



State of New Hampshire  
Department of Transportation

NH Route 1B Causeway  
New Castle, NH

## *Draft Feasibility Report*



Prepared By:



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State Project No. 29614

November, 2022

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## INTRODUCTION

The subject project proposes to determine the need and the feasibility of making modifications to the portion of Route 1B that runs from Goat Island to New Castle Island within the Town of New Castle, New Hampshire. This section of roadway is approximately 1,300' long and consists of an existing roadway located on top of a stone causeway. The causeway was constructed many years ago and dates to colonial times. In the last few years it has become apparent that the causeway is susceptible to flooding during extreme storm events, especially those that correspond with high tides. The frequency and severity of these events have been increasing resulting in flood events that could close and/or damage the causeway. The New Hampshire Department of Transportation (NHDOT) has been tasked with identifying and evaluating possible alternatives to mitigate or avoid impacts to the causeway resulting from projected sea level rise. Alternatives to be considered will include a "Do nothing" alternative, as well as build alternatives that involve raising the causeway or constructing a bridge.

## LITERATURE SEARCH

MJ reviewed currently available reports and documentation that were generally available regarding the effects of climate change on sea level rise and storm events, as well as locally available studies and documentation that are specific to the Piscataqua River and the waters around New Castle Island. McFarland Johnson (MJ) obtained readily available data concerning past storm events, including water level gauging data, pictures, and other historical information that may identify past flooding or water elevations.

The following documents were reviewed for information on sea level rise (SLR) predictions:

- *Global and Regional Sea Level Rise Scenarios for the United States* published in January 2017 by the National Oceanic Atmospheric Administration (NOAA). Sea Level Rise scenarios outlined in this report include six scenarios for 2100 which range from a low of 0.3m to an extreme of 2.5m.
- *Procedures to Evaluate Sea Level Change, Impacts, Responses, and Adaptation* published in 2012 by the U.S. Army Corps of Engineers (ACOE).
- *Nature-Based Solutions for Coastal Highway Resilience* published in February 2018 by US Department of Transportation (USDOT) and Federal Highway Administration (FHWA).
- *Flood Risk Report for Rockingham County NH* published in September 2016 by FEMA
- *Potential Impacts of Climate Change on Transportation Infrastructure* published in April 2014 by New Hampshire DOT (NHDOT)
- *From Tides to Storms: Preparing for NH Future Coast* published in September 2015 by the Rockingham Planning Commission. This report outlined three different SLR scenarios for 2100 including intermediate low of 1.7 feet, intermediate high of 4.0 feet, and a highest of 6.3 feet, and analyzed each scenario for storm surge.

- *Preparing NH for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation* published in November 2016 by NH Coastal Risk and Hazards Commission. This document uses the same SLR scenarios as “From Tides to Storms.”
- *Green Infrastructure to Enhance Transportation Resiliency* published in December 2017 by GEI Consultants, Inc. This report utilizes two SLR scenarios for 2065 of an intermediate low of 0.71 ft and intermediate high of 1.75 ft

During a meeting with NHDOT staff held on August 30, 2018 MJ staff presented the literature research summary matrix to NHDOT to select a set of Sea Level Rise scenarios to evaluate the proposed alternatives. The scenarios NHDOT selected to evaluate are today (current conditions), year 2050 with an assumed sea level rise of 2 feet, and year 2100 with an assumed sea level rise of 6.6 feet. These selected scenarios fall in line with the “high” estimates predicted by NOAA and the Climate Science Special Report both published in 2017.

## **PURPOSE AND NEED**

### **Purpose**

The purpose of the project is to evaluate alternatives that would minimize the vulnerability of the existing NH Route 1B causeway due to current and future flooding events from anticipated sea level rise and storm surge, while minimizing impacts to the natural environment.

### **Need**

Currently there are only two access points onto New Castle Island from the mainland, with both points being part of NH Route 1B. A portion of the northerly route utilizes a causeway constructed in colonial times and improved over the years. This causeway is the lowest point along the route carrying vehicles, bicycles and pedestrians over the waters collectively known as the Portsmouth Harbor providing ingress/egress to the Town of New Castle. The southerly route contains a bridge structure, the New Castle-Rye Bridge that is scheduled for replacement. Over the last few years the causeway has seen an increase in flooding events leading to closure of the causeway, leaving the southerly route as the only point of access to the island and town. Based on current data, it is expected that these flood events will continue to increase in frequency and severity, thereby increasing the risks to the town. During storm events, access to emergency services might be reduced or even completely severed, threatening the safety of the New Castle residents. Basic access to schools and work may also be threatened on a more frequent basis, reducing the quality for life for island residents.

## **RISK EVALUATION**

One goal of the New Castle Route 1B Causeway Feasibility Study is to develop a risk evaluation associated with the predicted sea level rise and storm surge events. This evaluation focuses on identifying risks and making qualitative comparisons of three sea level rise scenarios. The scenarios evaluated are today (current conditions), year 2050 with an assumed sea level rise of 2 feet, and year 2100 with an assumed sea level rise of 6.6 feet. The complete Risk Evaluation is enclosed as Appendix A.

The findings of the Risk Evaluation should be understood to evaluate the effectiveness of each of the alternatives described later in the report in providing additional resiliency of NH Route 1B as it relates to projected sea level rise and storm surge.

#### Summary of the Risk Evaluation

While it is difficult to predict how rapidly sea level will rise and when storm surges will occur, it is clear that sea level rise will adversely affect the island of New Castle. In an effort to provide more resiliency and continued access to the island, any improvements to the causeway should be considered in relation to other low points along Route 1B and the overall elevation of Route 1B. For example, raising the causeway to an elevation where no inundation will occur under a 6.6' sea level rise and storm surge scenario in 2100 may not be practical. Resiliency of this magnitude would prevent the causeway from being inundated but the island would still be inaccessible because the bridges from Portsmouth would be under water and a large portion of Route 1B on the island would also be under water. It would be impractical to raise the causeway to a point beyond what the overall access to the island can sustain for a rise in sea level combined with a storm surge.

In order to access the causeway, vehicles must travel across Goat Island. Most of Goat Island appears to be 2 to 3 feet higher than the causeway. Raising the causeway much beyond the elevation of Goat Island would be impractical. The elevations of other portions of Route 1B must be considered when determining potential elevation changes to the causeway. If other identified low points along Route 1B will not be improved and raised in elevation, then there is limited practicality in improving the causeway resiliency much beyond that of the other low points. Resiliency improvements that include raising the elevation of the causeway and other identified low points may best be balanced by a coordinated elevation change along Route 1B, looking at the system holistically. It is recommended that survey along Route 1B be obtained to more accurately define the low points and determine the best systematic elevation change.

In considering the effects of storm surge, especially along the NH Route 1B causeway where storm surge would not be as significant as other locations exposed to the open ocean, some may consider resiliency improvements to be impractical. Storms of significance are regularly predicted with today's technology and residents can be required to evacuate the island for these events. Based on the 10-year history reviewed, residents could have been required to evacuate for eight different storms. Input and evaluation on evacuation scenarios are not within the scope of this project.

For the purpose of moving forward with this study, it is recommended that an increase of 3 feet to the causeway and an increase of 2.5 feet to other identified locations along Route 1B be evaluated. This elevation change will match or slightly exceed elevations on Goat Island and will serve as a practical starting point until more complete survey of Route 1B can be collected. This will provide for a 6-foot change in sea level with full access from both directions on Route 1B. However, this recommended change in elevation would not preclude inundation of the causeway due to storm surge during severe storm events. As previously stated, raising the causeway to an elevation that would preclude inundation during a storm event under a 6.6 foot sea level rise scenario does not appear practical given the elevation of New Castle Island itself.

This recommended elevation change is anticipated to perpetuate the current frequency of inundation of the causeway until after year 2050 based on the worst case sea level rise predictions. It is possible that

over the next 30 to 80 years sea level rise predictions may change. Due to the numerous unknowns, resiliency should continue to be reviewed as new sea level information becomes available to allow for planning of practical improvements.

## **IDENTIFY AND EVALUATE ALTERNATIVES**

MJ identified and evaluated alternatives to raise the New Castle Causeway 3 feet. Long-term methods to achieve resiliency were considered and incorporated in the alternatives, as appropriate. Preliminary cost estimates of the work were also developed. These alternatives included:

- No-Build
- Raising the Causeway
- Raising the Causeway with provisions for bicycles and pedestrians
- Raising the Causeway and raising other portions of NH 1B to assure complete connection of New Castle Island to the mainland
- Constructing a bridge

A brief description of the alternatives follows and refer to the figures for each:

### ***No-Build Alternative***

The No Build Alternative serves as a benchmark for comparison to the build alternatives. The No Build assumes that no improvements are made to the Route 1B causeway. The causeway would continue to consist of two 11-foot lanes with 2-foot shoulders on both sides of the roadway. Pedestrians and bicyclists utilize the limited shoulder with vehicles needing to encroach into the oncoming lane to pass them. Refer to Figures 6.1 through 6.1-2c for a typical section, plan, and profile view of this alternative.

### ***Raising the Causeway Alternative***

Under this alternative, the elevation of the causeway would be increased by 3 feet. The typical section for the causeway would be similar to the existing condition but with slightly wider shoulders. Two 11-foot lanes with 3-foot shoulders would be provided. By providing 14 feet between the edge of pavement and the roadway centerline, it is expected that most vehicles could pass bicyclists and pedestrians in the shoulder without having to encroach into the oncoming lane. Pedestrians would continue to walk in the shoulder. Steep rip rap slopes (1.5 Horizontal:1 Vertical) would be utilized to minimize the amount of fill placed in the adjacent waterway since impacts beyond the highest observable tide line will require mitigation.

This alternative would only increase the elevation of the causeway and would not address any of the other low-lying portions of Route 1B on New Castle Island. Therefore, there could be instances during severe storm events that portions of Route 1B would need to be closed to traffic even though the causeway may be above the water surface elevation.

The preliminary cost estimate for this alternative is \$1.7 million. Refer to Figures 6.2 through 6.2-2c for a typical section, plan, and profile view of this alternative.

***Raising the Causeway with Provisions for Bicycles and Pedestrians Alternative***

Under this alternative, the elevation of the causeway would be increased by 3 feet. To provide additional accommodations for bicycles and pedestrians, the typical section would provide two 11-foot travel lanes with 4-foot shoulders. A sidewalk would also be provided on one side of the causeway for pedestrians. To minimize the impacts to the waterway, retaining walls would be utilized on both sides of the causeway.

The need for additional pedestrian and bicycle accommodations are well known as Route 1B is one of the most heavily used roadways by non-motorized users in the state. This is attributed to the scenic nature of the roadway and the fact that the Route 1B loop is exactly 10 kilometers in length, making it ideal for runners for training. Route 1B also serves as the East Coast Greenway and the NH Coastal Scenic Byway. New Castle is currently seeking funding for additional bicycle and pedestrian facilities on other stretches of Route 1B in New Castle. It should be noted though that there are no bicycle or pedestrian facilities on either approach to the causeway although there is a gravel shoulder that allows pedestrians to walk off of the paved surface.

Similar to the previous alternative, this alternative would only increase the elevation of the causeway and would not address any of the other low-lying portions of Route 1B on New Castle Island. Therefore, there could be instances during severe storm events that portions of Route 1B would need to be closed to traffic even though the causeway may be above the water surface elevation.

The preliminary cost estimate for this alternative is \$4.3 million. Refer to Figures 6.3 through 6.3-2c for a typical section, plan, and profile view of this alternative.

***Raising the Causeway and Raising Other Portions of NH Route 1B Alternative***

This alternative would include the improvements to the causeway described under the previous alternative with the addition of increasing the elevation of other low-lying portions of Route 1B. The locations are shown on Figure 6.4-1a and are near Neal's Pit Lane in New Castle, the Wentworth Country Club in Rye, and near the Rye/Portsmouth town line.

By raising the elevation of these low-lying points along Route 1B, along with raising the causeway, the entirety of Route 1B would be at or above the elevation of Goat Island. This would accommodate a 6-foot change in sea level rise. It should be noted that this increase in elevation would not preclude the causeway or other portions of Route 1B from being inundated with water during a storm surge event.

The preliminary cost estimate for this alternative is \$5.2 million. Refer to Figures 6.4 for a typical section used in areas where Route 1B would be raised and Figure 6.4-1a for locations of the low-lying areas along Route 1B. More detailed survey would be required to determine the actual limits of Route 1B that would need to be raised.

***Bridge Alternative***

This alternative would involve removing the causeway and replacing it with a bridge structure that could support the required highway loads. The elevation of the bridge would need to be significantly higher than the causeway to keep the bottom of the structure above the water elevation. The typical section

would provide two 11-foot travel lanes with 4-foot shoulders. A sidewalk would also be provided on one side of the bridge for pedestrians. To minimize the impacts to the waterway along the approaches to the bridge, retaining walls would be utilized on both sides of the roadway. This alternative would only increase the elevation of Route 1B in the area of the causeway and would not address any of the other low-lying portions of Route 1B on New Castle Island. This alternative would require reconstructing the waterline that currently runs within the causeway.

By replacing the causeway with a bridge structure, the flow of the Piscataqua River and tidal flow could be altered and potentially impact some existing uses on the eastern side of the causeway such as the junior sailing program and recreational boating due to increased navigational hazards. A detailed hydraulic study would need to be completed to determine how the removal of the causeway would impact the flow of water in this area.

The preliminary cost estimate for this alternative is \$15.6 million. Refer to Figures 6.5 through 6.5-2c for a typical section, plan, and profile view of this alternative.

## ENVIRONMENTAL CONSIDERATIONS

MJ identified the environmental constraints that each alternative would face, including NEPA requirements and permitting. Environmental resources were based on a site walk, existing public databases, and aerial imagery. Species of concern were identified from a NHB database review, USFWS Information for Planning and Consultation (IPaC) Report, and NOAA website to identify the type and level of Section 7 consultation that would be needed for each alternative. A formal delineation of wetlands and surveys for sensitive species was not conducted. Important resources and other items of interest were noted during the field review.

### Endangered Species and Natural Communities

Consultation with the New Hampshire Natural Heritage Bureau (NHB) identified several rare species in the vicinity of the project area which are listed below.

**Table 1 – Rare Species in Vicinity of Project**

| <b><u>Common Name</u></b> | <b><u>Scientific Name</u></b>   | <b><u>State Status</u></b> | <b><u>Federal Status</u></b>               |
|---------------------------|---------------------------------|----------------------------|--|
| Marsh Elder               | <i>Iva frutescens</i>           | Threatened                 | N/A  |
| Atlantic Sturgeon         | <i>Acipenser oxyrinchus</i>     | Threatened                 | Threatened                                 |
| Shortnose Sturgeon        | <i>Acipenser brevirostrum</i>   | Endangered                 | Endangered                                 |
| Smooth Green Snake        | <i>Opheodrys vernalis</i>       | Special Concern            | N/A  |
| Bald Eagle                | <i>Haliaeetus leucocephalus</i> | Special Concern            | N/A (Bald and Golden Eagle Protection Act) |
| Purple Martin             | <i>Progne subis</i>             | Threatened                 | N/A  |
| Unnamed Sensitive Species | N/A                             | Endangered                 | Threatened                                 |
| Unnamed Sensitive Species | N/A                             | Endangered                 | Threatened                                 |



The USFWS Information for Planning and Consultation (IPaC) Report identified federally threatened Northern Long-eared Bat (NLEB) (*Myotis septentrionalis*) and red knot (*Calidris canutus rufa*), as well as federally endangered Roseate Tern (*Sterna dougallii dougallii*) as potentially occurring within the vicinity of the project area. There are no designated critical habitats within the project area.

The NLEB was listed as threatened under the ESA in May 2015. This species is found across much of the eastern and north central U.S. and into Canada. The primary threat to the northern long-eared bat is white-nose syndrome. Populations of the northern long-eared bat in the Northeast U.S. have declined by 99 percent since symptoms of white-nose syndrome were first observed in 2006.

#### Fisheries

The NOAA Section 7 Mapper was accessed to determine if the project area overlapped with federally listed species under the jurisdiction of the National Oceanic and Atmospheric Administration. The mapper identified several listed species potentially occurring in the immediate vicinity of the project area.

The project area is in or near Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) designated critical habitat, and Atlantic sturgeon adults and sub-adults may be migrating and foraging throughout the project area year-round. Shortnose sturgeon (*Acipenser brevirostrum*) adults may also be present, migrating and foraging in the area from the beginning of April to the end of November. Atlantic Salmon (*Salmo salar*) adults and smolts from the Gulf of Maine Distinct Population Segment may be present in the area migrating and foraging year-round. Leatherback sea turtles (*Dermochelys coriacea*), Loggerhead sea turtles (*Caretta caretta*), Kemp's Ridley sea turtles (*Lepidochelys kempii*), and Green sea turtles (*Chelonia mydas*) may all be present in the area migrating and foraging from the beginning of June through the end of November.

#### Floodways/Floodplains

Executive Order 11988, Floodplain Management, directs all federal agencies to avoid the direct and indirect support of floodplain development wherever there is a practicable alternative. According to the Flood Insurance Rate Map (FIRM) panel containing the project corridor (FIRM 33015C0270E), dated May 17, 2005, the project is located in a special flood hazard area (SFHA). The area north of the causeway (along the river side) is zoned as VE for coastal high hazard area. The area south of the causeway (the bay side) is zoned as AE, the 100-year flood zone.

Preliminary updates were made to multiple FIRM panels in Rockingham County in 2014, including the two panels containing the project areas. The southeastern shore of Goat Island, adjacent to the causeway, changed from a 500-year flood zone to a 100-year flood zone. The low spot nearest the New Castle-Rye bridge was partially located in a 100-year floodplain and 500-year floodplain in the 2005 FIRM and was updated to all 100-year floodplain and the road itself to the "Limit of Moderate Wave Action" (LiMWA). The second low spot was located in a 100-year floodplain in the 2005 FIRM and was changed to include a sliver of 500-year floodplain along the roadway.

Impacts to jurisdictional areas will be qualitatively evaluated for each alternative to facilitate discussion of future permitting and mitigation requirements. No detailed evaluation of impacts is required at this time.

### Historic and Cultural Resources

A desktop screening of historic structures in the vicinity of the study area(s) was performed to identify properties over 50 years old. The New Castle Historic District, a local historic district, abuts the causeway and extends to the east and south into New Castle. There are multiple properties in this district over 50 years old, including Riverside Cemetery, which is adjacent to the causeway. There were several structures over 50 years old located on Wentworth Road identified in the vicinity of the two low spots. Additionally, Wentworth by the Sea Hotel and Resort is eligible for the National Register. Lastly, the New Castle Rye Bridge is one of two remaining single leaf fixed trunnion bascule bridges in the State of New Hampshire. All of the Build Alternatives are expected to have potential impacts to these resources.

### Coastal Zone

The Town of New Castle is located within the New Hampshire Coastal Zone. Federal agency activities, activities requiring a federal license or permit, or state and local government projects receiving federal financial assistance all require a Coastal Zone Consistency Review.

### Waterway/Wetlands

Due to impacts below the highest observable tide line (HOTL), an individual permit from the Army Corps of Engineers would be required for all of the Build alternatives which would also necessitate the need for an individual Water Quality Certification. A Major Impact NHDES Dredge and Fill permit will be required for work below HOTL and within the 100-foot tidal buffer zone. Finally, a standard NHDES Shoreland Permit for approach work located beyond the tidal buffer zone but within 250 feet of the Piscataqua River. Impacts below HOTL will require mitigation.

## **PUBLIC INVOLVEMENT**

A stakeholder meeting was held on June 26, 2018 at the New Castle Recreational Building. Attendees included representatives from the New Castle Selectmen, Portsmouth Fire Department, Safe Path, Rockingham Planning Commission, NHDOT and McFarland Johnson. NHDOT and MJ staff provided an overview of the project and possible alternatives. Discussion from stakeholders consisted of previous causeway closures, current evacuation routes, traffic that utilizes the causeway, other low spots along Route 1B, existing stormwater storage challenges on the island, etc. A summary of the meeting is included in Appendix B.

**RECOMMENDATIONS**

The matrix below summarizes the five (5) alternatives for improving the resiliency of the Route 1B causeway and compares the impacts, costs, advantages, and disadvantages of each.

|                                 | <b>No-Build</b>                    | <b>Raise Causeway 3 Feet</b>              | <b>Raise Causeway 3 Feet and Provide Bike/Ped Facilities</b> | <b>Raise Causeway 3 Feet and Raise Other Low-Lying Areas on Route 1B</b> | <b>Replace Causeway with Bridge</b>                            |
|---------------------------------|------------------------------------|---|--|--|--|
| <b>Bicycle Provisions</b>       | Ride in Traveled Way (2' Shoulder) | Ride in Traveled Way (3' Shoulder)        | Ride in Shoulder (4' Shoulder)                               | Ride in Shoulder (4' Shoulder)   | Ride in Shoulder (4' Shoulder)                                 |
| <b>Pedestrian Provisions</b>    | Walk in Shoulder (2' Wide)         | Walk in Shoulder (3' Wide)                | Walk on Sidewalk   | Walk on Sidewalk   | Walk on Sidewalk   |
| <b>Flood Resiliency</b>         | No Change                          | Only Causeway Improved                    | Only Causeway Improved                                       | Entire Route 1B Improved   | Only Causeway Improved   |
| <b>FEMA Coordination</b>        | No                                 | Yes                                       | Yes  | Yes  | Yes Extensive  |
| <b>NHB/NHFG Coordination</b>    | No                                 | Yes                                       | Yes  | Yes  | Yes  |
| <b>Section 7 Consultation</b>   | No                                 | Yes                                       | Yes  | Yes  | Yes  |
| <b>Section 106 Consultation</b> | No                                 | Yes                                       | Yes  | Yes  | Yes  |
| <b>Anticipated Impacts</b>      | None                               | Impacts to Causeway Sideslopes Below HOTL | Impacts to Causeway Sideslopes Below HOTL                    | Impacts to Causeway Sideslopes Below HOTL                                | Impacts to Causeway Below HOTL and Impacts to River Hydraulics |
| <b>Preliminary Cost</b>         | -                                  | \$1.7 Million                             | \$4.3 Million  | \$5.2 Million  | \$15.6 Million   |

Note: Construction cost estimates do not include ROW acquisition costs or mitigation costs.

In reviewing the alternatives, it is apparent that the cost associated with replacing the causeway with a bridge does not provide any significant benefits over the other alternatives that simply raise the causeway elevation. Further, the potential changes to the river and tidal flow in the area by removing the causeway could likely have more impacts to the environmental resources than simply raising the causeway. For these reasons, the alternative to replace the causeway with a bridge should be eliminated from consideration.

The decision to provide enhanced bicycle and pedestrian facilities along the causeway should be considered only as part of a future overall plan to improve bicycle and pedestrian facilities along the entire length of NH Route 1B. Given the additional costs associated with providing enhanced bicycle and pedestrian facilities, this investment may only be warranted if these facilities can connect to a network of facilities on both approaches, or such facilities are planned in the future. Continued coordination with the Town regarding the overall bicycle and pedestrian plans are recommended.

Comparing the alternatives that raise the causeway to the No-Build alternative requires taking sea level rise into account. Under existing conditions, the causeway is inundated with water multiple times per year, but for short durations. These events do not result in damage to the causeway and the southern portion of Route 1B is able to stay open, providing the lone connection of New Castle Island to the mainland until the debris on the causeway is removed and the causeway opened back up to traffic. Therefore, under existing conditions, the No-Build alternative is preferred as the causeway does not appear to be vulnerable to damage from the current level of flooding events.

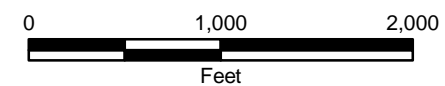
When looking at a future scenario with a potential 6-foot change in sea level rise, it would be expected that the causeway would need to be closed frequently throughout the year and damage would be expected to the causeway during storm events since it would be submerged by multiple feet of water, likely experiencing some wave action as well. Under this future scenario, the preferred alternative would be to raise the causeway 3 feet along with raising other low-lying areas along Route 1B. This alternative not only protects the causeway, but also provides the most resiliency to all of the residents on New Castle Island.

Since the rate and extent at which the sea level will rise in the future can change as new climate models are developed, these studies should be monitored to ensure that a project to improve the Route 1B causeway is completed prior to the sea level rising to a point where it would result in damage to the causeway and put the residents of New Castle Island at risk.



**Legend**

 Project Area



Portsmouth Avenue Causeway  
New Castle, NH

USGS Location Map

|                       |                    |                |
|-----------------------|--------------------|----------------|
| SCALE:<br>1" = 1,000' | DATE:<br>JUNE 2019 | FIGURE:<br>1.0 |
|-----------------------|--------------------|----------------|






 **McFarland Johnson**

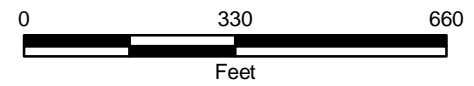


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

\\jpcolo-ism\18275.05 New Castle\Draw\GIS\Figures\2.0 New Castle NWI Wetlands Map.mxd

**Legend**  
 Project Area

- NWI Wetlands**
-  Estuarine and Marine Deepwater
  -  Estuarine and Marine Wetland
  -  Freshwater Emergent Wetland
  -  Freshwater Forested/Shrub Wetland
  -  Freshwater Pond



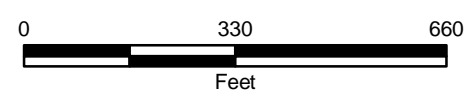
|   |                    |                |
|---|--------------------|----------------|
| Portsmouth Avenue Causeway<br>New Castle, NH  |                    |                |
| National Wetland Inventory  |                    |                |
| SCALE:<br>1" = 300'   | DATE:<br>JUNE 2019 | FIGURE:<br>2.0 |
|  |                    |                |

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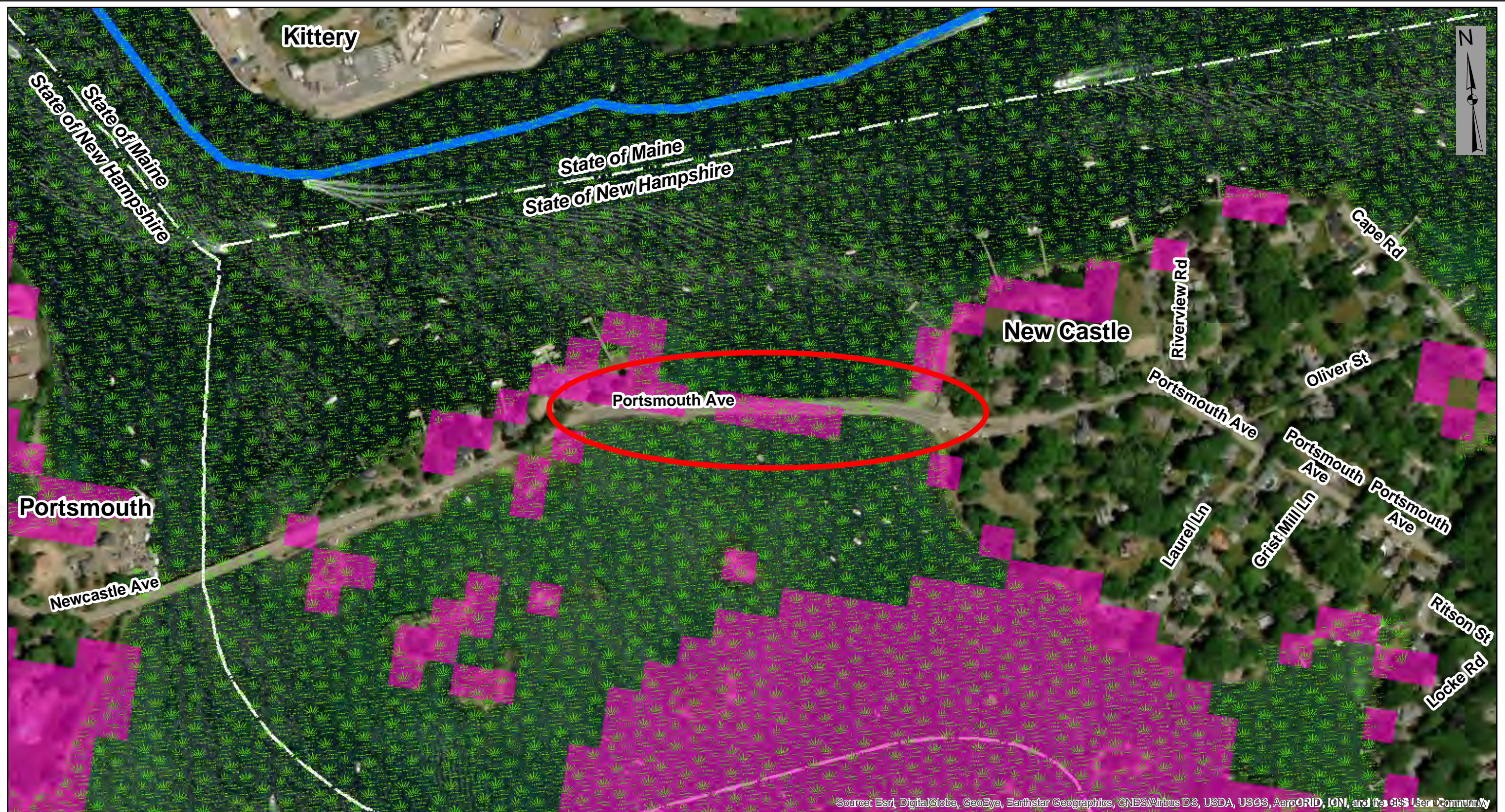


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Legend**
- Project Area
  - Streams and Rivers
  - Conservation Lands
  - Waterbodies



|  |                    |                |
|--|--------------------|----------------|
| Portsmouth Avenue Causeway<br>New Castle, NH |                    |                |
| Conservation Lands<br>and Parks              |                    |                |
| SCALE:<br>1" = 300'                          | DATE:<br>JUNE 2019 | FIGURE:<br>3.0 |
| <b>McFarland Johnson</b>                     |                    |                |

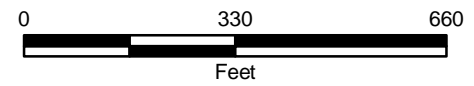


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

**Legend**

-  Project Area
-  Rivers and Streams
-  NWI Wetlands

- Wildlife Action Plan Habitat Tiers**
-  1 Highest Ranked Habitat in New Hampshire
  -  2 Highest Ranked Habitat in Biological Region
  -  3 Supporting Landscapes



|   |                    |                |
|---|--------------------|----------------|
| Portsmouth Avenue Causeway<br>New Castle, NH  |                    |                |
| NH Wildlife Plan<br>Habitat Features  |                    |                |
| SCALE:<br>1" = 300'   | DATE:<br>JUNE 2019 | FIGURE:<br>4.0 |
|  McFarland Johnson |                    |                |



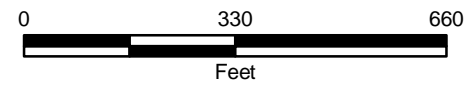
\\jpcolo-ism\m\18275.05 New Castle\Draw\GIS\Figures\5.0 Farmland Soil Classification.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

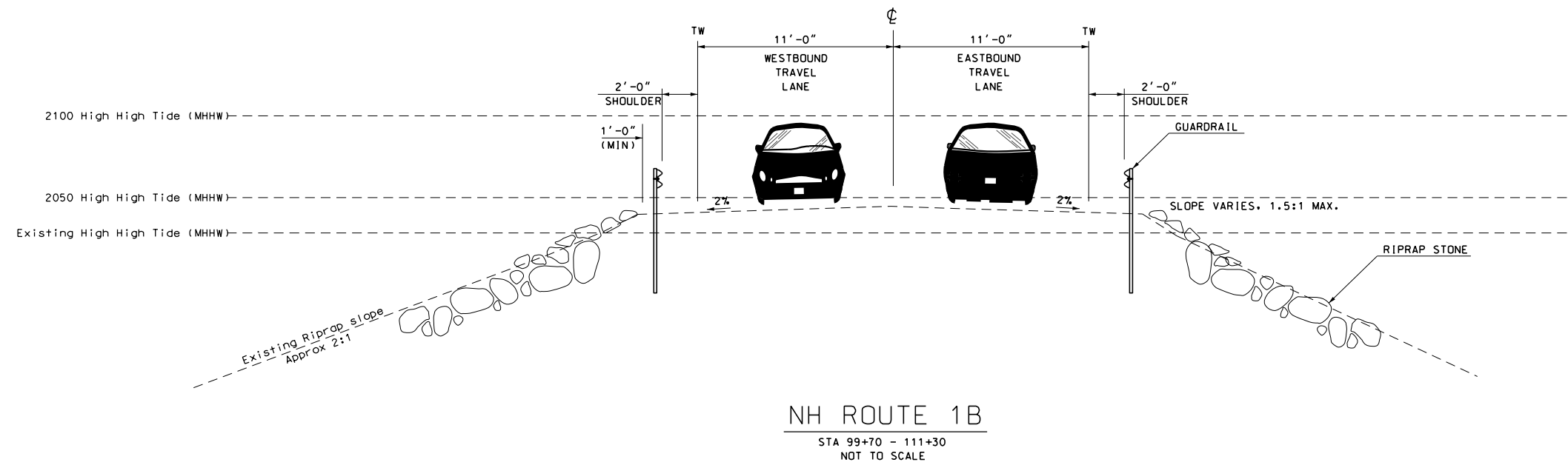
**Legend**

- Project Area
- All areas are prime farmland
- Farmland of local importance
- Farmland of statewide importance
- Not prime farmland

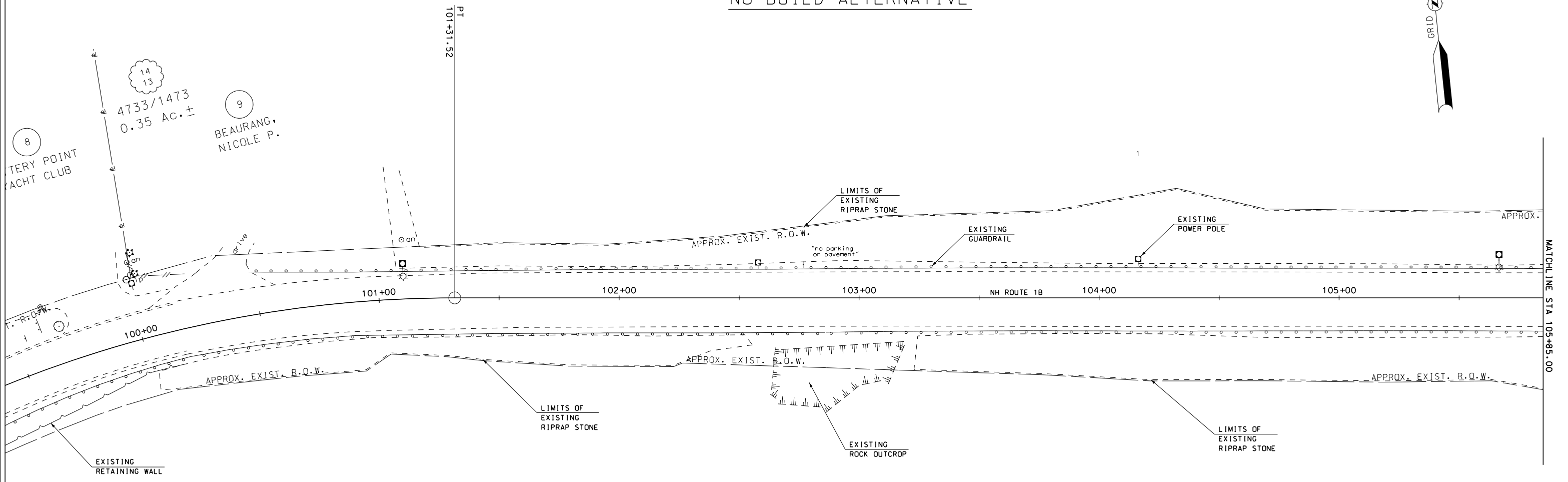


|  |                    |                |
|--|--------------------|----------------|
| Portsmouth Avenue Causeway<br>New Castle, NH |                    |                |
| Farmland Soil Classification                 |                    |                |
| SCALE:<br>1" = 300'                          | DATE:<br>JUNE 2019 | FIGURE:<br>5.0 |
| <b>McFarland Johnson</b>                     |                    |                |

NO-BUILD ALTERNATIVE



NO-BUILD ALTERNATIVE



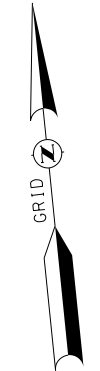
McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

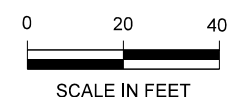
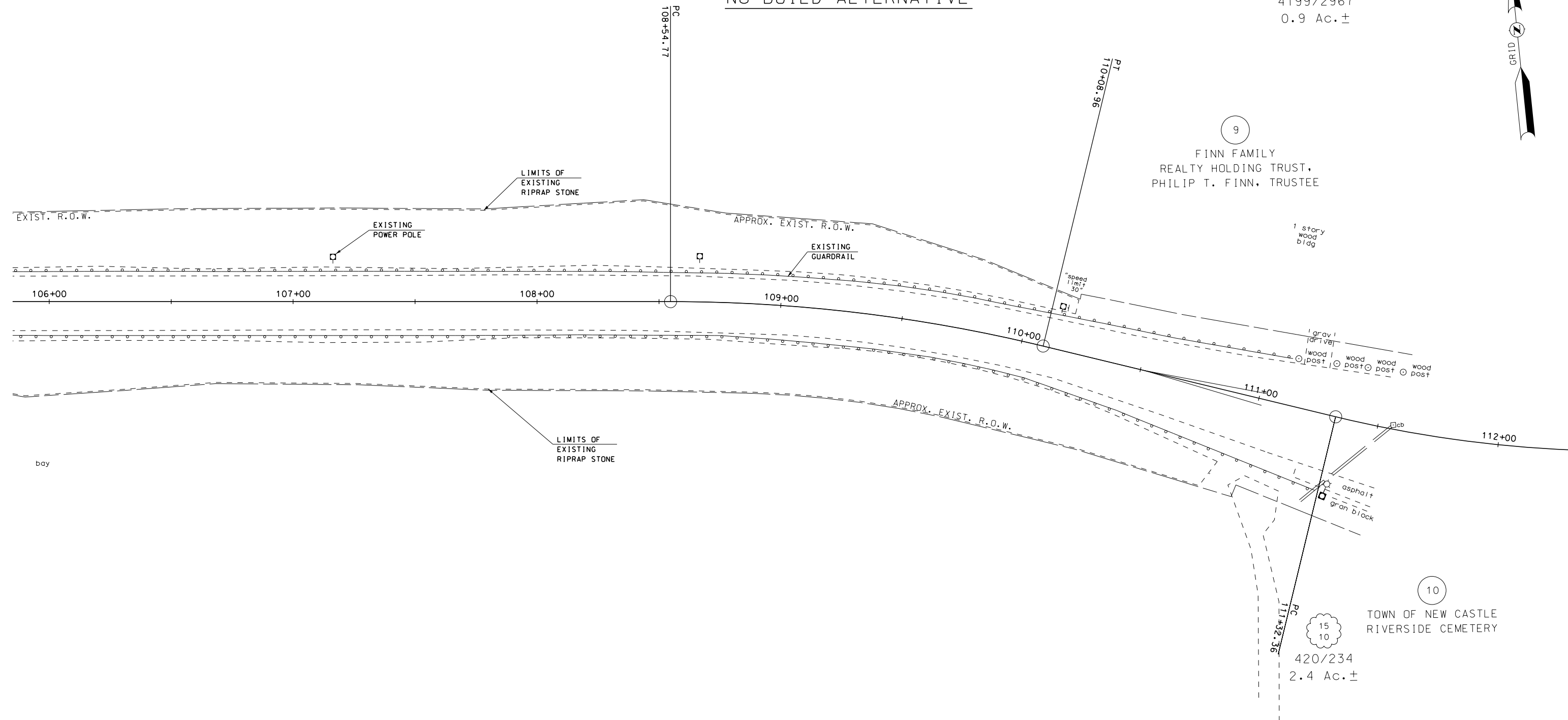
FIGURE 6.1-1a  
NO-BUILD  
PLAN VIEW

NO-BUILD ALTERNATIVE

15  
5  
4199/2967  
0.9 Ac.±



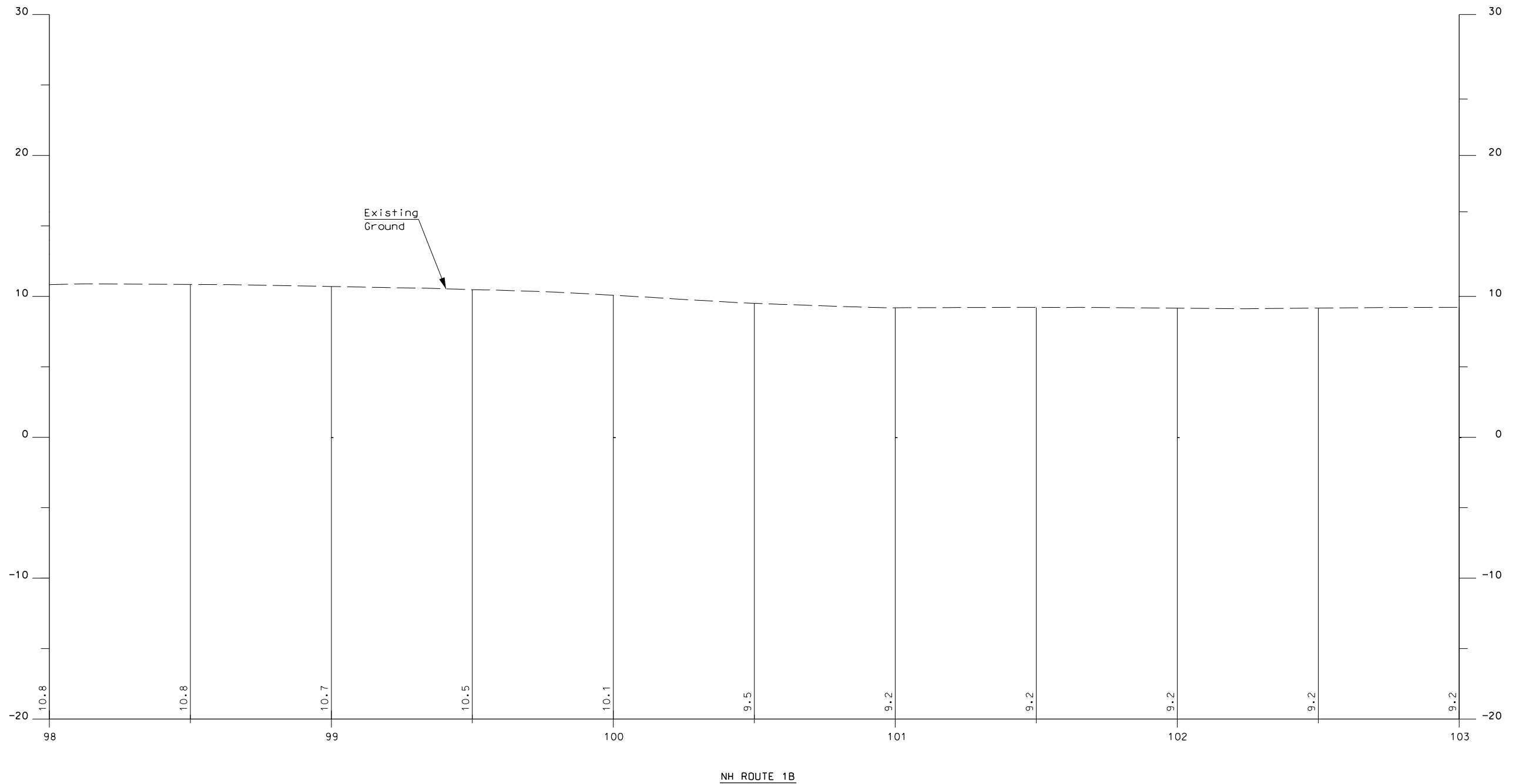
9  
FINN FAMILY  
REALTY HOLDING TRUST,  
PHILIP T. FINN, TRUSTEE



**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.1-1b  
NO-BUILD  
PLAN VIEW

NO-BUILD ALTERNATIVE



SCALE:  
1" = 40' HORIZ.  
1" = 8' VERT.

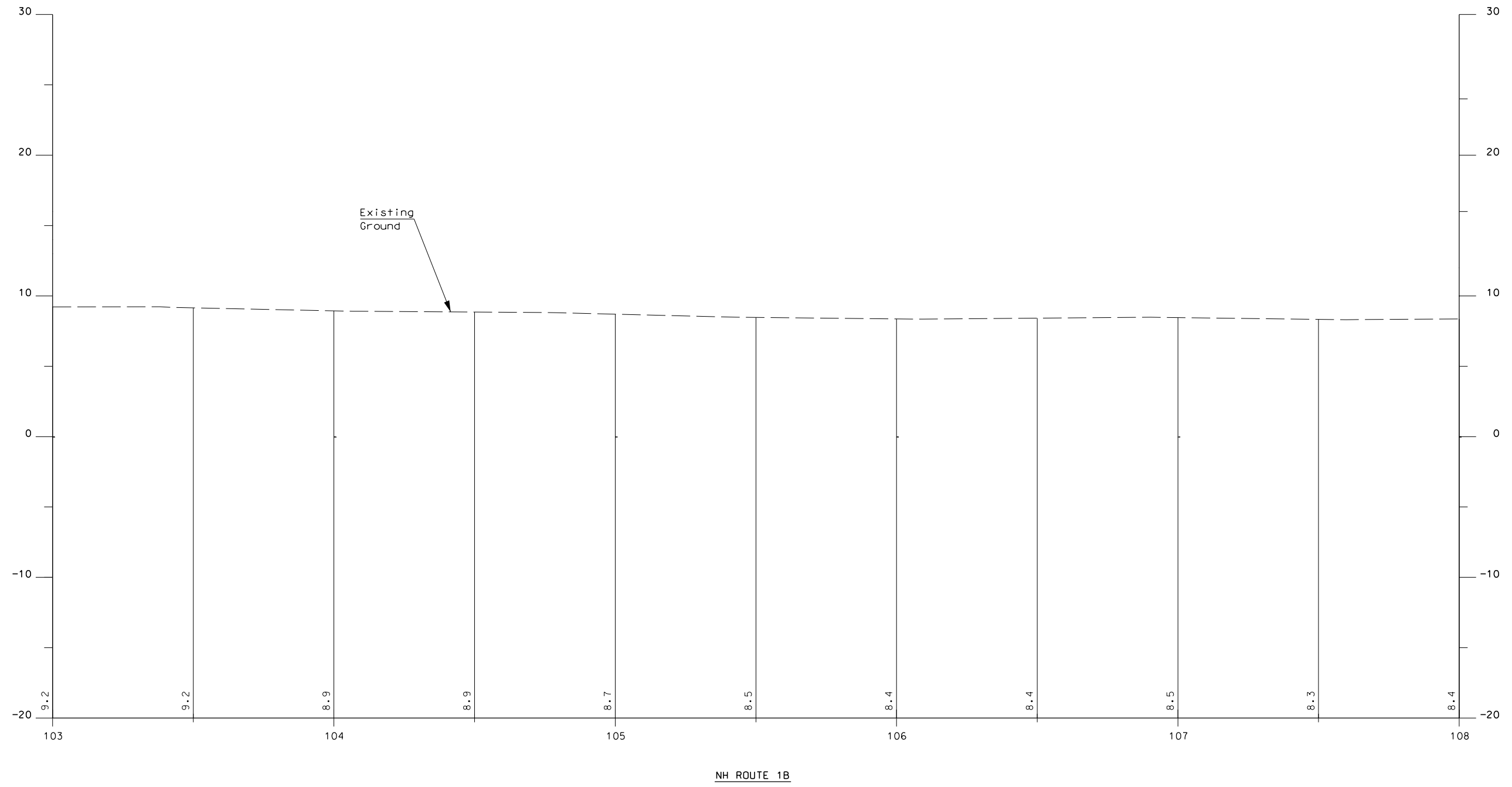


McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.1-2a  
NO-BUILD  
PROFILE VIEW

NO-BUILD ALTERNATIVE



SCALE:  
1" = 40' HORIZ.  
1" = 8' VERT.

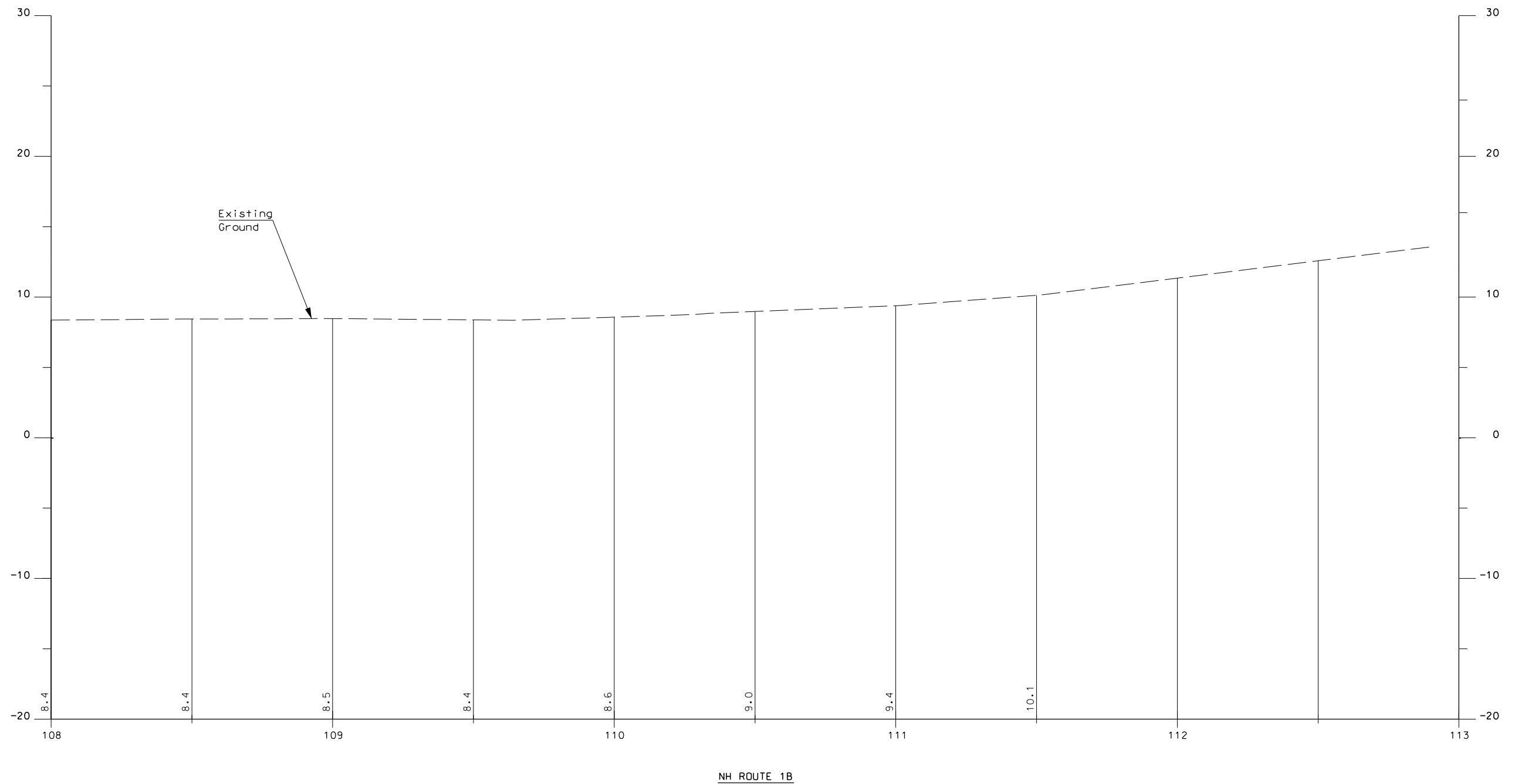


McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.1-2b  
NO-BUILD  
PROFILE VIEW

NO-BUILD ALTERNATIVE



SCALE:  
1" = 40' HORIZ.  
1" = 8' VERT.

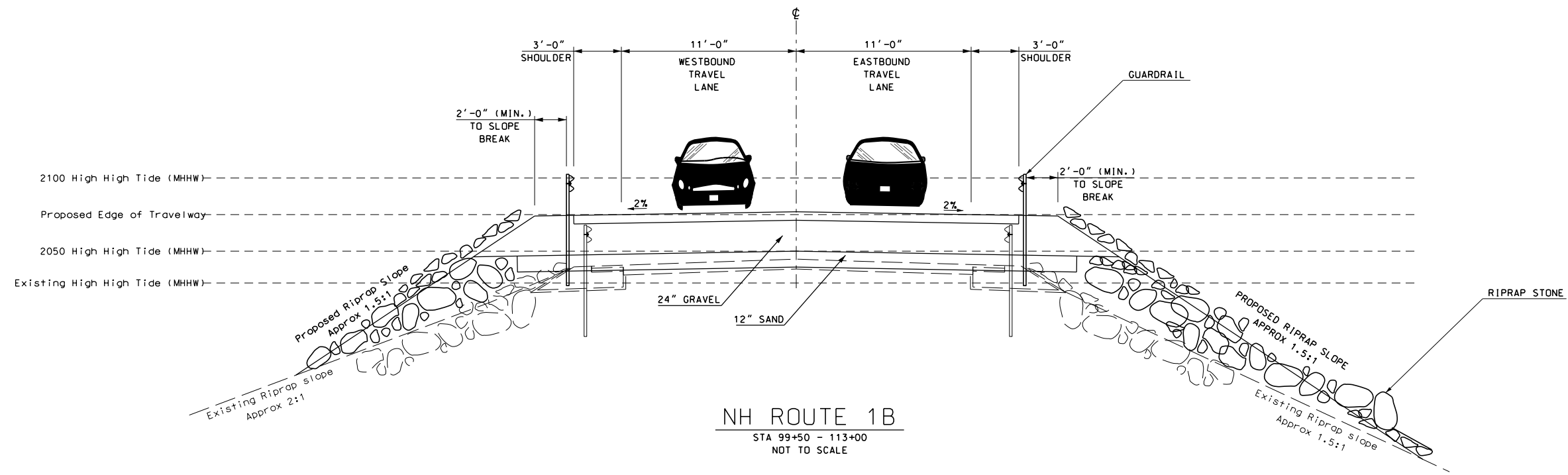


McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

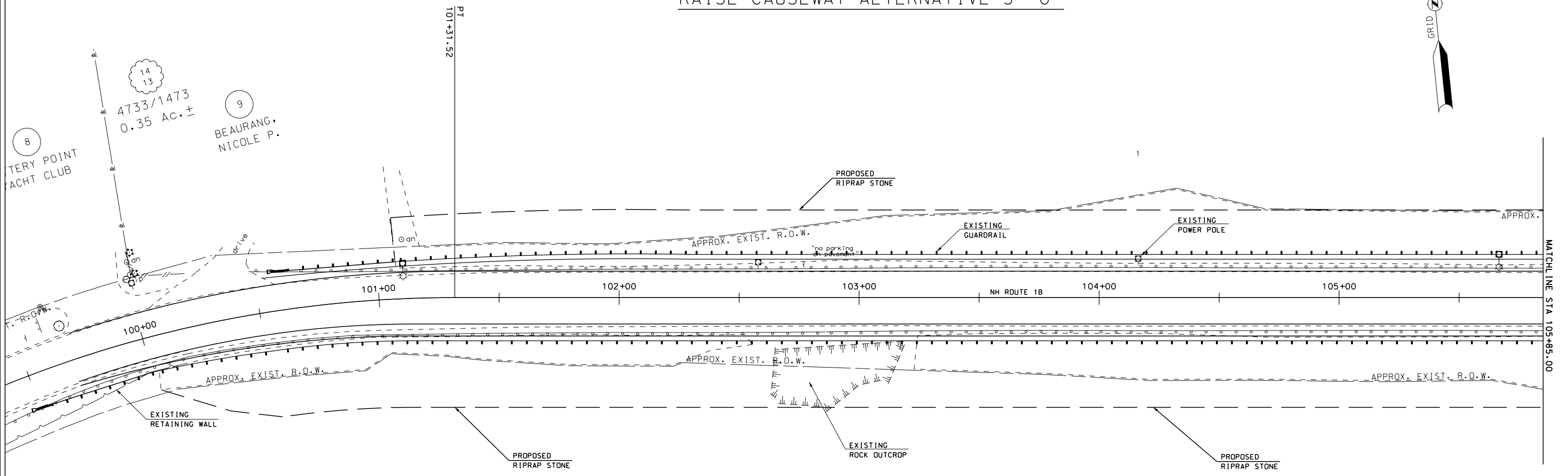
FIGURE 6.1-2c  
NO-BUILD  
PROFILE VIEW

RAISE CAUSEWAY ALTERNATIVE 3'-0"





RAISE CAUSEWAY ALTERNATIVE 3'-0"



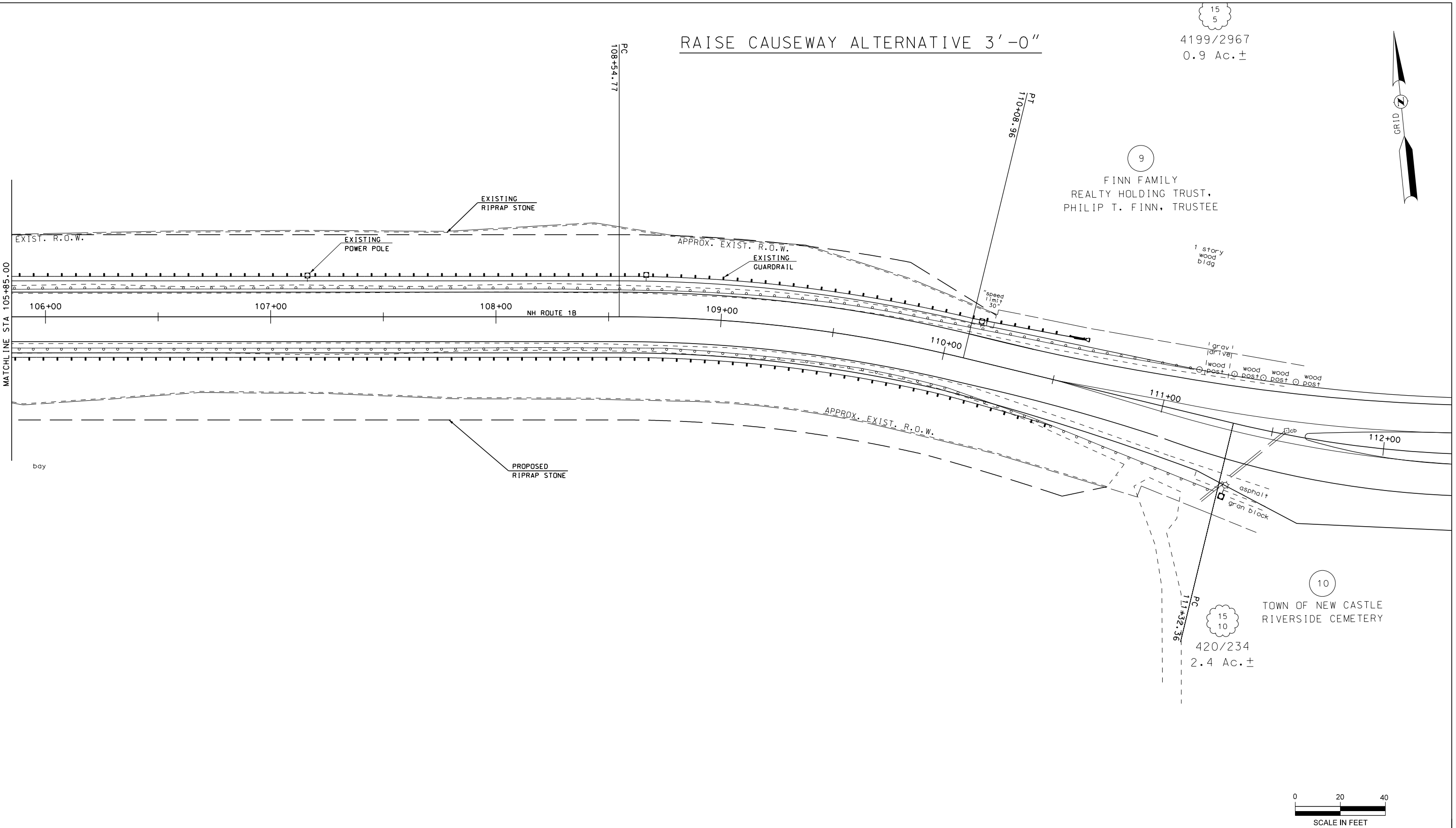
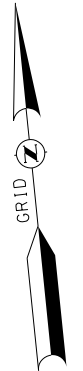
McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.2-1a  
RAISE CAUSEWAY  
PLAN VIEW

RAISE CAUSEWAY ALTERNATIVE 3' - 0"

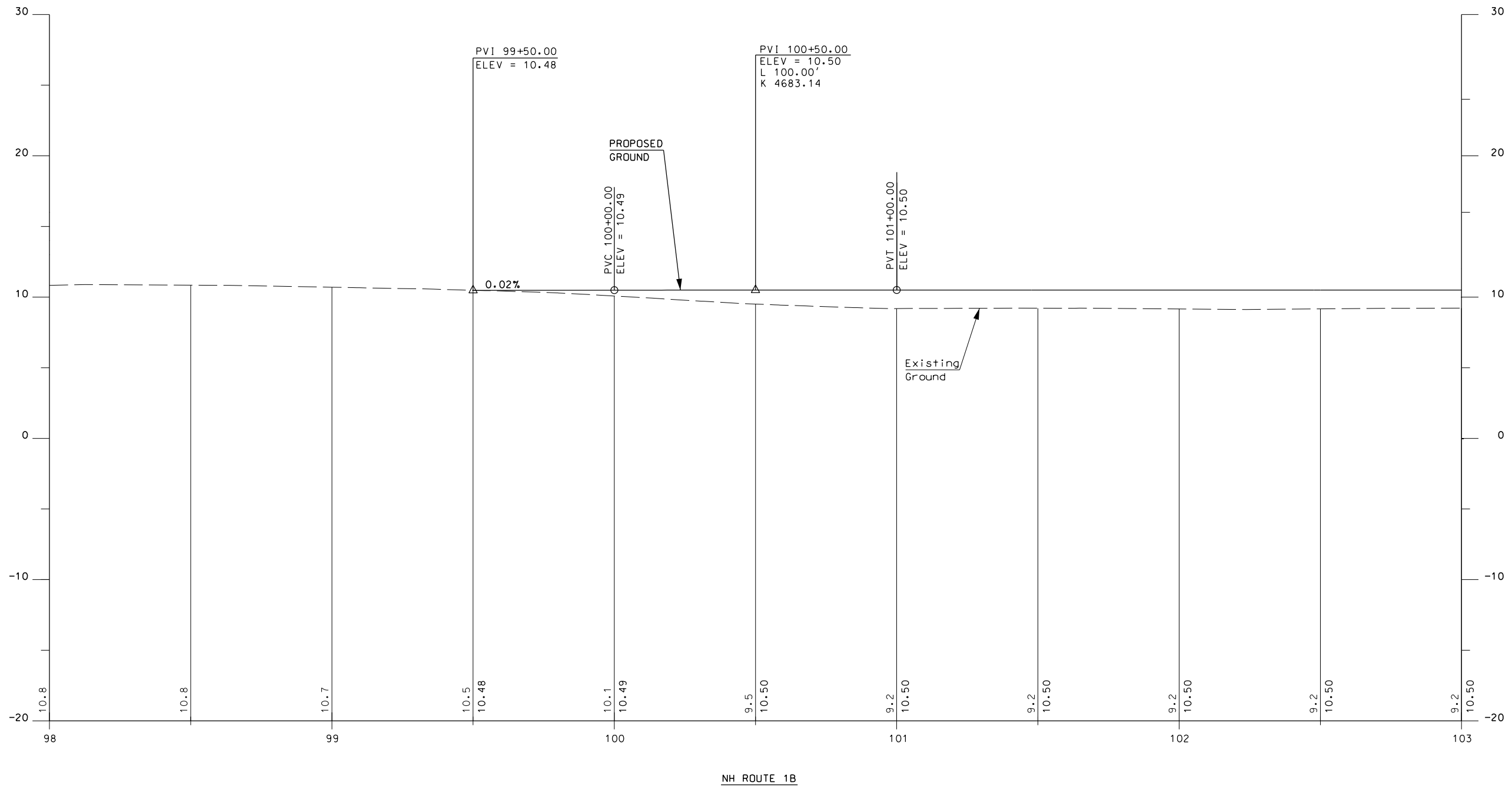
15  
5  
4199/2967  
0.9 Ac.±



**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.2-1b  
RAISE CAUSEWAY  
PLAN VIEW

RAISE CAUSEWAY ALTERNATIVE 3'-0"



SCALE:  
 1" = 40' HORIZ.  
 1" = 8' VERT.

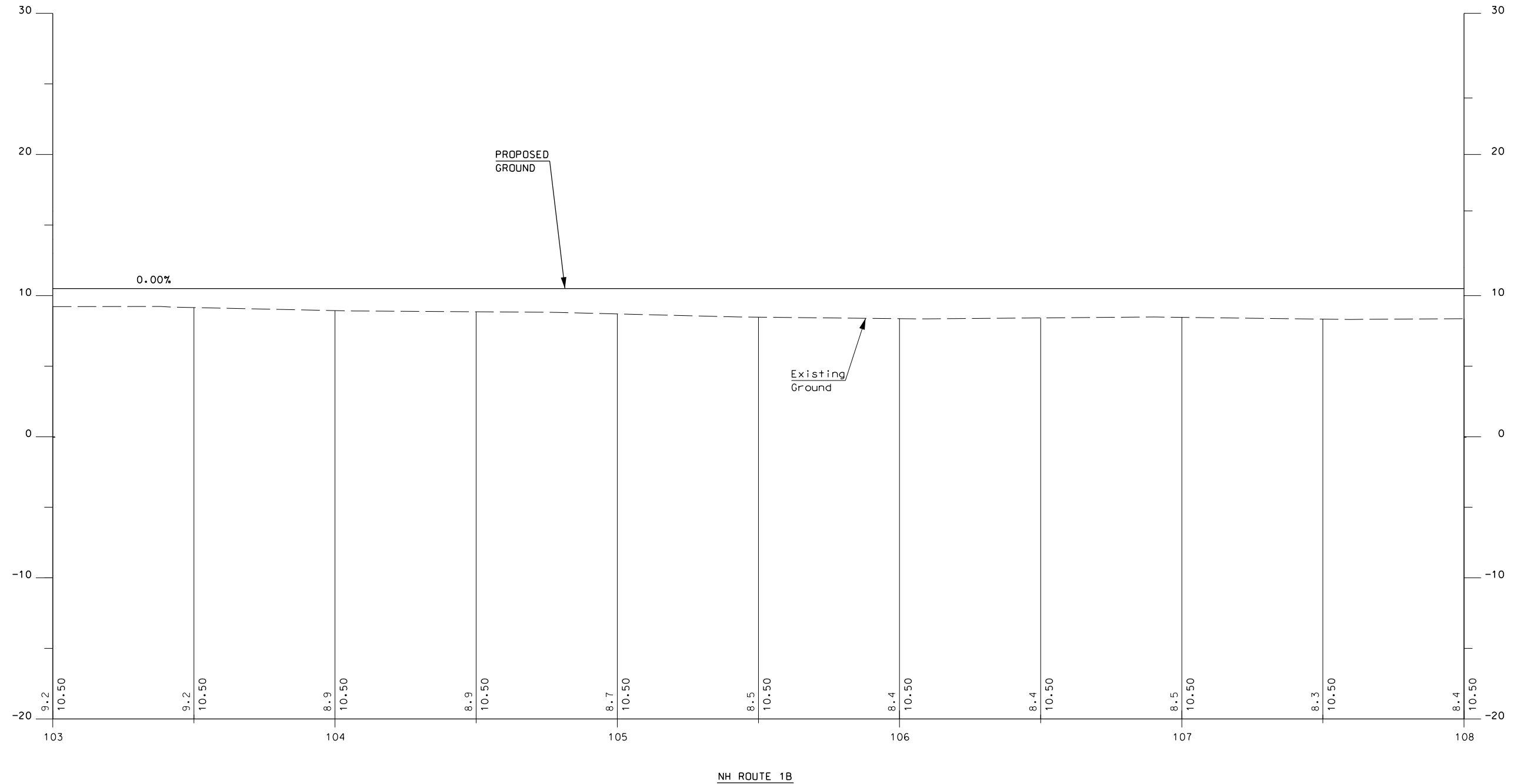


McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.2-2a  
 RAISE CAUSEWAY  
 PROFILE VIEW

RAISE CAUSEWAY ALTERNATIVE 3'-0"



SCALE:  
1" = 40' HORIZ.  
1" = 8' VERT.

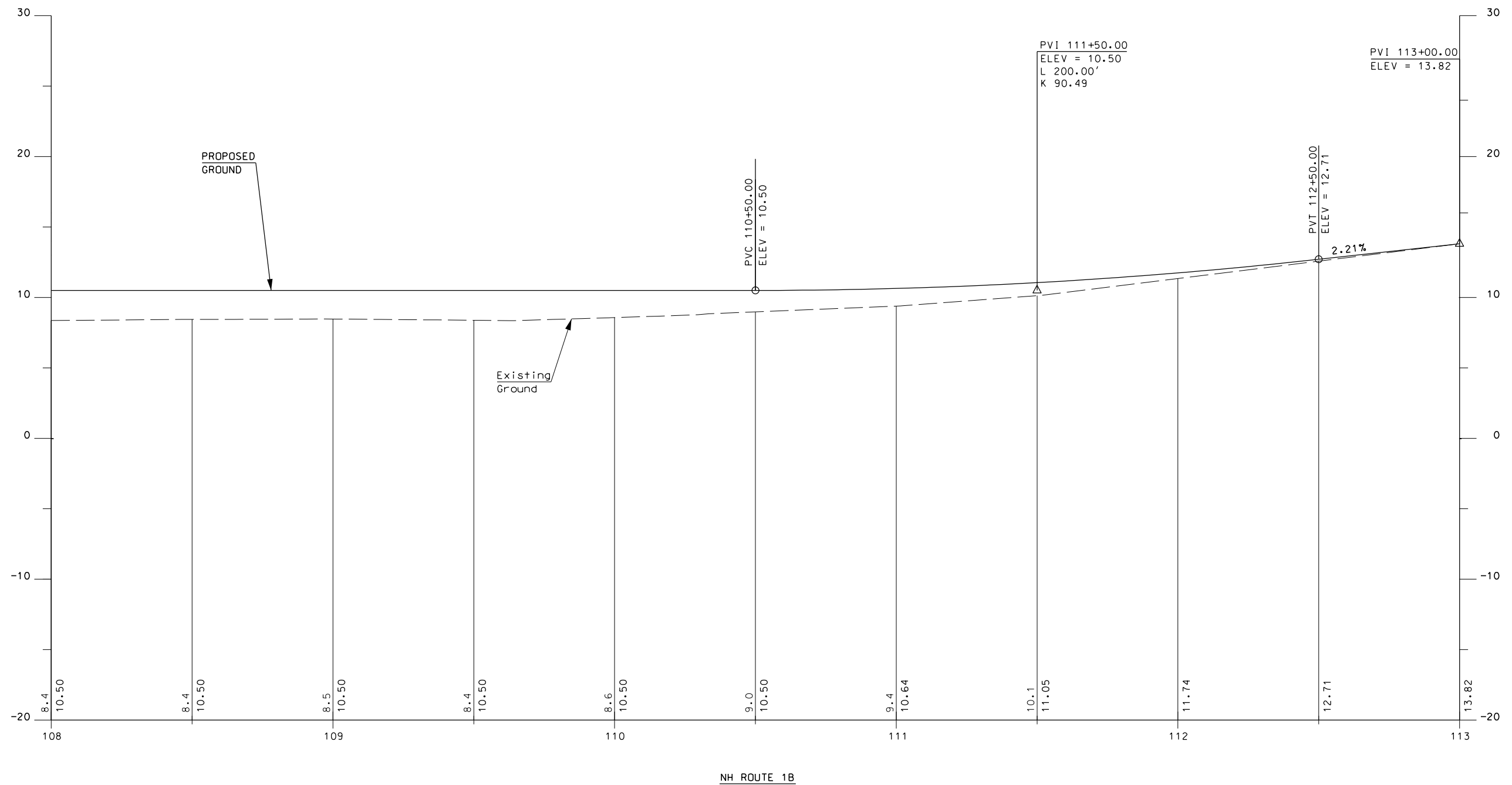


McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.2-2b  
RAISE CAUSEWAY  
PROFILE VIEW

RAISE CAUSEWAY ALTERNATIVE 3'-0"



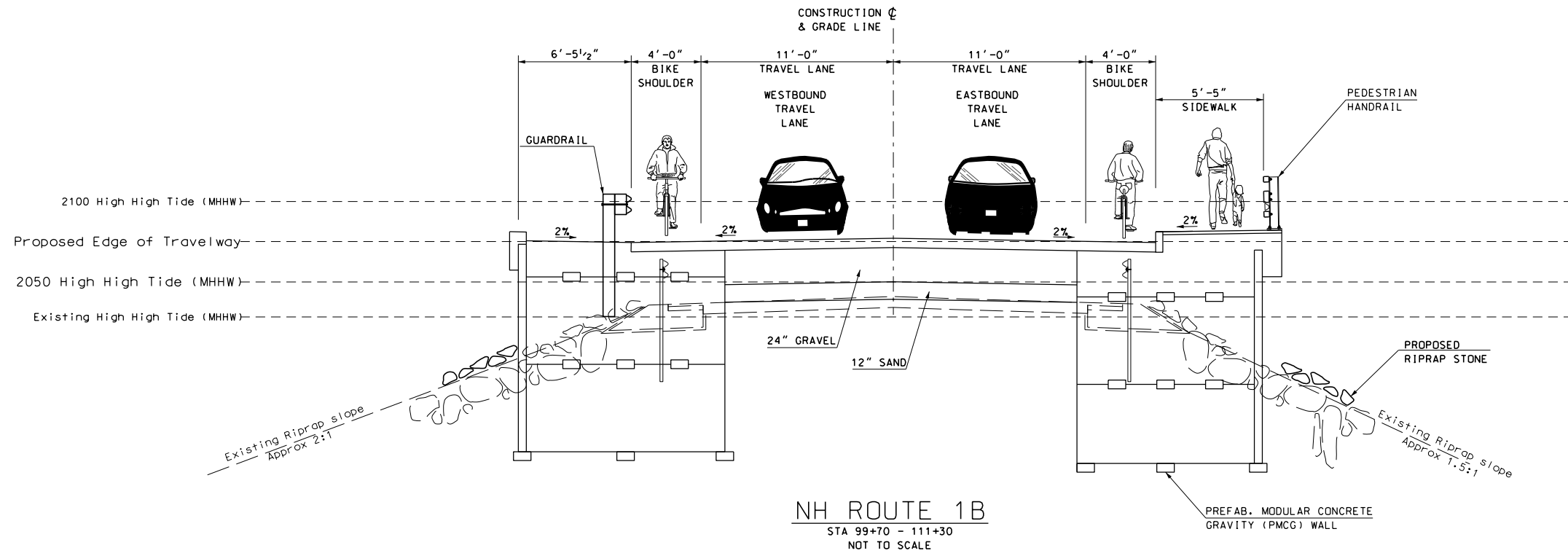
SCALE:  
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 1" = 8' VERT.



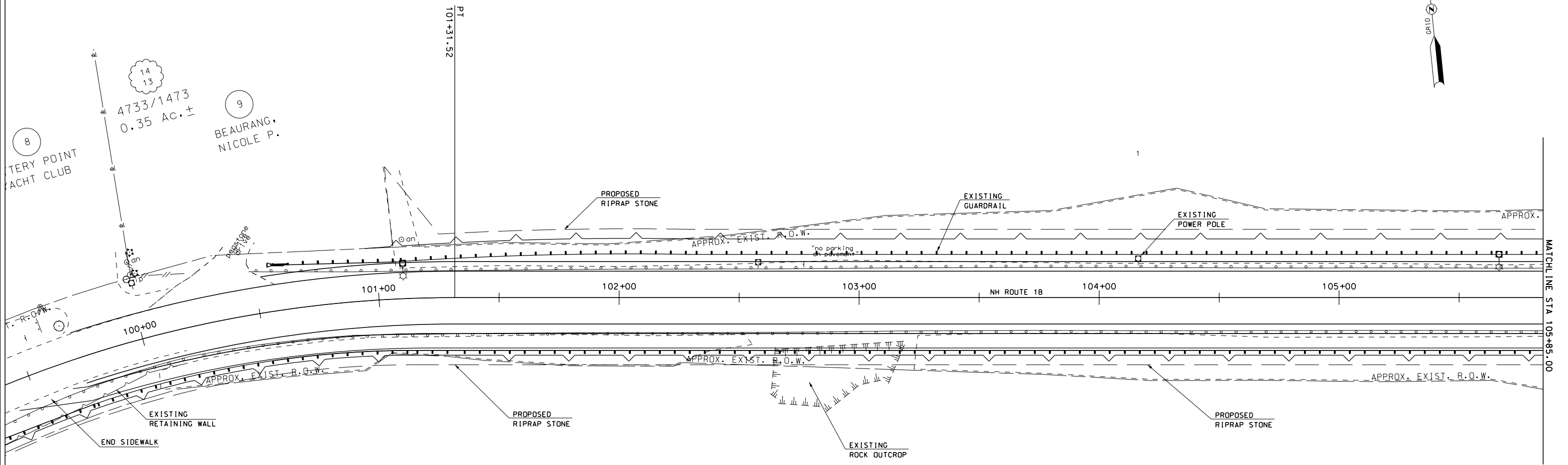
**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

**FIGURE 6.2-2c  
 RAISE CAUSEWAY  
 PROFILE VIEW**

RAISE CAUSEWAY ALTERNATIVE 3'-0"  
WITH BIKE AND PEDESTRIAN ACCOMMODATIONS



RAISE CAUSEWAY ALTERNATIVE 3'-0"  
WITH BIKE AND PEDESTRIAN ACCOMMODATIONS

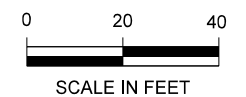
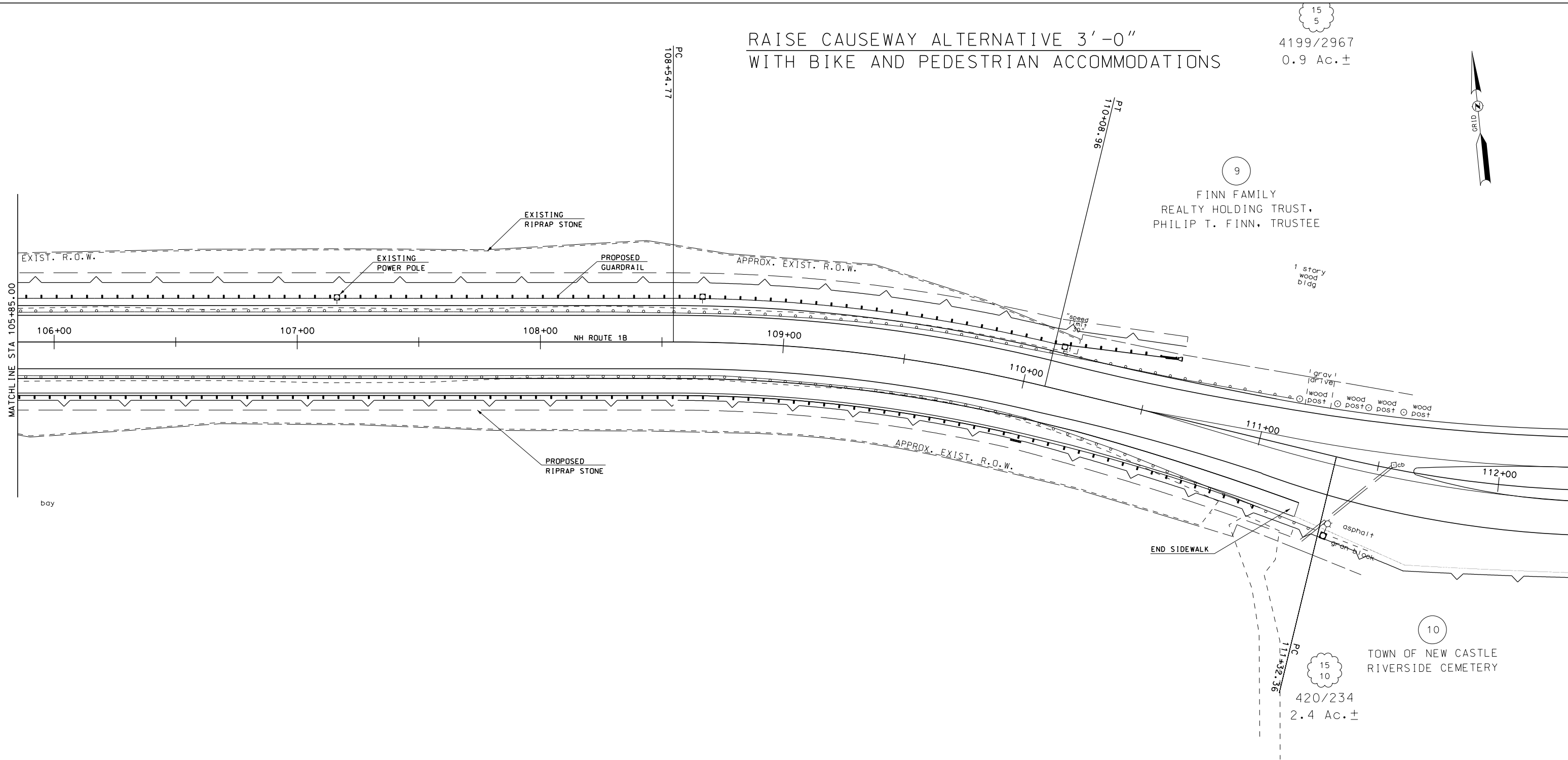


**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 4.3-1a  
RAISE WITH BIKE/PED  
PLAN VIEW

RAISE CAUSEWAY ALTERNATIVE 3'-0"  
WITH BIKE AND PEDESTRIAN ACCOMMODATIONS

15  
5  
4199/2967  
0.9 Ac.±

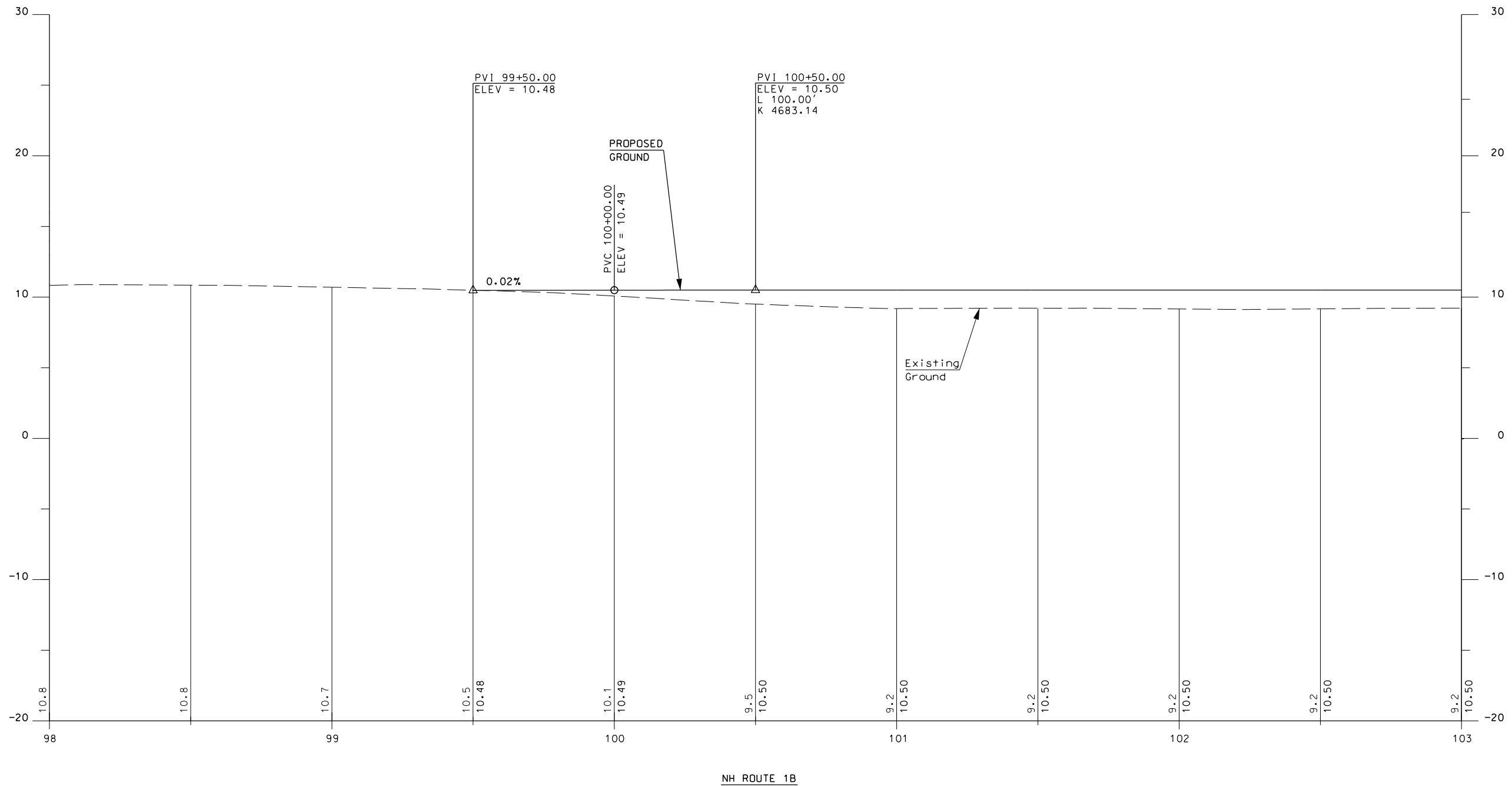


**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 4.3-1b  
RAISE WITH BIKE/PED  
PLAN VIEW



RAISE CAUSEWAY ALTERNATIVE 3'-0"  
WITH BIKE AND PEDESTRIAN ACCOMMODATIONS



SCALE:  
1" = 40' HORIZ.  
1" = 8' VERT.

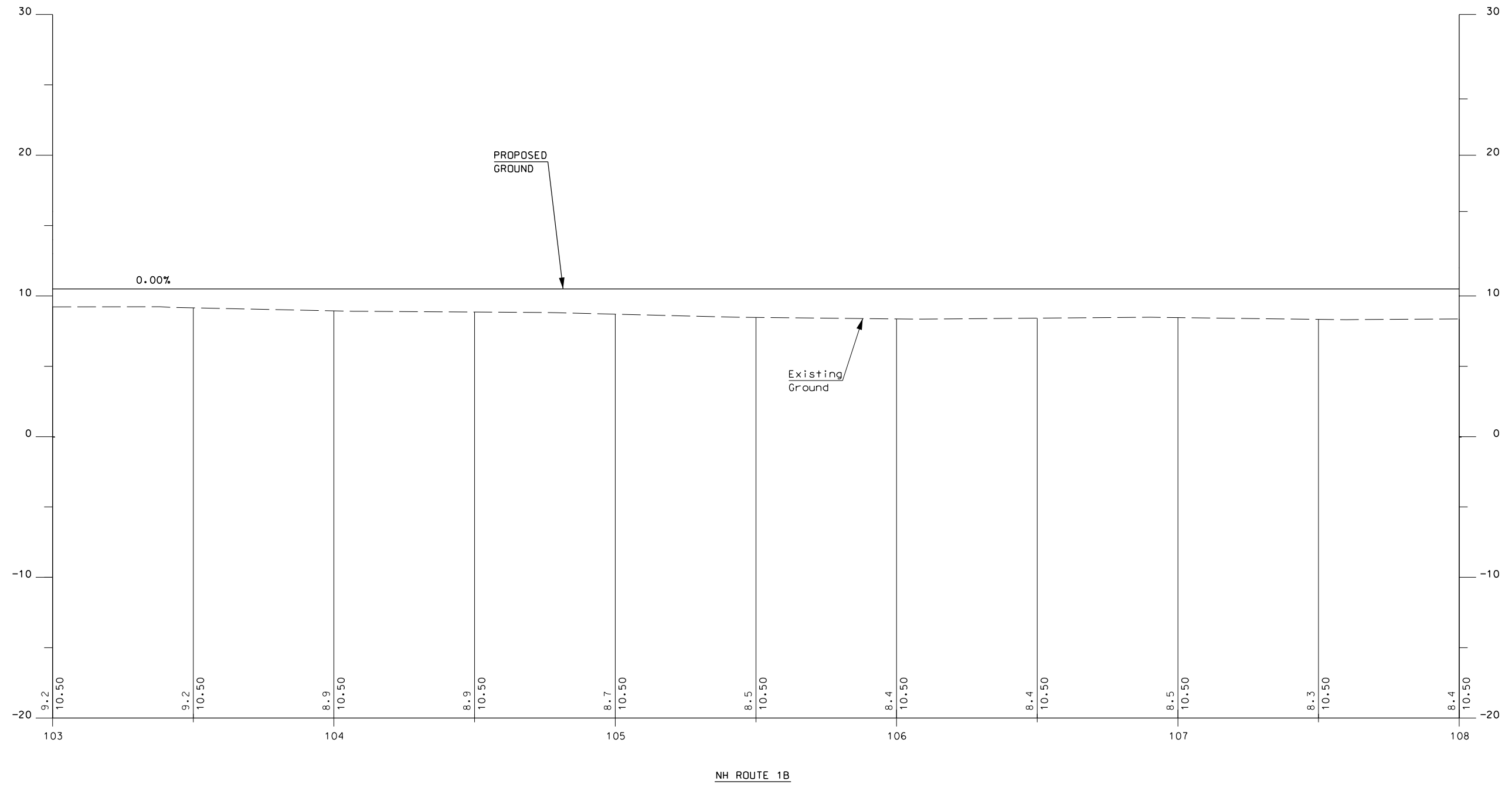


McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 4.3-2a  
RAISE WITH BIKE/PED  
PROFILE VIEW

RAISE CAUSEWAY ALTERNATIVE 3'-0"  
WITH BIKE AND PEDESTRIAN ACCOMMODATIONS



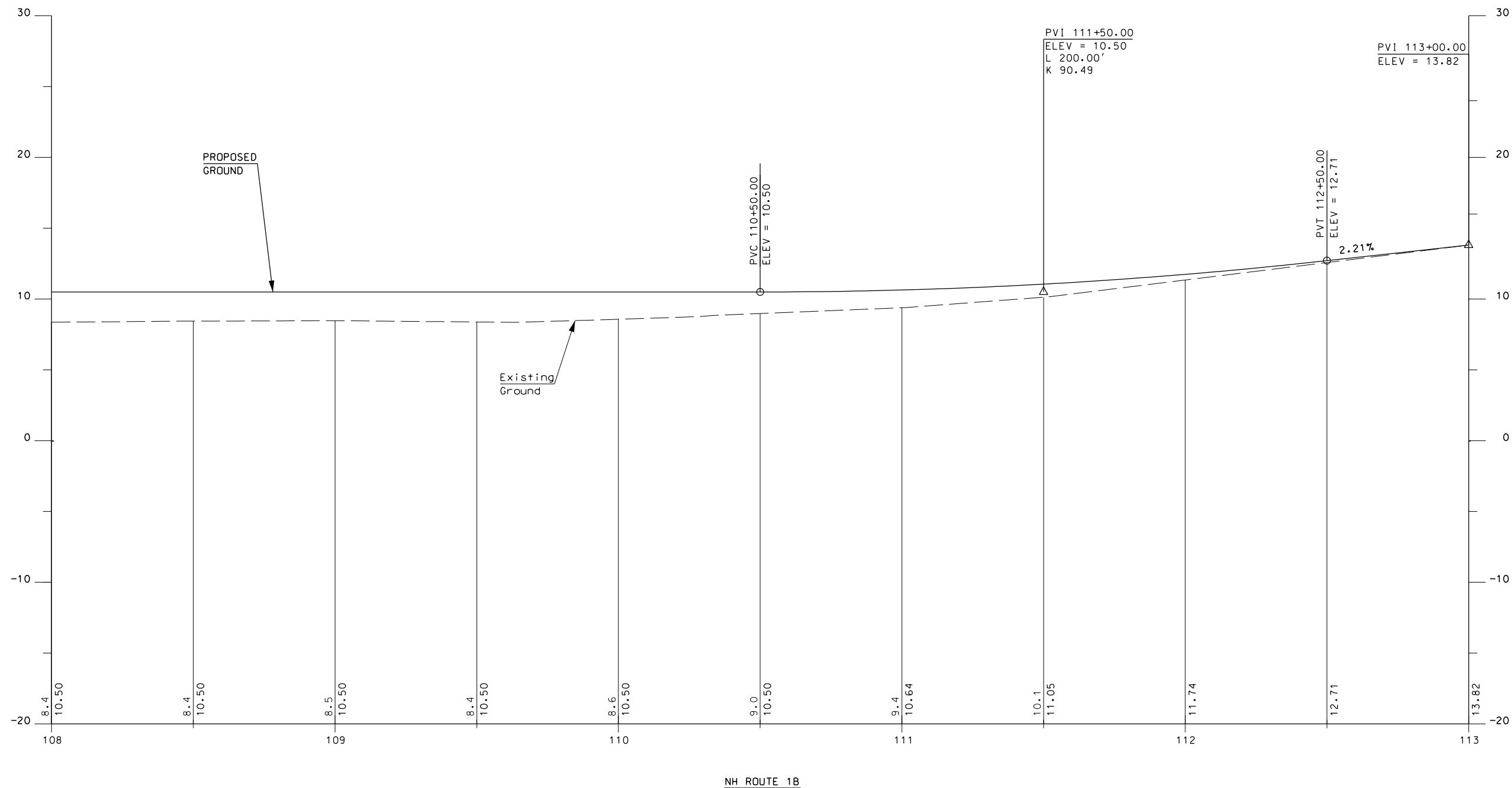
SCALE:  
1" = 40' HORIZ.  
1" = 8' VERT.



**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 4.3-2b  
RAISE WITH BIKE/PED  
PROFILE VIEW

RAISE CAUSEWAY ALTERNATIVE 3'-0"  
WITH BIKE AND PEDESTRIAN ACCOMMODATIONS



SCALE:  
1" = 40' HORIZ.  
1" = 8' VERT.

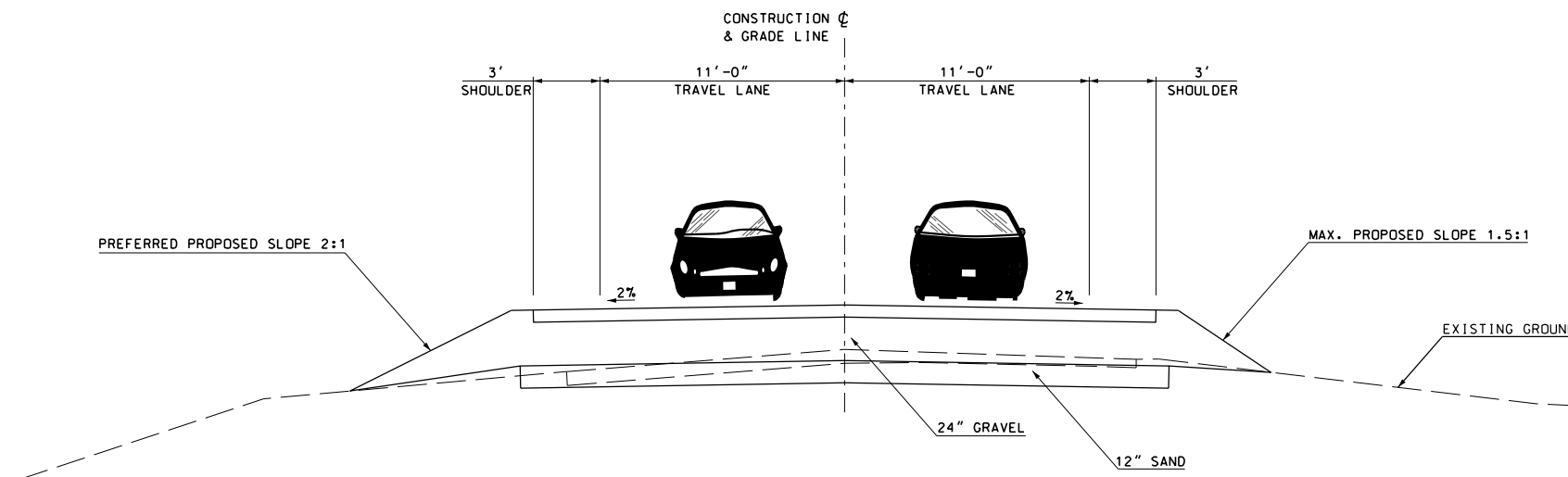


McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 4.3-2c  
RAISE WITH BIKE/PED  
PROFILE VIEW

RAISE ROUTE 1B LOW POINTS ALTERNATIVE



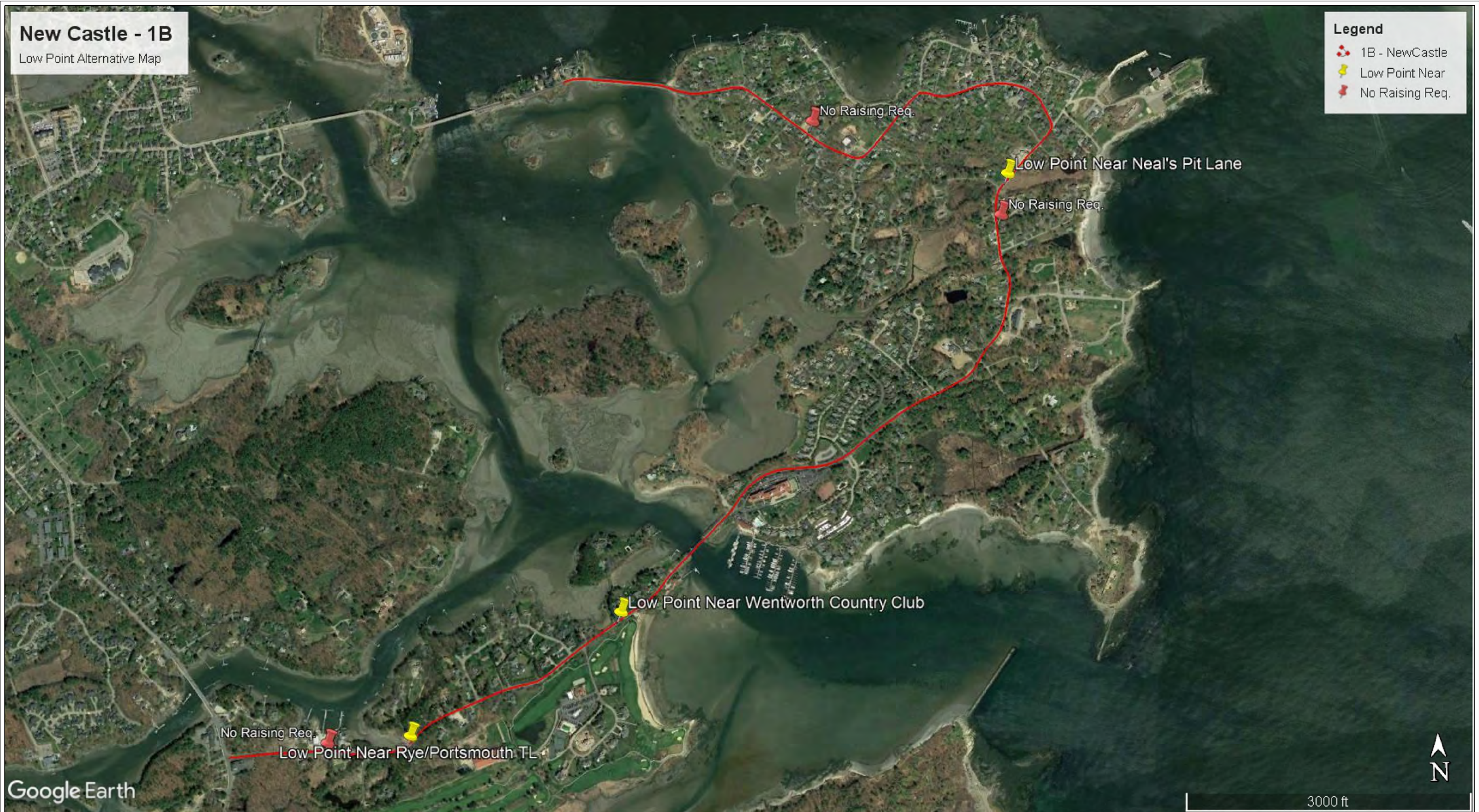
NH ROUTE 1B  
 1B LOW POINT TYPICAL SECTION  
 MINIMUM ELEVATION AT EDGE OF TRAVELWAY 10' 4"  
 EXISTING CONDITIONS ESTIMATED FROM GOOGLE EARTH  
 ADDITIONAL SURVEY REQUIRED BEFORE FINAL DESIGN  
 NOT TO SCALE

# New Castle - 1B

Low Point Alternative Map

## Legend

- 1B - NewCastle
- Low Point Near
- No Raising Req.



Google Earth

3000 ft

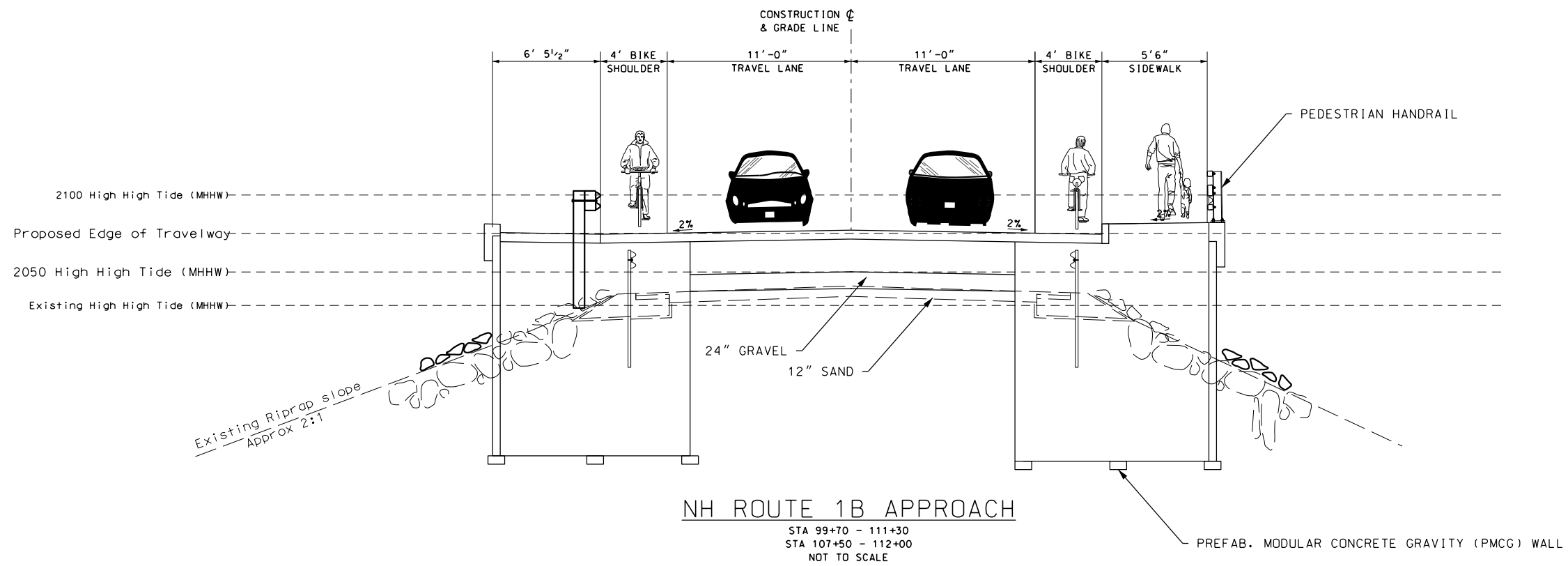
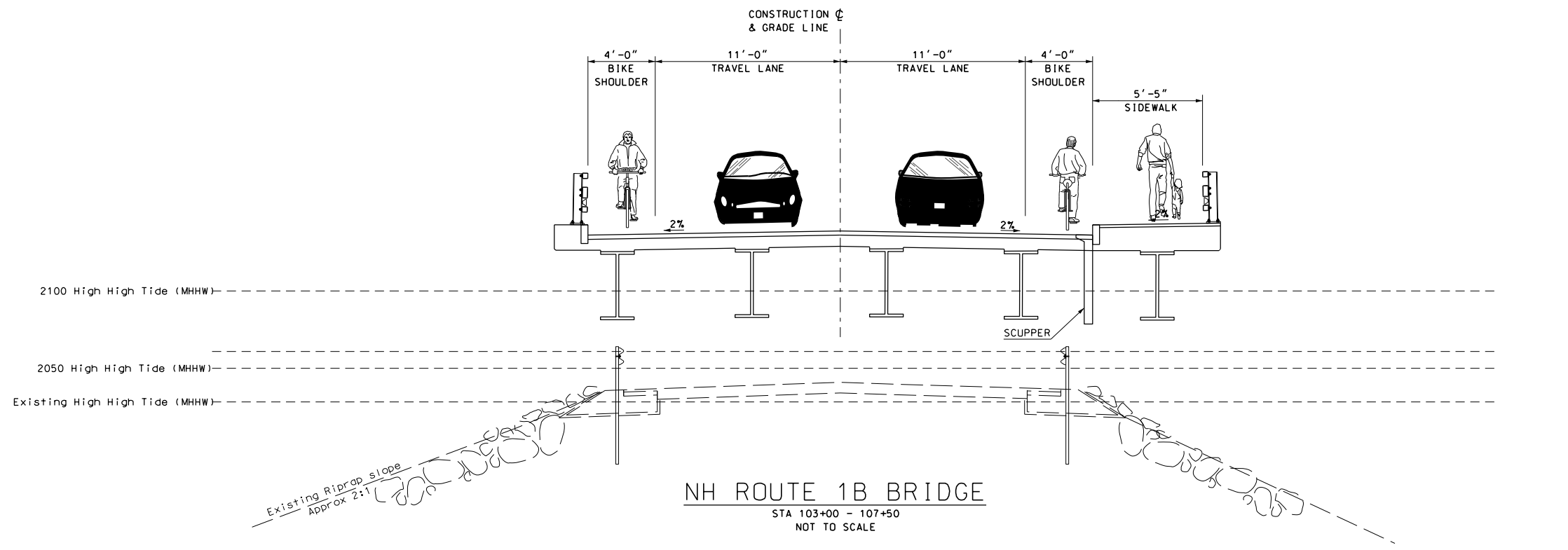


McFarland Johnson

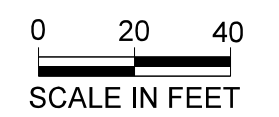
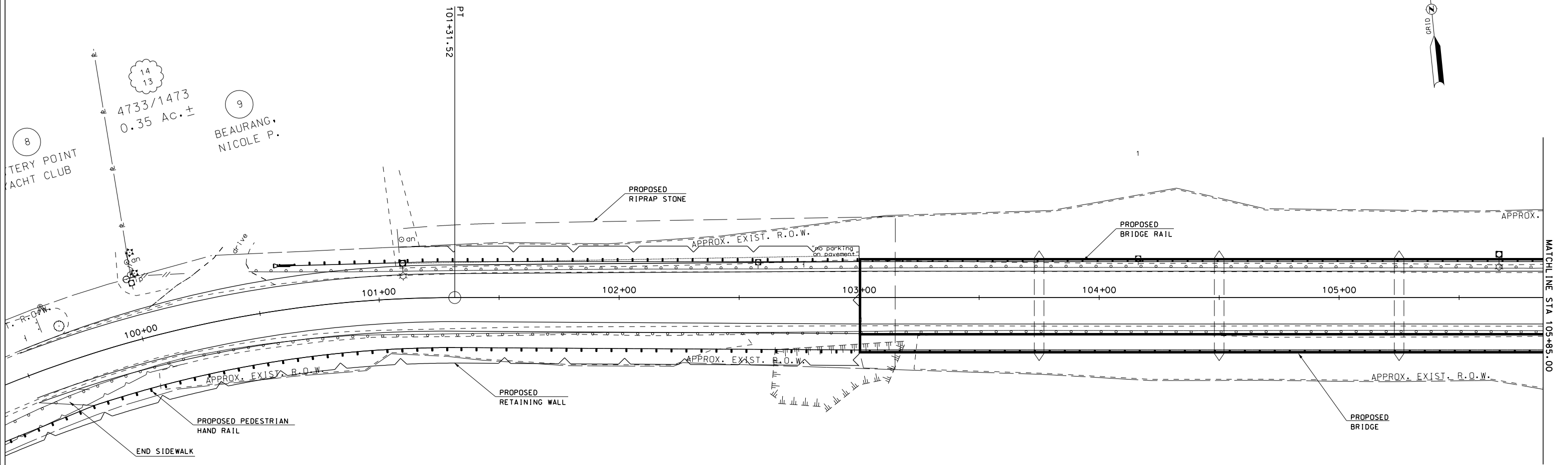
# NEW CASTLE CAUSEWAY FEASIBILITY STUDY

FIGURE 6.4-1a  
ROUTE 1B LOW POINTS  
PLAN VIEW

BRIDGE ALTERNATIVE



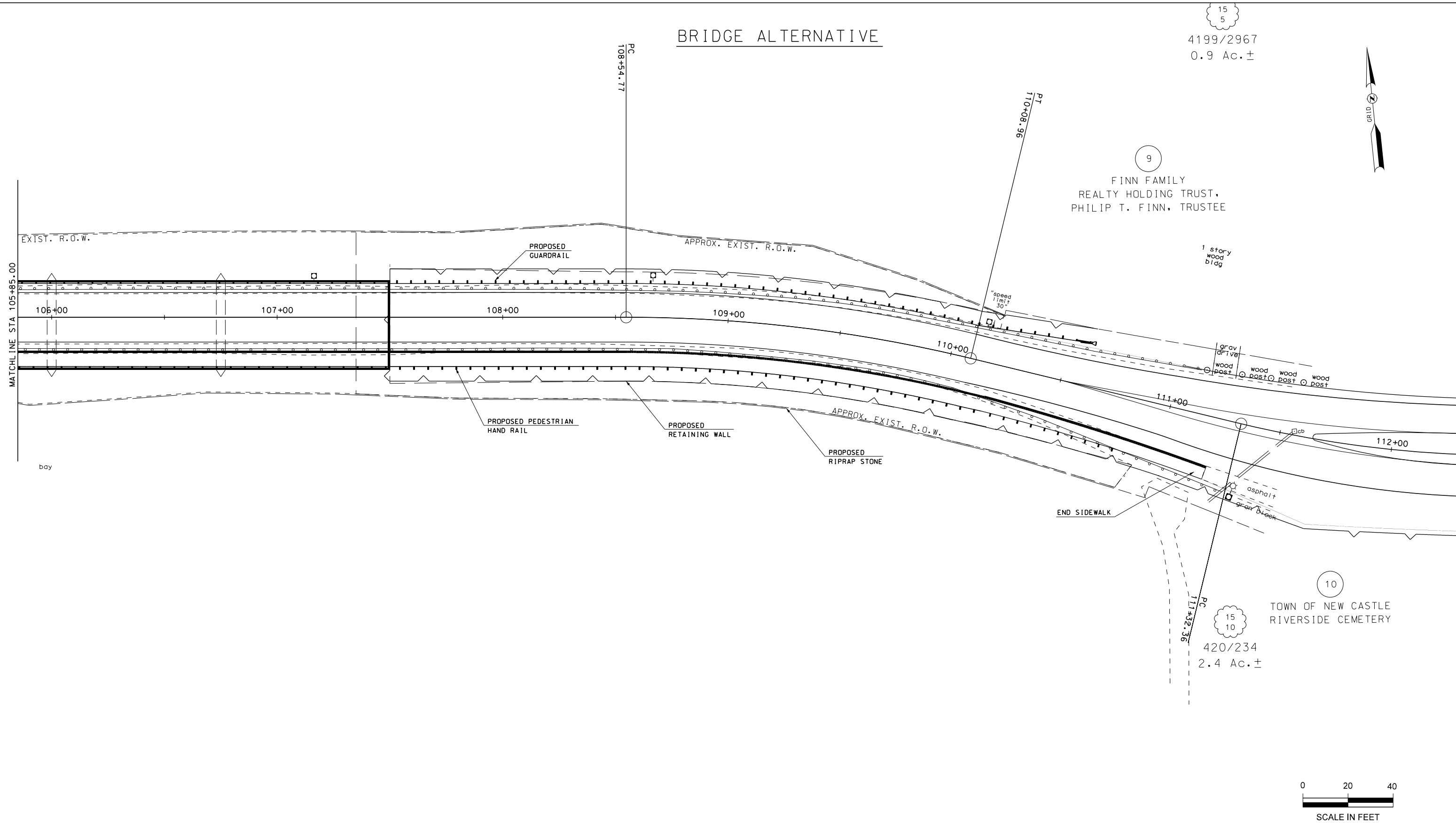
BRIDGE ALTERNATIVE



**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

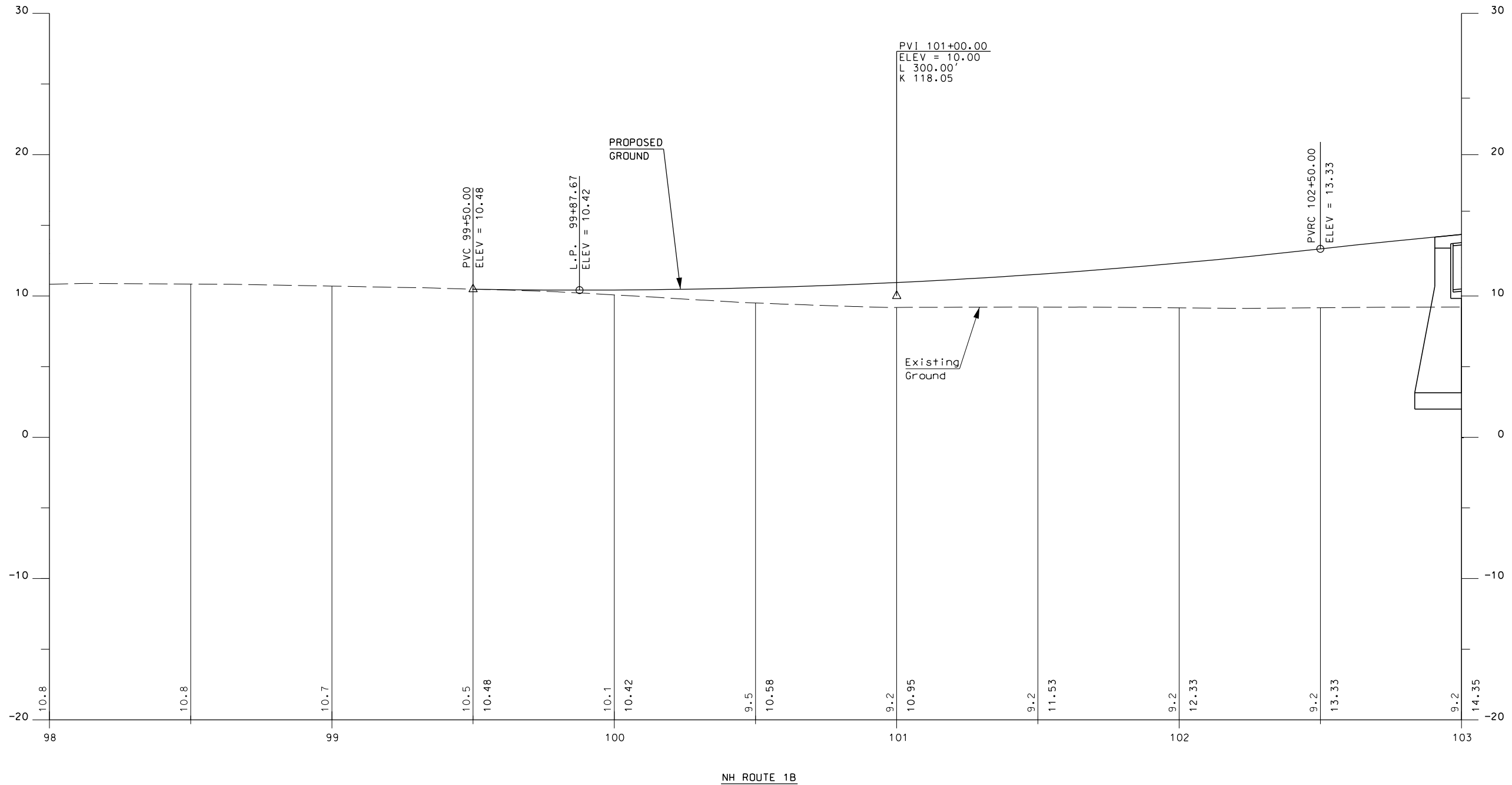
FIGURE 6.5-1a  
BRIDGE  
PLAN VIEW

BRIDGE ALTERNATIVE





BRIDGE ALTERNATIVE



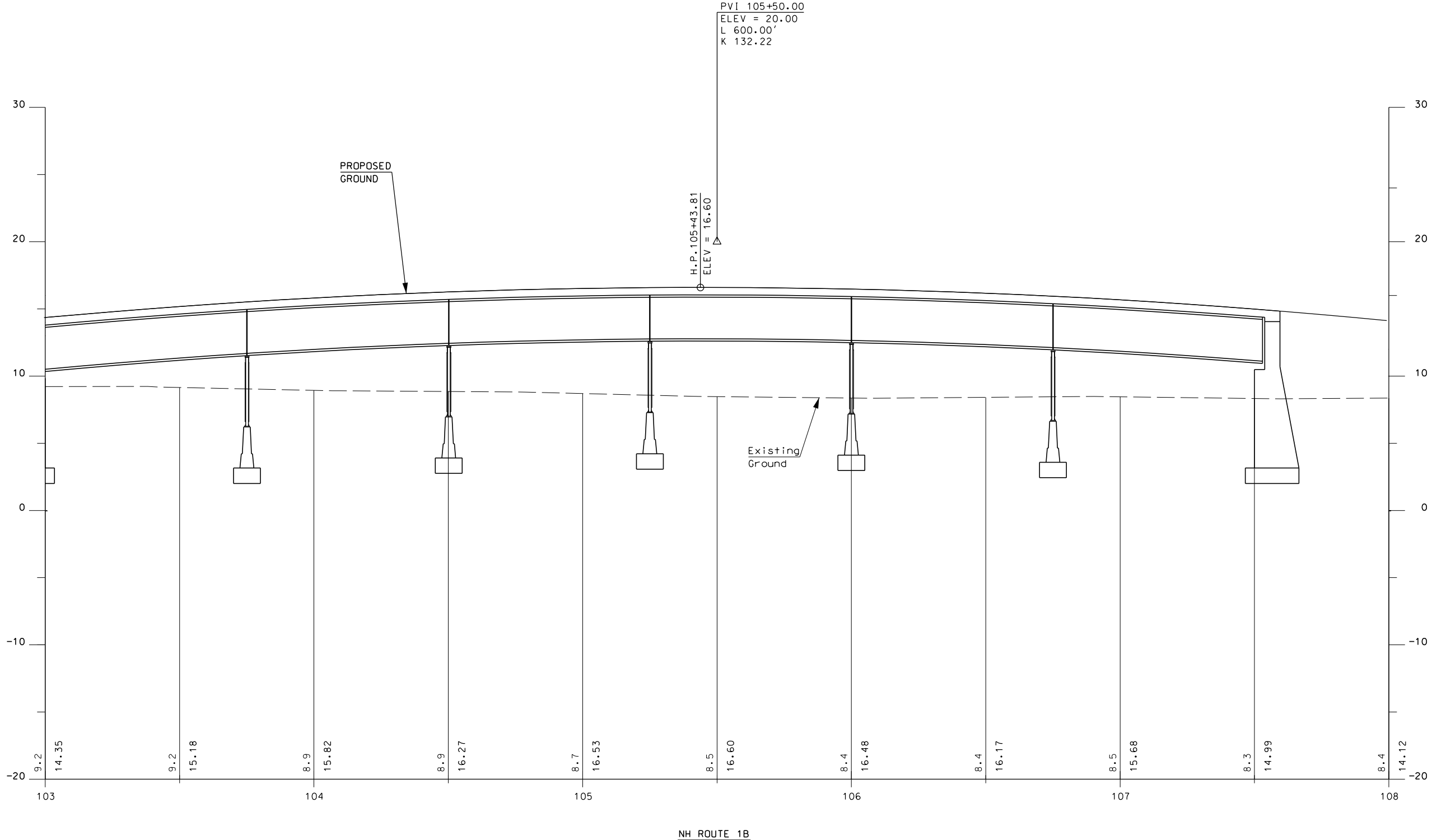
SCALE:  
1" = 40' HORIZ.  
1" = 8' VERT.



**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.5-2a  
BRIDGE  
PROFILE VIEW

BRIDGE ALTERNATIVE



SCALE:  
 1" = 40' HORIZ.  
 1" = 8' VERT.

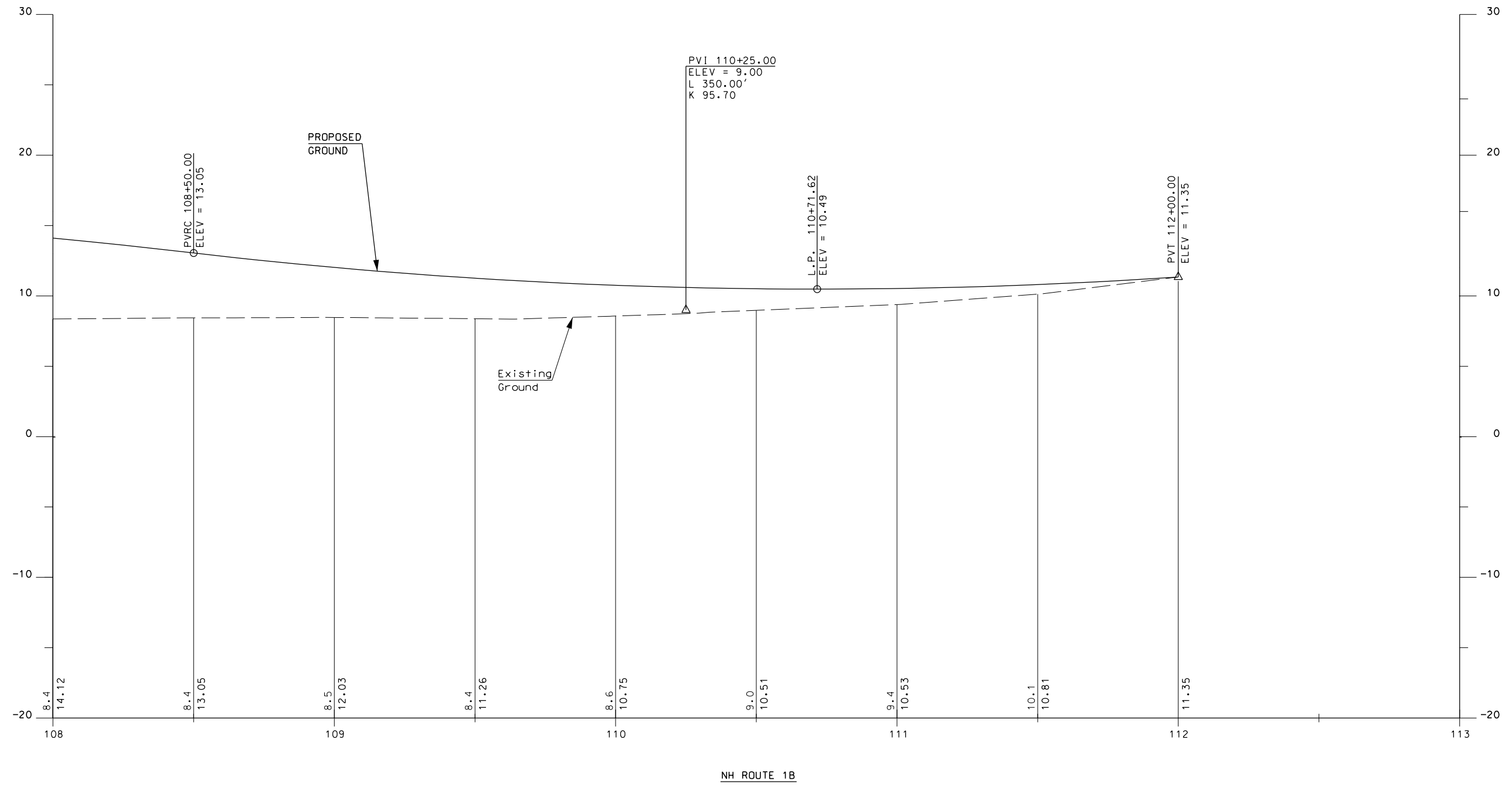


McFarland Johnson

**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.5-2b  
 BRIDGE  
 PROFILE VIEW

BRIDGE ALTERNATIVE



SCALE:  
 1" = 40' HORIZ.  
 1" = 8' VERT.



**NEW CASTLE CAUSEWAY FEASIBILITY STUDY**

FIGURE 6.5-2c  
 BRIDGE  
 PROFILE VIEW

# **Appendix A**

## **Risk Evaluation**

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## PROJECT MEMORANDUM

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**DATE:** March 15, 2019  
**TO:** Victoria H. Chase, P.E., - NHDOT  
**FROM:** Jennifer L. Zorn, AICP, and Steven K. Ireland, P.E., McFarland Johnson  
**PROJECT:** New Castle 29641  
**SUBJECT:** Risk Evaluation of NH Route 1B Causeway

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### **Introduction:**

One goal of the New Castle Route 1B Causeway Feasibility Study is to develop a risk evaluation associated with the predicted sea level rise and storm surge events. This evaluation focuses on identifying risks and making qualitative comparisons of three sea level rise scenarios. The scenarios evaluated are today (current conditions), year 2050 with an assumed sea level rise of 2 feet, and year 2100 with an assumed sea level rise of 6.6 feet.

The comparison has been broken down into two categories. These included the following:

#### Category I - Sea Level Rise With Daily Tides.

Impacts to daily travel, including typical life events such as; commuting to work or school, shopping for necessary items (groceries, clothing, medical supplies...), recreation (enjoyment of the beaches, walking, biking...), and appointments (doctors, dentists, job interviews...) are generally described in this category.

#### Category II- Storm Surge with Sea Level Rise.

These events will include an increase in need for services such as Police, Fire, EMS (emergency), and utility service calls due to outages from storm events.

### **Background and Assumptions:**

To develop this Risk Evaluation, multiple sources were researched. Data from four sources are referenced throughout this memorandum.

1. "Preparing NH for Projected Storm Surge, Sea-Level Rise and Extreme Precipitation" Section 5.2.2 Sea-Level Rise. This document has been referenced for the estimated sea level rise of 2 feet in year 2050 and 6.6 feet in year 2100.
2. "Sea Level Rise Adaptation Options for the New Castle Causeway", Final Report, 14 April 2014, Figure 3-3 Current Year Tidal Elevation. This document has been referenced for the tidal elevations plotted. This study correlated the elevation of the causeway to be 7 feet (which matches Google but not NHDOT survey).

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**PROJECT MEMORANDUM**  
Risk Evaluation of NH Route 1B Causeway

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3. US Harbors tide chart for Portsmouth Harbor:  
<https://nh.us harbors.com/monthly-tides/New%20Hampshire/Portsmouth%20Harbor>  
predicts the tidal changes based on lunar effects. These charts for the year 2019 were used to confirm the number of inundations from the “Sea Level Rise Adaptation Options for New Castle Causeway” document. An extreme high tide on February 20, 2019 was measured against pavement elevation at three (3) locations along Route 1B for correlation. These measurements were taken at high tide on a day without storm surge influences.
4. “Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal NH”, August 11, 2014, Table 3.2. This document has been referenced for the number of storm events and used to project the impacts of potential storm events in the future.

Due to the different datums used by different studies and data sets, determining the elevation of the causeway in reference to other sources required research shown in Table 1 with additional in-depth information following. For clarity and simplicity, tidal, water, and land elevations will be referenced against the elevation of the causeway for the remainder of this memorandum. An elevation below the causeway will be listed as a negative (-) number and elevations above the causeway will be listed as a positive (+) number.

**Table 1: Relationship of Elevations in Varying Data Sets**

| Data Set   | Causeway Elevation per Data Set | Relative Elevation difference to Causeway (Data Set – 8) | Notes                       |
|--|---------------------------------|--|-----------------------------|
| NHDOT Survey (NGVD 1929)                           | 8                               | 0  | Preferred datum by NHDOT    |
| Google Earth                                       | 7                               | -1   | Available data for Route 1B |
| “Sea Level Rise Adaptation Options for New Castle” | 7                               | -1   | Earlier Study for reference |
| US Harbors Tide Chart Portsmouth Harbor            | 11.75                           | +3.75  | Tide Charts for reference   |
| Mean Sea Level (MSL) (Fort Point New Castle NH)    | 8                               | 0  | Mean Sea Level reference    |

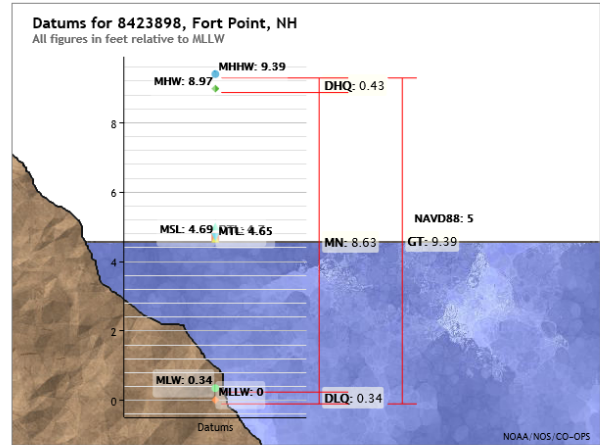
**PROJECT MEMORANDUM**  
Risk Evaluation of NH Route 1B Causeway

The correlation of many of these datums can be viewed graphically below.

NOTICE: All data values are relative to the MLLW.

**Elevations on Mean Lower Low Water**

|                                       |                  |  |
|---------------------------------------|------------------|--|
| Station: 8423898, Fort Point, NH      | T.M.: 0          |  |
| Status: Accepted (Dec 7 2016)         | Epoch: 1983-2001 |  |
| Units: Feet                           | Datum: MLLW      |  |
| Control Station: 8418150 Portland, ME |                  |  |
| <b>Datum</b>                          | <b>Value</b>     | <b>Description</b>                       |
| MHHW                                  | 9.39             | Mean Higher-High Water                   |
| MHW                                   | 8.97             | Mean High Water                          |
| MTL                                   | 4.65             | Mean Tide Level                          |
| MSL                                   | 4.69             | Mean Sea Level                           |
| DTL                                   | 4.70             | Mean Diurnal Tide Level                  |
| MLW                                   | 0.34             | Mean Low Water                           |
| MLLW                                  | 0.00             | Mean Lower-Low Water                     |
| NAVD88                                | 5.00             | North American Vertical Datum of 1988    |
| STND                                  | -2.71            | Station Datum                            |
| GT                                    | 9.39             | Great Diurnal Range                      |
| MN                                    | 8.63             | Mean Range of Tide                       |
| DHQ                                   | 0.43             | Mean Diurnal High Water Inequality       |
| DLQ                                   | 0.34             | Mean Diurnal Low Water Inequality        |
| HWI                                   | 3.74             | Greenwich High Water Interval (in hours) |
| LWI                                   | 9.85             | Greenwich Low Water Interval (in hours)  |
| Max Tide                              | 12.28            | Highest Observed Tide                    |
| Max Tide Date & Time                  | 01/02/2010 16:48 | Highest Observed Tide Date & Time        |
| Min Tide                              | -2.71            | Lowest Observed Tide                     |
| Min Tide Date & Time                  | 02/02/2018 23:42 | Lowest Observed Tide Date & Time         |
| HAT                                   | 11.51            | Highest Astronomical Tide                |
| HAT Date & Time                       | 06/14/1995 04:12 | HAT Date and Time                        |
| LAT                                   | -2.08            | Lowest Astronomical Tide                 |
| LAT Date & Time                       | 04/27/1994 10:48 | LAT Date and Time                        |



Showing datums for  
8423898 Fort Point, NH

Data Units  Feet  
 Meters

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

Image taken from: <https://tidesandcurrents.noaa.gov/datums.html?id=8423898>

**In Depth Elevation Determination:**

To determine the elevation of the remainder of Route 1B, a review of the existing NHDOT plans and project files and Google Earth was conducted. The elevation of the top of the causeway (road surface) has been determined to be approximately eight (8) feet (NAVD 1929), based upon a previous NHDOT project (State No. 15895). Google Earth lists the elevation of the causeway to be approximately seven (7) feet (NAVD 1929) which is one (1) foot below the surveyed elevation from the state project. Additionally, a second NHDOT project (State No. 16127) was examined and elevations along the existing profile used to calibrate the elevations in Google maps. Elevations from project 16127 compared to Google maps indicates that Google maps appears to be consistently one (1) foot below surveyed elevations. A profile was created in Google Earth and low points along Route 1B were identified, Table 2.

**Table 2: Identified Route 1B Low Points**

| <u>Location</u>                            | <u>Google Elevation</u> | <u>Elevation Relative to Causeway</u> |
|--|-------------------------|---------------------------------------|
| Grist Mill Lane and Rilson Street          | 8                       | +1                                    |
| North of Neals Pit Lane                    | 8                       | +1                                    |
| South of Beach Hill Road                   | 8                       | +1                                    |
| Wentworth Golf Course (Rye)                | 8                       | +1                                    |
| North of Rye/Portsmouth municipal boundary | 8                       | +1                                    |
| South of Rye/Portsmouth municipal boundary | 9                       | +2                                    |
| Causeway                                   | 7                       | 0                                     |

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**PROJECT MEMORANDUM**  
Risk Evaluation of NH Route 1B Causeway

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In an effort to correlate the tides with the causeway elevation and other elevations along Route 1B, measurements were taken at three (3) locations along Route 1B on February 20, 2019 during the AM high tide event. US Harbors Tide Charts for Portsmouth Harbor indicated a lunar high tide of 10.0 feet on February 20, 2019. The high tide was observed and photographed to reach approximately 1.75 feet below the existing causeway pavement surface. The low point identified by Google maps near the Wentworth Golf Club was observed and photographed to be approximately 2.2 feet above high tide and the low point just north of the New Castle/Rye municipal boundary was observed to be approximately 2.5 feet above high tide. The tide charts of the area show that an extreme low running high tide is approximately seven (7) feet while an extreme high running high tide is 10 feet. The average high tide is approximately 8.5 feet and the average low tide is 0.0 feet. Refer to Table 3.

**Table 3: Correlation of Tides**

| <b><u>Location</u></b>                        | <b><u>Tide Chart</u></b> | <b><u>Measurement<br/>Below Pavement</u></b> | <b><u>Elevation Relative to<br/>Causeway</u></b> |
|---|--------------------------|--|--|
| Wentworth Golf Course (Rye)                   | 10                       | 2.2  | +0.45  |
| North of Rye/Portsmouth town line<br>Causeway | 10                       | 2.5  | +0.75  |
| Average High Tide                             | 10                       | 1.75   | 0  |
| Average Low Tide (MLLW)                       | 8.5                      |  | -3.25  |
|   | 0                        |  | -11.75   |

**Category I - Sea Level Rise With Daily Tides**

The daily travel of both residents and visitors to the island are important to the culture, economics, and quality of life found on New Castle. There is a frequency of inundation of the causeway at which daily travel will be impacted to the detriment of the culture, economics, and quality of life. This frequency threshold may be best determined by further dialogue and input provided by the project stakeholders and general public. These findings will be presented in the draft and final Feasibility Study.

**Today (Current Condition)**

Frequency of inundation from normal tide events is estimated to be zero (0) times per year. The highest high tide has been measured to be approximately 1.75 feet below the causeway (measured on February 20, 2019 at a lunar high tide). During these tides, residents and visitors can access the island via both the northernly and southernly portion of Route 1B without difficulty. Recreation and quality of life by residents and visitors are not impacted.

**Year 2050 (2 foot Sea Level Rise)**

Frequency of inundation is estimated to be between one (1) and three (3) times per month (or 20 times yearly based on 2019 tide charts). This inundation occurs during the peak of the high tide (any high running tide exceeding 9.75 feet on the tide chart) and could be measured in minutes to an hour with a maximum inundation of +0.25 feet. This rise in sea level is unlikely to impact other locations (see Appendix A) along Route 1B. During these tides, residents and visitors are inconvenienced by the estimated one (1) to three (3) times per month the causeway would be inundated. Residents and visitors will be able to plan around these events with minimal impact to daily travel on a monthly or greater frequency. Recreation by residents and visitors may be skipped occasionally which would have minimal impacts to culture, economic, and quality of life of the community.



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**Year 2100 (6.6 foot Sea Level Rise)**

Frequency of inundation is estimated to occur on a daily basis with a maximum inundation of +4.85 feet. This inundation occurs during every high tide cycle, and on the average high tide, 1/3 of the tide cycle (approximately 4 hours) the causeway would be inaccessible twice daily. This rise in sea level will impact other locations (see Appendix A) along Route 1B with a maximum inundation of approximately +4 feet. The duration of inundation at these locations would be less than at the causeway, likely lasting hours, making the island inaccessible for as much as a ¼ of each day. During these tides, residents and visitors are regularly impacted by access issues. The ability to avoid these events becomes nearly impossible due to the frequency. Recreation by residents and visitors may be lost permanently. These tides would be expected to have significant cultural, economic, and quality of life impacts to the community. The inundation depths along multiple locations of Route 1B would significantly impact the ability of emergency services (EMS) to the island.

**Category II- Storm Surge with Sea Level Rise**

Emergency services (EMS) are generally relied upon by the residents of New Castle during storm events because most visitors would be advised to stay home and off the roads during these events. EMS calls are expected to be higher during a storm event. While residents are likely to be more prepared for the more severe storms forecasted, it is generally assumed that the more severe the storm is, the more EMS calls will be made by the residents. It is assumed that EMS service will not cross the causeway when the water depth over the causeway reaches or exceeds +1.0 foot.

It is not possible to predict over the next 30 to 80 years how many storm events will occur during low running high tides versus high running high tides. Because of this uncertainty, all storm events are assumed to occur during an average running high tide (approximately -3.25 feet from the causeway pavement today). Therefore, any storm surge exceeding 3.25 feet today is assumed to inundate the pavement at high tide.

It is important to note that storm event frequency and intensity cannot be predicted. Melting of polar ice caps, changes in the salinity of the oceans, and temperature variances may affect the frequency and intensity of storm events. For the purposes of this evaluation, a selected group of documented past storm events (the ten (10) largest water levels recorded in a 10-year period) is being used and applied to an increase in sea level rise. It is not known if a rise in sea level will increase or decrease the frequency and intensity of storm events. These events have been documented on the Fort Point web site ( <https://tidesandcurrents.noaa.gov/reports.html?id=8423898> ) and are similar to those events documented in “Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal NH”, August 11, 2014, Table 3.2.

**Today (Current Condition)**

The base line for the storm event evaluation was collected from storms between year 2009 and year 2018 (Table 4). During this 10-year period, data from eight (8) storm events were collected. These storm events ranged in observed storm surge heights of between 0.6 and 2.5 feet. This storm surge must be added to the elevation of a high tide to account for the full effect of the combined storm surge and tide. On March 3, 2018, a documented storm (shown in Table 4) registered the fourth highest water level at Fort Point in the last decade and created a storm surge of 1.5 feet with a predicted high tide of 8.4 feet (essentially an average high tide). This storm did inundate and close the causeway at one (1) high tide event. The combination of high tide plus storm surge alone would not reach the top of the causeway and cause a condition of inundation. However, these two factors do not account for the effects of wave action, wind strength and wind direction, or the flow of water entering/exiting the Piscataqua River. Due to the number of variables affecting water levels during a storm event, it is not possible to accurately predict how often the causeway will be inundated which may require its temporary closure. We can reasonably assume that a storm event does increase the likelihood that the causeway will become inundated and as the sea level rises these events will become more frequent.

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**Table 4: 10 Highest Water Levels at Fort Point over a 10-year period**

| <u>Rank</u> | <u>Date</u> | <u>MSL Measured</u> | <u>MSL Predicted</u> | <u>Storm Surge</u> |
|-------------|-------------|---------------------|----------------------|--------------------|
| 1           | 1/2/2010    | 7.57                | 6.21                 | 1.36               |
| 2           | 1/3/2014    | 7.55                | 6.44                 | 1.11               |
| 3           | 6/5/2012    | 7.32                | 6.70                 | 0.62               |
| 4           | 3/3/2018    | 7.46                | 5.95                 | 1.51               |
| 5           | 6/4/2012    | 7.45                | 6.74                 | 0.71               |
| 6           | 1/3/2010    | 7.40                | 6.10                 | 1.30               |
| 7           | 5/26/2017   | 7.36                | 6.79                 | 0.57               |
| 8           | 1/21/2011   | 7.45                | 5.86                 | 1.59               |
| 9           | 5/28/2017   | 7.41                | 6.73                 | 0.68               |
| 10          | 1/27/2015   | 7.43                | 4.96                 | 2.47               |
|             |             |                     | Average              | 1.19               |

Source: <https://tidesandcurrents.noaa.gov/reports.html?id=8423898>

**Year 2050 (2 foot Sea Level Rise):**

The same storm events would result in longer durations of closure and increased inaccessibility to New Castel by EMS. The additional two (2) feet of sea level rise will likely impact additional identified locations (see Appendix A) along Route 1B. The duration of inundation at these locations would be less than at the causeway but still may impact life safety with +1 foot of water over the causeway and other locations of Route 1B. Additionally, we can assume that smaller storm events not included in our base line will impact the causeway at a greater frequency with a sea level rise of two (2) feet. These smaller events may not be significant enough to impact all the additional locations noted but may impact the causeway. In general, a significant storm event in 2050 with sea level rise will result in the temporary and periodic isolation of New Castle.

**Year 2100 (6.6 foot Sea Level Rise):**

As mentioned under Scenario 1, a 6.6 foot sea level rise results in daily inundation of the causeway and other points along Route 1B. All storm events are expected to further inundate the causeway which would significantly increase the frequency that New Castle is isolated. The addition of a storm event and the 6.6 foot rise in sea level will likely inundate the causeway with water depths ranging between +4 and +8 feet. **Water depths of this level could result in a significant movement of water over the causeway which could result in erosion or pavement damage. Most of the flooding known to have occurred in the past is associated with the time frame around high tide when the water movement is less intense.** These occurrences would potentially impact the additional identified locations (see Appendix A) along Route 1B. A storm event where the storm surge and high tide combined result in a water elevation of +7 feet could impact as much as 1/5 of Route 1B in New Castle. Emergency access would be significantly impaired resulting in a significant life safety risk from lack of access to New Castle. Life safety risk could be further complicated by the time required to repair damage resulting from a storm to restore connectivity to the island. Additionally, it is assumed that smaller storm events not included in our base line will impact the causeway and the additional locations noted in Appendix A more frequently. In general, a significant storm event in 2100 with sea level rise could require an evacuation of the island.

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**Table 5: Summary**

|                                      | Risk Category      | Today   | 2050 assumed 2' Rise in Sea Level   | 2100 Assumed 6.6' Rise in Sea Level  |
|--------------------------------------|--------------------|---|---|--|
| <b>Daily Travel</b>                  | Work/School        | Frequency is 0 times per year. Residents and visitors are not impacted. Access to the island is not impacted. | Frequency is 1 to 3 times per month measured in minutes to an hour. This rise in Sea level will not impact other locations along Route 1B. Residents and visitors are impacted monthly with access issues. Expected economic and quality of life impacts are minimal. | Frequency is daily at the peak 1/3 of the high tide (hours of impact). This rise in Sea level will impact other locations along Route 1B with a frequency of daily and duration of hours. Residents and visitors are regularly impacted with access issues. Expected significant economic and quality of life impacts. |
|                                      | Groceries/Shopping |   |   |  |
|                                      | Recreation         |   |   |  |
|                                      | Doctors Apt.       |   |   |  |
| <b>Emergency (Storm Surge Event)</b> | Police call        | Base line years 2009 to 2018 (8 events )  | The same events would lead to longer durations of closure and inaccessibility to the island. These occurrences would impact additional locations on Route 1B and the access to the island. The frequency of closure is expected to increase.                          | All storm events would lead to water elevations over the causeway of +4' to +8'. These elevations could impact an estimated 1/5 of all Route 1B mileage. The frequency of closure is expected to significantly increase.   |
|                                      | Fire call          |   |   |  |
|                                      | Medical            |   |   |  |
|                                      | Utility outage     |   |   |  |

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**Recommendations:**

While it is difficult to predict how rapidly sea level will rise and when storm surges will occur, sea level rise will adversely affect the island of New Castle. In an effort to provide more resiliency and continued access to the island, any improvements to the causeway should be considered in relation to other low points along Route 1B and the overall elevation of Route 1B. For example, raising the causeway to an elevation where no inundation will occur under a 6.6 foot sea level rise and storm surge scenario in 2100 may not be practical. Resiliency of this magnitude would prevent the causeway from being inundated but would still be inaccessible because the bridges from Portsmouth would be under water and a large portion of Route 1B on the island would be under water. It would be impractical to raise the causeway to a point beyond what the overall access to the island can sustain for a rise in sea level combined with a storm surge.

In order to access the causeway, vehicles must travel across Goat Island. Most of Goat Island appears to be +2 to +3 feet higher than the causeway. Raising the causeway much beyond the elevation of Goat Island would be impractical. Raising the causeway versus the remainder of Route 1B must be considered as a whole in an effort to balance the causeway elevation in a practical manor. If other identified low points along Route 1B will not be improved and raised in elevation, then there is limited practicality in improving the causeway resiliency much beyond that of the other low points. Resiliency improvements in elevation to the causeway and other identified low points may best be balanced by a coordinated elevation change along Route 1B, looking at the system holistically. It is recommended that survey along Route 1B be obtained to more accurately define the low points and determine the best systematic elevation change.

In considering the effects of storm surge, some may consider resiliency improvements to be impractical. Storms of significance are regularly predicted with today's technology and residents can be required to evacuate the island for these events. Based on the 10-year history reviewed, residents could have been required to evacuate for these eight storms. Input and evaluation on evacuation scenarios are not in the scope of this project.

For the purpose of moving forward with this study, it is recommended that an increase of +3 feet to the causeway and an increase of +2.5 feet to other identified locations along Route 1B be evaluated. This elevation change will match or slightly exceed elevations on Goat Island and will serve as a practical starting point until more complete survey of Route 1B can be collected. This will provide for a 6-foot change in sea level with full access from both directions on Route 1B. This recommended change in elevation would not preclude inundation of the causeway due to storm surge during storm events. As previously stated, raising the causeway to an elevation that would preclude inundation during a storm event under a 6.6 foot sea level rise scenario does not appear practical given the elevation of New Castle Island itself.

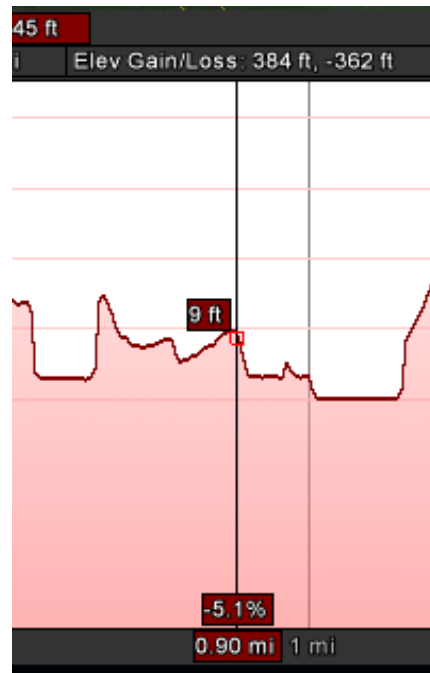
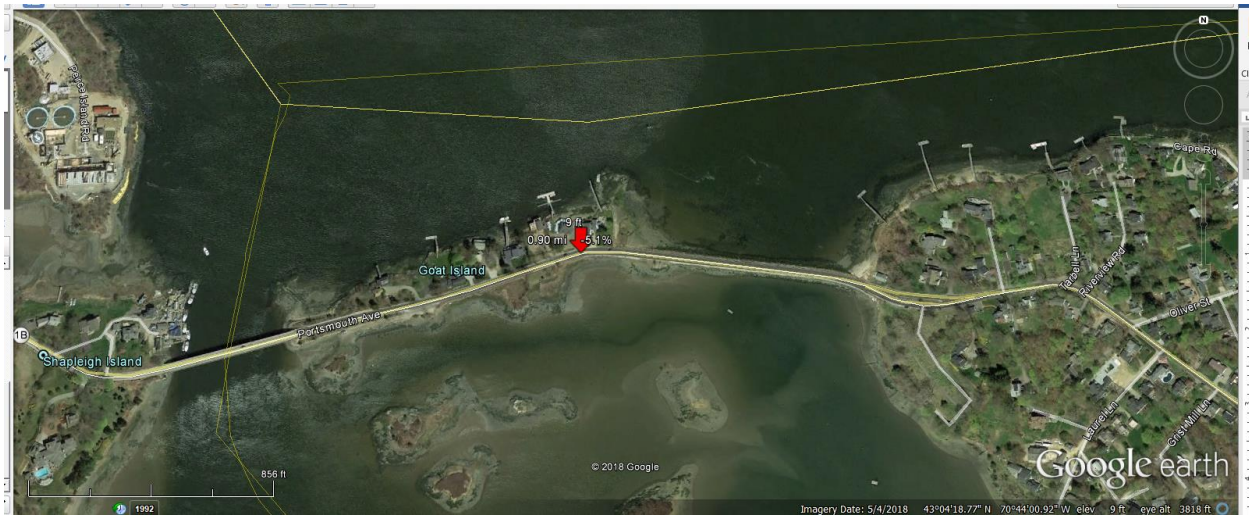
This recommended elevation change is anticipated to perpetuate the current frequency of inundation of the causeway until after year 2050 based on the worst case sea level rise predictions. It is possible that over the next 30 to 80 years sea level rise predictions may change. Due to the numerous unknowns, resiliency should continue to be reviewed as new sea level information becomes available to allow for planning of practical improvements.

## APPENDIX A

Entire Profile of Route 1B based upon Google Earth. Line is drawn on Goat Island by the KPYC

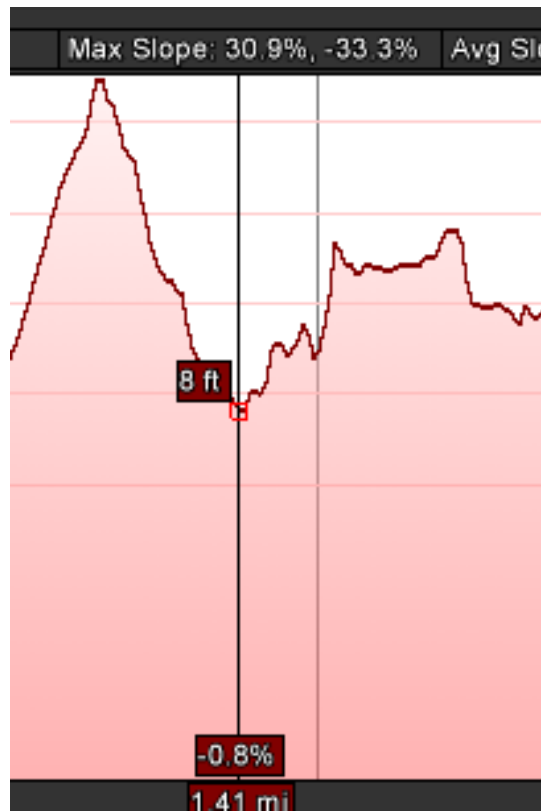
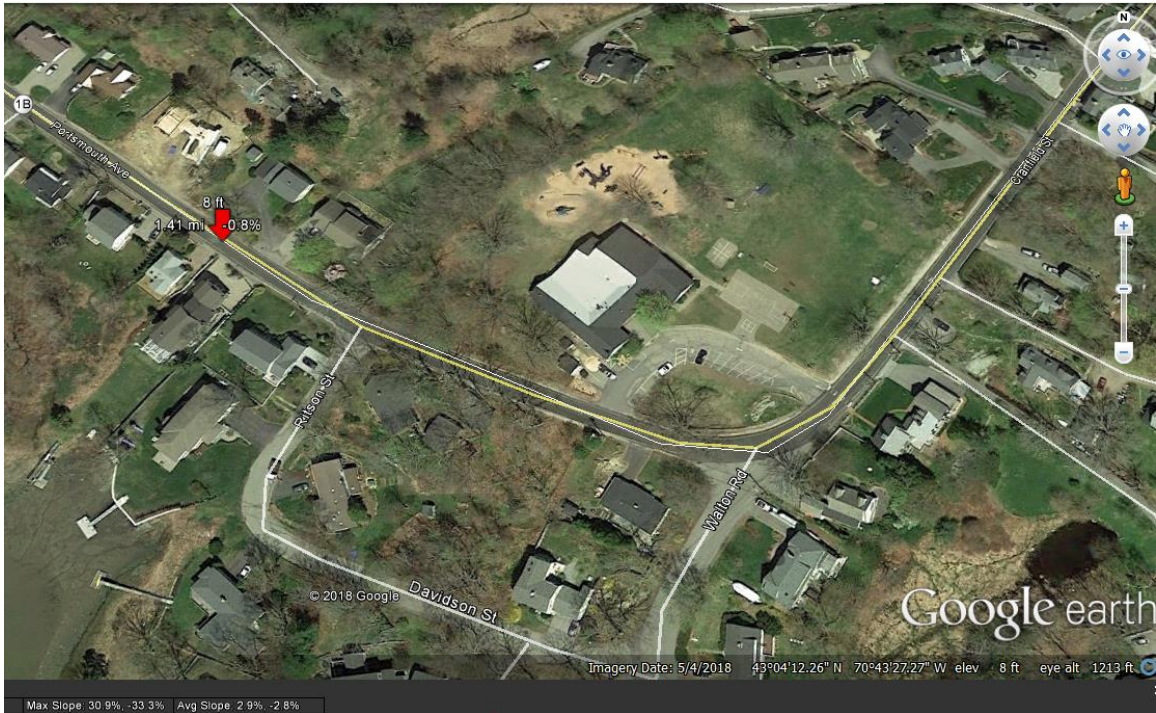


Below is a zoomed in location and profile for example:

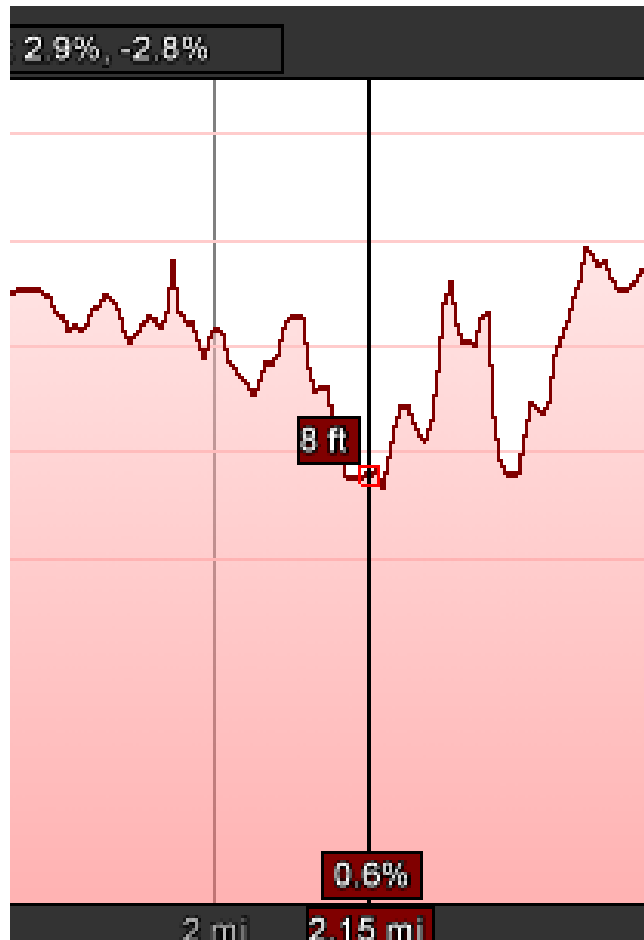


Google Earth Elevation 9: Goat Island

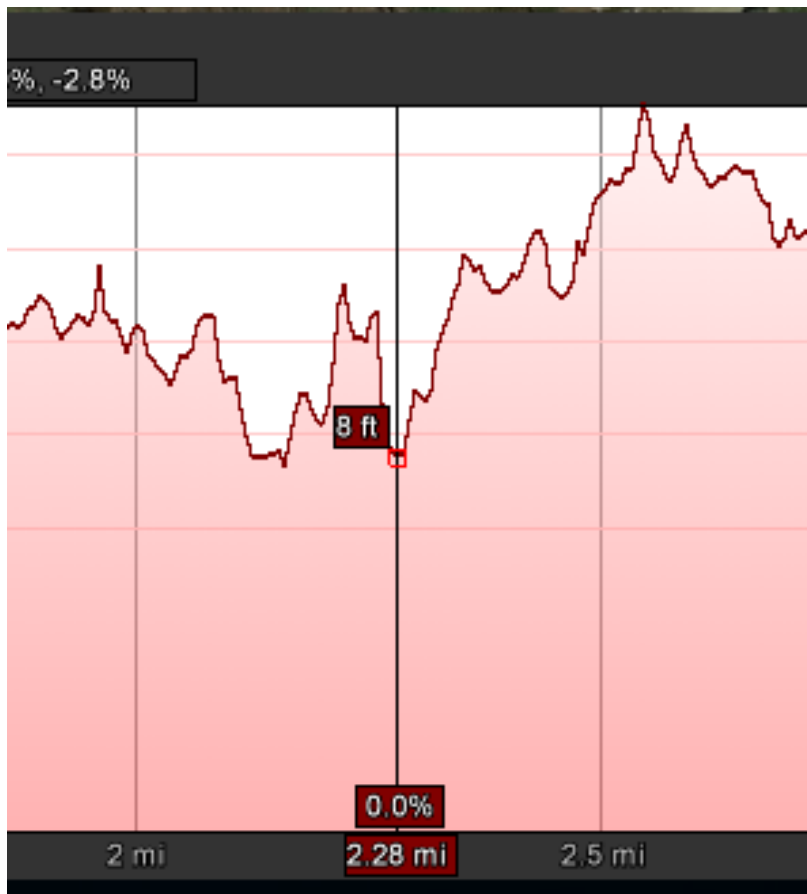
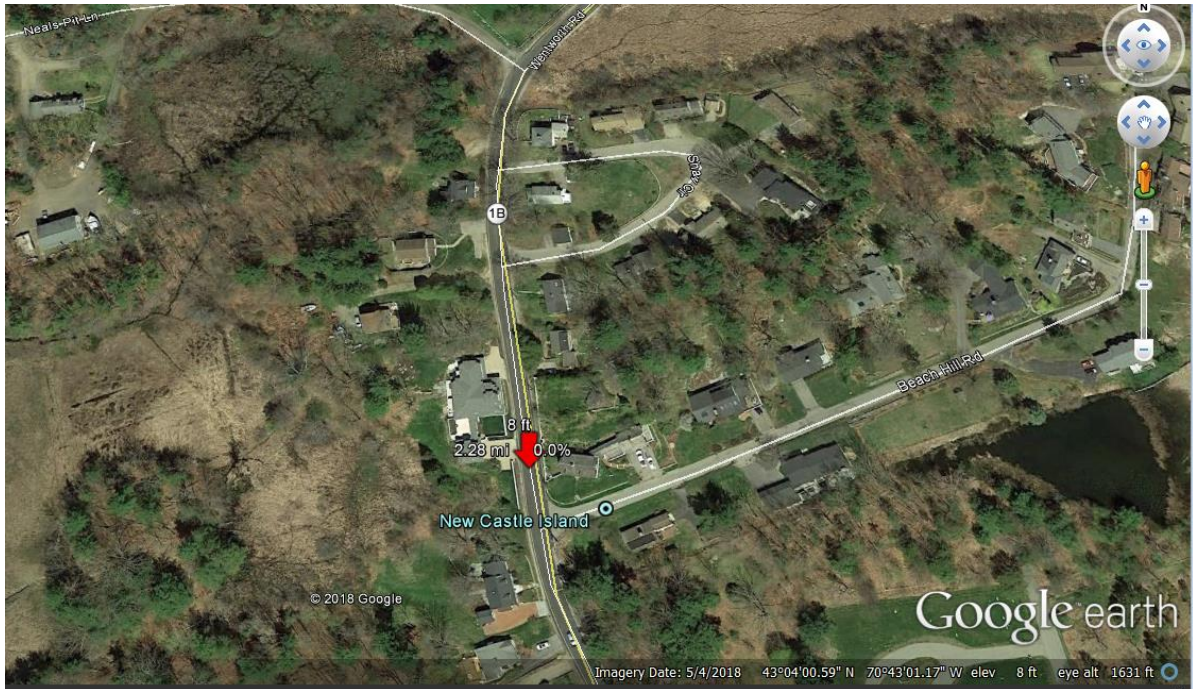
**Locations based upon Google Earth where Route 1B elevations are off interest follow:**



Google Earth Elevation 8: Route 1B location between Grist Mill Lane and Rilson Street

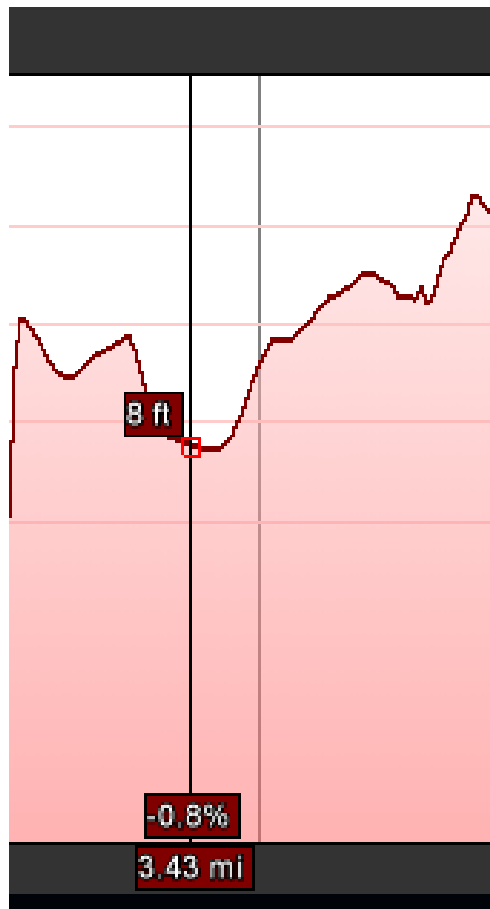


Google Earth Elevation 8: Route 1B location north of the intersection with Neals Pit Lane

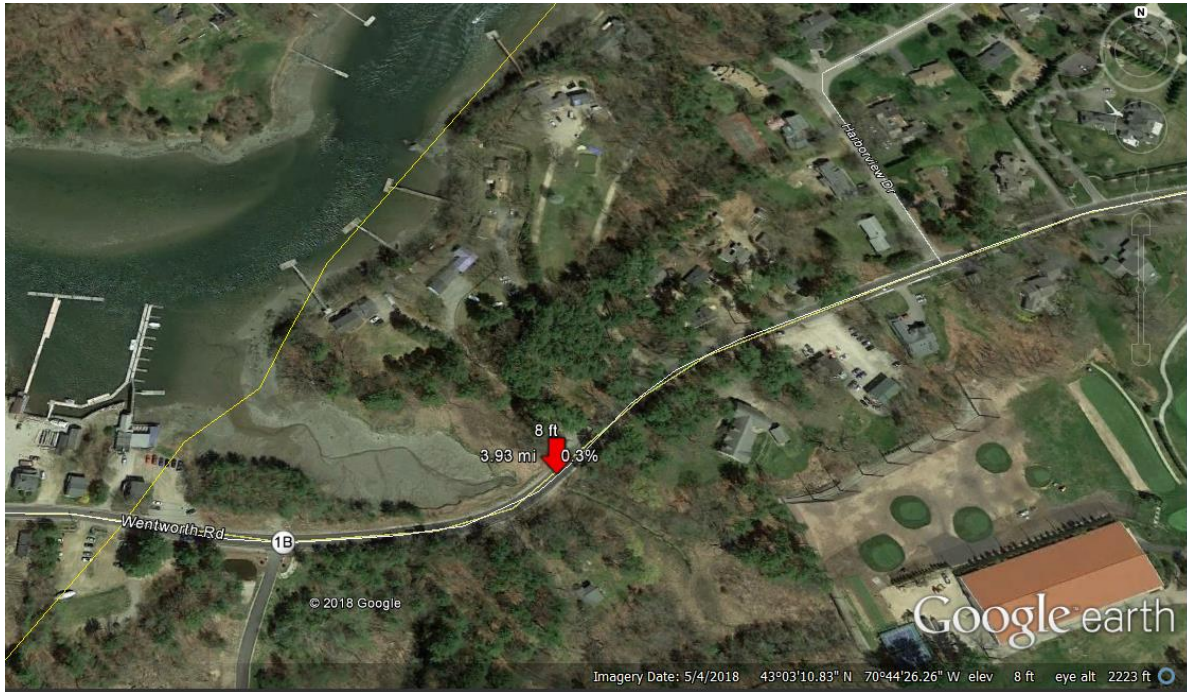


Google Earth Elevation 8: Route 1B location south of the intersection with Beach Hill Road

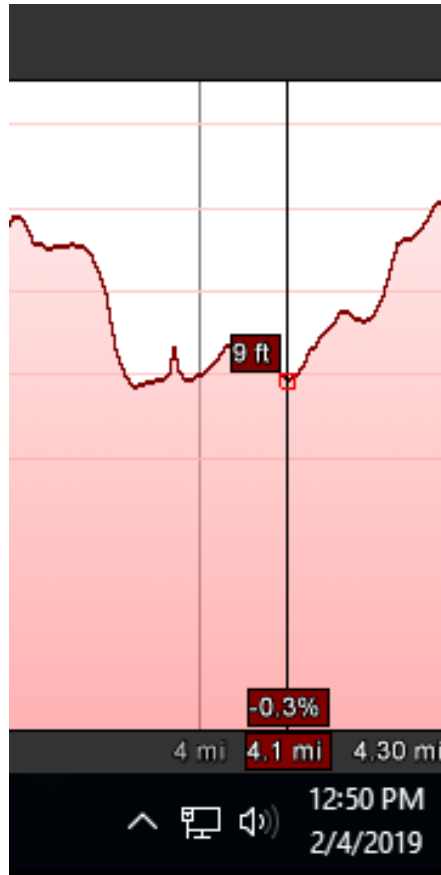




Google Earth Elevation 8: Route 1B location at northern edge of the Wentworth Golf Course in Rye



Google Earth Elevation 8: Route 1B location north of the Rye / Portsmouth town boundary



Google Earth Elevation 9: Route 1B location south of the Rye / Portsmouth town boundary

# **Appendix B**

## **Stakeholder Meeting Summary**

**Meeting Summary**  
**Stakeholder Meeting #1 - June 26, 2018**  
**4:30pm to 6:00pm**

**Attendees:**

Tomas Maher, Chair, New Castle Selectmen  
William Stewart, New Castle Selectmen  
Carl Roediger, Deputy Chief, Portsmouth Fire Department  
Ken McDonald, Safe Path  
Scott Bogle, Rockingham Planning Commission  
Victoria Chase, Project Manager, NHDOT  
Rebecca Martin, Senior Environmental Manager, NHDOT  
Jennifer Zorn, Public Outreach Coordination, McFarland Johnson  
Brian Colburn, Project Engineer, McFarland Johnson

**Meeting Summary**

After each person introduced themselves, Victoria Chase provided a summary of the purpose of the meeting. She informed the stakeholder committee that the Department was relying upon them to provide experience and expertise as it related to the Route 1B Causeway, also known as New Castle Causeway. The committee would serve an important advisory role to the project and would be asked about the frequency of storm events that have necessitated closure of the causeway, interruptions of access to/from New Castle and other concerns and input relating to this matter.

She additionally provided an overview of the project which consists of a feasibility study. This study is in the Department's 10-Year Plan, but no other component of the project, such as a possible modification to the causeway, was included. The purpose of the study is to investigate the need for and feasibility of making potential modifications to the 1,300 foot causeway, providing access from Goat island to New Castle Island. The Department has been tasked with identifying and evaluating possible alternatives to mitigate or avoid impacts to the causeway resulting from projected sea level rise. Various alternatives would be considered in this feasibility study.

Jennifer Zorn further explained that various alternatives were anticipated to be reviewed as part of this study and include the following:

- Do nothing or no build alternative
- Raise the causeway
- Raise the causeway, but add bicycle and/or pedestrian accommodations
- Raise causeway and evaluate how the rest of Route 1B acts as a system during storm events
- Replace the causeway with a bridge

These alternatives and the major considerations of each, including a preliminary cost estimate, would be prepared and presented as a matrix in the report. In addition, other details would include a summary of anticipated impacts to the environment, wildlife, historic resources and similar.

Jennifer Zorn then facilitated a discussing among the stakeholders that generally following a series of topics including: emergency service needs of New Castle; general needs and requirements of New Castle; needs of New Castle's major employer (Wentworth by the Sea Marriot Hotel and Spa and Country Club); maintenance issues or long-term needs of New Castle; projected timing of potential sea level rise; and consideration of the bicycle and pedestrian accommodation.

The following information was provided by the stakeholders during the facilitated discussion.

- The causeway closed during the early March 2018 Nor'easter during one high tide event. The closure time was a few hours long, until the tide receded. No records of other formal closures are known.
- During water inundation events, the water level over the causeway does not get too deep for truck passage. Large fire trucks are restricted to using the causeway because the Wentworth Bridge has a weight limit that precludes their passage.
- The vehicle weight limit of the Wentworth Bridge is 15 tons and most vehicles should be able to travel over the bridge.
- The official evacuation route from New Castle includes both directions, over the causeway and the over the Wentworth Bridge.
- A photo of the causeway was shown by William Stewart. The photo was taken during a storm event January 2018. Bill agreed to provide Victoria the photo via email.
- It is estimated that the causeway has been inundated during 2 storm events in 2018 (January and March). The inundation period was a short duration and the causeway remained passable to all vehicles, with the exception of the one high tide closure that occurred on March 2, 2018.
- School buses entering/exiting New Castle include: Rye Junior High, Portsmouth High School and the Berwick Academy.
- There is a low area on Route 1B near the Wentworth Golf Course/Rye beach access parking lot. When storm events inundate the causeway, water from the bay side goes over road at this low spot.
- There is a 2<sup>nd</sup> low spot on Route 1B near a tidal creek close to Pit Lane. There is a culvert under 1B connecting Rothwell Marsh to the Upper Lavenger Marsh. The culvert was not found during a recent site visit. It is believed to have been filled for a long time.

- New Castle currently has limited stormwater storage options. Many concerns were expressed relative to stormwater management and siltation occurring in the surrounding waters.
- The Wentworth Hotel is operated separately from the Country Club. Robert Diodati is manager of the Country Club (containing the golf course).
- Heavy trucks that need to access the Wentworth Hotel or other locations, use the causeway. Employees in cars use the Wentworth Bridge.
- According to NHDOT's District 6 office, there has been no need to address any storm damage on the causeway from recent storm events. Seaweed and gravel deposits are usually plowed off the travel lanes.
- The utility poles located on the north side of the causeway will be considered in the alternatives. As part of the feasibility study, the utility company will be contacted for input. The question was raised about the possible placement of the utility underground. This action is typically expensive and maintenance concerns are prevalent when utilities are placed underground.
- A water line is located on the bay floor, next to the southside of the causeway.
- New Castle experiences power outages on a regular basis probably due to the tree limbs/trees falling.
- New Castle is reaching its build capacity in terms of development and stormwater runoff. Plans are in motion to protect Lavenger Marsh by its designation as a prime wetland. A town conservation plan is in place.
- As part of bridge alternative, an exhaustive hydrological analysis would not be conducted. Currently the south side of the causeway is popular year-round recreational resource due to its calm waters. If a bridge was constructed in place of the causeway, it is assumed that an influence from the river velocities would occur in this area and would alter its current conditions.
- It is anticipated that many members of the public would support a wider causeway so bicycles and pedestrians can be accommodated.
- The speed limit has been reduced to 20 mph, but not on causeway.
- The Route 1B "loop" is exactly 10K and this lends itself to more people training on the roadway and race routes being located on the roadway. This "loop" is the 2<sup>nd</sup> most heavily traveled bicycle route in state. Route 1B also serves as the East Coast Greenway and the NH Coastal Scenic Byway (as presented in the corridor management plan).

- The Safe Path Committee is currently accepting private donations (\$71k collected thus far). The goal of committee is to identify areas where Route 1B can be expanded for bicycles and pedestrians. The committee has identified all points of concern and has prioritized sections based upon weight and scale and rank by priority.
- Rockingham Planning Commission is involved in a project listed in the NH 10-Year Plan, specifically for Bicycle and Pedestrian Safety Accommodations on NH 1A & NH 1B, for year 2028.

To close out the meeting discussion, the following action items were presented as the work that would occur moving forward prior to the next stakeholders meeting:

- Gather additional information based upon the important points discussed at this June 26<sup>th</sup> meeting.
- Reach out to additional stakeholders, if needed, for further information
- Research best data sources for potential sea level rise
- Advance the alternatives (concept level only) and develop a preliminary cost estimate of each
- Plan for the 2<sup>nd</sup> stakeholder meeting in the fall

Meeting adjourned at 6:00pm