Proactive by Design

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

477 Congress Street
Suite 700
Portland, ME 04101
T: 207.879.9190
F: 207.879.0099
www.gza.com

M E M O R A N D U M

TO: Laura Krusinski, Maine Department of Transportation

FROM: Andrew Blaisdell, P.E., Christopher Snow, P.E., Russell Morgan

DATE: March 30, 2016

FILE NO.: 09.0025899.01

SUBJECT: Geotechnical Engineering Evaluation
Naples Slope Evaluation and Design
Maine Department of Transportation WIN 20466.00, Naples, Maine

---

GZA GeoEnvironmental, Inc. (GZA) has prepared this geotechnical engineering evaluation for the proposed Route 11/114 Slope Stabilization Project in Naples, Maine. Our services have been provided in accordance with Multi-Pin General Consulting Agreement (GCA) with the Maine Department of Transportation Bridge Program (804.10 – Geotechnical Investigations and Engineering Services), and the attached *Limitations* included in **Appendix A**.

This memorandum presents the results of subsurface explorations and field measurements conducted in February 2016 for this project. GZA is also providing geotechnical engineering services for the replacement of the Crockett Bridge No. 2199 over the Muddy River. GZA provided a geotechnical engineering report for the bridge under separate cover.

BACKGROUND

The subject project consists of reconstruction of an approximately 250-foot-long slope on the southeast (Right) side of Route 11/114 in Naples, located on the north (upstation) side of the Muddy River and the Crockett Bridge, as shown on the **Boring Location Plan, Figure 1**. The slope is comprised of a combination of rock outcrops in the lower portion and soil with cobbles and boulders in the upper portion. Based on our observations of sloughed soil, cobbles and boulders in the catchment during GZA site visits in February and March 2016, the slope appears to be subject to frequent rock fall.

Based on our review of the cross sections, the existing slope has a typical height ranging from 15 to 26 feet, and the lower approximately 3 to 7 feet of the slope appears to consist of exposed bedrock between approximately Sta. 117+00 and 118+00. Due to the presence of a variable thickness of soil above the rock slope, the height and limits of the bedrock outcrop could not be directly observed in all areas during our site visits. The typical inclination of the slope ranges from approximately 50 to 65 degrees for both the rock and soil portions of the slope.

The intent of the proposed slope work is to assess bedrock depths within the existing slope and to develop design cross sections that meet the intent of MaineDOT design standards and limit the potential for future slope instability that could impact the roadway. The evaluation also included an assessment of kinematic rock slope stability.

SUBSURFACE EXPLORATIONS

The subsurface exploration program was completed to assess the top of bedrock and the nature of discontinuities in the rock mass in the slope area. The program included low angle rock probes, a seismic refraction survey, and field mapping of accessible bedrock outcrop features.

The as-drilled locations, ground surface elevations, station and offset of the probes were surveyed by MaineDOT on February 17, 2016. The start and end points along each seismic line, as well as turning points, were also surveyed by MaineDOT. The probe and seismic line locations are shown on **Figure 1**. Elevations referenced in this report are in feet and refer to North American Vertical Datum of 1988 (NAVD 1988). The results of the probes are presented in **Table 1**.

ROCK PROBES

GZA completed twenty-six (26) low-angle rock probes (HP-NAP-101 through HP-NAP-126) using an air track drill rig at approximate 25-foot stations for our use in estimating bedrock depths. The probes were drilled in a direction perpendicular to the project baseline (i.e., along a station line). Maine Drilling & Blasting of Gardiner, Maine provided rock probe drilling services and coordinated utility clearance for their work. The probes were completed on February 10 and 11, 2016.

The rock probe lengths ranged from approximately 5 to 57 feet. All probes, except HP-NAP-120, were terminated in bedrock. The probes were drilled at inclinations ranging between 4 and 42 degrees below horizontal. Soil and rock samples were not collected in the probes. A GZA field engineer observed the drilling of the probes and, with assistance from the drill rig operator, judged apparent top of rock depth based on relative drilling resistance. A GZA engineer was onsite to observe and document the probes and to measure the inclination of the drill string during completion of each probe. Probe lengths, inclinations, and bedrock locations at each probe are presented in **Table 1**.

SEISMIC LINES

GZA engaged Northeast Geophysical Services (NGS) of Bangor, Maine to conduct a seismic refraction survey adjacent to the roadway alignment. NGS conducted one, approximately 190-foot-long seismic refraction line, designated Seismic Line 1, on February 8, 2016 to evaluate depth to bedrock. The report prepared by NGS is included in **Appendix B**. Depths from ground surface to probable bedrock were interpreted by NGS along the seismic line and are plotted against the probe-based bedrock depths at the same locations on Figure 1 (page 6) of NGS's report.

ROCK MAPPING

A GZA engineer assessed bedrock types and made direct measurements of eight representative bedrock joints and features along the existing rock cut face that were accessible from the catchment area. Field mapping included measurements and observations of dip and dip direction. The field mapping data are summarized in **Table 2**.

SUBSURFACE CONDITIONS

SURFICIAL AND BEDROCK GEOLOGY

Based on available literature, surficial geologic units in the site vicinity are mapped as Glacial Lake Sebago Bottom Deposit (massive to stratified and cross-stratified sand, generally fine to medium, and massive to laminated silt and silty clay, may contain boulders and gravel) varying in thickness from 1 to 60 feet.

Bedrock at the site is mapped as the Sebago pluton. The Sebago pluton in the site vicinity is described as medium grained equigranular, biotitic-muscovite Granite, white to pale pink, locally pegmatitic. Two intrusive dikes are also mapped in the immediate site vicinity, including a mafic dike (reddish-brown weathering, black basaltic dikes) and a trachyte dike (dark gray weathering, chocolate-brown feldspar-bearing dikes).

EXPOSED SOIL AND ROCK CONDITIONS

As noted previously, the exposed slope consisted of a variable thickness of soil overlying a bedrock outcrop at the base of the slope. The soil was described as Lake Bottom Deposits, ranged in thickness from negligible to approximately 18 feet (based on the slope exposures and probe data), and consisted of tan to brown, fine to coarse SAND, trace Silt. Numerous cobbles and boulders up to about 6 feet in diameter were exposed in the slope. The appearance of the highest and steepest portions of the slope, between Sta. 117+25 and 117+75, was indicative of recent sloughing, based on the very steep inclination and overhanging forest mat layer at the top of the slope. Seepage was observed through the Lake Bottom Deposits during GZA's visits that followed rainfall events, and the seepage was accompanied by active movement and releases of small volumes of soil into the ditch.

The bedrock outcrop at the base of the slope was comprised of granite with several near-vertical intrusions (dikes) of apparent trachyte. The granite was typically fresh to slightly weathered, and the trachyte intrusions varied from fresh to highly weathered. The most weathered trachyte was observed near contacts with granite, but some contacts exhibited very little weathering. The outcrop was covered with too much soil to observe intrusion locations along about half of the slope. The typical joint spacing ranges from about 6 inches to 3 feet.

Measured discontinuities include a moderately dipping to high angle joint set (dip of 47 to 74 degrees) that dips toward the northeast (designated as J1), approximately normal and into the cut face, and high angle to vertical joints (dip of 72 to 84 degrees) that dip south to southwest (designated as J2) or northeast (designated as J3), rotated at least 39 degrees from the slope orientation. The dike contacts appear to follow joint set J3. The joint set designation and approximate rotation from the slope orientation are presented in **Table 2**.

GEOTECHNICAL EVALUATIONS AND RECOMMENDATIONS

ESTIMATED TOP OF ROCK SECTIONS

GZA developed approximate ledge lines for the cross sections based on the probe data. GZA used trigonometry to calculate the top of rock elevation and offset from the baseline based on the drill rod inclination and the distance to rock at each probe location. The probes were drilled perpendicular to the baseline, so the station was assumed to be the same at the (surveyed) probe location as at the encountered top of rock. The interpreted top of rock from the seismic refraction testing was similar, but varied by up to about 5 feet from the probe-based interpolated ledge lines in the same locations. The probe data was used as the design basis due to the potential variability in the seismic data resulting from loose and heterogeneous surface soils, and snow and variably frozen ground at the time of the survey. The calculated top of rock elevation and offset at each probe location are presented in **Table 1**.

The interpreted ledge lines are presented on the cross sections in **Appendix C**.

SLOPE STABILITY

In our opinion, the primary geotechnical condition affecting the existing slope is seepage through and erosion of the oversteepened Lake Bottom Deposit. Raveling and falling boulders currently pose a risk to vehicle traffic considering the limited catchment width and depth. We conclude this risk can be mitigated by excavating the soil portion of the slope to a conventional cut slope inclination, 2H:1V, and removing or stabilizing boulders that protrude significantly from the new cut slope. The soil cut slope will terminate above the bedrock cut face and will likely become saturated and periodically weakened over time. In order to contain the toe of the soil slope, a free-draining toe buttress should be constructed where the soil slope meets the bedrock.

We did not observe bedrock discontinuities that would create kinematically-possible planar, wedge or toppling instability. Therefore, in the absence of blasting damage and/or weathering, we conclude the potential for rock slope instability is low. The potential for blasting damage can be limited using controlled blasting techniques as recommended later herein. Based on the presence of dikes, some with differential weathering, in the vicinity of high angle to near-vertical contacts, we conclude there is potential for a blocky bedrock mass to remain after blasting that would result in release of rock fragments over time. Based on the observed joint spacing, typical falling rocks could vary from about 6 inches to 3 feet in diameter. The areas likely to experience rockfall soonest are the most weathered areas, which will be evident when the new rock cut face is exposed. Falling rocks are expected to be retained in the catchment ditch, but persistent rock fall from a localized release zone could undermine the toe buttress over time. Recommendations to promote stability and monitor weathered areas are presented below.

SLOPE DESIGN

We recommend that the proposed cuts be designed in general accordance with the typical sections of the Maine Highway Design Guide, with additional considerations and modifications as described herein.

A 1H:4V rock cut slope inclination is considered suitable for this project. The overburden soil should be completely removed to expose bedrock within about 6 feet laterally from the top of rock slope. The catchment geometry shown on the plans is suitable.

The base of the soil cut slope will experience frequent seepage, and saturation of the soil at the toe could result in soil loss, rock fall out and slope instability. A doweled gabion basket system is recommended to be used as a toe buttress to promote stability. The gabions should have a 3-feet by 3-feet cross section. Each basket should be at least 6 feet long, and the edge of the gabions closest to the rock slope should be set back 3 feet from the slope crest. The baskets should be galvanized and PVC- or HDPE-coated to limit the onset of corrosion. Each basket should have a positive connection to the rock consisting of at least two galvanized, No. 8 all-thread dowels, with galvanized bearing plates, washers and locking nuts. The dowel holes should be drilled roughly normal to the bedrock surface and grouted 2 feet into bedrock. Drainage geotextile should be wrapped beneath and along the uphill side of the gabion baskets to prevent migration of fines into the gabion fill. If the bedrock surface beneath the gabions is steeper than 4H:1V, the bedrock should either be benched or leveled with a lean concrete. The recommended detail for the gabion toe buttress is included in **Appendix C**.

The soil above the rock slope is recommended to be constructed with a 2H:1V slope, with the toe starting a minimum of six inches below the top of the gabions, extending back to the intersection with the existing slope.

We recommend that the soil cut slope be covered with Erosion Control Mix to promote stability in consideration of persistent seepage noted during our site visits. Erosion Control Mix should meet the requirements of MaineDOT Standard Specification Item 717.04 – Mulch, Item (e), and should be 4 inches thick. The slope should be seeded using Seeding Method 3 in accordance with MaineDOT Standard Specification 618 – Seeding. Erosion Control Mix should be placed in accordance with MaineDOT Standard Specification 619 – Mulch.

If large boulders are encountered protruding from the slope surface and can't be removed without risking destabilization of the slope above, the Geotechnical Engineer should be consulted to provide recommendations for stabilization (e.g., dowels). It may also be feasible to remove the boulders using lightly-loaded explosives if the final soil cut slope is prepared at the time of rock excavation.

ROCK SLOPE EXCAVATION METHODS

Controlled blasting techniques are recommended to excavate bedrock for this project to help retain a stable bedrock mass beneath the soil cut slope. The presence of weathered zones may create a potential for long-term rockfall even with appropriate blasting techniques. We recommend that loose rock left after blasting be scaled during excavation to limit near-term rockfall potential. The rock slope should be evaluated by the Geotechnical Engineer after scaling for a final assessment of stability, and potential zones of differential weathering. This evaluation should be completed while the site contractor is still available to complete additional scaling if recommended.

Additional recommendations for rock slope construction are presented below.

- In order to provide a uniform finished slope and reduce unintended overbreak, presplitting techniques should be used for the required rock cut. We recommend that the Contractor drill parallel slope holes to the full depth of the rock lift along the line and plane of inclination of the proposed slope using a 2-foot maximum center-to-center spacing and a 3-inch maximum hole diameter. Larger drill holes and/or spacing should not be allowed without one or more test blasts in small areas that are excavated and observed by the Engineer to show acceptable rock slope face conditions.

- The explosives used in the slope holes along the line of the finished slope and in the adjacent slope holes should be explosives for presplitting use only, and should be subject to review and approval by the Engineer.
- In areas beyond the presplit limits, the blast hole spacing, diameter, delays, and pounds of explosive per delay should be adjusted by the Contractor according to the characteristics and structure of the rock encountered to obtain the required finished slopes with a minimum of overbreak.
- Vibration and air overpressure monitoring should be conducted at nearby sensitive utilities and structures during blasting, if any exist. Utility operators should be contacted to obtain vibration criteria to limit the potential for damage to existing utilities.
- Blasting agents should comply with appropriate regulatory environmental requirements. Explosives containing perchlorates should not be used.
- The Contract Special Provisions should require the Contractor to submit a Blasting Plan to the Engineer for review and approval at least two weeks prior to commencing drilling and blasting operations. At a minimum, the plan should include the following information:
  - Sequence and schedule of blasting rounds, including the method of developing the excavation, lift heights, presplitting, etc.;
  - Methods of matting or covering of the blast area in open excavations to prevent flyrock and excessive airblast overpressure;
  - Written evidence of the licensing, experience and qualifications of the blasters who will be directly responsible for the blasting operations;
  - Name and qualifications of the person(s) responsible for design and directing the blasting. This submittal shall document by project lists that the person has the required experience in controlling blast vibrations in blasting rounds of the type required on the project;
  - Name and qualifications of the independent Professional Engineer responsible for conducting pre-blast condition surveys. This submittal shall document by project lists and samples of pre-construction surveys that the proposed independent professional Engineer has the required experience;
  - Name and qualifications of the person(s) responsible for monitoring and reporting blast vibrations and airblast overpressures;
  - Details of an audible advance signal system to be employed at the job site as a means of informing workers, Engineer, Owner, all abutters and the general public that a blast is about to occur;
  - A listing of instrumentation that the Contractor proposes to use to monitor vibrations and airblast overpressure levels complete with performance specifications and user's manuals supplied by the manufacturer;
  - Recent calibration certificate(s) (within previous six months) for the proposed blast monitoring instrumentation;
  - Details of a test blast prior to mass production blasting to confirm the suitability of the Contractor’s proposed hole spacing and explosives;

- A copy of the blasting permit(s) obtained to conduct blasting on the site; and
- A pre-blast condition survey.

ROCK SLOPE MONITORING

Upon completion of the rock excavation, soil slope grading and gabion buttress installation, we recommend that GZA evaluate the rock slope condition and develop recommendations for future inspection, if appropriate. If areas are identified as at-risk for differential weathering, we will recommend that the gabion buttress and underlying rock slope be inspected and photographed periodically as a part of bridge inspections to assess whether rock fall is impacting or will soon impact gabion stability.

CLOSURE

We trust that this information meets current project needs. Please feel free to call Andy Blaisdell at (207) 358-5117 for additional information.

ARB/CLS/RJM:erc
P:\09 Jobs\0025800s\09.0025899.00 - MDOT Naples\09.0025899.01 - Slope Evaluation\Report\FINAL 25899 01 Naples Design Memo 033016..docx

Attachments: Table 1 – Summary of Air Rotary Probes
Table 2 – Summary of Bedrock Feature Measurements
Figures 1 – Boring Location Plan
Appendix A – Limitations
Appendix B – Seismic Refraction Survey Report
Appendix C – Detail and Cross Sections

TABLES

Table 1 - Summary of Air Rotary Probes
Naples Slope Evaluation
MaineDOT WIN 20466.00

Probe Designation	Ground Surface at Probe Location					Probe Observations			Estimated Top of Rock	
	Elevation (ft - NAVD 88)	Northing	Easting	Station	Offset (ft)	Inclination (deg)	Distance to Rock (ft)	Total Exploration Depth (ft)	Elevation (ft - NAVD 88)	Offset (ft)
HP-NAP-101	291.0	398694.0	921262.7	116+73.6	31.6	11	10.0	21.0	289.1	41.4
HP-NAP-102	295.3	398686.7	921269.7	116+72.5	41.6	8	19.0	24.0	292.6	60.4
HP-NAP-103	292.0	398717.5	921269.8	116+96.2	22.0	42	1.0	9.0	291.3	22.7
HP-NAP-104	294.4	398716.8	921271.3	116+96.6	23.6	9	2.5	9.0	294.0	26.1
HP-NAP-105	296.4	398716.2	921272.8	116+97.1	25.1	36	3.0	9.0	294.6	27.5
HP-NAP-106	300.6	398714.7	921274.7	116+97.2	27.5	13	9.0	20.0	298.6	36.3
HP-NAP-107	296.8	398741.7	921284.1	117+23.9	17.4	--	0.0	10.0	296.8	17.4
HP-NAP-108	299.8	398739.7	921286.4	117+23.9	20.4	--	0.0	9.0	299.8	20.4
HP-NAP-109	303.5	398737.8	921288.7	117+23.8	23.4	13	8.0	16.0	301.7	31.2
HP-NAP-110	306.4	398735.9	921289.9	117+23.2	25.5	11	14.0	31.0	303.8	39.3
HP-NAP-111	310.6	398733.5	921291.5	117+22.4	28.3	16	21.5	32.0	304.7	49.0
HP-NAP-112	302.0	398762.3	921302.3	117+51.4	18.1	33	0.5	9.0	301.7	18.5
HP-NAP-113	304.5	398761.2	921303.8	117+51.5	20.0	23	1.0	8.0	304.1	20.9
HP-NAP-114	306.7	398759.9	921305.4	117+51.5	22.1	12	10.0	20.0	304.6	31.9
HP-NAP-115	309.9	398757.3	921306.7	117+50.4	24.8	7	37.0	57.0	305.4	61.5
HP-NAP-116	313.9	398756.4	921308.2	117+50.7	26.4	8	36.0	44.0	308.9	62.1
HP-NAP-117	302.5	398779.9	921315.0	117+73.0	16.6	--	0.0	8.0	302.5	16.6
HP-NAP-118	306.7	398777.4	921318.1	117+73.1	20.6	23	6.0	12.0	304.4	26.2
HP-NAP-119	311.6	398776.1	921320.5	117+73.6	23.3	19	24.0	33.0	303.8	46.0
HP-NAP-120	314.9	398775.2	921321.2	117+73.4	24.4	4	> 44.0	44.0	< 312.0	> 67.8
HP-NAP-121	304.6	398796.2	921334.7	117+98.2	21.3	--	0.0	5.0	304.6	21.3
HP-NAP-122	306.8	398794.9	921335.8	117+97.9	22.9	14	6.0	14.0	305.3	28.8
HP-NAP-123	310.5	398793.8	921336.7	117+97.6	24.4	10	19.0	28.0	307.2	43.1
HP-NAP-124	314.0	398791.9	921340.5	117+98.5	28.5	11	32.0	40.0	307.9	59.9
HP-NAP-125	308.7	398814.6	921352.3	118+23.5	23.0	13	2.0	9.0	308.2	24.9
HP-NAP-126	312.5	398811.4	921356.3	118+23.7	28.1	15	10.0	20.0	309.9	37.8

Notes:

1) Elevations are in feet and reference the North American Vertical Datum of 1988 (NAVD 88). Coordinates are in feet and reference the North American Datum of 1983 (NAD 83), Maine State Plane 2000 Coordinate System.
2) As-completed exploration elevations and coordinates were surveyed by a MaineDOT survey crew and provided to GZA.
3) Station and offset and ground surface elevation for probes was calculated by MaineDOT and provided to GZA.
4) At bedrock outcrop locations, distance to rock was recorded as 0.0 and inclination was not recorded.
5) Estimated Top of Rock Elevation and Offset from Station centerline were calculated by GZA, based on the inclination and length of the drilled hole.
6) HP-NAP-120 did not encounter bedrock.

Table 2 - Summary of Bedrock Feature Measurements
Naples Slope Evaluation
MaineDOT WIN 20466.00

Measurement Designation	Joint Set	Approximate Elevation (ft, NAVD 88)	Approximate Station	Dip (deg)	Dip Direction (deg / direction)		Approximate Rotation from Slope Orientation (deg)
1	J2	295	117+10	72	225	SW	85
2	J2	295	117+15	84	255	SW	55
3	J1	298	117+20	74	50	NE	100
4	J1	298	117+20	60	70	NE	120
5	J3	298	117+20	79	349	NW	39
6	J2	299	117+30	81	177	SE	133
7	J1	300	117+30	53	62	NE	112
8	J1	300	117+35	47	43	NE	93

Notes:

1) Elevations were estimated to the nearest 1 foot based on their location relative to the surveyed probe locations and should be considered approximate. Elevations are in feet and reference the North American Vertical Datum of 1988 (NAVD 88).

2) Stations were estimated to the nearest 5 feet based on their location relative to surveyed probe locations and should be considered approximate.

3) Dip and strike measurements were made by GZA on February 5 and 25, 2016 to represent typical exposed joint sets. Measured strike was converted to dip direction by adding 90 degrees and correcting for a magnetic declination of -15.4 degrees in Naples, Maine.

4) Discontinuities were grouped into joint sets J1, J2 and J3 based on similarity of dip and dip direction.

5) Rotation from slope corresponds to the angular difference in dip direction between the rock slope and each discontinuity. Values less than 90 degrees dip out of the slope, and values greater than 90 degrees dip into the slope.

FIGURES

APPENDIX A – LIMITATIONS

LIMITATIONS

Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions .

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

Subsurface Conditions

4. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs.

5. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

6. Water level readings have been made in test holes (as described in the Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.

7. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.

Compliance with Codes and Regulations

8. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

APPENDIX B – SEISMIC REFRACTION SURVEY REPORT

SEISMIC REFRACTION SURVEY
MDOT CROCKETT BRIDGE SITE
NAPLES, MAINE

For:
GZA Inc.
March, 2016

Northeast Geophysical Services
Division of NGS, Inc.
4 Union Street
Bangor, Maine

SEISMIC REFRACTION SURVEY
MDOT CROCKETT BRIDGE SITE
NAPLES, MAINE

INTRODUCTION

At the request of GZA Inc., a seismic refraction survey was completed at the MDOT Crockett Bridge Site located in Naples, Maine. The objective of this survey was to determine the bedrock depth and configuration beneath the survey area. The field survey was undertaken on February 8, 2016. One seismic line totaling about 190 lineal feet was surveyed. This report describes the equipment and methods used and the results of the survey, and includes a profile for the interpreted seismic line.

LOCATION AND SITE CONDITIONS

The survey line is located along the edge of the woods along the south side of the Sebago Road beginning northeast of Crockett Bridge and trending northeast about 190 feet in Naples, Maine. The approximate location of the seismic line is shown on the Seismic Line Location map (following page). Soil surface conditions along the line were generally partially frozen sandy soil with some large cobbles and boulders. The looseness of the soil and the inhomogeneity of the soil (variably frozen and rockiness) resulted in poor seismic transmission. The site was also noisy due to traffic and wind.

SUMMARY OF RESULTS

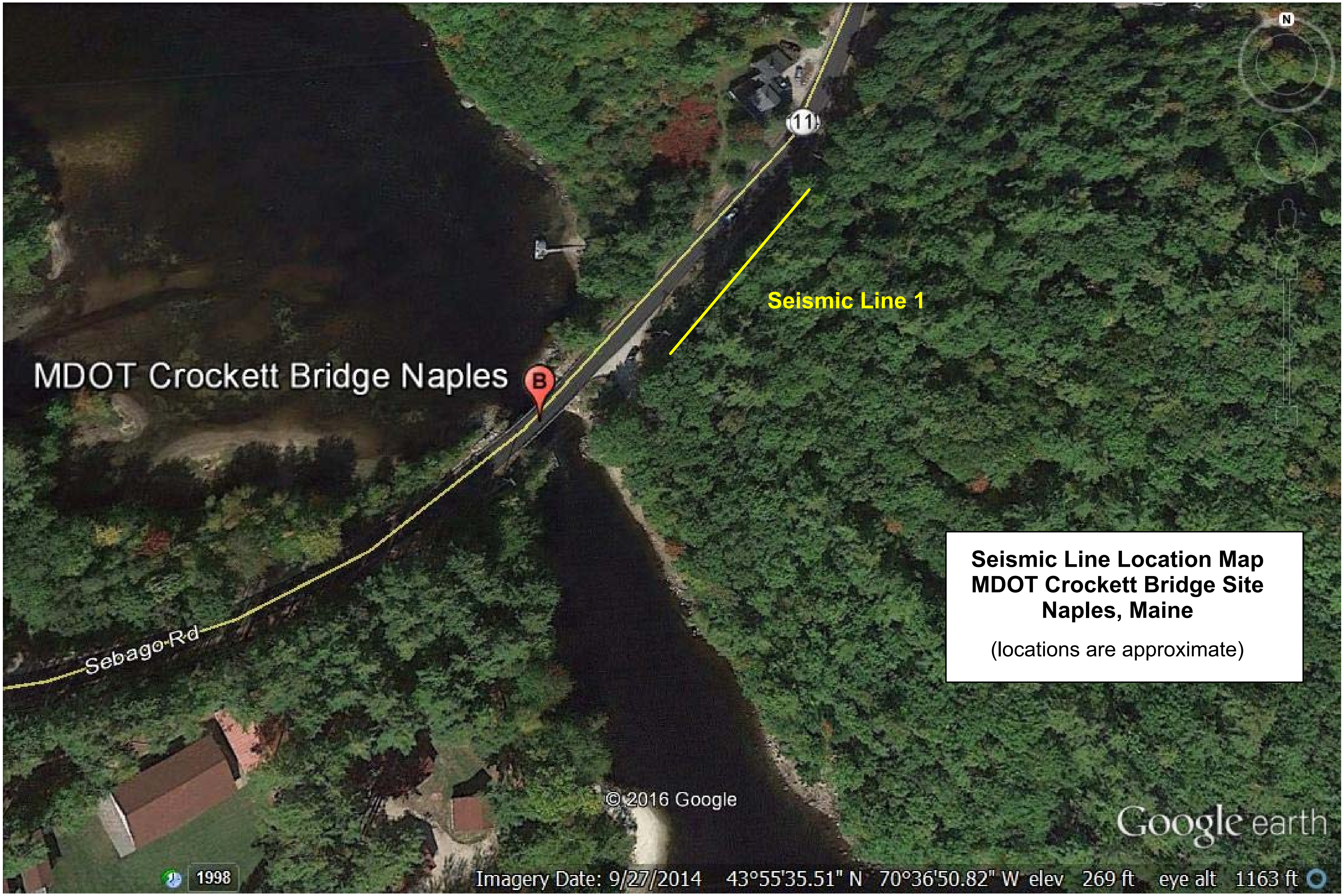
The seismic refraction results are attached as a profile of the survey line. The seismic results show the seismically interpreted depths to bedrock and configurations. Also shown on the profile are the estimated refusal depths (possible bedrock) derived from the GZA borings that were made proximal to the survey line. The seismically calculated bedrock depths range from approximately 8 feet to over 15 feet deep along the survey line.

SEISMIC METHODS AND INSTRUMENTATION

The seismic refraction method relies on travel times of sound waves, measured in milliseconds, traveling through and refracting from subsurface layers with contrasting densities. The seismic refraction lines were surveyed using a Geometrics Geode, 24-channel seismograph. Relative surface elevations were acquired using a pop level and stadia rod and then approximated to the actual elevations provided by GZA.

The line consisted of 2 segments with each segment containing 24 geophones. Geophones were spaced 4 feet apart. Each segment was tested with 8 shots. The general shot configuration consisted of one shot at either end of the segment, one off each end about 80 to 100 feet, and three shots or more within the segment. The energy source consisted of a small explosive charge (shotgun shell) buried about 3 feet or a hammer and metal strike plate.

The seismic data were processed and interpreted using the RIMRock Geophysics SIPT-2 (formerly U.S.G.S. SIPT-2) seismic interpretation program. This program calculates seismic


MDOT Crockett Bridge Naples
B
Seismic Line 1
11
Sebago Rd
Seismic Line Location Map
MDOT Crockett Bridge Site
Naples, Maine
(locations are approximate)
© 2016 Google
Google earth
1998
Imagery Date: 9/27/2014 43°55'35.51" N 70°36'50.82" W elev 269 ft eye alt 1163 ft
N

velocities by regression and by Hobson-Overton method, and solves for layer thicknesses using the delay-time method and iterative ray tracing modeling.

SEISMIC SURVEY RESULTS

Profiles of the line showing the seismically interpreted bedrock depths and configurations and tabulated data are attached.

The survey identified two velocity layers. The Layer 1 velocity for the survey was 1,057 to 1,338 feet per second (fps) and is interpreted to represent dry soil. The Layer 2 velocity was ranged from 14,352 to 17,830 fps and is interpreted to represent bedrock.

DISCUSSION OF SEISMIC RESULTS

In order for the seismic refraction method to accurately estimate velocity layer depths, certain natural conditions should exist:

a.) Layers should increase in velocity and in thickness with depth. A typical example would be ten feet of unsaturated soil at 1,100 fps overlying 50 feet of saturated soil at 5,000 fps that overlies bedrock at 15,000 fps.

b.) There should be a sufficient velocity contrast between different layers. Ideally, each velocity layer would be 2 to 3 times faster than the overlying layer.

c.) The velocity within a layer should be relatively constant throughout that layer (lateral homogeneity).

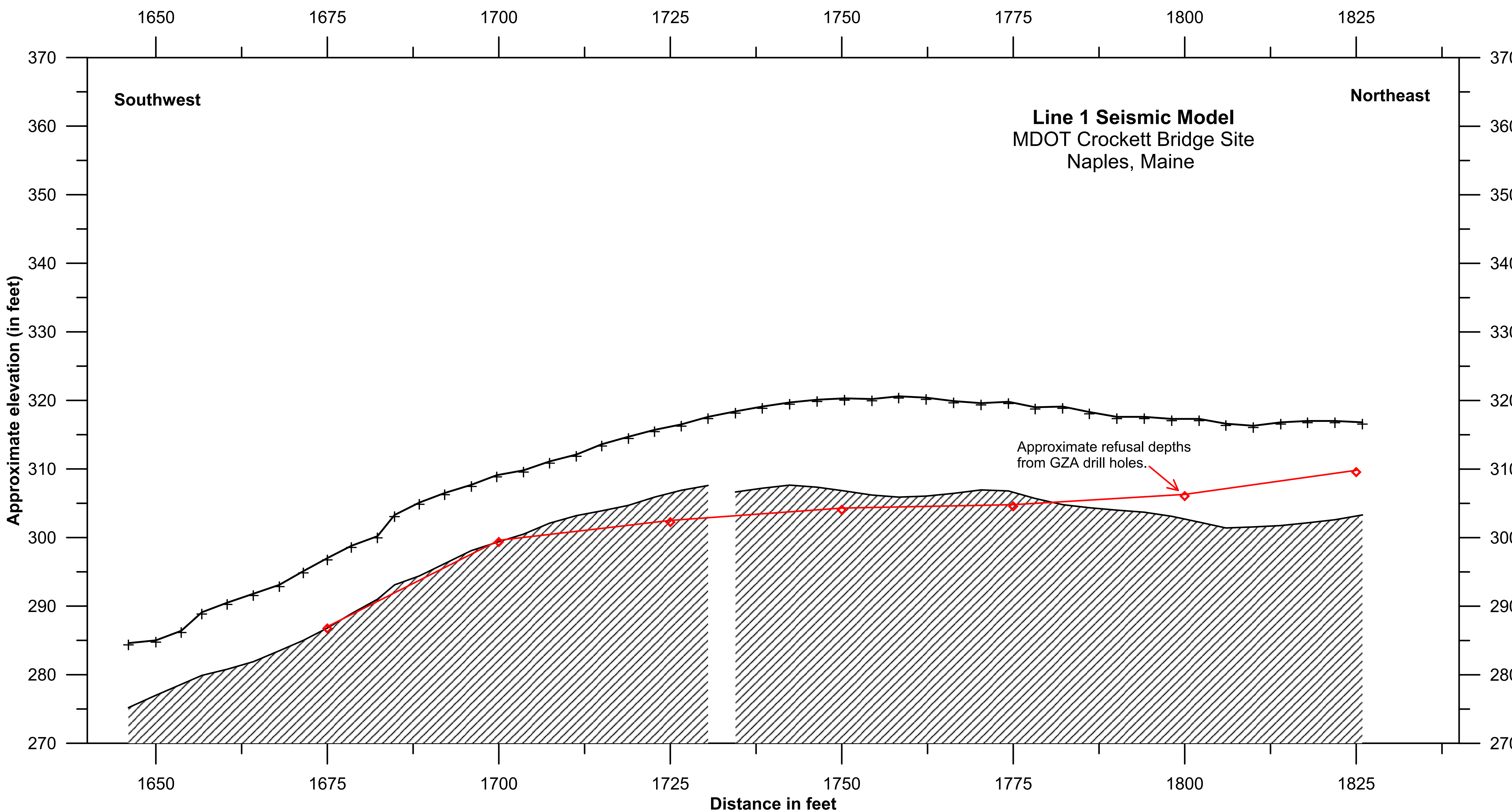
In addition to these conditions, it is also important that there be a low level of background noise at the site. It is also very helpful if there is some ground truth data, such as borehole data, to compare and calibrate the seismic information.

At the Naples site these conditions were generally met, however, the soil was very loose and uncompacted which resulted in poor transmission of the seismic energy. The soil was also inhomogeneous, being rocky and frozen in places. This causes lateral variability in the seismic velocity which, in turn, creates uncertainty in the model. This, coupled with the high background noise, resulted in generally fair to poor data quality. We partly overcame this problem by doing multiple shots along the line.

Under favorable conditions seismic refraction results can be fairly precise, within +/- 10 percent or within 5 feet. The conditions at the Naples site were difficult and the data quality ranged from fair to poor across the site. In general, on the survey line the most uncertainty in bedrock depths is at the ends of the line because there is less data at the ends to estimate the depths.

As with any indirect method it is possible that the seismically interpreted depths may not be accurate, however, it is believed that the seismic survey at the Naples site fairly accurately depicts the bedrock configuration.

ATTACHMENT
SEISMIC REFRACTION PROFILE
AND TABULATED DATA



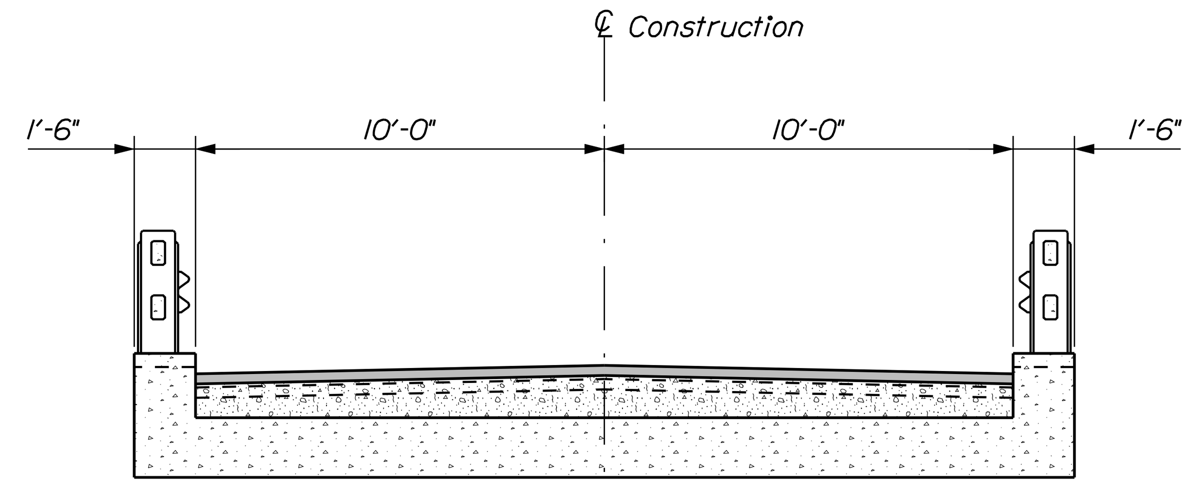
Northeast Geophysical Services

TABLE 1 - Seismically estimated bedrock depths and elevations
MDOT Crockett Bridge Site - Naples, Maine

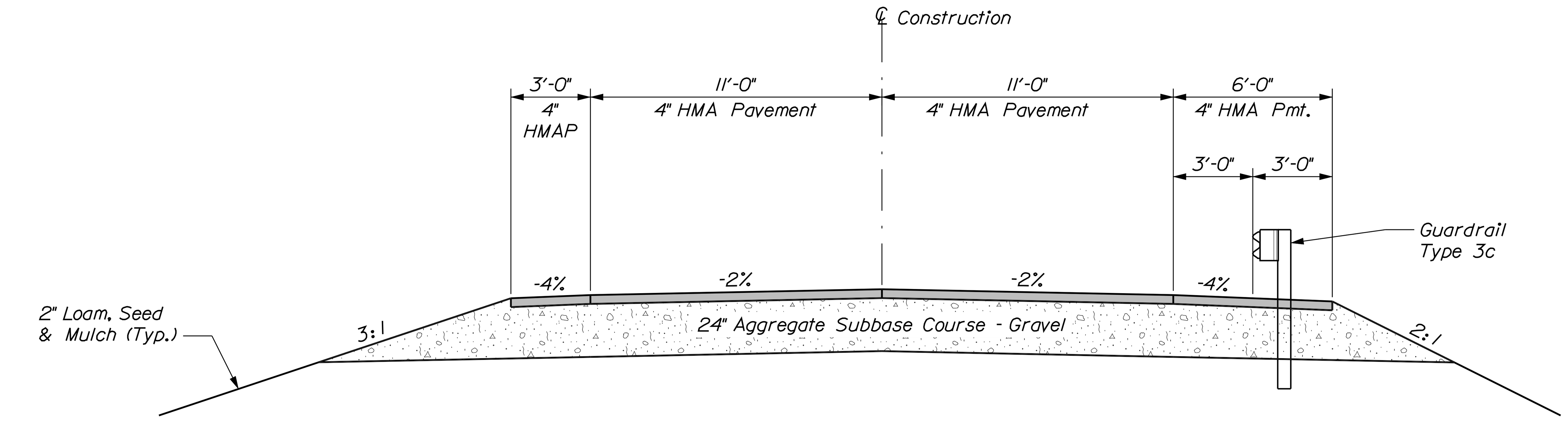
Geophone	X Distance in feet	Surface Elevation	Interpreted Bedrock depth	Interpreted Bedrock elevation
1	1646	284.6	9	275
2	1650	285	8	277
3	1654	286.4	8	279
4	1657	289.1	9	280
5	1660	290.5	10	281
6	1664	291.8	10	282
7	1668	293.1	10	284
8	1672	295.1	10	285
9	1675	297	10	287
10	1679	298.8	10	289
11	1682	300.2	9	291
12	1685	303.3	10	293
13	1688	305.1	11	294
14	1692	306.5	10	296
15	1696	307.7	10	298
16	1700	309.1	10	299
17	1704	309.8	9	301
18	1707	311.1	9	302
19	1711	312.1	9	303
20	1715	313.6	10	304
21	1719	314.7	10	305
22	1723	315.7	10	306
23	1727	316.5	10	307
24	1731	317.6	10	308
1	1735	318.4	12	307
2	1738	319.1	12	307
3	1742	319.7	12	308
4	1746	320.1	13	307
5	1750	320.3	14	307
6	1754	320.2	14	306
7	1758	320.6	15	306
8	1762	320.4	14	306
9	1766	319.9	13	306
10	1770	319.6	13	307
11	1774	319.8	13	307
12	1778	319	13	306
13	1782	319.1	14	305
14	1786	318.3	14	304
15	1790	317.6	14	304
16	1794	317.6	14	304
17	1798	317.3	14	303
18	1802	317.3	15	302
19	1806	316.6	15	301
20	1810	316.3	15	302
21	1814	316.8	15	302
22	1818	317	15	302
23	1822	317	14	303
24	1826	316.8	14	303

APPENDIX C – DETAIL AND CROSS SECTIONS

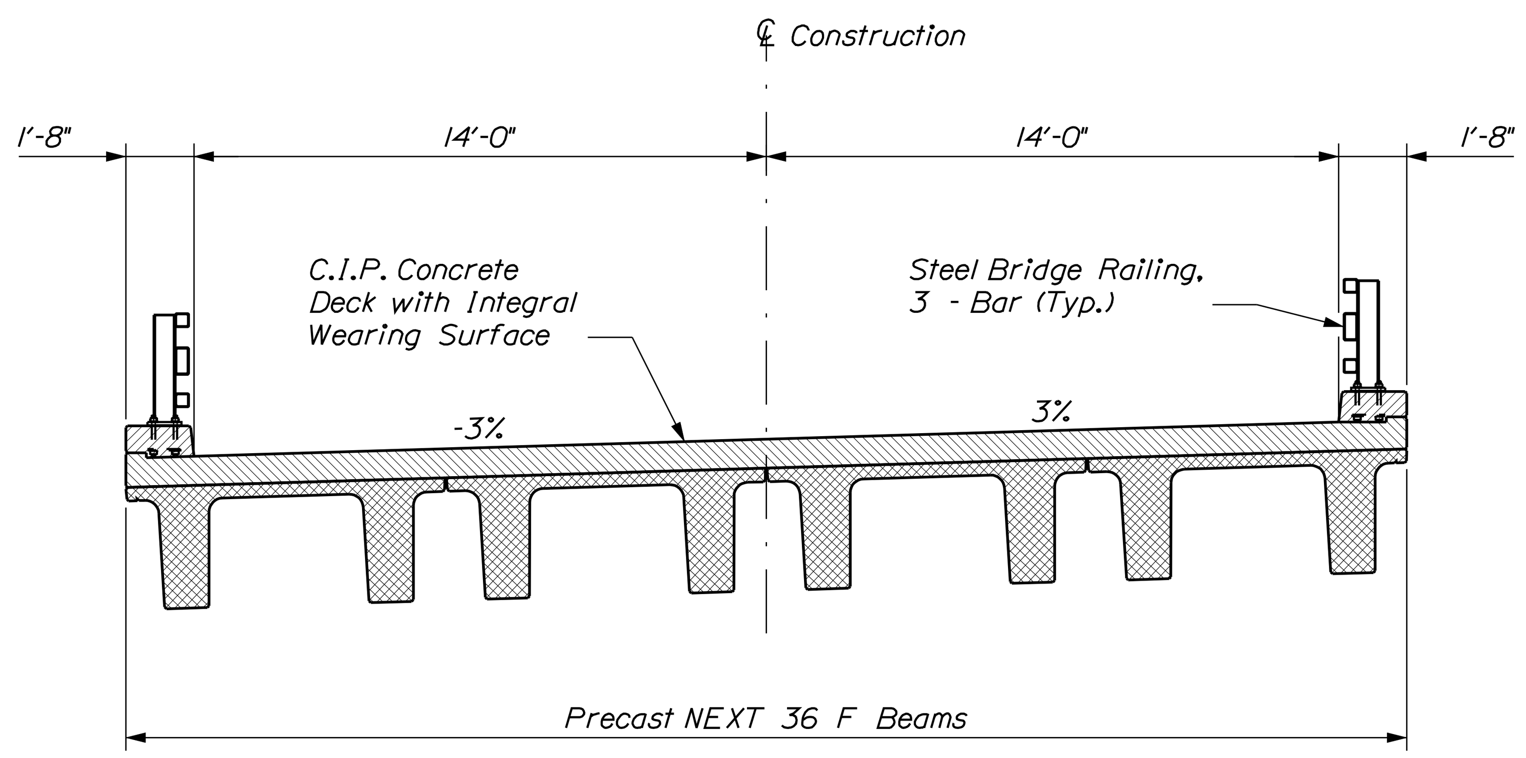
Filename: ...\MSTA\010_Typical Sections.dgn   Division: BRIDGE   Username: dana.damren   Date:3/24/2016



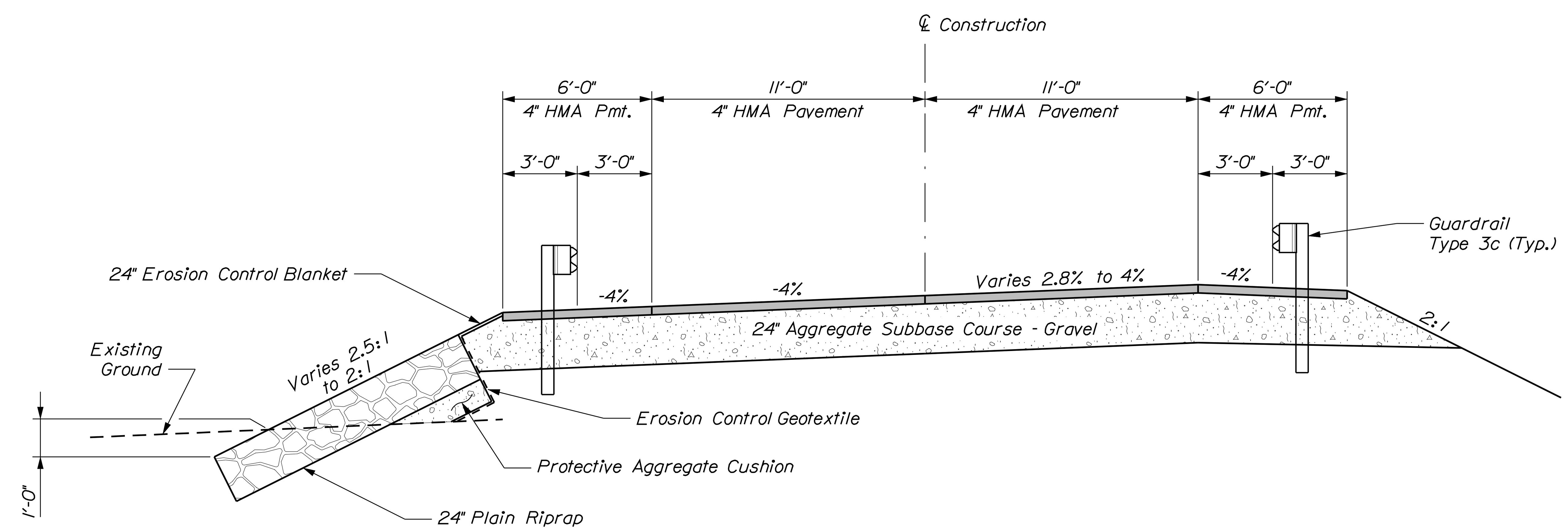
EXISTING TRANSVERSE SECTION



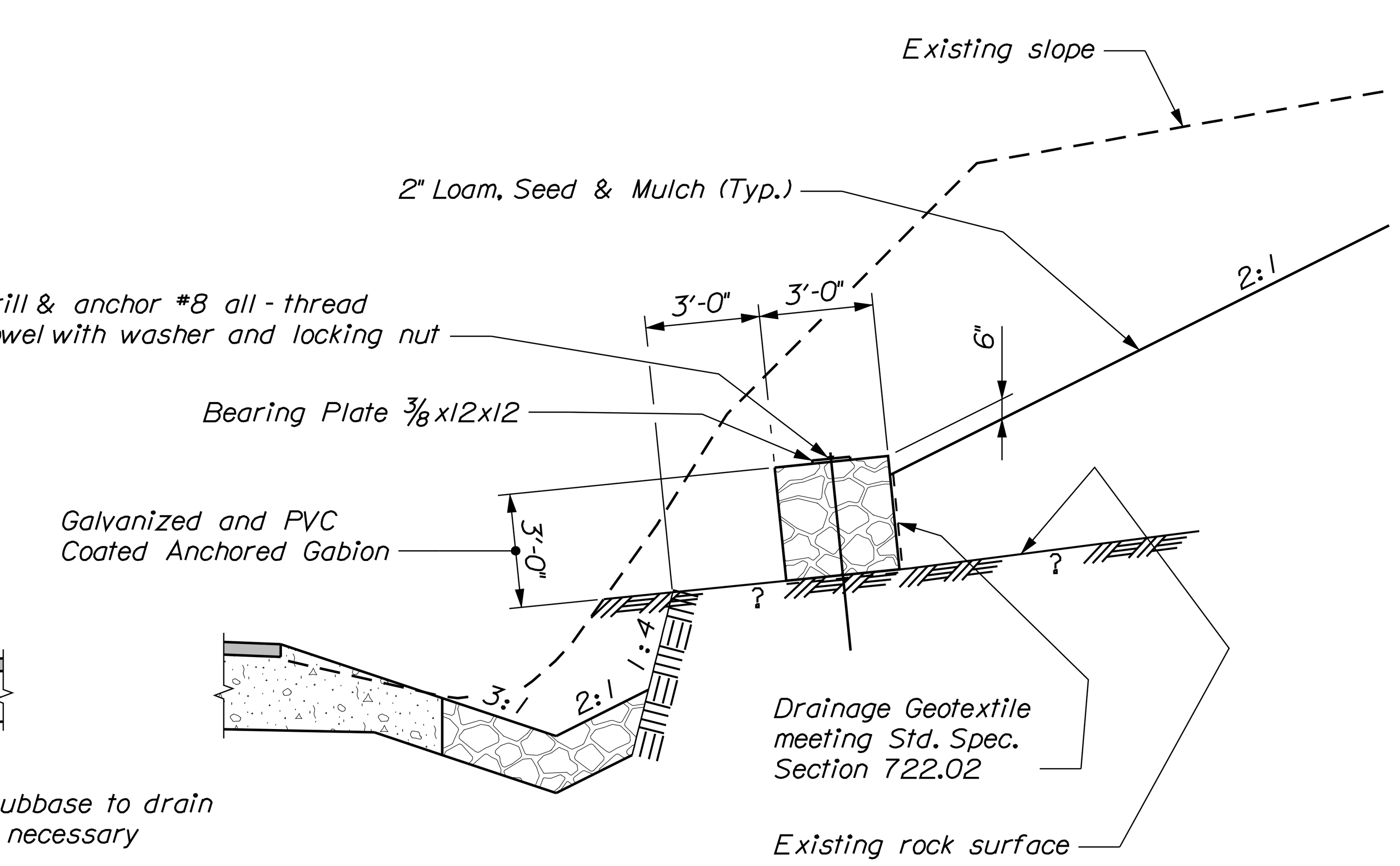
APPROACH DESIGN SECTION
Typical



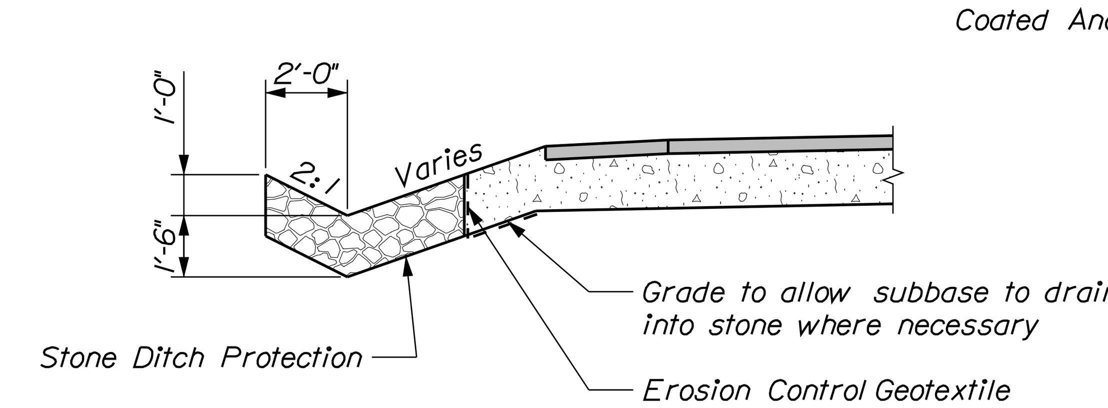
PROPOSED TRANSVERSE SECTION



APPROACH DESIGN SECTION
Sta. 113+00 to 114+00



ROCK CUT SECTION
Sta. 117+00 ± to 118+25 ±



DITCH SECTION
Sta. 116+75 ± to 118+15 ±

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2046(600)

WIN
20466.00

BRIDGE PLANS

BRIDGE NO. 2199

	BY	DATE
PROJ. MANAGER	M. Parlin	
DESIGN-DETAILED	G. Gustafson D. Damren	Mar. 2016
CHECKED-REVIEWED	-----	-----
DESIGN2-DETAILED2	-----	-----
DESIGN3-DETAILED3	-----	-----
REVISIONS 1	-----	-----
REVISIONS 2	-----	-----
REVISIONS 3	-----	-----
REVISIONS 4	-----	-----
FIELD CHANGES	-----	-----

SIGNATURE

P.E. NUMBER

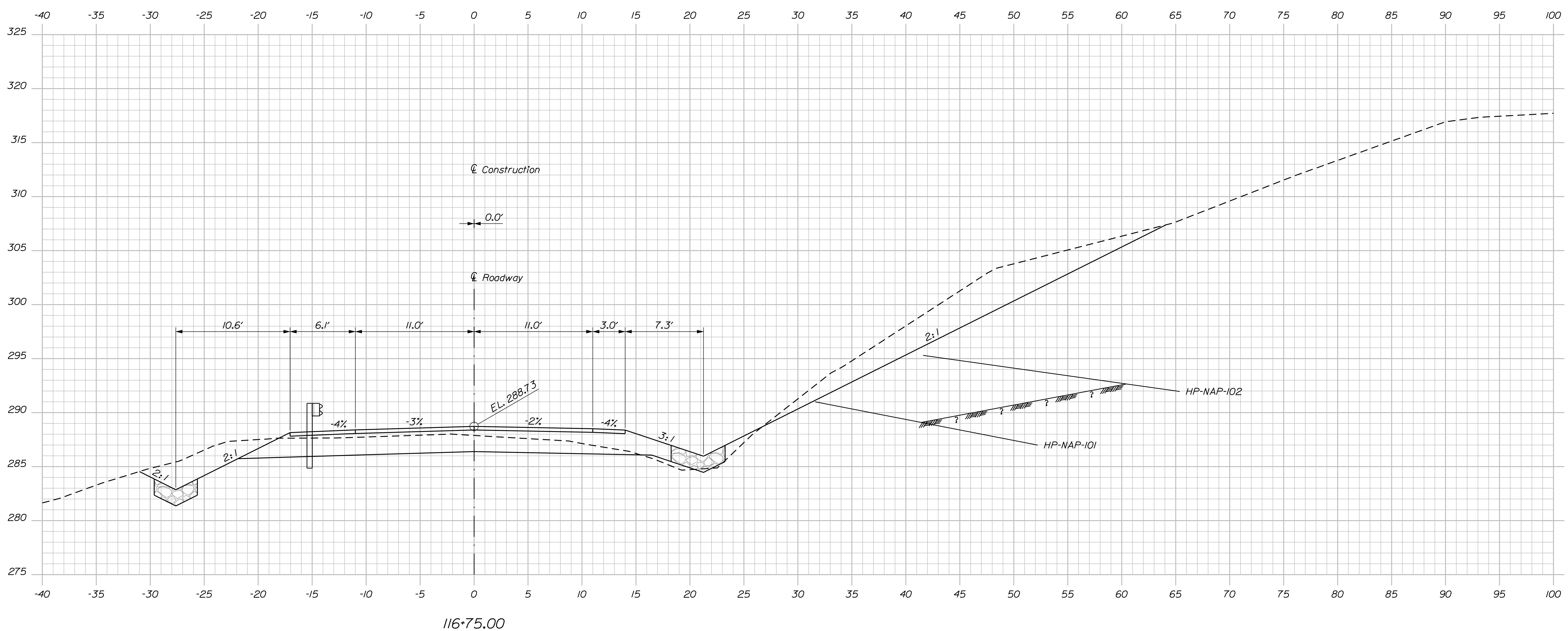
DATE

CROCKETT BRIDGE
MUDDY RIVER
NAPLES CUMBERLAND COUNTY

TYPICAL SECTIONS

SHEET NUMBER
10
OF 44

Filename: ...\MSTA\020_Xsect_116+75_004.dgn Division: BRIDGE Username: dana.damren Date:3/24/2016



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2046(600)

BRIDGE NO. 2199

WIN
20466.00

BRIDGE PLANS

		BY	DATE
PROJ. MANAGER	M. Parlin		
DESIGN-DETAILED	G. Gustafson	D. Damren	Mar. 2016
CHECKED-REVIEWED	-----	-----	-----
DESIGN2-DETAILED2			
DESIGN3-DETAILED3	-----	-----	-----
REVISIONS 1	-----		-----
REVISIONS 2	-----		-----
REVISIONS 3	-----		-----
REVISIONS 4	-----		-----
FIELD CHANGES	-----		-----

SIGNATURE

P.E. NUMBER

DATE

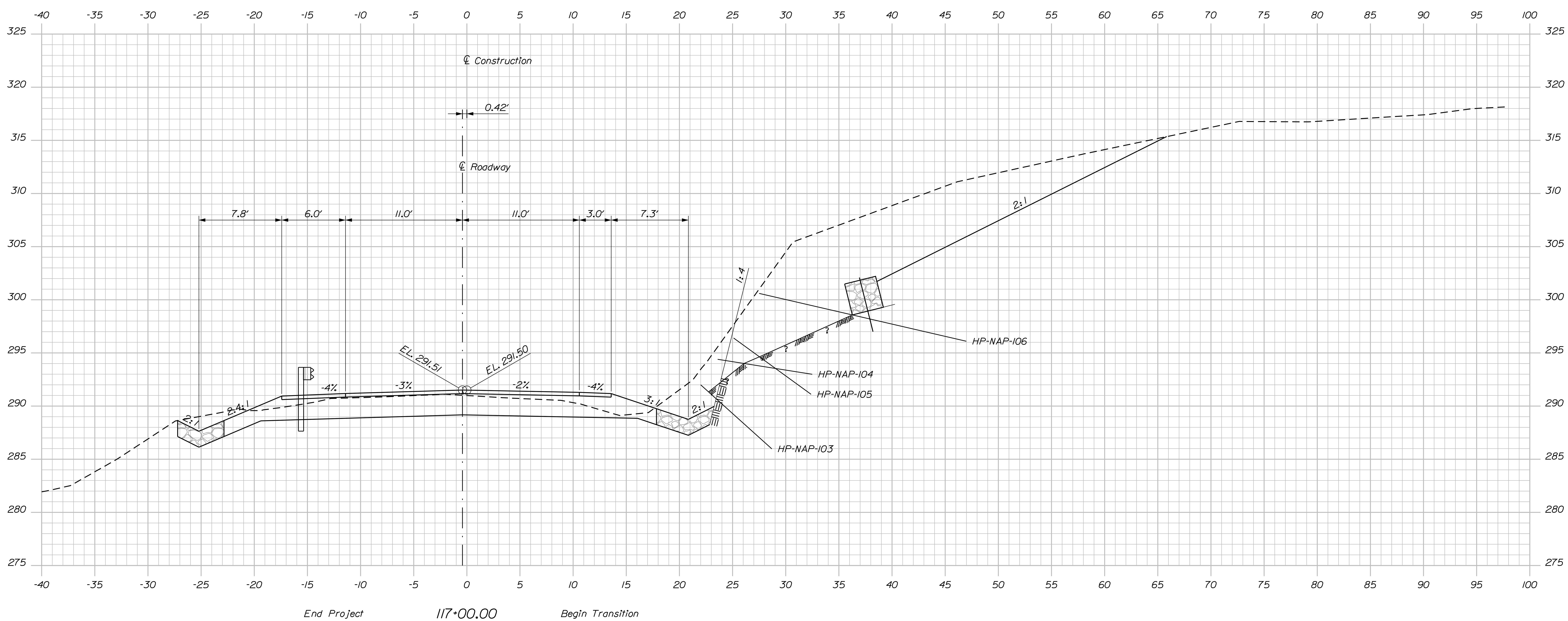
CROCKETT BRIDGE
MUDDY RIVER
NAPLES CUMBERLAND COUNTY

CROSS SECTIONS

SHEET NUMBER
20
OF 44

Sta. 116+75.00 to Sta. 116+75.00

Filename: ...\MSTA\021_Xsect_117+00_005.dgn Division: BRIDGE Username: dana.damren Date:3/24/2016



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2046(600)

WIN 20466.00

BRIDGE NO. 2199

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER	M. Parlin	
DESIGN-DETAILED	G. Gustafson	Mar. 2016
CHECKED-REVIEWED	D. Damren	
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

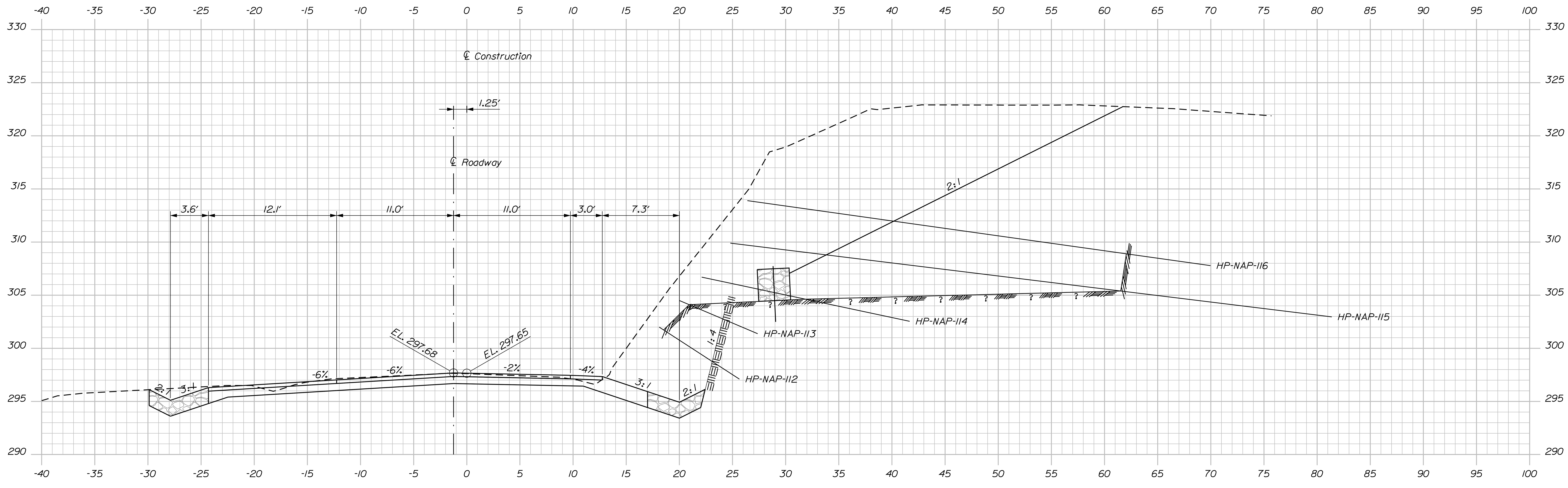
CROCKETT BRIDGE
MUDDY RIVER
NAPLES CUMBERLAND COUNTY

CROSS SECTIONS

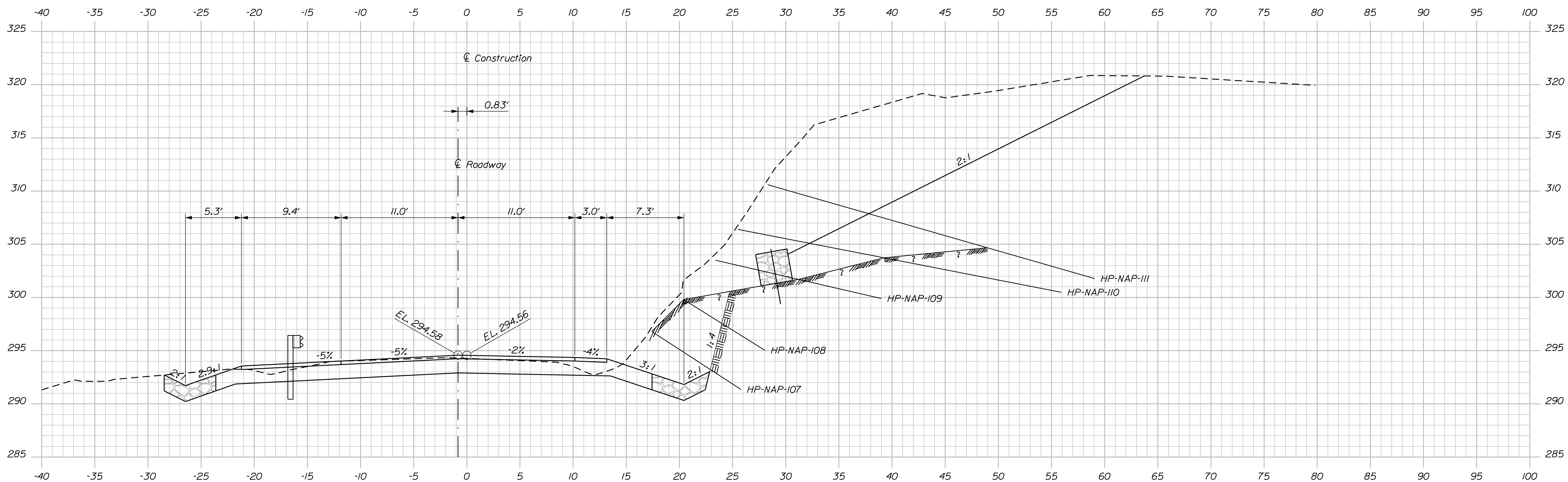
SHEET NUMBER
21
OF 44

Sta. 117+00.00 to Sta. 117+00.00

Filename: ...\MSTA\022_Xsect_117+25_006.dgn Division: BRIDGE Username: dana.damren Date:3/24/2016



117+50.00



Sta. 117+07.1, 14.0' Lt. to Sta. 117+44.4, 19.2' Lt.
Install GR 350 Flared Terminal

117+25.00

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2046(600)

WIN 20466.00

BRIDGE PLANS

BRIDGE NO. 2199

	BY	DATE
PROJ. MANAGER	M. Parlin	
DESIGN-DETAILED	G. Gustafson	Mar. 2016
CHECKED-REVIEWED	D. Damren	
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

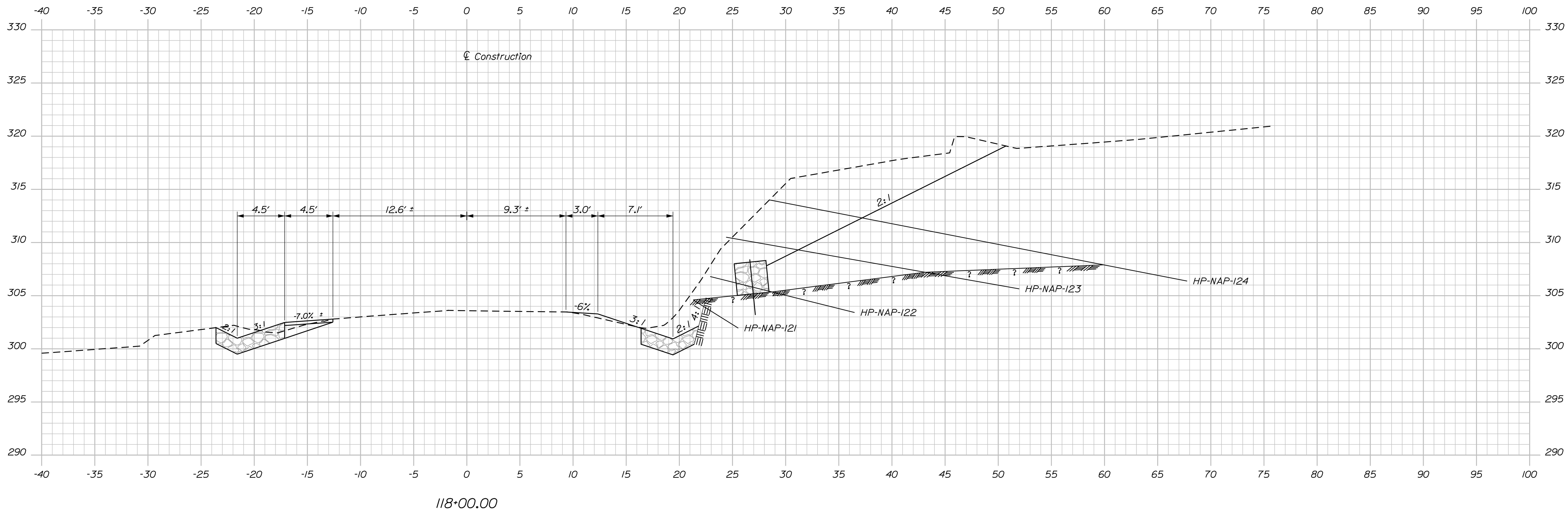
CROCKETT BRIDGE
MUDDY RIVER
NAPLES CUMBERLAND COUNTY

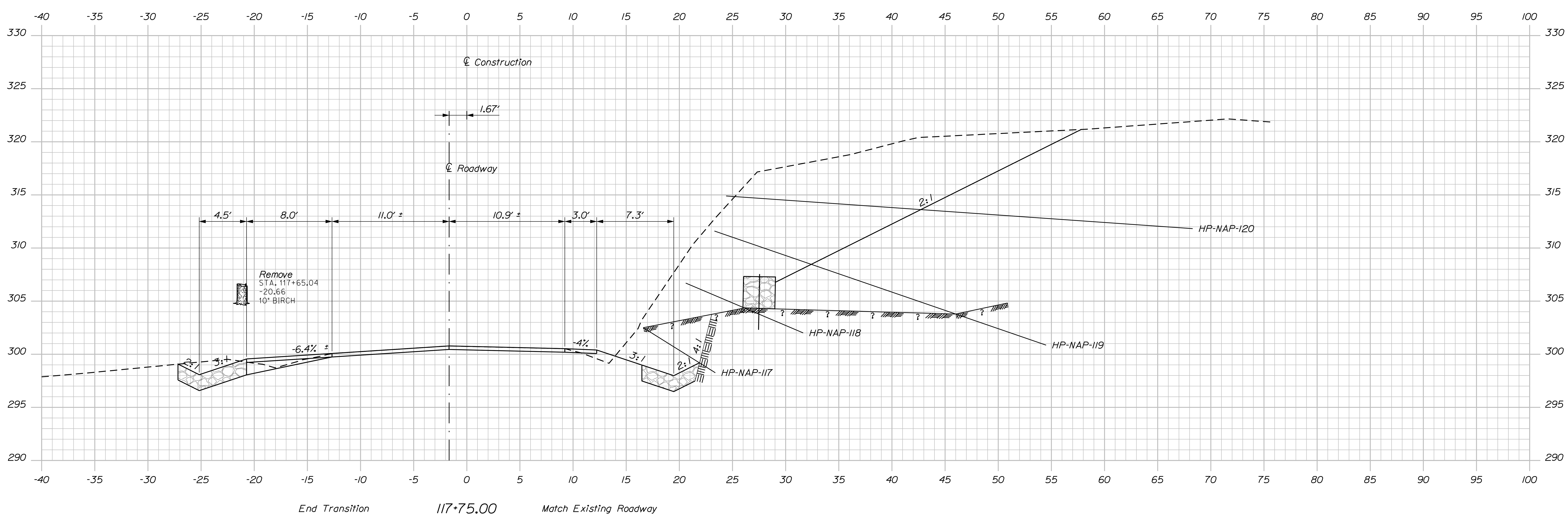
CROSS SECTIONS

SHEET NUMBER
22
OF 44

Sta. 117+25.00 to Sta. 117+50.00

Filename: ...\MSTA\023_Xsect_117+75_007.dgn Division: BRIDGE Username: dana.damren Date:3/24/2016





STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2046(600)

BRIDGE NO. 2199

WIN 20466.00

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER	M. Porlin	
DESIGN-DETAILED	G. Gustafson	D. Damren	Mar. 2016
CHECKED-REVIEWED		
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

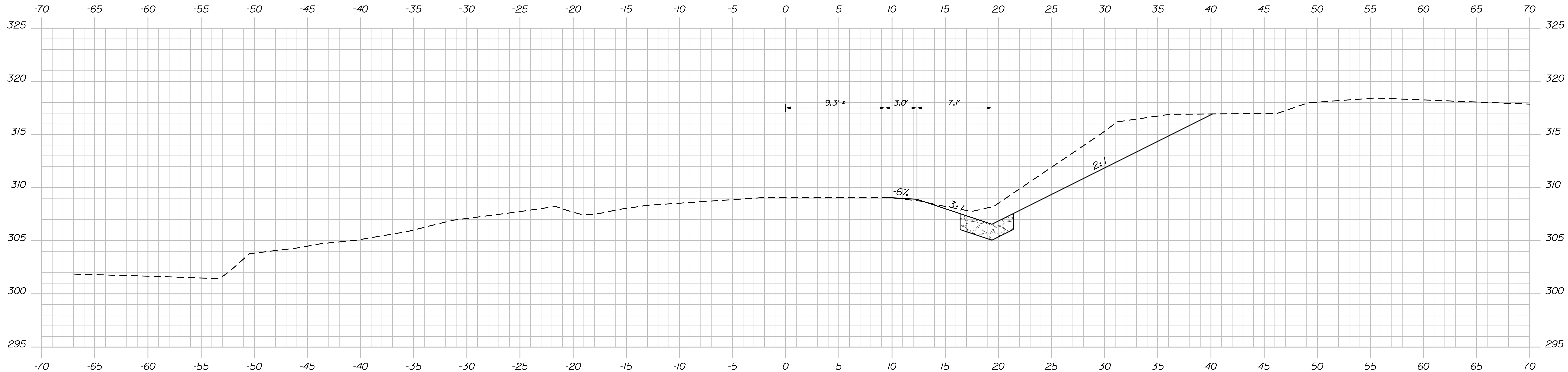
CROCKETT BRIDGE
MUDDY RIVER
NAPLES CUMBERLAND COUNTY

CROSS SECTIONS

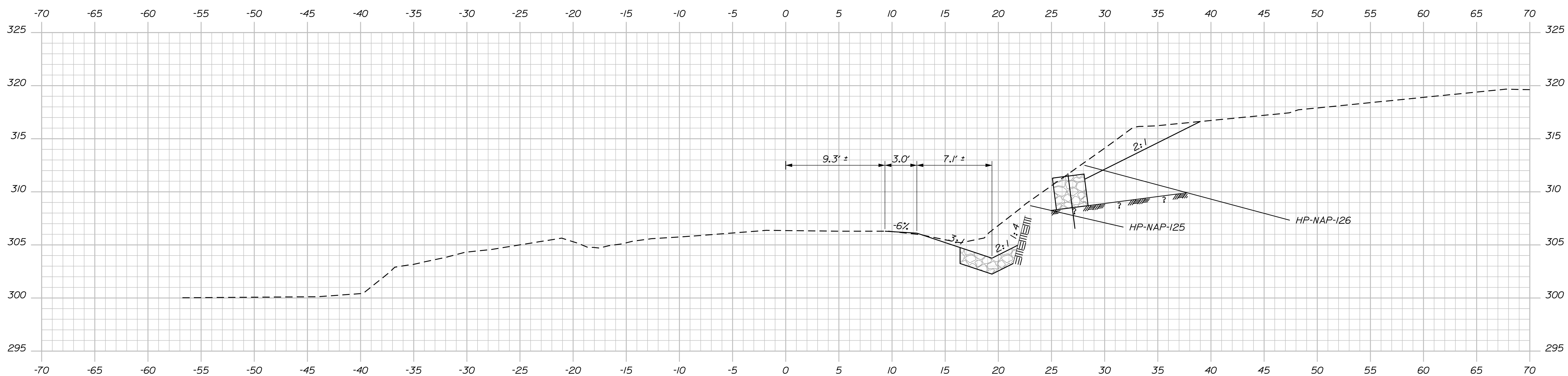
SHEET NUMBER
23
OF 44

Sta. 117+75.00 to Sta. 118+00.00

Filename: ...\MSTA\024_Xsect_118+25_002.dgn Division: BRIDGE Username: dana.damren Date:3/24/2016



118+50.00



118+25.00

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2046(600)

WIN 20466.00

BRIDGE NO. 2199

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER	M. Porlin	
DESIGN-DETAILED	G. Gustafson	D. Damren	Mar. 2016
CHECKED-REVIEWED	-----	-----
DESIGN2-DETAILED2	-----	-----
DESIGN3-DETAILED3	-----	-----
REVISIONS 1	-----	-----
REVISIONS 2	-----	-----
REVISIONS 3	-----	-----
REVISIONS 4	-----	-----
FIELD CHANGES	-----	-----

SIGNATURE

P.E. NUMBER

DATE

CROCKETT BRIDGE
MUDDY RIVER
NAPLES CUMBERLAND COUNTY

CROSS SECTIONS

SHEET NUMBER

24

OF 44

Sta. 118+25.00 to Sta. 118+50.00