VINAL COVE ALTERNATIVES ANALYSIS

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EXECUTIVE SUMMARY

In 2004, the Town of Vinalhaven replaced the culvert that conveys tidal waters from Vinal Cove beneath Round The Island Road with the assistance of the National Resource Conservation Service (NRCS). Conveyance capacity was increased to restore an area of salt marsh located at the south end of Vinal Cove. Following replacement of the culvert, a section of North Haven Road that crosses the low-lying wetland area has experienced increased frequency of flooding. In addition, the low-lying portion of North Haven Road, which was constructed on organic peat and marine clay, experiences ongoing settling, exacerbating the impacts of flooding.

To evaluate alternatives aimed at reducing flooding and maintaining wetland resources, Woodard & Curran (W&C) performed a hydrologic and hydraulic (H&H) analysis and coordinated a geotechnical investigation of the low-lying portion of North Haven Road. To support the H&H analysis, W&C installed two water level sensors, one on each side of the Vinal Cove culvert, and one barometric pressure sensor to collect water level data over a one-month duration. The collected data was used to develop a hydraulic model using HEC-RAS to simulate the flow through the culvert, the filling and draining of the estuary to the south of the Vinal Cove culvert, and flow under North Haven Road. A projected sea level rise scenario for the year 2080 was also simulated within the model to evaluate hydraulic connections and flooding during typical tidal cycles and extreme tidal events under future conditions.

W&C evaluated the following alternatives:

1. Implement hydraulic restrictions at the Vinal Cove culvert, including
    a. Passive hydraulic restriction
    b. Hydraulic restriction with self-regulating tide gate
2. Reconstruct approximately 550 linear feet of North Haven Road up to minimum elevation 8 to 11 feet NAVD88

W&C recommends implementation of two alternatives in a phased approach to address structural deficiency of North Haven Road, frequent flooding of North Haven Road, and flood protection of additional low-lying road and private property at the southern boundary of Vinal Cove, while maintaining tidal flushing and the restored wetlands. Phase 1 includes reconstruction of North Haven Road to elevation 11 NAVD88 based on the results of the hydraulic analysis ($895,000), and Phase 2 includes replacement of the existing culvert with dual 6-foot by 8-foot culverts with self-regulating tide gates ($765,000).

1. BACKGROUND

Vinal Cove, a salt marsh that experiences regular tidal inundation, is located in the center of the island of Vinalhaven, Maine. In the 1930's, Round The Island Road was built over a section of Vinal Cove. The road construction included a small culvert (size unknown) to allow tidal waters to flow to the southern portion of Vinal Cove. Within this southern portion of Vinal Cove, North Haven Road was also constructed over the salt marsh's western edge. The timeframe for construction of this stretch of North Haven Road is unknown.

Figure 1-1: Vinal Cove Site Location Map

In 2004, dialogue began at Town Meetings concerning the settling of North Haven Road. In October 2004, the Vinal Cove culvert was replaced and North Haven Road was raised. The culvert conveyance capacity was increased to restore an area of salt marsh at the south end of Vinal Cove. As a result, North Haven Road and abutting properties have experienced an increased frequency of flooding events.

The low-lying section of North Haven Road that crosses the wetlands on the western edge of Vinal Cove experiences flooding during monthly spring tides and storm surge events and has been settling due to poor underlying soil conditions. W&C has been contracted to evaluate the structural conditions of the settling section of North Haven Road, the hydraulic capacity of the Vinal Cove culvert, and provide alternatives to mitigate flooding events and further settlement of North Haven Road.

2. PROJECT AREA AND FIELD INVESTIGATION

W&C coordinated survey and geotechnical investigations within the project area to support modeling and the evaluation of alternatives at the Vinal Cove culvert and North Haven Road.

2.1 Existing Project Area

The existing project area consists of two main areas: the Vinal Cove culvert beneath Round The Island Road, and the 550-linear foot section of North Haven Road that is settling on the western edge of Vinal Cove. Round The Island Road is approximately 20 feet wide with two paved vehicular travel lanes lined with granite boulders. As shown in Figure 2-1, rip rap lines the slopes leading down to the 9-foot by 14-foot steel arch culvert that conveys tidal waters beneath Round The Island Road.

Figure 2-1: Vinal Cove Steel Culvert, facing northwest.

To the west of Vinal Cove, North Haven Road is adjacent to the low-lying coastal wetland of Vinal Cove, and prone to flooding as seen in Figure 2-2. North Haven Road is approximately 24 feet wide with two vehicular travel lanes, a steel guardrail on the eastern edge of roadway, and overhead electric utility along the western edge of roadway. A 28-inch reinforced concrete pipe conveys tidal waters beneath North Haven Road. The low point of North Haven Road is at approximately 6 feet, North American Vertical Datum of 1988 (NAVD88).

Figure 2-2: North Haven Road Flooding in December 2022, facing north.

2.2 Survey

W&C subcontracted with Vanasse Hangen Brustlin Inc. (VHB) to provide surveying services associated with the preparation of an existing conditions plan for the approximately 550 linear foot section of North Haven Road that crosses over the wetlands, the Vinal Cove culvert, and the longitudinal profile of the hydraulic connection from the Vinal Cove culvert to the North Haven Road culvert. The survey depicts surface evidence of utilities and site topography. The survey, dated February 2022, is provided in Appendix A.

2.3 Geotechnical Investigation

W&C subcontracted with Summit Geoengineering Services (SGS) to provide explorations and geotechnical engineering services. SGS coordinated an exploration program consisting of test borings, soil laboratory testing, and a geotechnical evaluation of the subsurface findings relative to the settlement and hydraulic capacity of North Haven Road. The geotechnical report, "Geotechnical Report Roadway Evaluation, North Haven Road, Vinalhaven, Maine" dated June 30, 2023, is attached in Appendix B.

SGS completed three test borings along North Haven Road. During the investigation, SGS determined subsurface conditions consisted of bituminous pavement overlying roadway fill to fill overlying marsh deposit to marine deposit.

3. WATER LEVEL DATA COLLECTION

3.1 Water Level Sensor Equipment & Set Up

W&C installed a water level sensor at the upstream (north) and downstream (south) side of the Vinal Cove culvert to collect water level data over a one-month duration from April 14th, 2023, to May 15th, 2023. The equipment used to collect water level data included two Solinst Levelogger5s and one Solinst Barologger5. The Levelogger5s measure the surface water level by recording temperature and absolute pressure at their respective locations. The Barologger5 measurements improve accuracy of the Levelogger5s by recording changes in atmospheric pressure. Atmospheric pressure measured at the Barologger5 is subtracted from the absolute pressure readings at the Levelogger5s to isolate water pressure. To prevent buildup of microorganisms, plants, or algae which could affect the reliability of the Levelogger5s measurements bio-foul screens were attached to both Levelogger5s.

The Levelogger5 on the north side of the culvert was zip tied to a PVC pipe driven into the salt marsh and anchored with a tether line to a cinderblock. Similarly, the Levelogger5 at the south side of the culvert was zip tied to a steel rod driven into the salt marsh and anchored with a tether line to a nearby boulder. The Barologger5 was placed within 500 feet of the two deployed Levelogger5s to record atmospheric pressures. To maximize submersion and data collection during the one-month period, the Levelogger5s were set up during low tide. The elevation of each sensor was recorded using a known elevation from the survey performed by VHB as a benchmark.

Figure 3-1: Levelogger5 North (Submerged) and South Set Up

4. HYDRAULIC MODELING

4.1 Modeling Approach

W&C developed a hydraulic model of the existing system using the Army Corps of Engineers (ACOE) Hydraulic Engineering Center River Analysis System (HEC-RAS) software, version 6.3.1. This software was selected because it is the industry standard for analyzing open channel flow and hydraulic structures, such as culverts. It was also chosen for its unsteady 2D flow capability, which better represents flow over the ground surface, automatically accounts for volume exchange, and facilitates the production of high-quality maps.

4.2 Model Development

The data sources used to develop the hydraulic model domain are summarized in Table 4-1 below:

Table 4-1: Model Data Sources

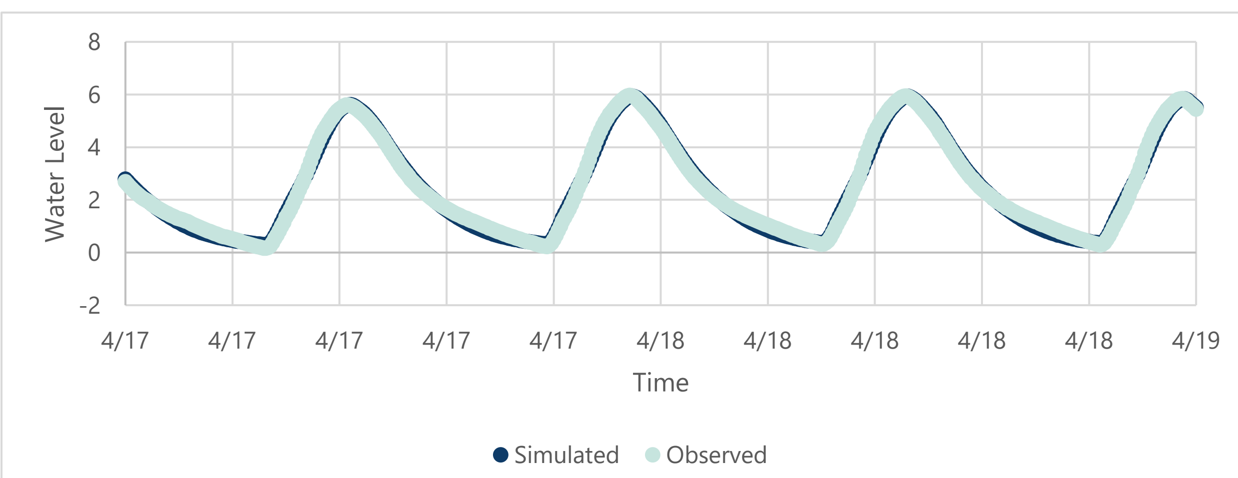
Data Type	Data Source
Elevation	USGS LiDAR compiled in 2021; Survey data collected in 2022.
Hydraulic Structures	Survey data collected in 2022.
Land Cover	USGS NLCD compiled in 2019.

Infiltration and evaporation losses were assumed to be negligible volumes compared to the tidal exchange volume, particularly during extreme events.

4.3 Calibration

The hydraulic model was calibrated against water level data collected from the project site as described in Section 3. Culvert characteristics, including primarily roughness, were adjusted until simulated results matched the observed data on the south side of the culvert over the course of the data collection period. An example is shown below in Figure 4-1.

Figure 4-1: Sample Calibration Plot

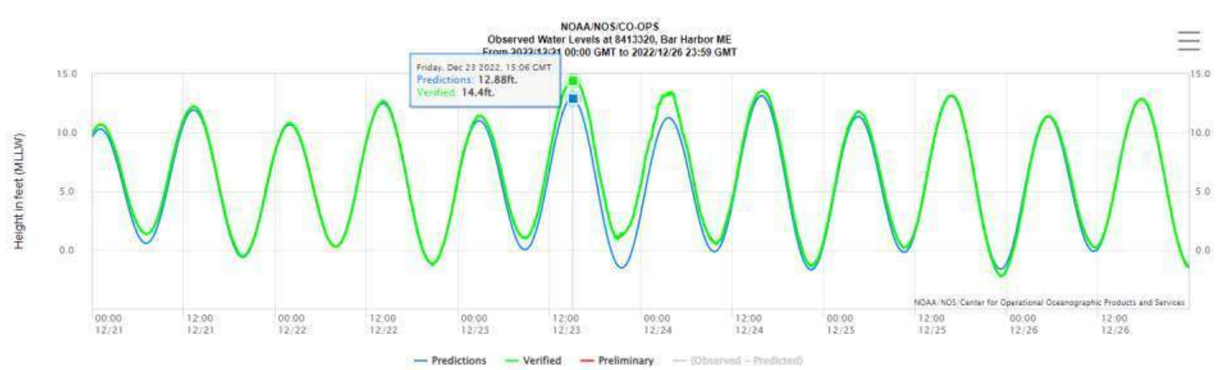


4.4 Validation

A simulation was performed using the observed high-water conditions at the tide gage in Bar Harbor (NOAA Station 8413320) during the storm event that occurred on December 23, 2022. As shown in Figure 4-2 below, there was approximately 1.5 feet of storm surge produced by low atmospheric pressure and wind wave induced water level increase (wave setup).

Water level data obtained from the Bar Harbor tide gage was adjusted by -0.4 ft based on the average difference between Bar Harbor high water level data and high-water levels recorded at the site and then applied as a boundary condition to the existing conditions model. The maximum water level produced by the simulation at the low point in North Haven Road was 8.1 ft NAVD88, which correlates well with the elevation observed by Sea Level Rise Committee members on December 23, 2022 (photographed in Figure 2-2) of approximately 8 ft NAVD88.

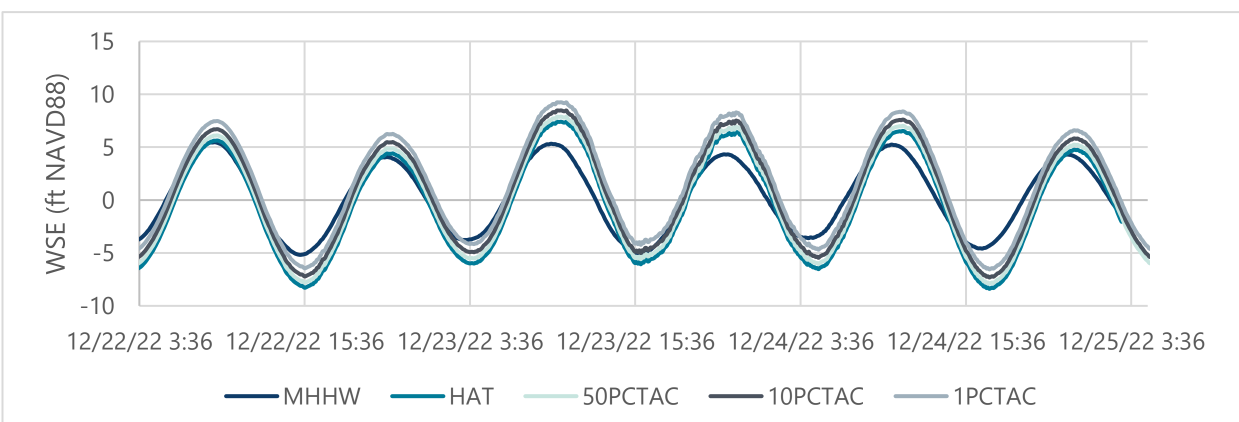
Figure 4-2: December 2022 Storm Event



4.5 Existing Conditions & 2080 (Intermediate) Sea Level Rise – Event Simulations

W&C mapped five different water level scenarios for present day conditions and conditions during a 2080 (Intermediate) Sea Level Rise scenario as published by the NOAA/NASA Interagency Sea Level Rise Scenario

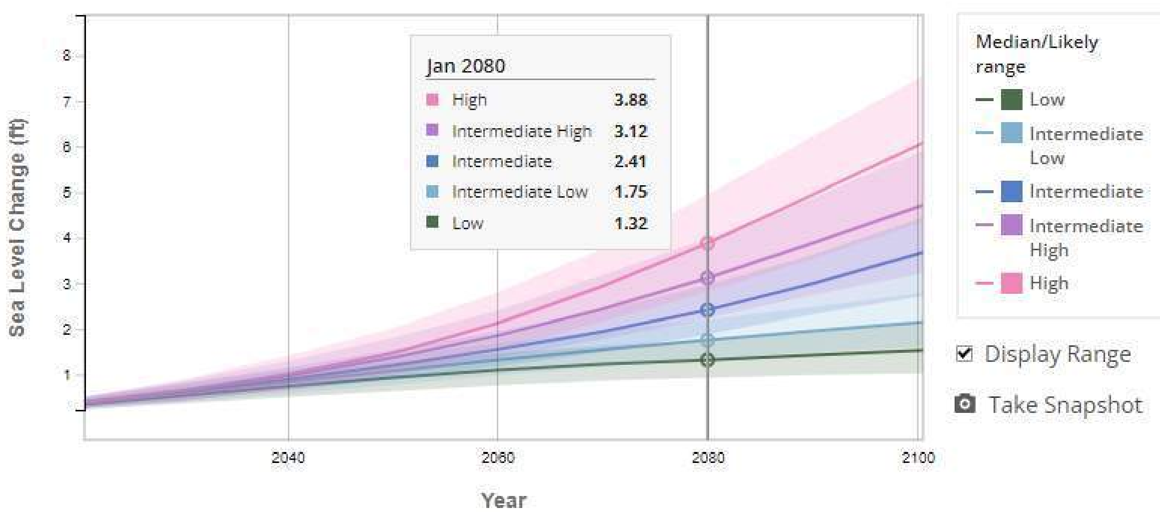
Figure 4-3: Simulation Event Timeseries



Tool. These five different water levels include: MHHW (Mean Higher High Water), Highest Astronomical Tide (HAT), 50% Annual Chance Storm, 10% Annual Chance Storm, and 1% Annual Chance Storm.

The 2080 (Intermediate) Sea Level Rise scenario (+2.41 feet) was selected as an applicable scenario for the model based on the assumption that the future emissions scenario will fall between the high and low ranges for predicted sea level change. The Intermediate Sea Level Rise scenario for 2080 is depicted below in Figure 4-4 with associated low to high median/likely ranges for sea level change (ft) in Bar Harbor, Maine (NOAA Station 8413320). The low to high ranges of sea level change are aligned with emissions based, conditional probabilistic scenarios and global model projections.

Figure 4-4: NASA/NOAA 2080 Intermediate Sea Level Rise Scenario



4.6 Results

Simulation results for existing conditions during each return period scenario for both present day and projected 2080 conditions are summarized in Table 4-2. Figures showing the extent of inundation for these events are included in Appendix B.

Table 4-2: Water Surface Elevation (ft NAVD88) South of Round The Island Road (Road El = 6)

Event	Present Day	2080
MHHW[1]	5.20	7.30
HAT	6.75	8.83
50% Annual Chance	7.17	9.28
10% Annual Chance	7.70	9.81
1% Annual Chance	8.36	10.50

A peak water surface elevation is informative but does not give a sense of how long the road would be impassable in each scenario. To better illustrate the impact flooding has on access, Woodard & Curran calculated the duration of flooding greater than 6 inches during each 72-hour simulation. Figure 4-5 depicts the number of hours each location is flooded over 6 inches during the 1 percent annual chance event as an example.

Figure 4-5: Example Inundation Duration Map

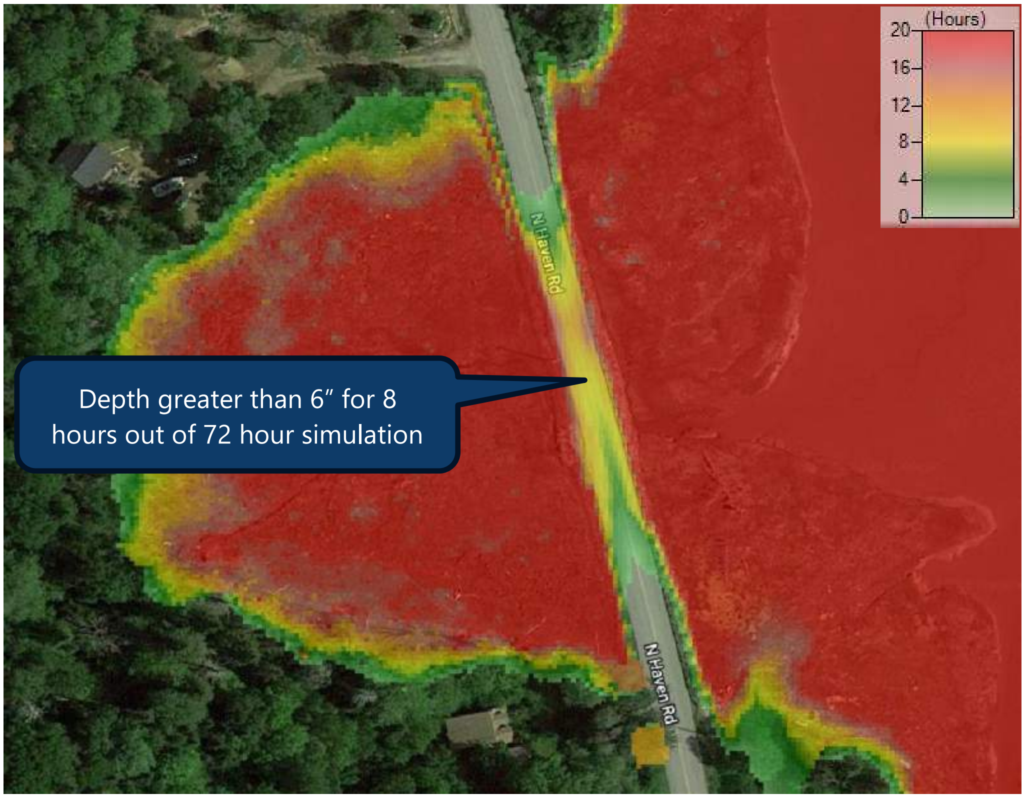


Table 4-3 summarizes the inundation durations for present day and 2080 projections for each of the simulation scenarios.

Table 4-3: North Haven Road Inundation Duration (Hours exceeding 6-inch depth per 72-hour simulation)

Event	Present Day	2080
MHHW[1]	0	6.25
HAT	1.0	11.5
50% Annual Chance	1.5	16.0
10% Annual Chance	4.2	20.0
1% Annual Chance	8.0	24.5

At the current road elevation, the duration of flooding increases substantially in the Intermediate 2080 sea level rise scenario for all events, but notably would be impassable for multiple hours during MHHW tides, which occur on average half of the days in the year.

5. DESIGN ALTERNATIVES

Using the field survey, geotechnical evaluations, hydraulic analysis and gathered information, W&C evaluated the feasibility and effectiveness of the following alternatives to address flooding and settlement of North Haven Road:

- Culvert Alternatives: Implement hydraulic restrictions at the Vinal Cove culvert by one of the following:
  - Passive hydraulic restriction
  - Hydraulic restriction with self-regulating tide gate
- Roadway Alternatives: Reconstruct approximately 550 linear feet of North Haven Road to a minimum elevation 8 to 11 feet NAVD88

5.1 Culvert Alternatives

5.1.1 Culvert Hydraulic Restriction

5.1.2 Passive Hydraulic Restriction

Passive hydraulic restriction alternatives include replacing the existing corrugated metal arch culvert with a rectangular precast concrete culvert of the following dimensions:

1. Culvert Alternative 1 - 6 feet by 6 feet
2. Culvert Alternative 2- 8 feet by 8 feet
3. Culvert Alternative 3 - Dual 8 feet high by 6 feet wide (intended to stay within the footprint of the existing culvert)

5.1.3 Hydraulic Restriction with Tide Gate

Hydraulic restriction alternatives including tide control consist of replacing the existing corrugated metal arch culvert with a rectangular precast concrete culvert with dimensions indicated in the previous section, including a water level activated closing gate. The intent of these alternatives is to allow regular tidal flushing during normal tidal scenarios to maintain ecological functions and values while providing a mechanism to close the gate once a certain water level is reached for protection of the low-lying portion of North Haven Road.

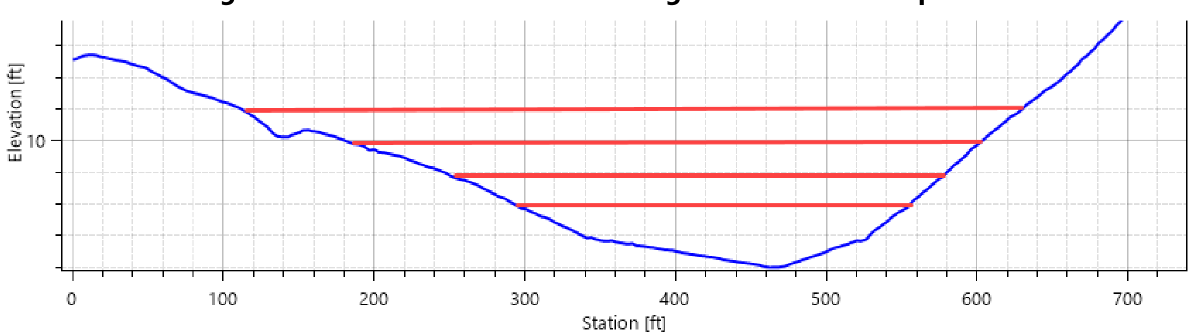
Only gates that do not require manual activation were considered, with the most suitable being side-hinged, passive hydraulic activated gate. This style gate is closed by hydraulic pressure once the tide surpasses a design elevation, releasing a mechanical switch. An example of this configuration is shown in Figure 5-1.

Figure 5-1: Side-Hinged, Passive Hydraulic Activated Gate

5.2 Reconstruction of North Haven Road Alternatives

North Haven Roadway alternatives consisting of reconstructing North Haven Road are intended to raise the elevation and stabilize the condition of the road. Rebuilding at an increased elevation will provide greater resilience, with the ultimate level of service dependent on the selected alternative at the Round The Island Road culvert crossing. Finished roadway grade elevations from 8 to 11 NAVD88 were evaluated. Figure 5-2 shows the existing profile of North Haven Road with conceptual fill elevations of 8, 9, 10, and 11 feet identified.

Figure 5-2: North Haven Road Existing Profile with Conceptual Fill



SGS recommended the following options to raise the grade of the roadway:

Option 1 - Construct road and allow settlement to occur with regrading and shimming prior to paving

Option 2 - Incorporate lightweight fill to reduce weight and associated total settlement

Option 3 - Incorporate ground improvement to include soil stiffness and reduce total settlement

Option 1, traditional fill placement with a preload period 6-12 months prior to placement of pavement is recommended over Options 2 or 3, which both have greater construction complexity, cost and potential failure due to excessive settling. SGS recommended approach for roadway fill includes bituminous pavement, base gravels, subbase gravels and gravel borrow or crushed stone for any additional fill necessary to raise the roadway. Additionally, a rock armor system is recommended along the embankment fill for stabilization.

Table 5-1 summarizes the length and fill depths associated with each roadway elevation. Any roadway filling project will likely result in additional settlement of the roadway as subsurface organic materials continue to compress. SGS estimated that 5 feet of fill over the existing roadway would cause +/- 2 inches of immediate settlement during construction, +/- 17 inches of consolidation settlement during 3-12 months of construction, and +/- 8 inches of secondary settlement 25 years after construction. In light of geotechnical findings, the majority of settlement will occur within the first twelve months after construction, therefore, all filling alternatives assume a temporary road surface for the first twelve months, followed by placement of additional material to reach design grade and final paving.

Table 5-1: Roadway Surface Elevation Length and Fill Depths

Road Surface Elevation (ft NAVD88)	Length (ft)	Max fill depth (ft)	Average fill depth (ft)
8	335	2	1.5
9	400	3	2.25
10	475	4	3
11	575	5	3.75

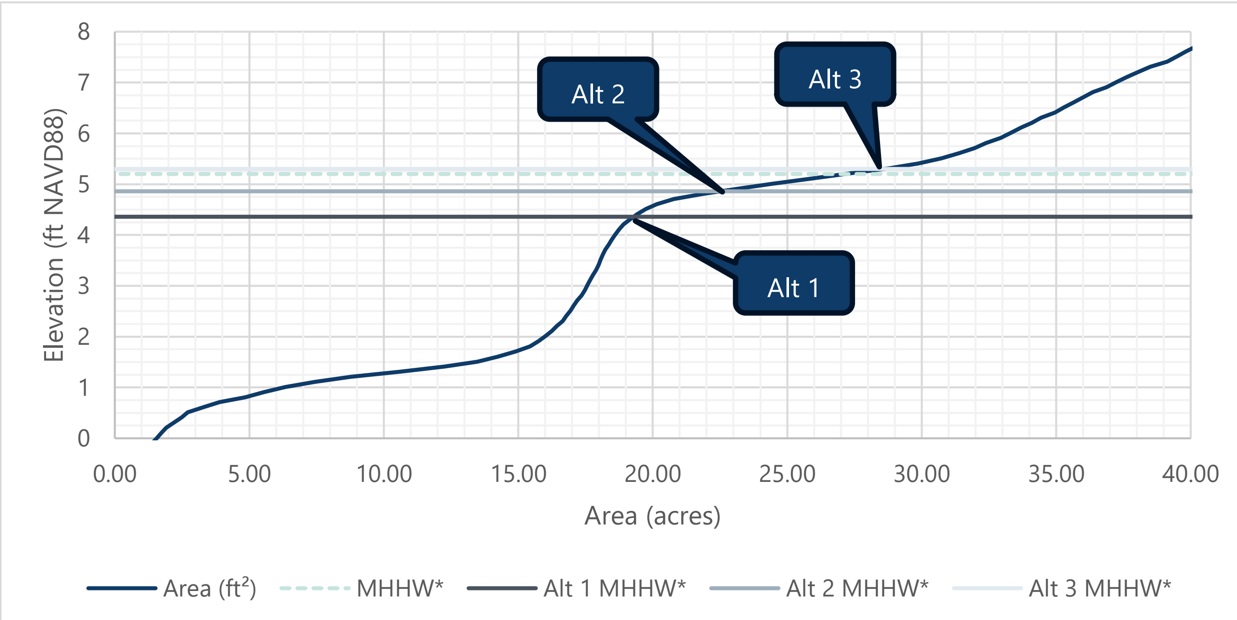
Conceptual drawings of the evaluated alternatives are included in Appendix D.

5.3 Summary of Alternatives Analysis Results

5.3.1 Ecological Considerations

Each culvert alternative was analyzed by using the observed water levels on the north side of the Vinal Cove culvert as the simulation boundary condition, calculating the water surface elevation on the south side of the road. The Mean Higher High Water (MHHW) level during the 30-day simulation was then calculated by finding the average of the higher of the high water levels occurring on days with two high tides. For the purpose of this analysis, no tide gate influence was assumed. A curve representing the land area at each elevation was developed, and change in land area at the MHHW for each alternative was used as a proxy for potential wetland impacts of each alternative. Figure 5-3 shows the elevation-area curve and the MHHW for existing conditions and each culvert alternative.

Figure 5-3: MHHW Elevation Area Curves



* - MHHW calculated in the project area is based on 30 days of site-specific data collected for this study and may differ from NOAA published MHHW data, which is based on interpolation of analysis of remote tide gauges over a 19-year tidal epoch. A site-specific measure is required for comparison of alternatives.

Table 5-2 summarizes the potential wetland impacts for each alternative.

Table 5-2: Potential Wetland Impacts

	MHHW* Elevation (NAVD88)	Approximate Wetland Area at MHHW* (acres)	Approximate Wetland Area Change (acres)
Existing Conditions	5.20	27.5	--
Culvert Alternative 1	4.36	19.25	-8.25
Culvert Alternative 2	4.86	22.5	-5.0
Culvert Alternative 3	5.30	28.75	+1.25

5.3.2 Flooding Considerations

Peak water surface elevations for the three culvert alternatives are summarized in Table 5-3 below. Elevations represent the peak water surface for each culvert alternative without the installation of a tide gate.

Table 5-3: Peak Water Surface Elevations

Water Surface Elevation				
Event	Existing Conditions	Culvert Alternative 1 (6′x6′)	Culvert Alternative 2 (8′x8′)	Culvert Alternative 3 (2x6′x8′)
MHHW	5.20	4.36	4.86	5.30
HAT	6.75	5.33	6.20	6.90
50% Annual Chance	7.17	5.66	6.58	7.35
10% Annual Chance	7.70	6.06	7.09	7.89
1% Annual Chance	8.36	6.55	7.70	8.57

Installation of a tide gate would control the peak water surface elevation in Vinal Cove at virtually any desired value by setting the hydraulic control to close the gate when the water surface exceeds the design elevation, which should initially be set to elevation 6 with opportunities to modify the elevation in the future.

5.3.3 Conceptual Cost Estimates

W&C prepared a conceptual-level opinion of probable project cost for each of the culvert alternatives and North Haven Road reconstruction to elevations 8 to 11 NAVD88 in Table 5-4 below. Consistent with findings of the geotechnical analysis, North Haven Road Reconstruction includes cost for additional material to be placed after initial settlement has occurred, approximately one year after completion of construction. Estimated project costs include construction cost, design, permitting, and construction administration cost (25% of construction) and contingency (30% of construction).

Table 5-4: Conceptual Opinion of Probable Project Costs

Culvert Alternatives	
Alternative 1: 6′x6′ Box Culvert with Side Hinged Passive Hydraulic Gate	$455,000
Alternative 2: 8′x8′ Box Culvert with Side Hinged Passive Hydraulic Gate	$540,000
Alternative 3: (2) 6′x8′ Box Culverts with Side Hinged Passive Hydraulic Gate	$820,000
North Haven Road Reconstruction Alternatives	
Road Elevation: 8′	$390,000 (including $40,000 for regrading post construction)
Road Elevation: 9′	$540,000 (including $50,000 for regrading post construction)
Road Elevation: 10′	$725,000 (including $65,000 for regrading post construction)
Road Elevation: 11′	$950,000 (including $80,000 for regrading post construction)

Additional detail on project cost estimates is included in Appendix E.

6. RECOMMENDATIONS

6.1 Recommended Alternatives

Based on the geotechnical investigation findings and alternatives analysis, Woodard & Curran recommends a phased approach to stabilize the North Haven Road, improve resilience by maintaining emergency access, and protecting additional public road infrastructure and private property at the southern boundary of Vinal Cove. Phases are described below.

1. **Phase 1 – Reconstruction of North Haven Road to elevation of 11 NAVD88 ($950,000):** This alternative prevents further settlement and flooding at North Haven Road, providing a 1% annual chance level of service during the present-day and 2080 projection at the roadway. Based on geotechnical findings and the documented settling of the road, the existing road will continue to settle and deteriorate over time, emphasizing the importance of reconstruction, independent of flooding concerns. Reconstructing at elevation 11 NAVD88 will address both the structural and flooding concerns associated with the road.

2. **Phase 2 – Culvert Replacement Alternative 3 – Dual 6′x8′ box conduits with self-regulating tide gates ($820,000):** Replacement of the existing Round The Island Road culvert with a smaller culvert as identified Culvert Alternatives 1 and 2 is not recommended due to potential reduction of tidal marshland area. Alternative 3 is recommended to provide protection to additional low-lying portions of North Haven Road and private properties at the southern boundary of Vinal Cove.

The proposed phased project approach addresses the highest priority first by establishing resilient emergency access and addressing the structural deficiency of the road. Phase 2 adds flexibility through the implementation of an innovative measure that allows tidal flushing to maintain the function and value of the restored wetland and provides additional flood protection beyond the reconstructed section of North Haven Road. Proceeding with two projects rather than one large project may make additional funding opportunities available to the Town.

6.2 Statement of Assumptions

W&C does not make any warranties, express or implied, or representations of likelihood of any specific outcomes, forecast/s or the likelihood or unlikelihood of any future events or outcomes. This work is based on assumptions that are likely subject to change as they are inherently dynamic and variable over time. To the extent that any information provided herein might be considered forward-looking in nature, it is subject to unknown variables, risks, and uncertainties. The analysis provided may be carried out using other frameworks, models, or scenarios, and the Town may form their own view as to the various frameworks, models, and scenarios that are most appropriate to the Town's circumstances.

7. PROJECT CONSIDERATIONS

7.1 Permitting

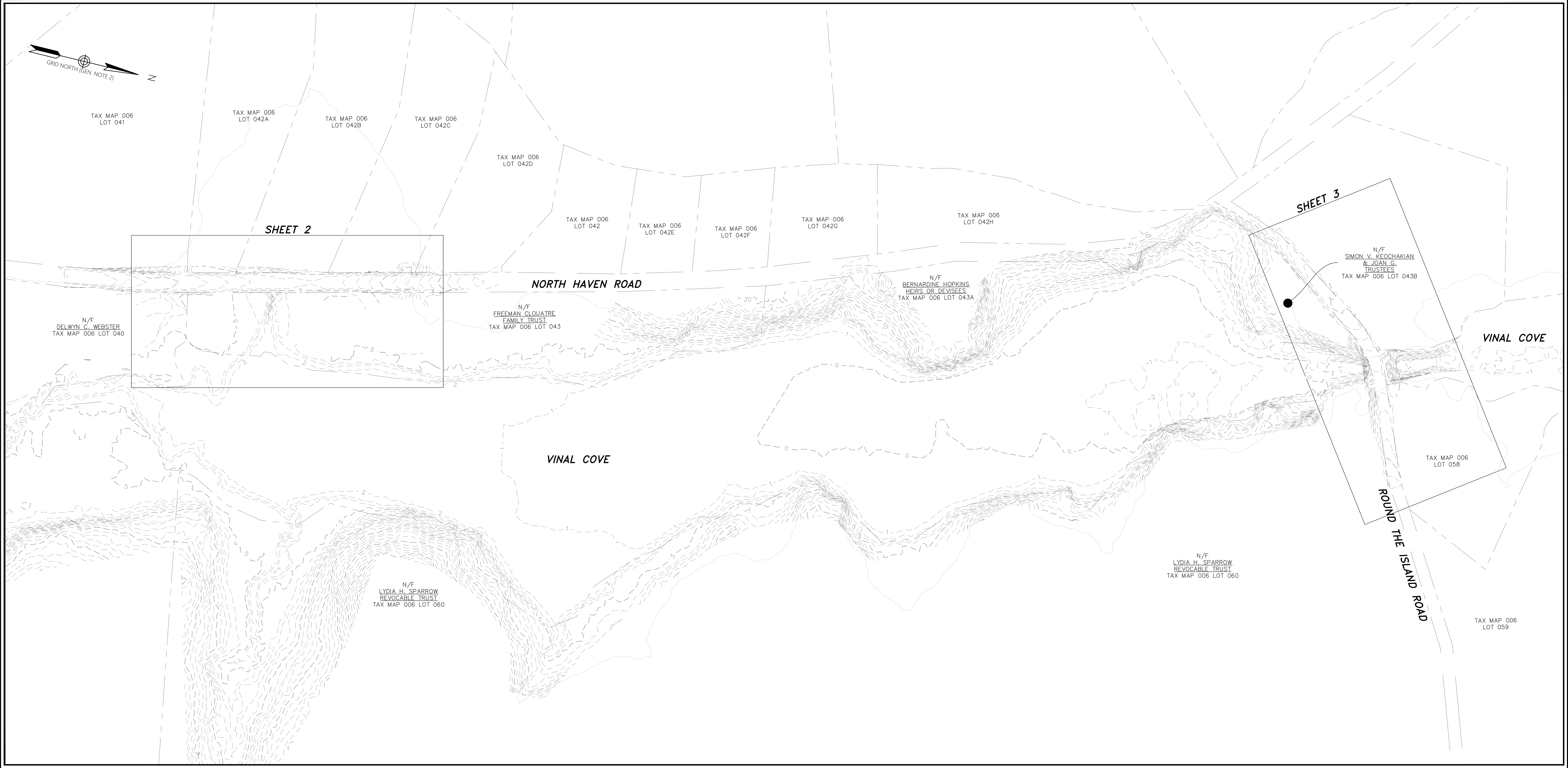
It is anticipated that an Army Corps of Engineers (ACOE) Pre-Construction Notification (PCN) Maine General Permit 10 – Linear Transportation Projects will be required for raising North Haven Road. A linear transportation project is defined by ACOE as activities required for the construction, expansion, modification, or improvement of linear transportation projects and attendant features. Linear transportation projects with 15,000 square feet to 3 acres of permanent and temporary fill, with discharge anticipated within special aquatic sites including mud flats require a PCN. Raising the roadway to elevation 11 ft will require approximately 14,000 square feet permanent fill on the east and west sides of the roadway. Additional temporary fill may also be required for erosion and sedimentation control during construction. A Wetland Delineation will be required to determine wetland boundaries and specific impacts to special aquatic sites on either side of the roadway.

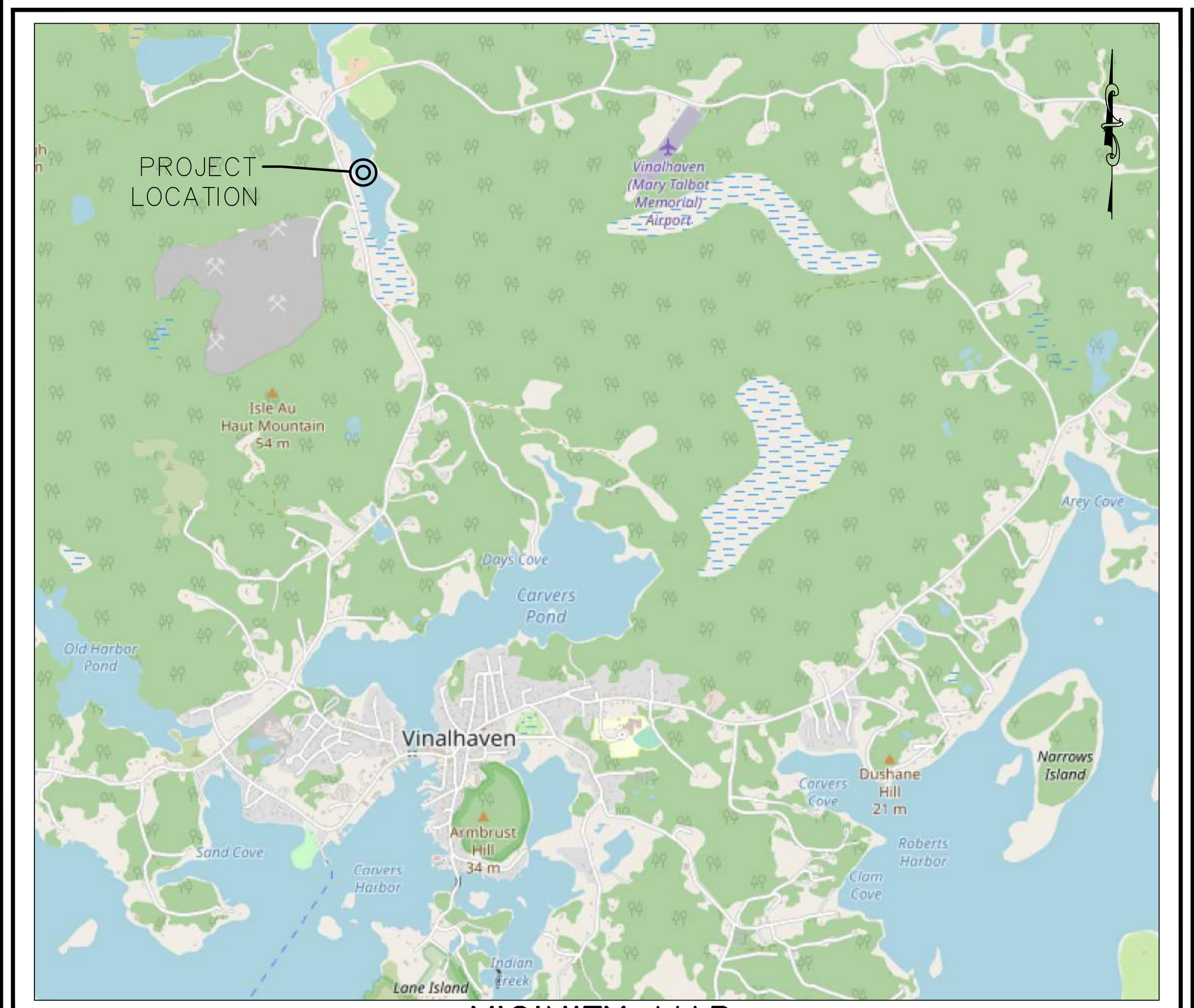
Raising North Haven Road will most likely not require a NRPA Permit because the project meets the Natural Resources Protection Act (NRPA) 480-Q-2-D exemption, which states a NRPA *"permit is not required for the repair and maintenance of an existing crossing or for the replacement of an existing crossing, including ancillary crossing installation activities such as excavation and filling, in any protected natural resource area, as long as erosion control measures are taken to prevent sedimentation of the water and the crossing does not block passage for fish in the protected natural resource area*."

7.2 Temporary Construction Licenses

The reconstruction of North Haven Road will remain within the Right-of-Way, however temporary construction licenses are anticipated due to grading impacts associated with raising the road. Seven parcels would potentially be impacted, requiring license agreements from five different property owners. Work on North Haven Road properties is limited to grading and slope stabilization installation and would not impact the access to or use of abutting properties.

APPENDIX A: SURVEY





VICINITY MAP NOT TO SCALE

GENERAL NOTES

1. THIS PLAN AND ALL WORK ASSOCIATED WITH IT WAS PERFORMED BY VANASSE HANGEN BRUSTLIN, INC (VHB) PURSUANT TO A PROFESSIONAL SERVICES CONTRACT BETWEEN WOODARD & CURRAN AND VHB, DATED OCTOBER 25, 2021.
2. THE BEARINGS SHOWN HEREON ARE GRID NORTH AND REFER TO MAINE STATE PLANE COORDINATE SYSTEM, EAST ZONE 1801, NORTH AMERICAN DATUM OF 1983 (2011), EPOCH 2010, GEOID 18, U.S. SURVEY FEET, ARE BASED ON GPS OBSERVATIONS PROCESSED USING ONLINE POSITION USER SERVICE (OPUS); ELEVATIONS REFERENCE NAVD88.
3. THIS PLAN IS THE RESULT OF A FIELD SURVEY CONDUCTED BY VHB IN NOVEMBER/DECEMBER OF 2021 UNDER THE DIRECT SUPERVISION OF DANIEL T. OAKES, LICENSED PROFESSIONAL LAND SURVEYOR ME 2549.
4. UTILITIES SHOWN HEREON ARE BASED ON SURFACE OBSERVABLE FEATURES. NO SUBSURFACE INVESTIGATION HAS BEEN PERFORMED BY VHB. DIG-SAFE SHOULD BE CONTACTED PRIOR TO COMMENCING ANY EXCAVATION. (888-344-7233).
5. THIS SURVEY WAS COMPLETED WITHOUT THE BENEFIT OF IN PERSON RESEARCH AND MAY BE SUBJECT TO ADDITIONAL INFORMATION THAT COULD NOT BE OBTAINED ONLINE THROUGH KNOX COUNTY REGISTRY OF DEEDS ONLINE DATABASE.
6. FLOOD ZONE CLASSIFICATION ZONES SHOWN HERE ON ARE AS SHOWN ON THE NATIONAL FLOOD INSURANCE PROGRAM (NFIP) FLOOD INSURANCE RATE MAP (FIRM) MAP NUMBER 23013C0404D PANEL 404 OF 925, DATED JULY 6, 2016.
7. PROPERTY LINES SHOWN HEREON ARE TAKEN FROM THE MAINE OFFICE OF GIS "GEOLIBRARY GEOPARCEL MAP VIEWER" ON NOVEMBER 8, 2021 AND ADJUSTED TO MATCH FIELD LOCATED BOUNDARY EVIDENCE.
8. THE OWNER OF LAND ADJOINING ROADS MAY HAVE OWNERSHIP RIGHTS EXTENDING INTO THE ROAD. THIS DOCUMENT DOES NOT INTEND TO LIMIT, DENY, OR LOCATE THESE RIGHTS. THE BOUNDARIES AS SHOWN ARE THE BOUNDARIES DESCRIBED IN THE DEED AND NOT NECESSARILY THE EXTENT OF TITLE THAT PASSES BY IMPLICATION OR OPERATION OF LAW.
9. CONTOURS SHOWN HEREON ARE FROM AN ON THE GROUND SURVEY SUPPLEMENTED WITH LiDAR DATA FROM THE MAINE OFFICE OF GIS.

LEGEND

PROPERTY LINE
RIGHT OF WAY LINE
CONTOUR (1' OR 2' INTERVAL) 74
CONTOUR (INDEX) 75

GRAPHIC SCALE: 1" = 100'
100 0 100 200
SCALE IN FEET

PREPARED BY

vhb

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WOODARD & CURRAN

REV	DESCRIPTION	DATE
1	ISSUED FINAL	04/21/22
0	ISSUED FOR REVIEW	02/25/22

DESIGNED BY: CHECKED BY: DO
DRAWN BY: M. PROVO 55557.00_VinalCove EX.dwg

TOWN OF VINALHAVEN
VINAL COVE
NORTH HAVEN ROAD & ROUND THE ISLAND ROAD
VINALHAVEN, ME 04863

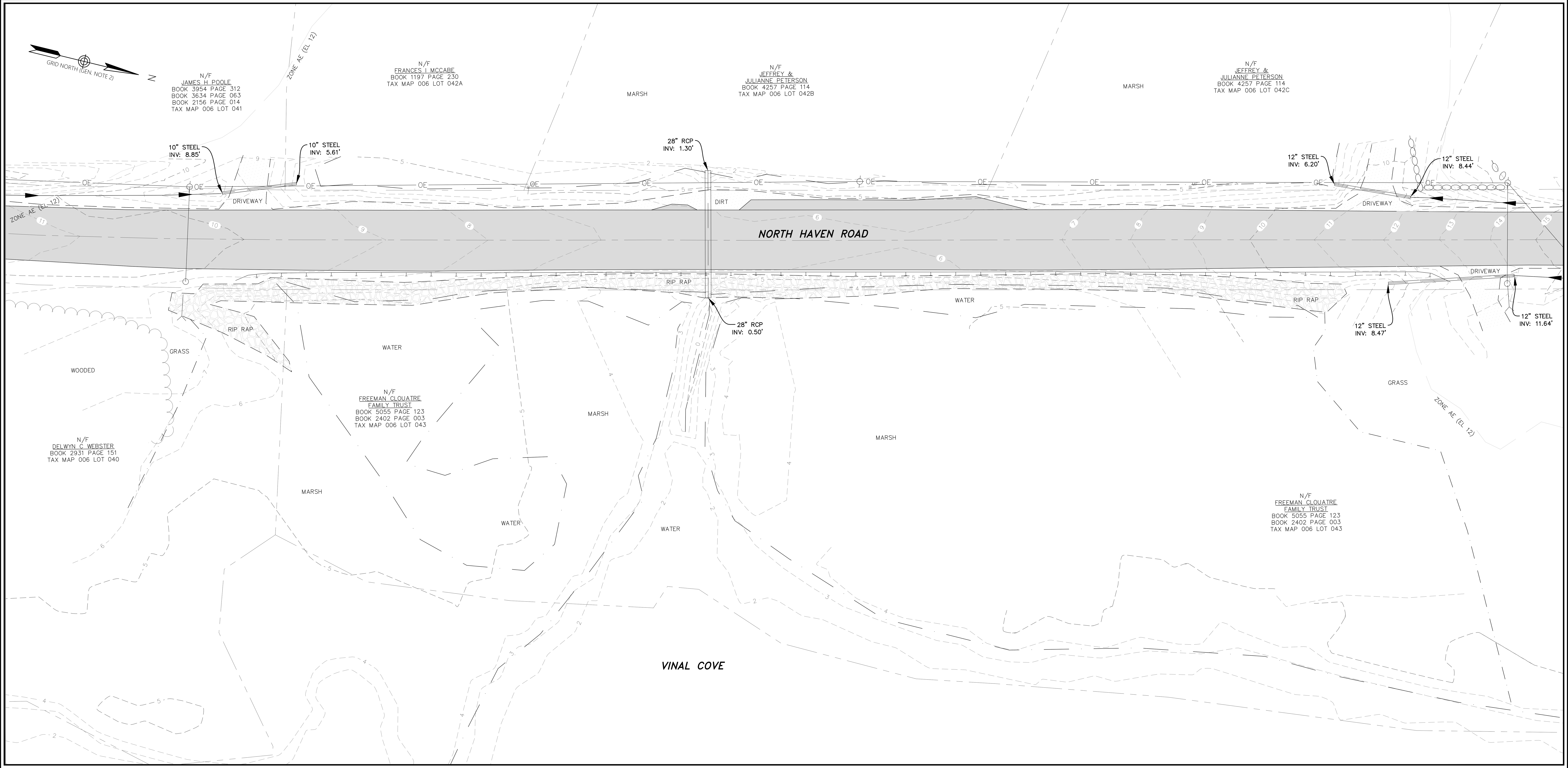
TOWN OF VINALHAVEN
VINAL COE OVERVIEW

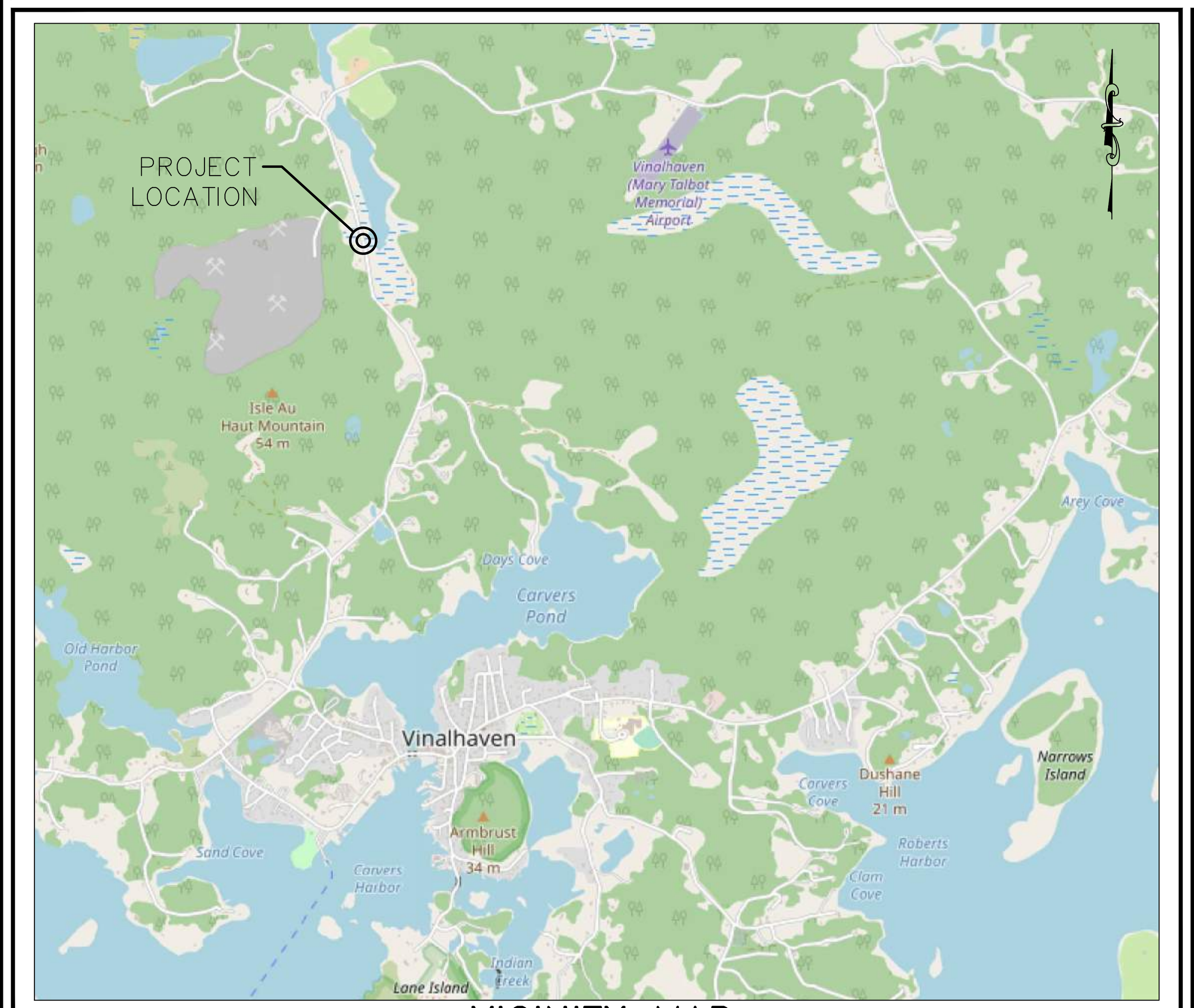
EXISTING CONDITIONS SURVEY

JOB NO.: 55557.00
DATE: Feb. 2022
SCALE: 1" = 100'
SHEET: 1 OF 3

\\woodardcurran.net\shared\Projects\0232140.00 Vinalhaven ME Downtown Improvement Design\Project Record\Phases\12 North Haven and Vinal Cove\Execution\Survey\55557.00_VinalCove EX.dwg, Jul 07, 2023 - 5:15pm

24x36 SHEET





VICINITY MAP NOT TO SCALE

SEE SHEET 1 FOR GENERAL NOTES

LEGEND

PROPERTY LINE	
RIGHT OF WAY LINE	
EDGE OF PAVEMENT	
EDGE OF GRAVEL	
CENTERLINE OF ROAD	
EDGE OF VEGETATION	
STONEWALL	
GUARD RAIL	
DRAINAGE DITCH	
OVERHEAD ELECTRIC	OE
CONTOUR (1' OR 2' INTERVAL)	74
CONTOUR (INDEX)	75
FEMA FLOOD ZONE	ZONE XX (XX)
GUY WIRE	
UTILITY POLE	

GRAPHIC SCALE: 1" = 20'
20 0 20 40
SCALE IN FEET

PREPARED BY

WOODARD & CURRAN
COMMITMENT & INTEGRITY DRIVE RESULTS
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REV	DESCRIPTION	DATE
1	ISSUED FINAL	04/21/22
0	ISSUED FOR REVIEW	02/25/22

DESIGNED BY: | CHECKED BY: DO
DRAWN BY: M. PROVO | 55557.00_VinalCove EX.dwg

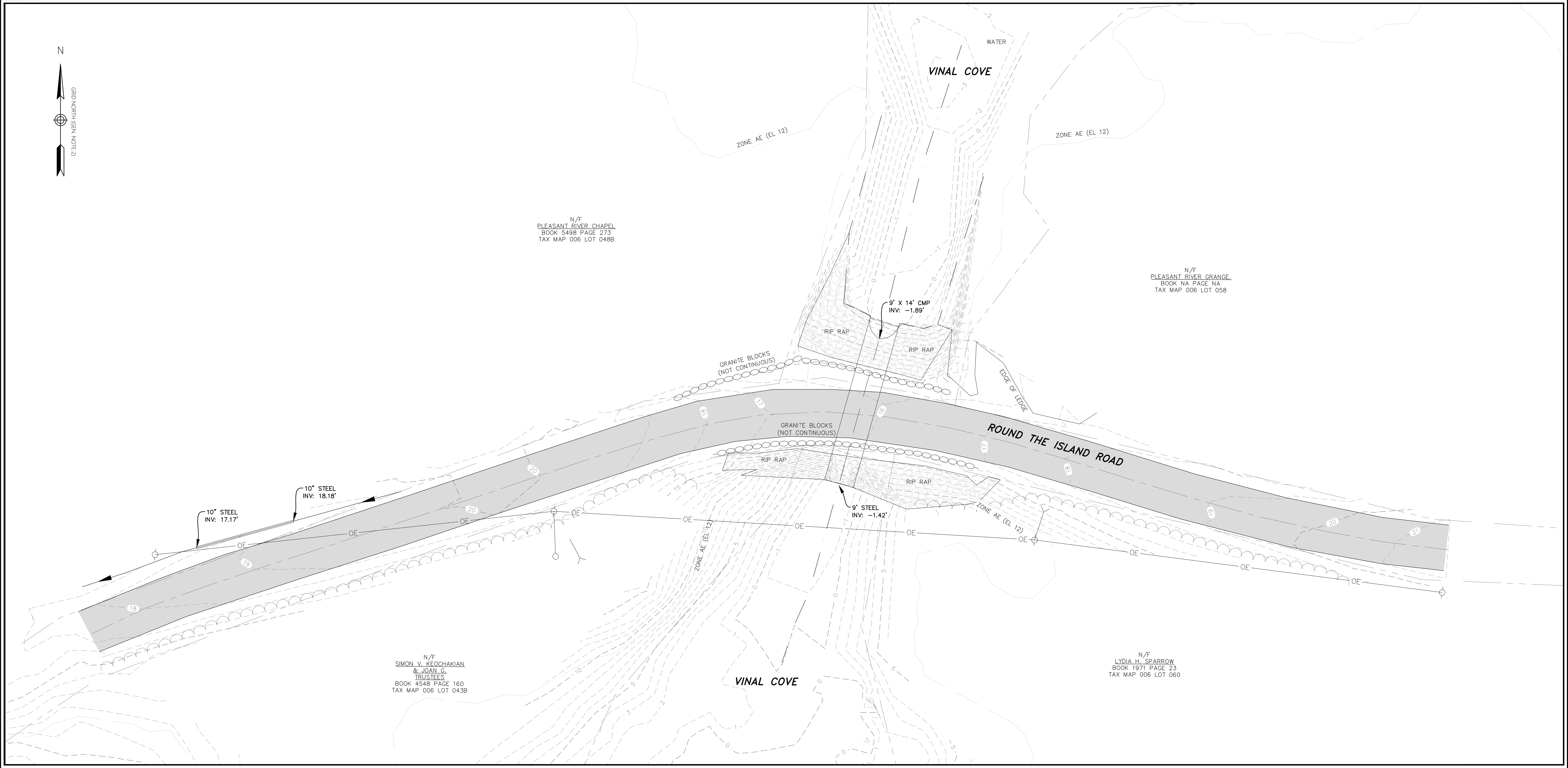
TOWN OF VINALHAVEN
VINAL COVE
NORTH HAVEN RD.
VINALHAVEN, ME 04863

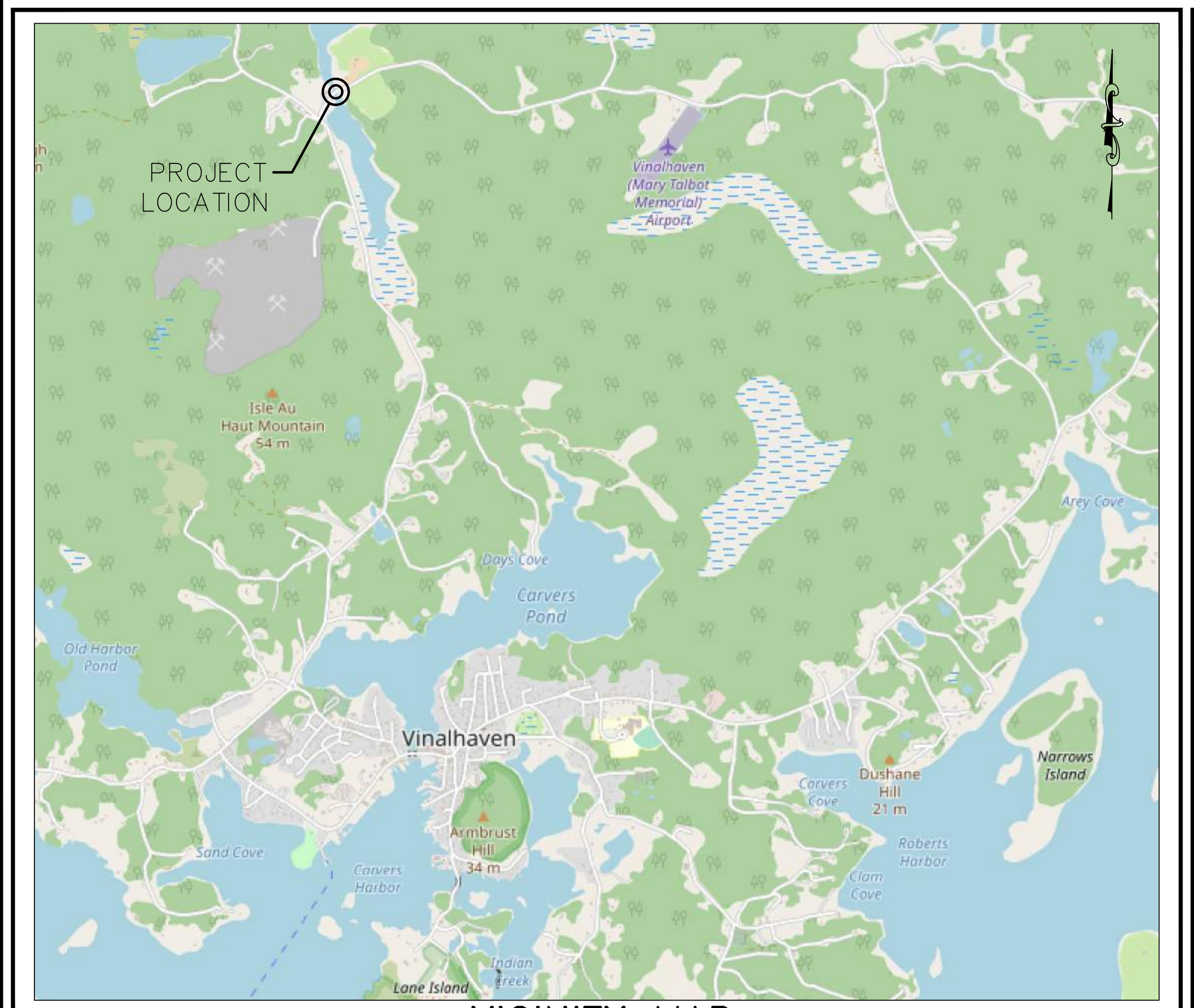
TOWN OF VINALHAVEN
VINAL COVE – NORTH HAVEN ROAD

EXISTING CONDITIONS SURVEY

JOB NO.: 55557.00
DATE: Feb. 2022
SCALE: 1" = 20'
SHEET: 2 OF 3

\\woodardcurran.net\shared\Projects\0232140.00 Vinalhaven ME Downtown Improvement Design\Project Record\Phases\12 North Haven and Vinal Cove\Execution\Survey\55557.00_VinalCove EX.dwg, Jul 07, 2023 – 5:15pm





VICINITY MAP NOT TO SCALE

SEE SHEET 1 FOR GENERAL NOTES

LEGEND

- PROPERTY LINE
- RIGHT OF WAY LINE
- EDGE OF PAVEMENT
- EDGE OF GRAVEL
- CENTERLINE OF ROAD
- EDGE OF VEGETATION
- STONEWALL
- GUARD RAIL
- DRAINAGE DITCH
- OVERHEAD ELECTRIC — OE
- CONTOUR (1' OR 2' INTERVAL) — 74
- CONTOUR (INDEX) — 75
- FEMA FLOOD ZONE — ZONE XX (XX)
- GUY WIRE
- UTILITY POLE

GRAPHIC SCALE: 1" = 20'

20 0 20 40

SCALE IN FEET

PREPARED BY

vhb

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REV	DESCRIPTION	DATE
1	ISSUED FINAL	04/21/22
0	ISSUED FOR REVIEW	02/25/22

DESIGNED BY: CHECKED BY: DO

DRAWN BY: M. PROVO 55557.00_VinalCove EX.dwg

TOWN OF VINALHAVEN
VINAL COVE
ROUND THE ISLAND RD.
VINALHAVEN, ME 04863

TOWN OF VINALHAVEN
VINAL COVE
ROUND THE ISLAND ROAD

EXISTING CONDITIONS SURVEY

JOB NO.: 55557.00
DATE: Feb. 2022
SCALE: 1" = 20'
SHEET: 3 OF 3

\\woodardcurran.net\shared\Projects\0232140.00 Vinalhaven ME Downtown Improvement Design\Project Record\Phases\12 North Haven and Vinal Cove\Execution\Survey\55557.00_VinalCove EX.dwg, Jul 07, 2023 - 5:15pm

APPENDIX B: GEOTECHNICAL REPORT

The key to success starts with a solid foundation.
ENGINEERING | EXPLORATION | EXPERIENCE

Geotechnical Report

Roadway Evaluation

North Haven Road, Vinalhaven, Maine

SUMMIT GEOENGINEERING SERVICES

Mailing: PO Box 515, Gardiner, ME 04345
Office: 210 Maine Avenue, Farmingdale, ME 04344
www.summitgeoeng.com

Client

Woodard & Curran
41 Hutchins Drive
Portland, Maine 04102

Project #: 23130
Date: 6/30/2023

June 30, 2023
Summit #23130

Attn: Megan McDevitt, P.E.
Woodard & Curran
41 Hutchins Drive
Portland, Maine 04102

Reference: Geotechnical Engineering Services
Roadway Evaluation – North Haven Road, Vinalhaven, Maine

Dear Ms. McDevitt;

Summit Geoengineering Services, Inc. (SGS) has completed a geotechnical investigation for North Haven Road in Vinalhaven, Maine. The scope of services includes performing explorations at the site, conducting soil laboratory testing, and preparing this report summarizing the findings and geotechnical recommendations for raising height of a portion of the road to reduce flooding.

The portion of North Haven Road evaluated for this report is a low-lying area approximate 400 linear feet located south of Loud's Pit Road which extends across a tidal marsh. The low-lying portion of the road experiences frequent flooding during annual higher tide or from storm surge events. To reduce the frequency of flooding, raising of the road finish grade is planned. Existing grade upon the road surface ranges from elevation 10 ft (stations 0+00 and 4+00) dipping to elevation 6 ft at the middle (station 2+00). The 100-year flood elevation is 11 ft. Based upon this, up to 5 ft of fill is anticipated to raise grade up to the flood elevation of 11 ft.

The subsurface conditions beneath the roadway includes fill (sand and gravel) overlying marsh deposit (peat) to marine deposit (clay) with depth. Refusal presumed as bedrock ranges from 21 to 46 ft in depth below roadway surface. Groundwater appears tidally influenced and likely fluctuates.

This report provides discussion of the geotechnical findings and preliminary recommendations for raising roadway grade to reduce potential for flooding. SGS appreciates the opportunity to serve you during this phase of your project.

Sincerely yours,
Summit Geoengineering Services

Craig W. Coolidge, P.E.
Vice President, Principal Engineer

STATE OF MAINE
CRAIG W. COOLIDGE
NO# 11569
LICENSED
PROFESSIONAL ENGINEER

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TABLE OF CONTENTS

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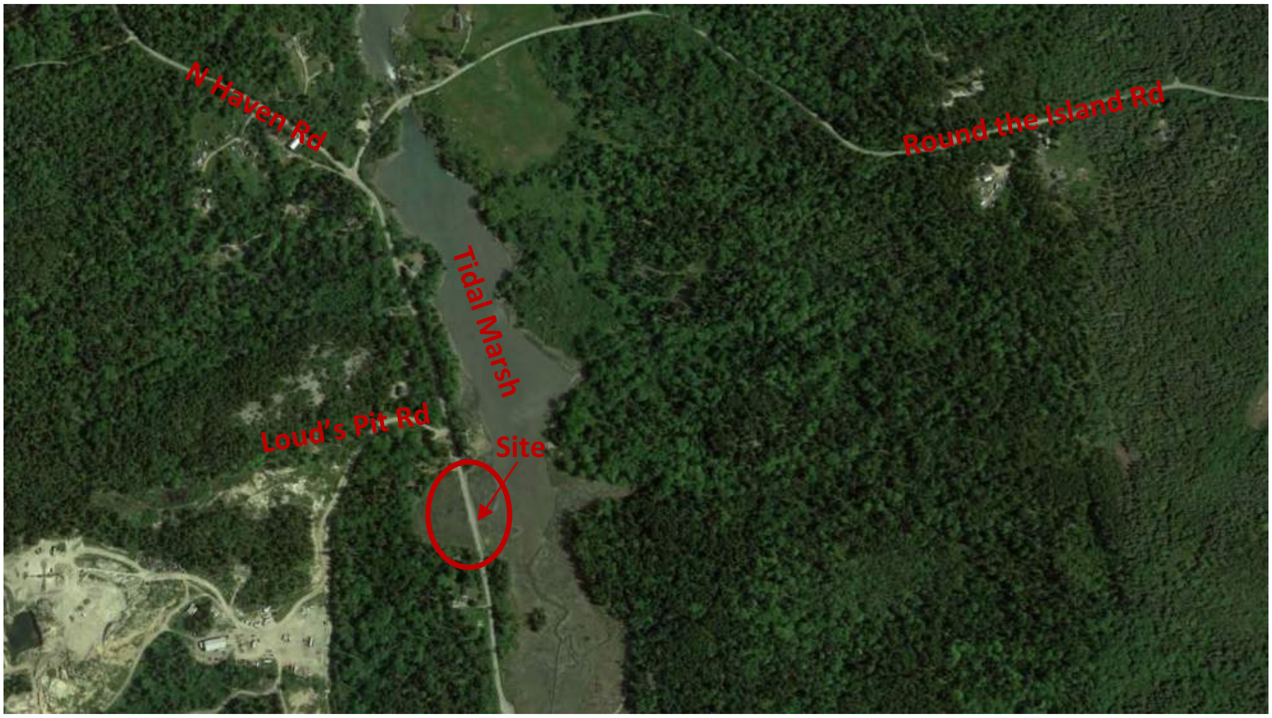
1.0 Project and Site Description

Summit Geoengineering Services (SGS) was asked to conduct a geotechnical investigation to evaluate existing conditions and provide geotechnical recommendations for a portion of North Haven Road in Vinalhaven, Maine. The site consists of a 400 linear foot section of roadway crossing a tidal marsh located south of Loud's Pit Road and Vinal Cove.



N. Haven Rd Aerial Image 2018 (Google Earth)

The low-lying portion of the road experiences frequent flooding during annual higher tide or from storm surge events. To reduce the frequency of flooding, raising of the road finish grade is planned. Existing grade crossing the tidal marsh ranges from elevation 10 ft (stations 0+00 and 4+00) dipping to elevation 6 ft at the middle (station 2+00). The 100-year flood elevation for the tidal marsh is 11 ft. Based upon this, up to 5 ft of fill is anticipated to raise grade up to the flood elevation of 11 ft.

North Haven Road (Facing North)

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2.0 Site Investigation

2.1 Test Boring Explorations

SGS explored the subsurface conditions with 3 test borings (B-1 through B-3) performed within the roadway on June 6, 2023. Test borings were performed using a trailer mount AMS PowerProbe 9630 by hollow stem augers and direct push drill casing. Sampling was performed using a gravel punch at roadway surface, split spoons with standard penetration test (SPT), and thin wall (Shelby) tubes. Field vane shear tests were performed to evaluate undrained shear strength of the marsh deposit. Soils were visually classified by a geotechnical engineer using the Unified Soil Classification System (USCS). An Exploration Location Plan and Interpretive Cross Section are provided in Appendix A. Logs of the test borings are provided in Appendix B. The site was pre-marked by SGS for notification of Dig Safe prior to drilling.

Drilling Test Boring B-1 (Facing North)

2.2 Laboratory Testing

SGS performed laboratory tests for select samples collected from the test boring explorations to evaluate physical and strength properties. Reports of the individual laboratory tests are in Appendix C. Moisture content was performed for select samples of the marsh deposit and marine deposit. Grain size analysis was performed for 1 sample of the upper roadway fill beneath pavement.

LABORATORY TEST SUMMARY – GRAIN SIZE ANALYSIS					
Test Boring	Depth	Gradation Analysis			Description
		Gravel	Sand	Fines	
B-2	0.6’ - 1.0’	42%	50%	8%	Gravelly Sand (SW-SM)

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Laboratory testing was performed by SGS for 2 thin wall tube samples of marsh deposit (peat) collected within the test boring B-2. Results of the laboratory tests for the thin wall tube samples are summarized as follows:

LABORATORY TEST SUMMARY – THIN WALL TUBE SAMPLES									
Boring /Tube	Depth	Atterberg Limit			Unit Weight	Shear Strength	Consolidation		
		LL	PI	MC	ϒ	S_u	P'c	C_c	C_r
B-2/UT-1	15'-17.5'	435	60	439	66 pcf	420 psf	0.9 ksf	3.47	0.52
B-2/UT-2	18'-20.5'	--	--	368	67 psf	570 psf	--	--	--

Soil box resistivity was performed for 3 soil samples of the marsh deposit (peat) per ASTM G57. Samples were also sent to Maine Environmental Lab for soil pH and ion chromatography for pH, organic matter, chloride content, and sulfate content. Results are summarized below:

LABORATORY TEST SUMMARY – ANALYTIC SAMPLES						
Sample	Depth	Resistivity (Ohm-cm)	Organic Matter (%)	Ion Chromatography		
				pH	Chloride	Sulfate
B-2/UT-1	15'-17.5'	170	72.20	7.42	36,000 ppm	230 ppm
B-2/S-4a	20.5'-21.5'	160	19.35	7.63	12,000 ppm	59 ppm
B-3/S-3	10'-12'	2,600	14.21	7.56	92 ppm	None Detect

3.0 Subsurface Conditions

The subsurface conditions consist of bituminous pavement (thickness of 7 inches) overlying ***roadway fill*** to ***fill*** overlying ***marsh deposit*** to ***marine deposit***. An interpretive cross section is provided on Figure 1 in Appendix A. Details of the subsurface conditions are provided on the test boring logs in Appendix B. Summary of the individual soil layers are provided below.

3.1 Soil Layers

Roadway fill is located beneath the pavement with a thickness with of 3 to 4 feet. The roadway fill is described as gray gravelly sand with with little silt and and classifies as SW-SM in accordance with the Unified Soil Classification System (USCS). Gradation test at test boring B-2 indicate a gravel content of 42 percent, sand of 50 percent, and fines of 8 percent. The roadway fill is dense to compact and damp to wet with depth.

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Fill is located beneath the roadway fill with a thickness of 4 to 6 feet. The fill is described as dark brown to gray mixture of gravel, sand, silt, and clay and classifies as SM, ML, and/or CL in accordance with the USCS. The fill consist of assorted fill mixed with reworked native soil. Cobbles in varying frequency are present within the fill. The fill is dense or stiff to loose with depth and wet.

Marsh deposit is located beneath the fill with a thickness of 10 to 14 feet. The marsh deposit is described as fibrous peat and classifies as PT in accordance with the USCS. Organic matter content ranges from 14 to 72 percent based on analytic laboratory testing. Moisture content ranges from 143 to 439 percent. Atterberg limit test indicate a liquid limit of 435 and a plasticity index of 60. Field vane shear tests and unconfined compressive strength tests indicate an undrained shear strength range of 300 to 700 psf. The marsh deposit is highly compressible and wet.

Marine deposit is interbedded within the marsh deposit or below the marsh deposit and above bedrock. The marine deposit is described as gray silty clay with trace sand and black organic streaks and classifies as CL in accordance with the USCS. Moisture content ranges from 26 to 63 percent. The marine deposit is soft and wet.

3.2 Bedrock

Bedrock estimated from drill rod refusal is located at a depth range of 21 to 46 feet below roadway surface. Mapping by the Maine Geological Survey indicates the bedrock at the site consists of coarse-grained biotite hornblende granite and quartz-monzonite with minor feldspars.

3.3 Groundwater

Groundwater is present beneath the roadway fill at or near the surface of the tidal marsh. Groundwater depth likely fluctuates during tidal ebb and flow. The 100-year flood elevation is 11 ft at the site which is currently above the roadway surface ranging from elevations 6 to 11 ft.

4.0 Geotechnical Evaluation

The primary geotechnical challenge to raising grade of North Haven Road along the tidal marsh is settlement related to the weight of new fill upon the underlying marsh deposit (peat). The marsh deposit is highly compressible when required to support new loads such as granular fill. Total settlement estimated for the road by the increase of 5 ft of fill is 27 inches as follows:

- Immediate Settlement = 2 inches +/- (During Construction)
- Consolidation Settlement = 17 inches +/- (3 to 12 Months of Construction)
- Secondary Settlement = 8 inches +/- (25 Years after Construction)

The factor of safety for bearing capacity upon the marsh deposit is 4 and stable to support the fill.

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While the marsh deposit is considered sufficient to support 5 feet of new roadway fill, settlement is estimated to be significant at 27 inches. In general, the immediate settlement will not be realized after completion of construction. The consolidation settlement is significant but estimated to occur within 1 year of construction. Secondary settlement in the form of creep will be observed at a slower rate over time, which is estimated using a timeline of 25 years. Based upon this, the following three options are presented to raise grade for the roadway:

1. Construct road and allow settlement to occur with regrading and shimming prior to paving
2. Incorporate lightweight fill to reduce weight and associated total settlement
3. Incorporate ground improvement to increase soil stiffness and reduce total settlement

Option 1. The use of traditional fill is possible with the understanding of settlement. It is understood that drainage structures such as small diameter corrugated culverts of similar may be constructed within the roadway fill section. Larger structures such as clear span culverts or bridges are not planned within the roadway. Buried utilities are not located within the roadway fill. Based upon this, the roadway fill could be placed and allowed to settle over time. It is suggested that settlement monitoring be performed to evaluate magnitude and rate of settlement. Once settlement has reduced over time, the road could be regraded and eventually paved provided the performance and risk for settlement are accepted and understood as part of continued maintenance. Damage to bituminous pavement surface or similar should also be expected.

Option 2. The use of lightweight fill such as ultra lightweight foam glass aggregate (UL-FGA) or similar could be incorporated as part of the new fill section. Over-excavation and replacement of a portion of the existing fill may be required to reduce overall settlement. The advantage to lightweight fill is relative ease for construction placement similar to crushed stone. The disadvantage is cost, transportation of aggregate, and risk for lightweight fill to become buoyant during flood. This is due to the unit weight of lightweight fill being less than that of water. The use of lightweight fill should be properly engineered for sufficient encapsulation beneath new roadway fill to resist uplift buoyance during flood. Product brochures and technical data sheets are provided for UL-FGA in Appendix D.

Option 3. The use of ground improvement such as vertical stone columns (VSC) or rigid inclusions (RI) could be used to improve stiffness of the marsh deposit. The vibro-displacement installation method of introducing ¾" crushed stone or concrete into the subgrade soil can create a stiffer matrix soil on which the roadway fill will bear. The matrix soil will have a higher modulus value to reduce settlements and increase bearing capacity. The length and spacing of ground improvement are designed to achieve the necessary bearing capacity beneath and to reduce long-term settlement. Bearing capacity failure typically occurs in one of three forms as general shear failure at bottom of fill, punching failure at the bottom of the stone columns, or bulging within the element. All three conditions would need to be evaluated as part of design for a ground improvement system. A load transfer platform (LTP) consisting of geotextile fabric and engineered fill is placed between the top of element and roadway fill to distribute the fill load. Design of a ground improvement system should be performed by a qualified engineer teamed with a qualified ground improvement contractor.

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5.0 Roadway Fill Recommendations

Option 1 utilizes traditional fill and construction methods provided settlement is acceptable. The roadway should consist of the following materials using a traditional roadway section design:

Roadway Section
Bituminous Pavement (4 Inches Minimum)
Gravel Base MDOT Type A (6 Inches Minimum)
Gravel Subbase MDOT Type D (18 Inches Minimum)

The existing roadway surface should be stripped of bituminous pavement and the granular subgrade should be proof-rolled prior to placement of subbase gravel. Base and subbase should be compacted to 95 percent of its maximum dry density determined in accordance with ASTM D1557. The maximum particle size for base is 2 inches and for subbase is 6 inches. The following gradations are for MDOT base and subbase gravel:

Sieve Designation	Percent Passing a 3-inch Sieve	
	MDOT Type A (Base)	MDOT Type D (Subbase)
3 Inch	100	100
2 Inch	100	--
½ Inch	45 – 70	35 – 80
¼ Inch	30 – 55	25 – 65
No. 40	0 – 20	0 – 30
No. 200	0 – 6	0 – 7

Reference: MDOT Specification 703.06, Aggregate for Base and Subbase (2020)

Additional fill necessary to meet grade beneath the new roadway surface and existing roadway grade should consist of Gravel Borrow. Gravel Borrow should be placed in maximum 12-inch lifts and compacted to 95 percent of its maximum dry density determined in accordance with ASTM D1557. Gravel Borrow should consist of well graded granular material with a maximum particle size of 6 inches. The portion passing a 3-inch sieve should meet the following gradation:

GRAVEL BORROW	
Sieve Size	Percent Passing
¼ inch	0 to 70
No. 200	0 to 10

Reference: MDOT Specification 703.20, Gravel Borrow (2020)

Alternatively, Crushed Stone could be used to improve drainage beneath the roadway section. Crushed Stone should be placed in maximum 12-inch lifts then tracked and compacted to lock the stone structure together. The Crushed Stone should meet the following gradation:

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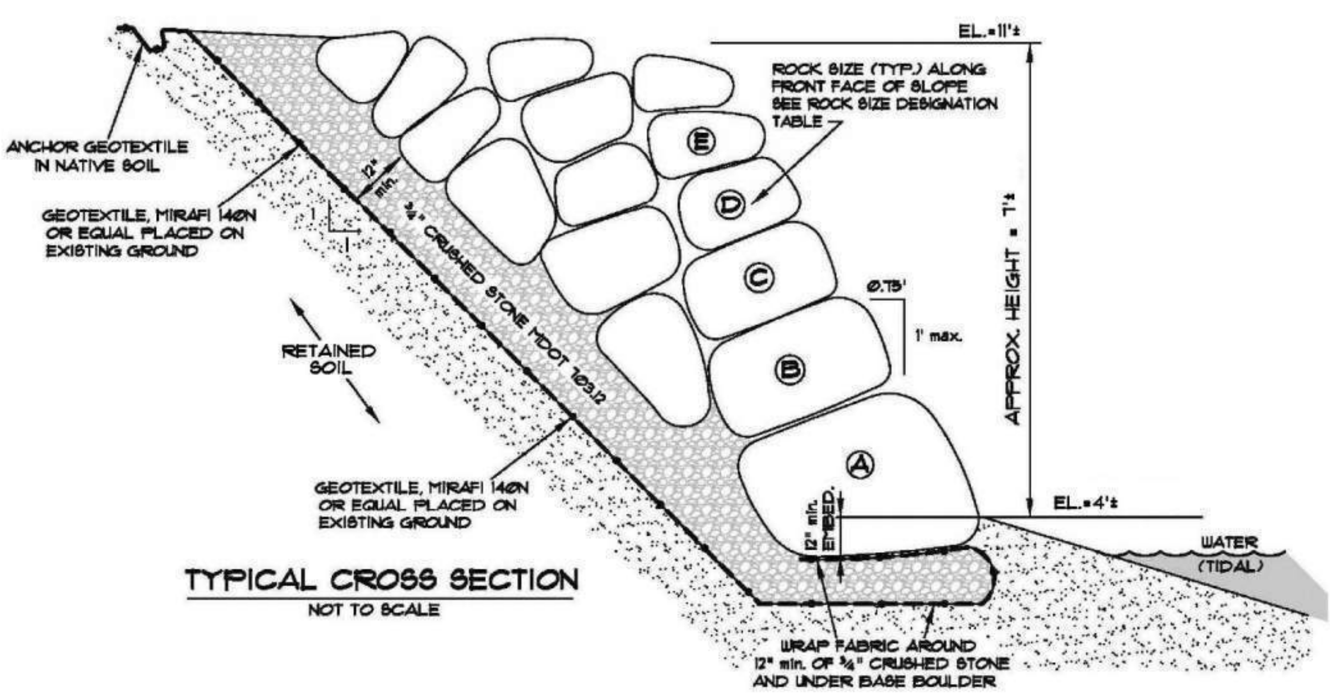
CRUSHED STONE ¾ INCH	
Sieve Size	**Percent finer**
1 inch	100
¾ inch	90 to 100
½ inch	20 to 55
⅜ inch	0 to 15
No. 4	0 to 5

Reference: MDOT Specification 703.13, Crushed Stone ¾-Inch (2020)

Geotextile is suggested as an option to improve soil strength, provide separation, and improve drainage or filtration. Geotextile at a minimum should be used to prevent migration of fines between gravel and crushed stone. Geotextile should only be used with a minimum thickness 6 inches for gravel or crushed stone to prevent damage to the geotextile fabric. A range of woven geotextile fabrics are available designed to improve strength, separation, and drainage. The selection of geotextile should be made based upon a balance of cost and applied solutions to improve the road.

To provide stabilization along the outer edge of the roadway embankment fill, a boulder wall or similar rock armor system could be used. A boulder wall includes keying larger rocks within the base of the tidal marsh and battering the rock along the face of embankment fill. Below are typical details for a boulder wall design concept.



Typical Detail for Boulder Wall w/Chimney Drain (Roadway Stabilization)

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Rock Type	Rock Weight (Pounds)	Average Dimension
1	200 - 660	1'-6" to 2'-4"
2	660 - 2000	2'-4" to 3'-0"
3	2000 - 4000	3'-0" to 4'-0"
4	4000 - 6000	4'-0" to 4'-6"

Wall Height	A	B	C	D	E
0 to 3'-3"	2	1	-	-	-
3'-3" to 6'-6"	3	2	1	-	-
6'-6" to 9'-9"	3	3	2	1	-
Taller Than 9'-9"	4	3	2	2	1

Number in Table Corresponds to Rock Type

The base of the boulder wall should be keyed into the base of the embankment fill at a relatively flat surface. Rocks should be positioned such that the rocks can be placed on the rock below without sliding or tipping towards the tidal marsh. The base of the wall should be angled back into the embankment fill such that the rocks are not inclined to fall out of the face of the wall. The batter of the face should be a maximum of 0.75H to 1V. The longest rock dimension should be oriented perpendicular to the face of the wall with the maximum dimension not exceeding three time the shortest dimension.

Utilization of a boulder wall 7 ft in height above the mudline will increase the overall slope stability due to the added weight of the rocks at the toe of the embankment fill, increase soil strength due to interlocking of the boulder wall, and drainage behind the wall to reduce groundwater pressure during tidal ebb and flow. The wider the wall, the greater the stability achieved. To provide drainage of groundwater at the toe of the fill, a chimney drain is recommended behind a boulder wall or similar retainment system. The chimney drain may consist of Crushed Stone separated by geotextile fabric such as Mirafi 140N or similar. The geotextile fabric will help reduce the potential for fines to migrate from the retained soil through the chimney drain and boulder wall.

For traditional fill placement upon the marsh deposit, a preload period is recommended of at least 6 to 12 months prior to placement of bituminous pavement. A surcharge of 1 to 2 feet could be applied to account for predicted settlement. Monitoring is suggested by the use of settlement plates to evaluate time rate of consolidation. Results of the settlement monitoring should be reviewed by the geotechnical engineer to evaluate and refine settlement estimates from observed field conditions.

Option 2 is the use of ultra lightweight fill to reduce total weight of fill bearing upon the marsh deposit. An example is ultra lightweight foam glass aggregate (UL-FGA). Product specification sheets are provided in Appendix D for further details. For preliminary design, the UL-FGA should be placed and installed beneath the roadway section and additional fill as deemed necessary to prevent buoyance or floating during flood. This might include partial removal of the existing roadway fill. For preliminary estimate, the UL-FGA should be approximately 5 ft in thickness to reduce settlement.

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Option 3 is to incorporate ground improvement such as vertical stone columns (VSC) or rigid inclusions (RI) installed within the subgrade beneath the roadway fill. Stone columns are a vibro-replacement or vibro-displacement ground improvement method intended to increase the stiffness and bearing capacity of the supporting soil. Well-graded gravel or crushed stone is installed into the subgrade by pre-drilled cavities or inserted with a hollow mandrel. The gravel or stone is compacted and densified in lifts to reinforce the existing soils and increase the net modulus to reduce settlement and increasing bearing capacity. Rigid inclusions are installed by a similar process but filled with concrete typically having a compressive strength of 4,000 psi.

Ground improvement is typically provided as a design/build package from a specialty contractor. To achieve capacity, stone columns or rigid inclusions should extend to the marine deposit or to bedrock. As preliminary design, we estimate an area replacement ratio of 20% or greater for VSC.

To verify capacity of the VSC or RI, load tests should be performed. Frequency of load tests should be at the discretion of the ground improvement designer. Installation logs summarizing length and quantity for each ground improvement element should be prepared in a summary report. Design of the ground improvement system should be performed by qualified engineer with a design report.

6.0 Closure

The recommendations provided in this report are based on professional judgment and generally accepted principles of geotechnical engineering and project information provided by others. No other warranty is expressed or implied. Our evaluations and recommendations are based on discrete and widely spaced data points. Some changes in subsurface conditions from those presented in this report are anticipated to occur. Should these conditions differ materially from those described in this report, SGS should be notified so that the provided recommendations may be re-evaluated.

SGS appreciates the opportunity to serve you during this phase of your project. If there are any questions or additional information is required, please do not hesitate to call.

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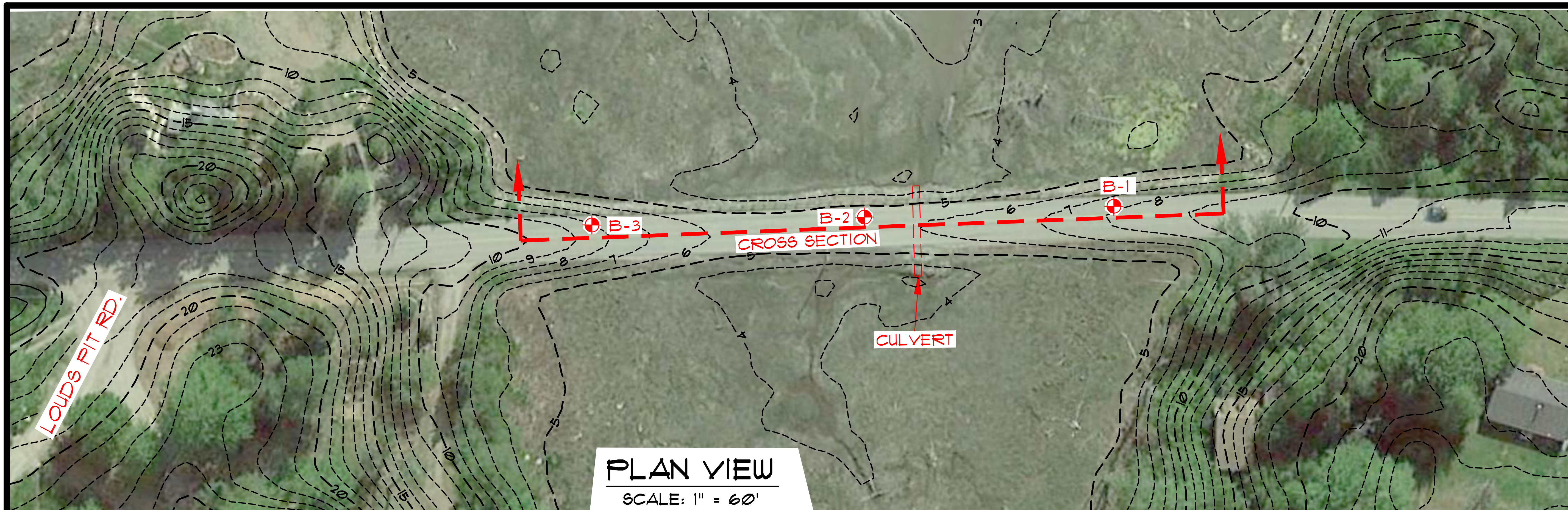
APPENDIX A

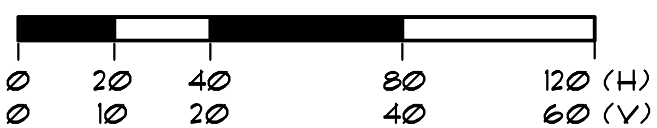
EXPLORATION LOCATION PLAN

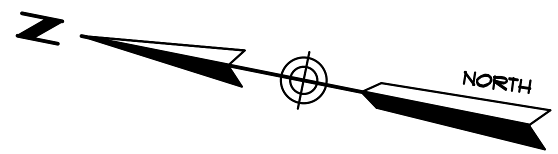


PLAN VIEW

SCALE: 1" = 60'

SCALE: HORIZ. - 1" = 40'
VERT. - 1" = 20'



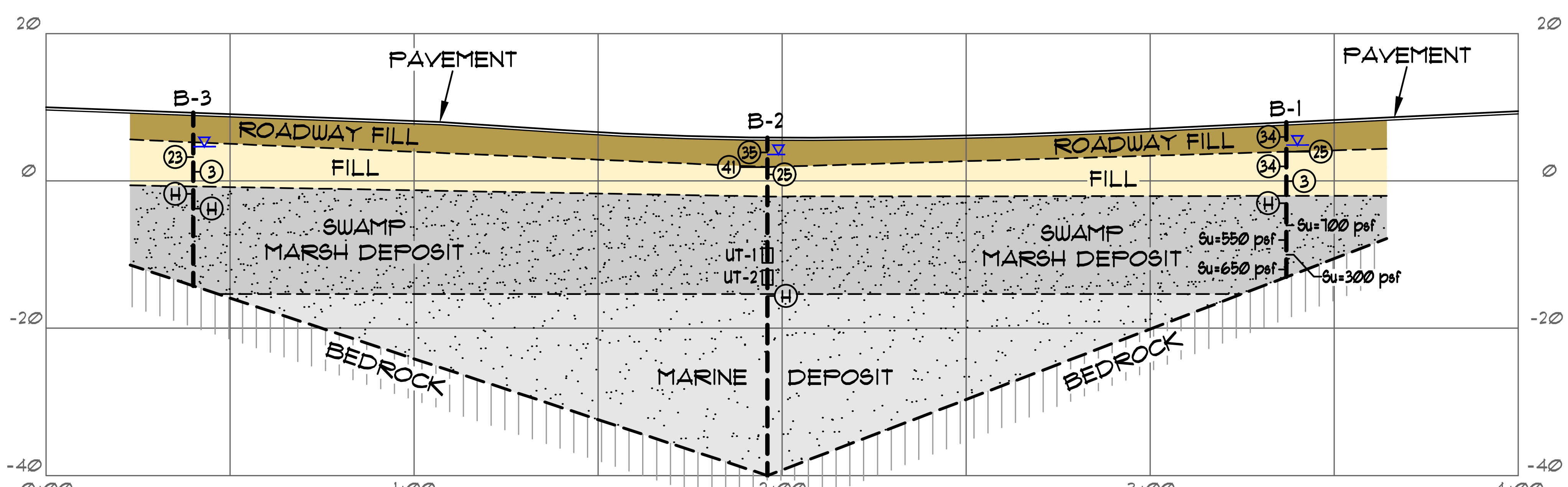


PLAN VIEW LEGEND

B-1 SUMMIT TEST BORING (JUNE 6, 2023)

PLAN REFERENCE

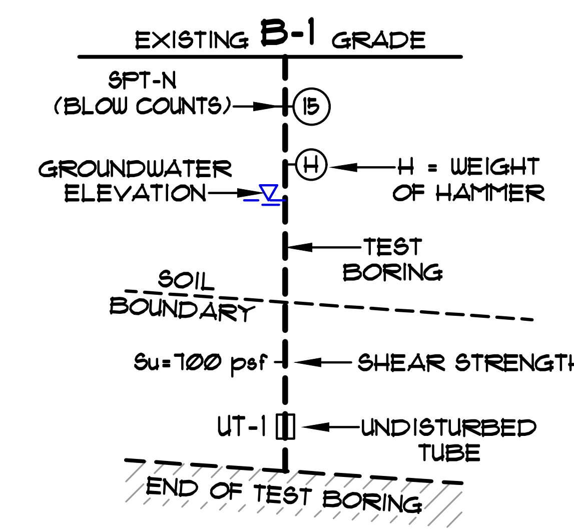
AERIAL IMAGE (JUNE 19, 2018) WAS OBTAINED FROM GOOGLE EARTH.



CROSS SECTION

SCALE: HORIZ. - 1" = 40'
VERT. - 1" = 20'

CROSS SECTION LEGEND



PROJECT: ROADWAY EVALUATION
NORTH HAVEN ROAD - VINALHAVEN, MAINE

CLIENT: WOODARD & CURRAN

TITLE: TEST BORING LOCATION PLAN AND CROSS SECTION

SCALE: AS NOTED
DRAWN BY: KRF
DATE: JUNE 16, 2023
APPR. BY: CRS

OFFICE: 210 MAINE AVENUE
FARMINGDALE, MAINE
TEL.: (207) 446-3360
MAIL: P.O. BOX 515
GARDINER, ME 04345
SUMMIT GEOENGINEERING SERVICES

PROJ.#: 23130
FIGURE: 1

APPENDIX B

TEST BORING LOGS

EXPLORATION COVER SHEET

The exploration logs are prepared by the geotechnical engineer from both field and laboratory data. Soil descriptions are based upon the Unified Soil Classification System (USCS) per ASTM D2487 and/or ASTM D2488 as applicable. Supplemental descriptive terms for estimated particle percentage, color, density, moisture condition, and bedrock may also be included to further describe conditions.

Drilling and Sampling Symbols:

SS = Split Spoon Sample
UT = Thin Wall Shelby Tube
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RW = Rotary Wash
SV = Shear Vane
PP = Pocket Penetrometer
RC = Rock Core Sample
FV = Field Vane Shear Test
PS = Concrete Punch Sample
Hyd = Hydraulic Advancement of Drilling Rods
Push = Direct Push of Drilling Rods
WOH = Weight of Hammer
WOR = Weight of Rod
PI = Plasticity Index
LL = Liquid Limit
W = Natural Water Content
USCS = Unified Soil Classification System
Su = Undrained Shear Strength
Su(r) = Remolded Shear Strength

Water Level Measurements:

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable groundwater levels. In impervious soils, the accurate determination of groundwater elevations may not be possible, even after several days of observations. Groundwater monitoring wells may be required to record accurate depths and fluctuation.

Gradation Description and Terminology:

Boulders:	Over 12 inches
Cobbles:	12 inches to 3 inches
Gravel:	3 inches to No.4 sieve
Sand:	No.4 to No. 200 sieve
Silt:	No. 200 sieve to 0.005 mm
Clay:	less than 0.005 mm

Trace:	Less than 5%
Little:	5% to 15%
Some:	15% to 30%
Silty, Sandy, etc.:	Greater than 30%

Density of Granular Soils and Consistency of Cohesive Soils:

CONSISTENCY OF COHESIVE SOILS		DENSITY OF GRANULAR SOILS	
SPT N-value blows/ft	**Consistency**	**SPT N-value blows/ft**	**Relative Density**
0 to 2	Very Soft	0 to 4	Very Loose
2 to 4	Soft	5 to 10	Loose
5 to 8	Firm	11 to 30	Compact
9 to 15	Stiff	31 to 50	Dense
16 to 30	Very Stiff	>50	Very Dense
>30	Hard		

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Boring #:	**B-1**		
Project:	Roadway Evaluation	Project #:	23130
Location:	North Haven Road	Sheet:	1 of 1
City, State:	Vinalhaven, Maine	Chkd by:	CWC

Drilling Co:	Summit Geoengineering Services	Boring Elevation:	8 ft +/-
Driller:	S. Floyd	Reference:	Estimated from Boring Location Plan by SGS and 1' Lidar Contours Obtained from N.O.A.A.
Summit Staff:	C. Sullivan, E.I.	Date started: 6/6/2023	Date Completed: 6/6/2023

DRILLING METHOD		SAMPLER	
Vehicle:	Trailer	Length:	24" SS
Model:	9630 Pro	Diameter:	2"OD/1.5"ID
Method:	2-1/4" HSA	Hammer:	140 lb
Hammer Style:	Auto	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
6/6/2023	3.1 ft	5 ft +/-	Measured in 10' of augers at 9:30AM

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	SP-1	12/12	0 - 1	PUNCH		7" Bituminuous Pavement		PAVEMENT
1				PUNCH	7+/-			0.6' +/-
	S-1	24/12	1 - 3	12		Gray Gravelly SAND, little Silt, compact-dense,		ROADWAY FILL
2				14		damp, SW-SM		
				20				
3				18				
	S-2	24/12	3 - 5	12		Same as above, 3"-crushed cobble at 3.5'+/-,		
4				12		slightly mottled, compact, wet, SW-SM		
				13	4+/-			4' +/-
5				13				FILL
	S-3	24/14	5 - 7	20		Brown SAND, some Gravel, little-some Silt, slightly		
6				15		mottled, dense, wet, SP-SM to SM		
				19		Olive gray SILT, little-some fine Sand, trace Gravel,		6' +/-
7				5		very stiff, wet, ML		
	S-4	24/1	7 - 9	2		Brown-gray Silty CLAY, some fine Sand, trace Gravel,		7' +/-
8				2		soft-firm, wet, CL		
				2				
9				2				
10								
	S-5	24/17	10 - 12	WOH	-2+/-	Dark brown fiberous PEAT, trace-little Silt & Clay, very	MC = 147.9%	10' +/-
11				WOH		soft, wet, PT		SWAMP MARSH
				WOH		Brown Silty CLAY, some fine Sand, trace Gravel,		10.7' DEPOSIT
12				WOH		very soft, wet, CL	PP = 1,000 psf	
						Gray Silty CLAY, trace Sand, very soft, wet, CL	to 2,000 psf	11' +/-
13	FIELD VANES						MC = 25.9%	
			Tip of Vane					
14	FV-1		14			S_u = 700 psf, $S_{u(r)}$ = 50 psf		
						(14 ft-lbs, 1 ft-lb)		
15								
16	FV-2		16			S_u = 550 psf, $S_{u(r)}$ = 50 psf		
						(11 ft-lbs, 1 ft-lb)		
17								
18	FV-3		18			S_u = 300 psf, $S_{u(r)}$ = 50 psf		
						(6 ft-lbs, 1 ft-lb)		
19								
20	FV-4		20			S_u = 650 psf, $S_{u(r)}$ = 150 psf		
						(13 ft-lbs, 3 ft-lbs)		
21						Vane Push Refusal at 20.5', Refusal on Probable Sand-		
						Silt seam		
22						Solid Stem Rod Probe to Refusal		
					-13+/-	End of Exploration at 21.1', Refusal on Bedrock		21.1'
								BEDROCK

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
Su = Undrained Shear Strength, Su(r) = Remolded Shear Strength

Bedrock Joints
Shallow = 0 to 35 degrees
Dipping = 35 to 55 degrees
Steep = 55 to 90 degrees

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SOIL BORING LOG		Boring #:	B-2
Project:	Roadway Evaluation	Project #:	23130
Location:	North Haven Road	Sheet:	1 of 2
City, State:	Vinalhaven, Maine	Chkd by:	CWC

SUMMIT GEOENGINEERING SERVICES

Drilling Co:	Summit Geoengineering Services
Driller:	S. Floyd
Summit Staff:	C. Sullivan, E.I.
Boring Elevation:	6 ft +/-
Reference:	Estimated from Boring Location Plan by SGS and 1' Lidar Contours Obtained from N.O.A.A.
Date started:	6/6/2023
Date Completed:	6/6/2023

DRILLING METHOD		SAMPLER	
Vehicle:	Trailer	Length:	24" SS
Model:	9630 Pro	Diameter:	2"OD/1.5"ID
Method:	3" Casing	Hammer:	140 lb
Hammer Style:	Auto	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
6/6/2023	2.3 ft	4 ft +/-	Measured in 5' of augers at 12PM

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	SP-1	12/12	0 - 1	PUNCH		7" Bituminuous Pavement		PAVEMENT
1				PUNCH	5+/-			0.6' +/-
	S-1	24/15	1 - 3	11		Gray Gravelly SAND, little Silt, compact-dense, damp,	GRAVEL = 42%	ROADWAY FILL
2				19		SW-SM	SAND = 50%	
				16			FINES = 8%	
3				18			MC = 2.7%	
	S-2	24/17	3 - 5	29		Same as above, black asphalt fragments from 3.2'-3.6',		
4				19		compact-dense, moist-wet, SP to SP-SM		
				22	2+/-	Brown medium-fine SAND, little Gravel & Silt,		3.6' +/-
5				16		slightly mottled, dense, wet, SP-SM		FILL
	S-3	16/3	5 - 6.3	6		3"-diameter +/- crushed cobble, pushed cobble in		
6				19		spoon tip		
				50/4"				
7								
8								
					-2+/-	Anticipated change in strata based on drilling resistance		8' +/-
9								SWAMP MARSH
								DEPOSIT
10								
						Attempted Shelby Tube at 10', No Recovery		
11								
12								
13								
14								
15								
	UT-1	30/26.5	15 - 17.5	PUSH		Dark brown fiberous PEAT, trace-little Silt & Clay,	MC = 423.6%	
16				↓		occasional wood fragments, very soft, wet, PT	UC = 840 psf	
							LL = 435, PI = 60	
17								
18								
	UT-2	30/8	18 - 20.5	PUSH		Dark brown fiberous PEAT, trace-little Silt & Clay,	MC = 364.3%	
19				↓		occasional wood fragments, very soft, wet, PT	UC = 1,140 psf	
20								
21	S-4	24/24	20.5 - 22.5	WOH		Dark brown fiberous PEAT, trace-little Silt & Clay, very	MC = 281.4%	
				WOH		soft, wet, PT		
22				WOH	-16+/-	Gray Silty CLAY, black Organic streaks, very soft, wet,	PP = 2,000 psf	21.5'
				WOH		CL	MC = 63.1%	MARINE DEPOSIT

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
Su = Undrained Shear Strength, Su(r) = Remolded Shear Strength

Bedrock Joints
Shallow = 0 to 35 degrees
Dipping = 35 to 55 degrees
Steep = 55 to 90 degrees

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Roadway Evaluation	Boring #:	B-2
Location:	North Haven Road	Project #:	23130
City, State:	Vinalhaven, Maine	Sheet:	2 of 2
		Chkd by:	CWC

Drilling Co:	Summit Geoengineering Services	Boring Elevation:	6 ft +/-
Driller:	S. Floyd	Reference:	Estimated from Boring Location Plan by SGS and 1' Lidar Contours Obtained from N.O.A.A.
Summit Staff:	C. Sullivan, E.I.	Date started: 6/6/2023	Date Completed: 6/6/2023

DRILLING METHOD		SAMPLER	
Vehicle:	Trailer	Length:	24" SS
Model:	9630 Pro	Diameter:	2"OD/1.5"ID
Method:	3" Casing	Hammer:	140 lb
Hammer Style:	Auto	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
6/6/2023	2.3 ft	4 ft +/-	Measured in 5' of augers at 12PM

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
23						Solid Stem Rod Probe to Refusal		MARINE DEPOSIT
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
*40						*Change in Depth Scale		
41								
42								
43								
44								
45						Increase in Density Based on Spear Tip Resistance		44.5'
46					-40+/-	End of Exploration at 45.7', Spear Tip Refusal on Probable Bedrock		45.7' BEDROCK
47								
48								

Granular Soils		Cohesive Soils		% Composition	Soil Moisture Condition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487	Dry: S = 0%
0-4	V. Loose	<2	V. soft		Humid: S = 1 to 25%
5-10	Loose	2-4	Soft	< 5% Trace	Damp: S = 26 to 50%
11-30	Compact	5-8	Firm	5-15% Little	Moist: S = 51 to 75%
31-50	Dense	9-15	Stiff	15-30% Some	Wet: S = 76 to 99%
>50	V. Dense	16-30	V. Stiff	> 30% With	Saturated: S = 100%
		>30	Hard		

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
Bedrock Joints Su = Undrained Shear Strength, Su(r) = Remolded Shear Strength
Shallow = 0 to 35 degrees
Dipping = 35 to 55 degrees
Steep = 55 to 90 degrees

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

SOIL BORING LOG

Project:	Roadway Evaluation	Boring #:	B-3
Location:	North Haven Road	Project #:	23130
City, State:	Vinalhaven, Maine	Sheet:	1 of 1
		Chkd by:	CWC

Drilling Co:	Summit Geoengineering Services	Boring Elevation:	8 ft +/-
Driller:	S. Floyd	Reference:	Estimated from Boring Location Plan by SGS and 1' Lidar Contours Obtained from N.O.A.A.
Summit Staff:	C. Sullivan, E.I.	Date started: 6/6/2023	Date Completed: 6/6/2023

DRILLING METHOD		SAMPLER	
Vehicle:	Trailer	Length:	24" SS
Model:	9630 Pro	Diameter:	2"OD/1.5"ID
Method:	2-1/4" HSA	Hammer:	140 lb
Hammer Style:	Auto	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
6/6/2023	4.6 ft	3 ft +/-	Measured in 10' of augers at 3:15PM

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	SP-1	12/12	0 - 1	PUNCH		7" Bituminuous Pavement		PAVEMENT
1				PUNCH	7+/-	Gray Gravelly SAND, little Silt, compact-dense, damp, SW-SM		0.6' +/- ROADWAY FILL
2								
3								
4					4+/-			4' +/- FILL
5								
	S-1	24/10	5 - 7	18		Dark brown-olive gray Silty SAND, little-some Gravel, compact, wet, SM		
6				14				
				9				
7				3				
	S-2	24/10	7 - 9	1		Dark brown-gray SILT-SAND, little-some Gravel, trace Clay, very loose-soft, wet, ML-SM		7' +/-
8				1				
				2				
9				1				
10								
	S-3	24/10	10 - 12	WOH	-2+/-	Dark brown-olive gray fiberous PEAT, trace-little Silt & Clay, very soft, wet, PT	PP = 2,000 psf to 2,500 psf MC = 143.1%	10' +/- SWAMP MARSH DEPOSIT
11				WOH				
				WOH				
12				WOH				
	S-4	24/15	12 - 14	WOH		Same as above, very soft, wet, PT	MC = 211.7%	
13				WOH		Gray Silty CLAY, trace fine Sand, very soft, wet, CL	PP = 2,000 psf to 2,500 psf MC = 28.7%	12.3' +/-
				WOH				
14				WOH				
						Solid Stem Rod Probe to Refusal		
15								
16								
17								
18								
*21						*Change in Depth Scale		
22						Increase in Density based on Spear Tip Resistance		22'
23								
24					-15+/-	End of Exploration at 23.4', Spear Tip Refusal on Probable Bedrock		23.4' BEDROCK

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
Su = Undrained Shear Strength, Su(r) = Remolded Shear Strength

Bedrock Joints
Shallow = 0 to 35 degrees
Dipping = 35 to 55 degrees
Steep = 55 to 90 degrees

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

APPENDIX C

LABORATORY TEST RESULTS

GRAIN SIZE ANALYSIS - ASTM D6913

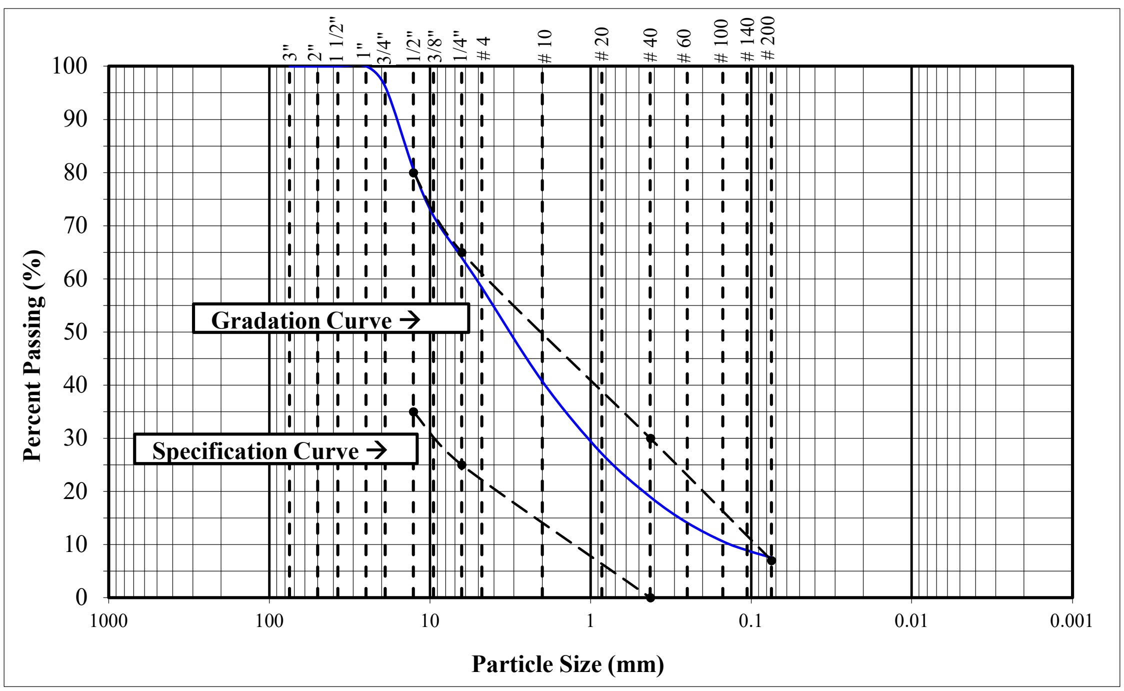
PROJECT NAME:	Roadway Evaluation	PROJECT #:	23130
PROJECT LOCATION:	North Haven Road, Vinalhaven, ME	EXPLORATION #:	B-2
CLIENT:	Woodard & Curran	SAMPLE #:	SP-1
TECHNICIAN:	Colleen Sullivan, E.I.	SAMPLE DEPTH:	0.6' - 1'
SOIL DESCRIPTION:	Gravelly SAND, little Silt, SW-SM	TEST DATE:	6/7/2023

TEST PROCEDURE

Sample Source: Gravel Punch	**Sieve Stack:** Composite	**Specimen Procedure:** Moist
Test Method: Method A	**Separating Sieve(s):** 3/8 Inch	**Dispersion Type:** Tap Water

DATA

STANDARD SIEVE DESIGNATION (mm)	ALTERNATIVE SIEVE DESIGNATION (in)	PERCENT PASSING (%)	MDOT 703.06 Type D
75	(3 in)	100	100
50	(2 in)	100	
37.5	(1-1/2 in)	100	
25.0	(1 in)	100	
19.0	(3/4 in)	96	
12.7	(1/2 in)	81	35 - 80
9.5	(3/8 in)	72	
6.35	(1/4 in)	64	25 - 65
4.75	(No. 4)	58	
2.00	(No. 10)	41	
0.850	(No. 20)	27	
0.425	(No. 40)	19	0 - 30
0.250	(No. 60)	14	
0.150	(No. 100)	11	
0.106	(No. 140)	9	
0.075	(No. 200)	8	0 - 7



REMARKS: Moisture Content = 2.7%

Reviewed By: ELS

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Office: 210 Maine Avenue, Farmingdale, ME 04344

Laboratory Determination of Water (Moisture) Content of Soil ASTM D2216

PROJECT NAME:	Roadway Evaluation	PROJECT #:	23130
PROJECT LOCATION:	North Haven Road, Vinalhaven, Maine	DRYING METHOD:	Oven Dried
CLIENT:	Woodard & Curran	DESCRIPTION:	Peat & Glacial Marine
SOURCE:	Borings	TECHNICIAN:	Colleen Sullivan, E.I.
COLLECTION DATE:	06/06/23	TESTING DATE:	06/07/23

Location	Sample No.	Depth	Moisture Content	Remarks
B-1	S-5a	10' - 10.7'	147.9%	Peat
B-1	S-5b	10.7' - 12'	25.9%	Silty Clay
B-2	SP-1	0' - 1'	2.7%	(Grain Size Analysis)
B-2	UT-1	15' - 17.5'	423.6%	(Unconfined Compression)
B-2	UT-2	18' - 20.5'	364.3%	(Unconfined Compression)
B-2	S-4a	20.5' - 21.5'	281.4%	Peat
B-2	S-4b	21.5' - 22.5'	63.1%	Silty Clay
B-3	S-3	10' - 12'	143.1%	Peat
B-3	S-4a	12' - 12.3'	211.7%	Peat
B-3	S-4b	12.3' - 14'	28.7%	Silty Clay

REMARKS:

Reviewed By: ELS

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Office: 210 Maine Avenue, Farmingdale, ME 04344

SOIL BOX RESISTIVITY REPORT
WENNER FOUR-ELECTRODE METHOD ASTM G57

Project #: 23130

Project Name: Roadway Evaluation

Project Location: North Haven Road, Vinalhaven, Maine

Collection Date: 6/6/2023

Test Date: 6/7/2023

Technician: Colleen Sullivan, E.I.

Test Performed: In lab

Test Procedure: Resistivity testing was performed using the Wenner Four-Electrode Soil Box method in accordance with ASTM G57. The small soil box used has approximate interior dimensions of 4.4 inches (11.2 cm) long, 1.2 inches (3.0 cm) wide, and 1.0 inches (2.5 cm) high with a total volume of 80 cm^3. The cross sectional area of the box is 7.2 cm^2 and the pins are spaced at 7.2 cm apart. Resistivity results are presented in the following table. Resistivity values were calculated using the following equation:

Resistivity (p) in ohm-cm = R*(A/L) (R=resistance in ohms, A=cross sectional are in cm^2, L=distance between pins in cm).
Resistivity (p) in ohm-cm = R*(7.2 cm^2/7.2 cm) = R*1

Soil Description: Swamp Marsh Deposit (Fiberous Peat)

Test Results:

Wenner Four-Electrode Soil Box Resistivity Test

Boring #	Sample #	Sample Description	Sample State	Sample Depth	Dial Multiplier	Measured Resistance (ohms)	Resistivity (ohm-cm)
B-2	UT-1	Peat	Saturated	15' - 17.5'	100	1.70	170
B-2	S-4a	Peat	Saturated	20.5' - 21.5'	100	1.60	160
B-3	S-3	Peat	Saturated	10' - 12'	1,000	2.60	2,600

MIN	160
MAX	2,600
AVG	977
STD	1,406

Remarks: The resistivity for the fiberous peat at boring B-2 at depths of 15 to 21.5 feet ranges from 160 to 170 ohm-cm, while the resistivity of the peat soil at boring B-3 at 10 to 12 feet is 2,600 ohm-cm. The small soil box was used to test all samples.

Reviewed By: ELS

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THIN WALLED TUBE SAMPLING - ASTM D1587

PROJECT NAME: Roadway Evaluation
PROJECT LOCATION: North Haven Road, Vinalhaven, ME
COLLECTION DATE: 6/6/2023
TEST DATE: 6/7/2023

PROJECT #: 23130
CLIENT: Woodard & Curran
SAMPLE #: UT-1
TECHNICIAN: Colleen Sullivan, E.I.

Test Boring Information

Boring Number: B-2
Drilling Method: Direct Push
Drilling Tooling: 3-inch Casing
Sampling Method: Tube Push

Sample Information

Tube Length: 30"
Recovery: 26.5"
Tube Diameter: 2.5"
Depth: 15' - 17.5'

Trial / Specimen Number	Moisture Content	Unit Weight	Torvane
1	418.8%	70 pcf	*
2	458.9%	62 pcf	*
3	439.2%	64 pcf	*
Average	439.0%	66 pcf	*

*Torvanes not conducted due to soil consistency

Visual Description (ASTM D2488):

Dark brown fiberous PEAT, trace-little Silt & Clay, occasional wood fragments, very soft, wet, PT

Photograph of cross sectional sample view.

Photograph of longitudinal sample view.

REMARKS:

Reviewed By: ELS

Mailing: PO Box 515, Gardiner, ME 04345
Office: 210 Maine Avenue, Farmingdale, ME 04344

SUMMIT GEOENGINEERING SERVICES

ATTERBERG LIMIT TEST - ASTM D4318

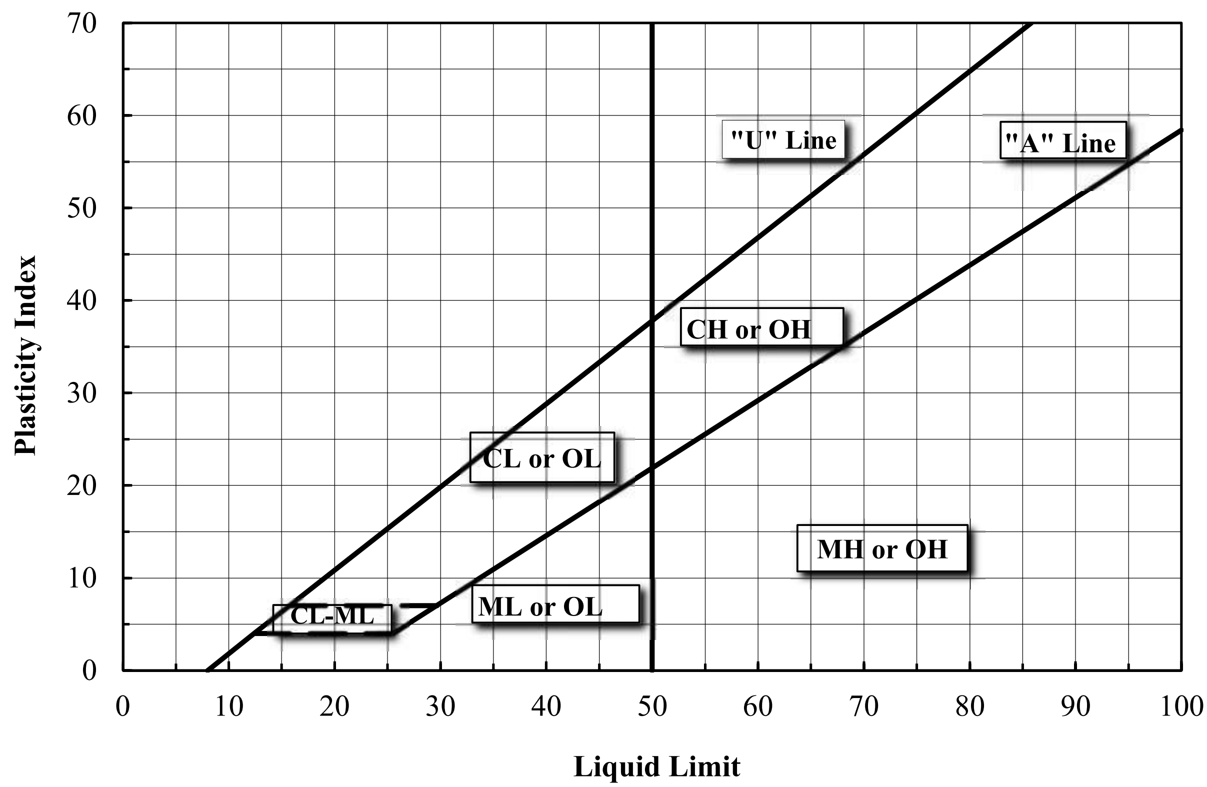
Method "A" (Multi-point)

PROJECT NAME:	Roadway Evaluation	PROJECT NUMBER:	23130
LOCATION:	North Haven Rd, Vinalhaven, Maine	SAMPLE NUMBER:	UT-1
CLIENT:	Woodard & Curran	DEPTH:	15' - 17.5'
TEST DATE:	6/14/2023	TECHNICIAN:	Erika Stewart, P.E.

DATA

Source	Depth	LL	PL	PI	Classification
B-2	15' - 17.5'	435	375	60	Dark brown fibrous PEAT, PT

*Sample plots off Casagrande's plasticity chart. Atterberg Limits are not strictly applicable to peat soils due to high organic content. Visual observations of soil behavior during the test indicate the soil is highly sensitive to moisture content and has low plasticity (PI is low relative to LL). Water is easily squeezed out of the soil.



Notes: Moisture Content = 423%

Reviewed By: CRS

Mailing: PO Box 515, Gardiner, ME 04345
Office: 210 Maine Avenue, Farmingdale, ME 04344

SUMMIT
GEOENGINEERING SERVICES

UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS - ASTM D2166

PROJECT NAME:	Roadway Evaluation	PROJECT #:	23130
PROJECT LOCATION:	North Haven Road, Vinalhaven, ME	CLIENT:	Woodard & Curran
COLLECTION DATE:	6/6/2023	TECHNICIAN:	Colleen Sullivan, E.I.
TEST DATE:	6/7/2023	CHECKED BY:	Erika Stewart, P.E.

Sample & Testing Information

Boring Number:	B-2	**Trimming Method:**	Tube	
Sample Number:	UT-1	**Liquid Limit (LL):**	435	
Sample Depth:	15' - 17.5'	**Plasticity Index (PI):**	60	
Sample Type:	Tube	**Rate of Strain:**	0.1	in/min
Sample State:	Intact	**H/D Ratio:**	2.3	

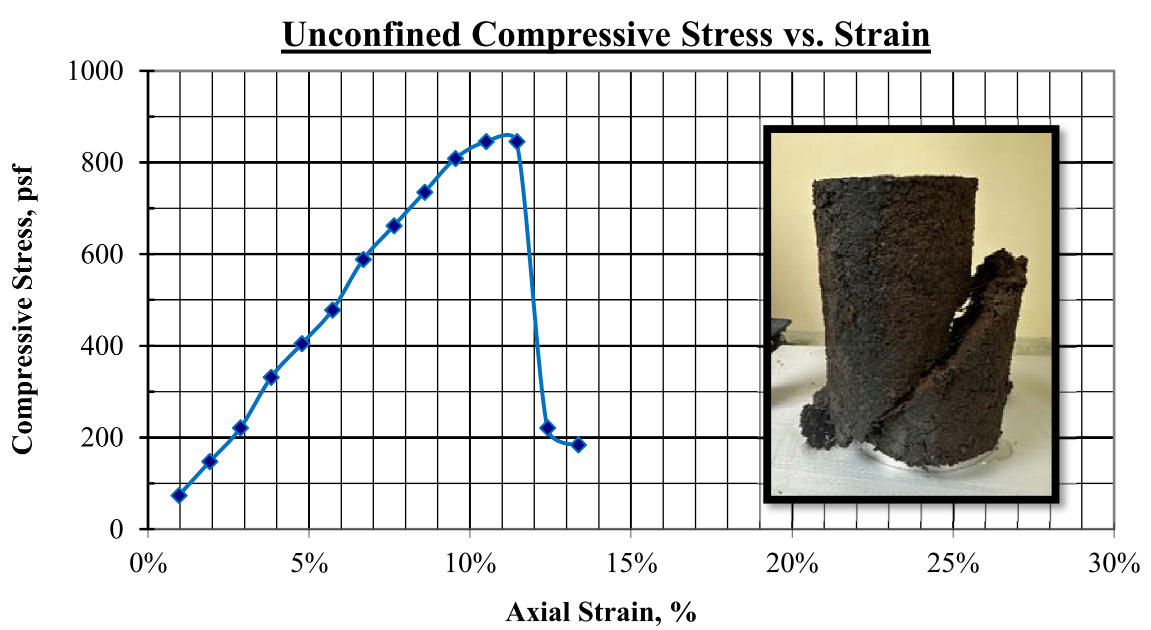
Sample Height:	5.24	in	**Sample Mass:**	377.7	g
Sample Diameter:	2.23	in	**Moisture Content:**	423.6%	
Sample Volume:	20.52	in^3	**Moist Unit Weight:**	70	pcf
Cross Sectional Area:	3.92	in^2	**Dry Density:**	13	pcf

Sample Description & Classification

Dark brown fiberous PEAT, trace-little Silt & Clay, occasional wood fragments, very soft, wet, PT

Test Results

Unconfined Compressive Strength:	840	psf	**Strain at Failure:**	11%
Shear Strength:	420	psf	**Failure Type:**	Shear



REMARKS:

Mailing: PO Box 515, Gardiner, ME 04345
Office: 210 Maine Avenue, Farmingdale, ME 04344

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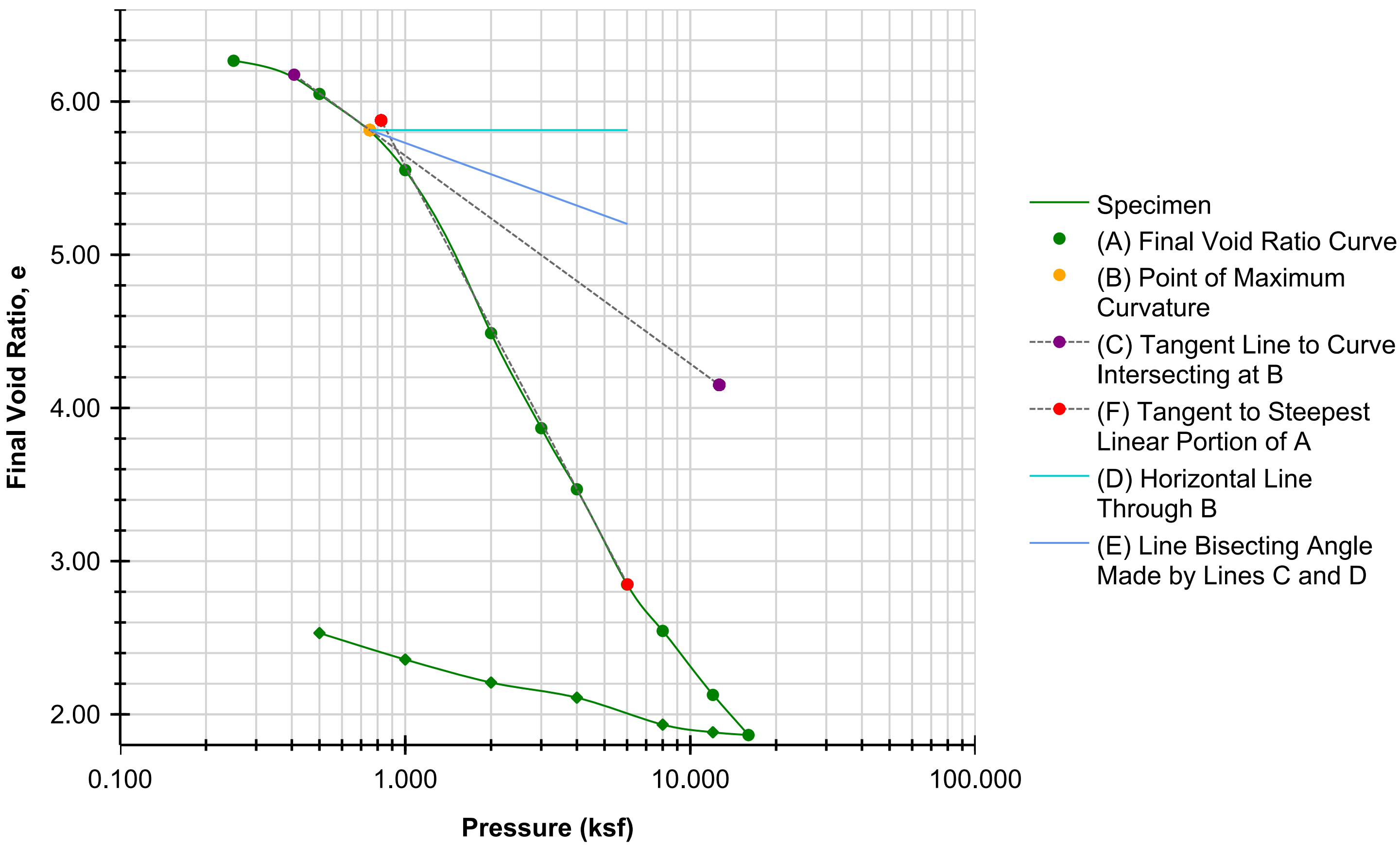
PO Box 515
Gardiner, Maine 04345

Final Voids [Log]

ASTM D2435



Preconsolidation Stress (ksf)	0.885	**Cc**	3.467	**Cr**	0.523

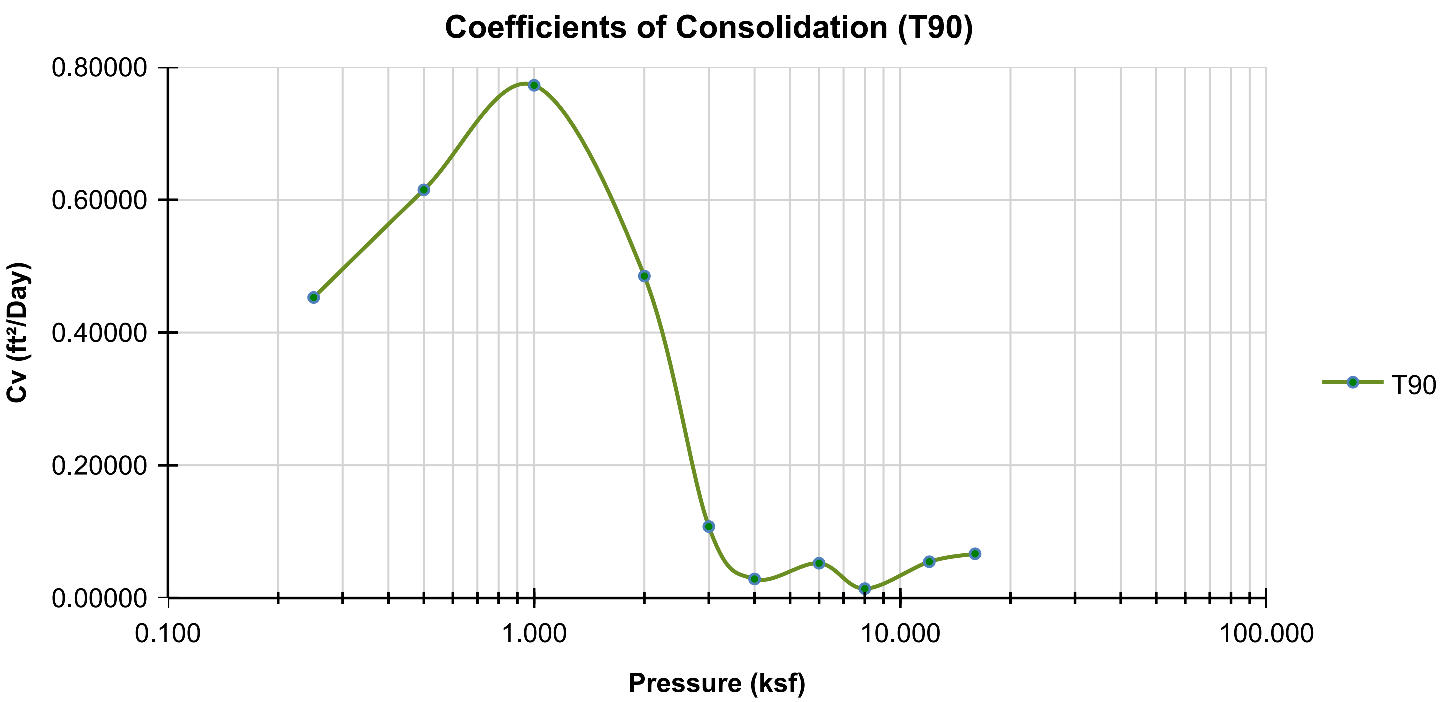
	BEFORE	AFTER			
			Liquid Limits	435	**Test Date** 6/7/2023
Moisture (%)	437.2	226.7	**Plastic Limits**	60	
Dry Density (pcf)	11.9	23.3			
Saturation (%)	96.0	115.5			
Void Ratio	6.38	2.75	**Specific Gravity**	1.4	ASSUMED

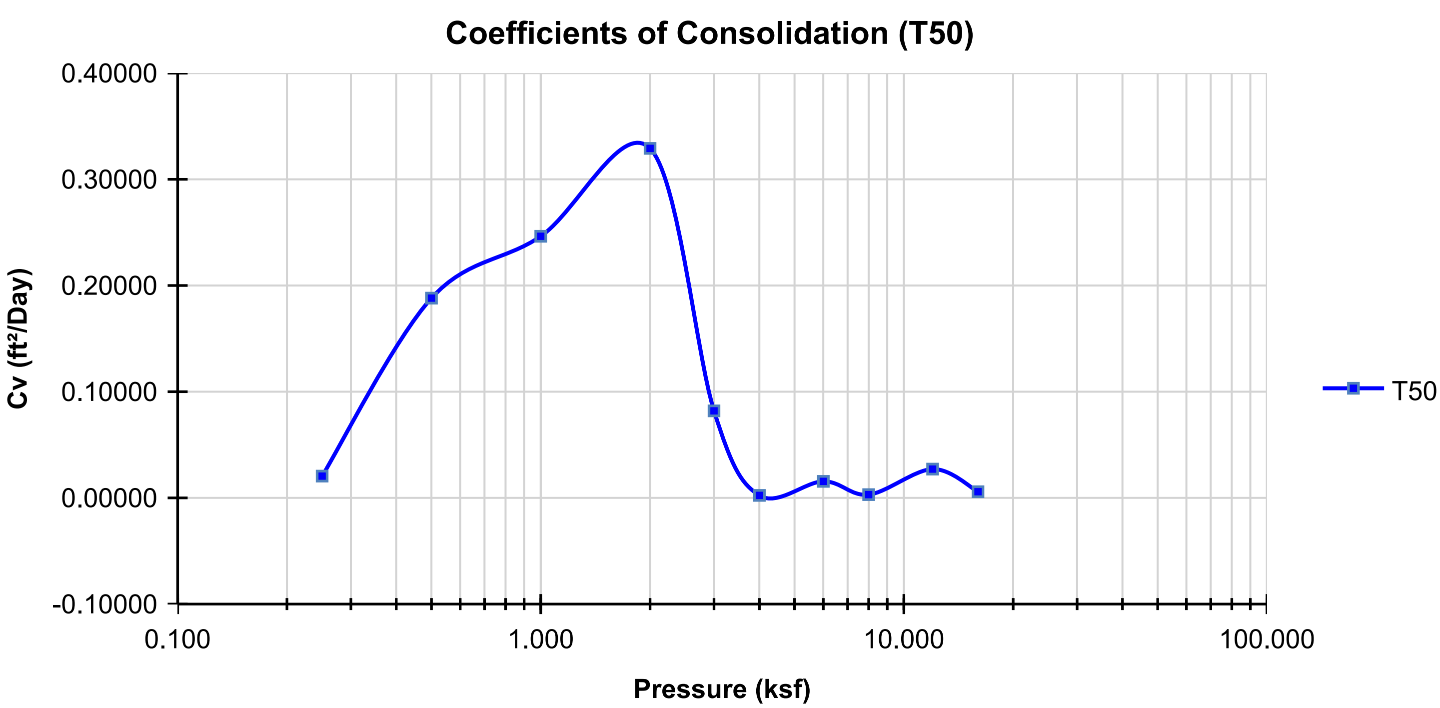
Sample Description	Dark brown fibrous PEAT, little to trace Silt & Clay, very soft, wet, PT			
Project Number	23130	**Depth (ft)**	15-17.5	**Remarks**
Sample Number	UT-1	**Boring Number**	B-2	
Project	Roadway Evaluation			
Client	Woodard & Curran			
Location	North Haven Road, Vinalhaven, Maine			

Summit Geoengineering Services
PO Box 515
Gardiner, Maine 04345

Coefficients of Consolidation

ASTM D2435





THIN WALLED TUBE SAMPLING - ASTM D1587

PROJECT NAME: Roadway Evaluation
PROJECT LOCATION: North Haven Road, Vinalhaven, ME
COLLECTION DATE: 6/6/2023
TEST DATE: 6/9/2023

PROJECT #: 23130
CLIENT: Woodard & Curran
SAMPLE #: UT-2
TECHNICIAN: Colleen Sullivan, E.I.

Test Boring Information

Boring Number: B-2
Drilling Method: Direct Push
Drilling Tooling: 3-inch Casing
Sampling Method: Tube Push

Sample Information

Tube Length: 30"
Recovery: 8"
Tube Diameter: 2.5"
Depth: 18' - 20.5'

Trial / Specimen Number	Moisture Content	Unit Weight	Torvane
1	365.8%	69 pcf	*
2	371.0%	66 pcf	*
3	363.3%	66 pcf	*
Average	366.7%	67 pcf	*

*Torvanes not conducted due to soil consistency

Visual Description (ASTM D2488):

Dark brown fiberous PEAT, trace-little Silt & Clay, occasional wood fragments, very soft, wet, PT

Photograph of cross sectional sample view.

Photograph of longitudinal sample view.

REMARKS:

Reviewed By: ELS

UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS - ASTM D2166

PROJECT NAME:	Roadway Evaluation	PROJECT #:	23130
PROJECT LOCATION:	North Haven Road, Vinalhaven, ME	CLIENT:	Woodard & Curran
COLLECTION DATE:	6/6/2023	TECHNICIAN:	Colleen Sullivan, E.I.
TEST DATE:	6/9/2023	CHECKED BY:	Erika Stewart, P.E.

Sample & Testing Information

Boring Number:	B-2	**Trimming Method:**	Tube
Sample Number:	UT-2	**Liquid Limit (LL):**	--
Sample Depth:	18' - 20.5'	**Plasticity Index (PI):**	--
Sample Type:	Tube	**Rate of Strain:**	0.1 in/min
Sample State:	Intact	**H/D Ratio:**	2.1

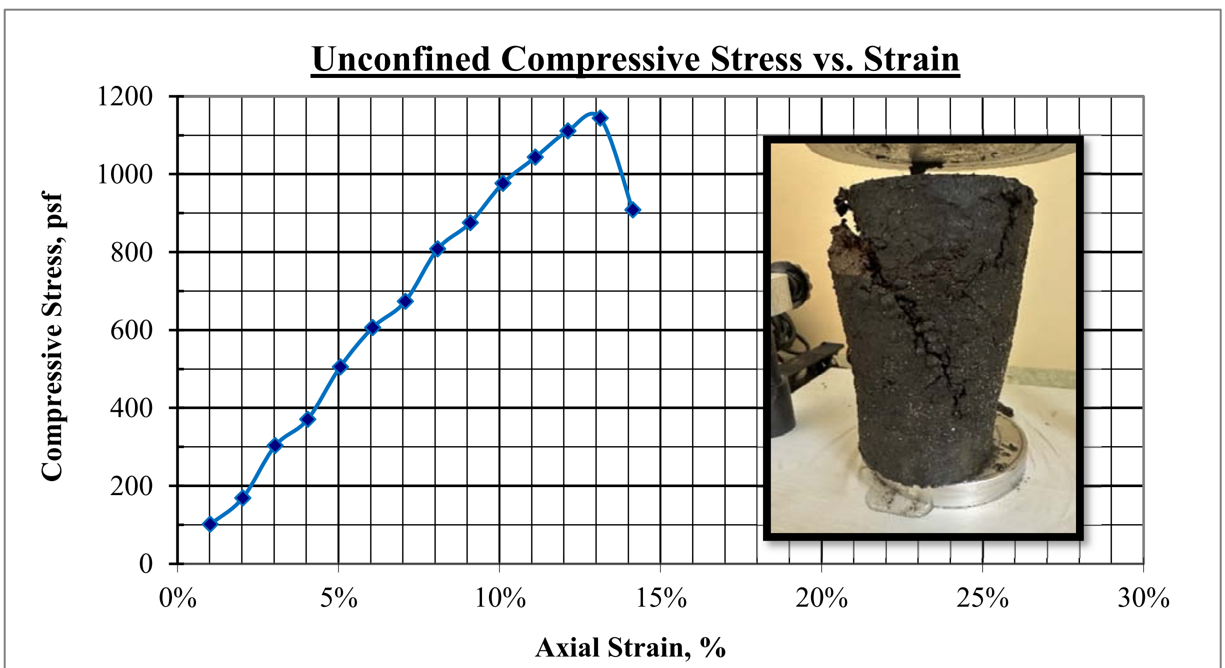
Sample Height:	4.95 in	**Sample Mass:**	380.1 g
Sample Diameter:	2.33 in	**Moisture Content:**	364.3%
Sample Volume:	21.17 in^3	**Moist Unit Weight:**	68 pcf
Cross Sectional Area:	4.27 in^2	**Dry Density:**	15 pcf

Sample Description & Classification

Dark brown fiberous PEAT, trace-little Silt & Clay, occasional wood fragments, very soft, wet, PT

Test Results

Unconfined Compressive Strength:	1140 psf	**Strain at Failure:**	13%
Shear Strength:	570 psf	**Failure Type:**	Shear



REMARKS:

Mailing: PO Box 515, Gardiner, ME 04345
Office: 210 Maine Avenue, Farmingdale, ME 04344

Maine Environmental Laboratory

1 Main Street, Yarmouth, ME 04096 Tel.: 207-846-6569 FAX: 207-846-9066 Email: melab@mel-lab.com

Report of Analyses

Report Prepared for:

Colleen Sullivan
Summit Geoengineering Services
210 Maine Ave.
Farmingdale, ME 04344

Report Information:

Batch ID: SME 15037
Report ID: 15037-230621-1025
Date of Issue: June 21, 2023

The complete report consists of the following parts:
Maine Environmental Laboratory report
Chain of Custody form

REPORT NARRATIVE:
Enclosed are results of the analyses for your samples as received by the laboratory. Results are for the exclusive use of the client named on the report and will not be released to a third party without written consent. This report shall not be reproduced except in full without the written consent of the laboratory.

Maine Environmental Laboratory is accredited by the States of Maine (Cert. #ME00028) and New Hampshire (NH ELAP) (Cert. #2031) and is TNI/NELAP accredited. Please refer to our website www.maineenvironmentallaboratory.com for a copy of our Maine and NH ELAP certificates and accreditied parameters. When a subcontracted laboratory is listed above, the data produced is by a Maine accredited laboratory accredited for the fields of testing performed.

Unless otherwise noted:
- Samples were received in acceptable condition and analyzed within method hold times.
- Soils, sediments, solids and tissues are reported on dry weight basis. Wipes are reported on an "as received" basis.
- All quality control data demonstrated acceptable limits
- The results reported herein conform to the most current NELAP standards where applicable.
- Analysis of solids for pH, flash point, ignitability, paint filter, corrosivity, conductivity and specific gravity are reported on an "as received" basis.
- Results for "immediate" field parameters tested at the lab such as pH were run outside of the EPA-recommended hold time.
- %RPD is not calculated when the native sample concentration is below 5 x LOQ.

DEFINITIONS:
LOQ / RL - The Limit of Quantitation / Reporting Limit is the minimum level for reporting quantitative data.
LOD / MDL - The Limit of Detection / Method Detection Limit is the minimum level for reporting estimated data.
J - Data reported between the Limit of Quantitation and Limit of Detection is J-flagged as "estimated."
ND or U - Not detected below the LOD / MDL
B – Detected in QC blank
S – Detection Limits increased due to sample matrix
4X – Native sample concentration was greater than 4 times the spike concentration so the spike added could not be distinguished from the native concentration.
% Rec – Percent Recovery; RPD - Relative Percent Difference
D – Duplicate sample
R – Reanalysis
DO – BOD: insufficient dissolved oxygen depletion to calculate Matrix Spike and MSD recoveries.

METHOD REFERENCES:
D2947: Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Organic Soils.
SM2540G: Standard Methods for the Examination of Water and Wastewater, 18th edition.
SW9045D: SW846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, USEPA, third edition. Updates I-IV, 2007.
SW9056A: SW846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, USEPA, third edition. Updates I-IV, 2007.

This report has been reviewed and authorized by
Jacquelyn R. Villinski, Laboratory Director: Jacquelyn R. Villinski

Maine Environmental Laboratory

Report of Analyses

One Main Street, Yarmouth, ME 04096 Tel.: 207-846-6569 FAX: 207-846-9066 Email: melab@mel-lab.com

Colleen Sullivan
Summit Geoengineering Services
210 Maine Ave.
Farmingdale, ME 04344

June 21, 2023

Report ID:	15037-230621-1025	Sample ID:	#23130 B-2, UT-1 (15-17.5')
Batch ID:	SME 15037	Sample date:	06/06/23 13:00
Date received:	06/07/23	Sample matrix:	SL - grab
Project ID:	Roadway Evaluation	Laboratory ID:	230607Q002

Parameter	Results	Units	Date Analyzed	Time Analyzed	LOD	LOQ	Method	Tech
Total Solids	17.29	%	06/08/23	14:00		0.01	SM2540G	DJC
Chloride	36,000	mg/kg	06/08/23	8:43	4.6	12	SW9056A	AD
Moisture	82.71	%	06/08/23	14:00		0.01	SM2540G	DJC
Organic Matter	72.20	%	06/19/23	9:40		0.01	D2947	DJC
pH @ 25°C	7.42	STU	06/19/23	14:00		0.01	SW9045D	DJC
Sulfate	230	mg/kg	06/08/23	8:43	8.1	23	SW9056A	AD

Notes:

Maine Environmental Laboratory

Report of Analyses

One Main Street, Yarmouth, ME 04096 Tel.: 207-846-6569 FAX: 207-846-9066 Email: melab@mel-lab.com

Colleen Sullivan
Summit Geoengineering Services
210 Maine Ave.
Farmingdale, ME 04344

June 21, 2023

Report ID:	15037-230621-1025	Sample ID:	#23130 B-2, S-4a (20.5-21.5')
Batch ID:	SME 15037	Sample date:	06/06/23 13:30
Date received:	06/07/23	Sample matrix:	SL - grab
Project ID:	Roadway Evaluation	Laboratory ID:	230607Q003

Parameter	Results	Units	Date Analyzed	Time Analyzed	LOD	LOQ	Method	Tech
Total Solids	33.18	%	06/08/23	14:00		0.01	SM2540G	DJC
Chloride	12,000	mg/kg	06/08/23	8:43	1.2	3	SW9056A	AD
Moisture	66.82	%	06/08/23	14:00		0.01	SM2540G	DJC
Organic Matter	19.35	%	06/19/23	9:40		0.01	D2947	DJC
pH @ 25°C	7.63	STU	06/19/23	14:00		0.01	SW9045D	DJC
Sulfate	59	mg/kg	06/08/23	8:43	2.1	6	SW9056A	AD

Notes:

Maine Environmental Laboratory

Report of Analyses

One Main Street, Yarmouth, ME 04096 Tel.: 207-846-6569 FAX: 207-846-9066 Email: melab@mel-lab.com

Colleen Sullivan
Summit Geoengineering Services
210 Maine Ave.
Farmingdale, ME 04344

June 21, 2023

Report ID:	15037-230621-1025	Sample ID:	#23130 B-3, S-3 (10-12')
Batch ID:	SME 15037	Sample date:	06/06/23 15:00
Date received:	06/07/23	Sample matrix:	SL - grab
Project ID:	Roadway Evaluation	Laboratory ID:	230607Q004

Parameter	Results	Units	Date Analyzed	Time Analyzed	LOD	LOQ	Method	Tech
Total Solids	48.04	%	06/08/23	14:00		0.01	SM2540G	DJC
Chloride	92	mg/kg	06/08/23	8:43	0.8	2	SW9056A	AD
Moisture	51.96	%	06/08/23	14:00		0.01	SM2540G	DJC
Organic Matter	14.21	%	06/19/23	9:40		0.01	D2947	DJC
pH @ 25°C	7.56	STU	06/19/23	14:00		0.01	SW9045D	DJC
Sulfate	ND	mg/kg	06/08/23	8:43	1.4	4	SW9056A	AD

Notes:

Maine Environmental Laboratory

One Main Street, Yarmouth, ME 04096 Tel: 207-846-6569 FAX: 207-846-9066 Email: melab@mel-lab.com

Report of Analyses

Colleen Sullivan
Summit Geoengineering Services
210 Maine Ave.
Farmingdale, ME 04344

Date of Issue: 6/21/2023

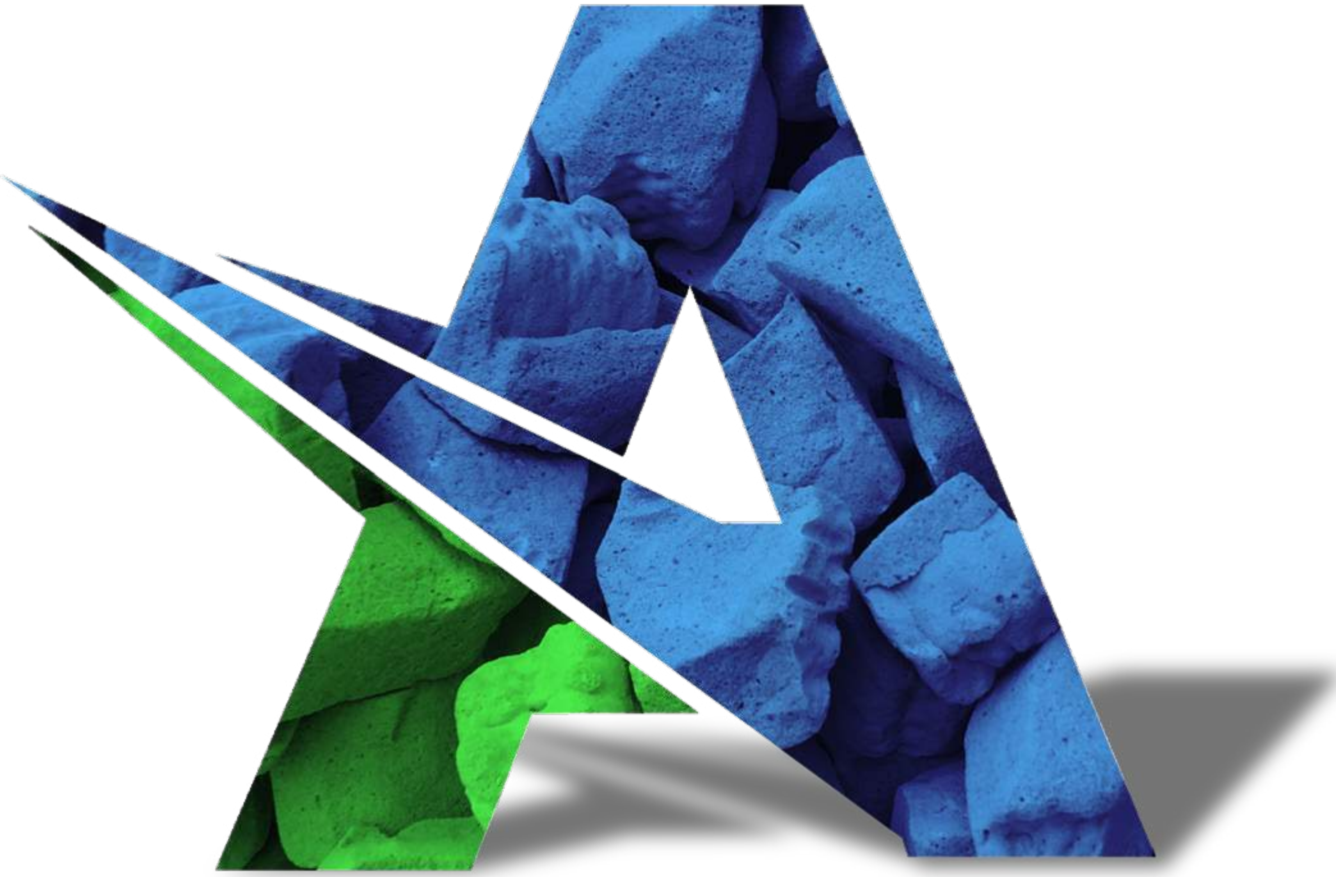
Report ID: 15037-230621-1025

QC Data
Method Blanks, Laboratory Control Samples, Sample QC

Analyte	QCType	Result	Value	Units	Max	Min	Reference	Ref. Value	Units	Lab SampleID
Chloride	Duplicate - S	RPD	2.0	%	16		Conc	34991.3	mg/kg	230607Q002
Chloride	LCS - S	Rec	99	%	121	79	Conc	497	mg/kg	
Chloride	Matrix Spike - S	Rec	100	%	121	79				230607Q002
Chloride	Method Blank - S	Conc	14 U	mg/kg	50					
Organic Matter	LCS - S	Rec	100	%	121	79	Conc	69.8	mg/kg	
Organic Matter	Method Blank - S	Conc	0 U	mg/kg	0.014					
pH @ 25°C	Duplicate - pH	RPD	0.0	%	3		Conc	7.6	STU	230607Q003
pH @ 25°C	LCS - pH 3.00	Rec	100	%	103	97	pH	3.01	STU	
pH @ 25°C	LCS - pH 5.00	Rec	100	%	103	97	pH	5	STU	
pH @ 25°C	LCS - pH 9.00	Rec	99	%	103	97	pH	8.93	STU	
Sulfate	Duplicate - S	RPD	0.0	%	16		Conc	209.4	mg/kg	230607Q002
Sulfate	LCS - S	Rec	98	%	121	79	Conc	980	mg/kg	
Sulfate	Matrix Spike - S	Rec	91	%	121	79				230607Q002
Sulfate	Method Blank - S	Conc	13 U	mg/kg	27					
Total Solids	LCS - S	Rec	100	%	121	79	Conc	49.9	mg/kg	
Total Solids	Method Blank - S	Conc	0 U	mg/kg	0.014			0.01		

APPENDIX D

PRODUCT SHEETS



AERO AGGREGATES

Ultra-Lightweight

Foamed Glass Aggregate (UL-FGA®)

MATERIAL & APPLICATIONS

HIGHLY FRICTIONAL • NON-LEACHING • ROT-RESISTANT • NON-FLAMMABLE • DURABLE • SAFE

made from recycled container glass

made from recycled container glass

aeroaggregates.com

UL-FGA®

AeroAggregates produces ultra-lightweight foamed glass aggregate (UL-FGA) from recycled container glass

The idea of foaming waste glass to create a building material has been known for decades but it wasn't until the 1980s when full scale production began in Europe. These aggregates are 85-90% lighter than quarried aggregates, have a high friction angle, and are good insulators due to their closed cell structure. The manufacturing process converts glass cullet into a chemically stable, non-leaching, rot-resistant, non-flammable and durable construction material.

The initial use of UL-FGA was to prevent frost heave in frost susceptible soils throughout Scandinavia. However, the low unit weight and high frictional properties of the material led to other applications and the demand for UL-FGA has continued to increase.

Current civil engineering challenges require construction on soft soils, reduction of lateral earth pressures, decreased loads on structures, and the protection of tunnels and underground utilities. The unique properties of UL-FGA can address these challenges and be a sustainable solution through the beneficial reuse of glass containers.

APPLICATIONS	UL-FGA has been successfully used in building and infrastructure construction projects for over 25 years.

INFRASTRUCTURE

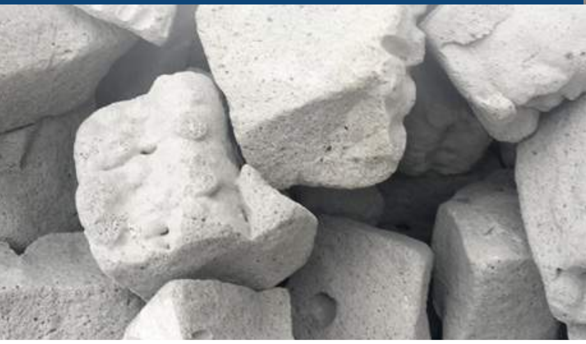
- Embankments
- Retaining Walls & Bridge Abutments
- Roadway Widening
- Tunnels & Culverts
- Utilities
- Load Distribution

COMMERCIAL CONSTRUCTION

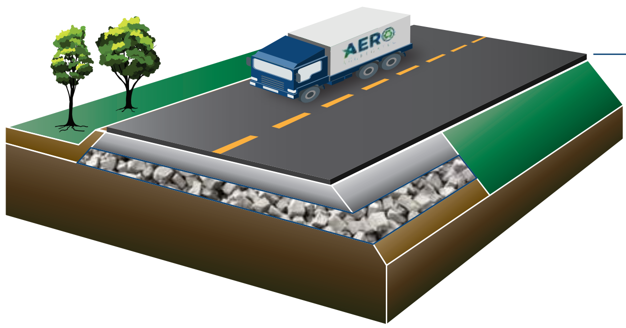
- Foundation Walls & Slabs
- Greenroofs
- Plaza Decks

HIGHLY FRICTIONAL • NON-LEACHING • ROT-RESISTANT • NON-FLAMMABLE • DURABLE • SAFE

INFRASTRUCTURE



Ultra-lightweight aggregate provides solutions for the challenges of today's infrastructure projects. Foamed glass aggregate is ideal for projects that require fill to be placed over soft compressible soils or over areas with underground utilities. Large embankments can be built with low net surcharge due to the low unit weight and high friction angle of UL-FGA.

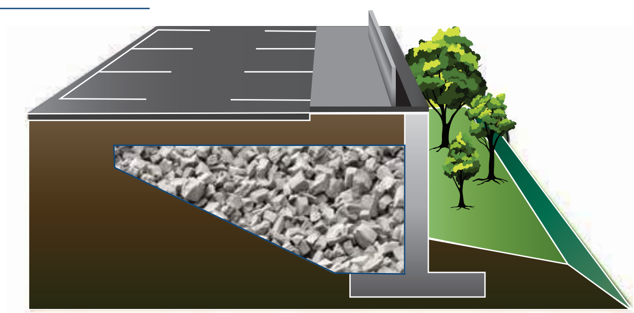


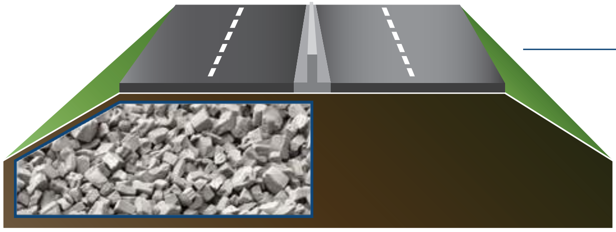
EMBANKMENTS

- Lightweight fill over compressible soils and/or utilities
- Insulating fills for frost susceptible soils
- Resiliency projects requiring fill on soft soil
- Reduced excavation for soil balancing
- Less soil removal and disposal
- Potential to stay out of the water table

RETAINING WALLS & BRIDGE ABUTMENTS

- Lightweight fill behind retaining walls and wing walls
- Greatly reduces lateral load
- Easily excavated for placement or repair of utilities
- Pullout testing completed on various types of reinforcement
- Free draining material
- Reduces settlement of embankments for bridge approaches



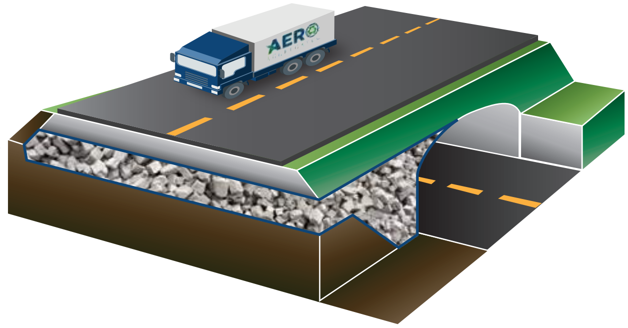


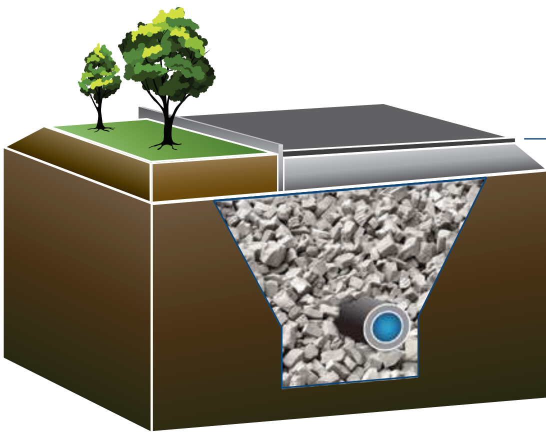
ROADWAY WIDENING

- Roadway widening and shoulder repair
- Slopes up to 1:1 can be built without additional reinforcement
- Increased slope inclination helps with right-of-way limitations

TUNNELS & CULVERTS

- Lightweight backfill over and around tunnels and culverts



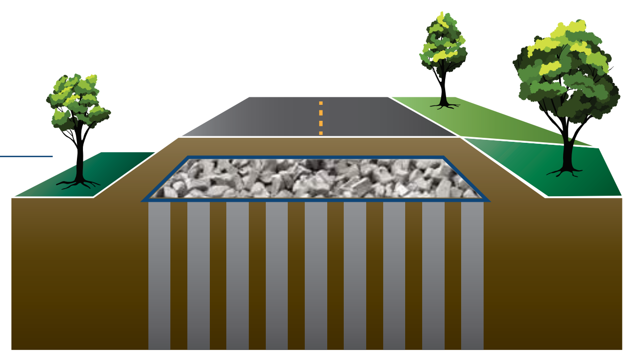


UTILITIES

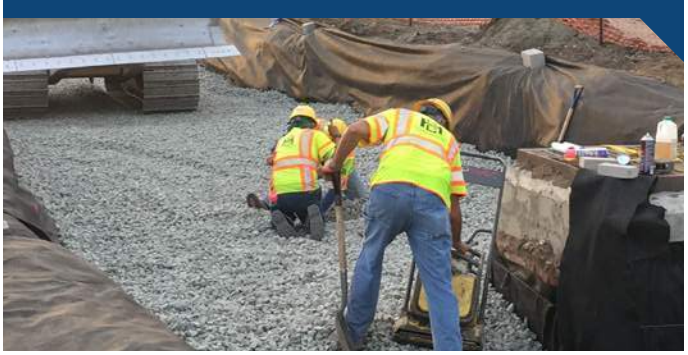
- Lightweight backfill for sensitive utilities
- Bedding layer for utilities on soft compressible soils
- Insulating backfill for frost protection
- High friction angle creates soil arching to further reduce loads on utilities
- Heat resistant up to 800° F

LOAD DISTRIBUTION

- Reduced weight of embankment fill over load distribution platforms
- Optimize number of piles
- Use in locations where in situ ground improvement is not possible due to underground utilities



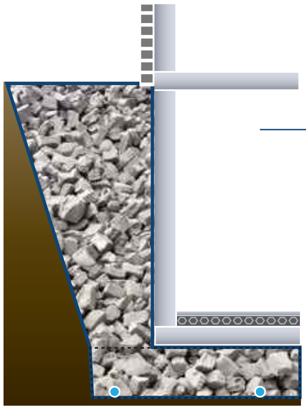
ACCELERATED CONSTRUCTION DUE TO LIFT THICKNESS



UP TO 100 CUBIC YARDS PER TRUCK

COMMERCIAL

AeroAggregates UL-FGA provides multiple functions in commercial construction applications. Foamed glass aggregate is lightweight against foundation walls or under slabs and provides excellent insulation and drainage. In addition, UL-FGA is not flammable, will not rot or decay, and is easy to place, especially in difficult to reach areas or confined spaces.

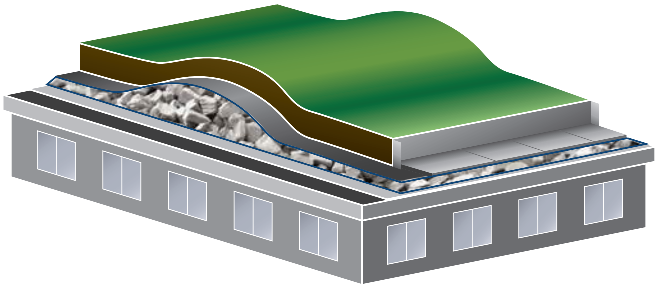


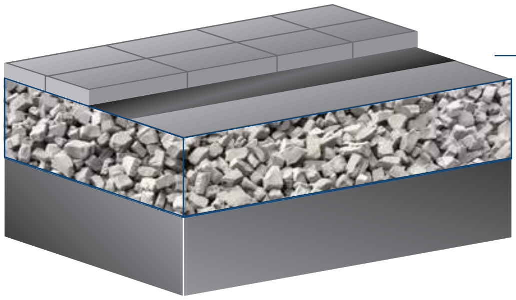
FOUNDATION WALLS & SLABS

- Support of excavation backfill and retaining walls
- Under concrete slabs – as a capillary break and insulator
- Vertical backfill for insulation drainage, and reduced load
- Rot-resistant, non-flammable
- Insulation protection against frost heave

GREENROOFS

- Easily contours and shapes due to friction angle of aggregate
- Insulating and draining layer on roofs
- Reduces load on roof structure





PLAZA DECKS

- Insulates substructure or protects against frost heave
- Free draining
- Reduces load on roof structure or soft soils

AERO AGGREGATES

TECHNICAL DATA

AERO AGGREGATES®

AeroAggregates UL-FGA G15

Ultra-Lightweight Foamed Glass Aggregate

Density (Unit Weight)	
Uncompacted dry bulk density (ASTM C29/C29M/ AASHTO T 19)[1]	12-15 pcf
Estimated compacted dry density	
1.11 Compression Ratio (10% Compaction of Each Lift)	13.3-16.7 pcf
1.25 Compression Ratio (20% Compaction of Each Lift)	15-18.8 pcf
Estimated buoyant unit weight	-15 pcf

Typical Gradation Characteristics (uncompacted) [ASTM C136/ AASHTO T 27] [1]	
D85	2.5” (maximum)
D15	0.375” (minimum)

Physical Characteristics	
Hydraulic Conductivity (ASTM D 2434-68)	3.0 cm/sec typical
Moisture Content	
Volumetric (%)	0-10 (6% typical)
Gravimetric (%) [ASTM C566/ AASHTO T 255][1]	0-60 (25% typical)
Particle Specific Gravity (AASHTO T 85)	0.4 (typical)
Porosity	
Uncompacted	0.5
1.25 Compression Ratio	0.38
Soundness (% Loss)	
Magnesium Sulfate (ASTM C88/AASHTO T 104[1])	4.1-14
Sodium Sulfate (ASTM C88/AASHTO T 104[1])	3.1- 6.9
Stability	
Angle of internal friction – loose	45°
Angle of internal friction – up to 1200 psf (ASTM D3080[1])	55°
Angle of internal friction – up to 3000 psf (ASTM D3080[1])	41°

[1]Modified test method due to particle size/density

Physical Characteristics (cont.)

Impurities	
Clay lumps (ASTM C142)	0
Organic impurities (ASTM C40)	0
Popouts (ASTM C151)	0
Electrical Resistance	
Lab (AASHTO T 288)	15,600 ohm-cm

Chemical Characteristics

Ignition loss (ASTM C114)	0
Sulfates (ppm) [AASHTO T 290]	11
Chlorides (ppm) [AASHTO T 291]	<10
TCLP (SW-846)	Non-leaching

Daily Quality Control Testing

Bulk dry density, maximum [EN 1097-3][1]	15 pcf
Compressive Strength at 20% Deformation, minimum [EN 1097-11][1]	15,000 psf

Advantages

Good Insulator	Capillary Break	Freeze-Thaw Stable	Rodent Resistant
Highly-Permeable	Volume Stable	Non-Flammable	Accelerated Construction

Shipping & Handling 100 CY/Truckload

By shipping up to 100 CY per truckload, we are not only reducing the number of trucks on the road, helping logistics, but we also are reducing the carbon footprint of your aggregate needs.

Material can also be supplied in super sacks for easy placement on sites with confined access.

[1]Modified test method due to particle size/density

For more information, please visit aeroaggregates.com or call (833) 261-8499.

AeroAggregates of North America, LLC
1500 Chester Pike | Eddystone, PA 19022
(833) 261-8499 | **www.aeroaggregates.com**





TECHNICAL SUPPORT

AeroAggregates offers in-house technical support for designers and contractors working with foamed glass aggregate. Our facility includes state-of-the-art testing equipment for both quality control, performance testing, and research and development.

06-2019

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1500 Chester Pike | Eddystone, PA 19022
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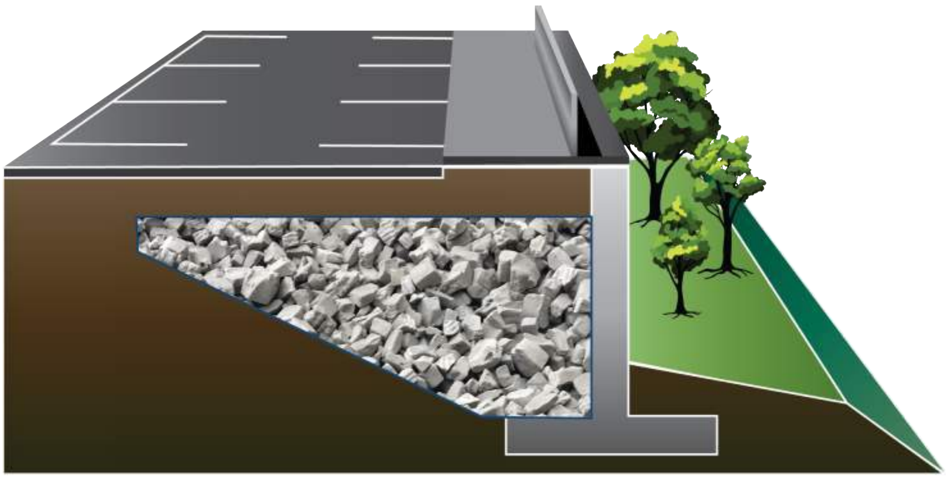

LIGHTWEIGHT BACKFILL

V 1.4 | UPDATED APRIL 2020

AERO AGGREGATES®

Ultra-Lightweight
Foamed Glass Aggregate (UL-FGA)

INSTALLATION GUIDELINES

HIGHLY FRICTIONAL · NON-LEACHING · ROT-RESISTANT · NON-FLAMMABLE · DURABLE · SAFE

MADE IN USA
100% RECYCLED CONTAINER GLASS

Installation of Ultra-Lightweight Foamed Glass Aggregate (UL-FGA)

Aero Aggregates AeroFill or G15 For Lightweight Backfill

A | PRODUCT HANDLING

1. Protect the UL-FGA before, during, and after installation, and protect the work and materials of all other trades.

B | INSTALLATION

1. Place UL-FGA at locations indicated on the drawings. The area to be filled shall not have any standing water (including ice) in it prior to placement of the UL-FGA.

2. Construction equipment, other than for placement and compaction, should avoid operating on the exposed UL-FGA. If construction sequencing necessitates trafficking on the UL-FGA layer, minimize construction traffic to the extent possible and contact Aero Aggregates for guidance.

3. Foamed glass aggregate for use as lightweight backfill (e.g. against structures or behind retaining walls) may be placed in maximum lift thicknesses of 12 inches and compaction shall be performed with a plate compactor weighing between 110 and 220 lbs. Compaction shall be completed by making a minimum of four (4) full passes with the plate compactor. One (1) full pass is defined as a minimum of 100% coverage of the plate passing over the top of the lift.

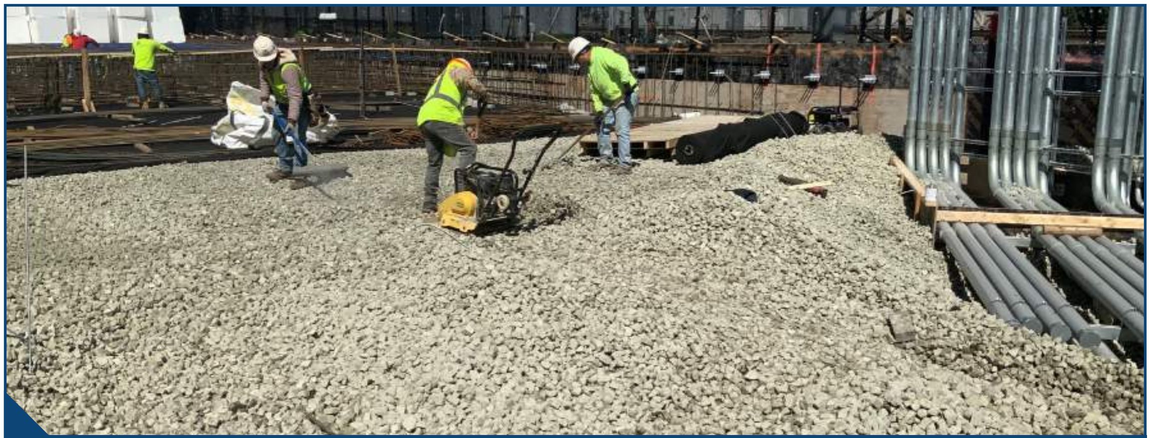

FIG. 1: Compaction of UL-FGA with a plate compactor.

4. For compaction using tracked equipment, foamed glass aggregate shall be placed in uncompacted lift thicknesses of 24 inches and compaction shall be performed with a tracked excavator or dozer with ground pressures of between 625 psf and 1,025 psf. Compaction using tracked equipment shall be completed by placing the initial lift thickness, and then raising the blade or bucket and tracking over the layer for a total of four (4) full passes. One (1) full pass is defined as a minimum of 100% coverage of the tracks passing over the top of the lift.

5. If the Contractor must vary the method described in B.3 or B.4 (i.e., differing lift thickness or equipment), the Contractor should reach out to Aero Aggregates for installation guidance.

6. For areas that will not experience typical highway loading, the number of passes used to compact the foamed glass aggregate lift may be reduced in accordance with the Project Documents.

FIG. 2: Spreading and compaction of UL-FGA with a dozer.

FIG. 3: Compaction of UL-FGA with an excavator.

7. Lifts of UL-FGA can be built with 1:1 side slopes without additional reinforcement.

8. A nonwoven geotextile is recommended as a separator between subgrade and the initial lift of foamed glass aggregates as well as above the final lift and on side slopes as a separator between the foamed glass aggregates and capping layer. A 6 oz./yd^2 (minimum) needle punched nonwoven with a grab tensile strength of 160 lbs. per ASTM D4632 is recommended. The geotextile shall be sewn together or overlapped 12 inches or greater at geotextile seams. The geotextile shall not be left exposed for longer than 14 days.

9. Capping material or subbase is placed above the final lift of UL-FGA in accordance with Project Documents.

FIG. 4: Placement of capping material on UL-FGA.

C | TESTING & SUBMITTALS

1. The Contractor will test each truckload of delivered UL-FGA for loose bulk density to ensure it meets specifications. If necessary, this value should be adjusted by the moisture content of the UL-FGA to determine the dry, loose bulk density. Bulk density testing shall be performed in the presence of the Owner's Representative if required.

2. The Contractor shall submit a Foamed Glass Aggregate Installation Plan to the Owner's Representative prior to foamed glass aggregate installation. At a minimum, the Installation Plan shall identify the area(s) to be filled, the equipment that shall be used for the compaction of the UL-FGA (include equipment data sheets to verify weight/ground pressures), the proposed number of passes (four [4] full passes unless otherwise specified in the design documents), and the approximate number of lifts that will be required in each area.

3. Compaction shall be performed in the presence of the Owner's Representative in order to observe and verify construction in accordance with the Foamed Glass Aggregate Installation Plan.

AERO AGGREGATES

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1500 Chester Pike | Eddystone, PA 19022
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APPENDIX C: HEC-RAS FIGURES

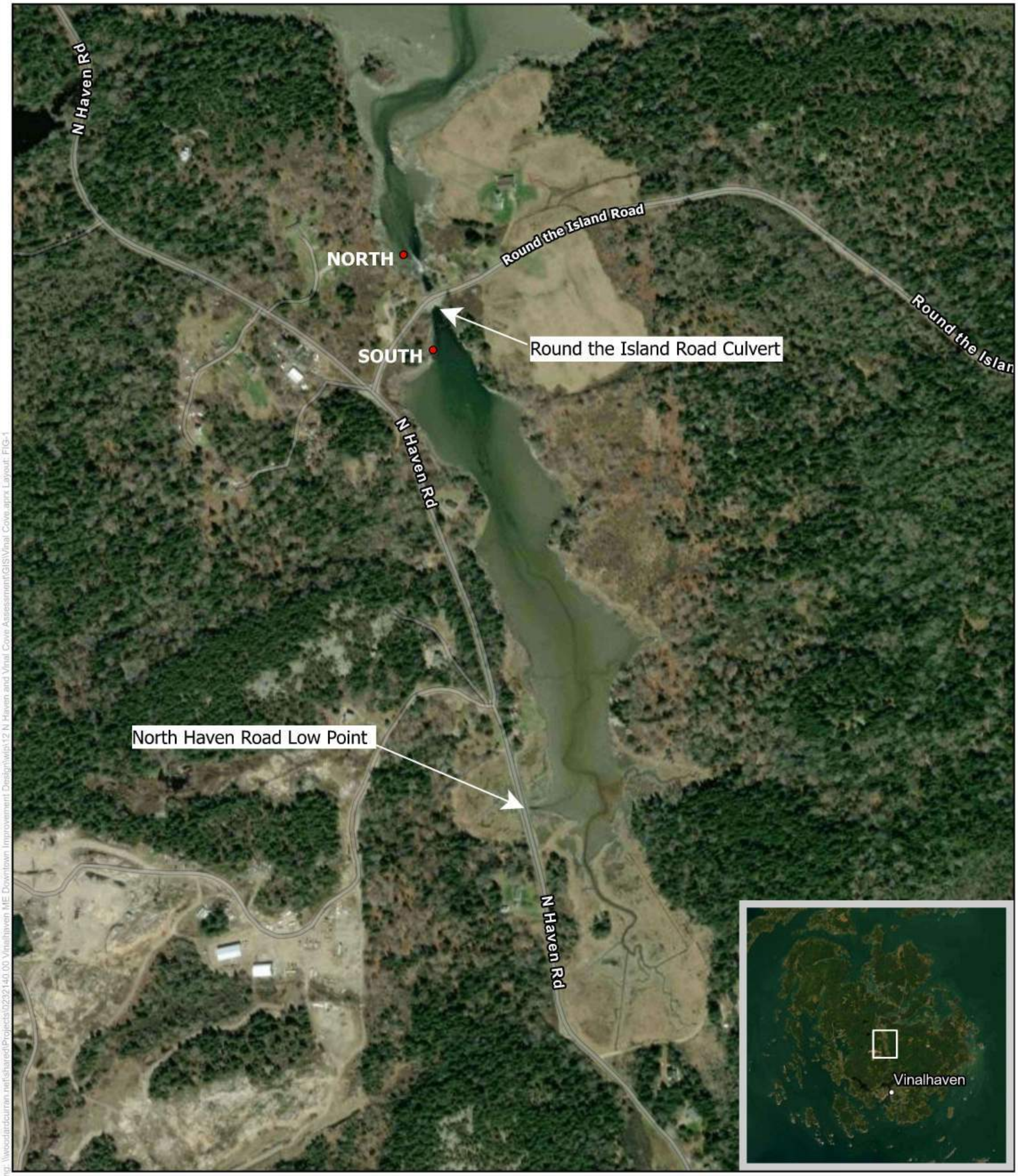


FIGURE 1 of 10

Project Location

Vinal Cove
Alternatives Analysis

Legend

● Data Logger Locations

0 100 200 400 600 800
US Feet
1 IN = 800 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:**

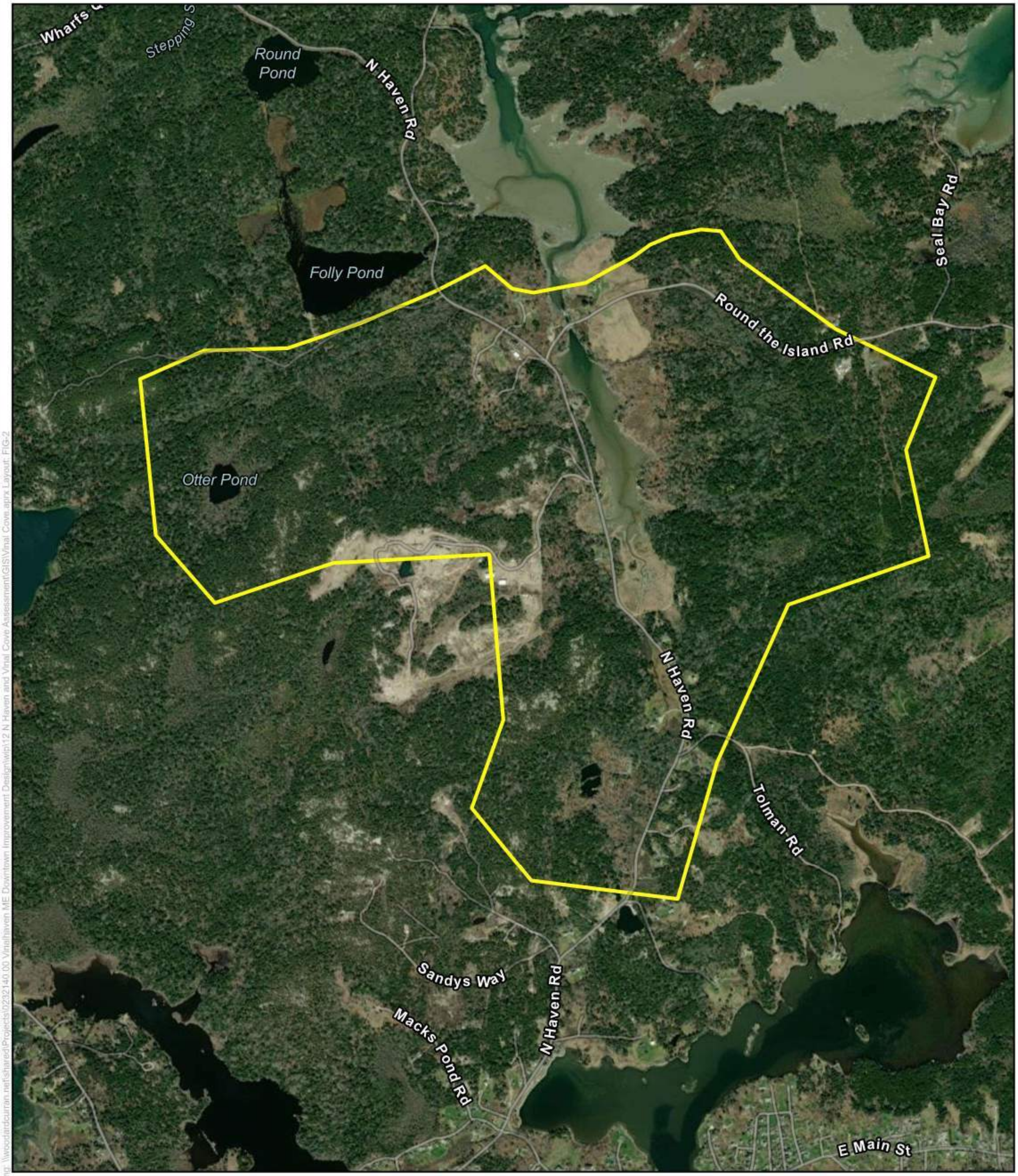


FIGURE 2 of 10

Study Area

Vinal Cove
Alternatives Analysis

Legend

Study Area

0 190 380 760 1,100 1,500 US Feet

1 IN = 1500 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

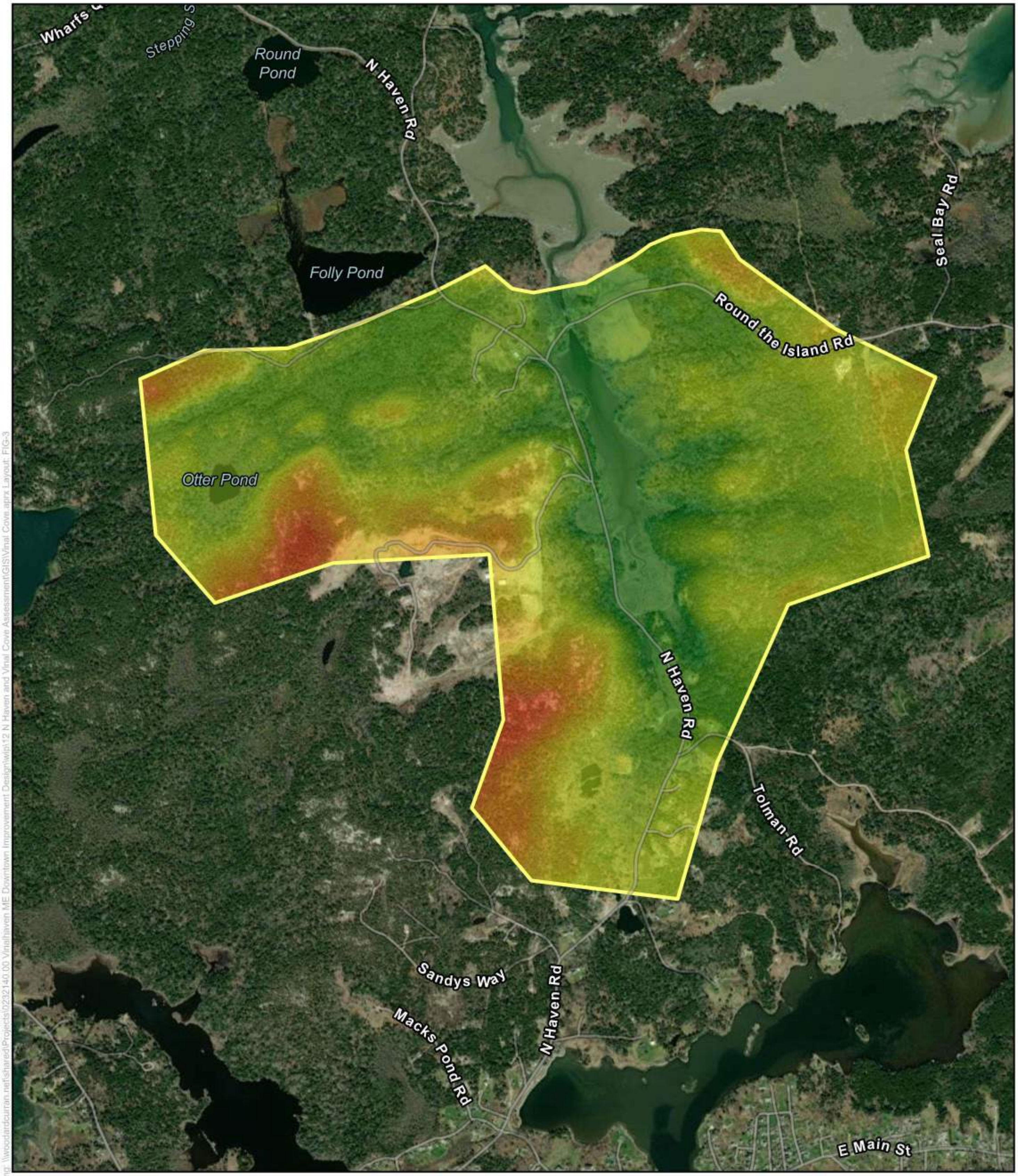


FIGURE 3 of 10

Topography

Vinal Cove
Alternatives Analysis

Legend

Study Area

Terrain (ft)

Value

182.719

-4.90625

0 375 750 1,125 1,500 US Feet

1 IN = 1500 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

Figure Exported: 7/6/2023 By: hschulz Using: \\woodardcurran.net\shared\Projects\0232140.00 Vinalhaven ME Downtown Improvement Design\wip\12 N Haven and Vinal Cove Assessment\GIS\Vinal Cove.aprx Layout: FIG-3

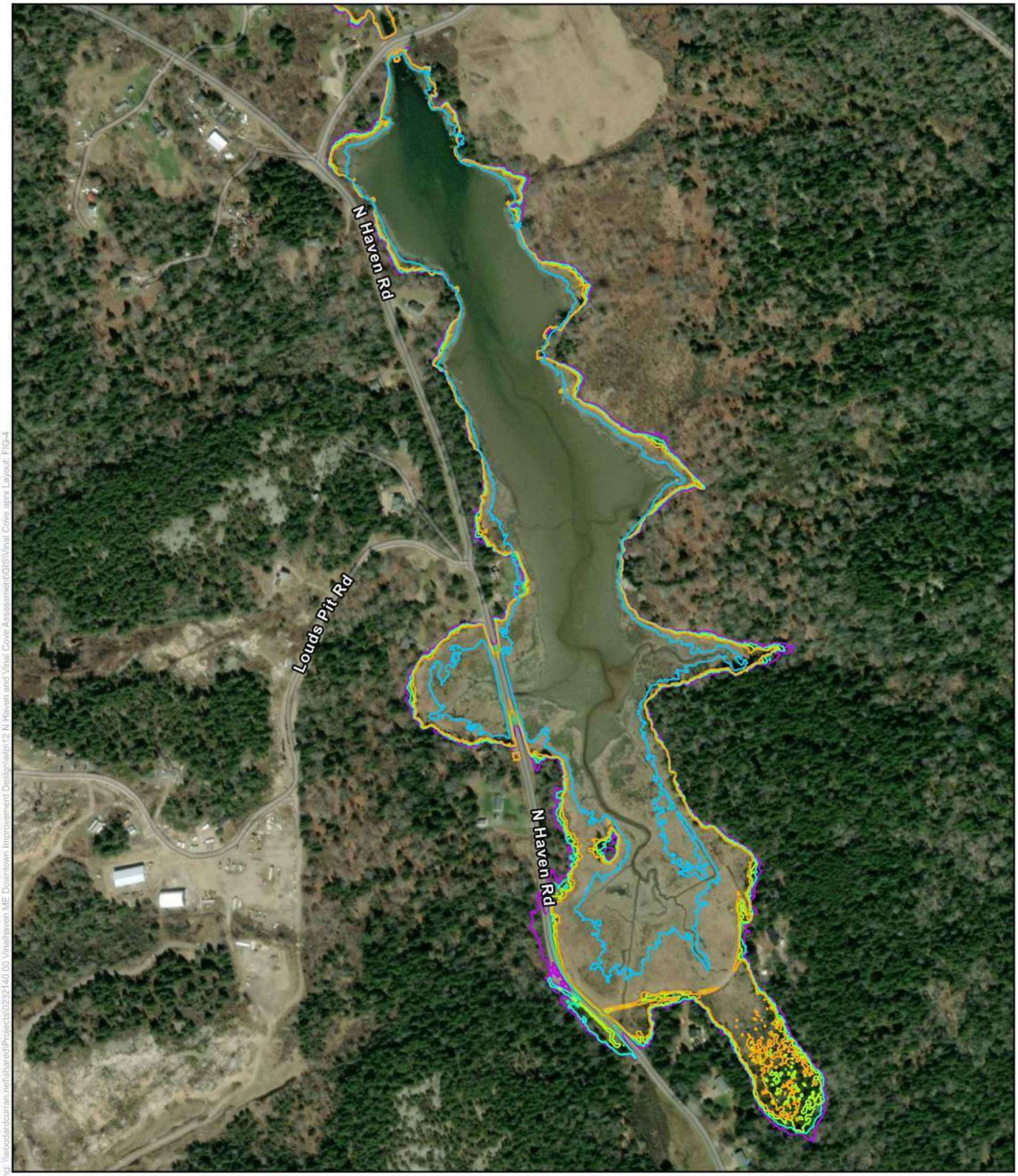


FIGURE 4 of 10

Present Day Existing Conditions Water Levels

Vinal Cove
Alternatives Analysis

Legend

- MHHW
- HAT
- 50% Annual Chance
- 10% Annual Chance
- 1% Annual Chance

0 112.5 225 450 US Feet

1 IN = 450 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:**

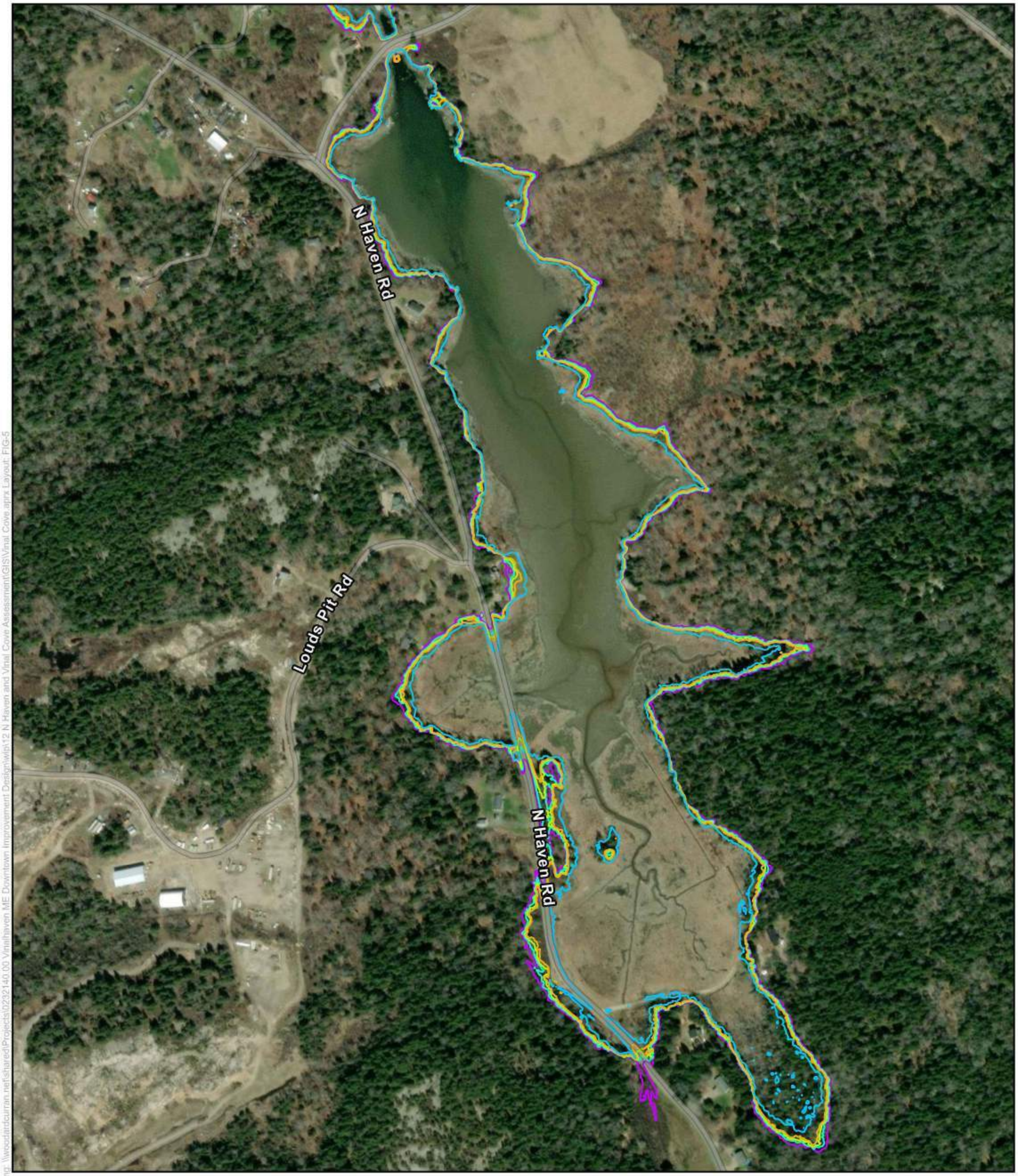


FIGURE 5 of 10

SLR 2080 Existing Conditions

Vinal Cove
Alternatives Analysis

Legend

- MHHW
- HAT
- 50% Annual Chance
- 10% Annual Chance
- 1% Annual Chance

0 112.5 225 450 US Feet
1 IN = 450 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

Figure Exported: 7/6/2023 By: hschulz Using: \\woodardcurran.net\shared\Projects\0232140.00 Vinalhaven ME Downtown Improvement Design\wip\12 N Haven and Vinal Cove Assessment\GIS\Vinal Cove.aprx Layout: FIG-5

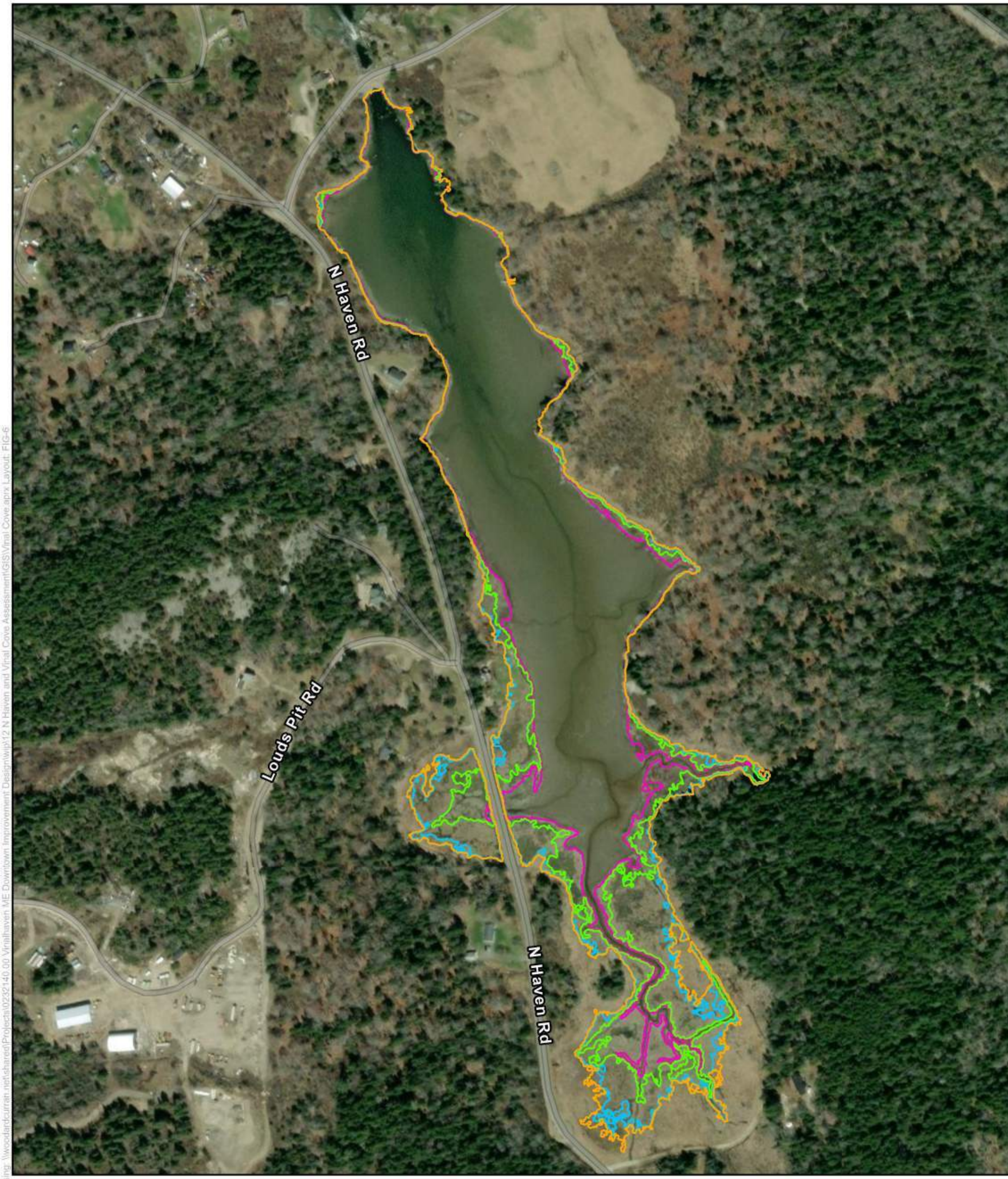


FIGURE 6 of 10

Round the Island Road Culvert Alternatives Mean Higher High Water

Vinal Cove
Alternatives Analysis

Legend

- Ex. Conditions (5.20')
- Alt 1 (4.36')
- Alt 2 (4.86')
- Alt 3 (5.30')

0 50 100 200 300 400
Feet
1 IN = 400 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

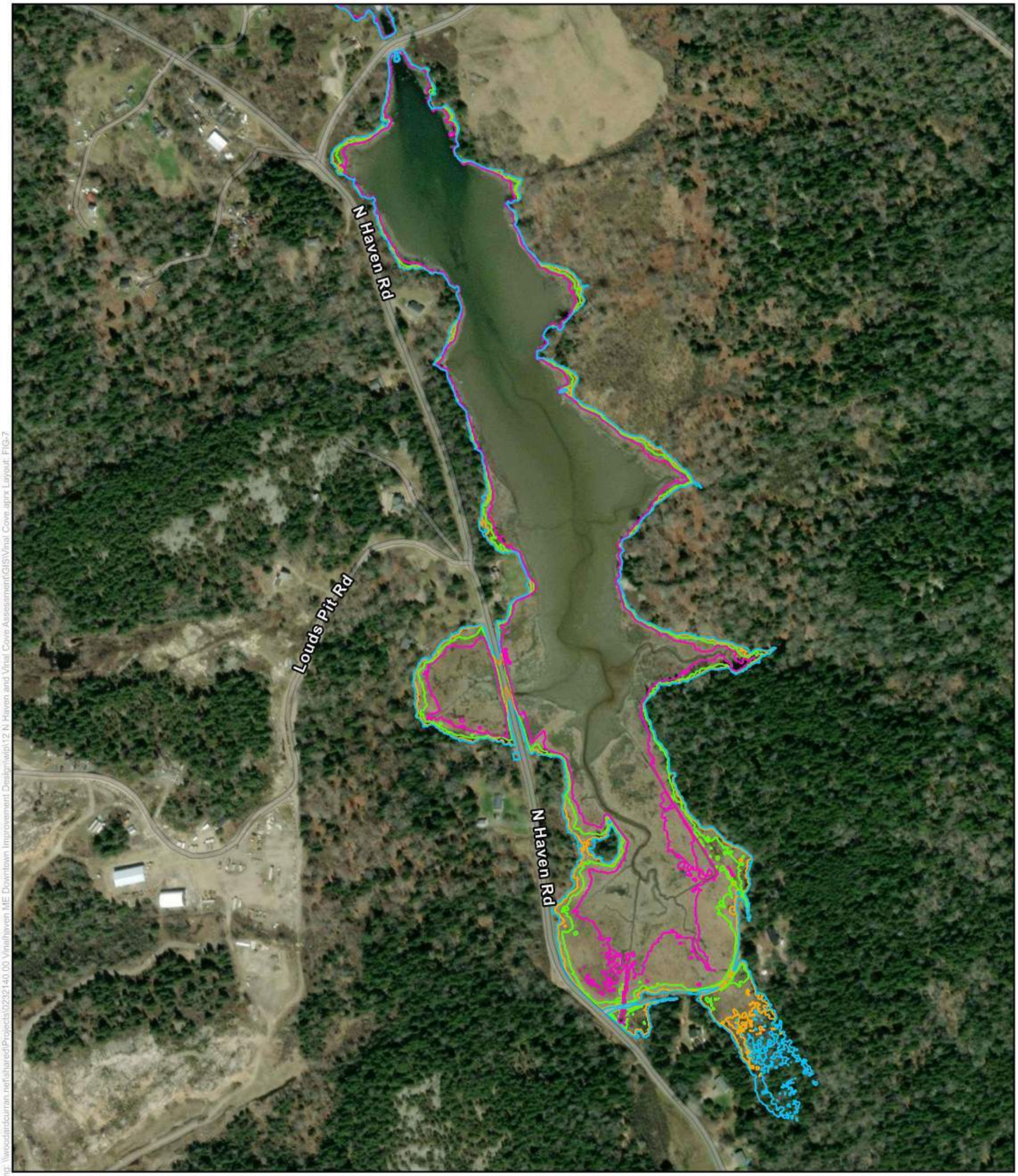


FIGURE 7 of 10

Round the Island Road Culvert Alternatives Highest Astronomical Tide

Vinal Cove
Alternatives Analysis

Legend

- Ex. Conditions HAT
- Alt 1 HAT
- Alt 2 HAT
- Alt 3 HAT

0 112.5 225 450 US Feet

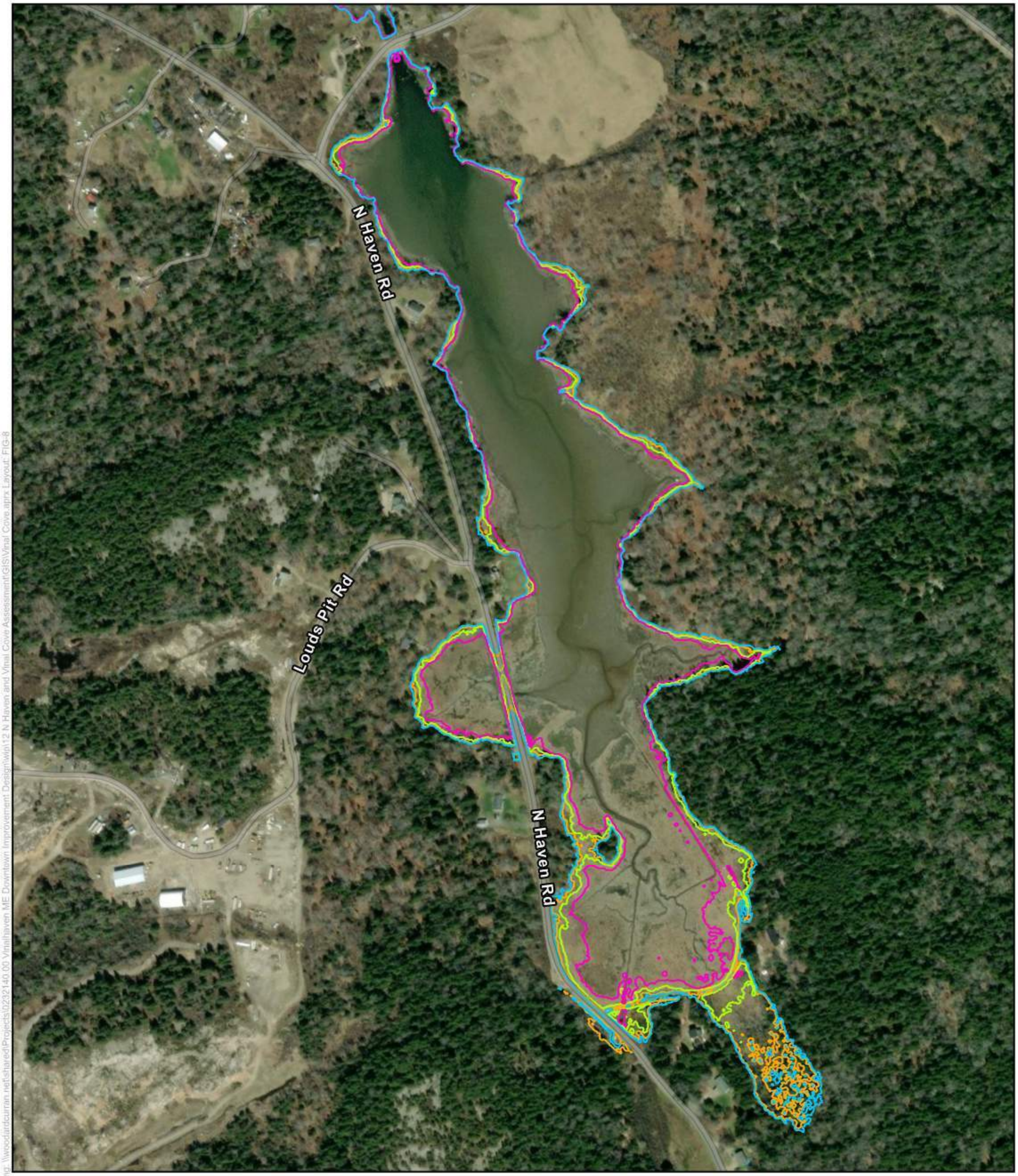
1 IN = 450 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

Figure Exported: 7/6/2023 By: hschulz Using: \\woodardcurran.net\shared\Projects\0232140.00 Vinalhaven ME Downtown Improvement Design\wip\12 N Haven and Vinal Cove Assessment\GIS\Vinal Cove.aprx Layout: FIG-7



Round the Island Road Culvert Alternatives 50% Annual Chance

Vinal Cove
Alternatives Analysis

Legend

- Ex. Conditions 50% Annual Chance
- Alt 1 50% Annual Chance
- Alt 2 50% Annual Chance
- Alt 3 50% Annual Chance

0 112.5 225 450 US Feet

1 IN = 450 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

Figure Exported: 7/6/2023 By: hschulz Using: \\woodardcurran.net\shared\Projects\0232140.00 Vinalhaven ME Downtown Improvement Design\wip\12 N Haven and Vinal Cove Assessment\GIS\Vinal Cove.aprx Layout: FIG-8

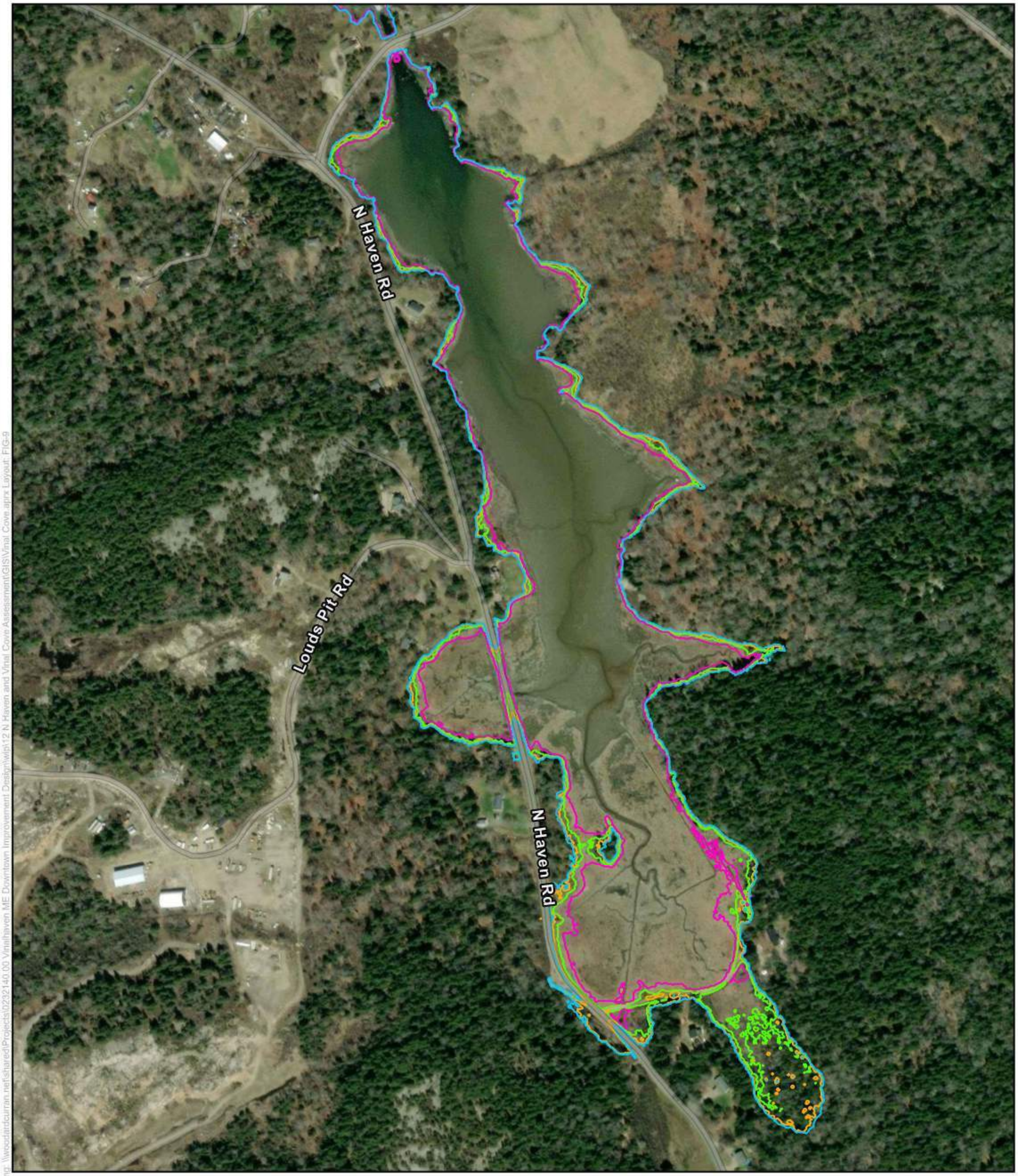


FIGURE 9 of 10

Round the Island Road Culvert Alternatives 10% Annual Chance

Vinal Cove
Alternatives Analysis

Legend

- Ex. Conditions 10% Annual Chance
- Alt 1 10% Annual Chance
- Alt 2 10% Annual Chance
- Alt 3 10% Annual Chance

0 112.5 225 450 US Feet
1 IN = 450 FT

N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

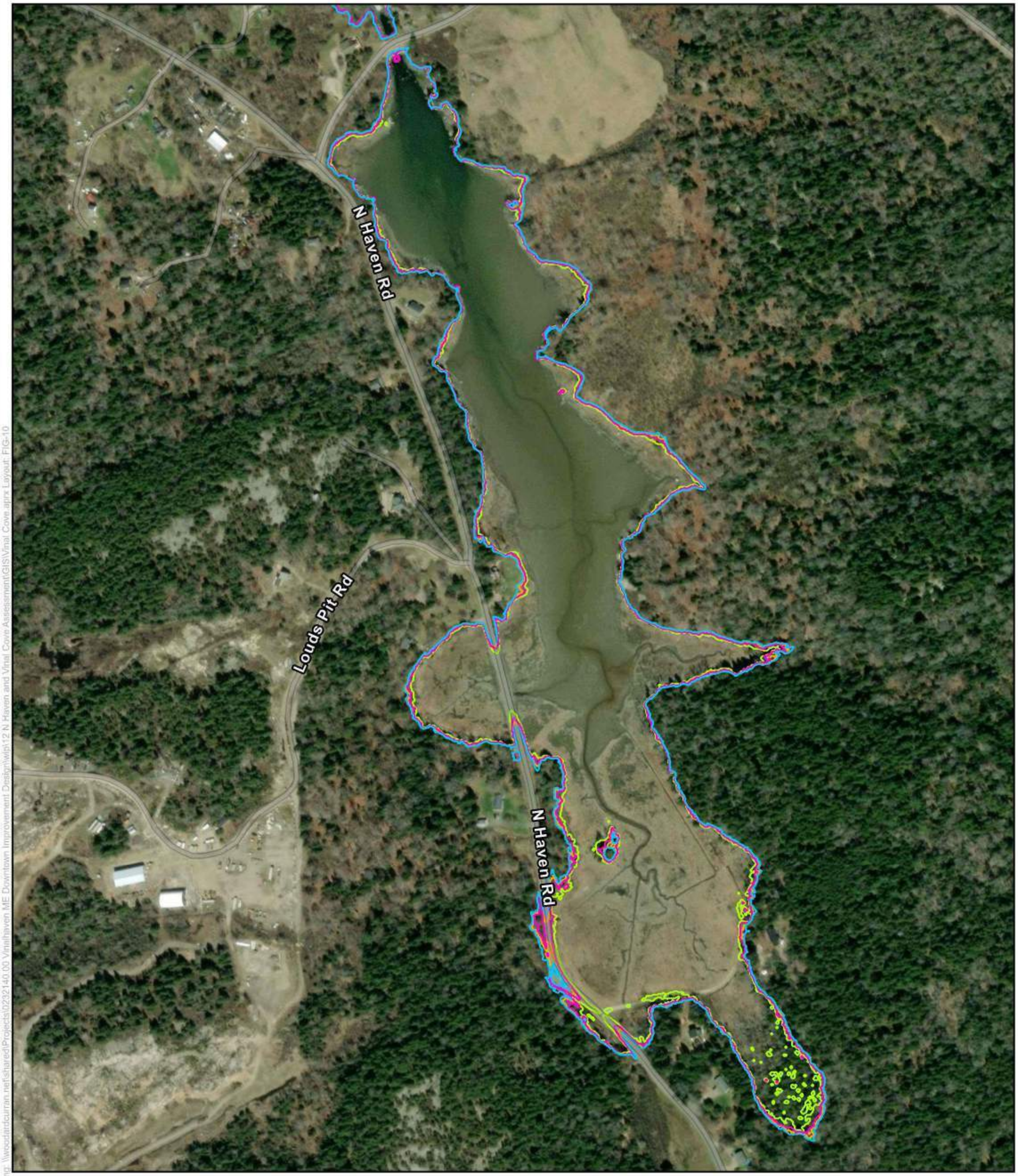


FIGURE 10 of 10

Round the Island Road Culvert Alternatives 1% Annual Chance

Vinal Cove Alternatives Analysis

Legend

- Ex. Conditions 1% Annual Chance
- Alt 1 1% Annual Chance
- Alt 2 1% Annual Chance
- Alt 3 1% Annual Chance

0 112.5 225 450 US Feet

1 IN = 450 FT

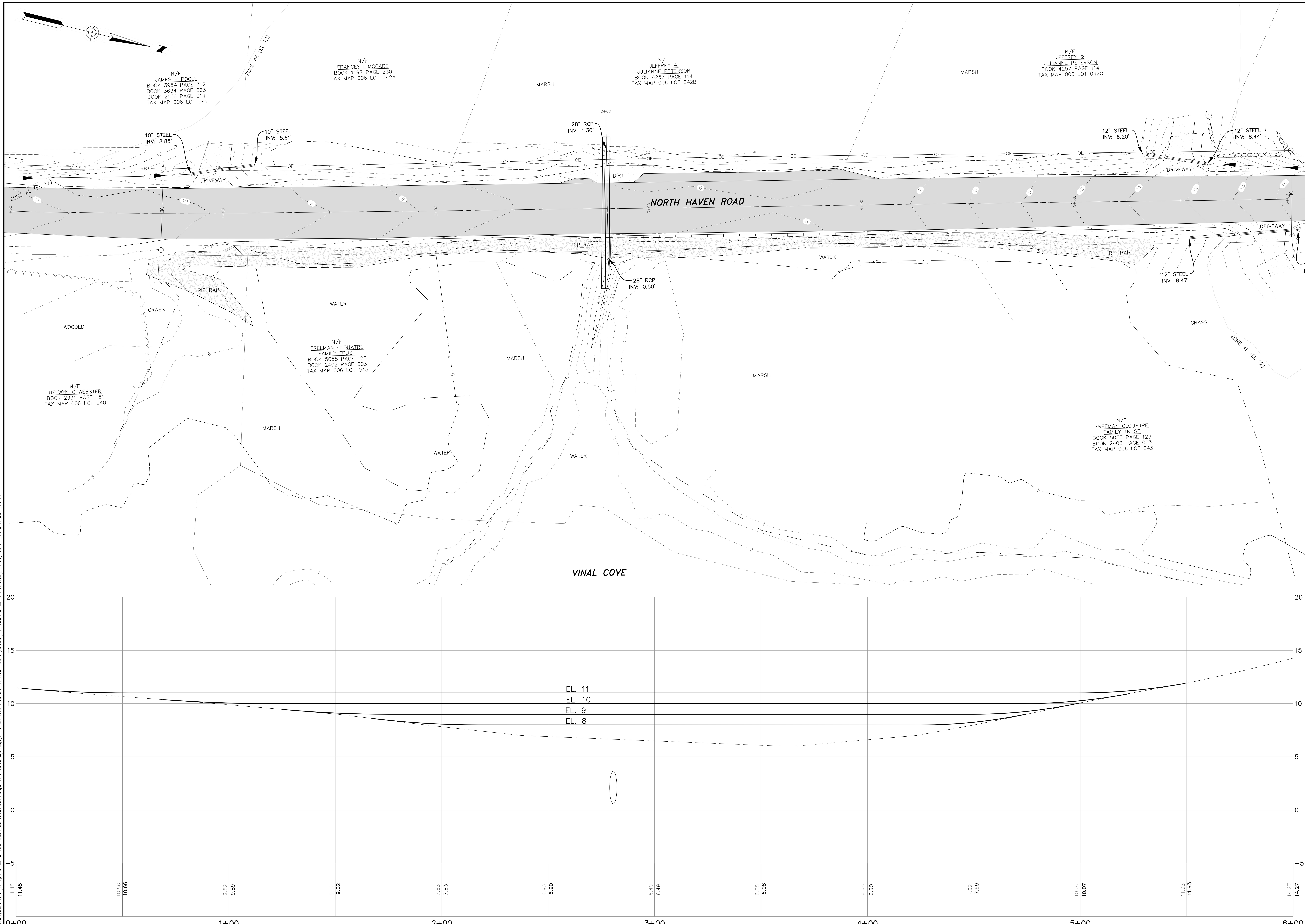
N

Woodard & Curran

Project #: 0232140.12
Map Created: July 2023

APPENDIX D: CONCEPTUAL ALTERNATIVES DRAWINGS

24x36
PLOT SCALE: 10:



NORTH HAVEN ROAD CENTERLINE
PROFILE STA. 0+00 TO STA. 6+00
HORIZONTAL SCALE: 1" = 20'

\\woodardcurran.net\shared\Projects\0232140.00 Vinalhaven ME Downtown Improvement Design\wip\12 N Haven and Vinal Cove Assessment\Drawings\Civil\0232140.12 C10X.dwg, Jul 07, 2023 - 11:00am BMCDEVITT

Woodard & Curran
41 Hutchins Drive
Portland, Maine 04102
800.426.4262 | www.woodardcurran.com

PE SEAL:

NOT FOR CONSTRUCTION

CLIENT INFO:

TOWN OF VINALHAVEN
VINALHAVEN, MAINE

NORTH HAVEN &
VINAL COVE CULVERTS

REV	MM/DD/YY	DESCRIPTION

JOB NO:	0232140.12
DATE:	JULY 2023
SCALE:	1"=20'
DESIGNED BY:	KJT
DRAWN BY:	BCM
CHECKED BY:	KJT
FILENAME:	0232140.12 C10X.dwg

DRAWING TITLE:
CIVIL
NORTH HAVEN PLAN & PROFILE

DRAWING NO:
C-100
SHEET: 1 OF 3

24x36
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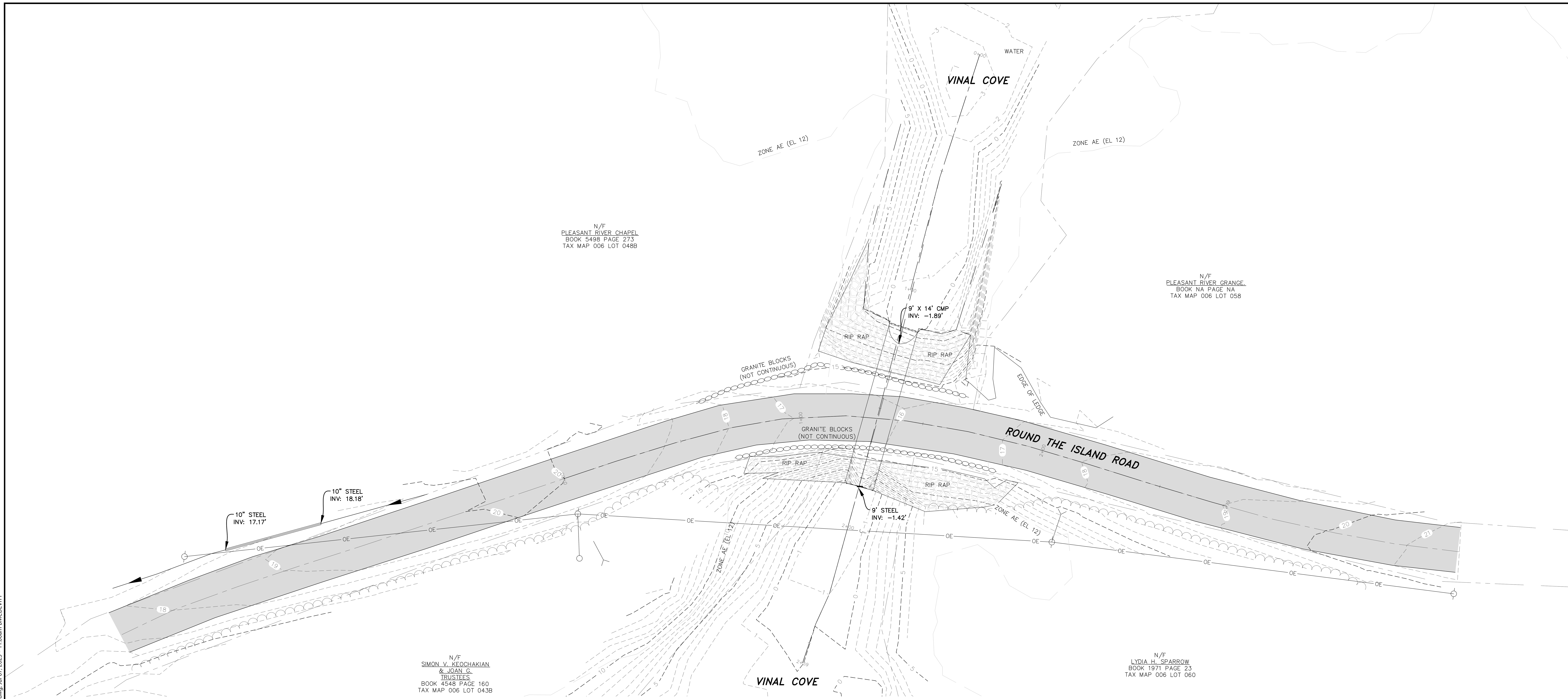
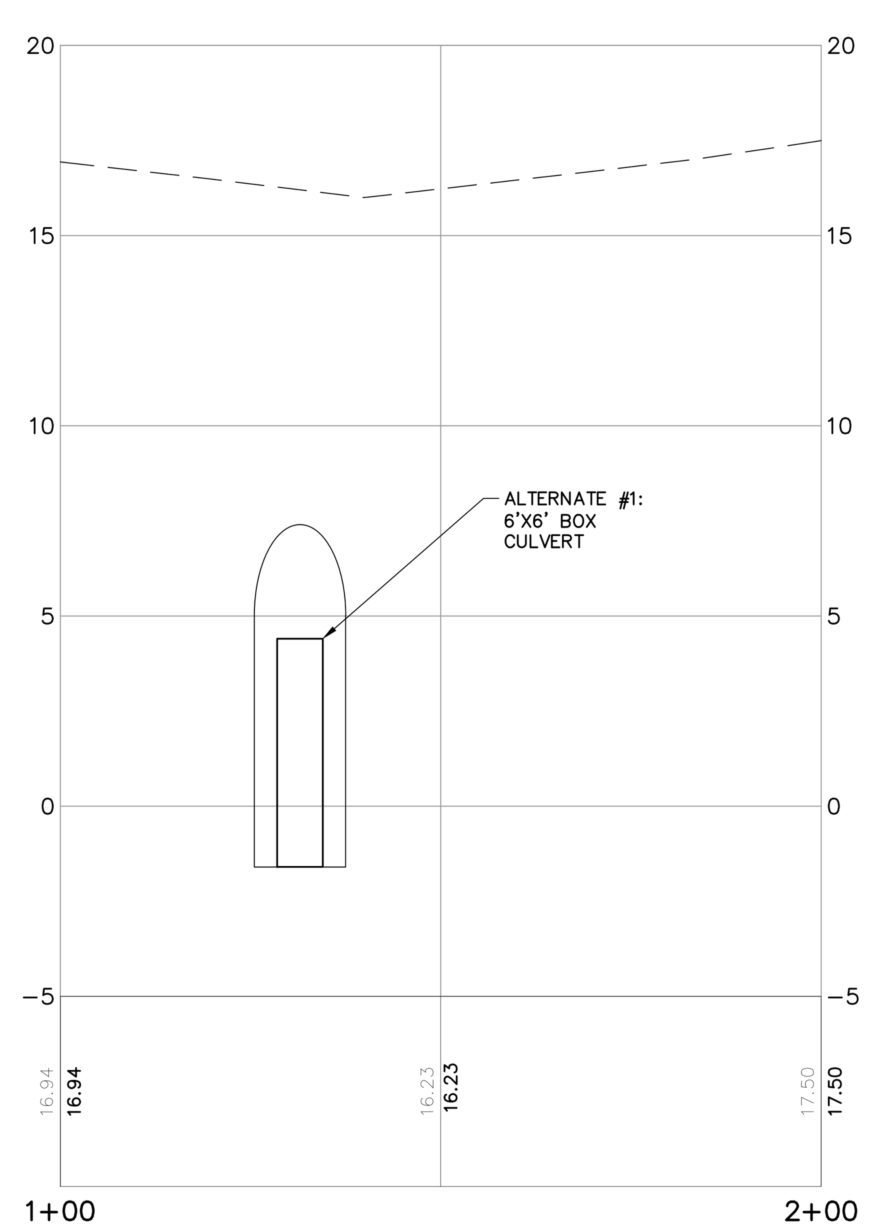
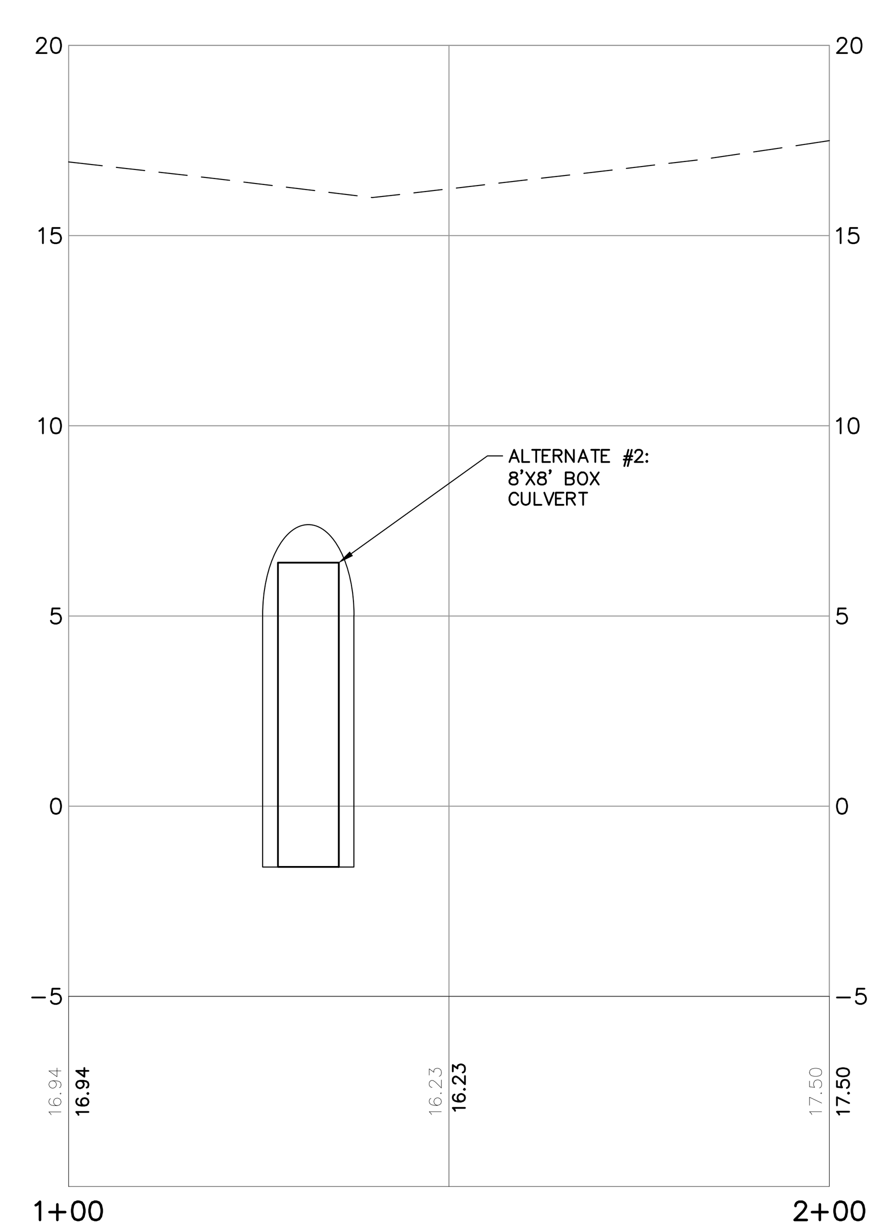




ROUND THE ISLAND ROAD CENTERLINE
PROFILE STA. 1+00 TO STA. 2+00



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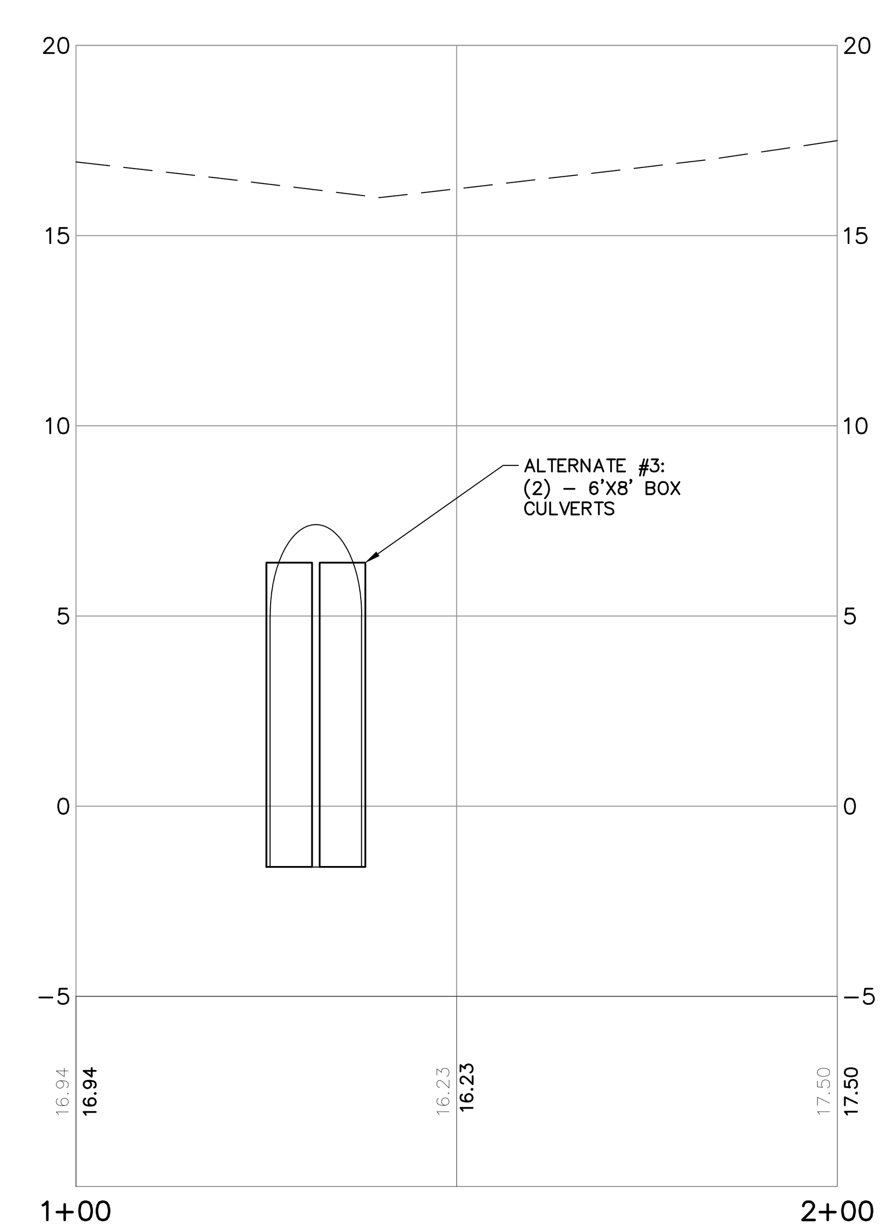
PROFILE STA. 1+00 TO STA. 2+00



ROUND THE ISLAND ROAD CENTERLINE
PROFILE STA. 1+00 TO STA. 2+00

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CLIENT INFO:

TOWN OF VINALHAVEN
VINALHAVEN, MAINE

NORTH HAVEN &
VINAL COVE CULVERTS

REV	MM/DD/YY	DESCRIPTION

JOB NO:	0232140.12
DATE:	JULY 2023
SCALE:	1"=20'
DESIGNED BY:	KJT
DRAWN BY:	BCM
CHECKED BY:	KJT
FILENAME:	0232140.12 C10X.dwg

DRAWING TITLE:
CIVIL
VINAL COVE PLAN & SECTIONS

DRAWING NO:
C-101
SHEET: 2 OF 3

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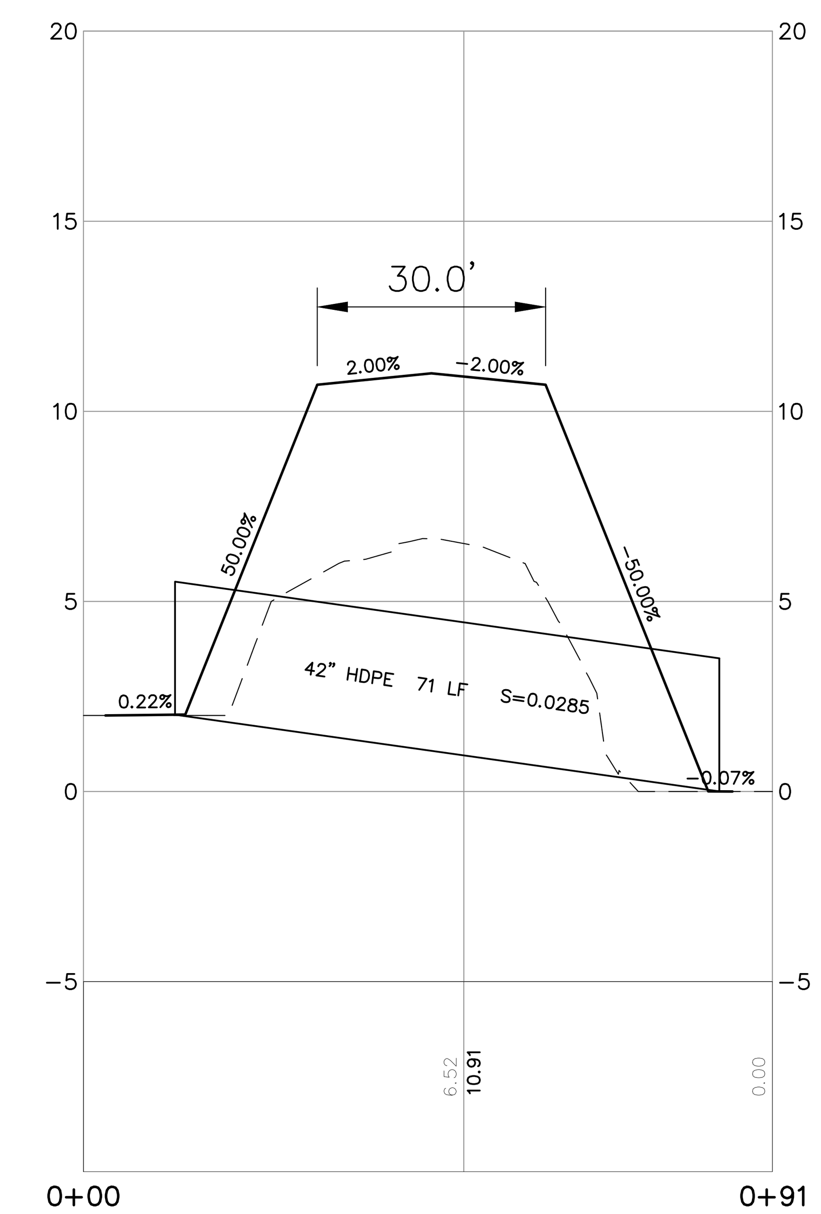
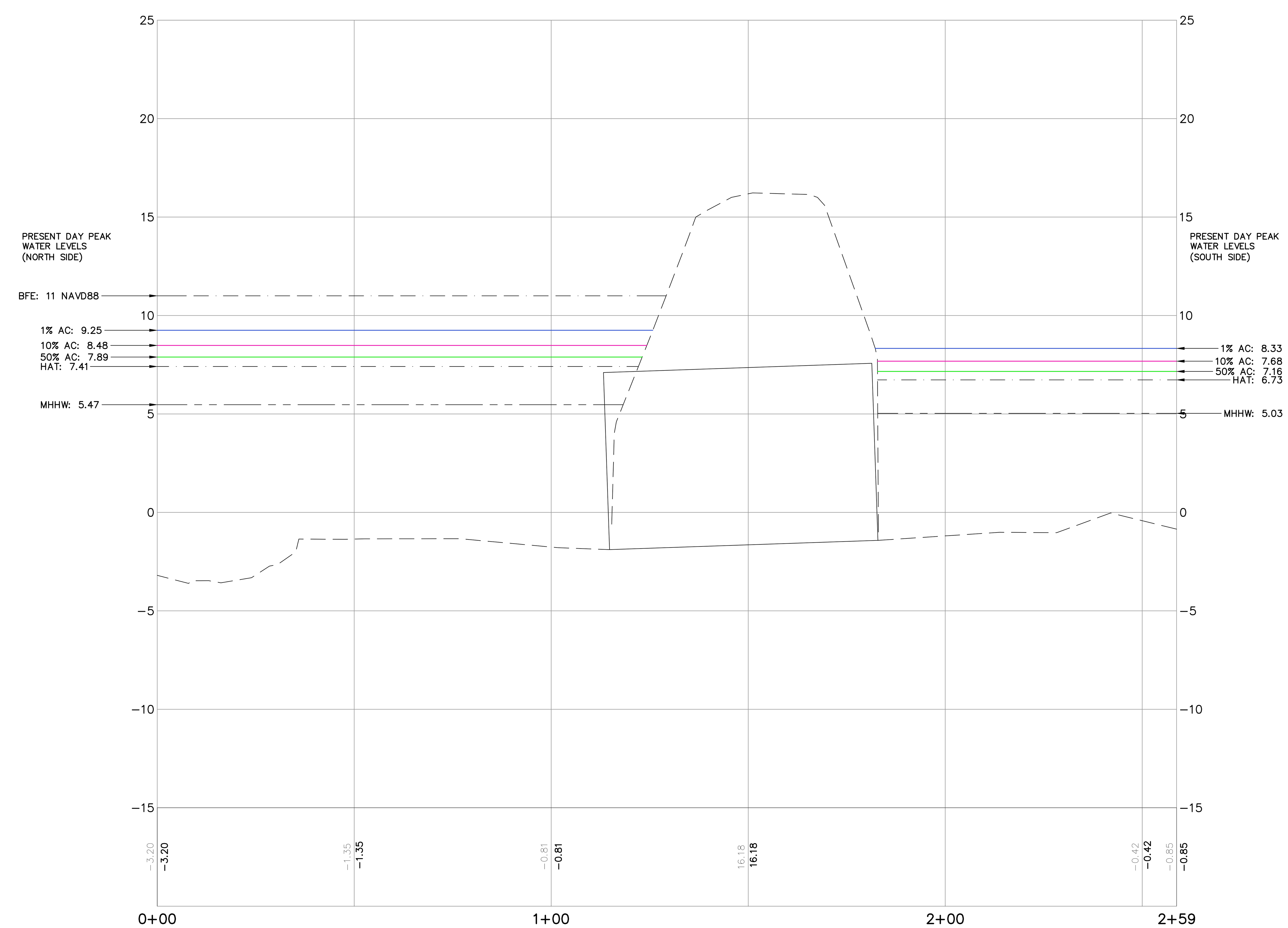
24x36
PLOT SCALE: 10:



NORTH HAVEN SECTION
PROFILE STA. 0+00 TO STA. 0+91
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 4'



ROUND THE ISLAND ROAD SECTION
PROFILE STA. 0+00 TO STA. 2+59
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 4'

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CLIENT INFO:

TOWN OF VINALHAVEN
VINALHAVEN, MAINE

NORTH HAVEN &
VINAL COVE CULVERTS

REV	MM/DD/YY	DESCRIPTION

JOB NO:	0232140.12
DATE:	JULY 2023
SCALE:	1"=20'
DESIGNED BY:	KJT
DRAWN BY:	BCM
CHECKED BY:	KJT
FILENAME:	0232140.12 C10X.dwg

DRAWING TITLE:
CIVIL SECTIONS

DRAWING NO:
C-102
SHEET: 3 OF 3

APPENDIX E: OPINION OF PROBABLE CONSTRUCTION COST TABLES

Woodard & Curran

Project Name:	Vinal Cove
Project Number:	232140.12
Date:	July 2023

North Haven Road Reconstruction
Engineer's Opinion of Probable Construction Cost Summary

Road Elevation: 8'					
No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
1	Fill	CY	350	$ 78	$ 27,300
2	Riprap	CY	569	$ 133	$ 75,800
3	Base Gravels	CY	478	$ 113	$ 54,000
4	Pavement	TON	193	$ 165	$ 31,900
5	Guardrail	LF	490	$ 75	$ 36,800
				Construction Subtotal	**$ 225,800**
				Design, Permitting, & CA (25%)	**$ 56,450**
				Contingency (30%)	**$ 67,740**
				Project Total	**$ 349,990**

Road Elevation: 9'					
No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
1	Fill	CY	680	$ 78	$ 53,100
2	Riprap	CY	925	$ 133	$ 123,100
3	Base Gravels	CY	563	$ 113	$ 63,700
4	Pavement	TON	228	$ 165	$ 37,600
5	Guardrail	LF	490	$ 75	$ 36,800
				Construction Subtotal	**$ 314,300**
				Design, Permitting, & CA (25%)	**$ 78,575**
				Contingency (30%)	**$ 94,290**
				Project Total	**$ 487,165**

Road Elevation: 10'					
No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
1	Fill	CY	1,080	$ 78	$ 84,300
2	Riprap	CY	1,378	$ 133	$ 183,300
3	Base Gravels	CY	677	$ 113	$ 76,600
4	Pavement	TON	274	$ 165	$ 45,300
5	Guardrail	LF	490	$ 75	$ 36,800
				Construction Subtotal	**$ 426,300**
				Design, Permitting, & CA (25%)	**$ 106,575**
				Contingency (30%)	**$ 127,890**
				Project Total	**$ 660,765**

Road Elevation: 11'					
No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
1	Fill	CY	1,590	$ 78	$ 124,100
2	Riprap	CY	1,900	$ 133	$ 252,700
3	Base Gravels	CY	820	$ 113	$ 92,700
4	Pavement	TON	332	$ 165	$ 54,800
5	Guardrail	LF	490	$ 75	$ 36,800
				Construction Subtotal	**$ 561,100**
				Design, Permitting, & CA (25%)	**$ 140,275**
				Contingency (30%)	**$ 168,330**
				Project Total	**$ 869,705**

Project Name:	Vinal Cove
Project Number:	232140.12
Date:	July 2023

Round the Island Road Culvert Replacement
Engineer's Opinion of Probable Construction Cost Summary

Culvert Alternative 1: 6'x6' Box Culvert					
No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
1	6'x6' Box Culvert	LS	1	$ 61,116	$ 61,200
2	Side Hinged Passive Hydraulic Gate	LS	1	$ 86,400	$ 86,400
3	Base Gravels	CY	143	$ 113	$ 16,200
4	Pavement	TON	58	$ 165	$ 9,600
5	Gate Installation	LS	1	$ 30,000	$ 30,000
6	Concrete Headwall	LS	1	$ 90,000	$ 90,000
				Construction Subtotal	**$ 293,400**
				Design, Permitting, & CA (25%)	**$ 73,350**
				Contingency (30%)	**$ 88,020**
				Project Total	**$ 454,770**

Culvert Alternative 2: 8'x8' Box Culvert					
No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
1	8'x8' Box Culvert	LS	1	$ 72,381	$ 72,400
2	Side Hinged Passive Hydraulic Gate	LS	1	$ 115,200	$ 115,200
3	Base Gravels	CY	143	$ 113	$ 16,200
4	Pavement	TON	58	$ 165	$ 9,600
5	Gate Installation	LS	1	$ 30,000	$ 30,000
6	Concrete Headwall	LS	1	$ 105,000	$ 105,000
				Construction Subtotal	**$ 348,400**
				Design, Permitting, & CA (25%)	**$ 87,100**
				Contingency (30%)	**$ 104,520**
				Project Total	**$ 540,020**

Culvert Alternative 3: (2) 6'x8' Box Culverts					
No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
1	(2) 6'x8' Box Culvert	LS	1	$ 131,028	$ 131,100
2	Side Hinged Passive Hydraulic Gate	EA	2	$ 103,000	$ 206,000
3	Base Gravels	CY	143	$ 113	$ 16,200
4	Pavement	TON	58	$ 165	$ 9,600
5	Gate Installation	LS	1	$ 45,000	$ 45,000
6	Concrete Headwall	LS	1	$ 120,000	$ 120,000
				Construction Subtotal	**$ 527,900**
				Design, Permitting, & CA (25%)	**$ 131,975**
				Contingency (30%)	**$ 158,370**
				Project Total	**$ 818,245**

Woodard & Curran

woodardcurran.com