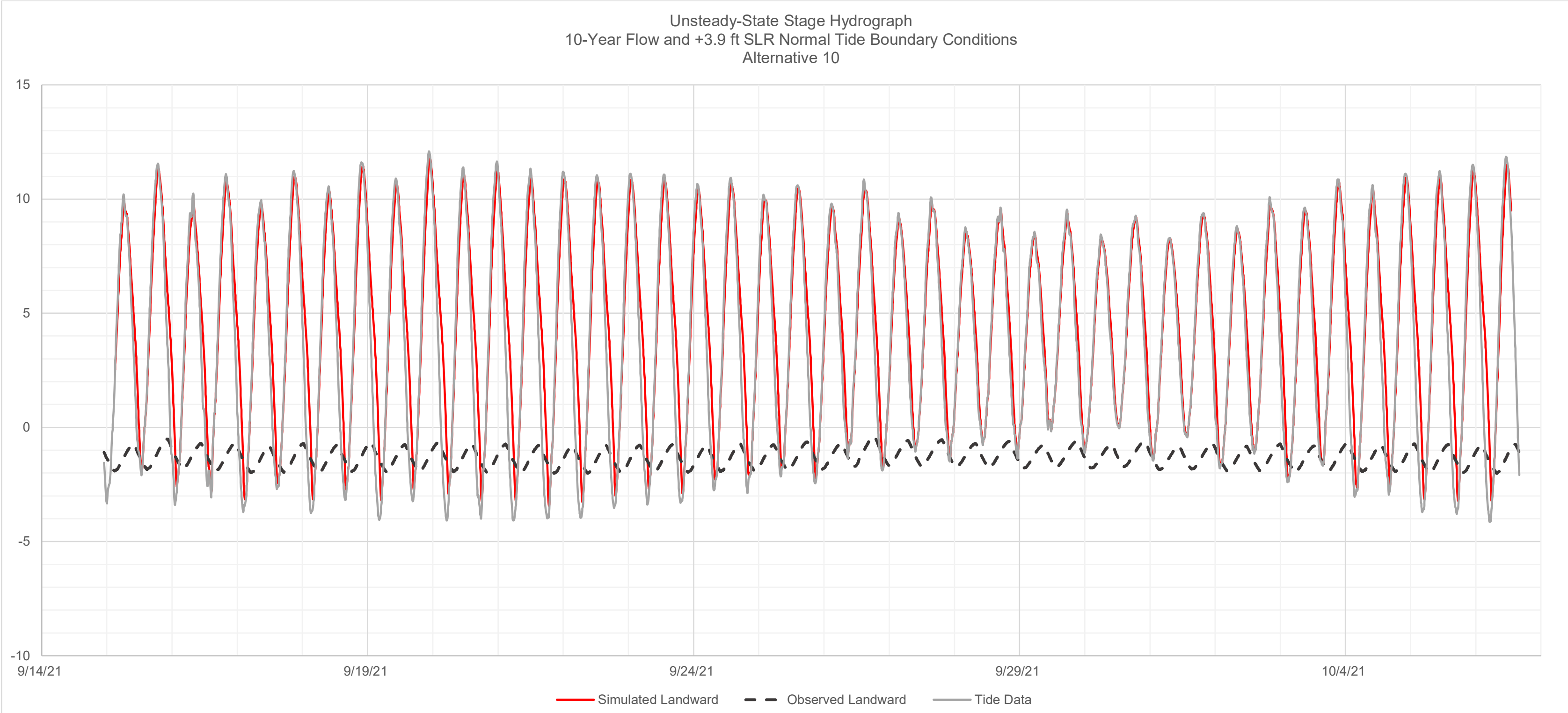


Figure A.27 - Unsteady-state stage hydrograph for 10-year riverine flow and +3.9 ft sea-level rise normal tide boundary conditions.

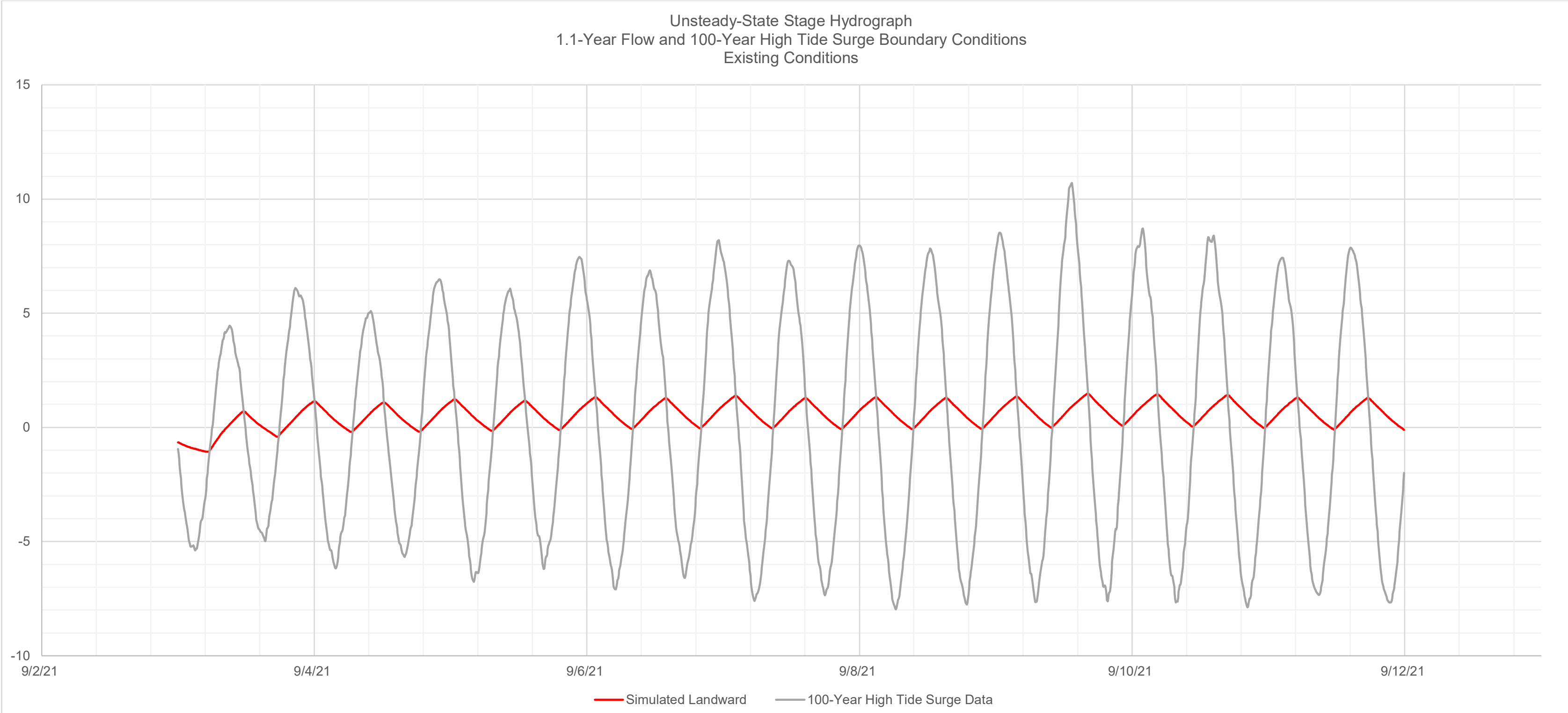


Figure A.28 - Unsteady-state stage hydrograph for 1.1-year riverine flow and 100-year high tide surge boundary conditions.

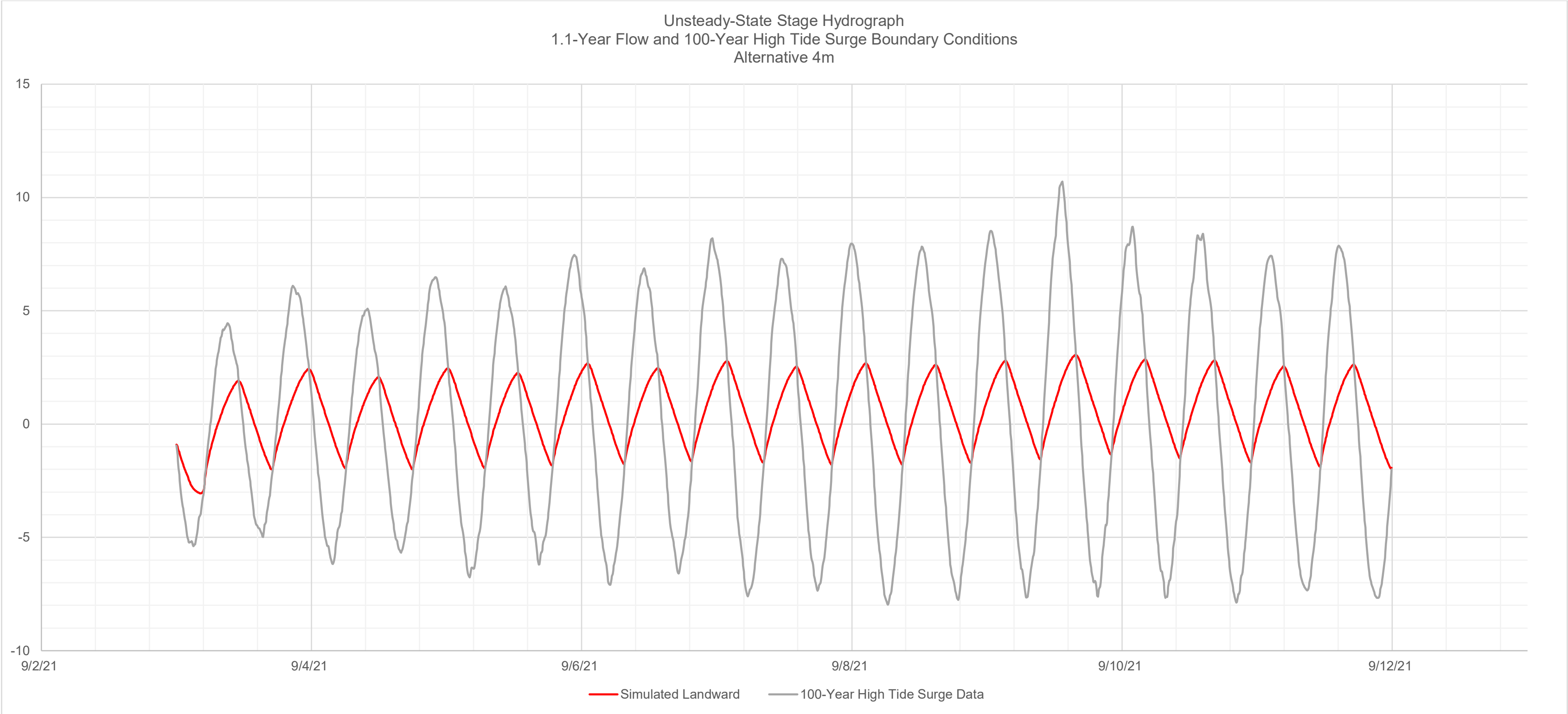


Figure A.29 - Unsteady-state stage hydrograph for 1.1-year riverine flow and 100-year high tide surge boundary conditions.

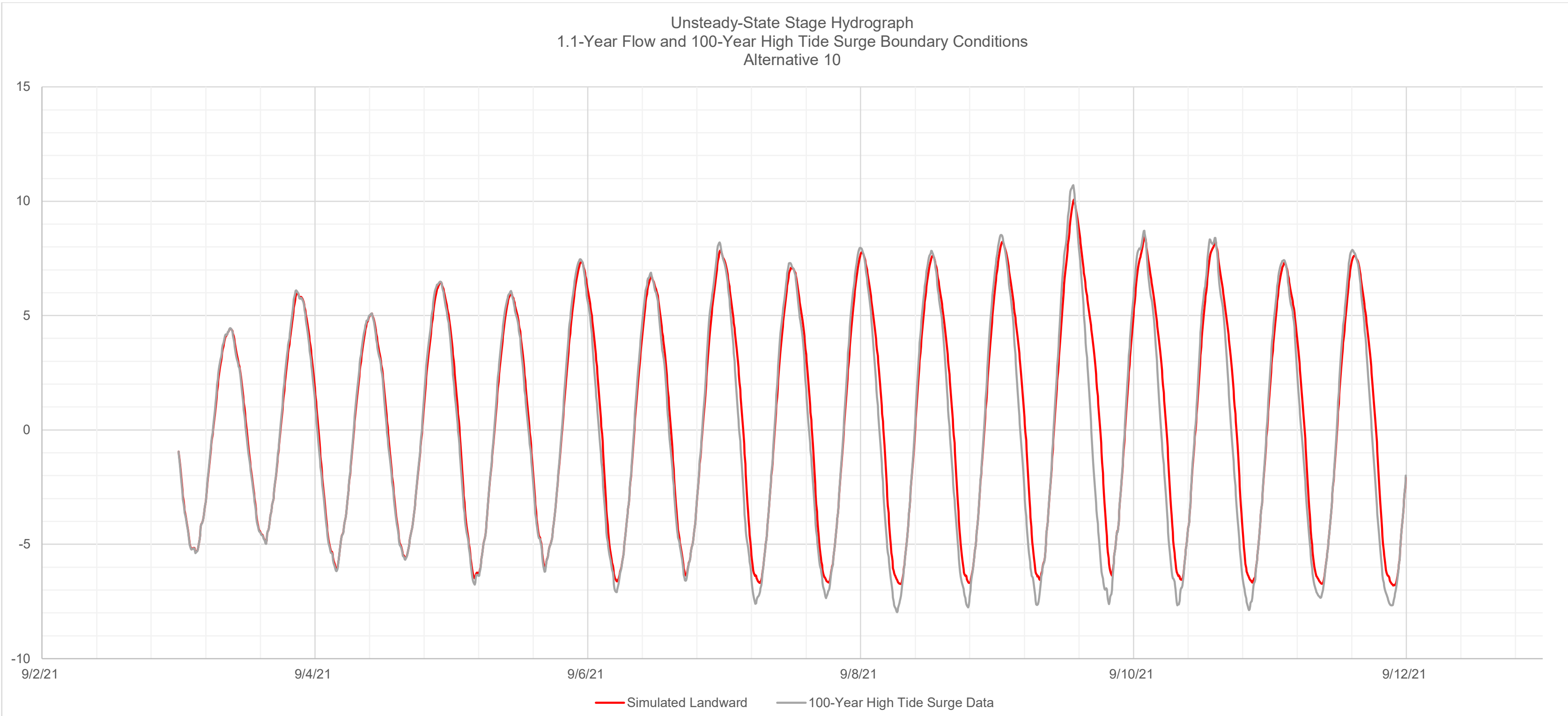


Figure A.30 - Unsteady-state stage hydrograph for 1.1-year riverine flow and 100-year high tide surge boundary conditions.

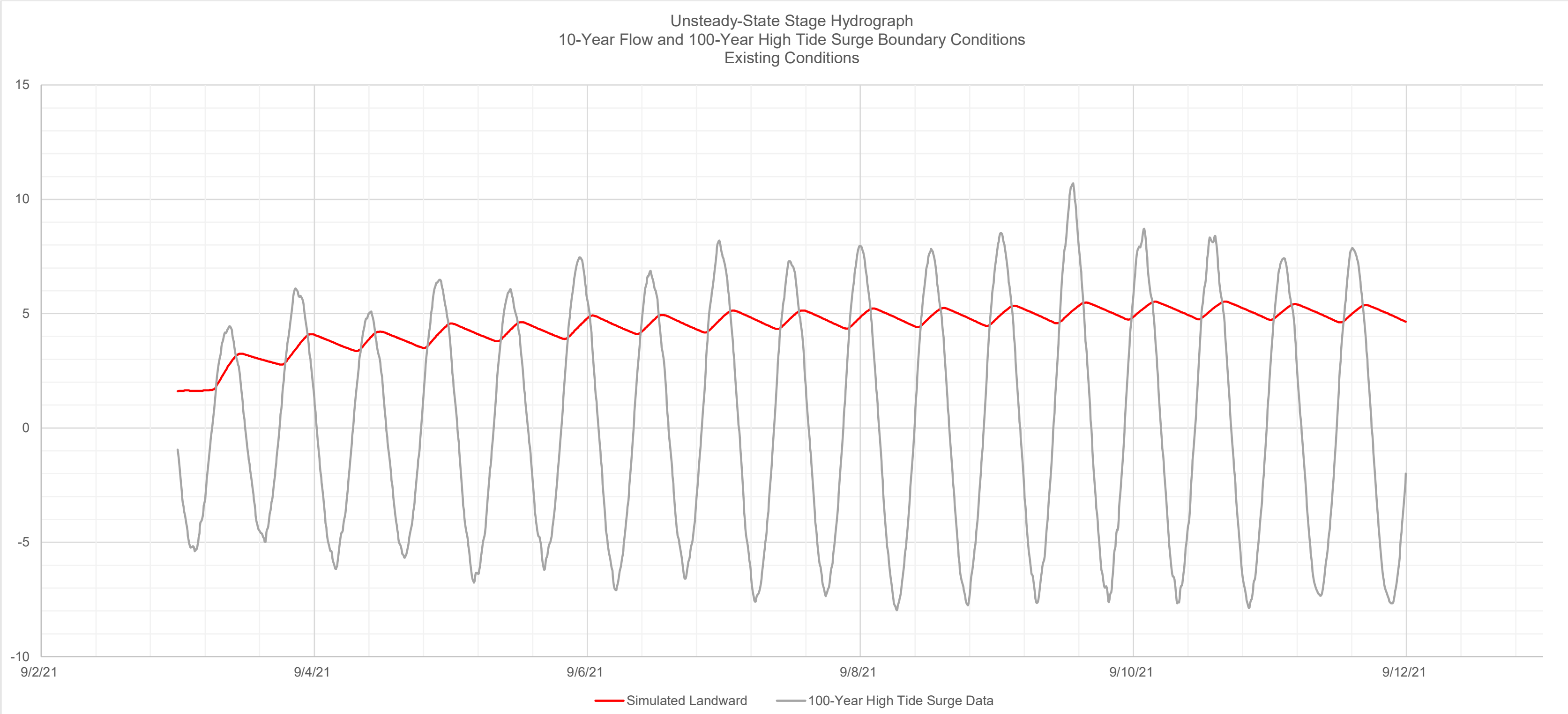


Figure A.31 - Unsteady-state stage hydrograph for 10-year riverine flow and 100-year high tide surge boundary conditions.

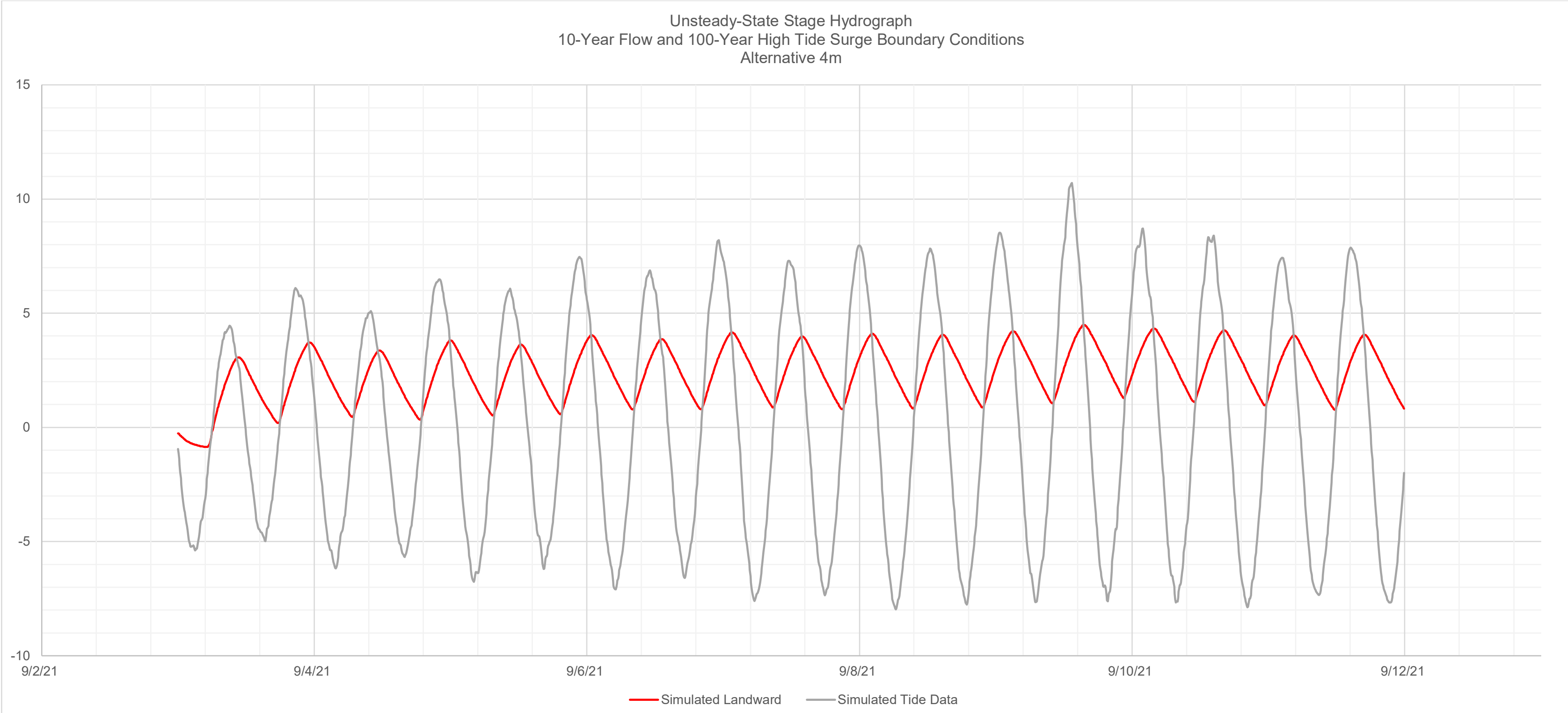


Figure A.32 - Unsteady-state stage hydrograph for 10-year riverine flow and 100-year high tide surge boundary conditions.

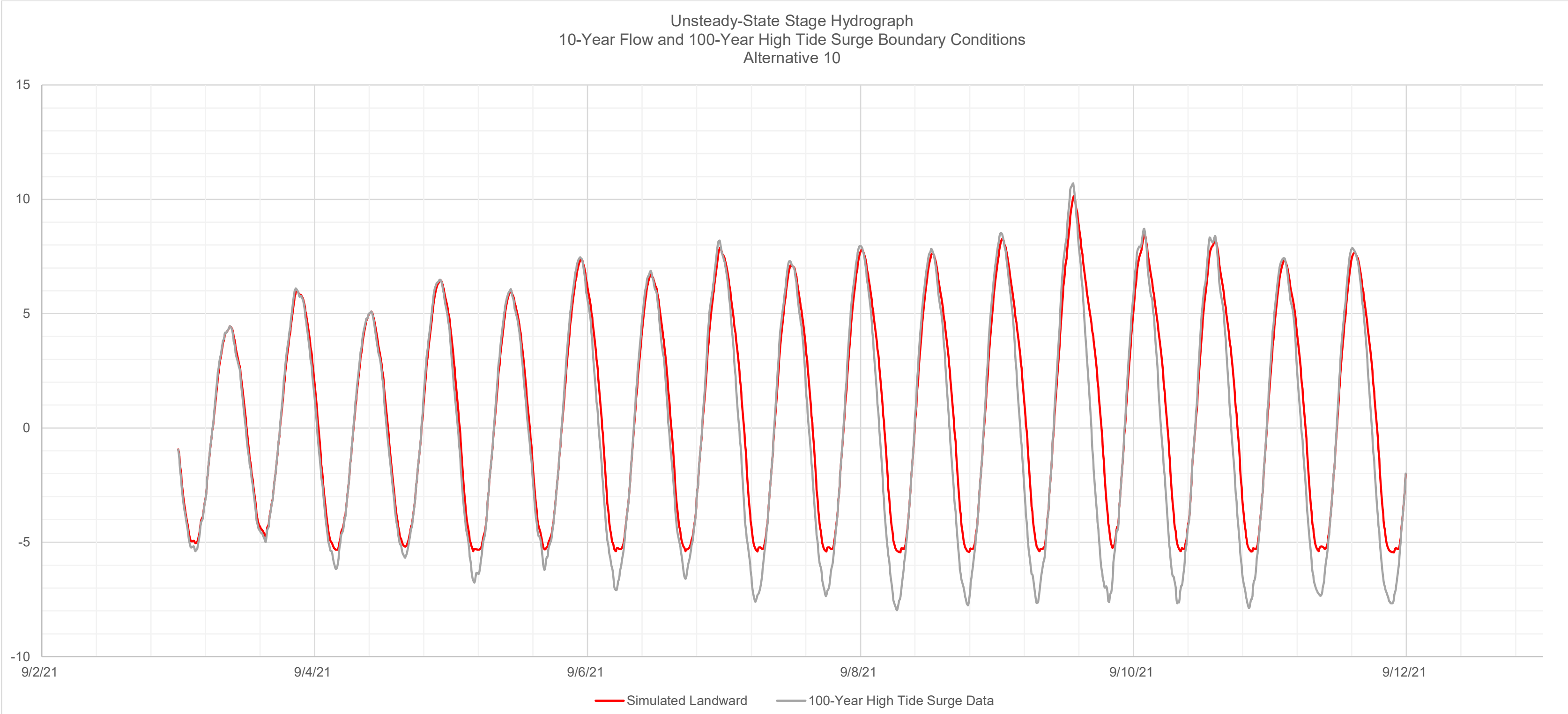


Figure A.33 - Unsteady-state stage hydrograph for 10-year riverine flow and 100-year high tide surge boundary conditions.

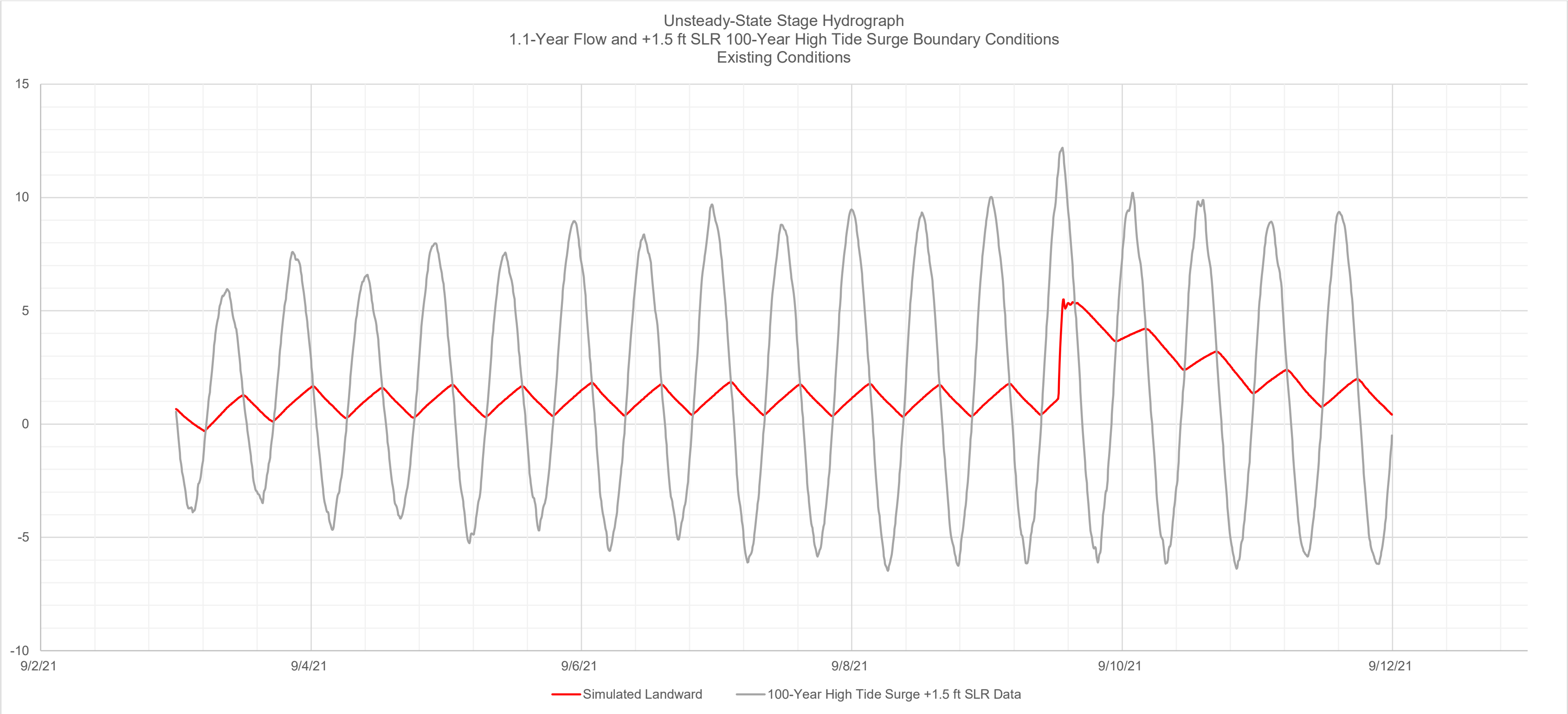


Figure A.34 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +1.5 ft sea-level rise on the 100-year high tide surge boundary conditions.

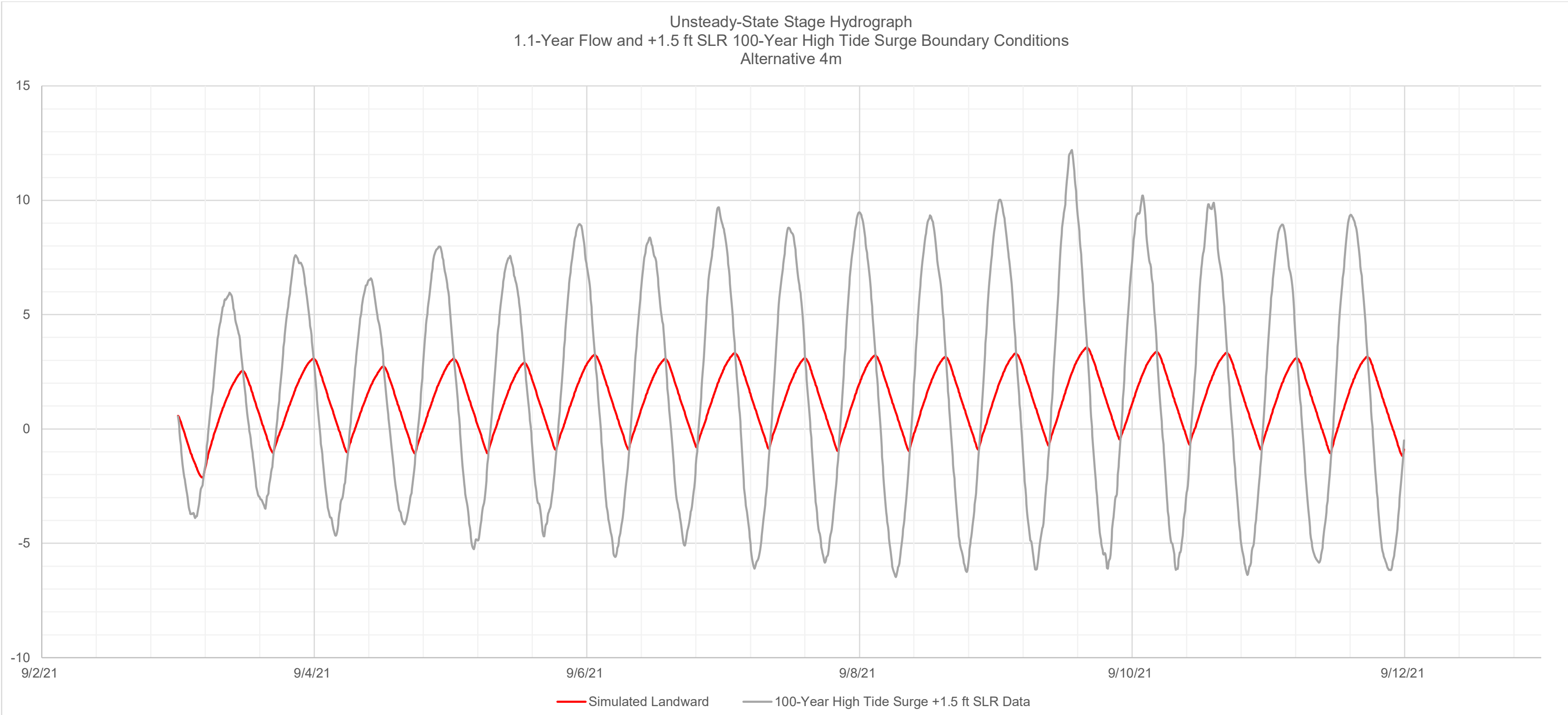


Figure A.35 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +1.5 ft sea-level rise on the 100-year high tide surge boundary conditions.

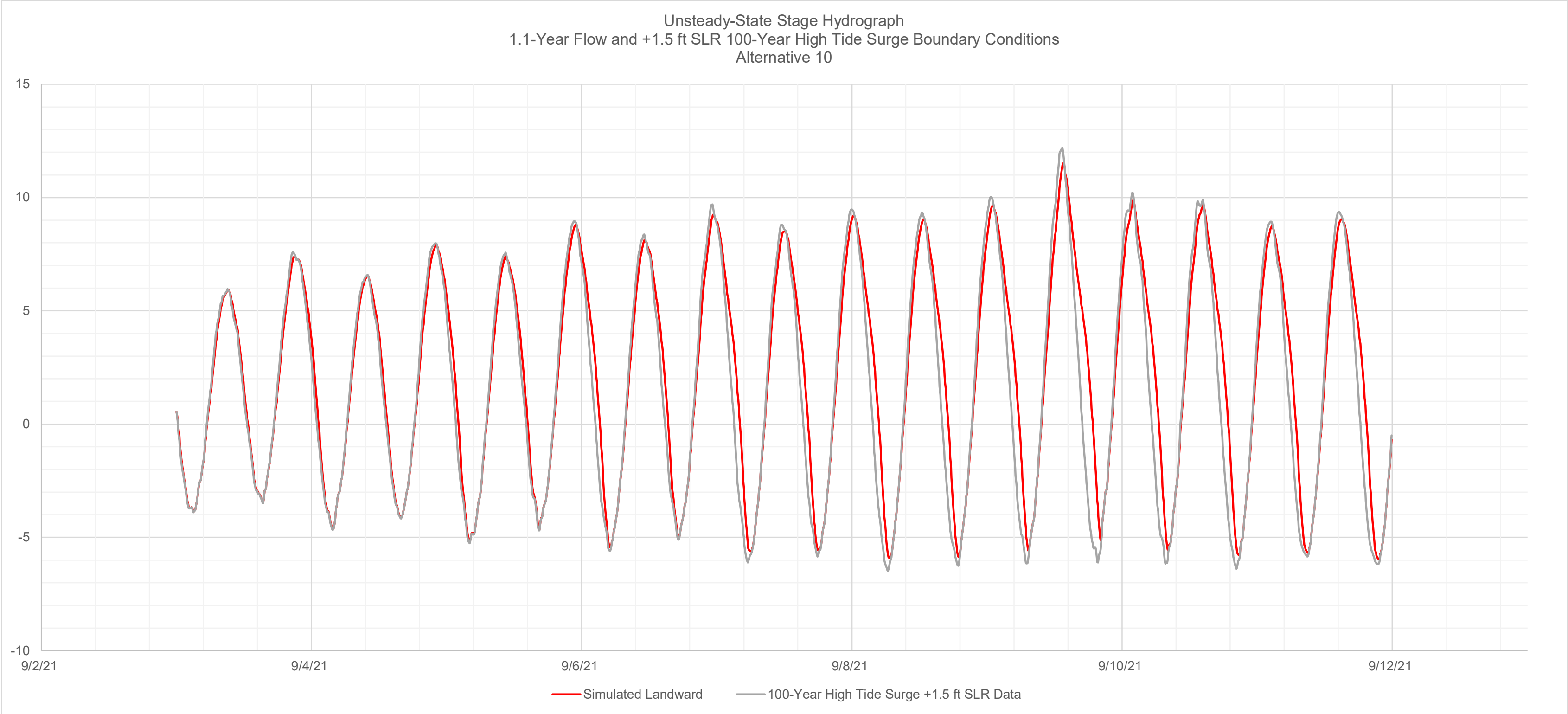


Figure A.36 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +1.5 ft sea-level rise on the 100-year high tide surge boundary conditions.

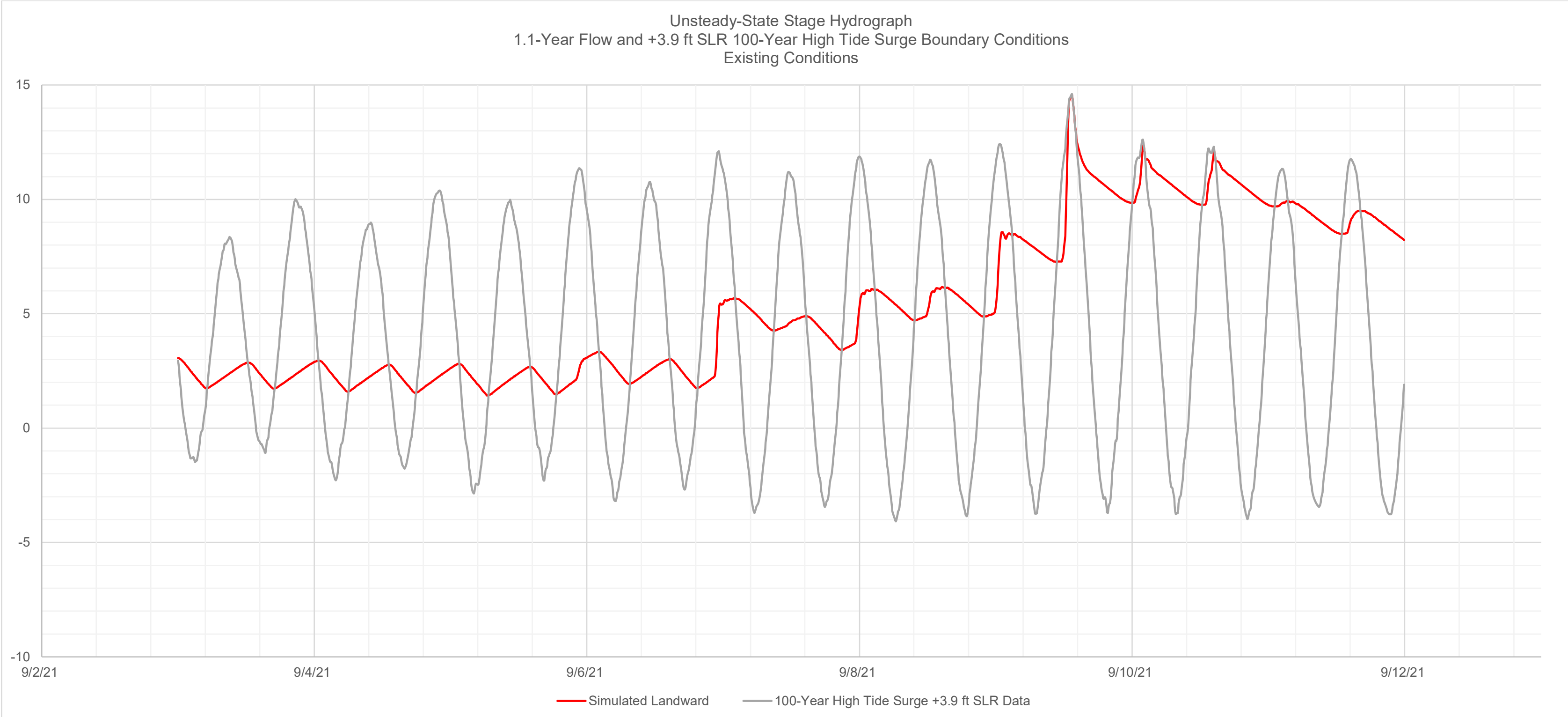


Figure A.37 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +3.9 ft sea-level rise on the 100-year high tide surge boundary conditions.

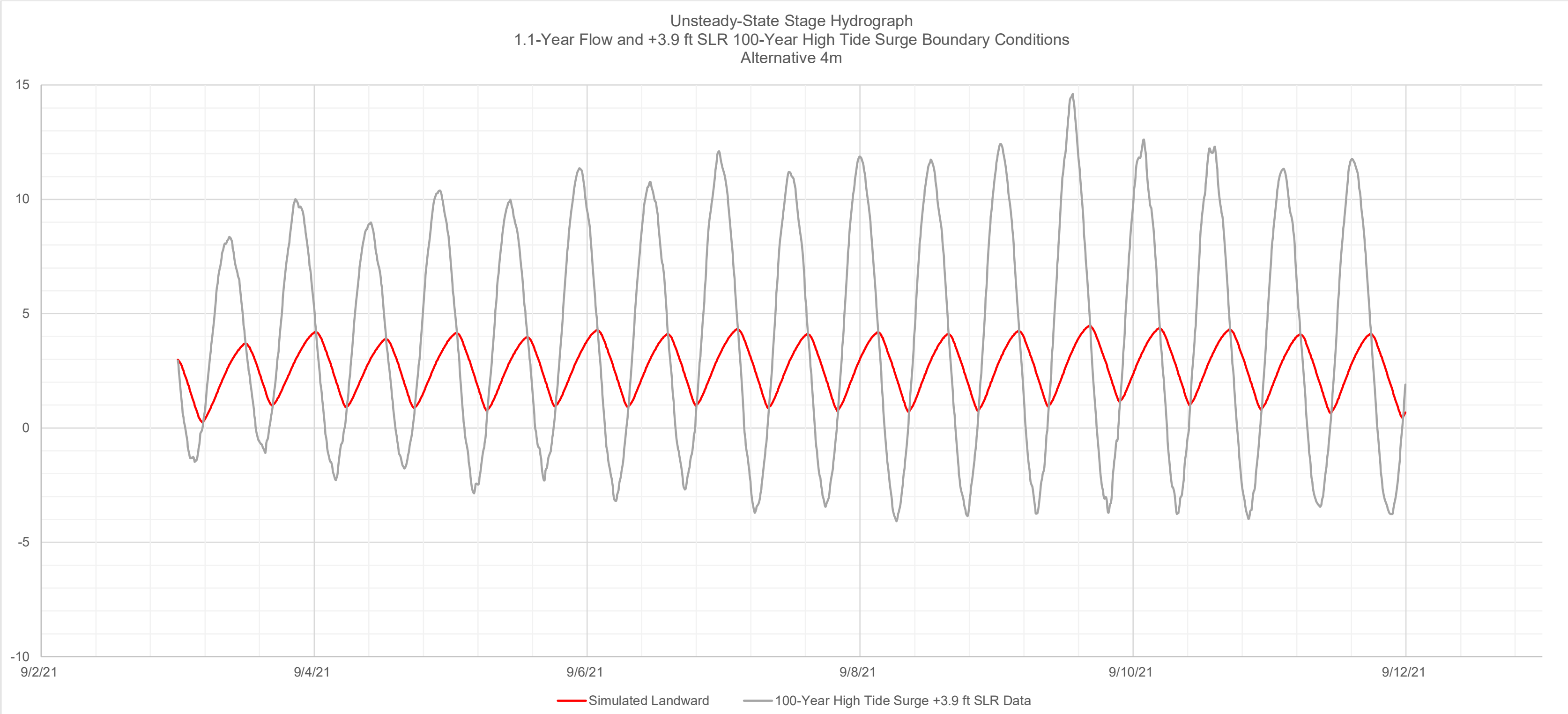


Figure A.38 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +3.9 ft sea-level rise on the 100-year high tide surge boundary conditions.

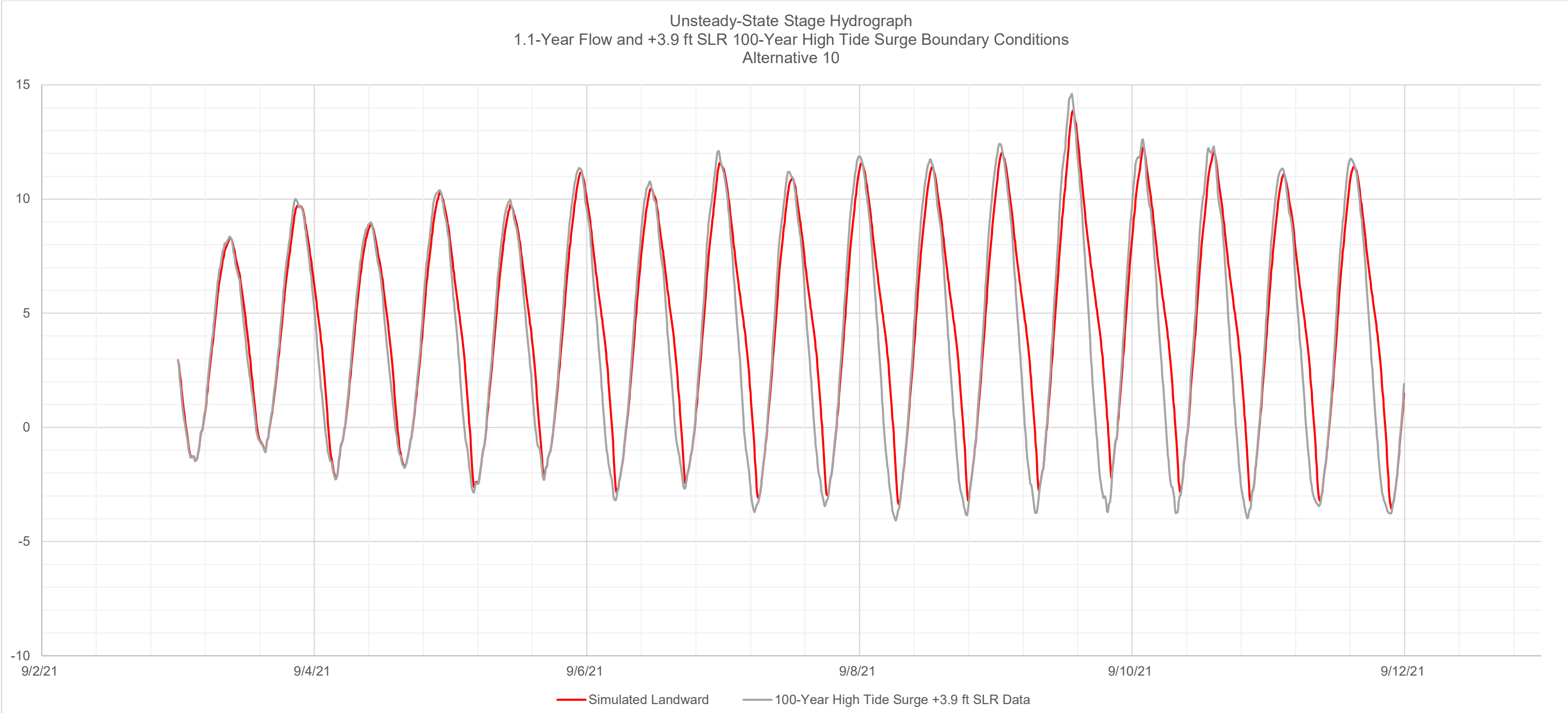


Figure A.39 - Unsteady-state stage hydrograph for 1.1-year riverine flow and +3.9 ft sea-level rise on the 100-year high tide surge boundary conditions.

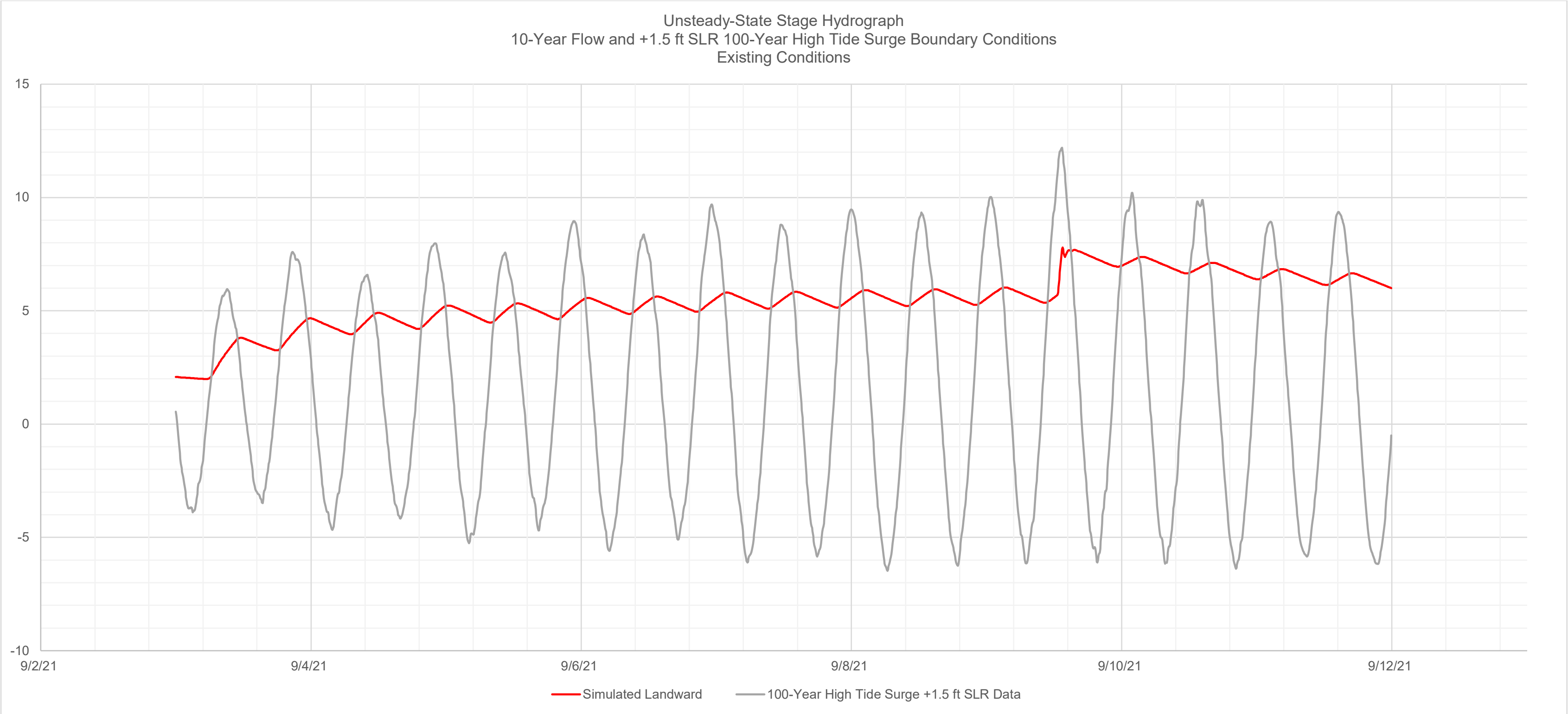


Figure A.40 - Unsteady-state stage hydrograph for 10-year riverine flow and +1.5 ft sea-level rise on the 100-year high tide surge boundary conditions.

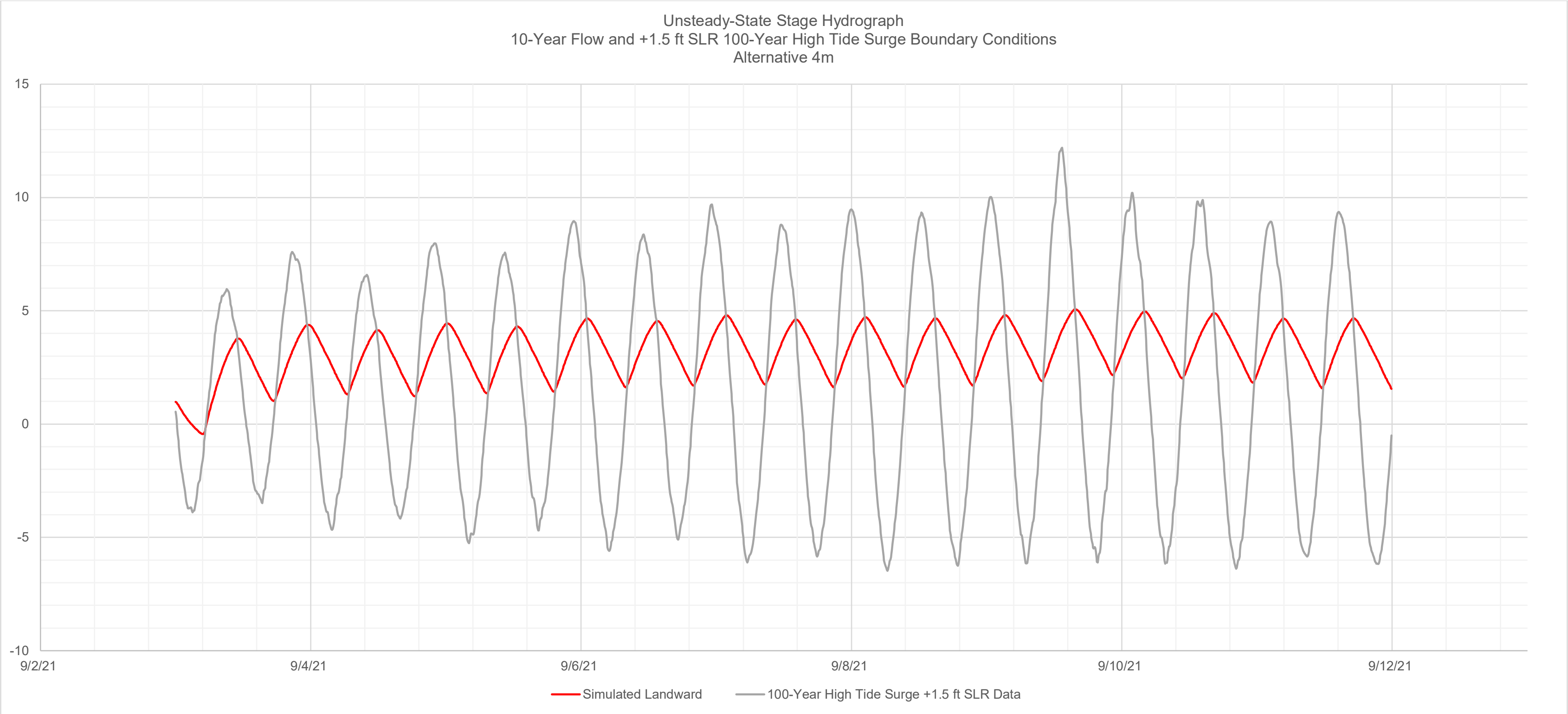


Figure A.41 - Unsteady-state stage hydrograph for 10-year riverine flow and +1.5 ft sea-level rise on the 100-year high tide surge boundary conditions.

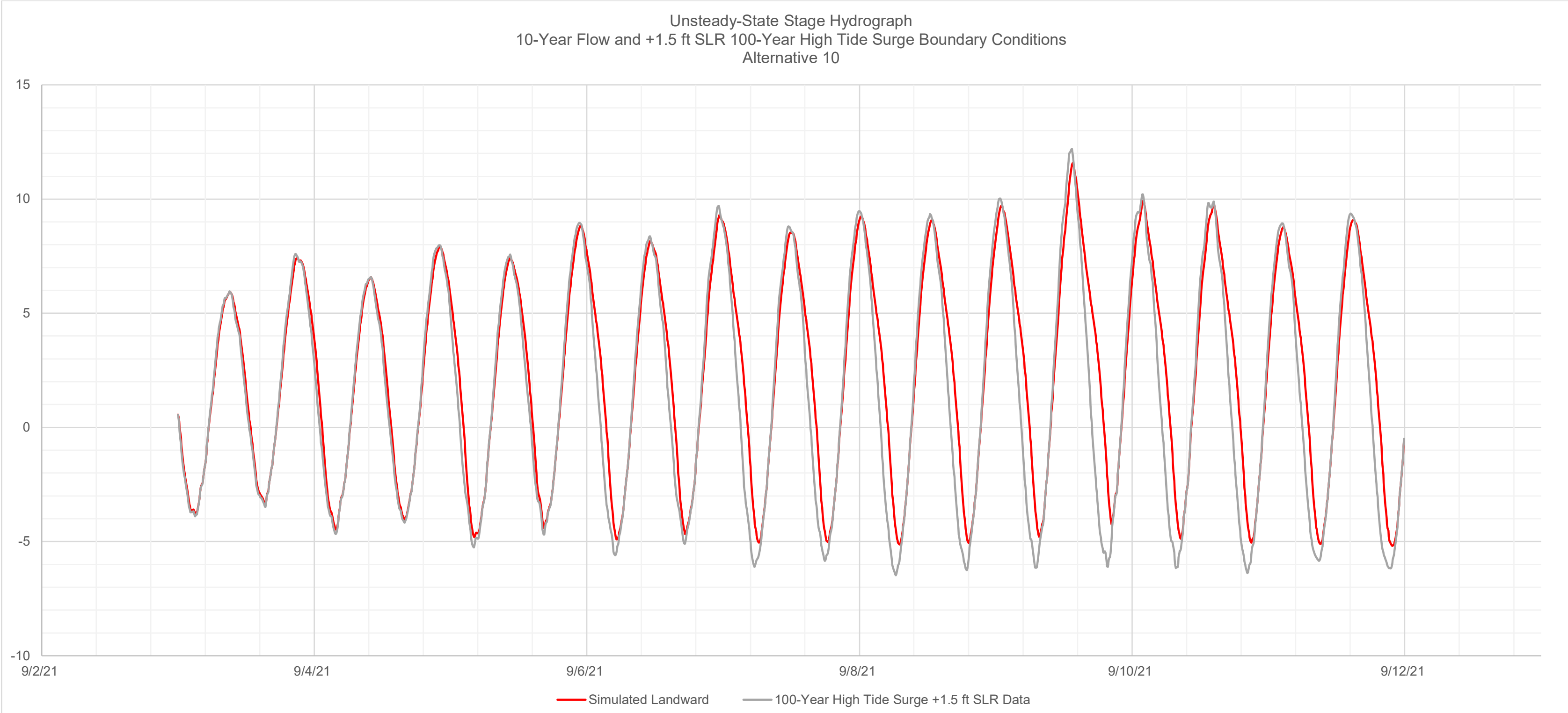


Figure A.42 - Unsteady-state stage hydrograph for 10-year riverine flow and +1.5 ft sea-level rise on the 100-year high tide surge boundary conditions.

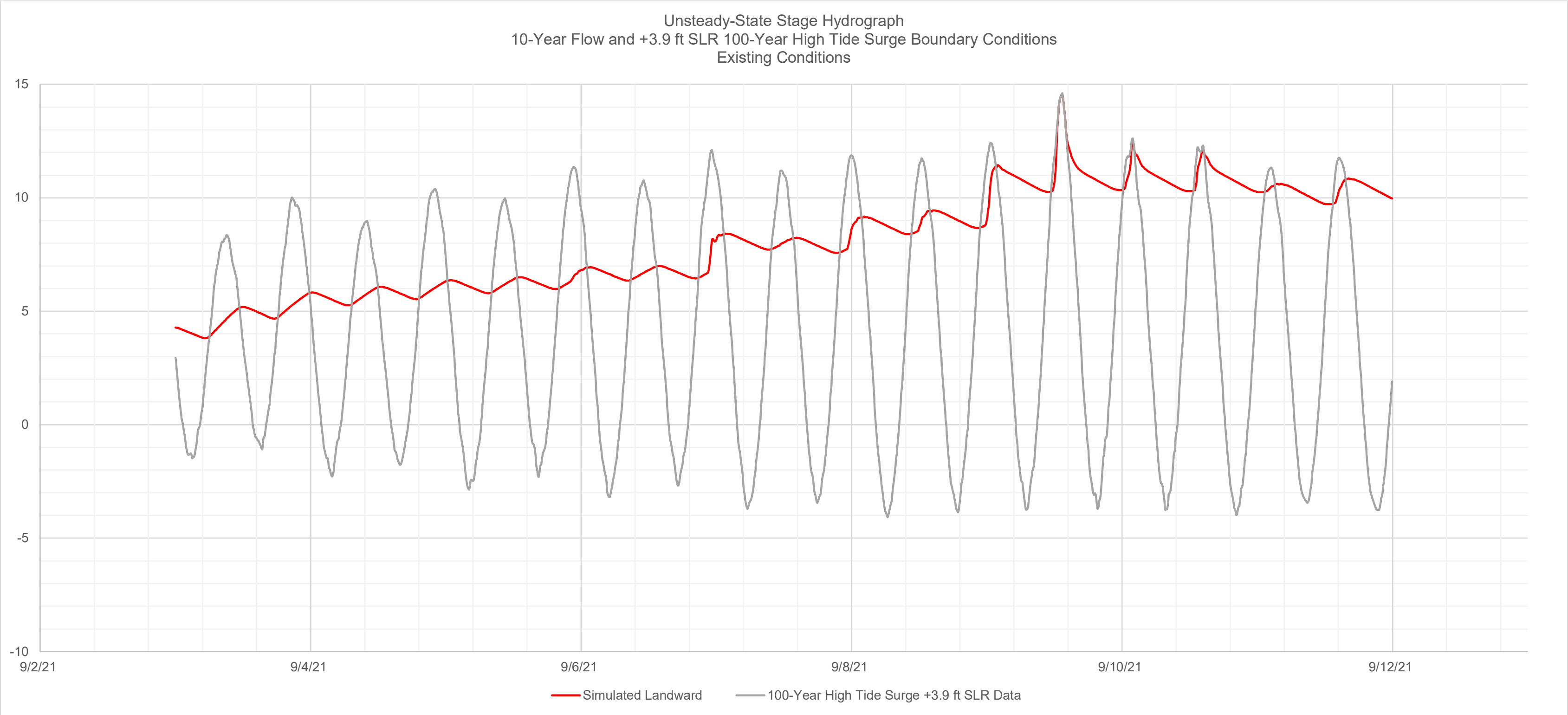


Figure A.43 - Unsteady-state stage hydrograph for 10-year riverine flow and +3.9 ft sea-level rise on the 100-year high tide surge boundary conditions.

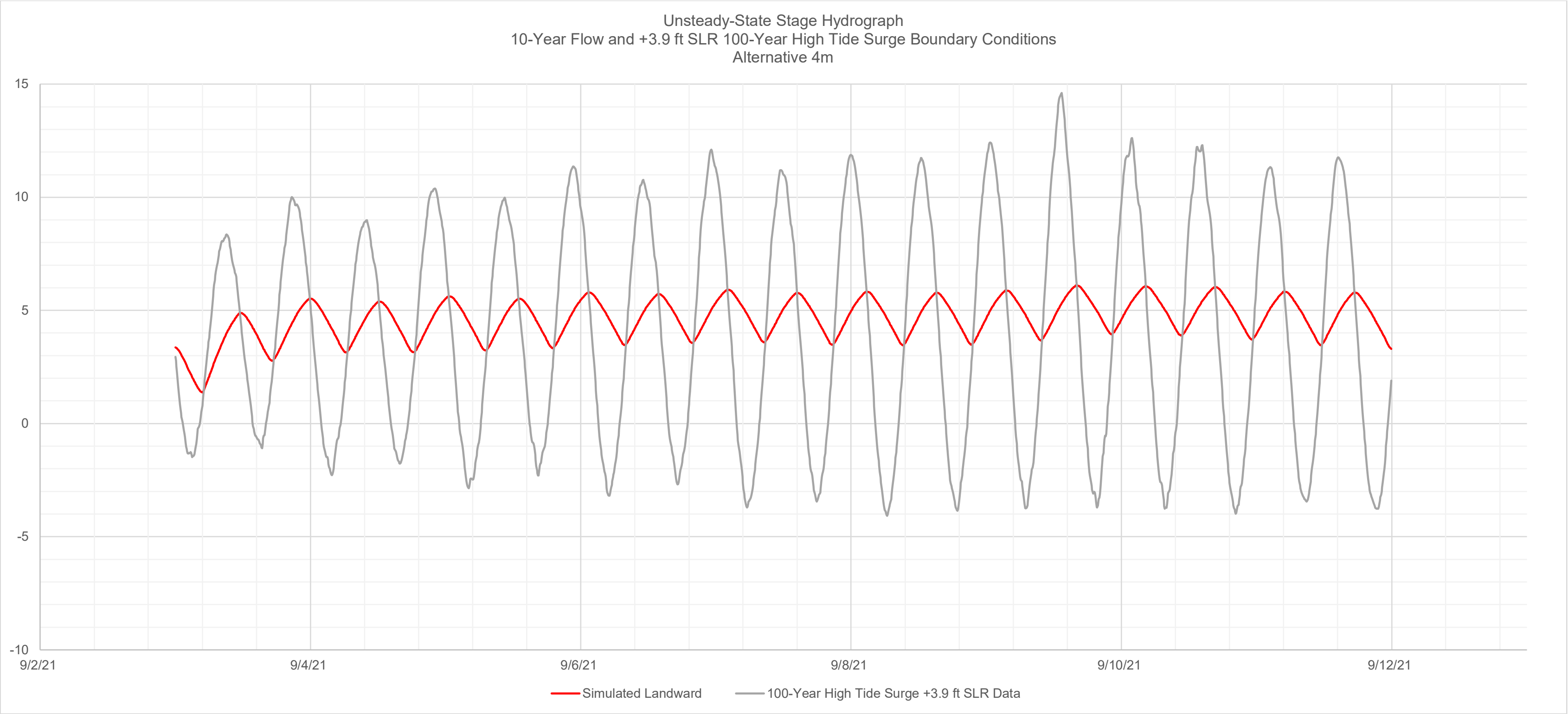


Figure A.44 - Unsteady-state stage hydrograph for 10-year riverine flow and +3.9 ft sea-level rise on the 100-year high tide surge boundary conditions.

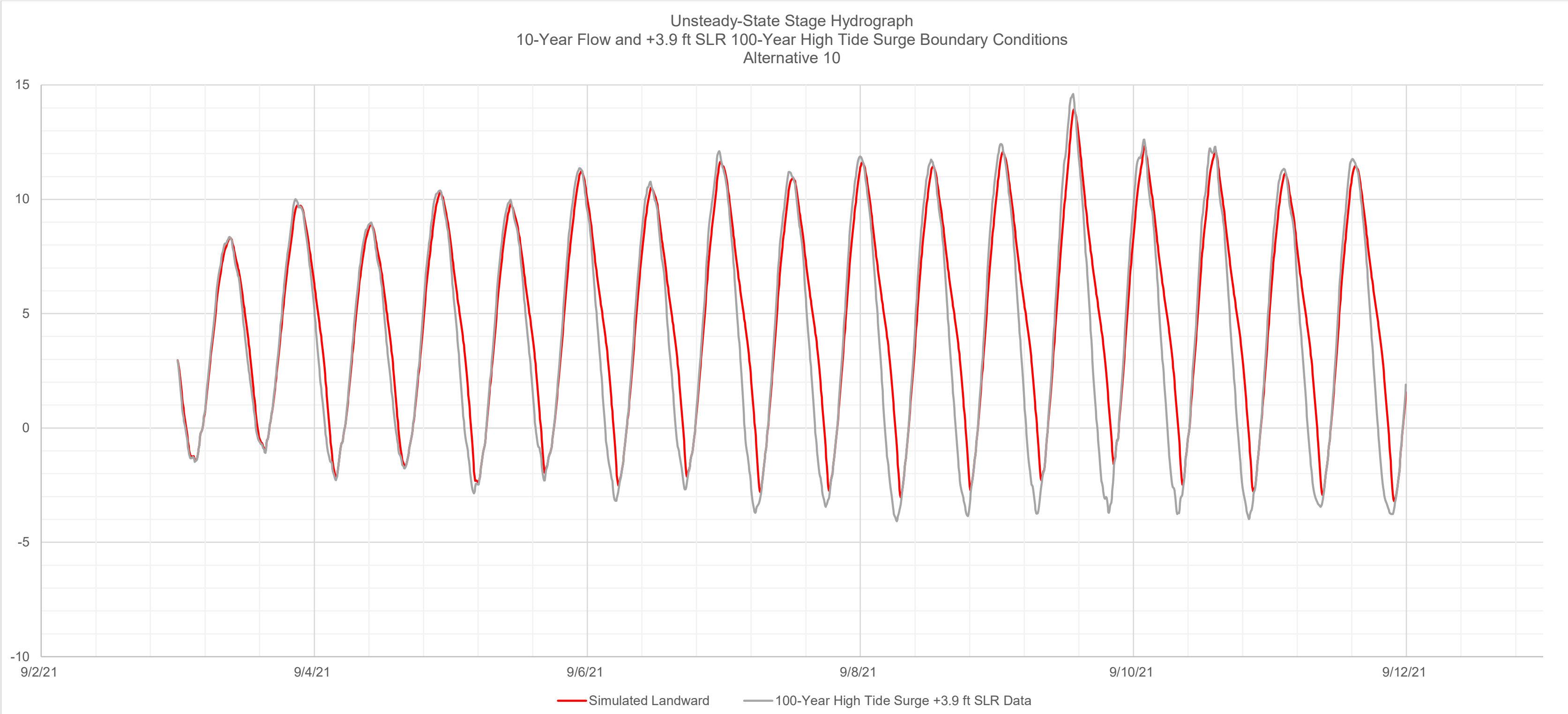
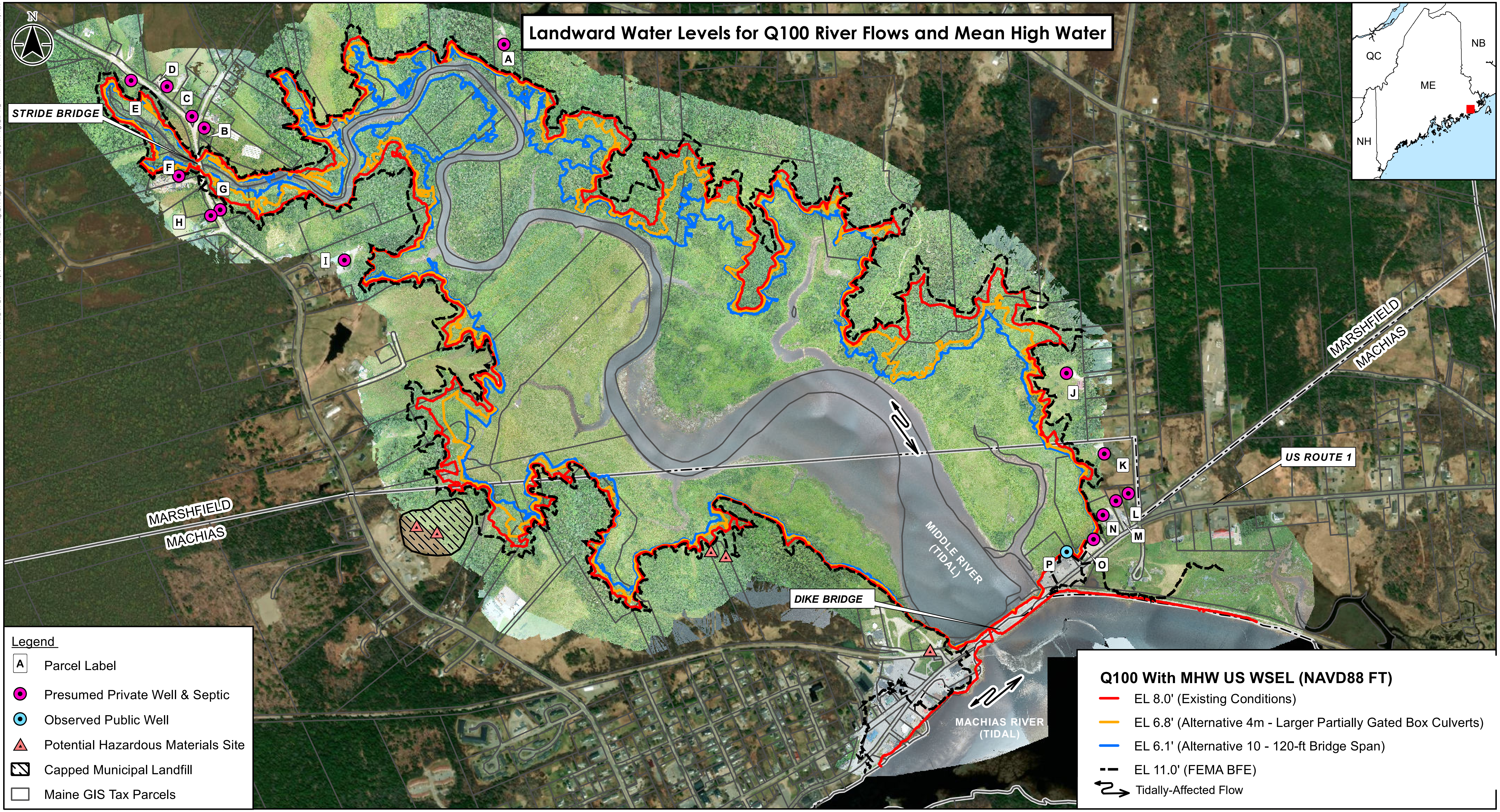


Figure A.45 - Unsteady-state stage hydrograph for 10-year riverine flow and +3.9 ft sea-level rise on the 100-year high tide surge boundary conditions.

APPENDIX B INUNDATION FIGURES



Stantec

30 Park Drive
Topsham, ME USA 04086
Phone (207) 729-1199

Prepared by EPL on 2021-12-06
Reviewed by TM on 2021-12-06

50347_DykeBridge_Q100_MHW.mxd

Notes

1. Existing conditions are based on 2021 tidal stage data that was collected after leaking gates were fixed and 2021 drone imagery collected by MaineDOT before the leaking gates were fixed and represent a range of potential existing conditions.
2. Approximate water surface elevations (WSEL) for proposed alternatives are based on the 2021 Phase 1 and Phase 2 hydraulics analyses using tidal stage data collected by MaineDOT in 2021.
3. Coordinate System: NAD 1983 UTM Zone 19N FT
4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

0 800 Feet
1 inch = 833 feet (At page size of 11"x17")

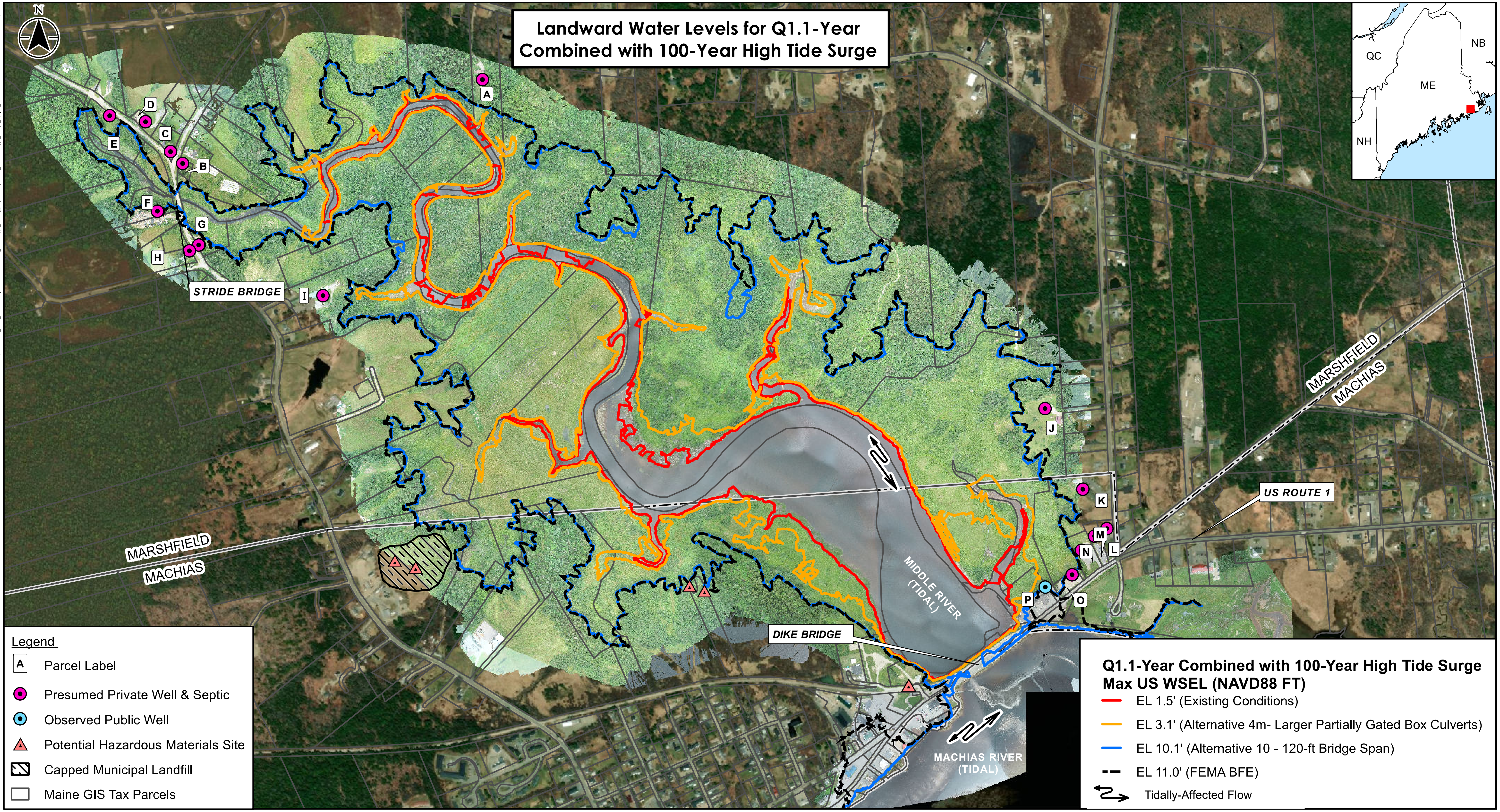
DRAFT

179450347

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.1

Title
Landward Water Levels for
Q100 River Flows and Mean High Water
12/20/2021



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Phone (207) 729-1199
Prepared by EPL on 2021-12-06
Reviewed by TM on 2021-12-06
50347_DykeBridge_100yr_Q1p1_norm.mxd

Notes

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7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

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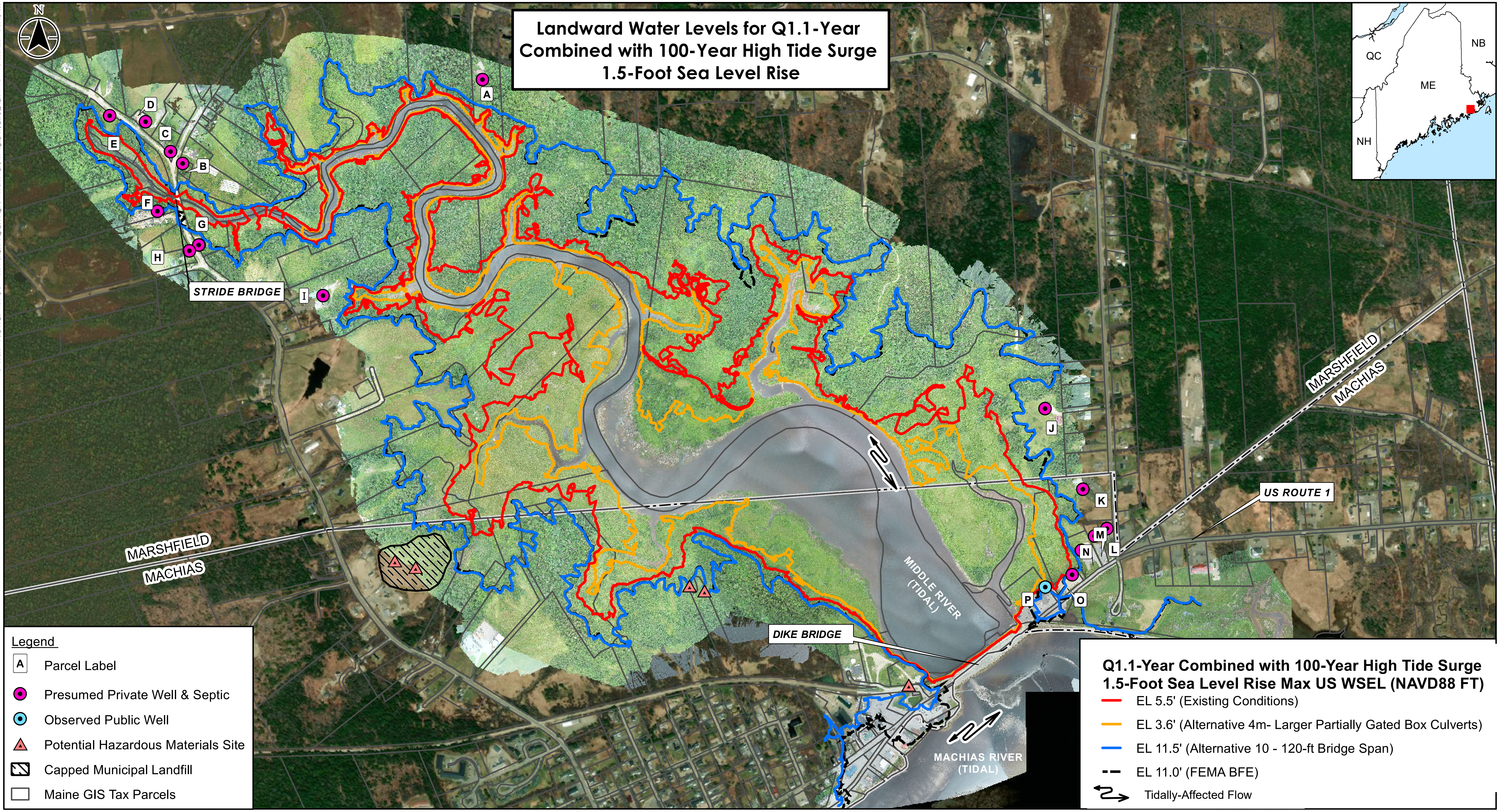
179450347

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.2

Title
Landward Water Levels for Q1.1-Year Combined with 100-Year High Tide Surge

12/20/2021



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Prepared by EPL on 2021-12-06
Reviewed by TM on 2021-12-06

50347_DykeBridge_100yr_Q1p_p5_SLR.mxd

Notes

1. Existing conditions are based on 2021 tidal stage data that was collected after leaking gates were fixed and 2021 drone imagery collected by MaineDOT before the leaking gates were fixed and represent a range of potential existing conditions.
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4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

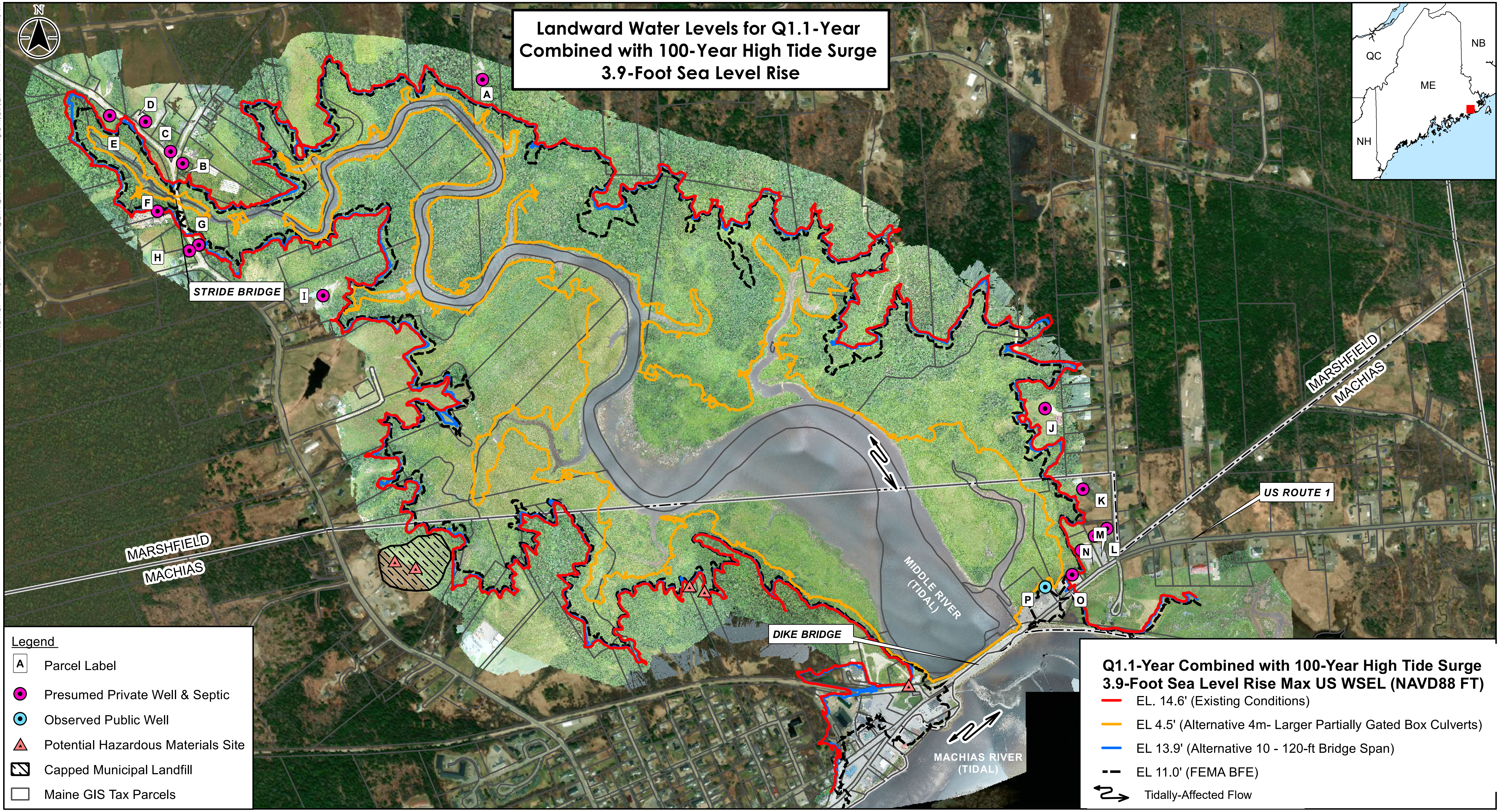
0 800 Feet
1 inch = 833 feet (At page size of 11"x17")

DRAFT

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.3

Title
Landward Water Levels for Q1.1-Year
Combined with 100-Year High Tide Surge
1.5-Foot Sea Level Rise
12/20/2021



179450347

Stantec
30 Park Drive
Topsham, ME USA 04086
Phone (207) 729-1199
Prepared by EPL on 2021-12-06
Reviewed by TM on 2021-12-06
50347_DykeBridge_100yr_Q1p_SLR.mxd

Notes

1. Existing conditions are based on 2021 tidal stage data that was collected after leaking gates were fixed and 2021 drone imagery collected by MaineDOT before the leaking gates were fixed and represent a range of potential existing conditions.
2. Approximate water surface elevations (WSEL) for proposed alternatives are based on the 2021 Phase 1 and Phase 2 hydraulics analyses using tidal stage data collected by MaineDOT in 2021.
3. Coordinate System: NAD 1983 UTM Zone 19N FT
4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

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1 inch = 833 feet (At page size of 11"x17")

DRAFT

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B.4

Title
Landward Water Levels for Q1.1-Year Combined with 100-Year High Tide Surge 3.9-Foot Sea Level Rise
12/20/2021

APPENDIX C CONCEPTUAL LANDWARD CHANNEL FIGURE

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2021.12.15 12:47:56 PM

Stantec

Stantec Consulting Services Inc.
30 Park Drive
Topsham ME 04086 U.S.A.
Tel: 207.729.1199
www.stantec.com

Notes

N

0 150' 300'

Client/Project
Maine Department of Transportation
Dike Bridge
Machias, Maine

Project No.
179450347

Title
Conceptual Scour Channel

Revision

Date
2021.12.15

Reference Sheet

Figure No.
1

Cut/Fill Report

Generated: 2021-12-15 11:47:47
By user: ELe
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Volume Summary

Name	Type	Cut Factor	Fill Factor	2d Area (Sq. Ft.)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Net (Cu. Yd.)
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Totals

	2d Area (Sq. Ft.)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Net (Cu. Yd.)
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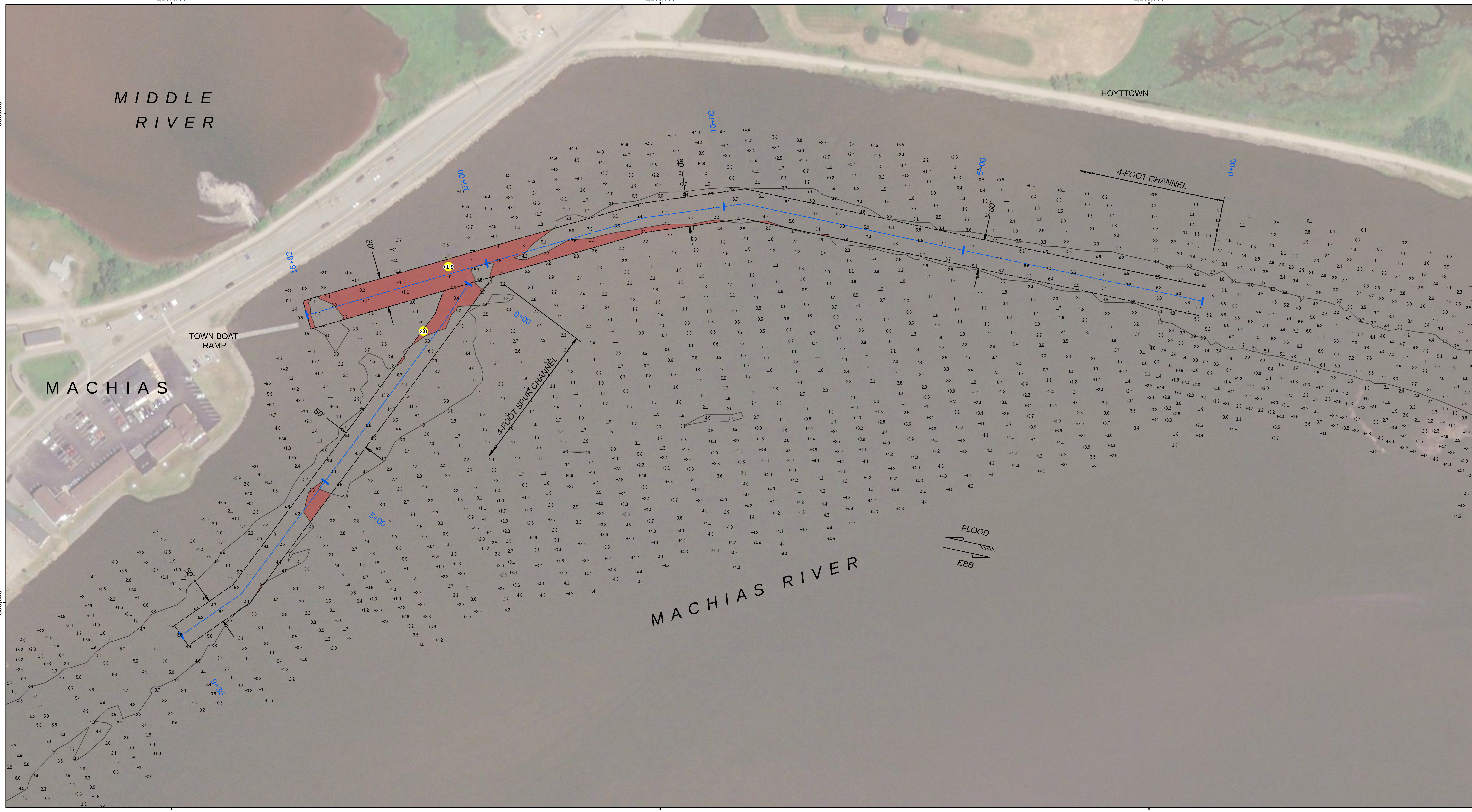
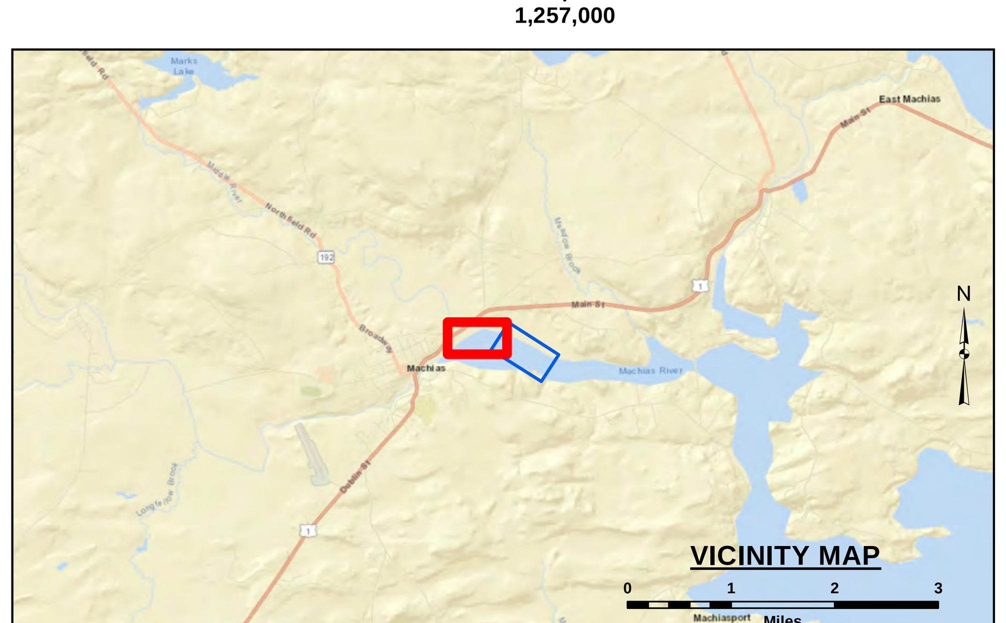
* Value adjusted by cut or fill factor other than 1.0

APPENDIX D USACE NAVIGATION CHANNEL FIGURES





LEGEND

- Federal Navigation Channel
- Channel Center Line
- Cable or Pipeline Area
- Contour Line
- Fixed Navigation Aids
- Red Navigation Buoy
- Green Navigation Buoy
- Shoaling Area
- Shoalest Sounding**

** Shoalest Sounding per Quarter per Reach

GRAPHIC SCALE

100 0 100 200

1" = 100' Feet

N W E S

Notes:

Horizontal Datum: Maine East, ME-1801 NAD 83
Distance Units: U.S. Survey Feet
Vertical Datum: MLLW
Depth Units: U.S. Survey Feet
Vessel Name: CELESTIAL
Sonar System: ODOM MK 3 (Singlebeam Sonar)
Sounding Frequency: 200 kHz
Survey Method: RTK GPS Tides
GPS_System: Trimble SPS 855 (RTK)
RTK Base Station: BM N 94 (1942)
Software Used: Hypack
Sounding Sort Distance: 20'
Field Books: R&H 3138
Survey No.: ME_04_MAC_20030425_CS_03652
Reference NOAA Chart No.: 13229

The information depicted on these charts represents the results of surveys made on the dates indicated, and can only be considered as indicating the conditions existing at that time.

General Notes

The sounding information shown on this map represents the SHOALEST soundings of those obtained from hydrographic surveys conducted during April 2003. The sounding information depicted on this map represents the results of surveys made on the dates indicated and can only be considered as indicating the conditions existing at that time. The positions of aids to navigation were located during survey operations, are provided for information only and should not be used for navigation. Orthoimagery is from a variety of sources and dates and is intended to portray general characteristics of the shoreline and other features. Temporal changes may have occurred since this dataset was collected and some parts may no longer be an accurate representation of the conditions. The information depicted on this map should NOT be used to determine volumes as volumes are determined from more sounding information than shown.

Project Remarks

None

Water Level Information

Bench Mark BM N94 (NGS Station PID PD0127) is a standard U.S.C & G.S. disk stamped "N 94 1942", located 0.3 miles east along the Maine Central Railroad from the station at Machias, Washington County, about 0.1 miles west of milepost (C44/P266), 13.0 feet north of the north rail, about level with the track and in the top of the southeast corner of an embedded boulder that the exposed portion is 4 x 5 foot and projects 2 feet. Elevation is 18.23 feet above MLLW.

US Army Corps of Engineers
District: CENAE

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT

SURVEYED BY: RWM
CHECKED BY: ZSM
ISSUE DATE: 4/2/2020
SUBMITTED BY: Zachary McAvoy
APPROVED BY: NAE Survey
MAP DOCUMENT: ME_04_MAC_20030425_CS_03652
SIZE: ANSI D

MACHIAS RIVER
MACHIAS, MAINE
CONDITION SURVEY
4-FOOT CHANNEL

File Name: ME_04_MAC_20030425_CS_03652

SHEET IDENTIFICATION
Machias River

Sheet 1 of 1

Revison Number: 4.1-20191105

US Army Corps of Engineers
District: CENAE

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U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT

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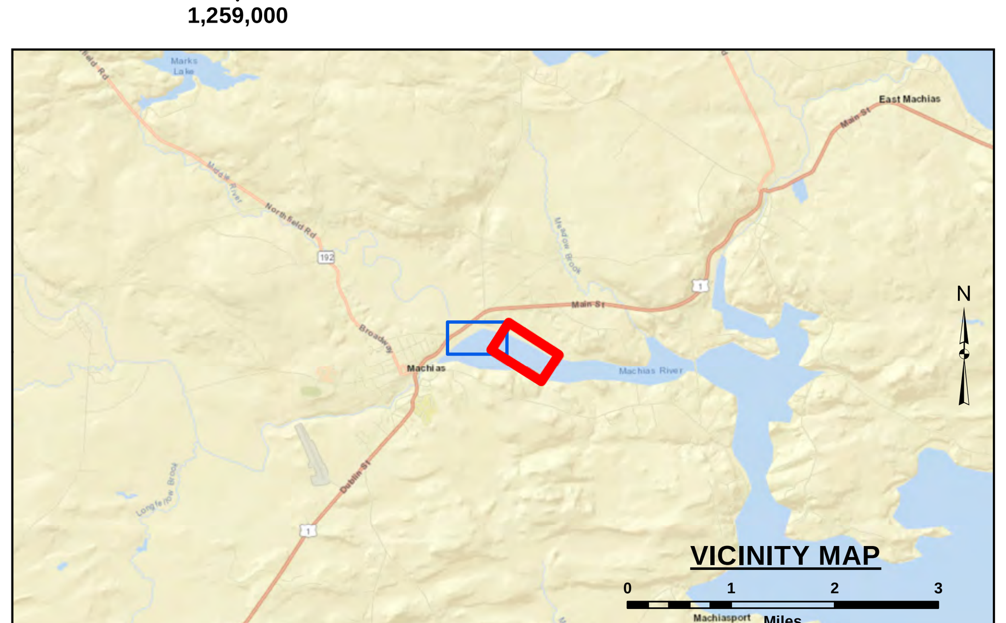
SIZE: ANSI D

MACHIAS RIVER
MACHIAS, MAINE
CONDITION SURVEY
4-FOOT CHANNEL

File Name: ME_04_MAC_20030425_CS_03652

SHEET IDENTIFICATION
Machias River

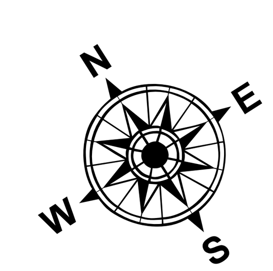
Sheet 1 of 1



LEGEND

- Federal Navigation Channel
- Channel Center Line
- Cable or Pipeline Area
- Contour Line
- Fixed Navigation Aids
- Red Navigation Buoy
- Green Navigation Buoy
- Shoaling Area
- Shoalest Sounding**

** Shoalest Sounding per Quarter per Reach



GRAPHIC SCALE
100 0 100 200
1" = 100' Feet

Notes:
Horizontal Datum: Maine East, ME-1801 NAD 83
Distance Units: U.S. Survey Feet
Vertical Datum: MLLW
Depth Units: U.S. Survey Feet
Vessel Name: CELESTIAL
Sonar System: ODOM MK 3 (Singlebeam Sonar)
Sounding Frequency: 200 kHz
Survey Method: RTK GPS Tides
GPS_System: Trimble SPS 855 (RTK)
RTK Base Station: BM N 94 (1942)
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Project Remarks
None

Water Level Information
Bench Mark BM N94 (NGS Station PID PD0127) is a standard U.S.C & G.S. disk stamped "N 94 1942", located 0.3 miles east along the Maine Central Railroad from the station at Machias, Washington County, about 0.1 miles west of milepost (C44/P266), 13.0 feet north of the north rail, about level with the track and in the top of the southeast corner of an embedded boulder that the exposed portion is 4 x 5 foot and projects 2 feet. Elevation is 18.23 feet above MLLW.

Revison Number: 4.1-20191105

STATE OF MAINE

MEMORANDUM

December 28, 2022

To: Julie Senk, ENV/Maine Department of Transportation

From: Kirk F. Mohney, State Historic Preservation Officer KFM

Subject: WIN 16714.00; Machias, Bridge Replacement; MHPC #1269-08

In response to your recent request, I have reviewed the information received December 8, 2022 to continue consultation on the above referenced undertaking pursuant to the Maine Programmatic Agreement and Section 106 of the National Historic Preservation Act of 1966, as amended.

In order to continue consultation, please provide the following additional information about the sea level rise (SLR) hydraulic study:

- What SLR scenarios were considered during the hydraulic study?
- Did MaineDOT explore SLR scenarios with astronomical high tides for the existing structure and each of the proposed alternatives?
- What is the water level difference between existing high tides and expected high tides under the various alternatives?
- What is the existing water level difference at astronomical high tides without accounting for SLR?

Alternatives of In-Kind Replacement (1), Partially-Gated Culvert Replacement (4 &4M), Open Box Culvert Replacement (A9) and Bridge Replacement (A10) discuss the vertical alignment increase to account for SLR. From the two cross sections provided, it is unclear what the exact proposed vertical alignment height is compared to the existing conditions. Please confirm the proposed vertical alignment height including the causeway for these five alternatives.

Please contact Megan M. Rideout of our office if we can be of further assistance in this matter.

STATE OF MAINE
Memorandum

Date: December 8, 2022

To: Kirk F. Mohney, MHPC
From: Julie Senk, MaineDOT Historic Coordinator
Subject: Section 106 request for concurrence
Project: Machias 16714.00, MHPC #1269-08
Scope: Bridge Improvements

The Maine DOT has reviewed this project pursuant to the Maine Programmatic Agreement (PA) and Section 106 of the National Historic Preservation Act of 1966, as amended.

The proposed project consists of bridge improvements to the Dike Bridge #2246 that carries Main Street/Route 1 over the Middle River in Machias, Washington County, Maine.

In accordance with 36 CFR Part 800.4, the following identification efforts of historic properties were made:

800.4(a) (1) – The Area of Potential Effect (APE) includes properties/structures adjacent to the bridge and bypass alternative within the project limits. The project limits are defined by the bridge and the immediately adjacent area. Properties/structures adjacent to this project limit are considered to be within the APE. The APE is shown as a defined polygon on the attached map.

800.4(a) (2) – Review of existing information consisted of researching the National Register and MHPC survey databases. The Maine Historic Preservation Commission's archaeological staff has also reviewed the undertaking.

800.4(a) (3) – The Town of Machias and applicable historical societies were contacted via email and asked to comment on knowledge of, or concerns with, historic properties in the area, and any issues with the undertaking's effect on historic properties. The Town was also requested to provide information regarding local historic societies or groups. See Public Involvement section in the attached memo.

800.4(a) (4) – Emails outlining project location and scope were sent to the 4 federally recognized Tribes in Maine. The Penobscot Nation and the Passamaquoddy Tribe replied with no concern.

800.4(c) – The MaineDOT did conduct historic architectural surveys within the APE and determined that one resource is eligible for listing in the National Register of Historic Places and one resource is listed in the National Register of Historic Places. The Maine Historic Preservation Commission's archaeological staff also reviewed this undertaking and recommended 'no archaeological properties affected'.

In accordance with 36 CFR Part 800.4, ***the MaineDOT requests concurrence on the finding of effect for each alternative under consideration for the proposed undertaking.***

In accordance with the PA and 36 CFR Part 800, please reply within 30 days.

Please contact me at Julie.Senk@maine.gov if you have any questions. Thank you.

cc: CPD e-file
enc: Supplemental Supporting Information for a Finding of Effect

Supplemental Supporting Information for a Finding of Effect

Project: Machias 16714.00
Scope: Bridge Improvements

Project Description
The proposed project consists of bridge improvements to the Dike Bridge #2246 that carries Main Street/Route 1 over the Middle River in Machias, Washington County, Maine. The Middle River joins the tidal portion of the Machias River immediately downstream of the bridge. The Dike Bridge consists of four box culverts within an embankment structure (causeway). The causeway also carries a section of the Downeast Sunrise Trail.

Federal Action
Federal funding.

Purpose and Need
The primary purpose of the project is to achieve an overall structure rating of Good and to preserve the Calais Branch Rail Corridor in the area in accordance with the State Railroad Preservation Act.

The need for this project is because the Dike Bridge's culverts and flap gates show significant deterioration.

Per the project's purpose, a structure rating of Good equates to 7 or better on a scale 0-9 in accordance with Federal Highway's Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridge (NBIS). The desired structure rating of at least 7 indicates there are no noticeable or noteworthy deficiencies which affect the condition of the structure.

Secondary Goals of the action and other desirable outcomes include:

- To improve fish passage through the transportation asset;
- To account for Sea Level Rise (SLR) in accordance with Maine's Climate Council guidance to manage for 1.5 feet of relative SLR by 2050 and to assess 3.9 feet of SLR by the year 2100;
- To minimize inundation of land upstream from Dike Bridge that may result from increased tidal exchange from the project;
- To accommodate existing transportation uses of the causeway (trail/railroad);
- To accommodate existing community uses of the causeway (parking/local markets and trade); and
- To coordinate with the ongoing Town of Machias flood protection project.

Project Background
The Dike Bridge #2246 was constructed in 1868; however, the current structure was built in 1930 and widened in 1944. It consists of four box culverts within an embankment structure (causeway). The culverts are constructed of timber and stone masonry and are approximately 130' long, 6' wide, and 5' high. Each culvert has a top-hinged flap gate

installed on its seaward side. The flap gates close during incoming (flood) tides to prevent tidal waters from moving upland. They open during outgoing (ebb) tides to allow upland water to flow through the culvert and into the Machias River. The causeway is constructed of timber cribbing with rubble and earthen fill and is over 1,000' long. The causeway is approximately 100' wide and includes 2-12' travel lanes, 2-8' shoulders, 20' of parking and 13'-16' of the Downeast Sunrise Trail on the former rail bed.

In 2008 a concrete slab was placed over the culverts to support the roadway. The repair was necessary as material loss through the timber culvert was causing the roadway to sag. The MaineDOT completed a dive inspection of the Dike Bridge in 2016 and routine inspections in 2016 and 2020. The inspections indicated large spalls, heavy scaling, wide cracks, loss of and rotten timber members, and roadway settlement. The MaineDOT replaced broken flap gates in 2012 and repaired pavement in 2017.

In 2009 the subject project was initiated and the MaineDOT hosted its first public meeting. The removal of the flap gates was a serious concern for upstream property owners at this meeting. The MaineDOT recognized that the range of potential solutions had flooding impacts that warranted further study. In 2015, the MaineDOT completed a Planning Feasibility Study. The study included hydrologic and hydraulic analyses to evaluate bridge and culvert alternatives. The study concluded that a culvert solution could provide improved fish passage while limiting flooding; and the installation of a bridge could provide tidal exchange and fish passage, but would result in substantial inundation of land upstream of the Dike Bridge, including the NRHP-eligible Trotting Park. In addition, the MaineDOT legal interpretations suggested limited ability to compensate affected upstream property owners.

Based on this information, the MaineDOT presented a replacement in-kind alternative as a preference at a public meeting held in 2018. This alternative was received favorably by meeting attendants. However, a series of developments arose in the following years that required continuous re-evaluations of alternatives.

- In November of 2018, the Town of Machias completed a Waterfront Study that proposed a seawall to lower the risk of flood damage to downtown Machias. The proposed seawall and the potential for SLR produced implications that required consideration for the Dike Bridge project.
- In August of 2020, permitting agencies expressed concerns that the replacement in-kind option would further inhibit fish passage between the Middle River and Machias River. The Dike Bridge does not currently allow landward flow of tides into the Middle River except by leakage through the flap gates and the causeway during flood tides. Residents have indicated anecdotally that some fish passage occurs at the Dike Bridge, however, it is generally considered a barrier to fish passage.

  In September 2020, the MaineDOT received written comments from the National Oceanic and Atmospheric Administration (NOAA). The agency administers the Endangered Species Act (ESA) for coastal species, as well as other laws that guide marine conservation and management. They are charged with coordinating local recovery efforts for Atlantic salmon in Downeast Maine.

NOAA stated substantial concerns over the in-kind replacement alternative, stating it "would provide even less opportunity for fish passage than exists now and will not remedy ongoing impacts". In addition, it would likely have detrimental effects on physical and biological features of critical habitat for Endangered Atlantic salmon. The ESA requires federal agencies to ensure that their actions do not jeopardize the continued existence of any listed species. Actions may not destroy or adversely modify any designated critical habitat. The National Marine Fisheries Service (NMFS) noted that under the ESA federal agencies are expected to go beyond minimizing project effects and proactively seek opportunities to work towards recovery of listed species. The letter suggested that working through ESA consultation and successfully permitting the in-kind replacement would be difficult.

- In August 2021, the MaineDOT sought legal clarification and determined that it would be possible to compensate upstream property owners for property inundated as a result of the project.

In order to address the concerns over fish passage through the Dike Bridge and the potential for SLR, the MaineDOT transferred the project from its Bridge Design Program to the Bureau of Planning.

Between September 2020 and April 2022, the MaineDOT completed the following tasks:

- Re-examined the project's purpose & need statement;
- Held a virtual public meeting to update the public on the change in direction and present the updated purpose and need statement;
- Reconsidered alternatives from the previous feasibility study and identified new variations to try to improve fish passage while minimizing flooding;
- Completed refined hydrology and hydraulic modeling of the alternatives;
- Completed further assessment of property impacts, including potential impacts to wells, septic systems, and known solid waste disposal sites;
- Requested technical assistance from NOAA to evaluate culvert alternatives for fish passage performance;
- Conferred with Federal Highway Administration (FHWA) and the Maine Historic Preservation Commission (MHPC) regarding the potential effects (by inundation) to the Machias/Riverside Park Trotting Park; and
- Held a public open house at the causeway to share information on alternatives and potential impacts and to collect public comment.

Based on preliminary analysis, the alternatives under consideration are focused to Alternative 1 (in-kind replacement), Alternative 4 and Alternative 4 Modified (partially-gated culvert options), Alternative 9 (open culverts), and Alternative 10 (120-150' bridge replacement).

The MaineDOT has initiated an Environmental Assessment that will discuss the environmental impacts of the bridge and culvert alternatives. To ensure that the final decision is informed by best available information on Section 106 effects, the MaineDOT is requesting concurrence from MHPC on effects for all alternatives.

Definition of Area of Potential Effect (APE)
The proposed project is located at the crossing over Middle River along Route 1, located 0.17 of a mile north of Route 1A in Machias. The map below shows the APE.

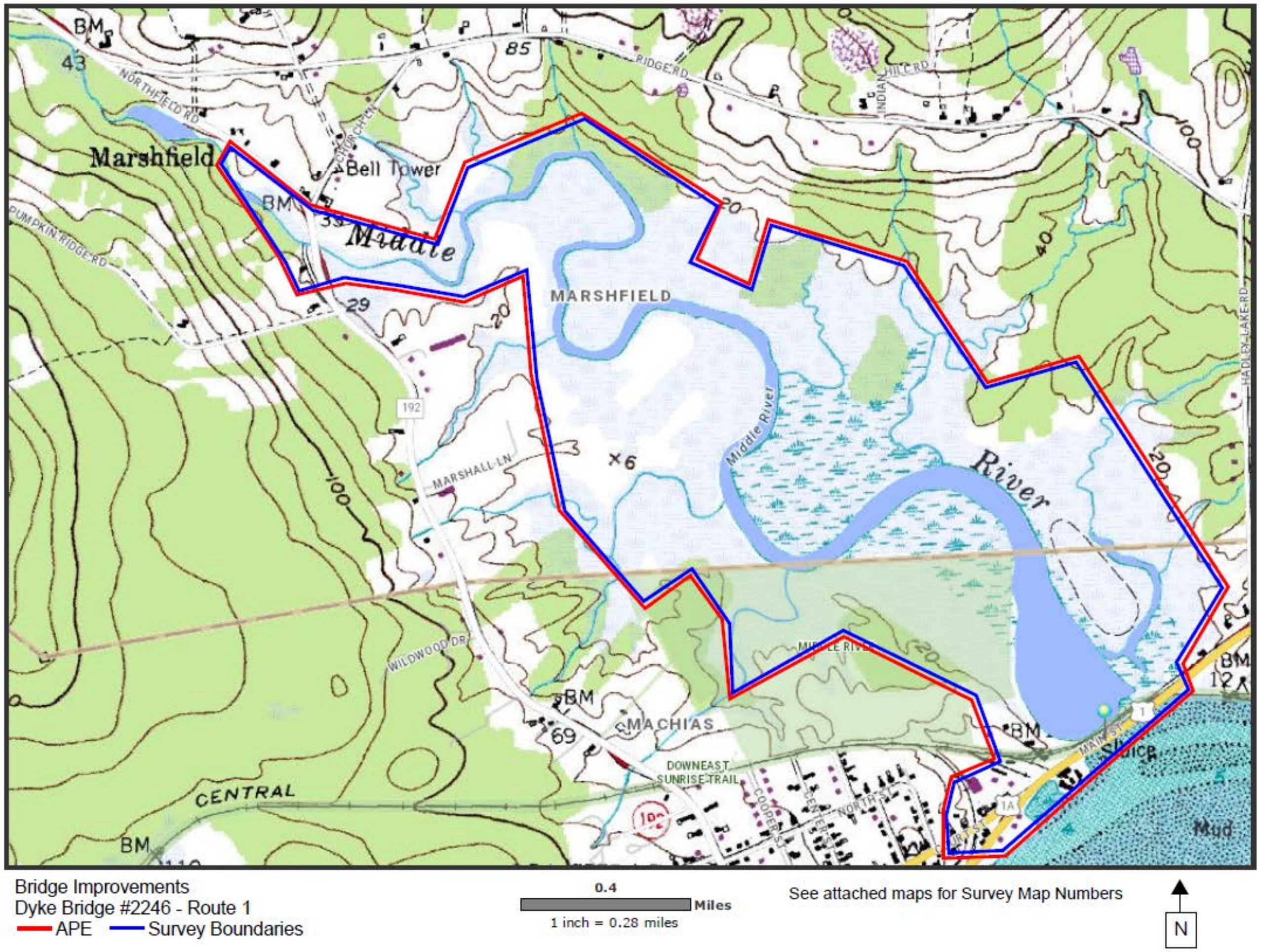


Figure 1. Machias 16714.00 Area of Potential Effect

Historic Properties
The proposed project is located in Machias. The following descriptions of historic properties found within the APE are based on the MaineDOT survey package submitted to and concurred with by the MHPC.

<u>Machias Railroad Station (Town of Machias)</u>
National Register-listed
Criteria A and C, Architecture and Transportation
The Machias Railroad Station is a one-story rectangular building with a side-gabled roof. The roof has overhanging eaves with knee braces. The building is covered in clapboard siding and wainscoting. It has four-over-one wood windows in simple wood frames. The north elevation, along the former rail line, has a projecting box bay, windows, and freight bays. The building is one of five railroad stations built in a specific design for the Washington County Railroad. Its period of significance is c. 1898 – 1942.

Figure 2. Machias Railroad Station

<u>Machias/Riverside Park Trotting Track (Sprague, Christopher & Lauren)</u>
National Register-eligible
Criterion C, Engineering
The Machias/Riverside Park Trotting Track is eligible for listing in the National Register of Historic Places. The track is a pear-shaped track located north of Route 1 on the eastern bank of the Middle River. The track consists of the track bed which is covered with grass.

The edges of the track are covered in thick vegetation. The track is a rare example of a pear-shaped trotting park. Its period of significance is c. 1883 – 1887.

Figure 3. Machias/Riverside Park Trotting Track

Archeological Resources

There are no archaeological resources in the APE.

Impacts to Historic Properties

The following addresses potential impacts to properties as a result of the evaluated alternatives.

Machias Railroad Station (Town of Machias)

National Register-listed

Criteria A and C; Architecture and Transportation

No Build:

The No Build Alternative would result in **No Historic Properties Affected** to the Machias Railroad Station. The alternative would take no action and would not affect the historic property. The No Build Alternative presumes the existing structure would remain unchanged except for required regular maintenance activities.

In-Kind Replacement (Alternative 1):

Alternative 1 would result in **No Historic Properties Affected** to the Machias Railroad Station. Alternative 1 would replace the existing structure with four new box culverts that would match the existing culverts' length and width. Flap gates would be installed to prevent landward flow. The horizontal alignment of the causeway would be approximate to the existing. The vertical alignment would be slightly increased to account for sea level rise; however, the proposed vertical alignment would tie into the existing roadway grade before the Machias Railroad Station. This alternative would avoid the historic property.

Partially-Gated Culvert Replacement (Alternative 4)[1]

Alternative 4 would result in **No Historic Properties Affected** to the Machias Railroad Station. Alternative 4 would replace the existing structure with five new box culverts with flap gates on four of the culverts. The horizontal alignment of the causeway would be approximate to the existing. The vertical alignment would be slightly increased to account for sea level rise; however, the proposed vertical alignment would tie into the existing roadway grade before the Machias Railroad Station. This alternative would avoid the historic property.

Partially-Gated Culvert Replacement (Alternative 4M)[2]

Alternative 4M would result in **No Historic Properties Affected** to the Machias Railroad Station. Alternative 4M would replace the existing structure with three larger culverts with flap gates on two of the culverts. The horizontal alignment of the causeway would be approximate to the existing. The vertical alignment would be slightly increased to account for sea level rise; however, the proposed vertical alignment would tie into the existing roadway grade before the Machias Railroad Station. This alternative would avoid the historic property.

[1] Alternative 4 is shown as the blue line on attached aerial map of predicted landward water levels
[2] Alternative 4M is shown as the green line on attached aerial map of predicted landward water levels

Open Box
Culvert Replacement
(Alternative 9)[3]

Alternative 9 would result in **No Historic Properties Affected** to the Machias Railroad Station. Alternative 9 would replace the existing structure with four open box culverts. The horizontal alignment of the causeway would be approximate to the existing. The vertical alignment would be slightly increased to account for sea level rise; however, the proposed vertical alignment would tie into the existing roadway grade before the Machias Railroad Station. The Machias Railroad Station would not be physically impacted by the significant flooding caused by Alternative 9, as it lies outside of the daily max landward water levels for typical tides and river flows. This alternative would avoid the historic property.

Bridge Replacement
(Alternative 10)[4]

Alternative 10 would result in **No Adverse Effect** to the Machias Railroad Station. The proposed action would replace the Dike Bridge #2246 with a single-span 120’ - 150’ bridge. The Machias Railroad Station would not be physically impacted by the significant flooding caused by Alternative 10, as it lies outside of the daily max landward water levels for typical tides and river flows. The vertical alignment would be moderately increased to account for sea level rise; however, the proposed vertical alignment would tie in to the existing before the Machias Railroad Station. Additionally, the new bridge span would be built on the existing horizontal alignment and avoid direct impacts to the property. These actions would not significantly impact the historic property’s integrity of setting.

<u>Machias/Riverside Park Trotting Track (Sprague, Christopher & Lauren)</u>
National Register-eligible
Criterion C; Engineering

No Build:

The No Build alternative would result in **No Historic Properties Affected** to the Trotting Track. The alternative would take no action and would not affect the historic property. The No Build Alternative presumes the existing structure would remain unchanged except for required regular maintenance activities.

[3] Alternative 9 is shown as the orange line on attached aerial map of predicted landward water levels
[4] Alternative 10 is shown as yellow and purple lines on attached aerial map of predicted landward water levels

In-Kind Replacement (Alternative 1):

Alternative 1 would result in **No Historic Properties Affected** to the Trotting Track. Alternative 1 would replace the existing structure with four new box culverts that would match the existing culverts' length and width. Flap gates would be installed to prevent landward flow. This alternative would avoid the historic property.

<u>Partially-Gated Culvert Replacement</u> (Alternative 4)

Alternative 4 would result in **No Adverse Effect** to the Trotting Track. Alternative 4 would replace the existing structure with five new box culverts with flap gates on four of the culverts. Hydraulic studies conducted by MaineDOT in 2021 show the landward water levels for typical tides and river flows would not significantly exceed current levels[5] under this alternative. The Trotting Track would not experience daily flooding under this alternative.

Partially-Gated Culvert Replacement (Alternative 4M)

Alternative 4M would result in **No Adverse Effect** to the Trotting Track. Alternative 4M would replace the existing structure with three larger culverts with flap gates on two of the culverts. Hydraulic studies conducted by MaineDOT in 2021 show the landward water levels for typical tides and river flows would not significantly exceed current levels under this alternative. The Trotting Track would not experience daily flooding under this alternative.

Open Box Culvert Replacement (Alternative 9)

Alternative 9 would result in an **Adverse Effect** to the Trotting Track. Alternative 9 would replace the existing structure with four open box culverts. Hydraulic studies conducted by MaineDOT in 2021 show the landward water levels for typical tides and river flows would exceed current levels under this alternative, thus flooding the Track twice a day at high tide. The regular flooding would cause the Track's natural features to erode and would diminish the historic resource's integrity of design, location, setting, association, materials, and workmanship.

---

[5] Existing tide condition is shown as the red line on attached aerial map of predicted landward water levels. The dotted red line represents the tide condition before the culvert leak was addressed in 2021.

Bridge Replacement
(Alternative 10)

Alternative 10 would result in an **Adverse Effect** to the Trotting Track. The proposed action would replace the Dike Bridge #2246 with a single-span 120' - 150' bridge built on the existing horizontal alignment. The vertical alignment would be increased from the existing in order to address sea level rise. Hydraulic studies conducted by MaineDOT in 2021 show the landward water levels for typical tides and river flows would exceed current levels under this alternative, thus flooding the Track twice a day at high tide. The regular flooding would cause the Track's natural features to erode and would diminish the historic resource's integrity of design, location, setting, association, materials, and workmanship.

Archaeological Resources
No archaeological resources would be impacted by the proposed action.

Determination of Effect for Each Alternative

Alternative	Effect
No Build	No Historic Properties Affected
In-Kind Replacement (A1)	No Historic Properties Affected
Partially-Gated Culvert Replacement (A4)	No Adverse Effect
Partially-Gated Culvert Replacement (A4M)	No Adverse Effect
Open Box Culvert Replacement (A9)	Adverse Effect
Bridge Replacement (A10)	Adverse Effect

Public Involvement
The MaineDOT contacted the four federally recognized Native American Tribes in Maine on January 24, 2011. The Penobscot Nation and the Passamaquoddy Tribe replied with no concerns. On July 1, 2022, the Tribes were provided updates on the project since they received the original notification. No replies were received.

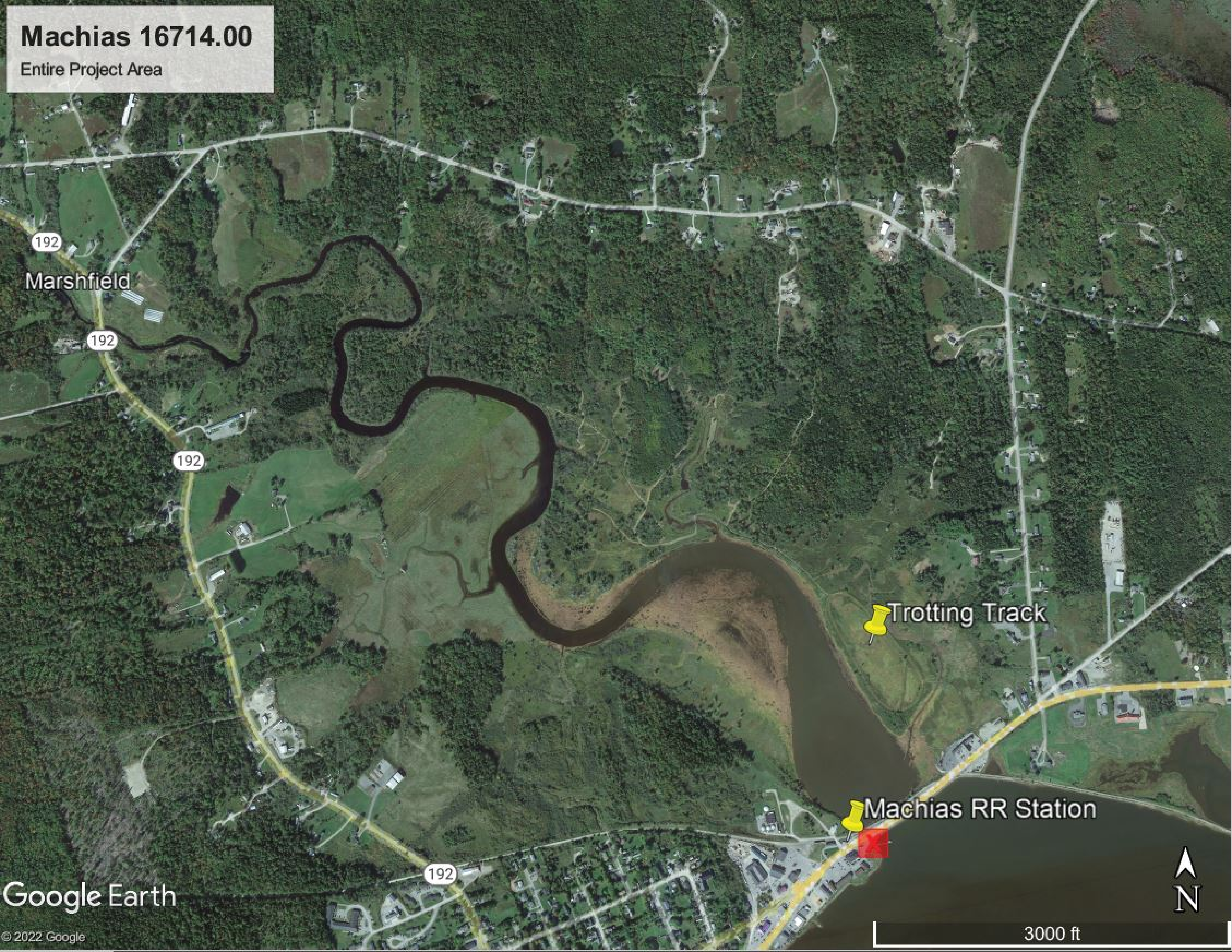
The MaineDOT contacted the Town of Machias on January 25, 2011, regarding the initiation of the Section 106 review. Letters were received from a local historian, the Town Manager, and the Machias Historical Society, all of whom expressed concern over the proposed project.

The MaineDOT held public meetings in 2009, 2018, 2021, and 2022. Information on the Section 106 review and the historic properties was described during the public meetings. During the 2009 and 2018 public meetings, the owner of the Machias/Riverside Park Trotting Track expressed interest in the track's preservation with regard to the potential impacts of the proposed project.

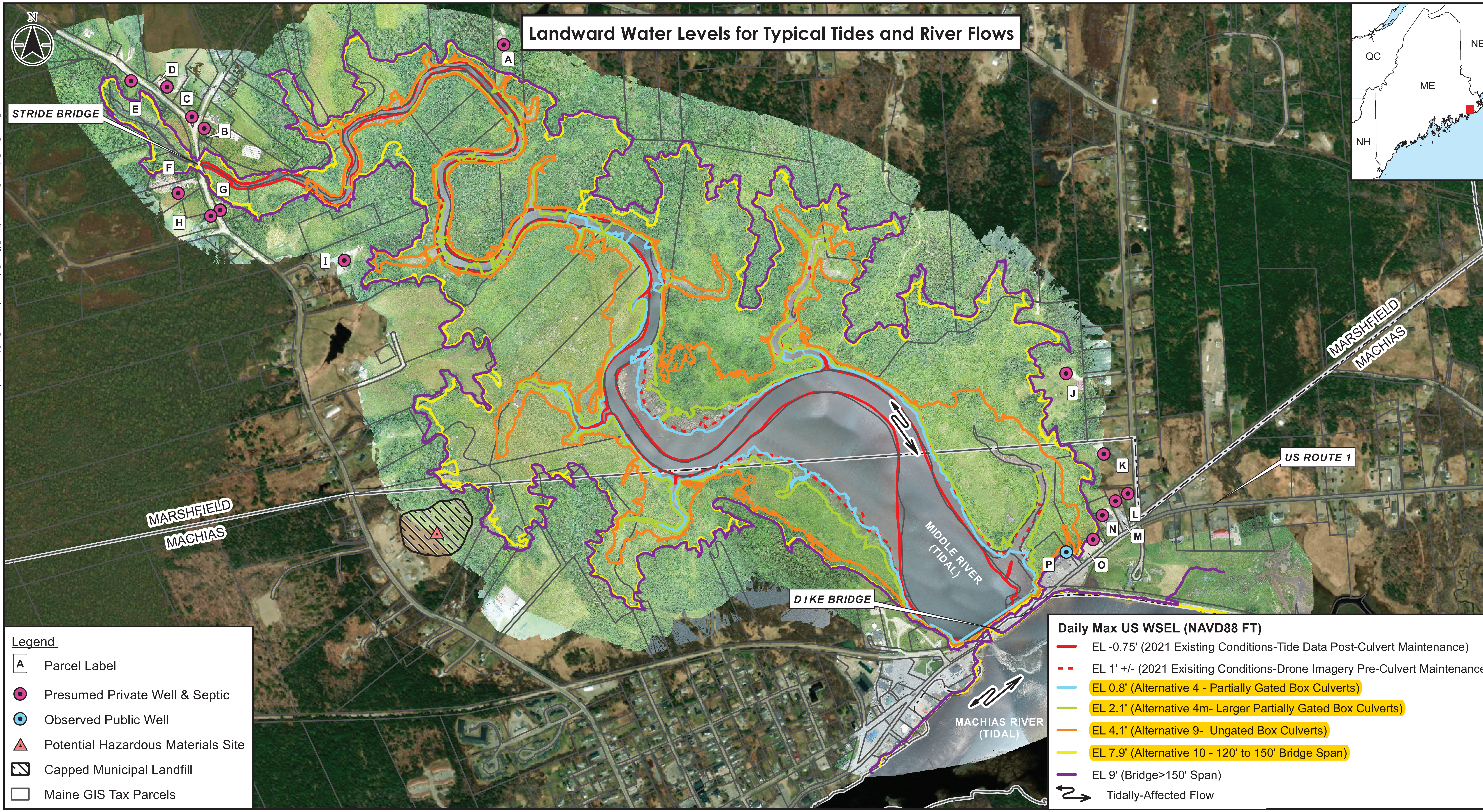
The MaineDOT posted a public notice in the Bangor Daily News to solicit public comments and questions regarding the historic review. This report was posted to the MaineDOT Environmental Office's public involvement webpage and was sent to the Town of Machias, the Washington County Historical & Genealogical Society, and the Washington County Manager. No comments were received.

Additional information on the historic review and effects to historic properties will be shared with the public and interested parties when this report is refined to one preferred alternative.

Attachments
Aerial Map of Project Area
Aerials Map of Landward Water Level for Typical Tides and River Flows
Approximate Elevations for Bridge and Culvert Alternatives
Kirk Mohney, MHPC, to Julie Senk, MaineDOT, September 20, 2021
J. N. Leith Smith, MHPC, to Julie Senk, MaineDOT, July 26, 2022



Machias 16714.00
Entire Project Area
192
Marshfield
192
192
Trotting Track
Machias RR Station
192
Google Earth
© 2022 Google
N
3000 ft



179450347

Stantec

30 Park Drive
Topsham, ME USA 04086
Phone (207) 729-1199

Prepared by EPL on 2021-12-06
Reviewed by TM on 2021-12-06
50347_DikeBridge_11x17_Alt-Cont_20211206.mxd

Notes

1. Existing conditions are based on 2021 tidal stage data that was collected after leaking gates were fixed and 2021 drone imagery collected by MaineDOT before the leaking gates were fixed and represent a range of potential existing conditions.
2. Approximate water surface elevations (WSEL) for proposed alternatives are based on the 2021 Phase 1 and Phase 2 hydraulics analyses using tidal stage data collected by MaineDOT in 2021.
3. Coordinate System: NAD 1983 UTM Zone 19N FT
4. Vertical Datum: NAVD88
5. Aerial imagery in the project area was obtained by unmanned aircraft vehicle (UAV) by MaineDOT on July 20, 2021.
6. Aerial imagery surrounding the project area is provided by ArcGIS Online World Imagery Mapping Service (http://server.arcgisonline.com/arcgis/services/World_Imagery/MapServer).
7. TIN Surface information is based on survey data provided by the Maine Department of Transportation.

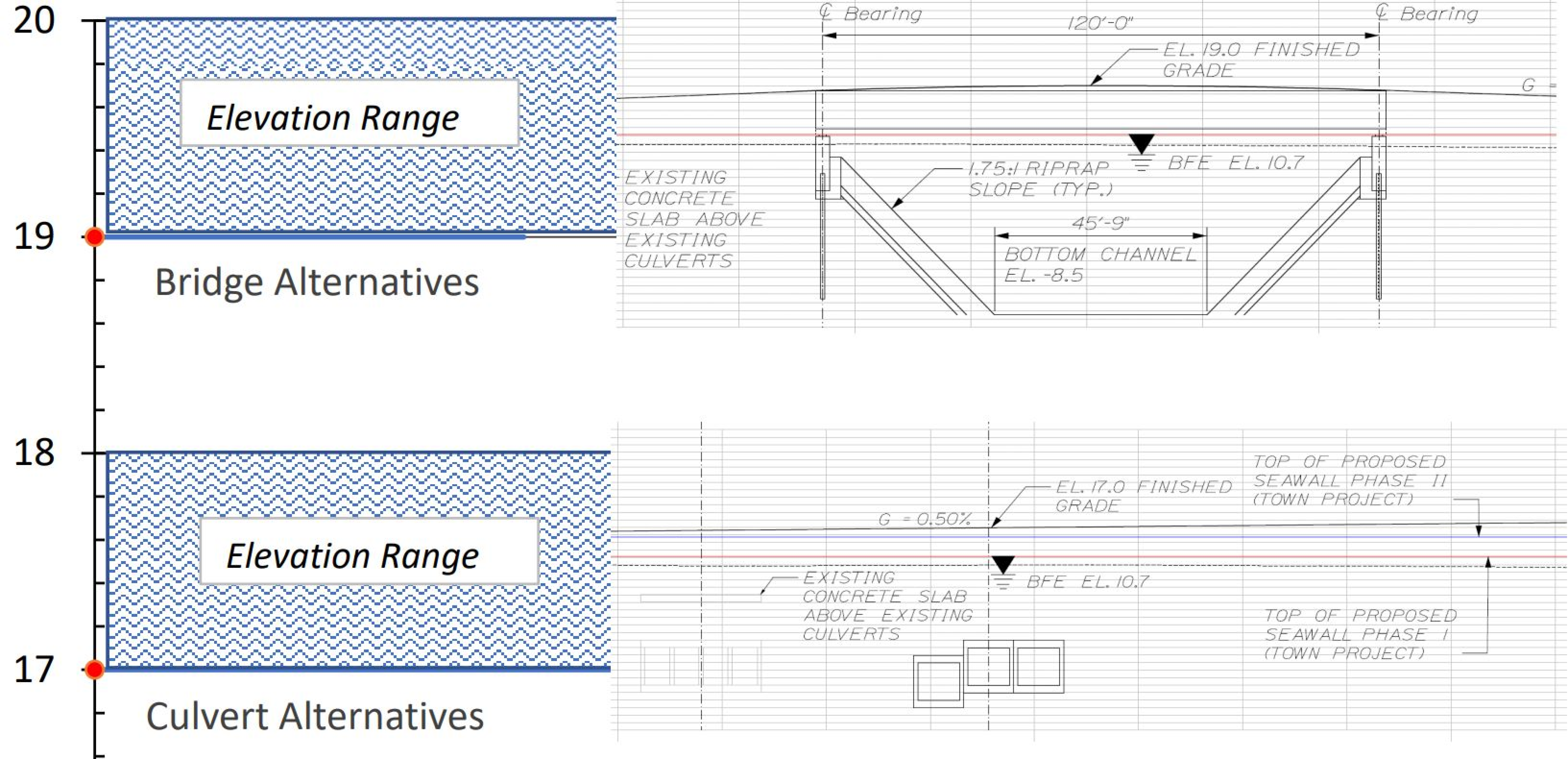
0 800 Feet
1 inch = 833 feet (At page size of 11"x17")

DRAFT

Client/Project
Maine DOT
Dike Bridge
Machias, Maine

Figure No.
B-1

Title
Landward Water Levels for Typical Tides and River Flows
2/3/2022


20
19
18
17
Elevation Range
Bridge Alternatives
Elevation Range
Culvert Alternatives
℄ Bearing
120'-0"
℄ Bearing
EL. 19.0 FINISHED GRADE
EXISTING CONCRETE SLAB ABOVE EXISTING CULVERTS
1.75:1 RIPRAP SLOPE (TYP.)
BFE EL. 10.7
45'-9"
BOTTOM CHANNEL EL. -8.5
EL. 17.0 FINISHED GRADE
G = 0.50%
TOP OF PROPOSED SEAWALL PHASE II (TOWN PROJECT)
EXISTING CONCRETE SLAB ABOVE EXISTING CULVERTS
BFE EL. 10.7
TOP OF PROPOSED SEAWALL PHASE I (TOWN PROJECT)

STATE OF MAINE

MEMORANDUM

September 20, 2021

To: Julie Senk, ENV/Maine Department of Transportation

From: Kirk F. Mohney, State Historic Preservation Officer KFM

Subject: PIN 16714.00, Machias, Bridge Improvements; Architectural Survey Report; MHPC #1269-08

In response to your recent request, I have reviewed the information received September 14, 2021 to continue consultation on the above referenced undertaking pursuant to the Maine Programmatic Agreement and Section 106 of the National Historic Preservation Act of 1966, as amended.

The Maine Historic Preservation Commission (Commission) staff reviewed the subject report, and we agree that the Machias Railroad Station (SM #3) is listed in the National Register of Historic Places.

With regard to Riverside Trotting Park (SM #5), on February 25, 2016, the MaineDOT supplied additional information on this and other trotting parks which included information about the past grading activity that removed the track's clay surface. The Commission determined the resource was eligible for listing in the National Register under Criterion C in the area of Engineering, on March 2, 2016. As we noted then, the pear-shaped tracks of the late 19th and early 20th century required a level of skill and horsemanship that was different from running on a symmetrical oval. Then and now, it is unclear how many of this type of pear-shaped track still exist in a distinguishable condition. As noted in the architectural survey report, "a property is not eligible, however, simply because it has been identified as the only such property ever fabricated." Riverside Trotting Park must be considered not as the only example of a type but as a rare surviving example. To summarize page 47 of National Register Bulletin 15, rare examples of a property type may be eligible based on comparison to other surviving examples. Rarity and poor condition in other examples may justify accepting a greater degree of alteration in a resource. Therefore, we continue to hold the opinion that even without the historically associated buildings on the site and with much of the track's surfacing removed, the former Riverside Trotting Park retains sufficient integrity of design, location, setting and association (and possibly materials and workmanship) when compared to other known tracks to merit nomination to the National Register under Criterion C at the local level of significance. The Commission also concludes that there is insufficient information potential for the track to be eligible under Criterion D.

Please contact Michael Goebel-Bain or me if you wish to discuss this matter.

STATE OF MAINE
Memorandum

Date: July 26, 2022

To: Julie Senk, Historic Preservation Coordinator, Maine DOT/ENV

From: J. N. Leith Smith, MHPC

Subject: Final Archaeology Review

Project: MHPC #1269-08, WIN 16714.00: Machias
Machias Dike Bridge (#2246) Project carrying Route 1 over the mouth of the Middle River.

Dear Julie,

An archaeological survey for the above referenced project was conducted in June of 2021. The goals of the survey were to determine potential effects of increased tidal flow on archaeological sites resulting from work on the Dike Bridge. Initial focus was on the site of the former trotting track where archaeological deposits associated with track construction and use were identified. The deposits were initially determined to maintain the potential to provide information important to the history of the trotting track, potentially making the site eligible for National Register listing under Criterion D. The track was already determined to be National Register eligible under Criterion C due to its unique design. Further assessment of the potential contribution that the archaeological deposits could provide beyond what was historically documented for the track resulted in a determination that the potential of the deposits to provide additional historic information was minimal. This resulted in a determination that the trotting track was not NR eligible under Criterion D.

The component of the 2021 archaeological survey that focused on potential impacts to pre-contact Native American archaeological sites found no evidence for prehistoric occupation within the pre-dike bridge intertidal zone. These findings suggested early Native American sites may have been located along the banks of the Middle River prior to sea level rise (now inundated) and at upper elevations bordering the intertidal zone prior to construction of the dike bridge.

The archaeological survey and follow-up assessment finds that no archaeological properties will be affected by the proposed undertaking.

APPENDIX 8 – SECTION 4(f)

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: Kristen Chamberlain, Eric Ham, Julie Senk

From: Charles Hebson

CC: David Gardner

Date: 2021 October 21

Re: 16714 Machias – Potential Racetrack Inundation Due to Tidal Restoration

---

Executive Summary

The frequency of racetrack inundation under Alternative 10 (tidal transparency) has been evaluated using 2011 data, 2021 data and modeling results provided by Stantec. The following discussion pertains to "normal" (i.e., non-storm) tides. Most generally, under Alternative 10 the track will see water twice daily, on every high tide. Using a racetrack elevation of 3-ft NAVD88 as the threshold for flooding, the data show that we can expect "flooding" about 33% of the time. This is somewhat conservative, since it assumes that the entire track is instantaneously covered with water as soon as the tide exceeds 3-ft. Mean High Water (MHW) is estimated at 6.40-ft from the 2021 data set, further confirming that the track will be inundated on a twice-daily basis if tidal transparency is established. Under the Alternative 4M model simulation (culverts allowing some tidal exchange), landward water levels never exceed 3-ft under "normal", non-storm conditions. There may be localized areas in the track domain below 3-ft with drainage connectivity to the Middle River that will flood at water levels less that 3-ft. The 4M simulated landward water levels (not measured data) are very similar to the August 2021 data period corresponding to a leaky flapper gate. Once the gate was repaired in late August, the subsequent 2021 landward levels reverted to 2011 conditions.

Discussion

Alternative 10 consists of an opening large enough so that tidal hydrology is restored landward (upstream) of the causeway. This has been referred to as "tidal transparency". The type of hydraulic structure (culvert or span) is immaterial, though to date Alternative 10 has been treated as a span. The idea is that the structure has no effect on tidal flow moving in and out of the Middle River. Under this scenario we can assume that the tides as measured seaward of the causeway in the Machias River will be duplicated landward (upstream) in the Middle River.

Figure 1 shows one complete tidal cycle spanning 31 July 2011. This is a "normal" spring tide, "normal" indicating "not a storm event"; the spring tides are the high tides that occur monthly. The tidal period is 24.83 hours; the water level exceeds 3-ft NAVD88 for (4.87 + 4.35) = 9.22 hours. This gives a water level exceedance duration of 37% above 3-ft for this cycle. The duration would be somewhat smaller for average and lower neap tides. Under Alternative 4M (culverts allowing some tidal exchange) high tides never exceed 3-ft. The tidal datums (MHW and MHHW) were calculated using the NOAA Tidal Datum Calculator and the 8/12 – 10/06/2021 data set used for Figure 2.

Figure 2 shows the Machias River tidal stage frequency distribution, based on the 8/12 – 10/06/2021 data set. As described above, we assume that this data is representative of what would result in the Middle River under Alternative 10. Since this data record covers a full range of tides, the calculated exceedance frequency is somewhat lower than for a single spring tide (35% vs. 37%) as in Figure 1.

Figure 3 shows the 2021 landward tidal data collected in the impoundment upstream of the causeway. The tides are significantly higher than the 2011 and the post-August 2021 landward data; the range is also larger (-0.75 to 1.25 ft; 2-ft range). This was due to a leaky flapper gate. These elevated water levels are consistent with aerial photos taken in the July 2021 drone flight, observations in the course of project field work prior to repair of the faulty gate, and anecdotal comments from local residents.

Model simulation results for Alternative 4M (two 10S x 5R culverts with flappers, one 10S x 5R open culvert) for a 2011 model period are superimposed on the 2021 data segment in Figure 4. The measured 2021 leaky hydrology is remarkably similar to the model results, particularly the peak water levels. Thus, the actual landward tidal experience through August 2021 gives a good idea of what Alternative 4M would be like if constructed. The gate was repaired around August 30 and the hydrology reverted almost immediately to what was seen in the 2011 data set. In Figure 5, 2011 measured landward water levels are superimposed over 2021 measurements. The post-repair water levels are essentially identical to what was measured in 2011 and indicates only a small amount of leakage.

Figure 1. Racetrack Inundation Illustrated Using 7/31/2011 Tidal Cycle

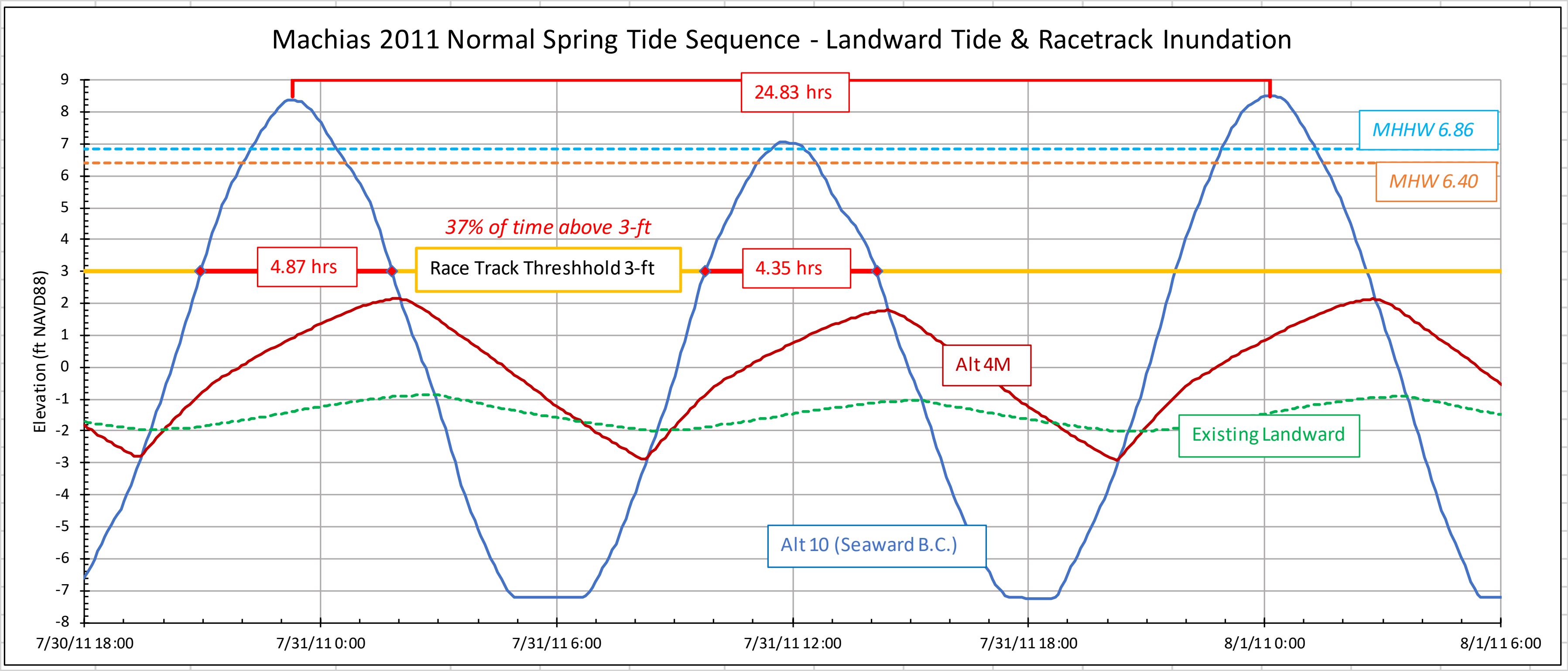


Figure 2. Machias River Tidal Stage Frequency Distribution

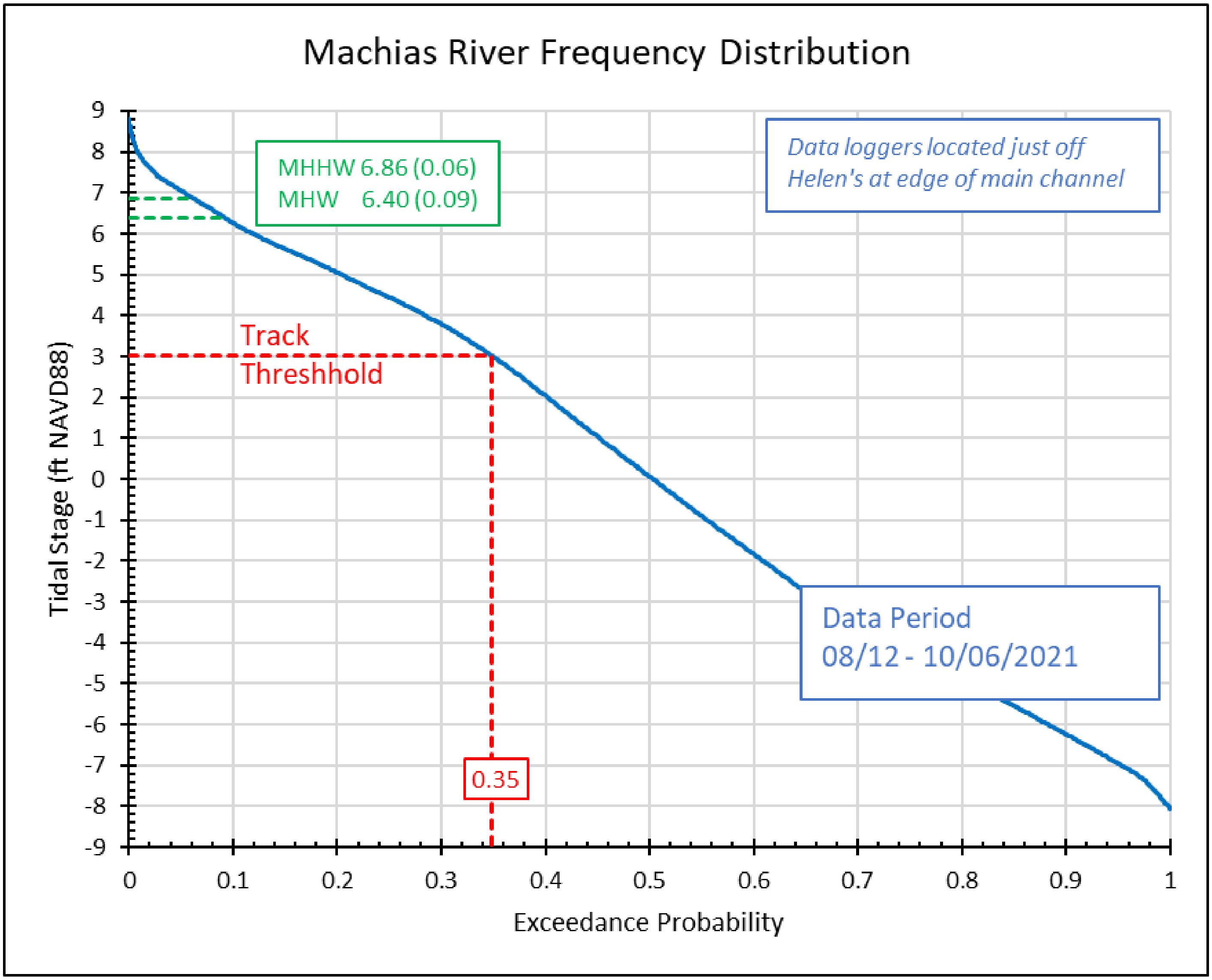


Figure 3. 2021 Landward Tide Data

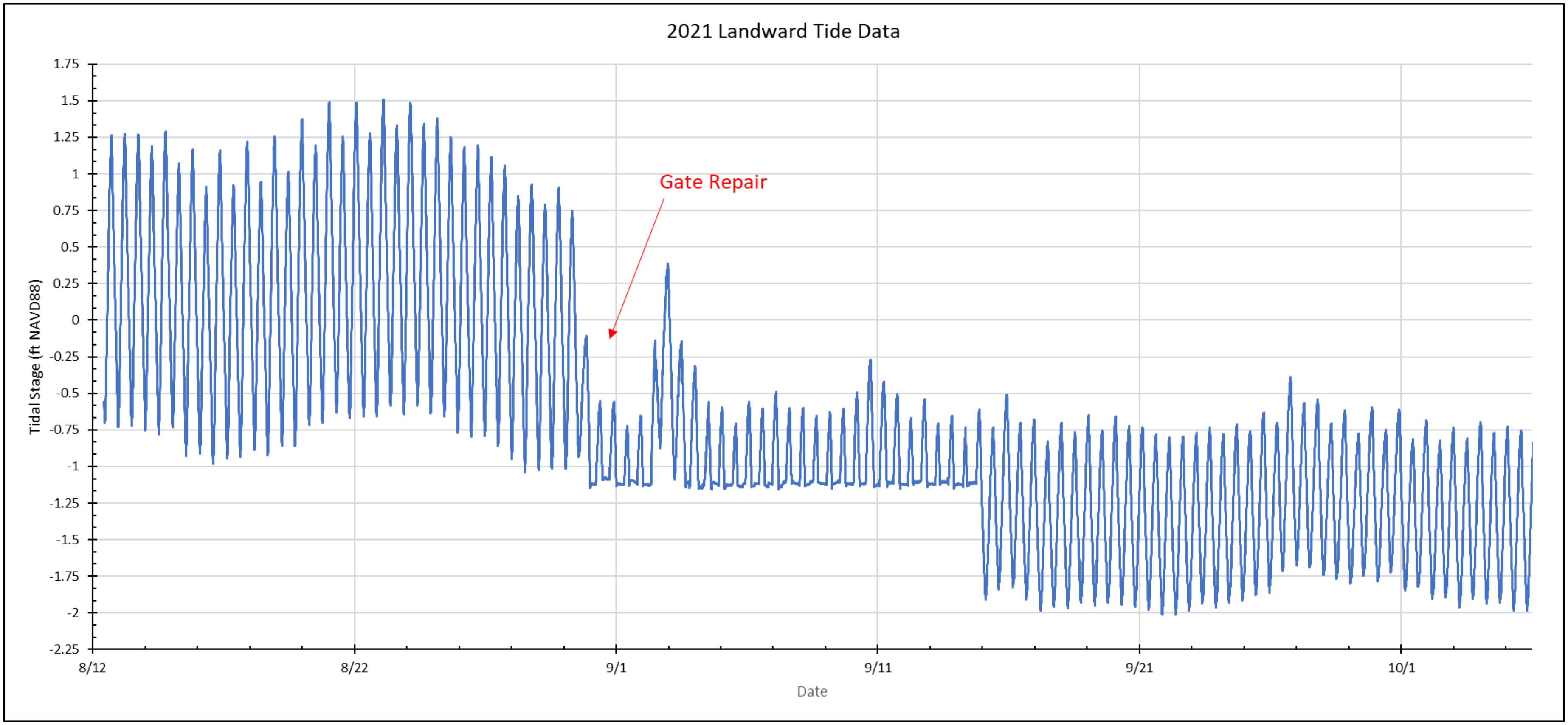


Figure 4. 2021 Tide Data Before Gate Repair

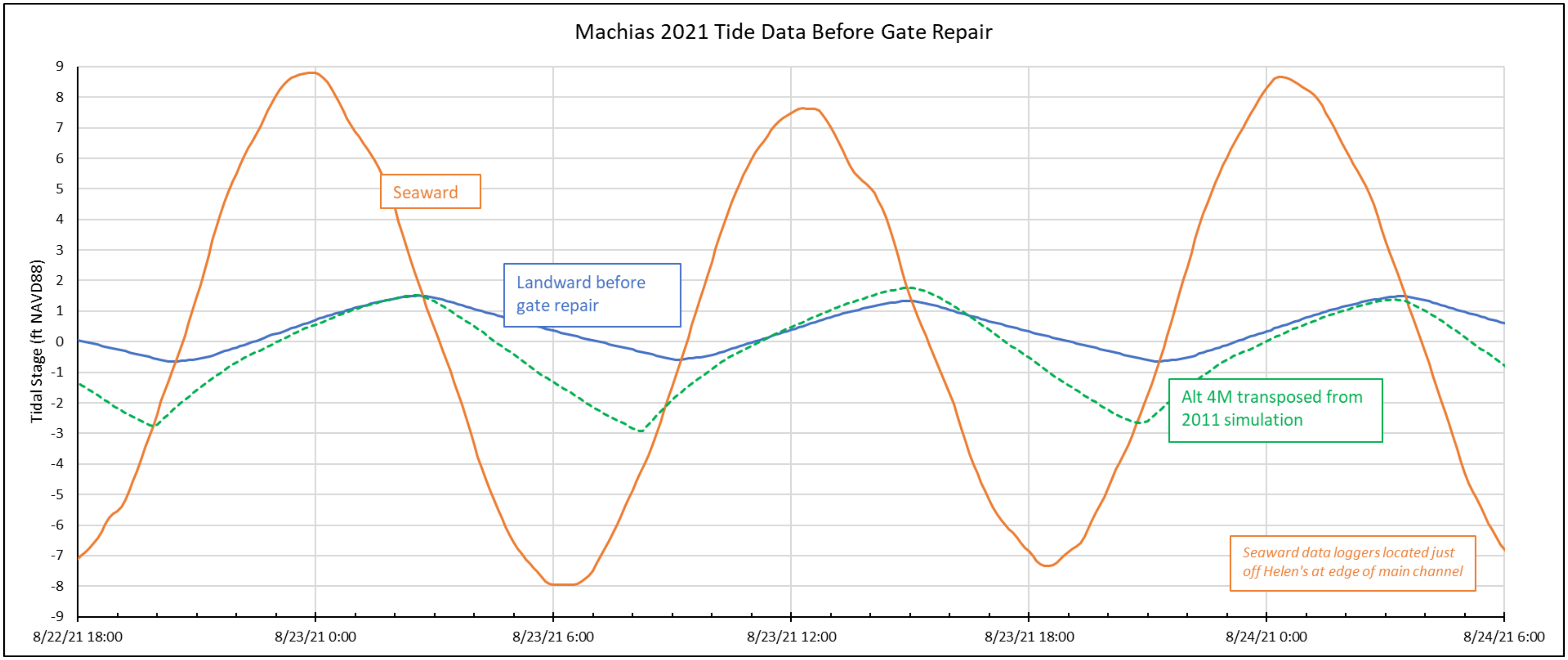
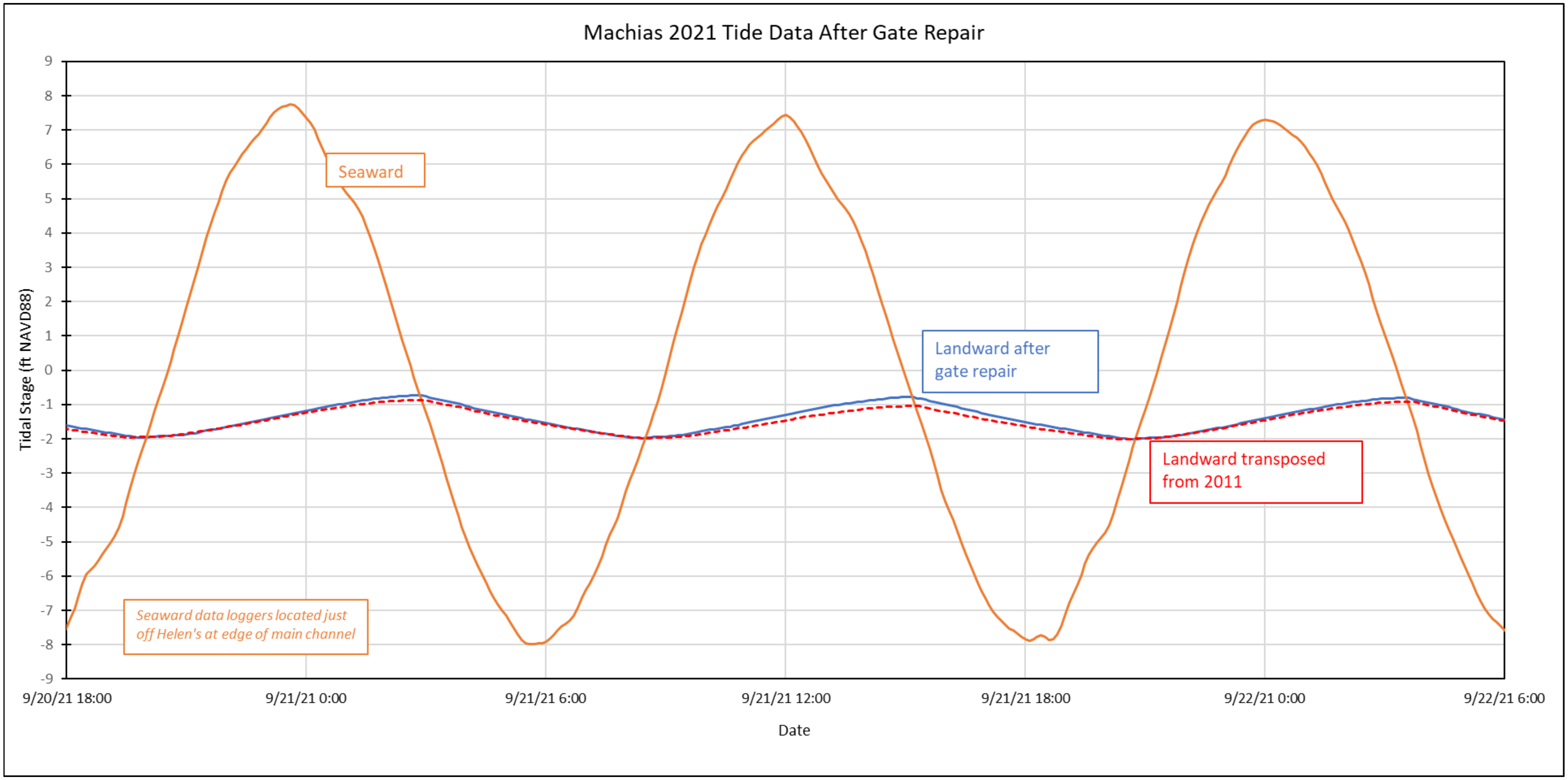


Figure 5. 2021 Tide Data After Gate Repair



Appendix A. Output from NOAA Tidal Datum Calculator

Run Time: 2021-10-19 16:58:15
Using DS-WL-for-Datum-Calc.csv
Time Zone = EDT-UTC4
13256 data points loaded.
Interval: 0:06:00
FEET

All calculations and results are in Feet

Gulf/East coast station:
Using Modified Range Ratio Method

Sampling Rate: 240.0 per day. Using cutoff frequency of 4.0 per day
107 highs 106 lows
Data Start: 2021-08-12 10:30:00
Data End : 2021-10-06 16:00:00
Mean Water Level: 0.10
Highest Water Level: 8.80
Lowest Water Level: -8.04
Duration: 55 days, 5:30:00
High Tides Found: 107
Low Tides Found : 106
Tides per day: 3.9
Semi-Diurnal - Using EXHL
54 Highs
53 Higher Highs
53 Lows
53 Lower Lows

3 Monthly plots generated
Control Datums for: 8411060

MHHW, MHW, DTL, MTL, MSL, MLW, MLLW
20.03 19.58 12.75 12.72 12.66 5.87 5.47
GT, MN, DHQ, DLQ, NAVD, LWI, HWI
14.56 13.71 0.45 0.40 12.99 9.51 3.25

SUBORDINATE MONTHLY MEANS:
9 / 2021 :
HWL = 8.33
MHHW = 7.10
MHW = 6.66
MSL = 0.09
MLW = -6.49
MLLW = -6.81
LWL = -7.94

TIDAL DATUMS BY Monthly Means Simultaneous Comparison:
Using Cutler Farris ref station

From 9 / 2021 to 9 / 2021
1 Months of control station means retrieved.
1 months in the analysis

Mean_Diff_MSL = -12.99
Mean Diff MTL = -13.04
Mean_Diff_DTL = -13.03
Mean_Ratio_MN = 0.98
Mean Ratio GT = 0.98
Mean_Diff_MHHW = -13.17
Mean_Diff_MHW = -13.17
Mean_Diff_MLW = -12.90
Mean_Diff_MLLW = -12.90

Corrected values for MN, GT, MTL, DTL
13.44 14.29 -0.31 -0.29
Corrected values for MHHW, MHW, MLW, MLLW
6.86 6.41 -7.04 -7.44

Datums by Monthly Means Simultaneous Comparison (MMSC):
HWL = 8.83 (2021/08/22 23:48)
MHHW = 6.86
MHW = 6.40
DTL = -0.29
MTL = -0.31
MSL = -0.32
MLW = -7.03
MLLW = -7.43
DHQ = 0.46
DLQ = 0.40
GT = 14.29
MN = 13.44
LWL = -8.08 (2021/08/22 05:30)

Feet

That is all.

APPENDIX 9 – NATURAL RESOURCE AGENCY CORRESPONDENCE

From: David Bean - NOAA Federal <david.bean@noaa.gov>
Sent: Friday, May 26, 2023 2:07 PM
To: Ham, Eric <Eric.Ham@maine.gov>
Cc: LeVee, Rachel (FHWA) <rachel.levee@dot.gov>; jennifer.anderson@noaa.gov; Rory <rory.saunders@noaa.gov>; Gardner, David <David.Gardner@maine.gov>; Chamberlain, Kristen <Kristen.Chamberlain@maine.gov>; Todd Jorgensen <Todd.Jorgensen@dot.gov>; julie.crocker <julie.crocker@noaa.gov>
Subject: Re: Request for Consultation on Machias Dike Bridge MaineDOT WIN 16714.00

Thanks Eric. I wanted to pass along a recently published paper that I think is relevant to this project in particular. I know we talked a lot about sea level rise and how it may impact the project during early consultation. This paper does a good job of laying out some of the changes to operation of the tide gate that may occur over the life of the project that should be considered in the BA.

Have a great weekend,
Dave

On Tue, May 2, 2023 at 3:44 PM Ham, Eric <Eric.Ham@maine.gov> wrote:

> Hey Dave and Rory,
>
> Thanks for the time today. Below is my interpretation of what we would like to start working on ASAP vs what is required to start the BA.
>
> **We agree to start working on, but not necessary for initiation of consultation.**
>
> We had a lot of discussion around the monitoring of some of the assumptions needed for an accurate take calculation for the life of the project. You had multiple comments on this for species concerns and critical habitat concerns. MaineDOT (and FHWA) has known that these complication long term monitoring request we going to be a part of the alternative that we is proposed in the most recent BA. We are happy to start discussions on this as soon as we can get together again. However, I contend that that information is not typically the responsibility of the action agency to have in the BA in order to initiate consultation.
>
> We understand the take calculation is likely going to be challenging. There is not a lot known about the migratory behavior of Atlantic salmon in the action area.   Working the action agency, I tried to clarify the extension, duration, and severity of the effects. Following that, I do not believe it is FHWA/ MaineDOT responsibility to figure out the number of Atlantic salmon that may be effected.

You had a comment below about the Maintenance and Operations plan that wasn't in the attachment. We did not get to discuss it today. I added additional information the most recent BA and the operation of the tide gates and how MaineDOT plans to maintain them. I would contend that we have made the intended operation of the gates pretty clear.

We know we need to engage with the EFH folks. It is common for us to start the consultation process for ESA first do to timeframes. Once we have that consultation moving, we will start working with the EFH folks. They have been involved in discussions along the way.

Need for BA

The project team is helping me understand the ramifications of the work window commitment that was discussed. If it is ok, we will update the BA with. I will circle back when I get an answer either way.

You requested the combination of a table in the attachment. I had actually done that at one point. I may not have done a good job 😊 because I thought it was to busy and confusing. We will tackle that again in the updated BA.

I will add the BMP about the soft start for pile driving. I can use the language out of the FHWA/NMFS programmatic consultation.

Eric Ham

MaineDOT Environmental Office

Senior Environmental Manager

207-215-7356

Eric.Ham@maine.gov

From: David Bean - NOAA Federal <david.bean@noaa.gov>
Sent: Friday, April 14, 2023 4:05 PM
To: LeVee, Rachel (FHWA) <rachel.levee@dot.gov>
Cc: jennifer.anderson@noaa.gov; Rory <rory.saunders@noaa.gov>; Gardner, David <David.Gardner@maine.gov>; Chamberlain, Kristen <Kristen.Chamberlain@maine.gov>; Todd Jorgensen <Todd.Jorgensen@dot.gov>; Ham, Eric <Eric.Ham@maine.gov>
Subject: Re: Request for Consultation on Machias Dike Bridge MaineDOT WIN 16714.00

EXTERNAL: This email originated from outside of the State of Maine Mail System. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Rachel,

After reviewing the draft BA dated March 16, 2023 we felt the information did not fully describe the potential for take to occur as a result of the operation of the proposed project (see attached comments). For example, you have stated several impacts to Critical Habitat features in the action area after the construction phase has been completed, and the operation of the project may cause further harm (long term migration barrier), but did not provide any information to better understand the extent of that incidental take or how you were proposing to monitor for those impacts. Additionally, if there are measures you can implement into the project that would avoid or minimize the potential for effects to adversely affect T&E species (i.e., incidental take), these should also be fully described in the BA. Accordingly, if the effects are such that they cannot be effectively reduced to a level that is considered to not likely adversely affect the species, then the stressor needs to be monitored in order to determine the extent of the take and whether take has been exceeded during the life of the project. We recognize it is early in the planning process, however, the BA should also include some type of operation, maintenance and monitoring plans to demonstrate that the project will be installed and operated as designed and any potential stressor (noise, turbidity, false attraction etc.) from construction and operation will not cause further harm, injury, and/or mortality, above what was determined/anticipated to occur as described in the BA and determined/estimated in the BO as part of the incidental take statement. Without these plans, we would not have a good understanding of how the project is being operated and if take was kept below any anticipated threshold and not exceeded as described in the BO. We need this type of monitoring information because if take is exceeded, then the action agency needs to re-initiate consultation with NOAA.

At this time, we would like to discuss our comments and concerns on a call with MEDOT and FHWA to see if we can come up with a reasonable monitoring approach that would work at this site. Please feel free to reach out if you have any questions.

Dave

On Thu, Mar 16, 2023 at 7:09 PM LeVee, Rachel (FHWA) <rachel.levee@dot.gov> wrote:

> Hello Jennifer,
>
> Please see the attached Biological Assessment for the Machias Dike Bridge project (MaineDOT WIN 16714.00) and FHWA's request to initiate consultation pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.).
>
> Rachel LeVee, PE, PMP
>
> *Deputy Division Administrator*
>
> FHWA Maine Division
>
> O: (207) 512-4912 | C: (202) 306-7665

F: (207) 626-9133 | rachel.levee@dot.gov

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….>`~(((*>.....>`~((*>….>`~((*>…..>`~(((*>….>`~(((*>
David Bean (he,him)
Fisheries Biologist
NOAA's National Marine Fisheries Service
Maine Field Station
17 Godfrey Drive
Orono, Maine 04473
I am currently working from home due to COVID 19 restrictions please call me on my cell phone: 207-249-2802
Office Phone: 207-866-4172
Fax: 207-866-7342
Email: David.Bean@noaa.gov
….>`~(((*>......>`~((*>….>`~((*>…..>`~(((*>….>`~(((*>

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David Bean (he,him)
Fisheries Biologist
NOAA's National Marine Fisheries Service
Maine Field Station
17 Godfrey Drive
Orono, Maine 04473
I am currently working from home due to COVID 19 restrictions please call me on my cell phone: 207-249-2802
Office Phone: 207-866-4172
Fax: 207-866-7342
Email: David.Bean@noaa.gov
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Estuaries and Coasts
https://doi.org/10.1007/s12237-023-01174-1

Forecasting Sea Level Rise-driven Inundation in Diked and Tidally Restricted Coastal Lowlands

K. M. Befus[1,2] · A. P. D. Kurnizki[2] · K. D. Kroeger[3] · M. J. Eagle[3] · T. P. Smith[4]

Received: 27 September 2022 / Revised: 17 December 2022 / Accepted: 10 January 2023

Abstract
Diked and drained coastal lowlands rely on hydraulic and protective infrastructure that may not function as designed in areas with relative sea-level rise. The slow and incremental loss of the hydraulic conditions required for a well-drained system make it difficult to identify if and when the flow structures no longer discharge enough water, especially in tidal settings where two-way flows occur through the dike. We developed and applied a hydraulic mass-balance model to quantify how water levels in the diked and tidally restricted coastal wetlands and water bodies dynamically respond to sea-level rise, specifically applied to the Herring River Estuary in MA, USA, from 2020 to 2100. Sensitivity testing of the model parameters indicated that primary outcomes were not sensitive to many of the chosen input values, though the terrestrial water input rate to the estuary and the flow coefficient for the hydraulic infrastructure were important. The relative importance of parameters, however, is expected to be site specific. We introduced a drainability metric that quantifies the net water volume drained over every tidal cycle to monitor and forecast how rising water levels on either side of the dike affected the net draining or impounding conditions of the system. Ensembles of model results across parameter and sea-level scenario uncertainties indicated that substantial impoundment of the Herring River Estuary was expected within ~ 20 years with the existing flow structures, a sluice and two flap gates. Simulations with up to three additional gates did not dampen this trend toward impoundment, suggesting that rising impounded water levels are likely even with major construction upgrades. Increasingly impounded diked coastal waterbodies present a hydrologic challenge with socioecological implications due to projected flooding and ecosystem impacts. Solutions to this challenge may be to allow coastal wetland restoration pathways or require substantial and recurring infrastructure improvement projects.

Keywords Impoundment · Hydraulics · Sea-level rise · Dike · Tidal restriction · Restoration · Wetland drainage

Introduction

A substantial fraction of coastal wetlands today is impacted to varying degrees by human activities (Gedan et al. 2009; Burdick and Roman 2012; Pendleton et al. 2012; Kroeger et al. 2017; Crooks et al. 2018). In both urban and rural settings, wetlands that have not been destroyed by filling or dredging commonly persist within disturbed hydrologic regimes. Such disturbances result from diking to restrict tidal inundation, ditching to drain either tidal or meteoric water more efficiently, and other alterations. Coastal hydraulic structures, such as dikes, are designed for the hydrologic setting when built. Performance of such infrastructure may decline as climate change, subsidence, and sea-level rise alter the hydrologic regime and raise the tidal frame (Spencer et al. 2016; Schuerch et al. 2018). Due to sensitivity to hydrology, changes in hydrologic regimes are likely to drive changes in the ecological and biogeochemical functioning of diked ecosystems, creating positive feedbacks in both climatic and hydrologic drivers by altering greenhouse gas fluxes and relative soil elevation (Portnoy 1999; Wang et al. 2019; Eagle et al. 2022). Further, aging dikes designed for historic

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hydrology could exacerbate flooding hazards and damage coastal infrastructure. Predictions and models are lacking for the hydrology, ecology, and carbon cycle processes in diked landscapes, and thus, as sea levels rise, the future hydrologic states and fates of widespread coastal diked lands are critical, and yet highly uncertain.

Coastal dikes are intended to protect low-lying areas from inundation or short-term flooding from marine, often tidal, waters. However, dikes can also impound freshwater flows and tidally exchanged water caused by storms and/or wave overtopping, requiring adequately sized outlet flow control structures to drain stored water. Depending on the diked system, the flow control structures can be limited to draining only during low tides with one-way features, such as flap gates, effectively maintaining low salinity in impounded water or discharge saline water intruded during extreme events. If some tidal exchange is allowed across the dike, culverts or sluices (i.e., gate with an adjustable height opening at the bottom) can be sized to limit the volumes of exchange. One-way flow control structures also commonly lead to more stable and overall lower water levels on the inland side of the dike and a drier landscape. We refer to these two inland diked conditions as either impounded (i.e., insufficient outflow) or drained (i.e., enhanced outflow and restricted inflow) dike systems, depending on the degree to which diked water levels remain consistently higher or lower than a natural tidal setting.

We anticipate that most dike systems were designed to protect or alter a specific area, such as by draining upland areas and restricting tidal inundation to expand coastal agricultural land and reduce mosquito habitat (Kroeger et al. 2017; Crooks et al. 2018). Higher sea levels would reduce the amount of time during each low tide for diked systems to drain. Among our hypotheses is that, without changes to the dike infrastructure, such reductions in drainage will eventually convert drained systems into impounded systems. This transition may take decades to manifest and may be obscured by tidal and sea level dynamics. Watershed morphology, hydrology, weather, and infrastructure complicate the magnitude and timing of the hydrologic changes and combine to create unique conditions for how each diked system will respond.

Transitioning hydrologic regimes feedback into coastal ecosystem dynamics, blue carbon cycling, and associated greenhouse gas emissions. With additional freshwater impoundment, increased terrestrial inundation and more extensive freshwater features could replace brackish or saltwater wetlands, expanding the potential for methanogenic conditions (Warren et al. 2002; Kroeger et al. 2017; Sanders-DeMott et al. 2022). In addition, while drained former coastal wetlands emit sequestered soil carbon, it is not straightforward to predict the impact of a transition to an impounded condition on the rate of carbon storage, since impounded coastal wetlands have suppressed rates of soil carbon storage relative to rates in natural tidal wetlands (Turner 2004; Eagle et al. 2022).

The focus of this study is to investigate how coastal diked systems respond to sea-level rise and test how the drainage performance of existing hydraulic infrastructure changes in the future. We develop a simplified water balance approach to model flow through hydraulic control structures and water level in a diked system. We test this model with observations from the Herring River Estuary in MA, USA, for present-day and future sea-level rise scenarios. We hypothesize that drained diked systems will become impounded with sea-level rise if existing infrastructure remains functional but not upgraded. For our study site, we forecast when the system converts from drained to impounded, and we test a methodology to perform such an analysis on other diked systems. We further demonstrate the potential of several alternative water control structure scenarios to change the impoundment forecasts of the Herring River Estuary.

Site Description

Our study used the diked Herring River Estuary (HRE; Fig. 1) watershed to develop and test the model framework. The HRE watershed spans ~ 19 km^2 of sandy glacial till deposits. A dike was constructed across the HRE in 1909, resulting in reduced tidal inflow, lower average water level, and drainage of the HRE (Portnoy and Giblin 1997; Portnoy 1999). The current flow controls consist of two identical flap gates and one static sluice gate that was historically adjustable. The flap gates allow the HRE to discharge to Wellfleet Harbor at lower tidal conditions and are otherwise closed. Wellfleet Harbor tides at the dike are semidiurnal and mesotidal with a principal lunar semidiurnal (M2) amplitude of 1.23 m (Mullaney et al. 2020). The elevation of the top of the dike is 3.6 m above the North American Vertical Datum of 1988 (NAVD88), which was also used as the datum for all other elevations and water levels. The sluice allows flow in both directions resulting in a dampened tidal response in the HRE with an M2 amplitude of 0.33 m (Mullaney et al. 2020). The underlying unconfined aquifer discharges an annual average of approximately 0.03 m^3/s of baseflow to the HRE based on numerical simulations (Masterson 2004).

Water levels have been recorded at a 5-min interval on each side of the flow control structure from September 2017 to present (site number 011058798)(U.S. Geological Survey 2022). Measurements of water level and discharge began in June 2015, but the discharge measurements were discontinued in September 2017 when a tidal radar water level measurement device was installed on the downstream side of the flow control structure. Without coincident discharge

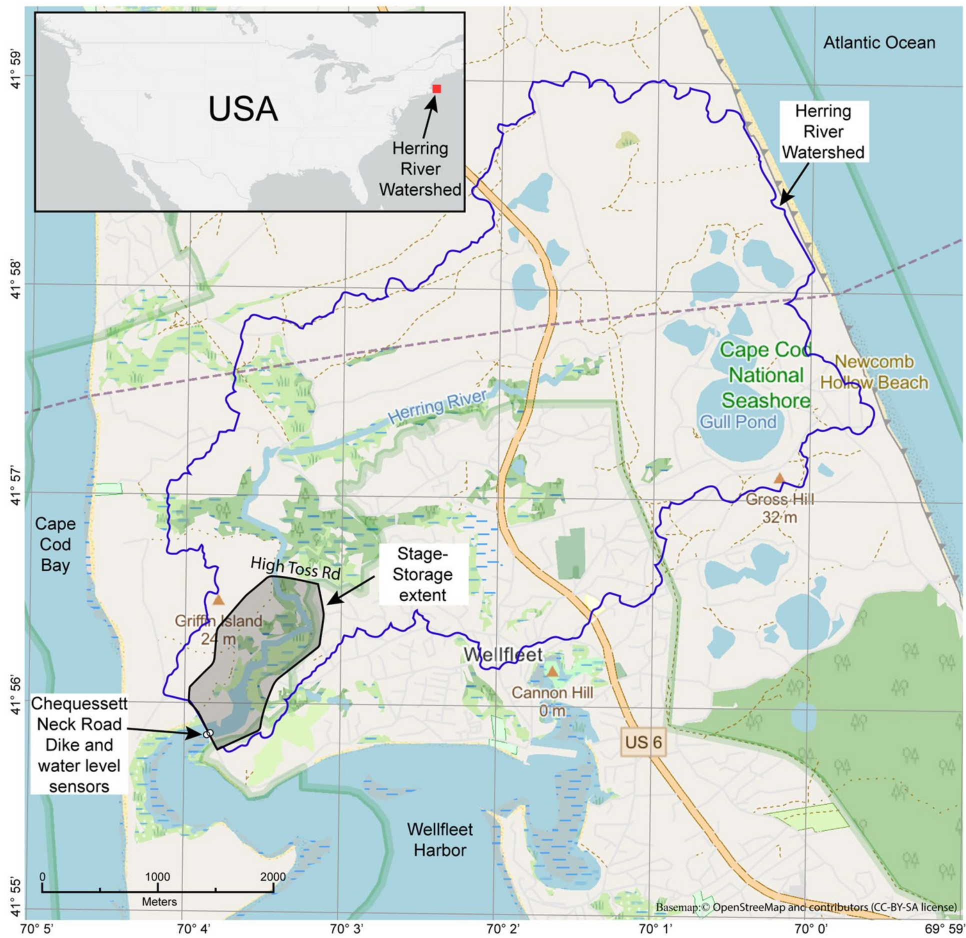

Fig. 1 Herring River watershed and diked estuary study area near Wellfleet, MA. The stage-storage extent approximately follows the 5-m topographic contour and terminates at an elevated road berm (i.e., High Toss Road). The Herring River watershed outline was extracted from the National Hydrography Dataset Plus, version 2 (McKay et al. 2012). Basemap data copyrighted OpenStreetMap contributors and available with explanations of basemap patterns and symbols at https://www.openstreetmap.org

observations with water level measurements on each side of the dike, we only tested the model performance with the water levels and not with discharge. Note, however, that the water level measurements on the harborside of the dike are raised by the discharge from the HRE during low tide, such that the water levels at this location remain above low tide levels farther offshore from the dike within Wellfleet Harbor. This water level difference with the harbor required an approximation for forecasting water levels using tide gauge measurements and sea-level rise rates for Cape Cod Bay described in the "Sea-Level Rise Forecasts" section.

Methods

In the following sections, we develop the formulation of the hydraulic flow model within the context of tidally restricted and diked coastal systems ("Hydraulic Flow Model" section), we establish how the model results for hindcast simulations are tested for accuracy while quantifying the uncertainty of the outputs using Sobol sensitivity testing ("Sobol Sensitivity Testing" section), and we introduce a framework for applying and analyzing the hydraulic flow model with future sea-level rise and alternative infrastructure for the HRE ("Sea-Level Rise Forecasts" section).

Hydraulic Flow Model

We developed a hydraulic mass-balance model for the flow through the two flap gates and sluice. The objective of the model was to solve for the water level in the HRE with the water level in Wellfleet Harbor as the main boundary condition. For the development of the model, we selected a present-day 2-year period with continuous water level observations on either side of the dike control structure, from 27 February 2020 to 27 February 2022. First, water level observations were downsampled from a 5-min interval to a 30-min interval, balancing a high enough resolution to simulate tidal levels and flow with computational efficiency. Second, we modeled the volumetric flow rate through the control structure using a series of hydraulic equations based on the relative water level difference between the HRE and the outflow to Wellfleet Harbor. Finally, the water level in the HRE was updated for each 30-min time step using a stage-storage relationship for the HRE upstream to the embankment of High Toss Road, up to approximately the 5-m elevation contour, and the dike (Fig. 1). The stage-storage relationship was developed with a low-tide 1-m spatial resolution elevation model with additional surveyed bathymetry extracted from a hydrodynamic model (WHG Inc. 2012) and higher elevations bilinearly interpolated from a 10-m resolution digital elevation model (U.S. Geological Survey 2018). The stage-storage relationship was developed across the elevation range − 2.5 to 3.6 m with the low value set below the invert elevation and the latter equaling the height of the dike. The net flow into or out of the HRE was calculated for each time step by summing the flow through each dike control structure with the amount of streamflow and groundwater discharge entering the HRE from its contributing watershed, q_{in}. We kept q_{in} constant in time, but it was varied between model runs, which was estimated in an earlier analysis to be a constant 0.34 m^3/s (WHG Inc. 2012). Once flow through each culvert bay was calculated, the volume of water stored in the HRE was calculated by multiplying the net flow rate by the time step. Finally, the stage-storage relationship provided the new HRE water level for the calculated volume.

We modeled the sluice gate using a series of hydraulic equations for five flow regimes that could occur in either flow direction (Fig. 2). The relative water levels on either side of the sluice gate controlled the flow direction and the flow regime with the relationships provided in Fig. 2 based on the implementation of sluice and weir flow in the HEC-RAS River Analysis System (Brunner 2016). All the equations for the flow followed the form (Brunner 2016):

$$Q = CA\sqrt{2ngH} \tag{1}$$

where Q is the volumetric flow rate of water flowing across the sluice, C is a unitless discharge coefficient, A is the cross-sectional area of the sluice or gate opening, H is the relative height of water driving flow, n is a unitless flow factor based on the hydraulic setting equal to one unless otherwise noted in Fig. 2 (Brunner 2016), and g is Earth's gravitational acceleration. For low water levels in the sluice, A is dependent on H. When submerged, A was calculated by the multiplication of the sluice gate width, $w = 1.829$ m, and its opening height, $B = 0.485$ m. For lower harborside water levels, A is equal to H multiplied by w. The height of the invert above the harborside bed, P, was not included in the calculations (Fig. 2a). The two parameters with definitions dependent on the flow regime are H and n. Additional head loss, H_{loss}, was subtracted within the H for free flow conditions and all flap gate flow regimes to account for energy lost in flow against the structures with (WHG Inc. 2012):

$$H_{loss} = H_{loss\_max}\left(1 - \frac{\frac{Z_M + Z_L}{2}}{D_{HL}}\right) \tag{2}$$

where H_{loss} decreases linearly from the maximum head loss, H_{loss_max}, as the water depth on the marine, Z_M, and land side, Z_L, approaches a minimum water depth difference, D_{HL}, where head losses created by the flow become negligible. Head losses in the culvert leading up to the gates were not considered.

The two rectangular flap gates were modeled using a moment balance to calculate the flap opening angle, θ, created by water flowing out of the HRE acting against both the weight of the flap and hydrostatic pressure on the outer side of the submerged portion of the flap with:

$$\begin{aligned} 0 = &- Wsin\left(\theta + \theta_0\right)\frac{h_{flap}}{\rho g} - w_{out}\left(\left[h_{flap}{}^2 cos^2\left(\theta + \theta_0\right) - 2h_{flap}d_{down}\cos\left(\theta + \theta_0\right) + \frac{d_{down}{}^2}{\cos\left(\theta + \theta_0\right)}\right]\left[h_{flap} - \frac{1}{3}(h_{flap} - \frac{d_{down}}{\cos\left(\theta + \theta_0\right)}\right]\right) \\ &+ w_{in}\left(\left[h_{flap}{}^2 cos^2(\theta + \theta_0) - 2h_{flap}d_{up}cos(\theta + \theta_0) + \frac{d_{up}{}^2}{cos(\theta + \theta_0)}\right]\left[h_{flap} - \frac{1}{3}(h_{flap} - \frac{d_{up}}{cos(\theta + \theta_0)}\right]\right) \end{aligned} \tag{3}$$

The moment balance included the weight of the gate materials, W, assumed to be uniformly distributed over the gate having a vertical length of h_{flap}. The forces of the water acting on each side of the gate were set by the wetted width of the gate on the Wellfleet Harbor side, w_{out}, and on the HRE side, w_{in}. On the Wellfleet Harbor side, the height of the gate hinge above the harbor water level at a given time was d_{down}. On the HRE side of the gate, the height of the gate hinge above the estuarine water level at a given time was d_{up}. The flap gates were not vertical when closed, having a starting angle, θ_0. We used the density of seawater, ρ, for water flowing out of the HRE, as the sluice gate allows seawater inflow during high tides that maintains high salinity across tides from salinity observations at the dike. The flap opening angle was solved numerically by finding the root of the zero-sum moment balance equation with the open-source Python *SciPy* package nonlinear function, *optimize.fsolve* (Virtanen et al. 2020). Once the flap opening angle was solved, the flow through the flap opening was modeled with weir equations (Eq. (1)) with an additional headloss term in H_{loss} (Eq. (2)). No flow was allowed to occur through the flap gates when they were closed (i.e., $\theta = 0$), although some leakage through the aging flaps was observed during a site visit in 2019.

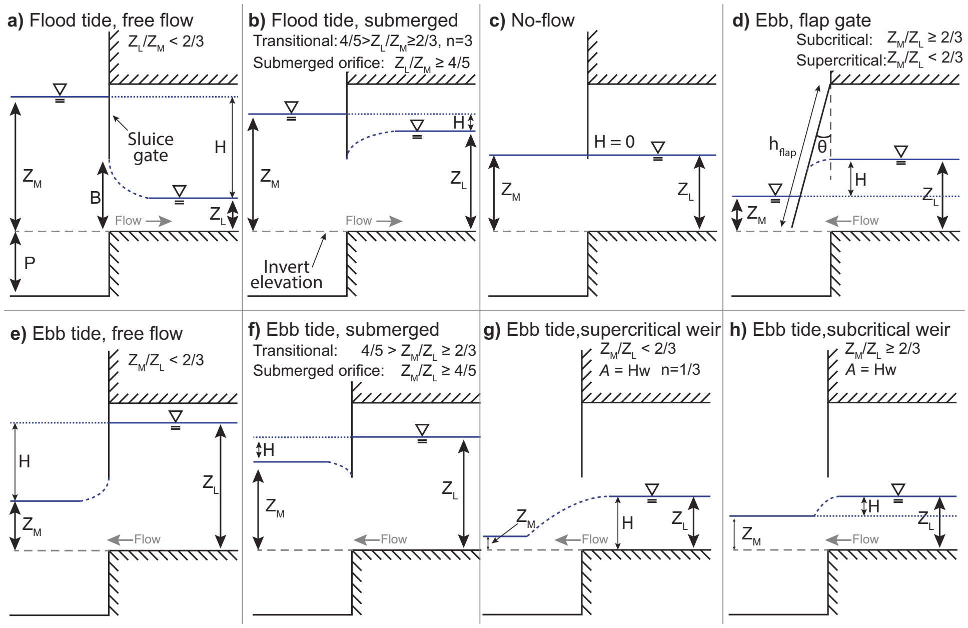

Fig. 2 Cross-sectional dike flow control structure hydraulic conditions used to simulate the HRE for **a**, **b** a sluice during flood tide, **c** instantaneous no-flow conditions, **d** a variably open flap gate allowing flow only during ebb tide, and **e–h** sluice flow conditions during ebb tide. The black hashed boundaries outline the cross-section view of the dike structures with the location of the sluice gate labeled in (**a**). See the discussion of the hydraulic equations in the "Hydraulic Flow Model" section for further explanation of variables. Z_M: harborside water depth; Z_L: upstream water depth; P: invert height above bed; B: gate opening height; H: water height difference driving flow; A: opening cross-sectional area; w: opening width; n: unitless flow factor; h_{flap}: vertical flap length; and θ: flap opening angle

Sobol Sensitivity Testing

A global sensitivity test was performed for the HRE application of the flow control structures with the Sensitivity Analysis Library in Python (Herman and Usher 2017). Flap gate and sluice flow coefficients, head loss terms, initial estuarine water level, and q_{in} were sampled for individual Sobol sensitivity tests using the extended form of the quasi-random samples of the parameter space including second order sensitivities (Saltelli 2002). The sampling routine was used 2^{10} times with the 18 hydraulic and initial condition parameters to produce 38,912 parameter combinations. Each parameter was allowed to range between a value of 0.01 to 2 with parameter-specific units. The values and ranges of C are dependent on the type, construction dimensions, and hydraulic regime (i.e., conditions in Fig. 2), where C for sluice gates is often in the range of 0.5–0.7 and for weirs between 2.6 and 4.1 (Brunner 2016). For infrastructure with available specification sheets, the C value for certain flow conditions may be available for different construction geometries from experiments performed by the manufacturer. Previous work at the HRE found that C under the weir conditions remained below 2.0 (WHG Inc. 2012), but testing with higher C values may be needed in other systems. Similarly, q_{in} is dependent on the site hydrology, climate, and size of the watershed, where an upper limit of 2 m^3/s would only apply for relatively small systems like the HRE. Since q_{in} integrates the combination of all rivers, streams, and groundwater to the diked or tidally restricted system being modeled, the range of q_{in} required will depend on the total freshwater influx.

For each parameter combination, the observed water levels within the HRE and outside of the dike in Wellfleet Harbor were run through the model with a 10-min time step over 30 days to calculate a non-parametric model efficiency, R_{NP} (Pool et al. 2018):

$$R_{NP} = 1 - \sqrt{(\beta - 1)^2 + (\alpha_{NP} - 1)^2 + (r_s - 1)^2} \tag{4}$$

with:

$$\beta = \frac{\mu_{sim}}{\mu_{obs}} \tag{5}$$

$$\alpha_{NP} = 1 - \frac{1}{2}\sum_{k=1}^{n}\left|\frac{h_{sim}(I(k))}{n\mu_{sim}} - \frac{h_{obs}(J(k))}{n\mu_{obs}}\right| \tag{6}$$

$$r_s = \frac{\sum_{i=1}^{n} \left[(R_{obs}(i) - \overline{R}_{obs})(R_{sim}(i) - \overline{R}_{sim}) \right]}{\sqrt{\left(\sum_{i=1}^{n} (R_{obs}(i) - \overline{R}_{obs})^2 \right) \left(\sum_{i=1}^{n} (R_{sim}(i) - \overline{R}_{sim})^2 \right)}} \tag{7}$$

β is the ratio of the mean observed, μ_{obs}, and mean simulated, μ_{sim}, water levels in the HRE. The normalized variability, α_{NP}, in the HRE simulated and observed water levels, h_{sim} and h_{obs}, used the difference between the ranked water levels, I and J. The Spearman rank correlation, r_s, described the similarity in the dynamics of the water levels using the difference between the rank, R_{sim} and R_{obs}, and the mean rank, $\overline{R}_{sim}$ and $\overline{R}_{obs}$, in the simulated and observed time series, respectively.

The sensitivity of the efficiency criteria to the flow coefficients can be used to identify which parameters influenced the accuracy of the model. Multiple output parameter combinations that yield high efficiency values (e.g., $R_{NP} > 0.8$) demonstrate the non-uniqueness of the hydraulic parameters in the model. These parameter combinations could be used for the remainder of the analysis for a quantification of model uncertainties. We adopted the R_{NP} as the goodness-of-fit criteria, although other efficiency metrics could serve the same overall purpose to constrain hydraulic parameter uncertainties. In addition to R_{NP}, we calculated the Nash–Sutcliffe efficiency, the relative efficiency, and the Kling-Gupta efficiency during model development with little effect on the total number of "good" model results (Nash and Sutcliffe 1970; Krause et al. 2005; Gupta et al. 2009). We focus on how these parameter combinations are tied to the implications of sea level changes on the operations of the existing and alternative flow control structures. Hence, we use multiple parameter combinations with high efficiency criteria from the sensitivity testing, with "good" defined as $R_{NP} > 0.9$, in the following analyses to constrain uncertainty introduced by the model parameters.

We further tested these parameter combinations for the present-day 2-year period with water level observations, 27 February 2020 to 27 February 2022, at the longer 30-min time step used for the forecasting models. We calculated a new R_{NP} for the longer model for all $R_{NP} > 0.9$ models from the sensitivity testing. Models that performed well, with $R_{NP} > 0.8$, for the 2-year simulation were included in the sea-level rise forecast models.

Sea-level Rise Forecasts

To quantify how the HRE water levels respond to sea-level rise, we constructed synthetic water level time series on the Wellfleet Harbor side, hereafter referred to as harborside, of the flow control structure. To accomplish this, we first calculated the amplitudes and phases of the tidal harmonic constituents with a least squares regression from the dike-adjacent harborside water level observations during the 2-year present-day simulation period (27 February 2020 to 27 February 2022) with the Python package *pytides* (https://github.com/sam-cox/pytides). Because the harborside water levels are influenced by discharge through the dike, the tidal reconstruction created lower low tide water levels compared to observations (Fig. 3a). We developed a method to restrict low harborside water levels based on an apparent linear relationship between the minimum harborside and HRE water levels. This rough linear relationship physically represents the role of relative water level differences controlling discharge to the harbor and setting the water level of the outflow. Thus, if both water levels are known, the harborside water level could be maintained above a minimum elevation and used to correct harborside tidal reconstructions. For the present-day simulation period, we found little change in the model performance for the tidal reconstructions with and without the minimum harborside water level linear relationship. Given this similarity in present-day results and the need for HRE water levels to be known to perform the correction, we chose to perform the sea-level rise forecasts with the uncorrected tidal reconstructions. Additionally, this simplification does not require the same linear stage-discharge relationship to hold as sea-level rises, which would intersect fewer tidal conditions as the harborside water levels increase with sea level.

Once the tidal reconstructions for the harborside water levels were made, we added future scenarios of sea-level rise. We used decadal relative sea level forecasts for the nearby Boston Harbor tide gauge (National Oceanic and Atmospheric Administration site 8,443,970) extending from 2020 to 2100 from a joint agency sea level change viewer (https://geoport.usgs.esipfed.org/terriaslc/). We selected three global mean sea-level rise scenarios of 0.3, 0.5, and 1.0 m, and we included the low, medium, and high sub-scenarios spanning climate projection uncertainties (Sweet et al. 2017). These sea level forecasts for Boston Harbor were relative to the year 2000 tide gauge water level, so we approximated that the relative increase from 2000 to 2020 for Boston Harbor was consistent with the increase for Wellfleet Harbor and that the discharge from the dike maintained a constant relationship with Wellfleet Harbor water levels in those forecasts. This allowed us to add the sea-level rise projections directly with the tidal reconstructions for the harborside water levels. We used a second-order polynomial interpolation of the decadal sea level projections to a 30-min sampling interval to be consistent with the tidal reconstructions. Together, these steps resulted in nine time series for the harborside water levels with sea-level rise from 2020 to 2100 to set the main boundary condition for the flow model (Fig. 3b).

We ran the hydraulic flow model for each parameter combination with $R_{NP} > 0.8$ from the 2-year simulations and

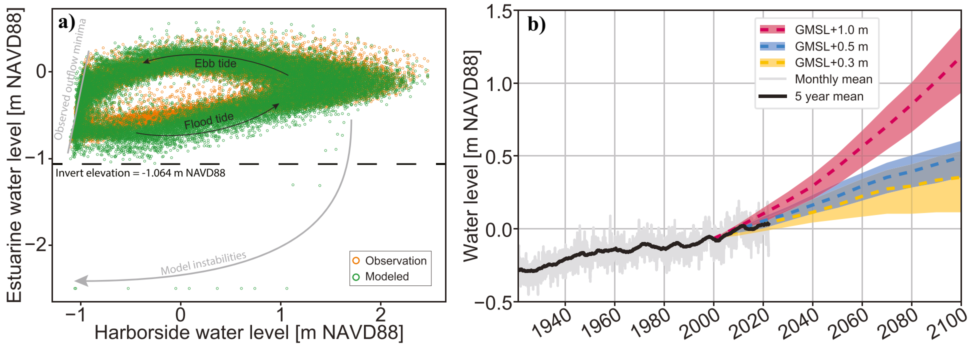

Fig. 3 **a** Tidal water level relationship on either side of the HRE dike with outflow effect at low tides. **b** Water level history and global mean sea-level (GMSL) rise projections for Boston Harbor used for the Wellfleet Harbor projections extending to 2100. Dashed GMSL curves represent the 50th percentile medium sub-scenario, and the light shaded areas span the 17th to 83rd percentile low to high sub-scenarios (Sweet et al. 2017)

each sea-level rise scenario with a 30-min time step from 1 January 2020 to 1 January 2100. We developed several metrics to quantify how the water level in the HRE responds to sea-level rise. First, we used the model outputs directly to provide HRE water level, water volume, and water surface area trajectories through 2100 and calculated moving annual arithmetic means to remove the substantial tidal variability in these values. Second, we used the modeled discharge time series to quantify how well the HRE drains over one tidal cycle. We introduce and have defined "drainability" as a new metric to track the draining or impounding behavior of a diked system, but the drainability alone does not quantify the volume stored beyond the drainage capacity of a given tidal cycle. To quantify this drainability, we separated periods of flow into and out of the HRE, representing flood and ebb tide conditions, and we integrated the discharge to yield the volume of water exchanged within each period. The water volumes contributing to the drainability included both flow through the dike structures and freshwater discharge from the contributing watershed (i.e., q_{in}). Starting with the first flood tide in the time series, we calculated the difference between the flood tide volume entering the HRE with the following ebb tide volume discharged from the HRE. If the ebb tide conditions discharge more water than entered the HRE during the preceding flood tide, we labeled that tidal cycle as drained. We quantify the long-term drainability behavior of the HRE from 2020 to 2100 by calculating the proportion of tides within a year that are drained. Thus, an annual drainability value of one indicates that all tides were net draining, and an annual drainability of zero indicates that, in that year, none of the ebb tides could effectively drain the water flowing into the estuary over the preceding flood tide. Decreasing drainability values track incipient and increasing impounding behavior for a diked system. Annual drainability values of zero establish the complete impoundment of a diked system.

We additionally demonstrate the application of the hydraulic flow model by testing how alternative infrastructure affects the response of the HRE to sea-level rise. These tests illustrate how the model could be used to develop water-level based restoration or infrastructure plans. We altered the number of sluices and flap gates in the forecast models, keeping the construction and properties of the existing infrastructure constant. We used a single parameter combination based on the best fit of the sensitivity testing ($R_{NP} = 0.97$). We ran the models with the infrastructure introduced in 2020, although the infrastructure could have been introduced at any time in the forecasts. We explored the drainage and water storage behavior of the HRE with only a sluice or only flap gates, increasing to five flap gates with one sluice, increasing to three sluices with two flap gates, and adding one sluice and one flap gate to the existing infrastructure.

Results

Parameterized Present-day Model

Sensitivity testing for the HRE dike flow control structures identified the sluice free-flow flow coefficient, C, during the flood stage as the most sensitive model parameter of all parameters tested (Fig. 4a). The upstream flow input into the HRE, q_{in}, was the next most important parameter followed by the sluice free-flow headloss terms (i.e., H_{loss_max} and D_{HL}). These results show the importance of the two hydrologic inputs to the HRE, q_{in} and C during flood stages, with the parameters controlling the drainage contributing less to the diked water levels. Our sensitivity results are site-dependent and controlled by the flow control structure construction (e.g., culvert dimensions, gate properties, and factors influencing C in Eq. (1)) as well as the hydrologic setting.

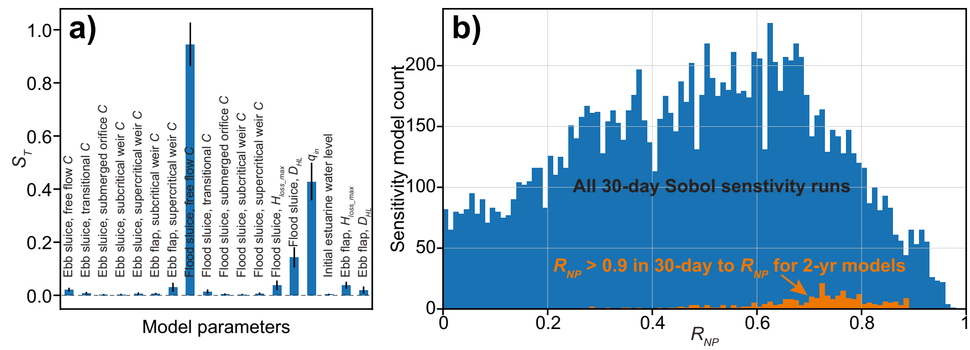

Fig. 4 Sobol sensitivity test results for the **a** parameter total sensitivity, S_T, with all 38,912 models and the **b** R_{NP} distributions for all 38,912 models and the resulting 2-year R_{NP} distribution for the 249 30-day models with an original $R_{NP} > 0.9$. All model parameters considered in the Sobol sensitivity test were included in (**a**)

Next, we confirm that the hydraulic model can accurately reproduce observed water levels within the HRE. A total of 249 30-day sensitivity testing models out of the 38,912 resulted in $R_{NP} > 0.9$ (Fig. 4b), with 1035 with $R_{NP} > 0.8$ and 27 with $R_{NP} > 0.95$. Of those 249 models, 45 models resulted in a $R_{NP} > 0.8$ for the 2-year, 30-min time step present-day models. Models with $R_{NP} < 0.8$ for the 2-year simulations generally predicted overly high water levels in the HRE with insufficient drainage capacity during low tides. The 45 higher efficiency model results matched the amplitude and timing of observed HRE water levels with residuals near zero (i.e., modeled values subtracted from observations) (Fig. 5). The median interquartile range (25th to 75th) for the residuals across the 249 high R_{NP} models was − 0.02 m (i.e., overprediction) to 0.11 m (i.e., underprediction). For 166 of the high R_{NP} models, flow instabilities resulting from too much drainage to the harbor led to short-lived (e.g., one tidal cycle) and unrealistically low modeled HRE water levels with residuals reaching > 1.5 m (Figs. 3a and 5a). Such excesses of outflow could be reduced by using a shorter time step or by enforcing a minimum water level allowed for outflow equal to the lowest invert elevation. A subset of 69 of the 249 high R_{NP} models resulted in residuals always < 0.5 m. The maximum overprediction of HRE water levels in each high R_{NP} models had a median of − 0.35 m. Overall, the hydraulic flow model provides useful information and forecasts estuarine water levels accurately for most tidal conditions (Fig. 5). The ensemble of numerous parameter combinations leading to high-efficiency models contained some short-term artifacts that did not influence the long-term water level forecasts. High-efficiency models did not demonstrate a clustering of hydraulic parameter values and instead spanned nearly the full range of the parameters input to the Sobol sensitivity analysis ("Sobol Sensitivity Testing" section). We used the 45 2-year high efficiency parameter combinations in the following analyses to constrain the long-term sea-level rise and alternative infrastructure scenario HRE water level forecasts. Each sea-level rise scenario consisted of 135 models, and 405 sea-level rise models with the existing infrastructure were run from 2020 to 2100.

Sea-level Rise Scenarios

All sea-level rise scenarios for the HRE with the existing infrastructure indicated a conversion from somewhat drained conditions in 2020 to nearly complete impounded

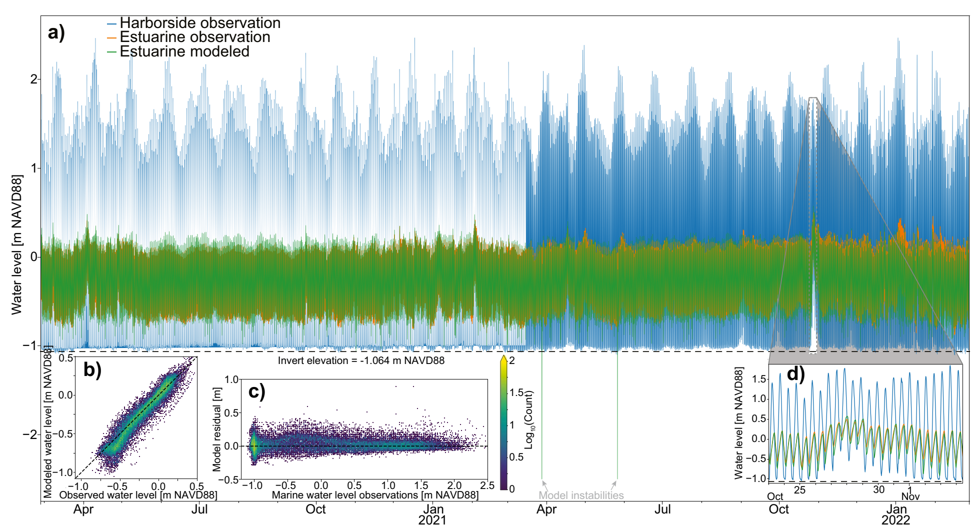

Fig. 5 **a** Present-day HRE simulated water levels for Sobol model scenario 20,255 (30-day sensitivity test $R_{NP} = 0.900$; 2-year present-day $R_{NP} = 0.868$). HRE water level performance **b** relative to observations and **c** residuals (i.e., observed estuarine water level – modeled estuarine water level) for the Sobol model scenario. **d** Example of shorter-term model performance during a storm in October 2021. Model instabilities are labeled for short-lived water level artifacts (i.e., two low tides) caused by excessive drainage in models with certain parameter combinations

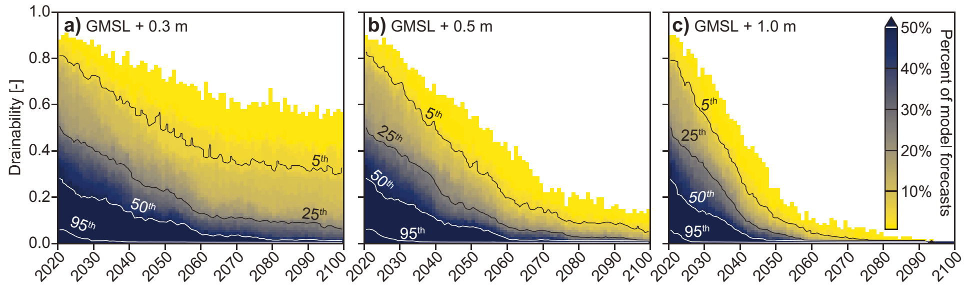

Fig. 6 Annual proportion of net-draining tides, or drainability, in the HRE decreases steeply to 2060 with the existing infrastructure for **a** GMSL + 0.3 m, **b** GMSL + 0.5 m, and **c** GMSL + 1.0 m for ensembles of 135 models per scenario. Each sea-level rise result combined the uncertainty from the low, medium, and high sub-scenarios and used the 45 $R_{NP} > 0.8$ parameter combinations from the 2-year simulations

conditions by 2100 (Fig. 6). Across the parameter combinations, the present-day simulated median drainability was ~0.3, signifying that on an annual basis only 30% of the tides today lead to net water removal from the HRE. The 95th percentile for present-day drainability was ~0.8 and the maximum simulated current drainability was ~0.9. The present-day low drainability results show that the existing infrastructure, designed to create net draining conditions in the HRE, are already under performing for a majority of tides. However, the drainability metric does not account for integrated drainage occurring over or across multiple tides. The simulated net annual storage change in the HRE also suggested the existing infrastructure would be incapable of draining the HRE in the future (Fig. 7). The water volume stored in the HRE was simulated to increase by 3–20% by 2030, 7–77% by 2050, and 11–600% by 2100 across the wide range of sea-level rise scenarios examined relative to the mean 2020 HRE volume. These results support the hypothesis that the HRE will become increasingly impounded with sea-level rise if no changes are made to the flow structures or system hydrology.

Alternative Infrastructure Scenarios

With the impoundment of the HRE likely with the existing hydraulic infrastructure in the dike, we tested several alternative infrastructure solutions to improve drainability in the future. Introducing more flap gates with the same construction as the existing flap gates extended the drained conditions within the HRE by up to several decades. Each extra flap gate accounted for roughly a decade extension of drained condition with the uncertainty in sea-level rise sub-scenarios leading to also about a decade of uncertainty for major losses in drainability (Fig. 8a–c). Additional sluice gates with the same construction as the existing sluice resulted in more rapid and severe impoundment relative to the existing infrastructure (Fig. 8d–f). None of the alternative infrastructure scenarios tested provides clear maintenance of the existing drainability conditions at the HRE, although the use of five flap gates with the lowest sea-level rise scenario and climate sub-scenario was effectively stable to 2100 (Fig. 8c). More hydraulic structure scenarios could be tested to optimize the drainability of the HRE, including testing more gates or gates with different designs and flow coefficients.

Discussion

Model Limitations and Opportunities for Enhancement

The implementation of the hydraulic flow model is computationally efficient, allowing rapid and numerous simulations with relatively few input parameters. Conceptually, the model consisted of a prescribed water level on one side of the hydraulic flow structures and the volumetric flow rates through those structures for a water level difference across the structures. The representation of how the diked water levels responded to input flow was simply a stage-storage relationship for the HRE. The stage-storage relationship removed the hydrologic complexities of flow within the estuary, not accounting for observed spatially varying water levels, flow velocities, salinities, or groundwater feedbacks (WHG Inc. 2012; S. M. Smith and Medeiros 2019; Mullaney et al. 2020). The model output within each time step is simply the volumetric flow rate across the dike flow control structure. This flow rate could be used to set a flux boundary condition in more advanced models that aim to understand spatially varying hydrology within the diked system, as was previously done for the HRE (WHG Inc. 2012).

Similarly, we tested the simulation using constant flow from the contributing Herring River watershed. Despite this simplification, the present-day modeled HRE water levels generally performed well, even without seasonal or event-based changes in streamflow in the Herring River. The hydraulic flow model was built to allow a time-dependent source term, which could also sum the streamflow and direct

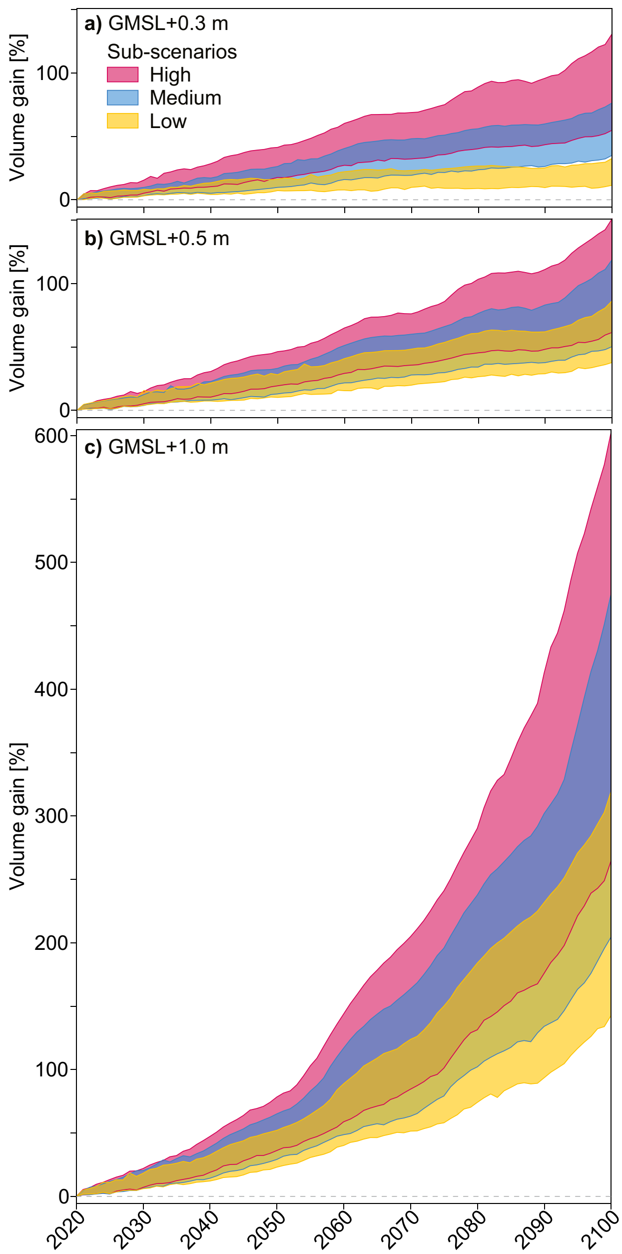

Fig. 7 Simulated water storage changes in the HRE with the existing infrastructure for the **a** GMSL+0.3 m, **b** GMSL+0.5 m, and **c** GMSL+1.0 m sea-level rise scenarios. All storage changes were positive, representing an increase in the water volume of the HRE. Overlapping semi-transparent shaded areas result from the ensemble of 45 high R_{NP} parameter combinations applied to each sea-level rise scenario and climate sub-scenario. Bold lines border each shaded area to highlight the forecast boundaries for a sub-scenario

surface runoff to the waterbody of interest with any other direct water inputs (e.g., groundwater discharge, storm sewer inflows, precipitation). This flow input could also be used to simulate the long-term effects of climate change on precipitation or the water balance more generally. Such a study could investigate the feedback between climate change and sea-level rise on diked water levels.

For the HRE, increasing and more extreme precipitation is predicted for the next century (Massachusetts Environmental Policy Act Office 2018). Thus, q_{in} would be expected to rise over our future scenario simulations, unless groundwater pumping from local municipalities reduced groundwater inputs to the HRE. The additional freshwater influx with climate change would likely accelerate the loss of drainability and create more impoundment than forecasted in our static q_{in} scenarios. Shorter-term variability in q_{in} related to the seasonality of precipitation, evapotranspiration, and pumping would influence the drainability calculations on weekly to monthly timescales. Additional feedbacks could occur with sea-level rise, where rising groundwater levels could lead to more baseflow to the HRE (Masterson and Garabedian 2007). Since the average magnitude of q_{in} is less than ~1/10th of the present-day outflow from the existing infrastructure (WHG Inc. 2012), we anticipate q_{in} dynamics and increases caused by climate change to be less influential on drainability than sea-level rise. Therefore, we chose to focus on the sea-level rise scenarios in the absences of these other hydrologic drivers to understand the long-term implications of the hydraulic infrastructure at the HRE. However, changes in the terrestrial hydrologic system and marine hydrodynamics with climate change could create sufficiently different fluxes and water levels to require incorporation in more detailed studies or for other diked or tidally restricted systems.

For the sea-level rise and alternative infrastructure scenarios, we tested how the HRE water budget would respond to specific forcing or structural changes to the system. Additional studies could investigate how incremental or delayed changes to the infrastructure could stabilize drainage and water levels. For example, additional flap gates could be installed every year to counter the time-dependent drainability losses. Adjustable flow control features could be tested and allow dynamic management of opening sizes or number of outlets. Precipitation or storm surge events could also be developed to simulate shorter-term diked system drainage performance, although more complex hydrodynamic models would be needed for constraining the exterior or harborside water levels. Under diked system restoration plans, this modeling framework could also be used to simulate incremental dike opening effects on surface water levels, although only basic salinity estimates could be calculated from the volume of tidal exchanges.

The model was developed to understand how the HRE would change with sea-level rise, but we generalized the model to allow it to be applied to other diked systems. As an open-source Python library (see Code and Data Availability), the model scripts and functions can be altered and expanded upon for other analyses and to incorporate other

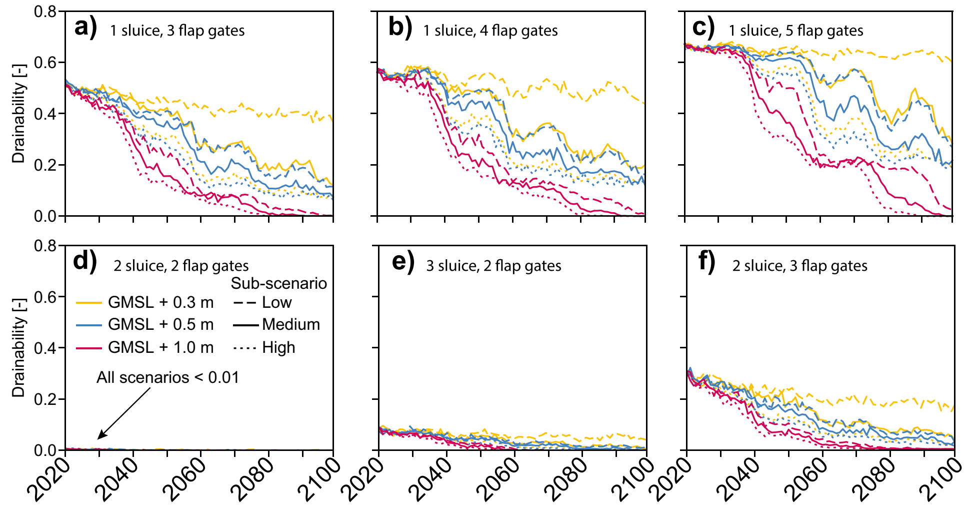

Fig. 8 Drainability forecasts for alternative infrastructure scenarios that consider different combinations of sluice and flap gates with the same dimensions as the existing infrastructure and hydraulic parameters from the highest R_{NP} Sobol test, 38,834 (**a–f**). All infrastructure initiated in the simulations with the first time step in 2020. The existing infrastructure (2 flap gates and 1 sluice) drainability results are shown in Fig. 6. All drainability results in (**d**) were effectively zero, and the legend therein applies to all panels

flow structure types (e.g., round flap gates). Our intention was to share the simple model as a useful screening tool that could later justify more complex hydrodynamic modeling or observation network development. The application of the model is site-specific, with hydrologic, topographic, and infrastructure-based inputs to parameterize for each system. We provided one example of how to use Sobol sensitivity testing to quantify the uncertainty of the model parameterization, but alternative sensitivity testing or optimization methods could be used to further understand dike flow control structure systems.

Socio-ecological Implications

Understanding how diked coastal hydrologic features respond to sea-level rise remains a challenging and a coupled problem across ecological and socioeconomic scales. Fundamentally, most diked systems today were the product of human socioeconomic and political choices, where environmental and ecological considerations have only been recognized in recent decades (Roman et al. 1984; Dionne et al. 1998). Such human choices will determine how, when, or if diked or otherwise tidally restricted systems are neglected, expanded, retrofit, managed, or otherwise restored to natural conditions in the next several decades. Coastal infrastructure could have been historically designed under the incorrect expectation of long-term hydrologic stationarity or for shorter operational lifetimes than their eventual tenure. The application of modeling the current and future drainability of such systems could identify priority systems for improvement of ecosystem function and/or flood control. The removal or alteration of existing diked systems could also be designed to slowly change hydrologic conditions, such as enhanced tidal mixing and increased salinity, allowing gradual ecosystem changes. For example, managed hydrologic conditions could aim to restore a salt marsh where hydrologic management actions have resulted in freshwater wetlands as displaced ecotones within the environment. In addition, as is planned for the HRE, ecosystem restoration could include initial elevation enhancement (e.g., sediment augmentation) to overcome subsidence and provide sufficient elevation capital to avoid flooded conditions with the removal of flow control structures (Cape Cod National Seashore and Herring River Restoration Committee 2012; Smith et al. 2020). Thus, maintaining existing or historic drainability is not a management goal for the HRE. Modeling changes in drainability could also be used to transition from gray infrastructure to more natural or nature-based strategies for currently diked systems (Sutton-Grier et al. 2015).

New coastal infrastructure that enables a return to more natural hydrology may provide pathways to avoid the physiochemical diked ecosystem conversion (Cadier et al. 2020). In the short term, additional infrastructure to allow more drainage only during low tide could maintain drained freshwater conditions. Over the long term, rising low tide elevation with sea-level rise would eventually require raising the barriers and flow structures or require pumping. Alternatively, restoring a tidal connection to diked lowlands can expand the habitat for saltmarsh ecosystems that sequester carbon, providing both protective function and a suite of other ecosystem services (e.g., Miller et al. 2008; Karberg et al. 2018; Janousek et al. 2021). The stored soil carbon can aid saltmarsh soil elevations to keep pace with sea-level rise and subsidence, offering a potentially longer-term solution than infrastructure upgrades.

Conclusions

We used a simple hydraulic flow model to forecast water levels of the HRE in Wellfleet, MA, to 2100 with expected trajectories of sea-level rise. We found that the HRE may already be incapable of draining the tidal, riverine, and groundwater inputs it receives over each tidal cycle. Simulation ensembles forecast increasing impoundment with sea-level rise over the next several decades. To further understand this conversion from drained to impounded conditions, we developed and demonstrated the application of a novel metric for monitoring and forecasting the drainability of diked systems with sea-level change. The drainability quantifies the net drainage or impoundment state occurring over tidal cycles. In our analysis, the ensemble median present-day annual drainability of the HRE was only 30% and decreased to below 10% by 2060. Fewer low tides per year that allow drainage of diked water leads to increasing water levels and net impoundment. Drainability can also be used in diked systems with one-way flow (e.g., tide gates only) to quantify freshwater or upland drainage performance across tides, as well as in natural or built tidally restricted systems. Similarly, the drainability metric could be calculated over different time spans, including lunar cycles or seasons, to provide shorter-term management and planning insights. The drainability metric that we introduced can be used as a normalized criterion for monitoring, managing, and forecasting the behavior of diked lowland systems. Drainability can aid in water level and volume analyses to develop site-specific thresholds for systems facing impoundment with relative increases in sea level.

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Code and Data Availability The dike hydraulic flow model code, supportive functions, and post-processing algorithms are available at github.com/kbefus/dike-flow-hydraulic. All other datasets are either produced by these scripts or are available from the original citations.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
GREATER ATLANTIC REGIONAL FISHERIES OFFICE
55 Great Republic Drive
Gloucester, MA 01930

April 15, 2022

Bruce Van Note, Commissioner
Maine Department of Transportation
16 State House Station
Augusta, ME 04333-0016

Todd Jorgensen, Administrator
Federal Highways Administration, Maine Division
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Dear Mr. Van Note and Mr. Jorgensen:

This responds to a March 21, 2022, letter from the Maine Department of Transportation (ME DOT) (attachment 1) that included several questions in relation to the Machias Dyke bridge replacement project located on the Middle River along Route 1 in Machias, Maine. Staff from ME DOT, NOAA's National Marine Fisheries Service (NMFS), and the Federal Highway Administration (FHWA) discussed these questions in a March 31, 2022, meeting. At that meeting, ME DOT requested that we also provide written responses.

As noted in previous correspondence, the project is located within the range of the endangered Gulf of Maine distinct population segment (GOM DPS) of Atlantic salmon. Additionally, the project is located within critical habitat designated for the GOM DPS of Atlantic salmon. Consultation pursuant to section 7 of the Endangered Species Act (ESA) will be required to consider effects of the proposed action on the GOM DPS of Atlantic salmon and its critical habitat. Here, we address the questions raised in the letter from March 21.

> *"1. Your technical assistance letter stated concerns with the culvert alternative providing safe, timely, and effective fish passage. MaineDOT shares these concerns (as noted above). If the understood fish passage standard (95% of all approaching fish pass within a 48-hour period) required for safe, timely, and efficient passage can't be met or committed to, is that likely to result in a jeopardy or an adverse modification determination?"*

In a number of ESA consultations considering effects of hydroelectric dams, we have determined that an action that includes a fishway that ensures that 95 percent of all salmon pass upstream within 48 hours is not likely to jeopardize the continued existence of the GOM DPS of Atlantic salmon or result in the destruction or adverse modification of designated critical habitat. That said, it is important to note that "95 percent in 48 hours" is not a jeopardy standard, and the conclusions reached in those consultations were based on the specifics of those proposed actions and the passage rate was only one factor among many considered in the analysis. During our

ESA section 7 consultation process, we consider whether the effects of the proposed action reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of the GOM DPS of Atlantic salmon. The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of the GOM DPS of Atlantic salmon. In addition, the analysis will determine whether the proposed action will adversely modify designated critical habitat for Atlantic salmon.

> *"2. The technical assistance process was clear that future monitoring of fish passage efficacy would be required for a culvert alternative. MaineDOT would like to understand how NOAA will use the monitoring results and what happens if the results do not meet passage standards."*

If, in the context of an ESA consultation, we determine that a proposed action is likely to result in the "incidental take" of ESA listed species (e.g., injury, mortality, harm, harassment), and that take is not likely to jeopardize the continued existence of the species, an Incidental Take Statement (ITS) would be included with our Biological Opinion. An ITS serves two functions: (1) It provides an exemption from the section 9 prohibitions for any taking incidental to the proposed action that is in compliance with the terms and conditions; and (2) it provides the means to insure the action as it is carried out as proposed and is not jeopardizing the continued existence of any ESA species by monitoring and reporting the progress of the action and its impact on the species such that consultation can be reinitiated if any of the criteria in 50 CFR 402.16 are met (e.g., if the amount or extent of take is exceeded). If take is anticipated, monitoring to document that take would be required. It is important to note that both short-term and long-term monitoring can be conditions of an ITS, depending on the extent and duration of take anticipated.

Considering the proposed Machias Dyke replacement project, we anticipate that the extent and duration of incidental take, and the associated monitoring requirements, would be significantly different depending on which alternative is selected. If a channel-spanning bridge is chosen as the preferred alternative, we anticipate that some monitoring would be required during construction. However, if consistent with our expectations, the bridge does not impact the passage of Atlantic salmon, long-term monitoring of fish passage would not be required.

If culverts and/or tide gates are chosen as the preferred alternative, we anticipate that long-term monitoring to evaluate the efficiency of fish passage through the structure would be needed to document the amount or extent of take of Atlantic salmon resulting from passage delays and/or disruptions. We expect that an ESA consultation that considered a culvert/tide gate alternative would anticipate ongoing effects to Atlantic salmon to result from at least the following mechanisms: (1) False attraction for adult Atlantic salmon attempting to enter the Machias River; (2) low upstream passage efficiency for adult Atlantic salmon attempting to enter the Middle River; (3) low downstream passage efficiency for smolts emigrating from the Middle River; (4) injury and mortality incurred by emigrating smolts given very high velocities at some flows; and (5) increased predation on adult Atlantic salmon by seals resulting from delayed passaged attempts and false attraction. It is important to note that the amount or extent of take over the life of the culvert and/or tide gates would likely be very difficult to estimate and any analysis would need to address significant uncertainty because this type of flow conveyance is largely untested in regards to passage efficiency for Atlantic salmon and other diadromous fish in Maine. As such, fish passage monitoring to document the effects of the structure on Atlantic salmon would be an extensive undertaking (see attachment 2). As noted above, monitoring would be required to document the amount and extent of take over the life of the structure. If monitoring indicates that the amount of take exempted by the ITS is exceeded, ESA section 7 consultation would need to be reinitiated. This could result in new analyses or additional measures to reduce the amount or extent of take. Predicting the outcome of the monitoring and any future measures to reduce take levels (if the extent of take identified in the ITS is exceeded) is not possible at this time.

Ensuring the long-term viability of Atlantic salmon is a high priority for NMFS and improving fish passage is a critical effort to improving the likelihood of the survival and recovery of this species, particularly within designated critical habitat. Given this, we encourage FHWA and ME DOT to select the alternative that would maximize fish passage and opportunities for recovery of Atlantic salmon and the ecosystem on which they depend. If you have any further questions about the ESA, please contact Julie Crocker in our Protected Resources Division (Julie.Crocker@noaa.gov).

Please note that in addition to the requirements to carry out ESA section 7 consultation, an Essential Fish Habitat (EFH) assessment for the proposed project will be required to initiate an EFH consultation. Characterizing and quantifying the habitats affected by the proposed project alternatives, both during construction and over the operational life of the project, will be necessary. Because this proposed project has implications related to climate change, we will require a climate assessment of future effects to habitats from a range of climate factors, including projected sea level rise, higher temperatures, and changes in precipitation patterns. The assessment should also include information for the project alternatives on implications for potential carbon sequestration gains and losses in salt marsh habitats within the Middle River over the life of the project. Questions regarding the EFH assessment should be directed to Chris Boelke in our Habitat and Ecosystem Services Division (Christopher.Boelke@noaa.gov).

Sincerely,

Michael Pentony
Regional Administrator

ec: Bean, Saunders, Johnson – GAR
Ham, Taylor – ME DOT

Attachment 1. March 21, 2022 ME DOT letter
Attachment 2. November 22, 2021 NMFS letter

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

Janet T. Mills
GOVERNOR

Bruce A. Van Note
COMMISSIONER

March 21, 2022

Ms. Jennifer Anderson
Assistant Regional Administrator for Protected Resources
National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office
55 Great Republic Drive
Gloucester, MA 01930

Dear Ms. Anderson:

Thank you for the technical assistance letter, dated November 22, 2021, regarding MaineDOT's Machias Dike Bridge project. National Marine Fisheries Service (NMFS) assistance over the past year has been valuable in understanding the requirements of Endangered Atlantic salmon and NMFS concerns. The MaineDOT Commissioner, Bruce Van Note, has requested that I follow-up with you regarding the technical assistance.

MaineDOT has put significant effort into understanding the available fish passage conditions for the culvert alternative (4M). MaineDOT has modelled various culvert sizes, arrangements, invert elevations, and gate combinations (including no tide gates) to ensure the culvert alternative carried forward represent optimized fish passage.

Alternative 4M consists of three box culverts (10 ft span x 5 ft rise) with tide gates on two of the culverts that would allow seaward flow but would not allow landward flow. The third box culvert would have no flow control so water can flow both directions. The invert of the open box culvert would be installed 2 feet below the existing inverts. As modeled, Alternative 4M would promote fish passage during periods of landward flow (approximately 50% of a 24-hour period).

The model showed that water velocities for the culvert alternatives effectively offer no fish passage during seaward flow for weak and moderate swimming fish. Comparing fish swimming capabilities to expected velocities during normal tides show that fish passage for weak and moderate swimming fish species is available for ~12 hours a day. Strong swimming fish may have available passage window of up to ~15 hours a day. As noted in your letter, the behavioral issues with the passage opportunities provided by Alternative 4M make the prediction of passage efficacy challenging.

NMFS has clearly stated a preference for the bridge alternatives and MaineDOT has noted and fully understands the preference. MaineDOT continues to seek guidance on the regulatory requirements of the Endangered Species Act as they would apply to the culvert alternatives to inform a legally defensible decision on a preferred alternative. Specifically, we need to understand the following items:

1. Your technical assistance letter stated concerns with the culvert alternative providing safe, timely, and effective fish passage. MaineDOT shares these concerns (as noted above). If the understood fish passage standard (95% of all approaching fish pass within a 48-hour period) required for safe, timely,

and efficient passage can't be met or committed to, is that likely to result in a jeopardy or an adverse modification determination?

2. The technical assistance process was clear that future monitoring of fish passage efficacy would be required for a culvert alternative. MaineDOT would like to understand how NOAA will use the monitoring results and what happens if the results do not meet passage standards.

The MaineDOT project team and the Federal Highway Administration would like to meet with you and your staff to discuss these items. The answers you provide are crucial as we continue to assess the potential impacts of culvert and bridge alternatives on natural resource, cultural, and social impacts of the alternatives.

Sincerely,

Joyce Noel Taylor

Joyce Taylor, Chief Engineer

cc: Todd Jorgenson, Administrator, FHWA Maine Division
Eva Birk, FHWA Maine Division
Patrick Keliher, Commissioner, Maine Department of Marine Resources

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
GREATER ATLANTIC REGIONAL FISHERIES OFFICE
55 Great Republic Drive
Gloucester, MA 01930

November 22, 2021

Bruce Van Note, Commissioner
Maine Department of Transportation
16 State House Station
Augusta, ME 04333-0016

Todd Jorgensen, Administrator
Federal Highways Administration, Maine Division
Edmund S. Muskie Federal Building
40 Western Avenue, Room 614
Augusta, ME 04330

Dear Mr. Van Note and Mr. Jorgensen:

This letter provides the technical assistance requested by the Maine Department of Transportation (DOT) regarding the proposed construction design plan for the Machias Dyke bridge replacement project located on the Middle River along Route 1 in Machias, Maine. Our agency's staff have continued to coordinate and meet virtually throughout 2021; we appreciate your staff's willingness to discuss and explore design alternatives while balancing the many challenging issues your agencies face with this project.

As we have previously noted, the project site is within or near areas that support a number of NOAA trust resources, including designated critical habitat for the endangered Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon, Essential Fish Habitat (EFH), and habitat for a number of diadromous fish species. We have also previously expressed the importance of developing a design alternative that provides safe, timely, and effective fish passage that will fully restore the function of these habitats and trust resources that occur in the Middle River watershed upstream of the existing Machias Dyke Bridge.

Technical Assistance

On September 21, 2021, DOT provided us information to gain a better understanding of the alternatives being considered and how these may affect our trust resources. As described, DOT is considering two preliminary design alternatives: A pile supported single span bridge (Alternative 10) or a solid-fill dyke bridge with a series of culverts and tide gates (Alternative 4M). Our preferred alternative here is one that will: minimize effects to diadromous fish, including endangered Atlantic salmon; maximize passage opportunities; maximize opportunities for tidal habitat restoration; and minimize negative effects on critical habitat designated for the Gulf of Maine DPS of Atlantic salmon. Alternative 10 appears to provide a better opportunity to meet these goals than Alternative 4M.

Safe, Timely, and Effective Fish Passage
One of our primary considerations in evaluating the different alternatives is the potential for it to provide safe, timely, and effective passage for fish species. Our goals are always to minimize the potential for migratory delay or deterrence for endangered species, including Atlantic salmon. For a project such as this one, we would expect designs to allow for passage of all diadromous species at least 95% of the time (between the 5% and 95% exceedance flows) during the entire migratory window.

While the Machias Dyke Bridge is not a nature-like fishway (NLF), passage criteria for depth, width, and velocity referenced in the *Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes* (Turek 2016) is relevant and should be fully considered here. Based on body length, depth, and swim speeds for Atlantic salmon, the guidelines recommend a minimum depth of passage of 2.25 feet, a minimum width of passage of 6.25 feet, and a maximum velocity of 13.75 feet per second (fps). Given the high swim speed of adult salmon, we expect that they might attempt passage at velocities that would deter other species. The NLF guidelines indicate that if passage for other diadromous fish is to be achieved most of the time, channel widths and depths should be greater than for Atlantic salmon, and velocities should be lower. For example, striped bass have a wider minimum width requirement (9.25 feet) and deeper minimum depth requirement (3.25 feet) than Atlantic salmon (note that if Atlantic sturgeon are to be afforded passage, the minimum depth should be 4.50 feet). Similarly, volitional passage of species with slower swimming speeds requires maximum velocities as low as 0.75 fps (Rainbow smelt, Atlantic tomcod, river herring and American eel ≤ 15 cm).

Alternative 4M
Alternative 4M includes three, 10-foot by 10-foot culverts with flap-gates on two of the culverts and bidirectional flow in the third culvert. According to the information presented by DOT on August 17, 2021, the use of culverts would substantially alter the flow regime and decrease the volitional passage opportunities for diadromous fish entering and exiting the Middle River to approximately 50% of the daily tidal cycle. As such, we remain concerned that this altered flow regime and constricted area with increased velocities through the culverts and tide gates would likely limit volitional passage opportunities to a much smaller percentage of time, mostly occurring around ebb and flood slack tides.

In addition, placing a structure such as a tide gate within a boxed culvert could have significant implications to fish passage. As documented by Rillahan (2021) and Alcotte et al. (2021), tide gates at the Herring River in Massachusetts have had a deleterious effect on fish behavior including unsuccessful passage and delay, injury and mortality and increased exposure to predators like striped bass. Any tide gate, whether fully open or partially open, is likely to provide an attraction flow that fish may try to use for passage. Additionally, partially open or fully open tide gates can create high velocities that sweep fish through narrow openings. When velocities exceed the burst speeds of fish, they cannot make evasive maneuvers away from predators and obstacles in the water, like debris, increasing the risk of injury and mortality. In particular, high velocity flow through the narrow openings of flap gates promotes collisions with the gate structure itself, including the gate and frame. Furthermore, the use of submerged orifices for fish passage can create high velocities that exceed the burst speeds of diadromous fish. The proposed culverts for a replacement dyke structure would be similar to the existing length of the tide gate culverts (reportedly 110 feet), likely exceeding the distance that most fish could sustain burst speeds.

Submerged passage also limits natural light in the flow conveyance which can adversely affect fish behavior. That is, even if velocities were manageable, many sea-run fish would be reluctant to enter these confined dark spaces volitionally. Deeply submerged passages can also introduce delay by requiring fish to sound or search for a narrow opening, making repeated attempts at entry. Therefore, given the potential to adversely change fish behavior during migration, or even cause injury or mortality, we recommend that no tide gates be used in the Machias Dyke Bridge replacement.

The uncertain performance of culverts, including tide gates, in passing diadromous species in Maine, especially endangered Atlantic salmon, would require more baseline information and long-term monitoring to better understand the potential effects from extensive operation using a type of flow conveyance that has largely been untested in regards to passage efficiency for diadromous fish within the GOM DPS. As such, we anticipate that should you pursue this alternative, we would recommend fish passage monitoring to document the effects of the structure on Atlantic salmon, their critical habitat, and the other diadromous fish in the project area.

Sea Level Rise

The effects of future sea level rise on the operation of the tide gates and fish passage is uncertain at this time. Under normal operation, the two flap gates would presumably stay in an open position and allow flow from the Middle River to Machias River when the water elevation on the Middle River side of the dyke bridge is higher than the Machias River (approximately 50% of the daily tidal cycle). The flap gates would be closed when water elevations are equal on both sides of the dyke bridge or higher in the Machias River. The only tidal exchange when the flap gates are closed would be through the single open box culvert. However, higher sea levels projected for the Gulf of Maine can impact flows in tidal structures such as tide gates and culverts. It will be critical to assess the effectiveness of fish passage over the full range of the normal tide cycle and during predicted storm water elevations from sea level rise. The assessment should evaluate the predicted water velocity through the tide gates and the open box culvert, and the estimated duration of gate closure during normal tide cycles with higher mean sea levels. At a minimum, sea level rise projections should be consistent with the Maine Climate Council's "commit to manage" recommendation of 1.5 feet of relative sea level rise by 2050, relative to the year 2000, and 3.9 feet of sea level rise by the year 2100. The assessment should also include the Maine Climate Council's "prepare to manage" recommended sea level rise projection of 3.0 feet of relative sea level rise by 2050, and 8.8 feet of sea level rise by the year 2100 (Maine Climate Council. 2020). In addition, the National Climate Assessment projects more extreme precipitation events in the Northeast U.S. and parts of New England with corresponding higher air temperature (Easterling et al. 2017). In an assessment of four unregulated rivers in Maine, Hodgkins and Dudley (2013) reported increases in maximum peak river flows based on projected higher temperature and precipitation rates by the end of the century. More extreme precipitation and river flows will also affect the operation of the dyke bridge tide gates, and hence flow rates and patterns for fish passage.

If you continue to pursue this alternative, a climate change assessment should be conducted to evaluate future sea level rise and increases in extreme precipitation and peak flows on the solid-fill dyke bridge with tide gates and box culverts, and its effects on fish passage.

Tidal Habitat Restoration
According to an October 2021 updated analysis conducted by Stantec and provided to us, this project has the potential to restore over 400 acres of tidal habitats, including salt marsh wetlands, intertidal mudflats, tidal streams, and other resources that provide important ecosystem services. Salt marsh wetlands not only serve as important nursery habitat for federally-managed species and their prey, but they provide the capacity to sequester atmospheric CO_2 (18–1,713 g of carbon per meter per year, according to Mcleod et al. 2011).

The DOT has indicated up to 100 acres of tidal habitat is currently available due to the existing state of the Machias dyke allowing some tidal flow into the Middle river during a flood tide. Furthermore, according to the updated Stantec analysis, design alternative 4M may re-establish approximately 116 acres of unvegetated intertidal/subtidal, low, and high marsh habitats in the Middle River compared to the no action alternative. This estimate includes approximately 60 acres and 13 acres of re-established low and high marsh habitats, respectively, and assumes the salinity range within the Middle River will be equivalent to the Machias River. However, this condition may not exist given the limitation of tidal flow through one, 10-foot by 10-foot culvert and the depressed tidal regime in the Middle River (i.e., -2.7 to +2.0 feet NAVD88) compared to tidal transparency (i.e., -6.7 to +7.4 feet NAVD88). We recommend that in light of this new information, the effects of Alternative 4M on the tidal regime and salinity, and the subsequent potential for salt marsh restoration in the Middle River be re-evaluated.

Preference for Alternative 10
According to recent information presented by DOT, Alternative 10 would provide unrestricted tidal flow between the Machias River and the Middle River (i.e. tidal transparency), which in turn would afford more time for fish to enter the Middle River estuary during daily tides. As in freshwater rivers, inverts should be set at the natural grades of riverbeds to allow fish passage even during low flow and low tide conditions. Since the channel velocity will largely be determined by the differential between water levels upstream and downstream of the Machias Dyke Bridge, the best way to minimize velocities over a range of flows and tide levels is for the structure to provide tidal transparency, as would be provided by a single span bridge. Specifically, tidally-influenced water levels upstream and downstream of the bridge structure should track closely in amplitude and period. According to hydraulic modeling results provided by DOT, tidal transparency would furthermore appear to maintain minimum depth and width requirements for diadromous fish per the guidelines. We also expect this alternative would provide the most effective fish passage conditions, and therefore reduce the potential need for additional fish passage monitoring.

A comparative climate change assessment, including sea level rise projections and changes in extreme precipitation and peak flows, should also be conducted for this alternative as it applies to the effectiveness of fish passage.

With regards to tidal habitat restoration, the Stantec analysis indicated the potential to re-establish approximately 403 acres of unvegetated intertidal/subtidal, low, and high marsh habitats in the Middle River for design Alternative 10. This amount of tidal habitat re-establishment is approximately three times the projected amount calculated for Alternative 4M. Salt marsh wetlands have a higher capacity to sequester carbon compared to terrestrial vegetation and soils, and have the capacity to migrate inland as sea levels rise (Chmura et al. 2003). In addition, coastal marshes have been shown to reduce wave heights, attenuate storm surge and higher sea levels, and reduce property damage compared to unvegetated or hardened shorelines (Gedan et al. 2011; Shepard et al. 2011; Arkema et al. 2013; Temmerman et al. 2013; Narayan et al. 2016). Therefore, this alternative appears to provide the best approach to restoring the habitat and stream function of the Middle River, as well as increasing the capacity for carbon sequestration by tidal marsh vegetation. This alternative also appears to be most consistent with two primary strategies in the Maine Climate Action Plan: protecting and promoting natural climate solutions that increase carbon sequestration and investing in climate-ready infrastructure (Maine Climate Council 2020).

Next Steps

In our view, Alternative 10 is the preferred opportunity for achieving an ecologically sound and climate resilient approach to the replacement of the Machias Dyke Bridge. We encourage you to pursue this alternative to provide safe, timely and effective fish passage while at the same time allowing for restoration of tidal wetland habitats. We recognize the complexity of this project and the need to consider multiple factors as you move this project forward. We look forward to continuing to provide assistance to you and your staff. Should you have any questions regarding the Endangered Species consultation process for this project should be referred to David Bean (David.Bean@noaa.gov), while questions regarding the EFH consultation process should be referred to Mike Johnson (mike.r.johnson@noaa.gov).

Sincerely,

Jennifer Anderson

Jennifer Anderson
Assistant Regional Administrator
for Protected Resources

cc. Eva Birk (FHWA)
Joyce Noel Taylor (MDOT)
Patrick Keliher (MDMR)

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STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

Janet T. Mills
GOVERNOR

Bruce A. Van Note
COMMISSIONER

October 20, 2020

Michael Pentony, Regional Administrator
United States Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Dear Mr. Pentony:

Thank you for your letter dated September 30, 2020, regarding the Maine Department of Transportation's (MaineDOT) Machias Dyke Bridge project located on the Middle River along Route 1 in Machias.

MaineDOT values NOAA's willingness to have on-going communication with our staff and the Federal Highway Administration (FHWA). MaineDOT understands your concern that the in-kind replacement will have detrimental effects on the physical and biological features of Atlantic salmon critical habitat; and a negative impact on Atlantic salmon recovery goals, which would be contrary to federal agency responsibility under Section 7(A)1 and 7(A)2 of the Endangered Species Act. MaineDOT also understands your concerns with Essential Fish Habitat under the Magnuson-Stevens Fishery Conservation and Management Act and the effects of projected sea-level rise on the project and surrounding area.

MaineDOT has considered NOAA's concerns and decided to move the project from our Bureau of Project Development to our Bureau of Planning. This will pause design work on the in-kind alternative. Planning will work closely with our Office of Environmental Services and FHWA to re-evaluate the project purpose and need and reconsider a larger range of alternatives through the National Environmental Policy Act (NEPA) process. MaineDOT staff will continue to work closely and collaborate with NOAA as well as other state and federal agencies and the community to meet the purpose, need, and goals of the project.

Sincerely,

Bruce A. Van Note, Commissioner

cc. Todd Jorgensen (FHWA)
Eva Birk (FHWA)
Patrick Keliher (ME DMR)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
GREATER ATLANTIC REGIONAL FISHERIES OFFICE
55 Great Republic Drive
Gloucester, MA 01930

September 30, 2020

Bruce Van Note, Commissioner
Maine Department of Transportation
16 State House Station
Augusta, ME 04333-0016

Todd Jorgensen, Administrator
Federal Highways Administration, Maine Division
Edmund S. Muskie Federal Building
40 Western Avenue, Room 614
Augusta, ME 04330

Dear Mr. Van Note and Mr. Jorgensen:

I am writing to express concern regarding a proposed construction plan for the Machias Dyke Bridge replacement project located on the Middle River along Route 1 in Machias, Maine. It is our understanding that this project will be carried out by the Maine Department of Transportation, be partially funded by the Federal Highway Administration, and will require permits from the U.S. Army Corps of Engineers. Please note that this letter follows a letter we sent to the Maine Department of Transportation on May 8, 2018 (Enclosure 1). This letter is also consistent with a letter sent to your agencies from the Downeast Coordination Committee (a group, including staff from NOAA's National Marine Fisheries Service, charged with coordinating local recovery efforts for Atlantic salmon in Downeast Maine) expressing concerns about the project's impacts to the Middle River (Enclosure 2). Both letters highlighted the project's potential negative impact on our ability to achieve our recovery goals outlined in the 2019 Atlantic Salmon Recovery Plan. The complete Recovery Plan can be found at https://www.fisheries.noaa.gov/resource/document/recovery-plan-2019-gulf-maine-distinct-population-segment-atlantic-salmon-salmo. The Machias Dyke Bridge is listed as site-specific threat number 10.0 in the existing work plan for the Downeast Coastal Salmon Habitat Recovery Unit (SHRU; Enclosure 3).

We appreciate your staff's willingness to discuss the matter with my staff and other agency representatives in a meeting on August 19, 2020. In particular, we are very appreciative of the leadership of Eric Ham and Eva Birk and their communication regarding the many challenging issues your agencies face with this project. At this meeting, we were concerned to learn that the preferred alternative remains a replacement in-kind. We have substantial concerns about the proposed alternative given that it would provide even less opportunity for fish passage than exists now and will not remedy ongoing impacts to our trust resources.

As you may be aware, the project site is within or near areas that support a number of NOAA trust resources, including designated critical habitat for the endangered Gulf of Maine Distinct

Population (GOM DPS) of Atlantic salmon, Essential Fish Habitat (EFH), and habitat for a range of diadromous fish species. In addition, this project area contains salt marsh, intertidal mudflats, and other important habitats that provide important ecosystem services. A replacement in-kind would negatively affect these public resources and would reduce opportunities to restore functions in the watershed.

Endangered Species Act
Atlantic salmon are listed as endangered under the Endangered Species Act of 1973 (ESA), as amended. The Middle River is designated critical habitat for the GOM DPS and occurs within the Downeast Coastal SHRU.

Section 7(a)(2) of the ESA, as amended, requires that federal agencies ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or destroy or adversely modify any designated critical habitat. Based on the information currently available to us, the preferred alternative is likely to have detrimental effects on the following physical and biological features of designated critical habitat: Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations; freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation; and, freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment. As such, we are concerned about the effects of the proposed in-kind replacement. We expect that many, if not all, of these negative outcomes could be avoided with selection of a different alternative that allows for fish passage and minimizes effects to sensitive habitats.

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. In other words, it is expected that federal action agencies will go beyond minimizing project effects and will proactively seek opportunities to contribute to the recovery of listed species. We encourage FHWA to pursue an alternative that would support the recovery of Atlantic salmon while also addressing regional transportation and infrastructure needs.

The in-kind replacement of the Machias Dyke Bridge would prevent fish passage into the Middle River for the foreseeable future. Our 2019 Recovery Plan for the GOM DPS identifies a number of recovery criteria that must be achieved before we can consider downlisting Atlantic salmon to threatened or removing the species from the endangered species list. One criterion for recovery is having 30,000 units of suitable rearing habitat fully accessible in the Downeast SHRU. If accessible, the Middle River would provide up to 259 units of rearing habitat for Atlantic salmon. An alternative design that allowed for fish passage would directly contribute to attaining the goal of 30,000 accessible and suitable habitat units in the Downeast SHRU.

Magnuson-Stevens Fishery Conservation and Management Act
The Magnuson-Stevens Fishery Conservation and Management Act (MSA) and the Fish and Wildlife Coordination Act (FWCA) require federal agencies to consult with one another on projects such as this. Insofar as a project involves EFH, as this project does, this consultation process mandates the preparation of EFH assessments and generally outlines each agency's

obligations in this consultation procedure. Machias Bay is EFH for a number of federally-managed species, including all life stages of winter flounder, windowpane flounder, and Atlantic cod. In addition, Machias Bay and the Machias River are EFH for Atlantic salmon that may use the project area as a migratory pathway and for foraging before and after spawning. The Machias River is also one of eleven rivers in Maine designated as a Habitat Area of Particular Concern (HAPC) for Atlantic salmon because it supports some of the only remaining U.S. populations of naturally spawning Atlantic salmon that have historic river-specific characteristics. These river populations harbor an important genetic legacy that is vital to the persistence of these populations and to the continued existence of the species in the United States. Furthermore, the Middle River contains historic spawning habitat for a number of other diadromous fish species, including rainbow smelt, blueback herring, alewife, and American eel. These species are important prey for federally-managed species and, therefore, are considered a component of EFH pursuant to the MSA.

The Middle River and the Machias Bay contain important habitats that are critical to a healthy marine ecosystem, including salt marsh wetlands, intertidal mudflats and fringing salt marshes, subtidal habitats, and eelgrass beds. The proposed in-kind replacement would effectively eliminate passage of fish through the structure and convert tidal habitats, including intertidal mud flats and salt marsh wetlands, to freshwater habitats. An alternative design that allows for fish passage and tidal exchange would minimize the potential for these negative impacts.

Climate Change

We are also concerned that an in-kind replacement would not adequately address concerns in regards to projected sea level rise (SLR) and flooding. We continue to question the efficacy and cost-benefit analysis of rebuilding the dyke as proposed with the explicit objective of preventing or reducing flooding of properties landward of the structure. In fact, it appears that flooding during high tides and storm surge events will not be reduced by the project as proposed and, as a result of SLR, these flooding occurrences will increase in frequency and intensity. Specifically, over the expected design life of the project (~75 years), sea level is projected to increase in this area (Eastport, Maine) under a 1.0 and 2.0 global SLR scenario by 2100 by about 4.0 and 8.9 feet, respectively (Sweet et al. 2017). According to information provided by the Maine Department of Transportation, the proposed finished grade of the causeway is between 11.1 feet and 11.9 feet NAVD 88, and the existing mean high high water line is 7.4 feet NAVD 88. This provides an approximate 4-foot freeboard on the highest average high tides in 2020. However, if the 4.0-foot SLR scenario occurs, the freeboard will be eliminated altogether, and under an 8.9-foot SRL scenario, the proposed structure would be inundated by almost 5 feet of water on the highest average high tides. Neither of these SLR projections accounts for higher water levels from spring tides or storm surge that occur multiple times per year. Furthermore, inland flooding of properties adjacent to the Middle River due to higher tides from areas on Route 1 beyond the Machias Dyke Bridge would continue unabated. As such, it does not appear that the in-kind replacement is an appropriate design to mitigate impacts of predicted SLR and flooding.

Potential Opportunities and Next Steps

As you may be aware, we have previously worked collaboratively with the Maine DOT on road crossings to improve public infrastructure and restore fish passage and habitat. For example, NOAA contributed significant federal funding for the replacement of two crossings over

Muscongus Brook in Bremen, Maine. The NOAA Restoration Center is also currently engaged with the Maine DOT in an interdisciplinary, interagency team on a feasibility study to raise Route 1 in Woolwich and restore tidal flow to Back River Creek, an important tributary to the lower Kennebec River, in conjunction with a FHWA-funded replacement of the Station 46 Bridge. Both projects underscore the importance of interagency collaboration in order to leverage technical assistance and federal funding to help build safe, resilient infrastructure that supports coastal communities, like Machias.

We would like to continue to work collaboratively to achieve an ecologically sound and climate resilient approach to the replacement of the Machias Dyke Bridge and would strongly encourage the state and federal agencies involved to pursue alternatives beyond an in-kind replacement. We hope to work together to find a solution that improves the resilience of our coastal marine ecosystem, protects and conserves EFH, advances the recovery of endangered Atlantic salmon, and ensures the economic vitality of Downeast Maine.

Sincerely,

Michael Pentony
Regional Administrator

Enclosures (3)

cc. Eva Birk (FHWA)
Joyce Noel Taylor (MDOT)
Patrick Keliher (MDMR)

References

Sweet WV, Kopp RE, Weaver CP, Obeysekera J, Horton RM, Thieler ER, Zervas C. 2017. Global and regional sea level rise scenarios for the United States. National Oceanic and Atmospheric Administration, National Ocean Service. NOAA Technical Report NOS CO-OPS 083. p. 1-56

Enclosure 1

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
GREATER ATLANTIC REGIONAL FISHERIES OFFICE
55 Great Republic Drive
Gloucester, MA 01930-2276

MAY - 8 2018

Michael Wight, P.E.
Senior Project Manager
Maine Department of Transportation
Bridge Program – North Team
16 State House Station
Augusta, Maine 04333-0016

Re: Maine Department of Transportation's preferred alternative for the proposed Machias Dyke Bridge (#2466) project

Dear Mr. Wight:

In April of 2018 you held a public meeting at the University of Maine in Machias to present the details of the Maine Department of Transportation's (DOT) preferred alternative for the replacement of the Route 1 bridge over the Middle River in the town of Machias, Maine. The existing structure is comprised of four box culverts with flap gates that are designed to block tidal flow into the Middle River. In your presentation, you described alternatives ranging from an in-kind replacement to the construction of a 60-foot bridge span. You presented the DOT's preferred alternative as an in-kind replacement of the existing structure. Below, we provide our comments on this alternative.

The Middle River was historically accessible to diadromous fish species, including Atlantic salmon, rainbow smelt, alewife, and blueback herring. In addition, the Middle River estuary supported a functioning saltmarsh ecosystem. The existing structure significantly limits migration of diadromous fish, and inhibits the functioning of the saltmarsh. Your preferred alternative would perpetuate this condition through the installation of flap gates that will provide minimal, if any, fish passage, and will not make any improvements regarding the restoration of tidal flow into the river. The preferred alternative is, in effect, a proposal to reconstruct a dam that will block fish access into the Middle River watershed for the next 75 years.

The Middle River is designated critical habitat for the critically endangered Gulf of Maine Distinct Population Segment of Atlantic salmon, and occurs within the Downeast Coastal Salmon Habitat Recovery Unit (SHRU). Atlantic salmon has been designated as federally endangered under the Endangered Species Act of 1973 (ESA). It is one of the eight species managed by NMFS that are most at risk of extinction in the near future, and as such, is one of the species highlighted in our "Species in the Spotlight: Survive to Thrive" initiative. Addressing the impacts of dams on Atlantic salmon and the ecosystems on which it depends is highlighted in the Species in the Spotlight action plan, the ESA listing determination and recent draft recovery plan.

This project has been specifically identified as a restoration priority within the draft Atlantic salmon recovery plan. As with all dam projects, our expectation is that your project on the Middle River will provide safe, timely, and effective upstream and downstream passage for endangered Atlantic salmon. According to the draft recovery workplan, the restoration objective for the Machisas Dike Dam is to "restore safe and effective passage for diadromous fish at the Machias Dike and at Marks Lake Dam on the Middle River" (USFWS and NMFS 2016). Therefore, we consider passage into the Middle River a restoration priority for our agency.

It is our understanding that this project will be partially funded by the FHWA, and will require permits from the Army Corps of Engineers (ACOE). Section 7(a)(2) of the Endangered Species Act of 1973 (ESA), as amended, requires that federal agencies ensure that any actions they authorize, fund or carry out are not likely to jeopardize the continued existence of any listed species or destroy or adversely modify any designated critical habitat. Furthermore, section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. In other words, it is expected that federal action agencies will go beyond minimizing project effects, and will proactively seek opportunities to contribute to the recovery of listed species.

We are concerned that the preferred alternative, as presented, will not achieve safe, timely, and effective passage for diadromous fish. We look forward to working with DOT and the federal action agencies during the section 7 process to develop minimization measures that will provide adequate fish passage for Atlantic salmon and other diadromous fish. If you have any questions concerning these comments, please contact Dan Tierney (207-866-3755 or Dan.Tierney@noaa.gov).

Sincerely,

Julie Crocker

Julie Crocker
Endangered Fish Recovery Branch Chief

Ec: Cheryl Martin-FHWA
Jay Clement-ACOE
Eric Ham-MDOT
Mark Murray-Brown-NMFS
Max Tritt-NMFS

File Code: Sec 7 technical assistance 2018 – Machias Dike Bridge/Dam

Eric Ham

Maine Department of Transportation

Environmental Office

Re: Machias Dike Bridge (#2466) project

June 30th, 2020

Dear Eric:

The Downeast Atlantic Salmon (*Salmo salar*) Habitat Recovery Unit (DESHRU) Coordination Committee (DCC) has been tasked with developing a 5-Year Work Plan of actions necessary to advance the DESHRU towards delisting criteria identified in the final recovery plan (2019).

DESHRU Work Plans initiated in 2015, identified the dike bridge in Machias as a connectivity threat (D10.1) to Atlantic salmon recovery. Specifically, the following action is identified: "Restore safe and effective passage for diadromous fish at the Machias Dike and at Marks Lake Dam on the Middle River."

Historically, the Middle River was accessible to a wide array of sea-run fish species, including Atlantic Salmon, Rainbow Smelt, Alewife, and Blueback Herring. The existing structure prevents upstream migration of sea-run fish, most notably, the endangered Atlantic Salmon. The lack of safe, timely, and effective passage at this site and its potential to disrupt efforts to recover Atlantic Salmon were recently highlighted by the National Marine Fisheries Service (attachment 1).

Securing fish passage into the Middle River would benefit recovery efforts for Atlantic Salmon in at least four ways. First, the Middle River may provide up to 259 units of rearing habitat for Atlantic Salmon. Opening this habitat would directly contribute to attaining the goal of 30,000 accessible and suitable habitat units in the DESHRU. Second, one of the essential features of critical habitat for Atlantic Salmon are migration corridors that include abundant, diverse native fish communities to serve as a protective buffer against predation. Once fish passage at Marks Lake is established, abundance of Alewives in the Middle River should soon exceed 56,000 adults if targets of 235 adults/acre are realized. Third, the Middle River should once again host a substantial population of Rainbow Smelt once passage is secured. Rainbow Smelt are a key prey item of post-spawn Atlantic Salmon (often referred to as "kelts"). The availability of anadromous Rainbow Smelt partially sustains the viability of this key life stage. Conversely, the broad declines in Rainbow Smelt populations may be partially responsible for the declining occurrence of repeat spawners in Maine's salmon rivers. Lastly, these anadromous species require a fully functioning estuarine ecosystem to maximize their life history requirements and enhancing tidal flow into the Middle River above the dike will help achieve that goal.

The DCC is aware that the current preferred alternative by Maine DOT would maintain the status quo and provide minimal, if any, fish passage, and will not make any improvements regarding the restoration of tidal flow into the Middle River. The preferred alternative is, in effect, a proposal to reconstruct a dam that will block fish access into the Middle River watershed for the next 75 years.

The DCC is keenly interested in working with you to find ways to improve the ecology of the Middle River for the benefit of salmon and their ecosystem. We urge you to consider a different alternative that would provide safe, timely and effective fish passage and we are interested in meeting with you to discuss potential alternatives. Thank you for your interest in helping the DCC preserve, protect and enhance Critical Habitat within the Gulf of Maine Endangered Atlantic Salmon Distinct Population Segment.

DCC Chair:

Ernie Atkinson, Maine Marine Resource – Division of Sea-run Fisheries

DCC Members:

Colby Bruchs, Maine Marine Resource – Division of Sea-run Fisheries

Denise Buckley, USFWS Craig Brook National Fish Hatchery

Scott Craig, USFWS Maine Fish and Wildlife Conservation Office

Rory Saunders, NOAA Fisheries, Maine-Orono Field Station

Enclosure 3

DOWNEAST SHRU SITE-SPECIFIC THREATS AND RECOVERY ACTIONS

SITE SPECIFIC THREATS	SUB-BASIN	WATERSHED	THREAT NUMBER	RECOVERY ACTIVITY	ACTIVITY NUMBER	REPORTING ACTION TEAM	IMPLEMENTING ENTITIES	DATE LISTED	STATUS/DATE COMPLETED	RECOVERY ACTION IN THE RECOVERY PLAN THAT THE ACTIVITY ADDRESSES
The Dennys River stock has much lower return rates than other rivers in the DPS that may be a function of natural or manmade conditions in the freshwater and/or estuary of the Dennys, or me be a function of a loss of genetic fitness within the Dennys River stock.	Dennys River	Dennys River	D1.0	Design and implement study to identify the cause for low return rates for the Dennys River Stock	D1.1	CHAT	NMFS, MEDMR	2015		
The Greatworks Dam, Meddybemps Dam, and Cathance Lake Dam impair habitat quality and impede access of alewives and salmon to habitat resources	Dennys River	Dennys and Cathance	D2.0	Conduct feasibility study of Greatworks Dam in Cathance to improve habitat quality and habitat access for salmon and river herring	D2.1	CAT	NGO's, NMFS, MEDMR, MEDIF&W	2015		
				Review IFIM for the operations of Meddybemps Dam to assure that it accounts for climate change	D2.2	CAT	NMFS	2015		
				Maintain and improve passage at Meddybemps and Cathance Dams to maximize passage efficiency of salmon and alewives	D2.3	CAT	MEDMR, MEDOT	2015		
Curry and Preston Brooks are important sources of cold water to the Dennys River. Road crossings can impair access and water quality within these tributaries.	Dennys River	Curry and Preston Brooks	D3.0	Work with landowners along Curry Brook to identify ways to minimize the impacts of road crossings on water quality and connectivity	D3.1	CAT	NGO's, USFWS	2015		
				Work with landowners along Preston Brook to identify ways to minimize the impacts of road crossings on water quality and connectivity	D3.2	CAT	NGO's, USFWS	2015		
Culverts and remnant dams in the tributaries of the East Machias, particularly Beaver Dam Stream, Chase Mill Stream and Northern Stream, reduce water quality and access to the most abundant and most suitable nursery habitat in the watershed, likely impeding survival of the East Machias stock.	East Machias River	Beaver Dam Stream, Chase Mill Stream, Northern Stream	D4.0	Identify and remove passage barriers in Beaver Dam Stream.	D4.1	CAT	NGO's	2015		
				Identify and remove passage barriers in Chase Mill Stream.	D4.2	CAT	NGO's	2015		
				Identify and remove passage barriers in Northern Streams.	D4.3	CAT	NGO's	2015		
The fishway at Pokey Dam, if not maintained, can impede or block passage to significant alewife spawning and nursery habitats as well as Atlantic salmon resting and nursery habitats	East Machias River	East Machias River	D5.0	Maintain, and if necessary, improve passage at Pokey Dam to maximize passage of salmon and alewives	D5.1	CAT	MEDMR, Crawford Lake Association	2015		
The Gardner Lake Fish Hatchery on Chase Mill Stream may still be leaking some fish from the hatchery that may pose a genetic risk to the East Machias locally adapted stock of Atlantic salmon	East Machias River	Chase Mill Stream	D6.0	Gather genetic samples of parr in Chase Mill stream to look for escapes from the Gardner Lake Hatchery	D6.1	GDAT	MEDMR	2015		
Storm and waste water discharge from the town of East Machias may impair water quality that could affect Atlantic salmon	East Machias River	East Machias River	D7.0	Assure storm and waste water discharge does not impair water quality necessary for salmon survival	D7.1	FWAT	Town of East Machias, USDA, USFWS, NMFS	2015		
The outlet dam at Sabao Lake on the West Branch Machias, Chain Lake dam on Chain Lake Stream, and Wizgig Dam on Old Stream block or impede access to nursery habitats for Atlantic salmon and alewives and affect water quality by reducing stream flow.	Machias River	West Branch Machias, Chain Lake Stream, and Old Stream	D8.0	Remove or improve passage at Sabao Lake Dam, to allow unimpeded passage of salmon and river herring.	D8.1	CAT	NGO's, dam owners	2015		
				Remove or improve passage at Chain Lake Dam, to allow unimpeded passage of salmon and river herring	D8.2	CAT	NGO's, dam owners	2015		
				Remove or improve passage at the Wizgig Dam to allow unimpeded passage of salmon and river herring	D8.3	CAT	NGO's, dam owners	2015		
On 3rd lake stream in the Machias, wing dams were constructed on side channels during the log drive era in an effort to straighten the channel and prevent log jams.	Machias River	3rd Lake Stream	D9.0	Remove wing dams on 3rd lake stream and assess changes to water quality, sediment transport, and habitat use by salmon to determine its value towards salmon recovery.	D9.1	FWAT	DMR, NGO's, land owners	2015		
On the Middle River, the Machias Dike and Marks Lake Dam block access for migratory fish, particularly alewives	Machias River	Middle River	D10.0	Restore safe and effective passage for diadromous fish at the Machias Dike and at Marks Lake Dam on the Middle River	D10.1	CAT	MDOT, NGO's, NMFS	2015		
Access to freshwater habitats and water quality are impaired by culverts, especially in Colonel Brook which has some of the more productive salmon habitats in the Pleasant River	Pleasant River	Colonel Brook	D11.0	Remove or improve passage at culverts and remnant dams, especially in Colonel Brook to improve passage and water quality	D11.1	CAT	NGO’s, Landowners	2015		
The fishway at Saco Falls is in need of maintenance which may impair fish passage	Pleasant River	Pleasant River	D12.0	Make improvements at the Saco Falls fishway to ensure safe and effective passage of salmon and river herring	D12.1	CAT	MEDMR	2015		
Agricultural practices and irrigation may be affecting water quality, water temperature and water quantity in the Pleasant River.	Pleasant River	Pleasant River	D13.0	Assess the effectiveness of the WUMP in protecting the Pleasant from the effects of water withdrawal	D13.1	FWAT	MEDEP, USGS	2015		
The Addison tide gates impairs access to the West Branch Pleasant River and significantly reduces the ecological function of the adjacent salt marsh	Pleasant River	West Branch Pleasant River	D14.0	Remove the Addison Tide gates to restore diadromous fish access to the West Branch Pleasant River and restore the ecological function of the salt marsh	D14.1	CAT	MEDOT, NGO’s	2015		
The Stillwater Dam in Cherryfield delays and sometimes blocks passage of Atlantic salmon, shad and river herring. Passage delays increases opportunities for predation by birds. The dam may also affect water quality and its head pond covers a historically important holding pool for adults.	Narraguagus River	Narraguagus River	D15.0	Conduct a feasibility study/alternatives analysis for the Stillwater Dam	D15.1	CAT	ACOE, USGS, NOAA,, MEDMR, NGO’s, Town of Cherryfield	2015		
				Implement the best fit alternative at the Stillwater Dam that results from the feasibility study	D15.2	CAT	ACOE, USGS, NOAA,, MEDMR, NGO’s, Town of Cherryfield	2015		
The Narraguagus River estuary has deposits of wood chips and saw dust from 19th and early 20th century saw mills that, in areas, is several feet deep. These deposits alter benthic habitats and may alter stream flow and morphology that may affect salmon.	Narraguagus River	Narraguagus River estuary	D16.0	Research the benthic habitats in the Narraguagus estuary and the role that dredging might play in estuary restoration	D16.1	MEAT	NOAA	2015		
Birds observed in the Narraguagus estuary are known to prey on emigrating smolts. Manmade features, such as bridges, piers and dams can give predators a competitve advantage by creating obstructions that slow fish migrations causing fish to congregate, or creating roosting sites that increase opportunities for birds to spot and feed on prey.	Narraguagus River	Narraguagus River estuary	D17.0	Identify and remove artifical barriers or features that increase opportunities for predation.	D17.1	CAT	NGO's, NOAA	2015		
Thermal issues appear to be a problem in the mainstem Narraguagus. This may be a function of clearing of nearby forests for agriculture, irrigation, problems with stream channel morphology, climate change, and remnant dams, dams and culverts that slow down water.	Narraguagus River	Narraguagus River	D18.0	Remove dams, culverts and remnant dams, especially in the upper Narraguagus, Shorey, and Humpback Brook to improve water quality.	D18.1	CAT	NGO’s, MEDMR	2015		
				Assess the effectiveness of the WUMP in protecting the Narraguagus from the effects of water withdrawal	D18.2	FWAT	USFWS, USGS, MEDEP	2015		
				Ensure land managers implement BMP’s that are protective of Atlantic salmon and salmon habitat	D18.3	FWAT	MEDEP, USFWS, Land Managers	2015		
Portions of the Narraguagus appear to be over wide and void of structure including boulders and large wood. Despite abundant glacial erratic’s in the riparian area, there are long stretches of mainstem habitats with very few if any large boulders or large wood features that would help support habitat features that juvenile salmon select for.	Narraguagus River	Narraguagus River	D19.0	Design and Implement a large wood/boulder project in the Narraguagus around Rt. 9 and assess its benefits to fish and water quality	D19.1	FWAT	NGO’s, land managers, MEDMR, USFWS	2015		
The Ellsworth Dam impairs upstream and downstream passage efficiency of adult salmon, smolts, and other diadromous fish, and decreases water quality above the dam. Graham Station does not have an upstream fishway blocking all upstream migratory fish. Current operations block upstream migration of diadromous fish and may delay or block downstream migration of emigrating smolts and other diadromous fish	Union River	Union River	D20.0	Continue to provide fry to the Union River Salmon Association to support stock rebuilding efforts in the Union River	D20.1	CHAT	USFWS, MEDMR	2015		
				Ensure hydro operations at the Ellsworth Dam minimizes harm to Atlantic salmon and adverse effects to their Critical Habitat	D20.2	CAT	NMFS, USFWS, FERC, Hydro-Developers	2015		
				Ensure hydro operations at the Graham Station minimizes harm to Atlantic salmon and adverse effects to their Critical Habitat	D20.3	CAT	NMFS, USFWS, FERC, Hydro-Developers	2015		
				Develop a stock rebuilding and management plan for the Union River	D20.4	CHAT, GDAT	MEDMR, USFWS, NMFS	2015		
Limited resources restrict our ability to evaluate habitats within these areas to check for occupancy and ensure protections of those fish and the habitats that they occupy	Boise Bubert, Chandler River, Grand Manan, Lamoine Coastal, Mt. Desert, Roque Bluff, and Tunk Stream	Boise Bubert, Chandler River, Grand Manan, Lamoine Coastal, Mt. Desert, Roque Bluff, and Tunk Stream	D21.0	Every five years monitor areas that have accessible and suitable habitats where straying might occur to check for occupancy.	D21.1	FWAT	MEDMR	2015		
				In areas with suitable habitats, implement proactive restoration when opportunities arise (e.g. a dam owner willing to remove his/her dam).	D21.2	FWAT, CAT	NGO’s, MEDMR, USFWS, MEDOT, NMFS, Landowners, Municipalities	2015		

APPENDIX 10 - ADJACENT PROJECTS

1. Town Flood Protection & Boat Ramp Project
2. Schoppee Marsh
3. Wastewater Treatment Plant

Town Flood Protection & Boat Ramp Project

Town of Machias, Maine

Waterfront Resilience Study

In Partnership With:

BAKER DESIGN CONSULTANTS
Civil, Marine, & Structural Engineering

RANSOM
Consulting Engineers and Scientists

West Falls Surveying
Machias, Maine

Acknowledgements

The following individuals and groups are thanked for their valuable contributions to the development of this plan:

Leaders

Judy East – Washington County Council of Governments

Christine Therrien – Machias Town Manager

Tora Johnson – University of Maine at Machias GIS Service Center

Key Stakeholders and Advisors

Anne Ball – Maine Development Foundation, Maine Downtown Center

Angela Fochesato – Chair, Machias Downtown Revitalization Committee

Ann Fuchs- State Hazard Mitigation Officer, Maine Emergency Management Agency

Charles Rudelitch – Sunrise County Economic Council

Pete Slovinsky – Maine Geological Survey

Consultant Team

Baker Design Consultants- Daniel Bannon, Barney Baker

Ransom Consulting- Nathan Dill

West Falls Surveying- Andrew Mulholland

This report was prepared for the Town of Machias and was made possible by a matching grant from the Maine Coastal Program with support from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

Contents

Appendicies

Figures

Tables

1. *Executive Summary*

The Machias Downtown Resilience and Renewal Study was made possible by a Maine Coastal Program Community Grant awarded to the Town Machias. The grant enabled the Town to retain a consultant team led by Baker Design Consultants, Inc. (BDC) to investigate and define the risk of flood damage to downtown Machias and to develop a concept engineering design for a flood protection system. On the BDC Team were West Falls Surveying (WFS) and Ransom Consulting (Ransom) who provided topographic survey and flood analysis respectively.

This study has drawn from related work programs undertaken and in progress by the Town of Machias, the Washington County Council of Governments and the University of Maine at Machias GIS Service Center. Refer to the APPENDIX located on page 27.

1.a. Introduction

The catalyst for this study is the periodic flooding that occurs in the historic Machias Downtown Area. The section of the 2017 FEMA Flood Map provided in Figure 1 below shows areas mapped as Special Flood Hazard Areas ([1]SFHAs). One SFHA extends east from the Route 1 Dyke into the Machias Downtown Area. Another isolated SFHA is next to the Machias Waste Water Treatment Plant. These areas and adjacent properties define the area considered for this project.

A separate initiative, in progress by the Maine Department of Transportation, includes design development for rehabilitation or replacement of the Route 1 Dyke with consideration of the Dyke location within the SFHA and tidal flow on the Middle River.

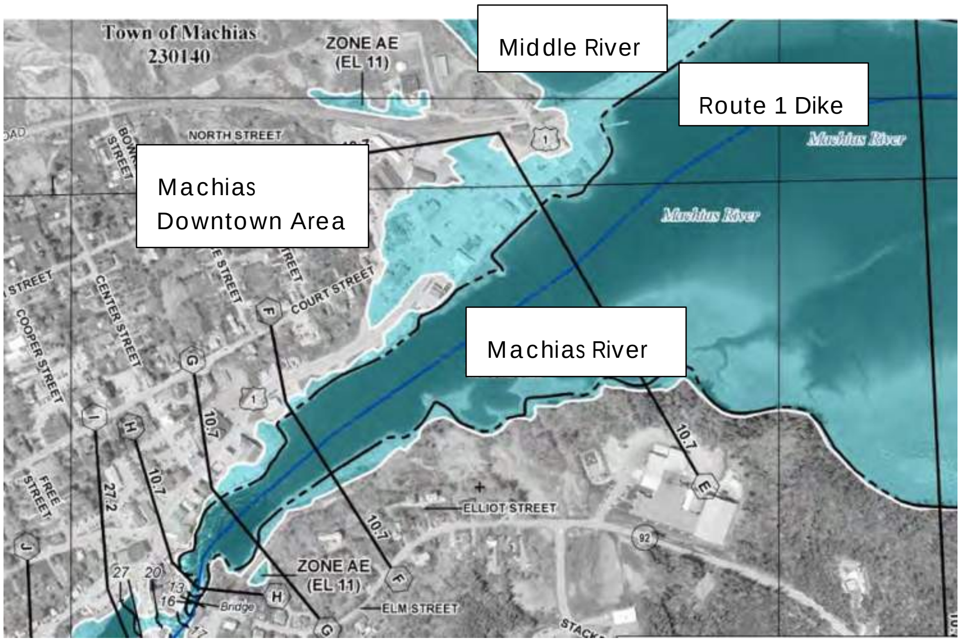

Figure 1 – Down town Machias on 2017 FEMA Flood Insurance Rate Map

[1] Special Flood Hazard Areas are where a flood that exceeds the Base Flood Elevation (BFE) is expected to occur with a probability of 1%. The BFE = 11 NAVD88 for the isolated Zone AE SFHA on the Town WWTP property. The BFE = 10.7 NAVD88 for those downtown area along the Machias River and across the Dyke.

1.b. Work undertaken for this Study

A summary of the concurrent activities that have been undertaken by the Baker Design Consultants Team and stakeholder are summarized below.

- West Falls Surveying (WFS) provided detailed mapping of the Machias downtown area using aerial survey drone technology rectified by and supplemented with detail ground measurements to determine building floor elevations.
- Ransom Consulting (Ransom) completed a flood hazard synopsis that considered current conditions, historical events and future sea level rise modeling to generate probability predictions for future flooding with sea level rise. This work is described in a report that is in *APPENDIX B-Present and Future Flood Risk.*
- The BDC team completed an inventory of buildings and properties in the downtown area in order to evaluate the impacts associated from a variety of flood inundation events that ranged from BFE+0-ft to BFE+6-ft.
- Staff and students from the University of Maine at Machias GIS Department completed a damage assessment modeling for the same series of flood inundation scenarios based on the building inventory, infrastructure and resources impacted by the flooding. This information provides an early cost-benefit indicator for the flood protection system concept design.
- The Washington County Council of Governments provided project management. Stakeholder selection and communication and collected oral history narratives referencing conditions in the Downtown area. Several Public Meetings were scheduled and well attended.
- BDC developed a concept design for a seawall system to protect the Downtown area based on the research, fieldwork and stakeholder input to date. The design is illustrated in drawings that are provided in Appendix E of this report.
- BDC prepared an estimate of construction cost based on the concept design presented in Appendix E. Refer to *Appendix D – Seawall System Program Costs*
- To move the project forward, BDC worked with the Town of Machias, Washington Council of Governments and the Maine Emergency Management Agency to define a Pre-Disaster Mitigation Advance Assistance Program for additional fieldwork and design necessary to move the project forward. Program tasks, costs and timeline are provided in *Section 6-Next Steps to move the Project forward.*

Figure 2 –Historical Development on Machias River looking downstream. Downtown Area is on left of River

Figure 3 –2018 picture looking upstream with remnants of cribwork that supported former docks.

1.c. The need for Flood Protection to the Downtown Area`

Based on the work completed for this study, a seawall system is needed to protect the Machias Downtown Area from flooding and associated property damage.

The Machias Downtown Area is primarily comprised of commercial development and includes the Waste Water Treatment Plant that is considered critical infrastructure. Highway Route 1 runs through this area and is considered the primary regional artery for north-south traffic.

The cost and property impact for single storm events at several flood inundation levels were estimated by staff and students from the University of Maine at Machias GIS Service Center. Inventory information for each property and plans that illustrate the extent of flooding for each inundation event are provided in *APPENDIX C- Flood Impacts to Machias Downtown Property*. It is not surprising that the number of properties impacted, and the cost associated with each storm event increases exponentially as the flood inundation level increases. What is also apparent is the acute reduction in primary road network access to the area that directly impacts fire, rescue and emergency response. Not only will a seawall protection system make the area safer by reducing the risk of flooding, but it will also reduce costs to property owners by effectively eliminating flood damage. With the installation of a Seawall System, the mapped SFHA areas are effectively removed from the FEMA FIRM with a Zone X designation.

Flood scenarios are summarized in the Table 1 below and illustrated in Figures 2 to 6 that follow.

<table>
<tr><th>Flood Event/Elevation</th><th>Total Economic Impact</th><th>No of Buildings Inundated</th><th>Route 1 Status</th><th>Notes</th></tr>
<tr><td>Base Flood</td><td>$ 713,297</td><td>1</td><td>Passable</td><td>Court Street Flooded</td></tr>
<tr><td>Base Flood Plus 2-ft</td><td>$ 7,918,338</td><td>12</td><td rowspan="3">Flooded for Length of Dyke</td><td>Many Buidings surrounded by water</td></tr>
<tr><td>Base Flood Plus 4-ft</td><td>$ 16,889,819</td><td>22 including WWTP</td><td rowspan="2">Significant Risk to Shellfish Habitat</td></tr>
<tr><td>Base Flood Plus 6-ft</td><td>$ 23,699,916</td><td>23 including WWTP</td></tr>
</table>

Table 1 – Building Inundation and Estimated Costs per Flood Event

The Downtown Area topography was mapped using drone technology that resulted in a very detailed survey that allowed for a more accurate determination of the Base Flood boundary and corresponding SFHA areas than currently shown on the 2017 FEMA FIRM (larger light blue area in . Figure 2 below.

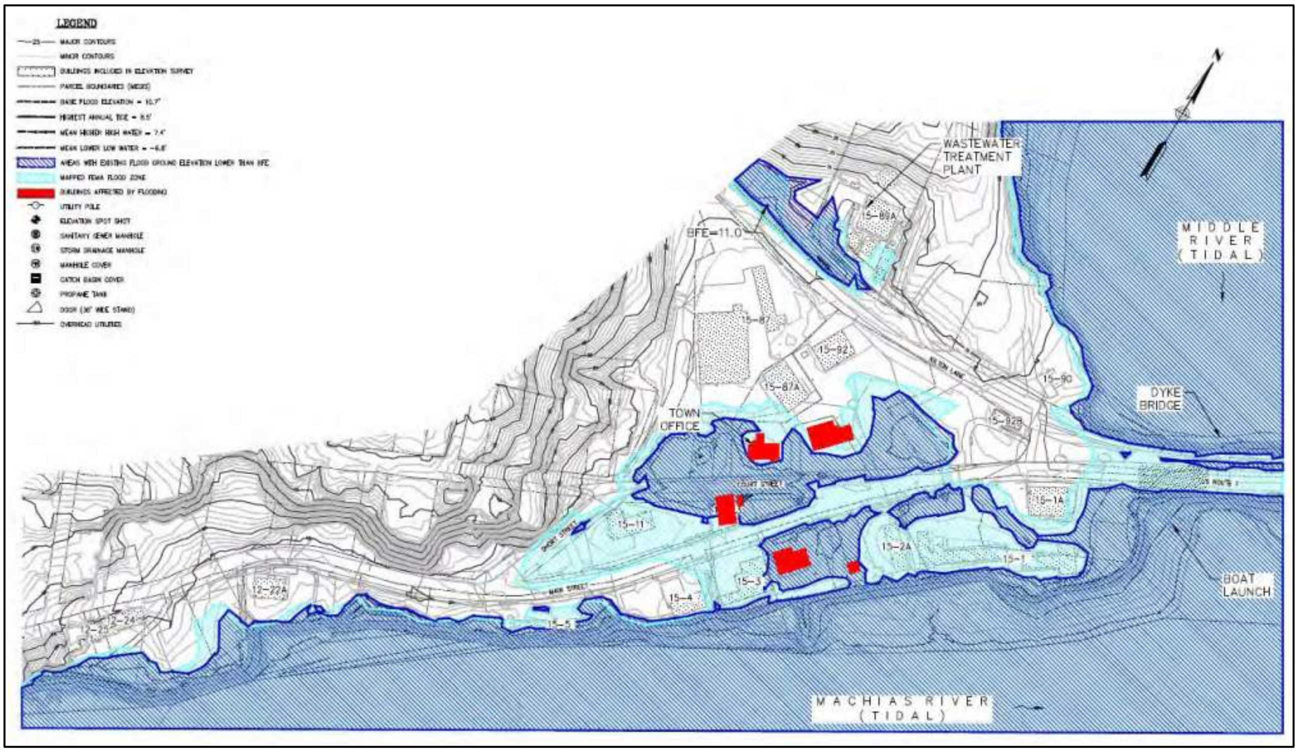

Figure 4 – Mapped SFHA's vs Surveyed Areas above BFE; Building Inundation shown in red.

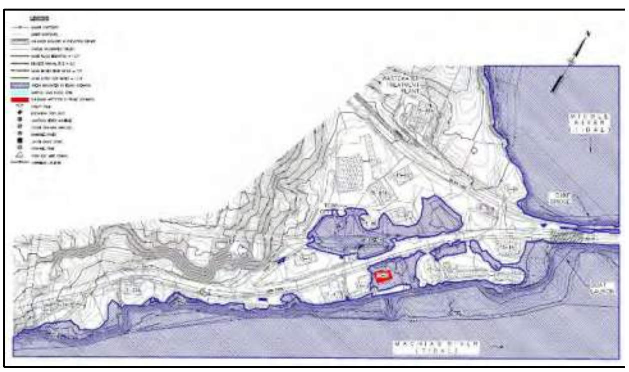

Figure 5 – Effective Base Flood Elevation;

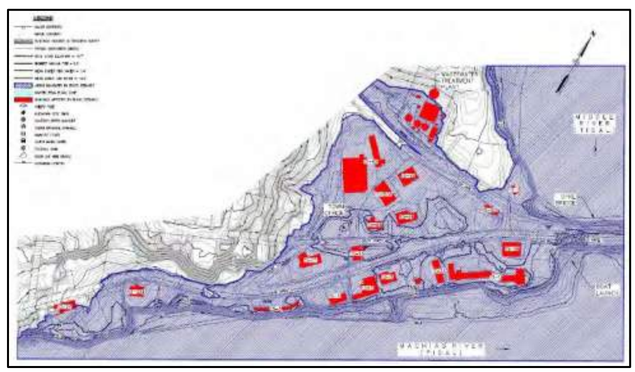

Figure 7 – Base Flood Elevation plus 4-FT

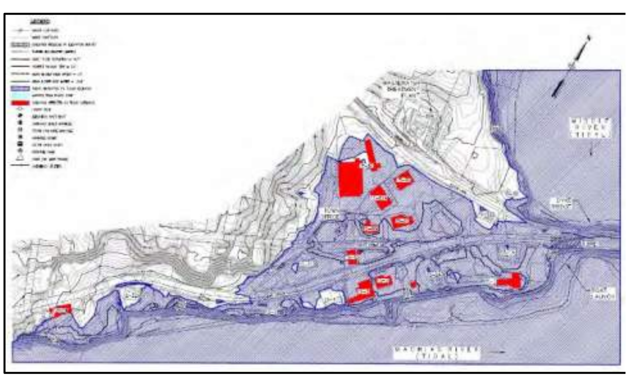

Figure 6 –Base Flood Elevation plus 2-FT

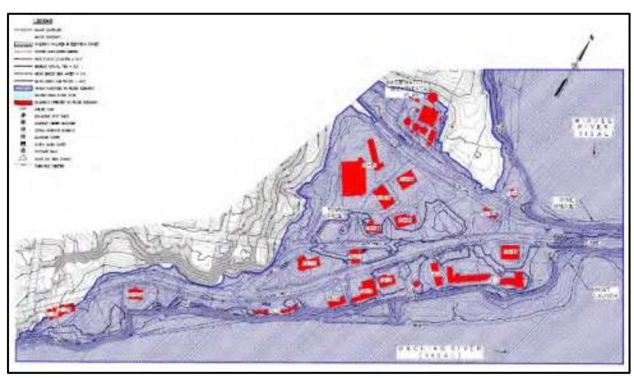

Figure 8 – Base Flood Elevation plus 6-FT

1.a. Recommended Design Height for the Seawall System

The primary goal of the seawall system is to protect property for the life of the structure. The basis for design height selection is discussed in detail in12 *Section 3 Predicting Future Flood Elevations* that starts on page12.

Freeboard and Sea Level Rise (SLR) are used to determine the height of the seawall protection system for Machias. Freeboard is the clearance of the seawall crest above the design flood elevation and is easily determined using standards established by FEMA. However, SLR will affect the future design flood elevation, so it is paramount to include some provision for SLR in determination of the height of the seawall. While existing FEMA determination of Base Flood Elevation is based on historical data, SLR can only be predicted by probability models.

A summary of SLR predictions for Cutler, Maine is tabulated and shown graphically in Figure 2.

Flood Scenario	Flood Elevation (FT, NAVD88)	Description	Sea Level Rise Accommodated* At 2060 (40 yrs)	Sea Level Rise Accommodated* At 2100 (80 yrs)
1	10.7	BFE	---	---
2	12.7	BFE + 2'	Intermediate	Intermediate-Low
3	14.7	BFE + 4'	High	Intermediate
4	16.7	BFE + 6'	Extreme+	Intermediate-High

**SLR scenarios based on NOAA et al. 2017 model for Cutler, ME*

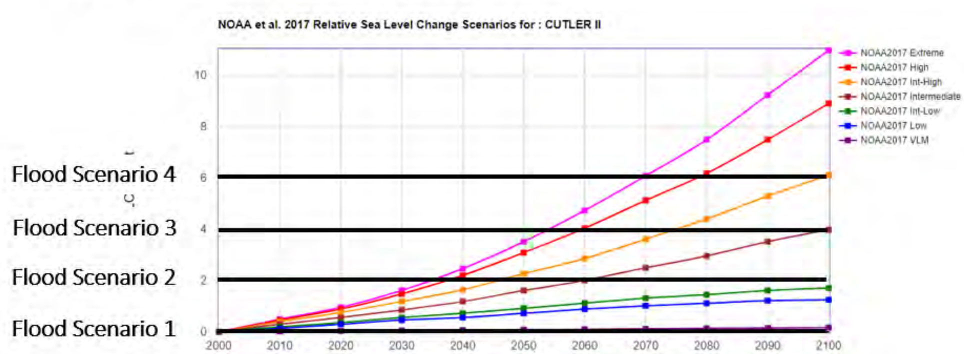

Figure 9 – SLR Predictions for Cutler Tidal Station based on NOAA 2017 Model

The basis for the recommended seawall system design height selected for this study is summarized in Table 2 on the next page with the primary factors being as follows.

- A minimum freeboard[2] of 2-ft is required to maintain a FEMA certification for a seawall shown on the FEMA FIRM maps.
- A minimum freeboard of 3-ft is required to protect the Machias Waste Water Treatment Plant which is considered critical infrastructure in compliance with the New

[2] The minimum 2-ft Freeboard above BFE was selected because the flooding in this area is more influenced by coastal storm surge than riverine conditions.

England Interstate Water Pollution Control Commission TR-16 Guides for the Design of Wastewater Treatment Works.

- If properly constructed, managed and maintained, a flood protection structures will effectively have an indefinite life span. Therefore, the Seawall System design must include provision for Sea Level Rise (SLR) over the life of the structure. A minimum of 2-ft SLR has been applied to the design with the understanding that this is an 'intermediate' model prediction over the next 80 years and with the understanding that the seawall system will include some provisions to increase height during this period if higher increases in SLR occur.
- It is recognized that the lowest cost opportunity to increase future seawall height is to incorporate adaptability features into the seawall system that would allow it to be modified in the future to increase flood protection in a cost-effective manner that did not require total reconstruction. Future height adaptability to accommodate a higher SLR should be considered in final design of the seawall system.

The Concept Design developed for this report was for a seawall system that provides protection in accordance with the Tabulated elevations in Table 2 below. Protection against overtopping is BFE + 4-ft for the entire downtown area with additional protection (BFE+ 5-ft for the WWTP which is considered critical infrastructure. The Seawall System concept design includes provisions to increase the height to maintain recommended freeboard.

Flood Protection	2017 BFE NAVD88	Min criteria for FEMA FIRM Designated Seawall (Levee)		NE Interstate Water Pollution Control Commission TR-16		SLR Allowance (FT)	2020 Design Seawall Ht (Nearest FT)	Future Ht Adaptability	
		BFE Freeboard (FT)	Min Seawall Ht NAVD88	BFE Freeboard (FT)	Min Seawall Ht NAVD88			Increased SLR	Seawall Ht NAVD88
Downtown Buildings	10.7	2	12.7			2	15	2	17
WWTP (Critical Infrastructure)	11			3	14	2	16	2	18

Table 2 – Determination of Seawall Design Height

1.b. Seawall System Design Summary and Cost

The concept design for the seawall system is illustrated in the Appendix E –Seawall System Concept Design Drawings. An overview plan is provided below. The design is discussed in detail in *Section 4 Design Development of the Seawall System.*

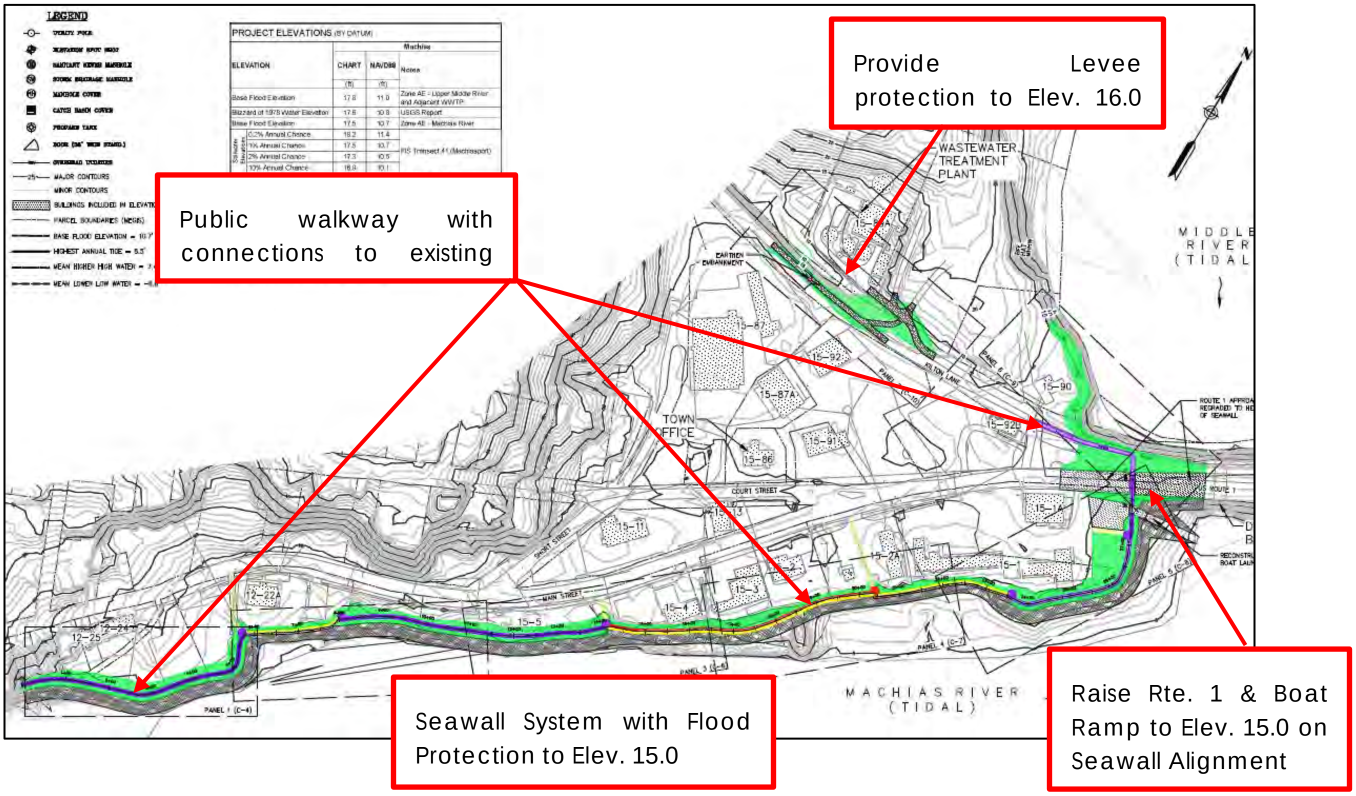

Figure 10 – Machias Downtown Seawall System Overview Plan

Three (3) distinct cross-sections combine to form contiguous elements of a perimeter flood protection system around the downtown area. One section is an earthen embankment, one incorporates a shorefront bulkhead and the third section includes an elevated timber walkway in combination with the bulkhead. In accordance with the Machias Comprehensive Plan, the seawall system is integrated with a pedestrian walkway with links to internal sidewalks within the downtown area and connections to an established and popular trail corridor that is used extensively by Town residents and visitors to the area.

The alignment for the seawall system was selected to minimize impacts to existing upland properties and to address coastal embankment erosion which extends into an intertidal area that has a history of marine development. Today, the remnants of former docks that lined the Machias River are deteriorating exposing the shorefront properties to coastal erosion. The proposed seawall system is intended to stabilize the shore. While stone armoring is used extensively as an effective measure against wave action and river scour, the seawall system is intended to include 'living shoreline' features such as plantings, vegetation and habitat restoration.

The cost for the Seawall system based on the Concept Design Drawings provided in APPENDIX E estimated to be in the range of $11 Million Dollars. Refer to the Construction Cost Estimate provided in *Appendix D – Seawall System Program Costs.*

2. *Background, Purpose, and Need*

The Town of Machias is in Washington County, Maine with a historic downtown waterfront along the Machias River.

The focus of this study is the Downtown Waterfront area which includes low-lying areas on the north/west side of the Machias River downstream of Bad Little Falls, and west of the Middle River, with the Dyke on the Downstream end.

The Downtown Waterfront area has a long and storied history dating back to the 1600's that includes shipbuilding, log driving, and other water-dependent commerce that has relied on connections to the Machias River and the Gulf of Maine downstream. In more recent history, marine traffic has been limited to smaller vessels due to the construction of a fixed bridge downstream in Machiasport in 1971 with limited vertical clearances.

As a transportation corridor, this area is important locally and regionally. US Route 1 (Main Street) passes through the Downtown Waterfront area before it crosses the Dyke and continues into East Machias.

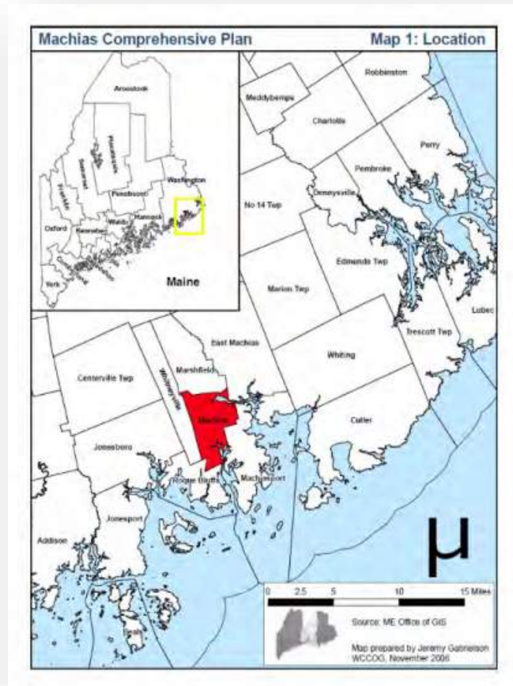

Figure 11 - Location Map of Machias, ME (Source: Town of Machias 2006 Comprehensive Plan)

Today, a range of upland uses are present in the Downtown Waterfront area that includes residential homes, commercial businesses, municipal buildings (the Town Office), and open space. The Town's Shoreland Zoning Map delineates downtown areas as General Development and Maritime, or Commercial Fisheries/ Marine Activities. These zones generally allow dense development with support for water-dependent and traditional maritime uses of the waterfront.

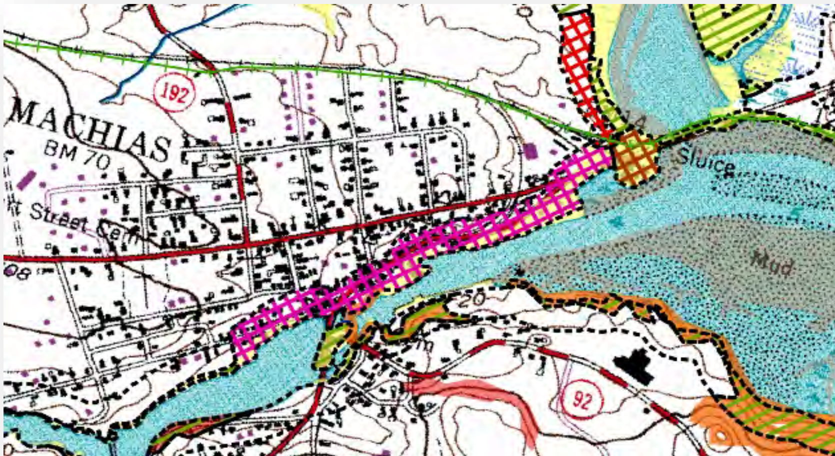

Figure 12 - Section of Machias Zoning Map

The geographical setting and development history of the Downtown Waterfront area each contribute to current flood exposure and an increasing vulnerability that will occur with sea level rise (SLR). **The purpose of this study has been to evaluate current flood stage conditions, model the impact of Sea Level Rise and to identify solutions to improve flood resiliency.** The report considers each of these items in detail and concludes that a **Disaster Mitigation Plan** that includes a flood protection seawall is needed to address flood resiliency for the Downtown Waterfront Area. The outline below provides a summary of the critical findings/components of this plan:

2.a. Flood Risk

Much of the Downtown Waterfront area is located below or only slightly above the Base Flood Elevation (BFE) as established by FEMA. The location of the BFE serves as a benchmark from which to compare historical and recent flooding and defines the regulatory standards for an evaluation of current building compliance within the Town's Floodplain Management Ordinance.

It is recognized that both buildings and non-building infrastructure (roads and utilities) are currently impacted by flooding in the Downtown Waterfront area. The report presents damage estimates for costs that have occurred in recent storm events that approach the BFE and makes projections for costs associated with flooding associated with an increase in Sea Level Rise (SLR).

2.b. Bank Erosion

The immediate shoreline along the Machias Waterfront has been heavily altered during a long history of waterfront development where fill, timber cribs and wharves were used to create upland above tidal wetlands and an armored shorefront along the river. Today, there are sections where structures are deteriorating, resulting in the exposure and erosion of fill material. Stabilization is primarily needed to protect upland property and to reduce migration of fines into the coastal wetland. A secondary goal that goes beyond the scope of this study is to incorporate 'living shoreline' concepts to restore sections of the intertidal resource.

2.c. Stormwater Management

Ineffective stormwater management contributes to flooding issues in Downtown Machias. For example, low area ponding on Court Street in front of the Town Office effectively close that road to access during flood stage conditions.

An inventory of storm drain grate inlets in the Downtown Waterfront area found many to be at elevations only 1'+/- above the highest annual tide which is significantly below the BFE. Clearly, the storm water system needs to be upgraded with improvements that include backflow prevention and storage and/or pumping infrastructure to address flood stage stormwater runoff.

2.d. Critical Infrastructure (WWTP) At Risk of Flooding

The Wastewater Treatment Plant is in the Downtown Waterfront Area and is partially within a FEMA mapped Special Flood Hazard Area. Currently, the facility outfall discharges by gravity when tidal elevations are low, but during normal high water (and flood stage conditions) the outfall must be pumped to prevent back-flow through the system. Clearly, any increase in the duration or height of flooding will put greater stress on the facility.

2.e. Revitalization

The Downtown Waterfront area is ripe for revitalization, and the completion of shoreline stabilization and installation of flood protection structures provides an opportunity to extend an existing coastal trail, to create public spaces on the shore, and to improve waterfront access for recreational and commercial boating. These enhancements would serve to increase public access and interest in a beautiful setting and contribute the transformation into a vibrant downtown.

In summary, this study provides a survey and an assessment of downtown infrastructure to support flood risk and damage projections and considers a new seawall system to protect downtown Machias, along with associated improvements to stormwater and transportation networks.

3. *Predicting Future Flood Elevations*

3.a. Historical Data Review

The Machias River experiences fluctuations in daily and seasonal water level that are influenced by semi-diurnal tides in the Atlantic Ocean, as well as riverine conditions in the 60-mile-long Machias River that originates at Fifth Lake in T36 MD BPP.

Several sources were referenced to establish the range of potential water levels in Downtown Machias, including normal tides, storms of record, and regulatory flood elevations. Additionally, a review of recent storm surge modeling completed by Ransom Consulting Engineers (included in Appendix B) provides a candid review of potential future water levels in consideration of sea level rise, storm surge, and uncertainty with future projections.

In 2011, Maine DOT completed tidal monitoring in the Machias River just downstream of the Dyke as part of a Hydrology and Hydraulic study associated with the replacement of the Dyke Bridge. For this study, the Maine DOT data was used to establish MLLW, MLW, MHW, and MHHW elevations. The total tidal range based on this data is 14.2'.

For comparison, tidal data in Eastport and Machiasport are provided in Table 3, along with predicted tidal elevations using NOAA's online vertical datum transformation tool. The data suggest that the tidal data established by Maine DOT are appropriate.

Table 3 – Tidal Elevations at Machias and Nearby Locations

Location	**Eastport**	**Machiasport, Machias River**	**Machias River Downstream of Dyke**	**Machias River, Downstream of Dike**
Source	**NOAA Tidal Station 8410140**	**NOAA Tidal Station 8411467***	**Maine DOT 2011 Tidal Monitoring**	**Predicted using NOAA VDATUM**
MHHW	9.34	6.44	7.40	6.88
MHW	8.86	6.11	6.50	6.46
NAVD88	0.00	0.00	0.00	0.00
MLW	-9.49	-6.55	-6.40	-6.62
MLLW	-9.93	-6.85	-6.80	-6.93
Tidal Range	19.27	13.29	14.2	13.81

**Subordinate Station of Eastport, Tidal elevations predicted by multiplying values at Eastport by a conversion factor of 0.69.*

The report "Coastal Flood of February 7, 1978 in Maine, Massachusetts, and New Hampshire" published by U.S. Geological Survey lists a water elevation of 10.8' (converted to NAVD88 from the published elevation of 11.51' in NGVD29) observed at the Sears store on Route 1.

FEMA has published a new Flood Insurance Study and corresponding Flood Insurance Rate Maps as of summer 2017. Based on the mapping for the Machias River, the Base Flood Elevation is 10.7'.

Additionally, some of the most severe coastal flooding in recent history occurred during Winter Storm Grayson on January 4, 2018. During this time, the following verified elevations were recorded or predicted at nearby tidal stations on the Maine Coast:

Table 4 – Winter Storm Grayson Water Elevations

Location	Bar Harbor	Cutler	Eastport	Machiasport
Winter Storm Grayson	**9.07**	**11.06**	**13.46**	*10.5 (Estimated from Photographs[3])*
Predicted	7.33	9.33	12.37	8.54
MHHW	5.40	7.01	9.34	6.44
Difference between recorded water elevation and:				
Predicted	1.74	1.73	1.09	1.66 to 1.96
MHHW	3.67	4.05	4.12	*3.76 to 4.06*

Photo evidence from the Machias Downtown area during the storm event, combined with survey data from this study, show the water level to be in the range of 10.5'+/-. Localized conditions may have caused the water level to exceed the Base Flood Elevation. Several photos are shown for reference on the following page.

[3] From the data that was recorded at Bar Harbor and Cutler, and the predictions for Machiasport during the corresponding tide cycle, it can be estimated that the water level in Machias likely reached an elevation in the range of 10.2' – 10.5'.

Typical Conditions | **Winter Storm Grayson, Jan. 4, 2018**

Machias Boat Ramp

Parking Lot Adjacent Machias River Inn

Machias River Redemption

Figure 13 – 1.4.18 Winter Storm Grayson Pictures- Flooding approaches BFE

3.b. Sea Level Rise

In addition to regular tidal fluctuations, storm surge, wave action, and riverine flooding, another potentially significant factor in the future water elevations experienced in Downtown Machias is Sea Level Rise.

The plot below shows projections for Sea Level Rise at the Cutler tidal station based on NOAA's 2017 model. The plot provides a range of scenarios that can be considered, however provides no basis for assessing how likely any of these scenarios is to occur.

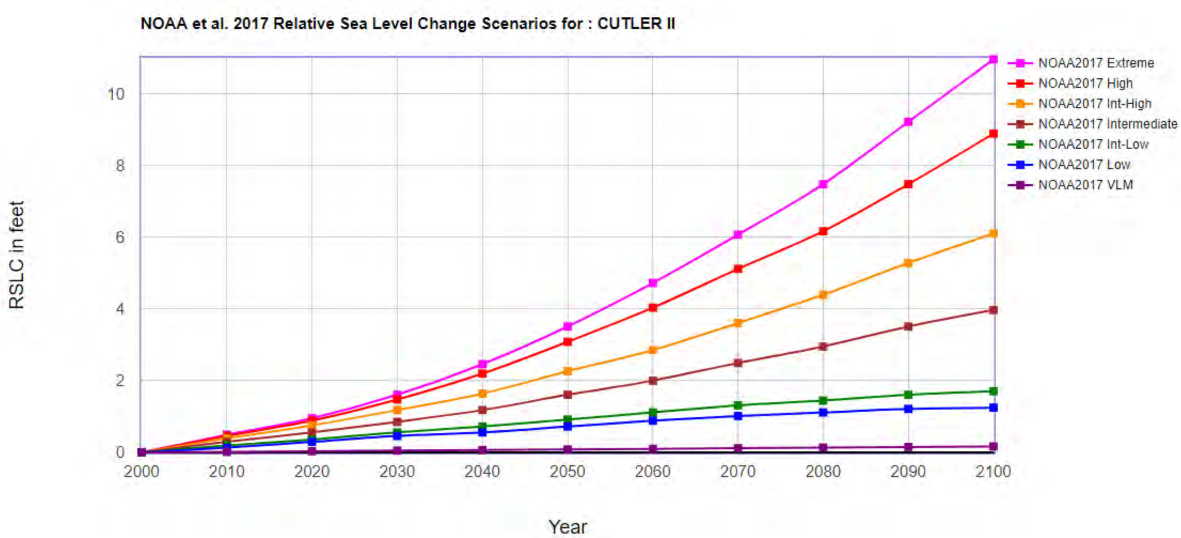

Figure 14 – SLR Predictions for Cutler Tidal Station based on NOAA 2017 Model (produced by BDC using Corps Climate Sea Level Change Curve Calculator)

In order to develop a more detailed understanding of potential future water levels that may be experienced by the Downtown Machias area, a review was completed by Ransom Consulting Engineers. This review considers the complex factors contributing to sea level rise, as well as statistical variability in mean sea level, potential storm surge events, and reasonable levels of uncertainty, to develop projected Total Water Levels at future times and at a range of recurrence intervals. This data is presented in *APPENDIX B-Present and Future Flood Risk.*

3.c. Determining Economic Losses from Future Flood Events

Flood damage assessments are traditionally tied to the BFE mapped by FEMA. The Ransom report provided in *Appendix B – Present and Future Flood Risk Assessment Memo* contains water surface elevations for various recurrence intervals that change by decade to incorporate long-term sea level rise and/or changing storm intensities (e.g., a 100-year recurrence interval has a BFE of 10.7 ft today but the 100-year recurrence interval has a BFE of 12.2 ft in 2050). Therefore, an assessment of future flood damages should consider and increase in BFE. Furthermore, an estimate of the cumulative economic losses that the proposed flood protection structures would protect against throughout their useful life would have two distinct components

- An estimate of the frequency and magnitude of flood events that may occur throughout the lifespan of the flood protection structures
- An estimate of economic losses resulting from these flood events.

TWL in Feet NAVD88		Average Recurrence Interval (years)							
		2	5	10	20	50	100 (BFE)	250	500
Future Year	2020	8.3	9.5	10.1	10.7	11.3	**11.7**	12.3	12.7
	2030	8.8	10.0	10.6	11.2	11.7	**12.1**	12.7	13.1
	2040	9.0	10.3	10.9	11.5	12.1	**12.5**	13.0	13.3
	2050	9.3	10.5	11.2	11.8	12.4	**12.9**	13.4	13.7
	2060	9.5	10.8	11.5	12.1	12.7	**13.2**	13.7	14.0
	2070	9.7	11.1	11.8	12.4	13.1	**13.6**	14.2	14.8
	2080	10.0	11.4	12.1	12.8	13.5	**13.9**	14.7	15.2
	2090	10.2	11.7	12.4	13.1	14.0	**14.5**	15.3	16.1
	2100	10.4	12.0	12.8	13.6	14.4	**15.2**	16.2	17.8
	2110	10.7	12.3	13.2	14.0	15.0	**15.9**	17.4	18.5
	2120	10.9	12.6	13.5	14.4	15.4	**16.4**	17.5	19.4

Scenario1: Flood Elevation = 10.7' (Current BFE)

Scenario 2: Flood Elevation = 12.7' (Current BFE + 2')

Scenario 3: Flood Elevation = 14.7' (Current BFE + 4')

Scenario 4: Flood Elevation = 16.7+A4:J23' (Current BFE + 6')

Table 5 – Future Year Flood Water Levels (Ransom Consulting)

In the Table above, the Ransom report (located in Appendix B) is shaded to coincide with the specific flood scenarios considered for the damage assessment by the University of Maine Machias GIS Service Center. The table provides predicted water levels and average recurrence interval over for future years.

For example: if you consider a Scenario 1 event, this would be a 20 to 50-year ARI in 2020, a 10-20-year ARI in 2030, a 5 to 10-year ARI in 2040-2050, and a 2 to 5 year ARI from 2060-2100. Altogether, this method would predict that you may see anywhere from approximately 12 to 30 Scenario 1 events between 2020 and 2100. A similar approach would result in a prediction of approximately 0 to 6 Scenario 3 events between 2020 and 2100.

The estimation of economic losses becomes more complicated, as you must consider not only the damages that could occur from a single flood event, but also what remedial actions may be taken after that flood event that would alter the potential for future flood damage and economic impact projections. For example, it may be that multiple severe (say, Scenario 3) flood events will occur in the next 100 years, however after the first event of this magnitude many buildings and roads that are substantially damaged would likely (hopefully) be rebuilt in a more resilient manner so the losses from future similar flood events would be lessened. On the other hand, multiple Scenario 1 storms may occur and due to the less severe nature of damages, owners may elect to repair in-kind or not at all, leaving the structures still susceptible to similar damages from future events.

There are several methods that could be used to come up with a cumulative damage estimate that could be used in a Benefit Cost analysis. These are considered beyond the scope of this study and they require more refinement in the construction cost estimate for the seawall system . That said, the comparison of damages for single storm events with the concept design construction estimate would indicate that the Benefit Cost ratio for a seawall protection system is significantly greater than 1.

3.d. Determining Economic Losses from Future Flood Events

Depth damage assessments were developed in collaboration with Dr. Tora Johnson and her students at the University of Maine at Machias GIS Service Center and Laboratory (UMM-GIS). To weigh costs of alternative designs against risks, UMM-GIS gathered best available data on flood impacts and applied best practices for mapping and science communication to estimate potential impacts for a variety of flood scenarios. The approach involved co-production of knowledge, focus on local priorities and vulnerabilities, and scaling maps and economic information to local needs.

UMM-GIS found inundation at the base flood elevation (BFE = 10.7 feet) could cause $700,000 in damage and take two months for recovery with relatively minor ecosystem impacts. The Town had experienced two floods near BFE in recent years. With floods two or more feet above BFE--increasingly likely due to climate change--potential impacts rise dramatically: BFE plus two feet could cost $8 million with six months recovery. BFE plus 4 feet could cost $17 million with 11 months recovery and major impacts on shellfisheries.

Map/Lot		Machias Downtown Building Invento	Property Value	Lowest Floor Elev	Within SFHA ?	Inundation Scenario (Flooding exceeds level indicated)				
						Scenario 1 BFE	BFE+1-ft	Scenario 2 BFE+2-ft	Scenario 3 BFE+4-ft	Scenario 4 BFE+6-ft
12	24	Machias Hardware	$ 95,200.00	11.9	---	No	No	Yes	Yes	Yes
12	25	Barber Shop	$ 24,300.00	16.0	---	No	No	No	No	Yes
15	1A	Helen's Restaurant	$ 727,200.00	13.3	AE 10.7	No	No	No	Yes	Yes
15	2A	Berry Vines	$ 75,800.00	14.0	AE 10.7	No	No	No	Yes	Yes
15	2A	Rivers Edge Drive-In/Shake Pit	$ 75,800.00	11.5	AE 10.7	No	Yes	Yes	Yes	Yes
15	11	Bluebird Restaurant	$ 283,600.00	13.3	AE 10.7	No	No	No	Yes	Yes
15	91	US Cellular, Subway, Etc.	$ 209,000.00	10.9	AE 10.7	No	Yes	Yes	Yes	Yes
15	92	Pellon Center	$ 216,700.00	11.9	---	No	No	Yes	Yes	Yes
15	92B	Machias Bay Chamber of Commerce	$ 15,000.00	13.0	---	No	No	No	Yes	Yes
15	1	Machias River Inn, East	$ 1,171,100.00	12.4	AE 10.7	No	No	Yes	Yes	Yes
15	1	Machias River Inn, West		13.6	AE 10.7	No	No	No	Yes	Yes
15	2	Living Innovations	$ 166,800.00	10.1	AE 10.7	Yes	Yes	Yes	Yes	Yes
12	22A	Bar Harbor Bank & Trust	$ 209,700.00	14.08	---	No	No	No	Yes	Yes
15	3	Wall's Appliance	$ 135,700.00	11.7	AE 10.7	No	No	Yes	Yes	Yes
15	4	Irving*	$ 530,000.00	13.7	---	No	No	No	Yes	Yes
15	13	Skywalker's Bar & Grille	$ 143,000.00	11.0	AE 10.7	No	Yes	Yes	Yes	Yes
15	86	Machias Town Office	$ 134,500.00	11.14	AE 10.7	No	Yes	Yes	Yes	Yes
15	87/87A	EBS Building Supplies, Back		12.0	---	No	No	Yes	Yes	Yes
15	87/87A	EBS Building Supplies, Side	$ 137,900.00	12.1	AE 10.7	No	No	Yes	Yes	Yes
15	87/87A	EBS Building Supplies, Main	$ 416,100.00	12.3	---	No	No	Yes	Yes	Yes
15	5	Machias River Redemption	$ 43,900.00	13.51	AE 10.7	No	No	No	Yes	Yes
15	89	Wastewater Treatment Plant	$ 1,024,800.00	16.0	AE 10.7	No	No	No	No	Yes
15	90	Private Residence	$ 45,000.00	13.4	---	No	No	No	Yes	Yes
15	85	Private Garage 13 Court St	$ 4,500.00	8.1		Yes	Yes	Yes	Yes	Yes
15	84	Private Abandoned 15 Court	$ 14,000.00	10.1		------	------	------	------	------
Notes:			$ 5,899,600.00		14	2	6	13	22	24
	1	All elevations are to NAVD88 Vertical Datum								
	2	LAG - Lowest adjacent finished grade next to building; HAG - Highest adjacent finished grade adjacent to building								
	3	Properties identified as "Mapped within SFHA" based on 2017 FEMA FIRMs for Machias, ME								
	4	Based on Town of Machias Floodplain Management Ordinance, minimum FFE elevation is 1' above BFE for buildings in AE Zone								
		*US Army Corps of Engineers (Table 43) (http://www.mvn.usace.army.mil/Portals/56/docs/PD/Donaldsv-Gulf.pdf)								

Table 6 –Machias Downtown Building Inventory impact by Flood Scenario

4. Design Development of the Seawall System

This section reviews options to provide flood protection to the Machias Downtown Area,

4.a. Flood Protection Options Considered

Coastal flood protection can be accomplished through a variety of techniques that can be summarized in the categories below. Notes on the practicality of incorporating these measures in the Machias Downtown area are provided.

- **Elevate – increase the elevation of flood prone properties and/or buildings in order to reduce their effective flood risk. This will generally involve setting building elevations or finish grades above a reference flood elevation, with some additional accommodation for freeboard.**

  Raising the entire downtown area would require a cost prohibitive full-scale reconstruction of the urban environment with the attendant loss in character and history of the downtown.

- **Floodproof – In-place floodproofing that does not reduce the risk of flooding but reduces the risk of damage associated with flooding.**

  Refer to the flood inundation scenarios depicted in the flood inundation scenarios on page 5, Currently, large sections of the Downtown are within a Special Flood Hazard Area (SFHA). These areas will increase significantly with sea level rise. The ability to flood proof existing buildings and infrastructure is at best, a short-term solution to flood protection.

- **Permanent Flood Protection – Installation of levees or floodwalls that protect from flooding by providing perimeter protection for low-lying areas at risk of flooding.**

  This is the most practical long-term solution. The geographical setting of the downtown favors a perimeter seawall running along the shore to protect landward properties . The seawall will provide flood protection, stabilize an eroding shore and will support a public walkway. Providing flood protection will serve to revitalize the downtown and ensure safe passage along the major Route 1 corridor that runs through the area.

- **Temporary Flood Protection – Installation of temporary flood wall panels and/or dams that can be installed in advance of a severe storm event and removed after the event is complete.**

  It is recommended that a permanent seawall system for Machias include some provisions for increasing the height of protection in the future. The practicality of installing temporary panels needs to be weighed against the manpower requirements, the timing required to put these measures in place and the feasibility of doing the work in winter/freezing conditions.

- **Retreat – abandon a facility or location and relocate to higher ground with less flood risk.**

  Retreat will be necessary if a seawall system is not put into place. Relocation of the history and character of the area would not be possible.

4.b. Design Elevations (for the Project Area

A summary for key elevations that define the project area are included in the Table below. These elevations guide the design of a seawall system by providing flood and tidal parameters and are also used to establish the regulatory limits of the coastal wetland.

ELEVATION		Machias CHART (ft)	Machias NAVD88 (ft)	Notes
Base Flood Elevation		17.8	11.0	Zone AE - Upper Middle River and Adjacent WWTP
Blizzard of 1978 Water Elevation		17.6	10.8	USGS Report
Base Flood Elevation		17.5	10.7	Zone AE - Machias River
Stillwater Elevations	0.2% Annual Chance	18.2	11.4	FIS Transect 41 (Machiasport)
	1% Annual Chance	17.5	10.7	
	2% Annual Chance	17.3	10.5	
	10% Annual Chance	16.9	10.1	
Highest Annual Tide		15.30	8.50	Maine DEP 2018 HAT (Machiasport, Machias River)
MHHW		14.20	7.40	Maine DOT 2011 Tidal Monitoring Data
MHW		13.30	6.50	
NAVD88		6.80	0.00	
MLW		0.40	-6.40	
MLLW		0.00	-6.80	

1. BASE FLOOD INFORMATION TAKEN FROM FEMA FLOOD INSURANCE RATE MAP
2. HIGHEST ANNUAL TIDE TAKEN FROM MAINE DEP PUBLISHED PREDICTIONS
3. TIDAL INFORMATION TAKEN FROM MDOT PUBLISHED DATA

Table 7 – Machias Downtown Elevation Table

4.c. Levee (Seawall System) Design and Accreditation Criteria

The regulations governing the certification of a levee or floodwall by FEMA are contained in 44 CFR 65.10 which includes standards for riverine and coastal conditions. The FEMA mapping for Machias presents flood elevations to the nearest decimal suggesting riverine conditions. However, the features and exposure of the Downtown Waterfront area are more representative of a coastal environment and throughout this study, it is assumed that conditions in Machias are Coastal, and the appropriate conditions apply.

Requirements for certification (for both riverine and coastal) are summarized below:

1. Design Requirements for levees to be recognized by FEMA include the following:
    - o Freeboard
        - ▪ Riverine conditions

          A minimum of 3-ft above the water surface of the base flood with an additional 1-ft within 100-ft of structures or wherever the flow is restricted.

- Coastal Conditions

  No less than the greater of:

  - 1-ft above the 1% wave height
  - 1-ft above the 1% annual chance wave runup
  - 2-ft above the Stillwater surge elevation

- Closures
  - All openings must be provided with closure devices. This includes any penetrations in the seawall system that includes:
    - Drainage, Outfalls, vents.
    - Openings in the seawall system for use during non-flood stage conditions for access or maintenance.
- Embankment Protection
  - Embankment must be designed so that no appreciable erosion of the embankment can be expected during the Base Flood.
- Embankment and Foundation Stability
  - Engineering analysis of embankment and foundation stability must be submitted
- Settlement analysis
  - An engineering assessment is required that assess the potential magnitude of future losses of freeboard as a result of levee settlement.
- Interior drainage
  - An engineering analysis must be completed to size stormwater infrastructure (e.g. drainage lines and pumps) needed to address secondary and cumulative interior flooding that would occur during the design storm event.

2. Operations plans and criteria
   - For a levee system to be accredited by FEMA, a comprehensive Operations Plan is required that includes:
     - flood warning system protocol
     - provisions for levee maintenance, monitoring and management. Current and Future Water Levels
   - The plan must be officially adopted by the operator under the jurisdiction of a federal or state agency (likely to be the Maine Emergency Management Agency).

4.d. Regulatory Review/Permit Requirements

Town, State and Federal regulatory permits will be required for a flood protection system. The lead agencies are listed below together with permit considerations that have been discussed for this project. Moving forward into design development, it will be necessary to continue to engage lead and sub agencies in design development.

Town of Machias

The seawall system, stormwater improvements and public walkway will have a significant impact on downtown property within the General Development and Maritime, or Commercial Fisheries/ Marine Activities Districts and the Shoreland Overlay Districts. As a minimum, the proposed work will require Planning Board approval, a Flood Hazard Development permit and a Shoreland permit. It is anticipated that property owner and stakeholder communication and participation will be a key component of the public and municipal project review process.

Maine Department of Environmental Protection (MeDEP)

MeDEP is the clearing house for all state agencies that are concerned with the impact of the proposed seawall system on the coastal wetland and intertidal area. The work will require a Natural Resource Protection Act (NRPA) permit. A coastal wetland and wildlife assessment will be required. Wetland impacts greater than 500 SF may need to be mitigated at the discretion of the MeDEP. The seawall system outlined in the concept design drawings located in Appendix E does exceed the 500 SF threshold but stays within the area of shoreline that has been previously altered by development.

Separate permits will need to be obtained for new or modified outfalls for the Municipal Stormwater System and the Waste Water Treatment Plant.

Maine Department of Transportation

It is anticipated that the design associated with the Dyke/Route 1 improvements that are currently being considered by the Department will overlap with the Seawall System design to address the need to elevate Route I at the intersection with the seawall system so that flood protection is maintained for the Downtown Area.

US Army Corps of Engineers

A Department of the Army permit will be required for the construction program that develops. The Army Corps of Engineers has federal jurisdiction for any work that extends seaward of the highwater line. All federal agencies (Environmental Protection Agency (EPA), US Fish &Wildlife (USF&W), National Marine Fisheries and the US Coast Guard) will review the proposed development for compliance with federal Standards. Historic Preservation and Tribal Nations will have input.

It is likely that the coastal Wetland impacts will require a Public Hearing to be orchestrated by the Maine Project Office of the Army Corps of Engineers.

A joint review of the proposed seawall system design will likely be undertaken by the Army Corps and FEMA as part of the levee (seawall) certification process to make sure the design follows Federal standards

Federal Emergency Management Agency and Maine Emergency Management Agency

FEMA and MEMA will coordinate the certification review of the seawall system and the Map changes that develop.

4.e. Concept Design Development

Refer to Drawings provided in Appendix E which illustrate the proposed Seawall System, Public walkway, Boat Ramp, Route 1 Corridor Improvements, Stormwater and Outfall provisions and associated impacts to the Downtown area.

The mitigation strategy recommended by the conclusions reached in the assessments listed in #2 is a flood protection structure that will protect the downtown and the wastewater treatment plant from a Base Flood Elevation (BFE)+4 flood event. Advance Assistance is requested to complete additional fieldwork and design development to optimize the project footprint as highlighted at the start of this section. This information will be the basis for discussions with local properties on the need for Right of Way acquisition and will establish the parameters needed to develop a fully engineered design.

The Downtown area that will be protected by the proposed seawall system will benefit from a seawall system that protects current businesses and critical infrastructure (Waste Water Treatment Plant) from current and future flood events. The seawall construction will also address existing coastal erosion associated with sections of unstable shore and will incorporate a public waterfront walkway that will connect with an existing trail network for the enjoyment of the public. The sum of the improvements will serve to increase the economic vitality and interest in the downtown area.

5. *Next Steps to Move the Project Forward*

The next steps needed to move the flood protection project beyond concept design for the Machias Downtown is discussed in this section.

The tasks, timeline and estimated cost for this work is summarized in the Table below and has been used as the basis for a **Pre-Disaster Advance Assistance** grant application to FEMA. Getting the grant maintain the project momentum. With a successful grant award, A Request for Proposals will be issued to obtain the services of a qualified engineering consultant team.

Pre-Disaster Mitigation	Town Contribution			Consultant	Program Cost		Timeline (months)
Cost Breakdown & Timeline by Task	Staff/UMM	Materials	SHIP	Services	Task	Summary	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Project Management						$ 16,300	
Consultant RFP; Grant Monitoring;	$ 1,500				$ 1,500		
Program Coordination/Management	$ 4,800			$ 10,000	$ 14,800		
Field Investigation						$ 60,000	
Coastal Wetland Survey				$ 15,000	$ 15,000		
Geotechnical Investigation				$ 30,000	$ 30,000		
Survey Support				$ 15,000	$ 15,000		
Coastal Protection System Design Development						$138,962	
Concept Design & Alignment Review				$ 10,000	$ 10,000		
Seawall Footprint Assessment/Optimization				$ 10,000	$ 10,000		
Public Walkway Parameters				$ 2,500	$ 2,500		
MDOT Route 1 Coordination				$ 5,000	$ 5,000		
Boat Ramp Design (SHIP Program)	$ 2,160	$ 9,503	$ 66,800	$ 14,000	$ 92,462		
Living Shoreline Opportunities	$ 1,000			$ 3,000	$ 4,000		
Value Engineering and Cost Benefit Analysis				$ 15,000	$ 15,000		
Stormwater/Waste Water Treatment Plant Assessment						$ 15,000	
Existing Network Infrastructure				$ 5,000	$ 5,000		
Pump System & Outfall Location				$ 10,000	$ 10,000		
ROW Acquisition						$ 15,000	
Landowner Outreach/Education				$ 5,000	$ 5,000		
Easement Negotiation				$ 10,000	$ 10,000		
Regulatory Permitting						$ 13,000	
Town of Machias	Permit Fees Waived			$ 3,000	$ 3,000		
Maine DEP				$ 5,000	$ 5,000		
Army Corps of Engineers				$ 5,000	$ 5,000		
Construction Phase Preparation						$ 34,200	
Design Build Documents				$ 31,200	$ 31,200		
2020 FEMA Grant Application				$ 3,000	$ 3,000		
Total	$ 9,460	$ 9,503	$ 66,800	$ 206,700	$ 292,462	$292,462	
	$ 85,762	29%				$ 292,462	

PROJECT FUNDING		
FEMA Pre-Disaster Mitigation Grant	$200,000	
25% Town Match (SHIP Funds)	$ 73,116	$92,462
SHIP Balance	$ 19,347	
Total	$292,462	

NOTES
1. Project Funding dependent on pending Small Harbor Improvement Program (SHIP) grant consideration with MaineDOT.
2. SHIP funding program is 100% funded by the State of Maine with no federal fund support.
3. The Schedule may need to be adjusted once the grant is awarded as it is not practical to complete some elements of field survey work in Maine during snow cover or freezing conditions..
4. Timeline extensions to Task Items indicate built in flexibility to accommodate time delays.
5. Task item costs are based on best available information. Rebalancing with new information is anticipated.

Table 8 – Next Steps Summary- Tasks, Timeline, And Cost

5.a. Field Investigation

Undertake an assessment of environmental impacts associated with the concept design footprint by wetland scientists and wildlife biologists to provide the basis of an environmental assessment. Include an assessment of site opportunities and habitat potential for coastal stabilization using living shoreline techniques.

Complete an investigation of subsurface conditions to obtain the parameters necessary to analyze the quality and depth of native soils, the presence and quality of fill material, subsurface permeability, groundwater infiltration, bearing capacity and settlement to mitigate seawall structure behavior and performance.

Review the presence and extent of historical cribwork structures that were constructed to define the waterfront.

5.b. Coastal Protection System Design Development

Complete seawall and walkway alignment optimization to achieve regulatory requirements for ‘avoidance’ and ‘minimization’ of resource impacts and to support stable embankment construction that addresses existing coastal erosion.

The concept design is based on providing a FEMA certified flood protection structure with an elevation of BFE +4-ft (BFE + 5-ft for the Waste Water Treatment Plant). While fully reasoned and based on detailed topographic survey, predictions for sea level rise and thorough analysis of damage assessments for several flood scenarios, the concept design has been based on limited fieldwork. It is important to take a step back once the fieldwork has been completed to confirm the optimum seawall/levee crest elevations together with a review of the cost benefit analysis that develops with further design.

Prepare Maintenance Plan and Operation Criteria for seawall certification.

5.c. Stormwater/Wastewater System Assessment

Evaluate the existing Stormwater and Waste Water Treatment Facility piping network to determine requirements to upgrade collection, storage and outfall infrastructure with consideration of a perimeter seawall.

Determine the design basis for a pump system to operate in conjunction with the seawall in periods of flooding.

5.d. ROW Acquisition

Review the impact of new construction with local property owners to convey an understanding of the benefits of seawall (flood protection, coastal erosion control, shorefront walkway) .

Continue one-on-one contact with affected landowners,

Identity impacts to property frontage and Right of Way acquisition.

5.e. Regulatory Permitting

Meet with Local, State and Federal regulatory representatives to discuss regulatory permit requirements for the project.

File applications with property owner and stakeholder support.

5.f. Construction Phase Preparation

Prepare Design-Build bid documents and support grant applications for a future construction phase. These documents, together with project permits provide the parameters needed for final design and construction of the seawall system. The Design-Build method of project delivery will allow the successful team to tailor the project to respective equipment and personnel expertise to achieve a certified seawall system.

Appendix A – References

1. Project Documentation
    a. Public Forum Notices/Presentations/Meeting Minutes- APRIL 9, 2018; June 11, 2018; JUNE 27, 2018; September 17, 2018; October 15, 2018
2. Beginning with Habitat Mapping (BWH) -https://www.beginningwithhabitat.org/the_maps/.
    a. Data Sets for Machias Maine
        i. Map2 -Rare, Threatened and Endangered Wildlife, Rare or Exemplary Plants and Natural Communities; Essential Wildlife Habitats; Significant Wildlife Habitats; Atlantic Salmon Spawning/Rearing Habitat: 2018.
        ii. Shape Files- Tidal Marshes.
3. Federal Emergency Management Agency (FEMA).
    a. Code of Federal Regulations
        i. Title 44, Chapter 1, Section 65.10 (44 CFR 65.10); "Mapping of areas protected by levee systems."
    b. Flood Insurance Studies (FIS)
        i. Washington County Maine; Vol 1 of 1; Effective 18Juy 2017.
        ii. Machias Maine- Community Number 230140; 11.18.1988.
    c. Flood Insurance Rate Maps- (FIRMS)
        i. Washington County Maine; PANELS 1627 & 1629 of 2075; Machias Town of- 230140; Version No. 2.2.2.1 Map Nos. 23029C1627E/23029C1629E; Effective 18Juy 2017.
        ii. Town of Machias Maine; Washington County; Community Number 230140; 11.18.1988.
    d. Guidelines, Memorandums and Fact Sheets
        i. Meeting the Criteria for Accrediting Levee Systems on NFIP Flood Maps; How to guide for Floodplain Managers and Engineers; Nov 2008.
        ii. LEVEE MAPPING- COMPLYING WITH 44 CFR 65.10; Oct 2012.
        iii. FEMA Coastal Flood Hazard- ANALYSIS AND MAPPING GUIDELINES; Feb 2005.
4. GROWashington-Aroostook
    a. Climate Vulnerability Assessment for Washington County; University of Maine at Machias GIS Service Center; Washington County Council of Governments; June 2014.
5. Maine Department of Transportation
    a. WIN 16714 Machias Dyke Bridge #2226- Replacement Alternatives
        i. Bridge Inspection Reports.
        ii. Existing Bridge Plans
        iii. Alternatives Matrix

iv. Geotechnical Logs and Grain Size Distribution Curve; BB-MMR-101; BB-MMR-101A; 11.4.2014.

v. Historic Bridge Inventory and Management Plan.

vi. HYDROLOGIC ANALYSES AND ALTERNATIVES EVALUATIONS, DYKE BRIDGE AND STRIDE BRIDGE, MIDDLE RIVER, MACHIAS, MAINE; Stantec; 6.30.2015.

vii. Preliminary Public Meeting; Machias Dyke Bridge #2246 (Route 1 over Middle River).

6. Maine Flood Management Program.
   a. UPDATES TO COASTAL FLOOD INSURANCE RATE MAPS: WHAT A LOCAL OFFICIAL SHOULD KNOW; Presentation by Jennifer Curtis; Sept 2016
7. Maine Geological Survey
   a. A SUMMARY OF CLIMATE CHANGE TRENDS, SEA LEVEL RISE, AND SOME HIGHLIGHTED LOCAL EFFORTS TO ADDRESS VULNERABILITY OF TRANSPORTATION INFRASTRUCTURE; Presentation to Maine DOT; 1.28.2014.
   b. Maine Sea Level Rise Storm Surge Scenarios 2018 -Spatial Datasets; https://mgs-maine.opendata.arcgis.com/datasets/maine-sea-level-rise-storm-surge-scenarios
8. Maine Interagency Climate Adaptation Work Group (MICA)
   a. MAINE PREPARES FOR CLIMATE CHANGE; MICA; Jan2018 Update
9. National Society of Professional Engineers (NSPE)
   a. NSPE Position Statement (No. 07-1771- FEMA Levee Certification; July 2018.
10. New England Interstate Water Pollution Control Commission
    a. TR-16 GUIDES FOR THE DESIGN OF WASTEWATER TREATMENT WORKS; May 2016.
11. NOAA CHART 13326- Machias Bay to Tibbett Narrows.
12. Ransom Consulting
    a. PRELIMINARY FLOOD RATE INSURANCE MAPS INITIAL REVIEW; 24Feb2017; Memo to Town of Machias 24Feb 2017.
    b. MACHIAS FLOOD RESILIENCE STUDY, PRESENT AND FUTURE FLOOD RISK; 24Feb2017; Memo to Baker Design Consultants; 24Sept 2018. Refer to Appendix B.
13. Town of Machias
    a. Machias Downtown and Riverfront Master Plan; Coplon Associates; 7.15.2009.
    b. Town of Machias Shoreland Zoning Map.
    c. Ordinances
       i. Flood Hazard Development Ordinance
       ii. Floodplain Ordinance
       iii. Shoreland Zoning Ordinance.
    d. Olver Associates Inc. Environmental Engineers; Winterport, Maine.
       i. Machias Pollution Control Facility; Town of Machias; Peak Flow Upgrade Project; Oct 2013

1. Sheet C-2 Proposed Site Plan
2. Sheet C-4 Proposed Outfall Sewer Plan
3. Sheet C-7 Sewer Plan and Profile
4. Sheet C-8A Main St (US Route 1) Services & Court St Sanitary Sewer Plan & Profile
5. Sheet C-9 Main St (US Route 1) Sanitary Sewer Abandonment Plan & Profile

ii. East Side Sewer Extension- Phase I; Oct 2013

1. Sheet C-1 Sanitary Sewer Plan & Profile.
2. Sheet C-2 Sanitary Sewer Plan & Profile.

14. US Army Corps of Engineers (ACOE)

a. Machias River Federal Navigation Project

i. Map; MACHIAS RIVER ME; 9.30.1976; Showing limits of FNP.

ii. Narrative Description of Machias River Federal Navigation Project- Author Unknown.

b. Design Manuals

i. EM 1110-2-1913; DESIGN AND CONSTRUCTION OF LEVEES; Engineering and Design; 4.30.2000.

ii. EM 1110-2-2502; RETAINING AND FLOOD WALLS; Engineering and Design; 9.29.1989.

iii. EC 1110-2-6067; USACE PROCESS FOR THE NATIONAL FLOOD INSURANCE PROGRAM (NFIP) LEVEE SSTEM EVALUATION; Engineering and Design; 8.31.2010.

c. Technical Reports

i. CERC-89-15; CRITERIA FOR EVALUATING COASTAL FLOOD PROTECTION STRUCTURES; Dec 1989.

d. Presentations

i. Levee Accreditation for the NFIP; 11.2.2015 15; Presentation with FEMA.

ii. Upcoming Changes for EM 1110-2-1913 Design Construction and Evaluation of Levees; 11.3.2015.

e. Condition Surveys

i. MEMO; RESULTS OF MACHIAS RIVER SURVEY; CENAE-EP-DS(11-2-240a); 5.12.2005.

ii. SHEETS V-1/V-2; MACHIAS RIVER CONDION SURVEY 4-FT CHANNEL; 5.7.2005.

15. US Environ mental Protection Agency (EPA)

a. EPA 817-B-14-006; FLOOD RESLILIENCE- A Basics Guide for Water and Wastewater Utilities; Sept 2014.

16. U.S. Geological Survey

a. COASTAL FLOOD OF FEBRUARY 7, 1978 IN MAINE, MASSACHUSETTS, AND NEW HAMPSHIRE”.

Appendix B – Present and Future Flood Risk Assessment Memo

a. MACHIAS FLOOD RESILIENCE STUDY, PRESENT AND FUTURE FLOOD RISK; 24Feb2017; Memo to Baker Design Consultants; 24Sept 2018