PAVEMENT REPORT NUMBER FY07-14
FHWA Project PRA-CACO 12(1), 14(2), 17(1), 18(1)

Cape Cod National Seashore

Barnstable County, Massachusetts

Reconfiguration of Intersection at US Route 6 (NPS Route 18), Moors Road (NPS Route 18) and Province Lands Road (NPS Route 17)
Pavement Preservation of Marconi Beach Road (NPS Route 12) and Race Point Road (NPS Route 14)
Reconfiguration of Herring Cove Beach Fee Station and Parking Area Entrance Road

July 2007

U.S. Department of Transportation
Federal Highway Administration
Eastern Federal Lands Highway Division
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Note: Design changes, made subsequent to distribution of this report and prior to project advertisement, will be documented by a memo inserted after the title page

PAVEMENT REPORT NUMBER FY07-14
FHWA Project PRA- CACO 12(1), 14(2), 17(1), 18(1)
Cape Cod National Seashore
Barnstable County, Massachusetts

Intersection Reconfiguration of:
Province Lands Road (Route 15), Milepost 2.12 to 2.29
Moors Road (Route 17), Milepost 0.00 to 0.30
U.S. Route 6 (Route 18), Milepost 0.00 to 0.35
Pavement Preservation of:
Marconi Beach Road (Route 12)
Race Point Road (Route 14)
Traffic Improvements to:
Herring Cove Fee Station and Parking Area Entrance Road (Route 929)

INTRODUCTION

General

This report presents the results of the pavement and subsurface investigations, analysis, design, and recommendations for Cape Cod National Seashore in Barnstable County, Massachusetts. A Project Location Map is presented in Figure 1 of Appendix A.

Project Description

This report presents the results of the pavement investigation for Project PRA-CACO 12(1), 14(2), 17(1), 18(1). The project consists of reconstructing the intersection of Moors Road (NPS Route 17) /State Route 6 (NPS Route 18) with Province Lands Road (NPS Route 15), within the Cape Cod National Seashore Park, in Barnstable County, Massachusetts. Moors Road/State Route (SR) 6 is a four-lane, asphalt paved, divided roadway at the area of the intersection. Moors Road/ SR 6 is the principal road going to and through the National Seashore. Province Lands Road is a two-lane, asphalt paved, connector road providing access between Moors Road/SR 6 and Race Point Road. Refer to Figure 1 in Appendix A for a Project Location Map.

Also included in the project is the reconfiguration of the Herring Cove Entrance Station, stripping and other work. Pavement preservation is planned for Race Point Road, (Route 14), an asphalt paved, two-way roadway that was last rehabilitated in 1995. Marconi Beach Road, (Route 12) a two-way asphalt paved road that is planned to be treated with a light rehabilitation.

Project Purpose-and-Need

According to Highway Design and Cape Code National Seashore, the Purpose-and-Need for this project is to provide a structurally and functionally adequate pavement with a long- term service life for all Roads within the limits of intersection reconfiguration, perform preventive maintenance on Race Point Road, and perform light rehabilitation to extend the life of the pavement on Marconi Beach Road.

Regional Geology

Based on the "Bedrock Geologic Map of Massachusetts, 1983" the site lies within the Milford-Dedham Zone and more specifically in the area of the Brittlely Deformed and Gneissic Terranes. The bedrock of these terranes consists of Upper Proterozoic age quartzite, volcanic and plutonic rocks intruded by granite and metamorphosed to gneiss in the west and southwest. The bedrock underlying Cape Cod is overlain by 200 to 600 feet of glacial deposits. The "Geologic Map of Cape Cod and the Islands, Massachusetts, 1986", shows that the post-glacial deposits in the area of the subject site are Dune Deposits, Marsh and Swamp Deposits, and some areas of Artificial Fill. Dune Deposits are areas composed primarily of sand. Marsh and Swamp Deposits include decaying salt marsh plants mixed with silt, sand, and clay, with some fresh water marsh and swamp deposits. Artificial Fill contains sand and gravel. According to the "Soil Survey of Barnstable County, Massachusetts", the surficial soils at the site consist of deep, well-drained, sandy soils formed in glacial outwash and/or wind-blown deposits. There are also areas of deep, poorly drained peat formed in marine organic and sandy deposits. A Geologic Map and Soils Map of the project vicinity are presented as Figures 2 and 3, respectively, in Appendix A.

PROCEDURES AND RESULTS

Field Investigation

Eastern Federal Lands Highway Division's (EFLHD) Geotechnical personnel conducted a field investigation in September 2002. The field investigation consisted of a visual pavement condition survey and a total of 6 soil borings. The pavement condition survey was conducted in general accordance with the "Distress Identification Manual for the Long-Term Pavement Performance Project (SHRP-P-338)." The purpose of the pavement condition survey was to make a preliminary determination of the types and limits of the different repair/rehabilitation techniques that would be required based on the type, severity, and extent of pavement distress. The roadway borings were drilled to obtain additional information about the existing pavement and subgrade conditions. Asphalt cores were taken at each of the boring locations. Refer to Appendix F for Boring Logs and Location Map.

The EFLHD pavement personnel conducted another field investigation on May 21st and 22nd, 2007 consisting of drilling 12 test pit borings. The location of each boring is presented on the Boring Location Plans in Appendix B. Pavement cores were taken at each location to determine the asphalt thickness and composition. Where possible, borings were advanced

using 4-inch augers mounted on a trailer mounted drill to a maximum depth of 1.5 feet. Boring Logs are presented in Appendix B.

Sampling

September 2002 Field Investigation:
Sampling of materials beneath the tip of the solid-stem augers was performed as the borings were advanced. Representative samples were recovered with a 2-inch outside diameter split-barrel sampler in accordance with AASHTO T206. The sampling sequence for each boring is summarized on the boring logs in Appendix F. Standard Penetration Tests (SPT's) were performed as part of the sampling procedure, in accordance with AASHTO T206. The sampler was driven into the soil using an automatic hammer. Sample recovery measurements were made and recorded for each sampling attempt. A field description by color and texture was made for each recovered sample. The depth of groundwater, if present, was measured at the time of completion of each boring.

May 2007 Field Investigation:
Sampling of asphalt was performed at Test Pits B-8 through B-10, where the scoping report indicated that this section of roadway will be obliterated. Asphalt cores were recovered and transported back to EFLHD for laboratory testing as needed.

Field Tests and Measurements

Non-destructive pavement testing using a Falling Weight Deflectometer (FWD) was performed at Borings B-1 through B-7 and B-10 through B-12 on May 22, 2007. Deflection responses were recorded with 9 different sensors spaced 0, 8, 12, 18, 24, 36, 48,60, and 72 inches from the 12-inch diameter load plate in response to 3-9 kip loading sequences at each test location. At each test location, asphalt concrete (AC) pavement temperature was measured by inserting a temperature probe down to near mid-depth in a 1/2 –inch diameter hole drilled into the AC pavement and filled with mineral oil. The recorded deflection responses and pavement temperatures are presented in Appendix C.

Data Summary

Measured FWD data was collected through Dynatest data acquisition computer files and the collected raw data were transferred to the ModTag Analyser computer program (Version 3.1.68) for back-calculation. The measured data only represent deflection response at selected locations, thus deflection discrepancies are expected between test locations due to changes in layer thickness, material properties, moisture and temperature conditions, subgrade support, and contact pressure under the load plate. Also, the measured data represents pavement response only during our field investigation time periods mentioned above; therefore, deflection variations are expected due to seasonal and climatic variations.

The results and measurements of the pavement coring and hand augers were recorded on hand auger boring logs and appropriate data sheets in the field. These logs and data sheets contain information concerning the field investigation methods, samples attempted and

recovered, indications of the presence of various materials such as gravel, pebbles, organic matter, etc., and observations of groundwater. They also contain interpretations by the pavement personnel based on the performance of the equipment and cuttings brought to the surface by the field tools at that particular time. Therefore, the field data represents both factual and interpretive information. The boring logs in Appendix B of this report represent a compilation of field and descriptions of the soil samples by a pavement engineer. These records occasionally do not include all data recorded on the boring logs and field data sheets, but do include all information considered relevant to design and construction of this project.

Findings

September 2002 Investigation:
The borings revealed that the pavement consists of asphalt concrete (AC) overlying a crushed stone aggregate base material and subgrade soils consisting of dune sand. The AC thickness ranges from approximately 4 to 7 inches, with an average thickness of approximately 5-1/2 inches. Large size aggregate in a matrix of asphalt cement was observed at the bottom of cores for borings B-3, B-4 and B-5. This layer is believed to be a hot asphalt treated base course. Some of the lower asphalt treated material broke up during coring and was left in the hole at the bottom of the cores for borings B-3, B-4 and B-5, and it is believed to be asphalt treated aggregate base material. The subgrade soils generally consist of dry, brown, medium dense, medium textured sand. The SPT blow counts of the subgrade soils ranged from 8 to 29, with an average of 18.8. The findings of the September 2002 Investigation are summarized in the Boring Logs located in Appendix F.

May 2007 Investigation:
Pavement cores were taken on Us Route 6, Moors Road, Province Lands Road, and the Herring Cove entrance station. The pavement cores taken during the investigation showed that the pavement thickness varies from approximately 5.5 inches on Moors Road to 8-11 inches on US Route 6, and 6 inches on Province Lands Road. The pavement core at Boring B-2 on US Route 6 showed a crack extending through the entire asphalt pavement layer. The remaining findings, and pavement core photos are summarized in the Boring Logs located in Appendix B.

Water was not encountered in borings at the time of drilling. Water levels were measured in the borings at the times and under the conditions stated on the borings logs. Fluctuations in the water level due to seasonal and climatic effects should be expected.

Pavement Condition

US Route 6, Moors Road and Province Lands Road- Based on the pavement condition survey, the main distress on the roadways in the vicinity of the intersection reconfiguration were transverse and longitudinal cracking. The asphalt surface has also become oxidized due to age. Pavement cores showed that these transverse cracks extend through the full depth of asphalt pavement. Due to the proposed project limits, two borings were drilled outside the park boundary on the state maintained portion of Route 6. On this portion in both the eastbound and westbound lanes the pavement depth was measured to be 10 to 11 inches of

asphalt. In the remaining locations, asphalt depths ranged from 8 to 10 inches on US Route 6, 5 to 6 inches on Moors Road, and 6 inches on Province Lands road. Aggregate Base layers encountered on Moors Road measure 6 to 7 inches in depth and on Province Lands Road and the Herring Cove Fee station area the thickness of aggregate base was 6 inches.

Marconi Beach Road- Marconi Beach Road is a two-lane, two-way roadway that starts at US Route 6 and ends 1.62 miles later at the Marconi Beach Parking Area. The average pavement width is approximately 22 feet. According to the recommendations from a Pavement Management System analysis of the Northeast Region, this roadway was selected and prescribed a thin structural overlay. A Pavement condition survey was conducted on this roadway to determine the feasibility of this treatment. The main distress observed during the condition survey was transverse cracking. On average, a full width transverse crack was encountered at intervals of 89 feet, based on approximately 67 full width cracks observed and 61 partial width cracks observed. Most cracks measured from 1/2" to 3/4" with occasional cracks measuring up to 1" in width. Due to their severity, it is presumed that these cracks extend to the bottom of the asphalt. A few areas are experiencing longitudinal cracking in the wheelpaths with light to moderate rutting. A detailed Pavement condition survey by station is presented in Table 1.

Table 1 – Pavement Condition Survey of Marconi Beach Road, NPS Route 12

Station or Range	Severity and Type of Pavement Distress
0+00	PK Nail in Intersection
0+20	Begin Marconi Beach Road at Route 6
0+50 to 5+00	M Longitudinal Centerline Joint Crack
1+00	M Transverse Crack, LT Lane
1+43	Crosswalk
1+71	M Transverse Crack, RT Lane
2+09	M Transverse Crack, LT Lane
2+54	M Transverse Crack, LT Lane
3+51	M Transverse Crack, LT Lane
3+70	M Transverse Crack, RT Lane
3+92	M Transverse Crack, RT Lane
4+10	M Transverse Crack, RT Lane
4+38	M Transverse Crack, LT Lane
4+60	M Transverse Crack, Full Width
4+75	M Transverse Crack, Full Width
5+16	M Transverse Crack, RT Lane
5+16 to 5+90	M Longitudinal Crack, RT Lane, LWP and RWP
5+70	M Transverse Crack, LT Lane
5+90	M Transverse Crack, RT Lane
6+58	M Transverse Crack, LT Lane
7+06	M Transverse Crack, Full Width
7+23	Pavement Change

Station or Range	Severity and Type of Pavement Distress
8+07	M Transverse Crack, LT Lane
8+73	L Transverse Crack, LT Lane
9+03	H Transverse Crack, Full Width
9+49	M Transverse Crack, Full Width
10+08	M Transverse Crack, Full Width
10+60	M Transverse Crack, LT Lane
11+00 to 11+75	Cracking and Settlement in RT Lane, RWP
11+26	M Transverse Crack, Full Width
11+54	M Transverse Crack, Full Width with settlement
12+30	M Transverse Crack, Full Width
12+60	M Transverse Crack, Full Width
14+86	M Transverse Crack, Full Width
15+05 to 15+15	M Longitudinal Crack, RT Lane, RWP
15+31	M Transverse Crack, Full Width
15+53	M Transverse Crack, Full Width
16+00	M Transverse Crack, RT Lane
17+12	M Transverse Crack, Full Width
17+39	M Transverse Crack, LT Lane
17+70	M Transverse Crack, Full Width
17+80	M Transverse Crack, RT Lane
18+12	M Transverse Crack, RT Lane, Traffic Detector Loop
18+25	M Transverse Crack, Full Width
19+10	M Transverse Crack, Full Width
19+31	M Transverse Crack, LT Lane
19+56	M Transverse Crack, Full Width
20+04	M Transverse Crack, LT Lane
20+23	M Transverse Crack, Full Width
20+51	M Transverse Crack, Full Width
20+73	M Transverse Crack, Full Width
21+43 to 21+57	L Longitudinal Crack in RT Lane, LWP
21+45	M Transverse Crack, Full Width
21+98	M Transverse Crack, LT Lane
22+50 to 22+80	M Longitudinal Centerline Joint Crack
22+58	M Transverse Crack, Full Width
22+82	M Transverse Crack, Full Width
23+05	M Transverse Crack, Full Width
23+11	M Transverse Crack, LT Lane
23+40 to 23+55	M Longitudinal Crack w/ Settlement in RT Lane, RWP
23+54	H Transverse Crack, Full Width
24+27	H Transverse Crack, Full Width

Station or Range	Severity and Type of Pavement Distress
24+74	M Transverse Crack, Full Width
25+14	M Transverse Crack, Full Width
25+33	M Transverse Crack, RT Lane
25+57	M Transverse Crack, LT Lane
25+88	M Transverse Crack, Full Width
26+01	M Transverse Crack, Full Width
26+30	M Transverse Crack, Full Width
26+74	M Transverse Crack, Full Width
26+92	M Transverse Crack, RT Lane
28+20	M Transverse Crack, Full Width
28+36	M Transverse Crack, LT Lane
28+51	M Transverse Crack, Full Width
28+93	M Transverse Crack, LT Lane
29+19	M Transverse Crack, Full Width
29+40	L Transverse Crack, Full Width
29+50 to 30+50	RT Edge Dropoff at Intersection
30+35	M Transverse Crack, Full Width
30+54	M Transverse Crack, LT Lane
31+27	M Transverse Crack, Full Width
31+35	M Transverse Crack, Full Width
31+78	M Transverse Crack, Full Width
32+39	M Transverse Crack, Full Width
33+46	Begin Fog Seal in LT Lane
33+50 to 35+00	L Block Cracking in LT Lane
33+57	M Transverse Crack, Full Width
34+25 to 35+00	M Longitudinal Centerline Joint Crack
34+92	M Transverse Crack, LT Lane
35+82	M Transverse Crack, Full Width
36+68	Left Edge Potholing, Patching, Cracking and Settlement
36+68	H Transverse Crack, Full Width
36+98	M Transverse Crack, Full Width
37+31	M Transverse Crack, LT Lane
37+52	M Transverse Crack, Full Width
37+80	Left Edge Pothole Patch
38+26	M Transverse Crack, Full Width
38+62	M Transverse Crack, LT Lane
38+94	M Transverse Crack, LT Lane
39+32	M Transverse Crack, Full Width
39+76	M Transverse Crack, Full Width
40+08	M Transverse Crack, Full Width

Station or Range	Severity and Type of Pavement Distress
40+35 to 40+70	M Rutting and L Alligator Cracking in LT Lane, RWP
40+50	M Transverse Crack, Full Width
41+05	M Transverse Crack, Full Width
41+12	M Transverse Crack, Full Width
41+60	M Transverse Crack, RT Lane
41+74	M Transverse Crack, Full Width
42+50 to 42+75	M Longitudinal Centerline Joint Crack
42+60	M Transverse Crack, LT Lane
42+70	M Transverse Crack, Full Width
43+12	M Transverse Crack, Full Width
43+30 to 43+70	M Longitudinal Centerline Joint Crack
43+54	M Transverse Crack, LT Lane
43+60	M Transverse Crack, RT Lane
44+15	M Transverse Crack, Full Width
44+90	M Transverse Crack, Full Width
45+15	M Transverse Crack, Full Width
45+24	M Transverse Crack, RT Lane
45+35 to 46+00	M Longitudinal Centerline Joint Crack
45+36	M Transverse Crack, RT Lane
45+63	M Transverse Crack, Full Width
46+05	M Transverse Crack, Full Width
46+36	M Transverse Crack, Full Width
46+45	M Transverse Crack, Full Width
47+15	M Transverse Crack, Full Width
47+49	M Transverse Crack, Full Width
47+73	M Transverse Crack, RT Lane
47+85	M Transverse Crack, Full Width
48+35	M Transverse Crack, Full Width
48+71	RT Lane Pothole Patch
48+80	M Transverse Crack, Full Width
49+00 to 50+50	M Longitudinal Centerline Joint Crack
49+10	M Transverse Crack, LT Lane
49+88	M Transverse Crack, Full Width
50+05	M Transverse Crack, Full Width
50+75	M Transverse Crack, Full Width
50+90	M Transverse Crack, Full Width
51+15	M Transverse Crack, LT Lane
51+33	M Transverse Crack, Full Width
51+45	M Transverse Crack, Full Width
51+50 to 54+40	Median Island and Fee Station with Granite Curb

Station or Range	Severity and Type of Pavement Distress
51+75	H Transverse Crack, LT Lane
52+06	H Transverse Crack, Full Width
52+08	H Transverse Crack, LT Lane
52+25	H Transverse Crack, LT Lane
52+50	H Transverse Crack, Full Width
52+60	H Transverse Crack, LT Lane
52+92	H Transverse Crack, Full Width
53+09	H Transverse Crack, LT Lane
53+18	H Transverse Crack, LT Lane
53+40	H Transverse Crack, LT Lane
53+60	H Transverse Crack, Full Width
53+75	H Transverse Crack, LT Lane
53+90	H Transverse Crack, LT Lane
54+10	H Transverse Crack, RT Lane
55+01	M Transverse Crack, Full Width
55+24	M Transverse Crack, Full Width
55+88	M Transverse Crack, Full Width
56+15	M Transverse Crack, Full Width
56+79	M Transverse Crack, Full Width
57+05	M Transverse Crack, Full Width
57+26	M Transverse Crack, Full Width
57+60	M Transverse Crack, Full Width
57+99	M Transverse Crack, Full Width
58+30	M Transverse Crack, Full Width
58+63	M Transverse Crack, LT Lane
58+85	M Transverse Crack, Full Width
59+15	M Transverse Crack, Full Width
59+30	M Transverse Crack, Full Width
59+72	M Transverse Crack, Full Width
59+94	M Transverse Crack, Full Width
60+03	M Transverse Crack, RT Lane
61+03	M Transverse Crack, Full Width
61+33	M Transverse Crack, Full Width
61+42	M Transverse Crack, RT Lane
61+81	M Transverse Crack, Full Width
62+66	M Transverse Crack, Full Width
63+05 to 63+45	L Longitudinal Crack in RT Lane, RWP
63+45	M Transverse Crack, Full Width
63+45 to 63+95	M Longitudinal Centerline Joint Crack
64+15 to 64+60	M Longitudinal Centerline Joint Crack

Station or Range	Severity and Type of Pavement Distress
64+30	M Transverse Crack, LT Lane
64+60	M Transverse Crack, Full Width
64+90	M Transverse Crack, Full Width
65+40 to 66+30	M Rutting and L Longitudinal Cracking in RT Lane, RWP
65+60	M Transverse Crack, Full Width
66+27	M Transverse Crack, Full Width
67+30	M Transverse Crack, Full Width
68+60	M Transverse Crack, RT Lane
69+00 to 73+00	M Rutting in RT Lane, RWP
69+65	H Transverse Crack, Full Width
70+85	M Transverse Crack, Full Width
70+85	3' x 24' M Alligator Cracking in RT Lane, RWP
71+25	M Transverse Crack, Full Width
72+00 to 72+10	M Alligator Cracking with Patch in RT Lane, LWP
72+85	M Transverse Crack, Full Width
72+85	3' x 45' M Alligator Cracking in RT Lane, RWP
73+67	M Transverse Crack, Full Width
73+88	M Transverse Crack, Full Width
74+00 to 75+00	L Block Cracking, Full Width
75+12	M Transverse Crack, Full Width
75+40	M Transverse Crack, Full Width
75+58	M Transverse Crack, Full Width
75+90	M Transverse Crack, Full Width
76+30	M Transverse Crack, Full Width
76+48	M Transverse Crack, Full Width
77+00 to 79+00	M Rutting in RT Lane, RWP
77+21	H Transverse Crack, Full Width
77+92	H Transverse Crack, Full Width
79+00 to 81+00	M Rutting in LT Lane, LWP
79+45	M Transverse Crack, Full Width
80+24	M Transverse Crack, LT Lane
80+45	M Transverse Crack, Full Width
81+05	M Transverse Crack, Full Width
81+80	M Transverse Crack, Full Width
82+00 to 82+50	M Longitudinal Centerline Joint Crack
82+00	H Transverse Crack, Full Width
82+75	H Transverse Crack, Full Width
82+75 to 83+00	M Rutting and L Alligator Cracking in RT Lane, RWP
82+90 to 83+75	M Longitudinal Centerline Joint Crack
83+06	H Transverse Crack, Full Width

Station or Range	Severity and Type of Pavement Distress
83+54	H Transverse Crack, Full Width
84+09	M Transverse Crack, LT Lane
84+78	H Transverse Crack, Full Width
85+30	M Transverse Crack, Full Width
85+66	M Transverse Crack, Full Width
86+25	End Marconi Beach Road at Parking Area

Race Point Road- Race Point Road is a 1.96 mile long two-lane two-way road measuring approximately 22 feet in width. The last major rehab on Race Point Road occurred in 1995, Project CACO 14(1). The pavement is currently in good condition overall. Along the roadway there is occasional low severity transverse and longitudinal cracking. The pavement management system analysis selected this roadway to have a Surface Treatment applied. The ride of the pavement is relatively smooth and there was little to no rutting observed.

ANALYSIS AND CONCLUSIONS

Pavement Design

Flexible pavement overlay design analyses and pavement design analyses were conducted for US Route 6, Moors Road, Province Lands Road, Herring Cove Entrance Station and Marconi Beach Road using the DARWin Pavement Design System computer program (Version 3.01) and in accordance with the AASHTO Guide for Design of Pavement Structures, 1993. Based on the Purpose-and-Need established by the NPS, a 20-year performance period for design was performed.

The design analysis to determine the 18-kip Equivalent Single Axle Load (ESAL) for the site was performed using the Rigorous ESAL Calculation in DARWin and was based on traffic count and vehicle classification data provided in the Cape Cod National Seashore Engineering Study of 1997. Average Daily Traffic (ADT) values were obtained from the report and using an annual growth rate of 2 percent, projected to 2007. The values obtained from the study and values used in the pavement design are presented in Table 2. Other parameters specified in the analysis included a reliability of 75 percent, an overall standard deviation of 0.49, an initial serviceability index of 4.2, and a terminal serviceability index of 2.0. The average truck factors corresponding to these vehicle classifications were obtained from the Federal Lands Highway Project Development and Design Manual, September 2003 Minute Memo insert. The results of all design analyses are presented in Appendix F.

Table 2 – Average Daily traffic for Project Routes

NPS Route	1997 ADT	2007 ADT
Route 12 – Marconi Beach Road	435	530
Route 14 – Race Point Road	8,600	10,483
Route 15 – Province Lands Road	965	1,176
Route 17 – Moors Road	2,150	2,620
Route 18 – US Route 6	1,211	1,476

The proposed rehabilitation is designed primarily to improve surface condition and to support the future traffic in the areas exhibiting pavement oxidation, and moderate to high severity transverse and longitudinal cracking. A rehabilitation design was performed using mean back-calculation values of US Route 6, Province Lands Road, Moors road and herring Cove entrance Station. The back-calculated mean effective pavement modulus (Ep) of these routes was 111,589 psi. The Ep value was based on back-calculated mean design roadbed soil resilient modulus (M_R) value of 10,000 psi and on acceptable design FWD load range from 8,100 to 9,900 lbf. A modulus correction factor (C) of 0.33 was used to backcalculate the M_R value.

Full-depth pavement sections were designed for all areas proposed for roadway widening, or the realignment areas for intersection reconfiguration. Based on back-calculation results from FWD data in these localized areas, a mean design approach was utilized. The average back-calculated M_R values and the calculated design SNs for 20-year performance period for both overlay and full-depth design sections are presented in Appendix D. Different traffic values were used for each roadway based on the information available from the Engineering Study.

RECOMMENDATIONS

The following pavement recommendations are based on the existing conditions at the time of the field reconnaissance in May 2007. The recommendations included here reference the FP-03, "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects" (FP-03 Specifications).

Pavement Section

Minimum pavement section recommendations based on a 20-year performance period for all roadways included in the scope of work are provided in Tables 3a through 3f below.

Table 3a – Minimum Pavement Section for US Route 6 Widening and Realignment

Layer	Minimum Thickness (in)	Comments
Asphalt Concrete Surface Course	2	Superpave Asphalt Concrete Pavement (SACP), 0.3 to 3 million ESALs, ½" Nominal Maximum Size Aggregate (NMSA), Type IV Pavement Smoothness
Asphalt Concrete Base Course	2	SACP, 0.3 to 3 million ESALs, ½" NMSA
Aggregate Base	8	Base Aggregate, Grading C or D as per Subsection 703.05(b) of the FP-03 Specifications

Table 3b – Minimum Pavement Section for US Route 6 Rehabilitation

Layer	Minimum Thickness (in)	Comments
Asphalt Concrete Surface Course	1.5	Superpave Asphalt Concrete Pavement (SACP), 0.3 to 3 million ESALs, ½" Nominal Maximum Size Aggregate (NMSA), Type IV Pavement Smoothness
Asphalt Concrete Base Course	1.5	SACP, 0.3 to 3 million ESALs, ½" NMSA
Pulverize Asphalt Base Courese	6	Pulverize Existing Asphalt 6" as per Section 303.08 of the FP-03 Specifications

Table 3c – Minimum Pavement Section for Moors Road Widening and Realignment

Layer	Minimum Thickness (in)	Comments
Asphalt Concrete Surface Course	2	Superpave Asphalt Concrete Pavement (SACP), 0.3 to 3 million ESALs, ½" Nominal Maximum Size Aggregate (NMSA), Type IV Pavement Smoothness
Asphalt Concrete Base Course	2	SACP, 0.3 to 3 million ESALs, ½" NMSA
Aggregate Base	10	Base Aggregate, Grading C or D as per Subsection 703.05(b) of the FP-03 Specifications

Table 3d – Minimum Pavement Section for Moors Road Rehabilitation

Layer	Minimum Thickness (in)	Comments
Asphalt Concrete Surface Course	2	Superpave Asphalt Concrete Pavement (SACP), 0.3 to 3 million ESALs, ½" Nominal Maximum Size Aggregate (NMSA), Type IV Pavement Smoothness
Asphalt Concrete Base Course	2	SACP, 0.3 to 3 million ESALs, ½" NMSA
Pulverized Asphalt Base Course	10	Pulverize Existing Asphalt and Aggregate base 10" as per Section 303.08 of the FP-03 Specifications

Table 3e – Minimum Pavement Section for Province Lands Road and Herring Cove Fee Station Widening and Reconfiguration

Layer	Minimum Thickness (in)	Comments
Asphalt Concrete Surface Course	2	Superpave Asphalt Concrete Pavement (SACP), 0.3 to 3 million ESALs, ½" Nominal Maximum Size Aggregate (NMSA), Type IV Pavement Smoothness
Asphalt Concrete Base Course	2	SACP, 0.3 to 3 million ESALs, ½" NMSA
Aggregate Base	8	Base Aggregate, Grading C or D as per Subsection 703.05(b) of the FP-03 Specifications

Table 3f – Minimum Pavement Section for Province Lands Road and Herring Cove Fee Station Rehabilitation

Layer	Minimum Thickness (in)	Comments
Asphalt Concrete Surface Course	2	Superpave Asphalt Concrete Pavement (SACP), 0.3 to 3 million ESALs, ½" Nominal Maximum Size Aggregate (NMSA), Type IV Pavement Smoothness
Asphalt Concrete Base Course	2	SACP, 0.3 to 3 million ESALs, ½" NMSA
Pulverized Asphalt Base Course	8	Pulverize Existing Asphalt and Aggregate base 8" as per Section 303.08 of the FP-03 Specifications

Marconi Beach Road- Due to the presence of frequent medium and high severity transverse and longitudinal cracking along most of Marconi Beach Road, the specific treatment type recommended by the network level Pavement Management System (PMS) would not be applicable to address site-specific conditions of Marconi Beach Road. It is imperative to note that the PMS is a network-level planning tool and it should not be used for the selection of specific treatments at a project level design analysis. Due to the aging of the pavement surface and frequent freeze-thaw cycles, full depth cracking is present which has allowed the infiltration of water into the subgrade and has caused the medium severity rutting, alligator cracking and potholing shown in the pavement condition survey. A thin overlay would not address these problems, and the new overlay would begin to show reflective cracking in under 5 years. Two alternative design solutions are presented below in Table 4a and 4b for Marconi Beach Road.

Table 4a – Rehabilitation Strategy for Marconi Beach Road long-term design

Layer	Minimum Thickness (in)	Comments
Asphalt Concrete Surface Course	1.5	Superpave Asphalt Concrete Pavement (SACP), 0.3 to 3 million ESALs, ½" Nominal Maximum Size Aggregate (NMSA), Type IV Pavement Smoothness
Asphalt Concrete Base Course	1.5	SACP, 0.3 to 3 million ESALs, ½" NMSA
Pulverized Asphalt Base Course	6	Pulverize Existing Asphalt and Aggregate base 6" as per Section 303.08 of the FP-03 Specifications

Table 4b – Spot Fix and Surface Treatment Strategy for Marconi Beach Road near-term design

Treatment	Estimated Quantity	Comments
Single Course Chipseal	22,000 yd^2	After patching and crack sealing, place Single Course Surface Treatment, Designation 1C, according to Section 409.11
Crack Sealing	2,500 LNFT	Seal Cracks greater than or equal to ¼" in width according to Section 404.05
Full Depth Patching (See Summary Table Below)	1600 yd^2	Excavate existing surface 10 inches, scarify existing subgrade a minimum of 12 inches and recompact to at least 95% of maximum density in accordance with the AASHTO T 180 Method D. Place 6 inches of Aggregate base, Grading C or D, place 1.5" SACP Base Course (See Table 4a) and 1.5" SACP Surface Course

Summary of Full Depth Patch Area Recommendations for Marconi Beach Road
(Additional area may be required as directed by the CO)

Station or Range	Lane	Area (yd^2)
11+00 to 11+75	RT	100
21+25 to 21+75	RT	67
23+25 to 23+75	RT	67
33+50 to 35+00	LT	200
36+25 to 36+75	LT	67
40+25 to 40+75	RT	67
65+25 to 66+25	RT	133
70+75 to 71+25	RT	67

Station or Range	Lane	Area (yd^2)
72+50 to 73+00	RT	67
74+00 to 75+00	RT	133
77+00 to 81+00	RT	533
82+50 to 83+25	RT	100
TOTAL AREA		**1601**

Construction Considerations

Subgrade Preparation: Trees, sod and vegetative materials within the proposed construction limits should be cleared and scalped as per Sections 201 of the FP-03 Specifications. Proposed embankments and all cut areas should be scarified to a minimum depth of 6 inches and should be recompacted to at least 95% of maximum density in accordance with the AASHTO T 180 Method D. Excavated granular materials classified as A-1 and A-2-4 below vegetative and/or unsuitable materials within the project site may be reused for embankment material.

Obliteration Areas: In areas proposed for obliteration, material obtained from the obliteration of these areas can be re-used as embankment to prepare the subgrade and base for proposed widening and acceleration/deceleration lanes. The proposed subgrade extending the full width between embankment side slopes should be compacted to at least 95% of maximum density in accordance with the AASHTO T 180 Method D. If there is no need to re-use the obliterated AC pavement, the material should be left in place to provide emergency access via the old footprint.

Soil Cover for Buried Structures: All proposed and existing pipes and other buried structure should have a minimum soil cover of 12 inches or as shown in the Standard Details.

DISCLAIMER/LIMITATIONS CLAUSE

The subsurface explorations and tests described in the section on Procedures and Results have been conducted in accordance with standard practices and procedures (except as specifically noted). The results of these explorations and tests represent conditions at the specific locations indicated. Subsurface and conditions between these locations may vary. The Analysis and Conclusions section and the Recommendations section in this report include interpretations and recommendations developed by the Government in the process of preparing the design. These interpretations are not intended as a substitute for the personal investigation, independent interpretation, and judgment of the Contractor.

William Eshbaugh

Digitally signed by William Eshbaugh
DN: cn=William Eshbaugh, c=US, o=EFLHD - TS - Pavements, ou=FHWA, email=william.eshbaugh@fhwa.dot.gov
Reason: I am the author of this document
Date: 2007.07.30 14:09:03 -04'00'

Prepared by:
William Eshbaugh
Pavement Engineer

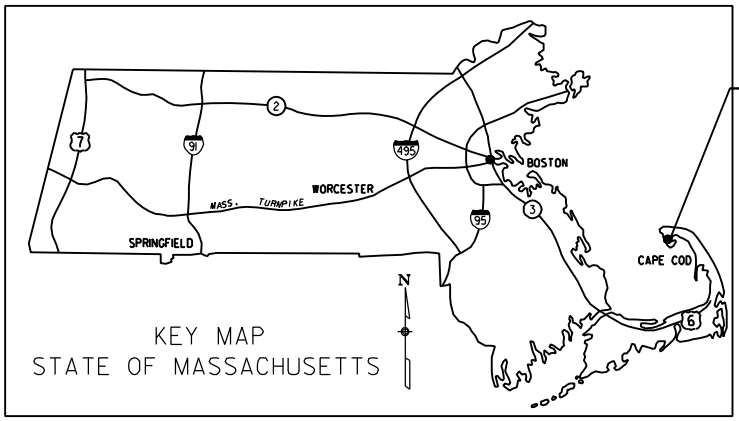
Christopher Chang

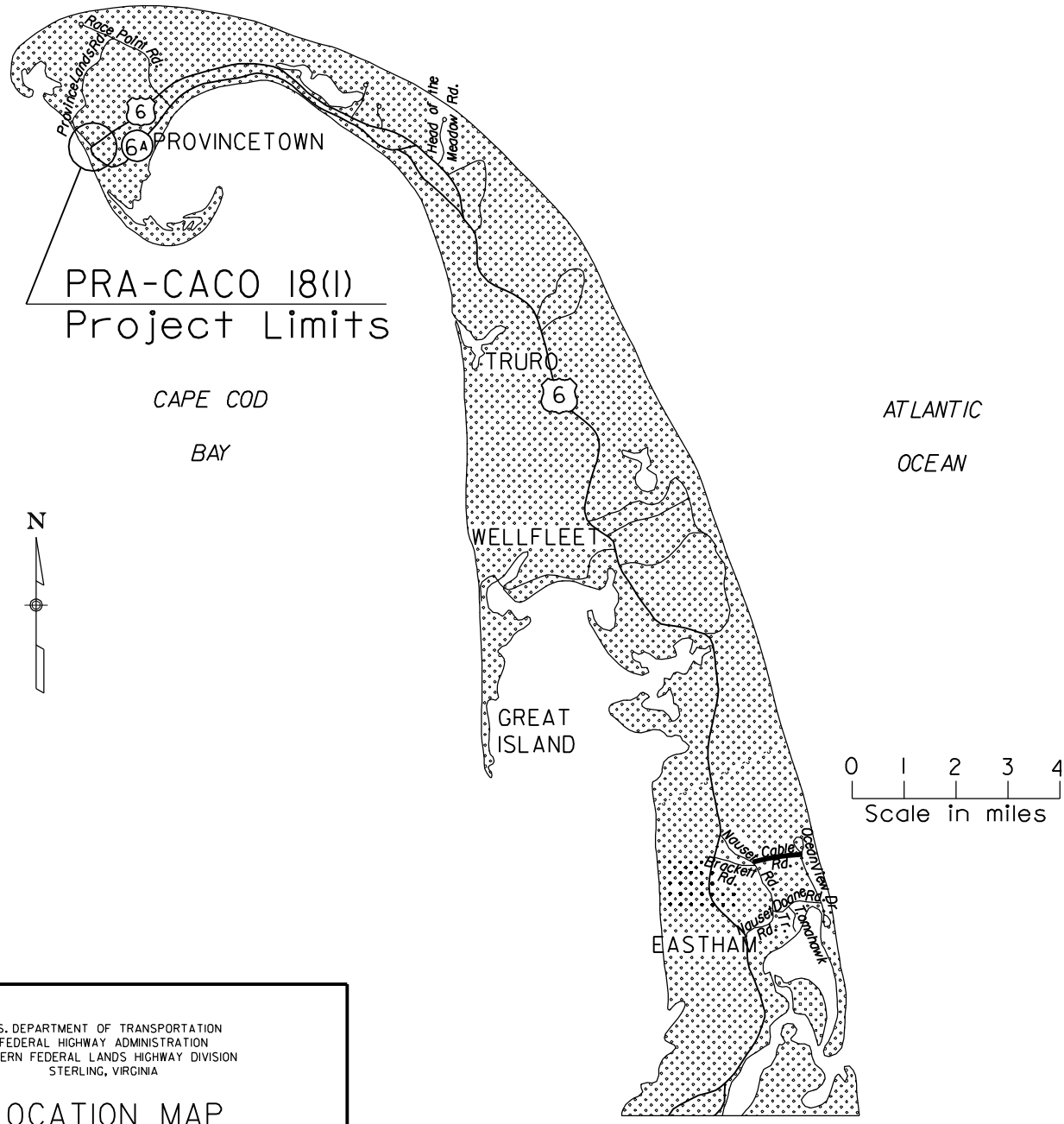
Digitally signed by Christopher Chang
DN: cn=Christopher Chang, c=US, o=FHWA, ou=FHWA-EFLHD-TS-Pavement, email=christopher.chang@fhwa.dot.gov
Reason: I have reviewed this document
Date: 2007.07.30 14:13:30 -04'00'

Reviewed by:
Christopher Chang, P.E.
Pavements Team Leader

APPENDIX A
Project Location Map
Geologic Map
Soil Map

REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
NE	MA	PRA-CACO 18(1)	1	1



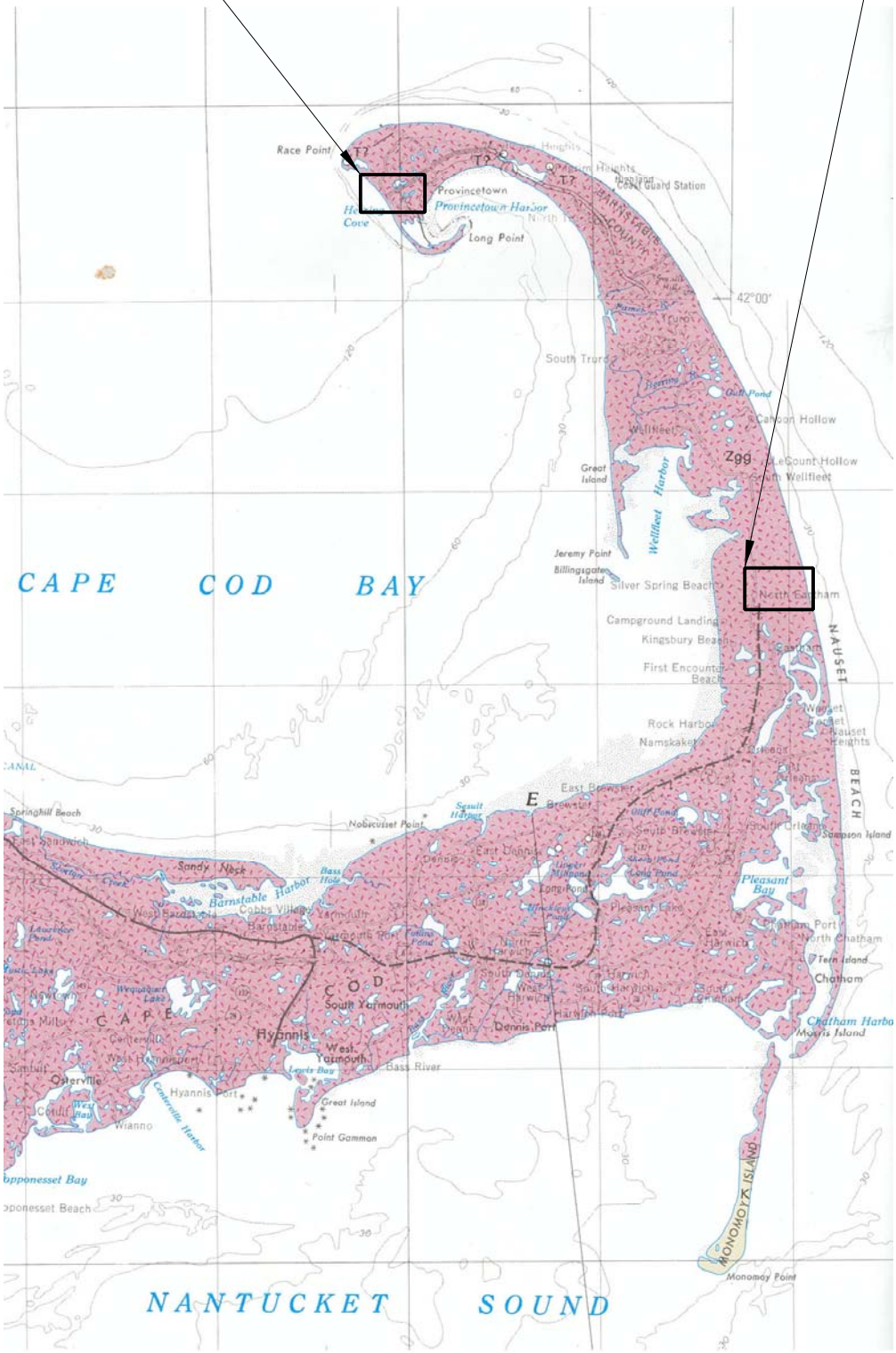


U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

LOCATION MAP
PRA- CACO 18 (1)

CAPE COD NATIONAL SEASHORE

PROJECT PRA-CACO 18(1), ETC.



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U.S. DEPARTMENT OF TRANSPORTATION FEDERAL HIGHWAY ADMINISTRATION EASTERN FEDERAL LANDS HIGHWAY DIVISION STERLING, VIRGINIA	GEOLOGIC MAP	REG	STATE	PROJECT	SHEET NO.
		NE	MA	PRA-CACO 18(1)	-

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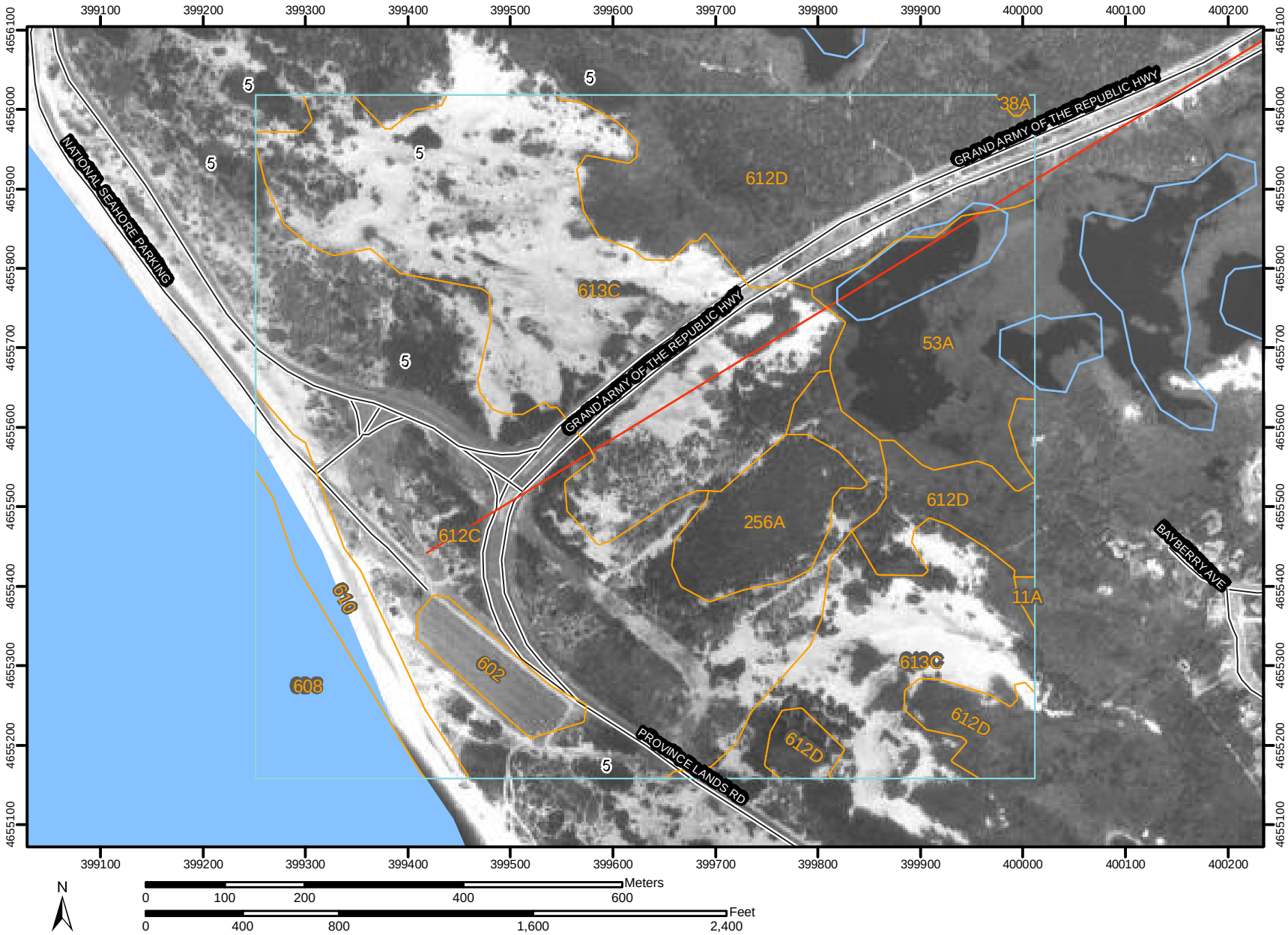
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399200
399300
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399500
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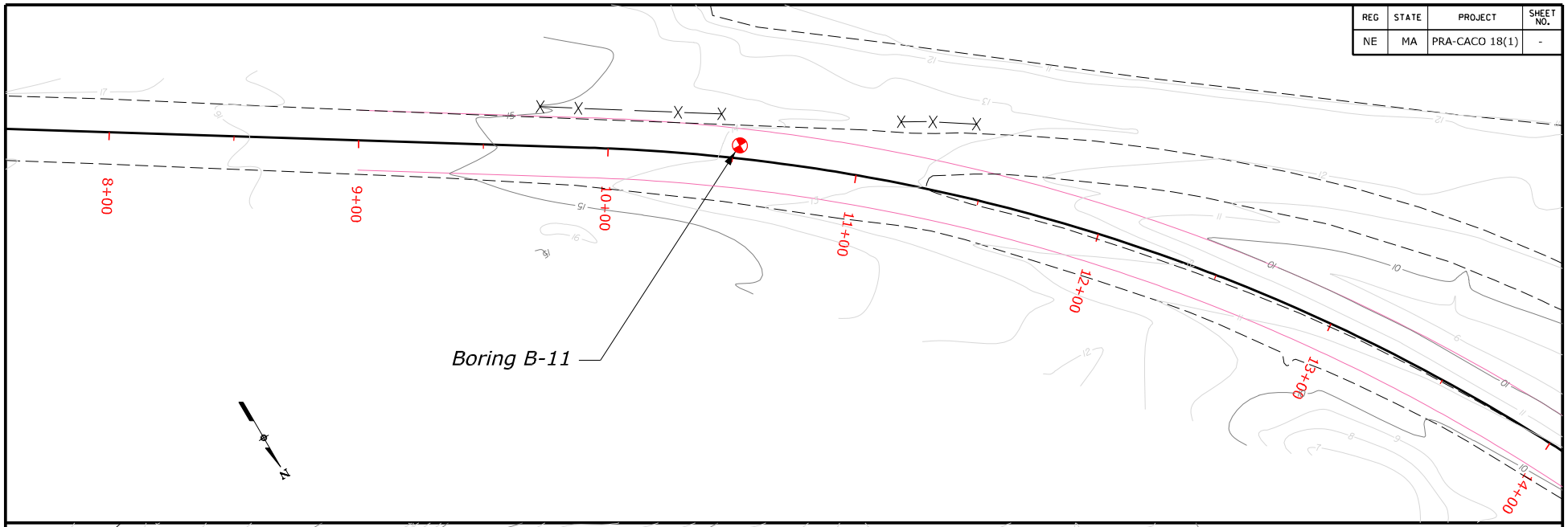
400100
400200
4656100
4656000
4655900
4655800
4655700
4655600
4655500
4655400
4655300
4655200
4655100
NATIONAL SEAHORE PARKING
GRAND ARMY OF THE REPUBLIC HWY
PROVINCE LANDS RD
BAYBERRY AVE
5
38A
612D
613C
53A
256A
612C
610
608
602
11A
N
Meters
0
100
200
400
600
Feet
0
400
800
1,600
2,400

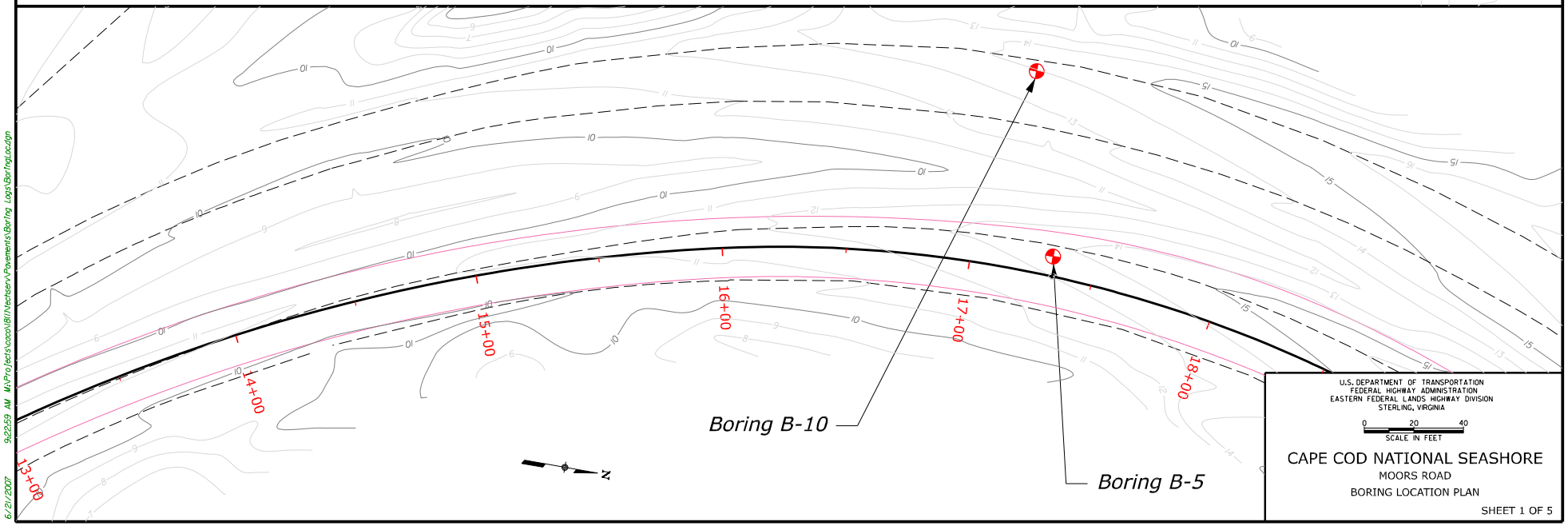
Map Unit Legend

Barnstable County, Massachusetts (MA001)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
11A	Berryland mucky loamy coarse sand, 0 to 2 percent slopes	0.2	0.1%
38A	Pipestone loamy coarse sand, 0 to 3 percent slopes	0.2	0.1%
53A	Freetown mucky peat, 0 to 1 percent slopes, ponded	17.0	8.2%
256A	Deerfield loamy fine sand, 0 to 5 percent slopes	7.3	3.5%
602	Urban land	3.7	1.8%
608	Water, ocean	9.6	4.6%
610	Beaches	7.2	3.5%
612C	Hooksan sand, rolling	61.6	29.5%
612D	Hooksan sand, hilly	37.6	18.0%
613C	Hooksan-Dune land complex, hilly	64.2	30.8%
Totals for Area of Interest (AOI)		208.6	100.0%

APPENDIX B – Boring Location Plan and Boring Logs

REG	STATE	PROJECT	SHEET NO.
NE	MA	PRA-CACO 18(1)	-





U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

0 20 40
SCALE IN FEET

CAPE COD NATIONAL SEASHORE

MOORS ROAD

BORING LOCATION PLAN

SHEET 1 OF 5

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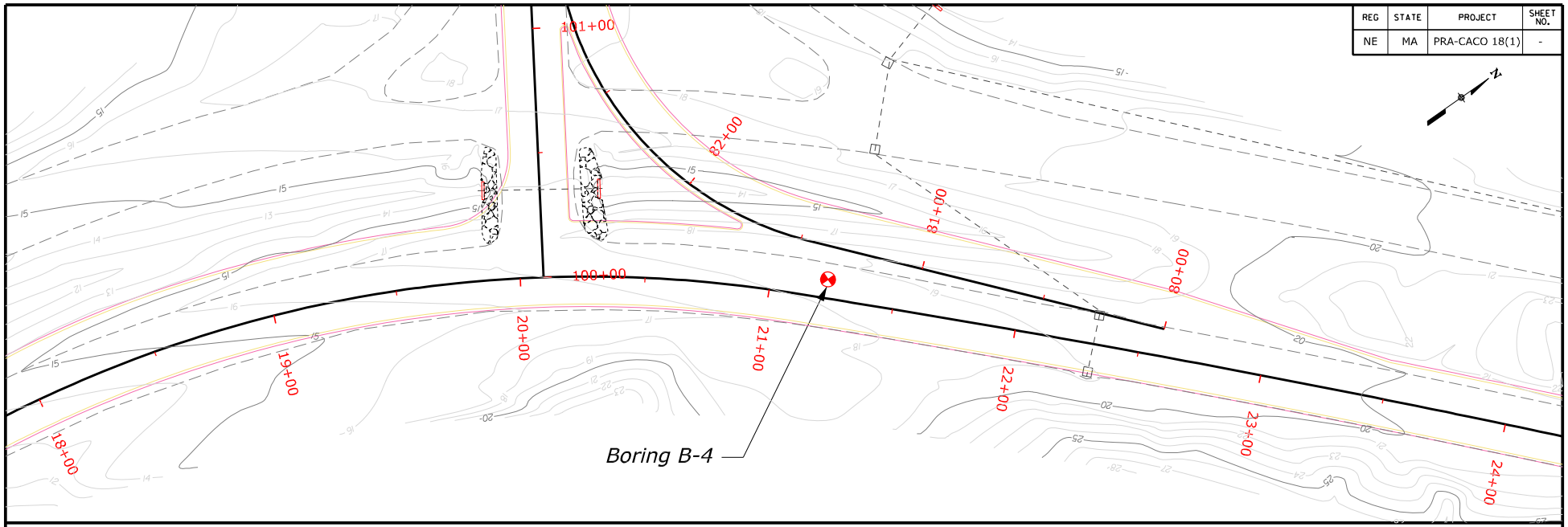
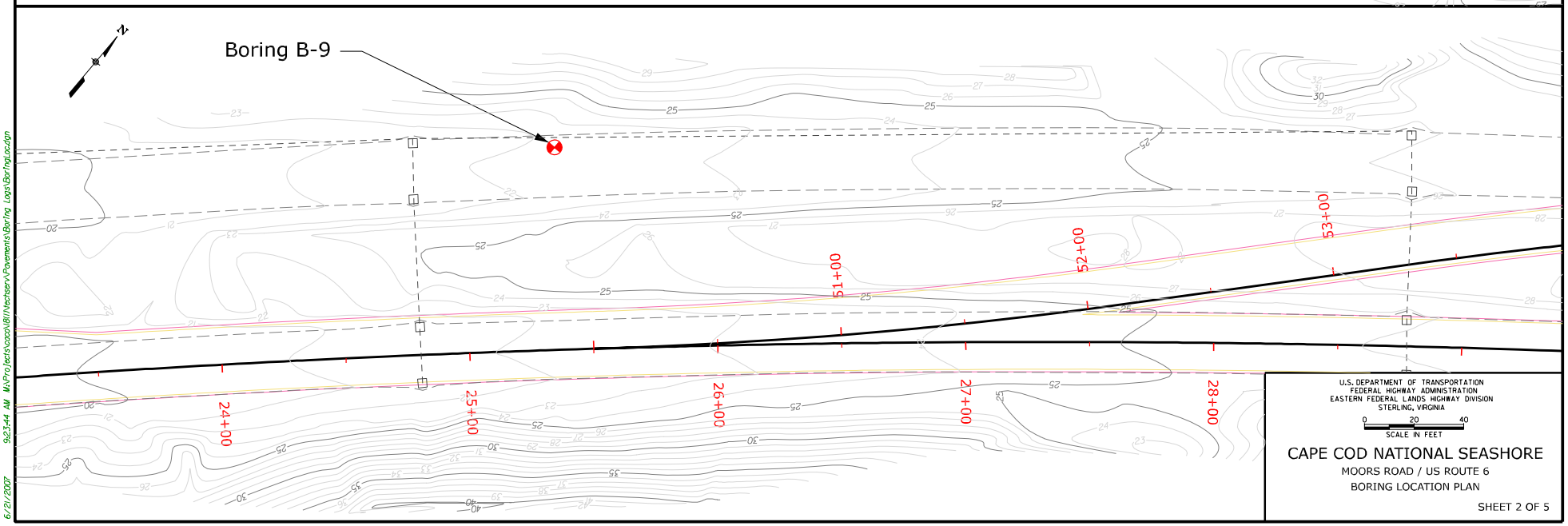
NE	MA	PRA-CACO 18(1)	-





U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

0 20 40
SCALE IN FEET

CAPE COD NATIONAL SEASHORE

MOORS ROAD / US ROUTE 6

BORING LOCATION PLAN

SHEET 2 OF 5

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REG	STATE	PROJECT	SHEET NO.
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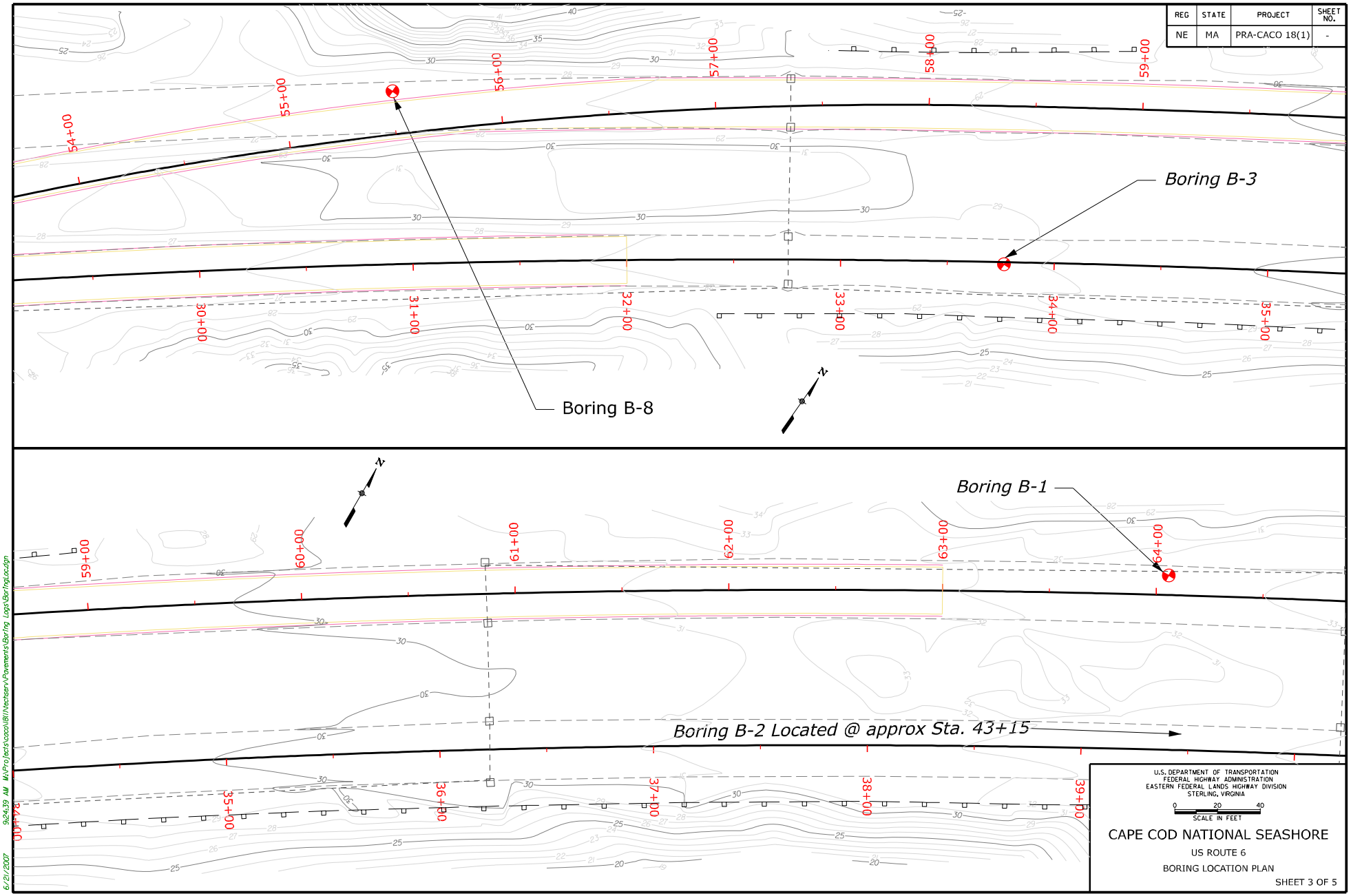

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

0 20 40
SCALE IN FEET

CAPE COD NATIONAL SEASHORE

US ROUTE 6

BORING LOCATION PLAN

SHEET 3 OF 5

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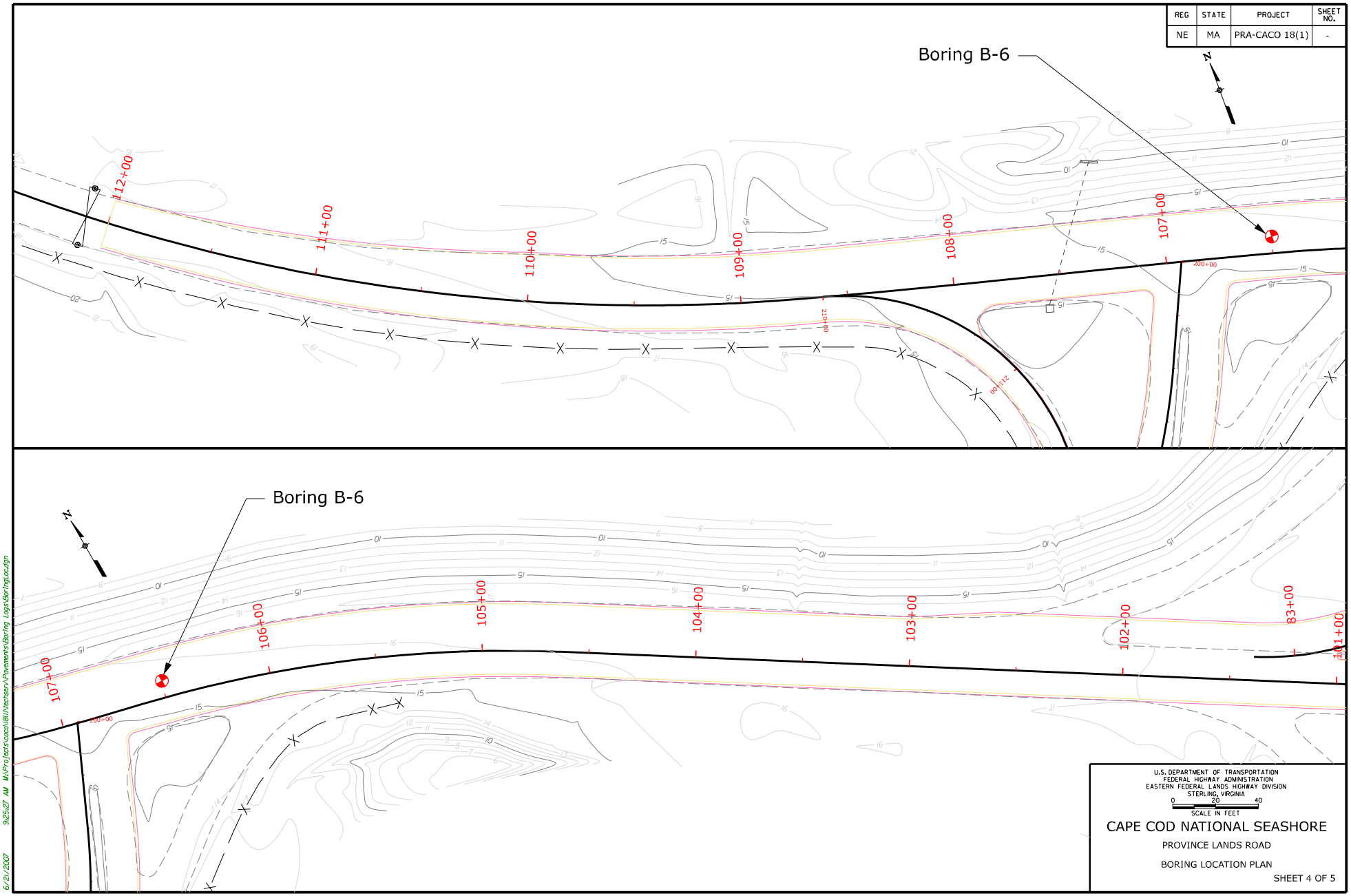

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

0 20 40
SCALE IN FEET

CAPE COD NATIONAL SEASHORE

PROVINCE LANDS ROAD

BORING LOCATION PLAN

SHEET 4 OF 5

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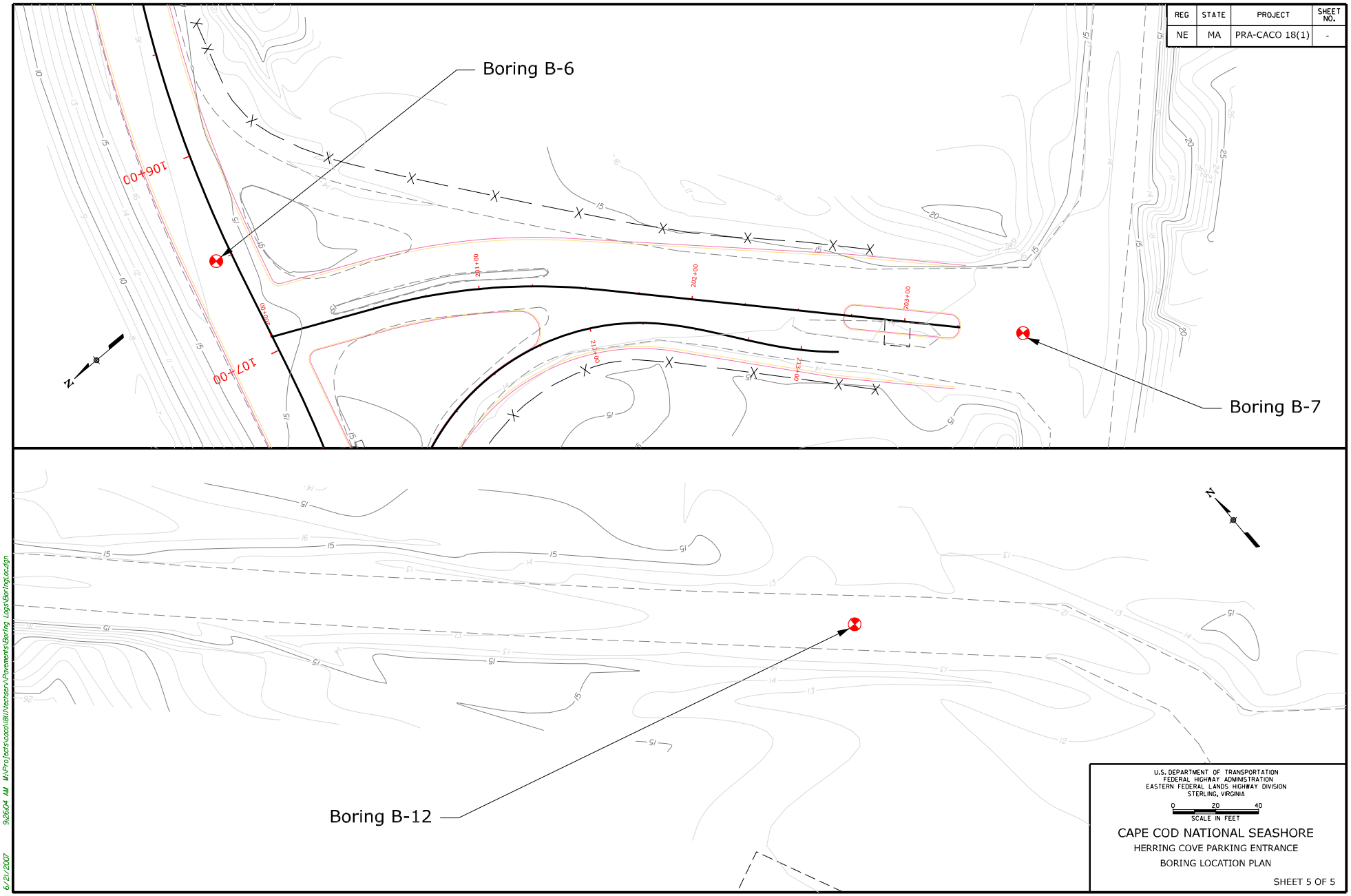
REG	STATE	PROJECT	SHEET NO.
NE	MA	PRA-CACO 18(1)	-



U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

0 20 40
SCALE IN FEET

CAPE COD NATIONAL SEASHORE
HERRING COVE PARKING ENTRANCE
BORING LOCATION PLAN

SHEET 5 OF 5

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BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-01 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 18

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.6	Hot asphalt concrete pavement						
		1.0	Stone mastic						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-02 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 18

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.7	Hot asphalt concrete pavement						
		1.0	Stone Mastic						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-03 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 18

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit — Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.7	Hot asphalt concrete pavement						
		1.0	Stone mastic						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

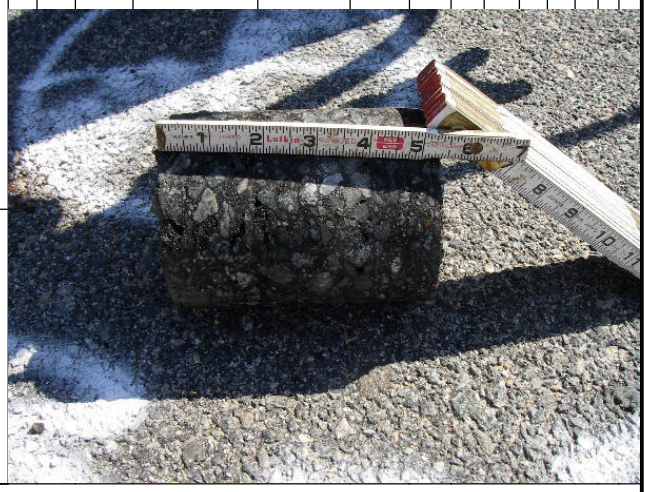
U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-04 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Intesection of 18, 17, and 15

Groundwater Depth: | Surface Elevation: | Boring Began: 5/22/07 | Completed: 5/22/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % Plastic Limit ⊢—⊣ Liquid Limit ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.5	Hot asphalt concrete pavement						
		1.0	Base course						
			Borehole terminated @ depth 1.04'						
				5					



Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-05 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 17

Groundwater Depth: | Surface Elevation: | Boring Began: 5/22/07 | Completed: 5/22/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit — Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.5	Hot asphalt concrete pavement						
		1.1	Base course						
			Borehole terminated @ depth 1.09'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-06 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 15

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: PARTIALLY CLOUDY

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.5	Hot asphalt concrete pavement						
		1.0	Base course						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-07 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 929

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: PARTIALLY CLOUDY

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit — Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.5	Hot asphalt concrete pavement						
		1.0	Base course						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) Boring No.: B-08 Sheet: 1 of 1

Project Location: Cape Cod National Seashore Boring Location: Route 18

Groundwater Depth: Surface Elevation: Boring Began: 5/21/07 Completed: 5/21/07
Encountered at: Caved at: Boring Method: CORE TRAILER Inspector: ESHBAUGH
At Completion: Hammer Wt. & Type: Hole Diameter: Operator: 0'BRIEN
After hrs Hammer Drop: Rock Core Diam: Weather: PARTIALLY CLOUDY

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.8	Hot asphalt concrete pavement						
		1.0	Stone mastic						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-09 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 18

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.8	Hot asphalt concrete pavement						
		1.0	Stone mastic						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-10 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 17

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.5	Hot asphalt concrete pavement						
		1.0	Base course						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-11 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 17

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % Plastic Limit ⊢—⊣ Liquid Limit ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.4	Hot asphalt concrete pavement						
		1.0	Base course material						
			Borehole terminated @ depth 1.0'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO12(1), 14(2), 17(1), 18(1) | Boring No.: B-12 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Route 929

Groundwater Depth: | Surface Elevation: | Boring Began: 5/21/07 | Completed: 5/21/07
Encountered at: | Caved at: | Boring Method: CORE TRAILER | Inspector: ESHBAUGH
At Completion: | Hammer Wt. & Type: | Hole Diameter: | Operator: 0'BRIEN
After hrs | Hammer Drop: | Rock Core Diam: | Weather: CLEAR

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.3	Hot asphalt concrete pavement						
		0.7	Stone mastic						
		1.5	Sand						
			Borehole terminated @ depth 1.5'						
				5					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
No ground water was encountered during or after Boring

APPENDIX C – FWD Field Data

Dynatest FWD Data - CACO 12(1), 14(2), 17(1),18(1)

SessionID	Program	Operator	Trailer	Electronics
1		so	8002-229	9000-366
TestSetup	**Units**	**Date**	**FacilityName**	**District**
target9000lb	US	21-May-07	Intersection Reconfiguration	Cape Cod, MA
Class	**Start**	**End**	**Lane**	**LaneNumber**
AC			Right-1	1R

X1	X2	X3	X4	X5	X6	X7	X8	X9
0	8	12	18	24	36	48	60	72

			TEMPERATURES					DEFLECTIONS								
StationID	**Station**	**DropID**	**Asphalt**	**Surface**	**Air**	**Stress**	**Force**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**
1	-139	1	80.00	80.70	59.20	83.6	9156	8.56	7.79	7.44	6.44	5.7	4.3	3.21	2.41	1.84
1	-139	2	80.00	80.70	59.20	81.8	8965	8.39	7.65	7.29	6.33	5.58	4.23	3.15	2.36	1.81
1	-139	3	80.00	80.70	59.20	82.2	9008	8.43	7.68	7.31	6.35	5.6	4.24	3.17	2.42	1.81
1	-139	4	80.00	80.70	59.20	82.6	9053	8.41	7.67	7.31	6.35	5.59	4.24	3.17	2.37	1.82
2	2215	5	80.00	83.50	58.10	80.3	8802	14.88	12.1	10.2	7.49	5.82	3.89	2.94	2.38	2.01
2	2215	6	80.00	83.50	58.10	81.4	8918	14.9	12.15	10.35	7.54	5.86	3.93	2.97	2.41	2.02
2	2215	7	80.00	83.50	58.10	82.6	9048	15.02	12.26	10.14	7.62	5.91	3.97	2.99	2.45	2.05
2	2215	8	80.00	83.50	58.10	81.5	8929	14.81	12.09	10.07	7.54	5.87	3.93	2.99	2.42	2.03
3	2907	9	80.00	81.20	57.90	80.6	8825	16.73	13.89	11.31	8.47	6.47	4.35	3.33	2.76	2.31
3	2907	10	80.00	81.20	57.90	83	9096	17.05	14.17	11.46	8.67	6.61	4.46	3.41	2.81	2.36
3	2907	11	80.00	81.20	57.90	81.8	8957	16.77	13.94	11.3	8.53	6.53	4.4	3.38	2.79	2.35
3	2907	12	80.00	81.20	57.90	82	8984	16.77	13.94	11.35	8.56	6.55	4.41	3.38	2.81	2.35
4	2295	13	78.70	90.30	62.70	80.5	8822	16.26	12.66	10.5	7.67	5.98	4.07	2.98	2.38	2.12
4	2295	14	78.70	90.30	62.70	83.2	9111	16.46	12.88	10.82	7.82	6.1	4.17	3.06	2.46	2.16
4	2295	15	78.70	90.30	62.70	80.7	8838	16	12.56	10.49	7.63	5.96	4.09	2.98	2.41	2.11
4	2295	16	78.70	90.30	62.70	82.3	9016	16.19	12.72	10.61	7.74	6.07	4.15	3.03	2.44	2.15
5	1892	17	82.10	89.10	61.50	80.3	8802	16.95	13.81	11.06	8.29	6.19	3.69	2.76	2.17	1.91
5	1892	18	82.10	89.10	61.50	82.2	9008	17.08	13.93	11.03	8.4	6.32	3.81	2.8	2.22	1.9
5	1892	19	82.10	89.10	61.50	82.3	9021	16.9	13.78	10.86	8.32	6.31	3.85	2.76	2.2	1.93
5	1892	20	82.10	89.10	61.50	82.7	9056	16.85	13.71	10.77	8.3	6.28	3.85	2.76	2.2	1.91
6	628	21	79.70	91.30	61.40	82.7	9061	11.19	9.41	9.02	7.43	6.31	4.48	3.28	2.56	2.08
6	628	22	79.70	91.30	61.40	82.2	9008	11.03	9.32	8.91	7.33	6.24	4.44	3.24	2.55	2.07
6	628	23	79.70	91.30	61.40	82.2	9005	11.01	9.33	8.9	7.36	6.26	4.44	3.25	2.56	2.07
6	628	24	79.70	91.30	61.40	82.2	9005	10.99	9.3	8.85	7.35	6.24	4.45	3.26	2.52	2.06
7	-326	25	88.60	92.00	62.30	84	9199	7.13	6.52	6.27	5.65	5.11	4.12	3.22	2.57	2.09
7	-326	26	88.60	92.00	62.30	82.3	9021	7.01	6.39	6.17	5.55	5.02	4.04	3.18	2.54	2.06
7	-326	27	88.60	92.00	62.30	81.8	8965	6.97	6.34	6.13	5.51	4.98	4.02	3.15	2.52	2.05
7	-326	28	88.60	92.00	62.30	82.9	9084	7.04	6.4	6.2	5.56	5.03	4.06	3.17	2.55	2.07

Dynatest FWD Data - CACO 12(1), 14(2), 17(1),18(1)

SessionID	Program	Operator	Trailer	Electronics
2		so	8002-229	9000-366
TestSetup	Units	Date	FacilityName	District
target9000lb	US	21-May-07	Herring Cove Entrance Area	Cape Cod, MA
Class	Start	End	Lane	LaneNumber
AC			`	1R

X1	X2	X3	X4	X5	X6	X7	X8	X9
0	8	12	18	24	36	48	60	72

			TEMPERATURES					DEFLECTIONS								
StationID	**Station**	**DropID**	**Asphalt**	**Surface**	**Air**	**Stress**	**Force**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**
1	563	1	82.90	88.30	61.30	79.3	8687	13.82	11.41	9.89	7.22	5.59	3.57	2.52	2	1.67
1	563	2	82.90	88.30	61.30	82.4	9024	14.06	11.65	10.04	7.4	5.74	3.7	2.59	2.07	1.74
1	563	3	82.90	88.30	61.30	81.6	8933	13.91	11.52	9.89	7.34	5.7	3.67	2.59	2.06	1.74
1	563	4	82.90	88.30	61.30	82.6	9045	13.94	11.56	9.73	7.37	5.73	3.68	2.6	2.07	1.74
2	978	5	82.60	82.70	59.90	81.3	8910	10.3	8.74	7.88	6.02	4.72	3.25	2.33	1.9	1.62
2	978	6	82.60	82.70	59.90	82.4	9029	10.37	8.8	7.98	6.07	4.8	3.28	2.39	1.94	1.65
2	978	7	82.60	82.70	59.90	82	8981	10.26	8.73	7.99	6.02	4.76	3.27	2.37	1.83	1.63
2	978	8	82.60	82.70	59.90	82.1	8989	10.23	8.71	7.81	6.02	4.7	3.26	2.33	1.93	1.63
3	1497	9	82.60	89.40	59.50	80.1	8778	17.9	14.85	11.69	9.46	7.3	4.51	3.07	2.37	1.98
3	1497	10	82.60	89.40	59.50	82.4	9024	18.19	15.1	11.68	9.66	7.43	4.6	3.14	2.45	2.03
3	1497	11	82.60	89.40	59.50	81.9	8976	18.05	14.97	12.06	9.57	7.39	4.57	3.12	2.43	2
3	1497	12	82.60	89.40	59.50	81.7	8953	18	14.93	11.96	9.57	7.37	4.56	3.12	2.43	2

APPENDIX D – Back Calculation Analysis

CACO 18(1) Mainline

Station	Units	LayerCount	Type1	Layer1	Type2	Layer2	Type3	Layer3	RMSE
-326	ENGL	3	0	1140000	0	371000	0	18100	2.62
-139	ENGL	3	0	799000	0	27400	0	16100	11.6
628	ENGL	3	0	722000	0	26800	0	16600	1.73
1892	ENGL	3	0	688000	0	3520	0	34700	31.12
2215	ENGL	3	0	607000	0	3820	0	22900	17.07
2295	ENGL	3	0	456000	0	17500	0	19700	11.21
2907	ENGL	3	0	1040000	0	690	0	335000	59.29
							Mr =	21350	
							Design Mr =	7,117	

Herring Cove Parking Entrance

Station	Units	LayerCount	Type1	Layer1	Type2	Layer2	Type3	Layer3	RMSE
563	ENGL	3	0	767000	0	3160	0	36500	194.6
978	ENGL	3	0	1190000	0	8230	0	28100	147.7
1497	ENGL	3	0	1670000	0	895	0	878000	221.4
							Mr =	32300	
							Design Mr =	10,767	

APPENDIX E – Pavement Design Analysis

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

FHWA-EFLHD
21400 Ridgetop Cir
Sterling, VA 20165

Flexible Structural Design Module

Widening and Re-Alignment Pavement Areas
Herring Cove Entrance Station

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	307,495
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.44 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,176
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,176
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	94	2	0.0007	0	3,363
2	2	2	0.25	0	25,557
3	3	2	1.2	0	184,012
4	1	2	1.85	0	94,562
Total	100	-	-	-	307,495

Growth Simple

Total Calculated Cumulative ESALs 307,495

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	4	12	1.68
2	Aggregate Base	0.14	0.8	8	12	0.90
Total	-	-	-	12.00	-	2.58

Layered Thickness Design

Thickness precision Actual

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Spec Thickness (Di)(in)	Min Thickness (Di)(in)	Elastic Modulus (psi)	Width (ft)	Calculated Thickness (in)	Calculated SN (in)
Total	-	-	-	-	-	-	-	-	-

*Note: This value is not represented by the inputs or an error occurred in calculation.

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

FHWA-EFLHD
21400 Ridgetop Cir
Sterling, VA 20165

Flexible Structural Design Module

Pulverize and Overlay Existing Pavement Areas
Herring Cove Entrance Station

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	307,495
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.44 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,176
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,176
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	94	2	0.0007	0	3,363
2	2	2	0.25	0	25,557
3	3	2	1.2	0	184,012
4	1	2	1.85	0	94,562
Total	100	-	-	-	307,495

Growth	Simple
Total Calculated Cumulative ESALs	307,495

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	4	12	1.68
2	Pulverized HACP and Base	0.14	0.8	8	12	0.90
Total	-	-	-	12.00	-	2.58

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

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Computer Software Product

FHWA-EFLHD
21400 Ridgetop Cir
Sterling, VA 20165

Flexible Structural Design Module

Pulverize and Overlay Existing Pavement Areas
Marconi Beach Road

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	67,185
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	1.91 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	530
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	530
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

FHWA-EFLHD
21400 Ridgetop Cir
Sterling, VA 20165

Flexible Structural Design Module

Pulverize and Overlay Existing Pavement Areas
Marconi Beach Road

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	67,185
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	1.91 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	530
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	530
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	95	2	0.0007	0	1,532
2	4	2	0.25	0	23,036
3	1	2	1.85	0	42,617
Total	100	-	-	-	67,185

Growth	Simple
Total Calculated Cumulative ESALs	67,185

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	3	11	1.26
2	Pulverized HACP and Base	0.14	0.8	6	11	0.67
Total	-	-	-	9.00	-	1.93

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Flexible Structural Design Module

Widening and Re-Alignment Pavement Areas
Moors Road

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	685,065
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.77 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,620
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,620
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	94	2	0.0007	0	7,493
2	2	2	0.25	0	56,939
3	3	2	1.2	0	409,960
4	1	2	1.85	0	210,674
Total	100	-	-	-	685,065

Growth	Simple
Total Calculated Cumulative ESALs	685,065

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	4	24	1.68
2	Aggregate Base	0.14	0.8	10	24	1.12
Total	-	-	-	14.00	-	2.80

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Flexible Structural Design

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Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.77 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,620
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,620
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
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2	2	2	0.25	0	56,939
3	3	2	1.2	0	409,960
4	1	2	1.85	0	210,674
Total	100	-	-	-	685,065

Growth	Simple
Total Calculated Cumulative ESALs	685,065

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	4	24	1.68
2	Pulverized HACP and Base	0.14	0.8	10	24	1.12
Total	-	-	-	14.00	-	2.80

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US Route 6

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	385,937
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.53 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	94	2	0.0007	0	4,221
2	2	2	0.25	0	32,077
3	3	2	1.2	0	230,954
4	1	2	1.85	0	118,685
Total	100	-	-	-	385,937

Growth Simple

Total Calculated Cumulative ESALs 385,937

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	4	24	1.68
2	Aggregate Base	0.14	0.8	8	24	0.90
Total	-	-	-	12.00	-	2.58

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Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.53 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

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Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
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Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
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Total	100	-	-	-	385,937

Growth Simple

Total Calculated Cumulative ESALs 385,937

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	3	24	1.26
2	Pulverized HACP	0.14	0.8	6	24	0.67
3	Existing HACP	0.2	0.8	4	24	0.64
Total	-	-	-	13.00	-	2.57

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	95	2	0.0007	0	1,532
2	4	2	0.25	0	23,036
3	1	2	1.85	0	42,617
Total	100	-	-	-	67,185

Growth	Simple
Total Calculated Cumulative ESALs	67,185

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	3	11	1.26
2	Pulverized HACP and Base	0.14	0.8	6	11	0.67
Total	-	-	-	9.00	-	1.93

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Flexible Structural Design

18-kip ESALs Over Initial Performance Period	685,065
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.77 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,620
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

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Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,620
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
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Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	94	2	0.0007	0	7,493
2	2	2	0.25	0	56,939
3	3	2	1.2	0	409,960
4	1	2	1.85	0	210,674
Total	100	-	-	-	685,065

Growth	Simple
Total Calculated Cumulative ESALs	685,065

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	4	24	1.68
2	Aggregate Base	0.14	0.8	10	24	1.12
Total	-	-	-	14.00	-	2.80

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Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

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Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,620
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Total	100	-	-	-	685,065

Growth	Simple
Total Calculated Cumulative ESALs	685,065

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
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Widening and Re-Alignment Pavement Areas
US Route 6

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	385,937
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.53 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
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1	94	2	0.0007	0	4,221
2	2	2	0.25	0	32,077
3	3	2	1.2	0	230,954
4	1	2	1.85	0	118,685
Total	100	-	-	-	385,937

Growth Simple

Total Calculated Cumulative ESALs 385,937

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	4	24	1.68
2	Aggregate Base	0.14	0.8	8	24	0.90
Total	-	-	-	12.00	-	2.58

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Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

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Rigorous ESAL Calculation

Performance Period (years)	20
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Total	100	-	-	-	385,937

Growth Simple

Total Calculated Cumulative ESALs 385,937

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
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Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	95	2	0.0007	0	1,532
2	4	2	0.25	0	23,036
3	1	2	1.85	0	42,617
Total	100	-	-	-	67,185

Growth	Simple
Total Calculated Cumulative ESALs	67,185

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	3	11	1.26
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Simple ESAL Calculation

Performance Period (years)	20
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Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

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Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,620
Number of Lanes in Design Direction	1
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Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	94	2	0.0007	0	7,493
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3	3	2	1.2	0	409,960
4	1	2	1.85	0	210,674
Total	100	-	-	-	685,065

Growth	Simple
Total Calculated Cumulative ESALs	685,065

Specified Layer Design

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Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

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Rigorous ESAL Calculation

Performance Period (years)	20
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Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
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Flexible Structural Design

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Stage Construction	1
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Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
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Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	94	2	0.0007	0	4,221
2	2	2	0.25	0	32,077
3	3	2	1.2	0	230,954
4	1	2	1.85	0	118,685
Total	100	-	-	-	385,937

Growth Simple

Total Calculated Cumulative ESALs 385,937

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	4	24	1.68
2	Aggregate Base	0.14	0.8	8	24	0.90
Total	-	-	-	12.00	-	2.58

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21400 Ridgetop Cir
Sterling, VA 20165

Flexible Structural Design Module

Pulverize and Overlay Existing Pavement Areas
US Route 6

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	385,937
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	85 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	10,000 psi
Stage Construction	1
Calculated Design Structural Number	2.53 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	- %
Average Initial Truck Factor (ESALs/truck)	-
Annual Truck Factor Growth Rate	- %
Annual Truck Volume Growth Rate	- %
Growth	Simple
Total Calculated Cumulative ESALs	- *

*Note: This value is not represented by the inputs or an error occurred in calculation.

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,476
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	94	2	0.0007	0	4,221
2	2	2	0.25	0	32,077
3	3	2	1.2	0	230,954
4	1	2	1.85	0	118,685
Total	100	-	-	-	385,937

Growth Simple

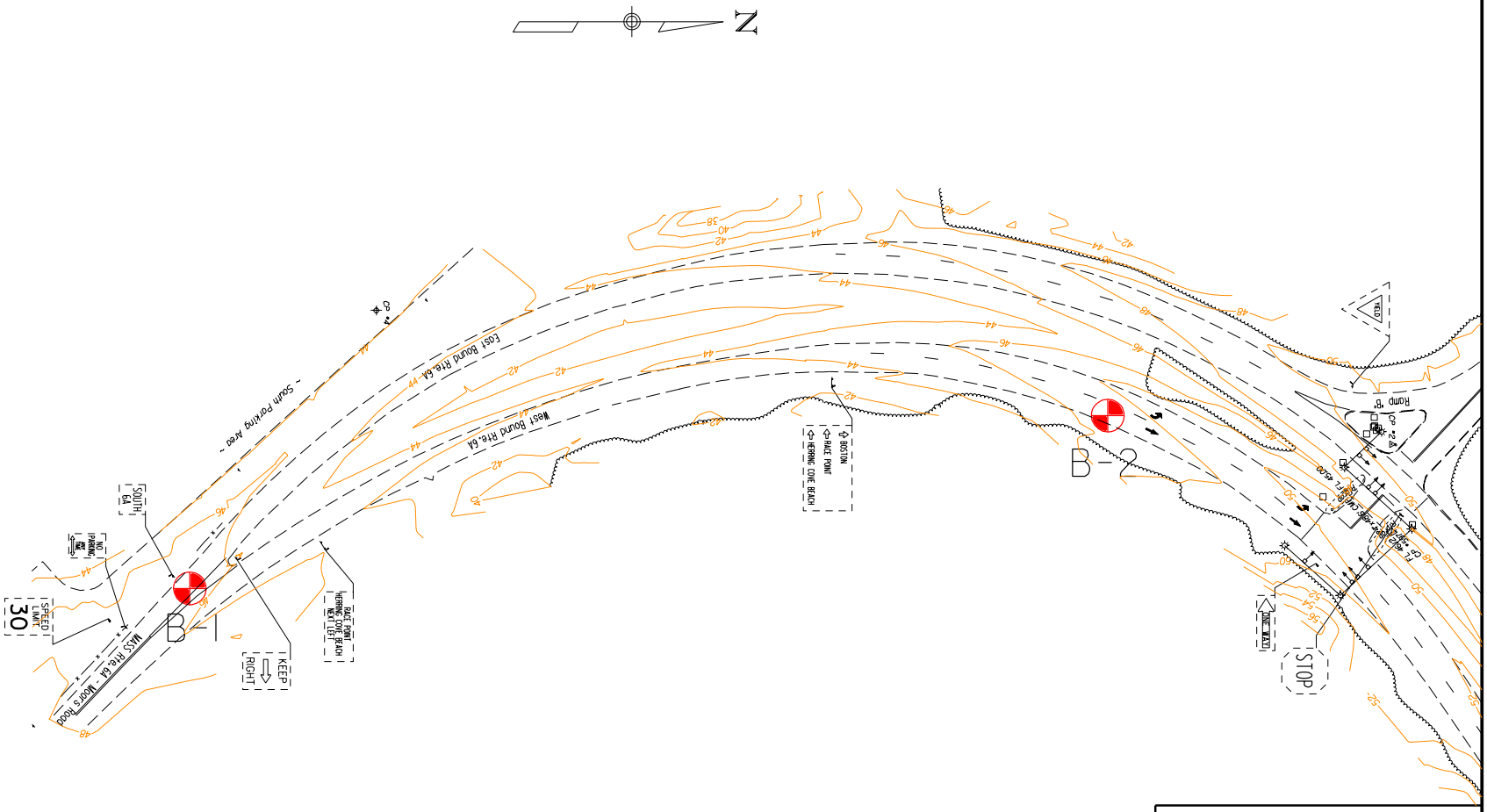
Total Calculated Cumulative ESALs 385,937

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	SACP Surface Course	0.42	1	3	24	1.26
2	Pulverized HACP	0.14	0.8	6	24	0.67
3	Existing HACP	0.2	0.8	4	24	0.64
Total	-	-	-	13.00	-	2.57

APPENDIX F – Boring Location Plan and Boring Logs from Sep. 2002 Investigation

REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
NE	MA	PRA-CACO 18(1)		



APPROXIMATE BORING LOCATION

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

BORING LOCATION PLAN
STATE ROUTE 6 / PROVINCE LANDS ROAD

0 40 80
SCALE IN FEET

Sheet 1 of 3

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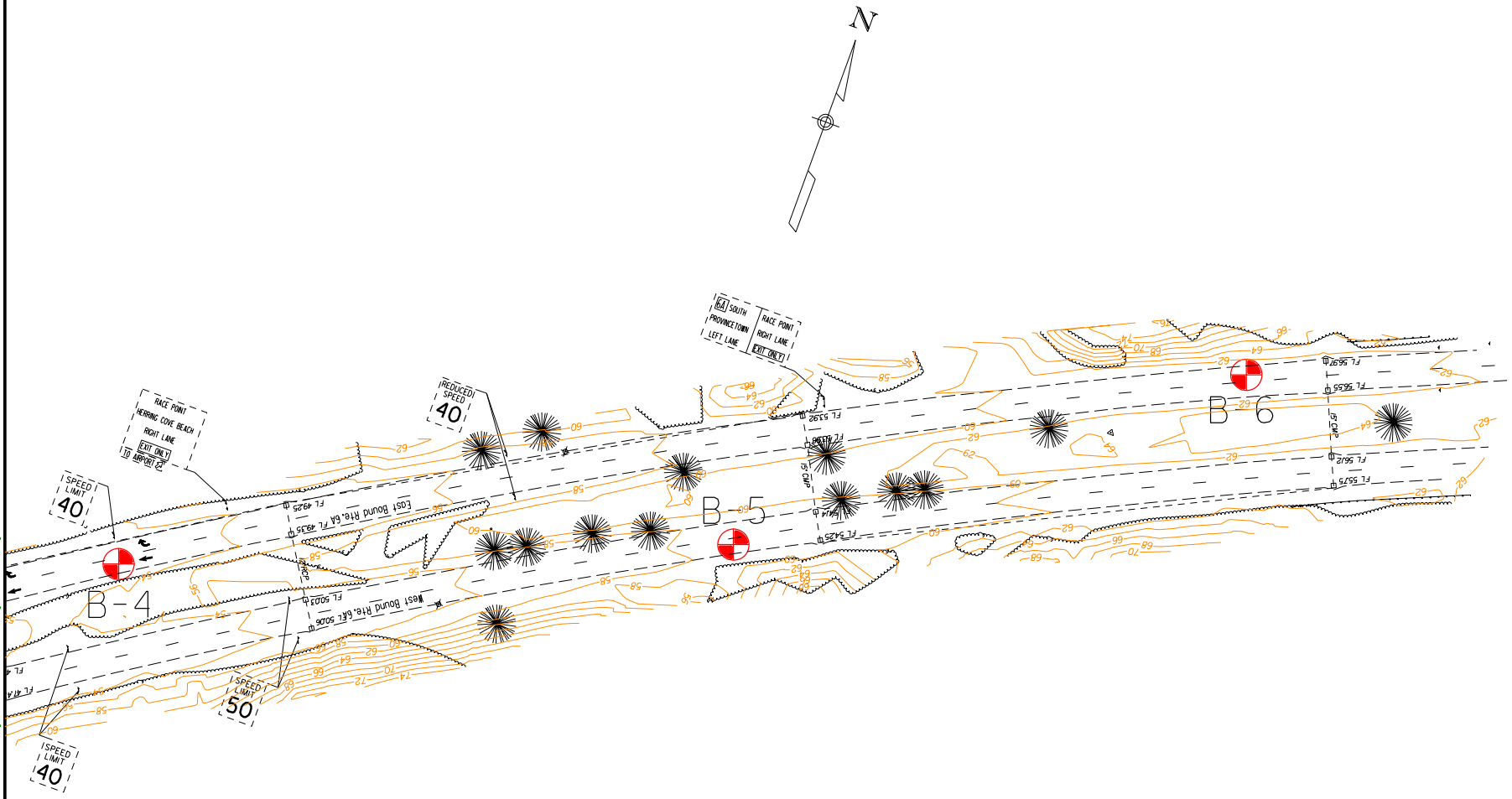
REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
NE	MA	PRA-CACO 18(1)		



APPROXIMATE BORING LOCATION

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

BORING LOCATION PLAN
STATE ROUTE 6 / PROVINCE LANDS ROAD

0 40 80
SCALE IN FEET

Sheet 3 of 3

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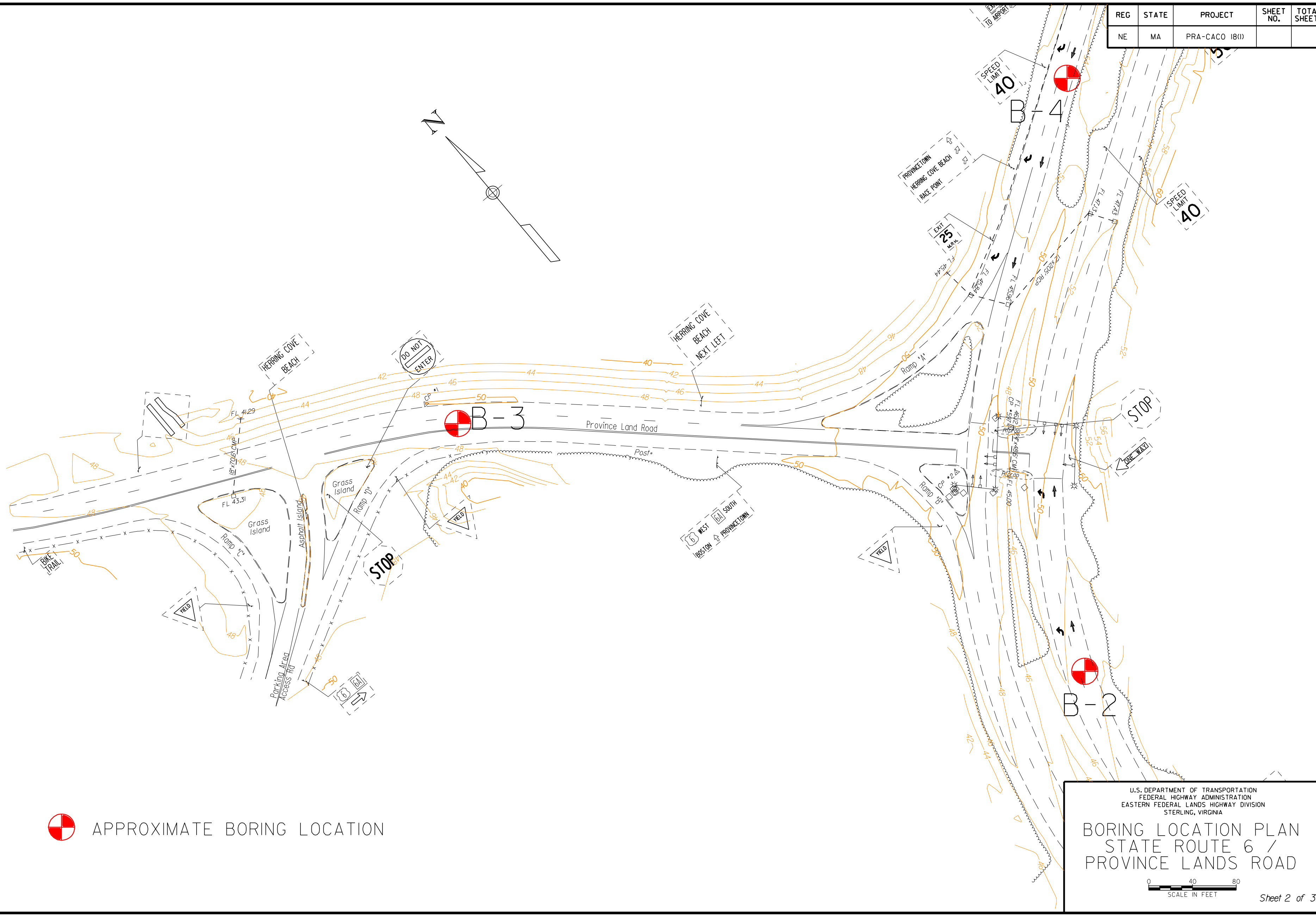
REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
NE	MA	PRA-CACO 18(1)		



APPROXIMATE BORING LOCATION

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

BORING LOCATION PLAN
STATE ROUTE 6 / PROVINCE LANDS ROAD

0 40 80
SCALE IN FEET

Sheet 2 of 3

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BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO 18(1) Boring No.: SR-1 Sheet: 1 of 1

Project Location: Cape Cod National Seashore Boring Location: Rt. 6A, Moors Rd.

Groundwater Depth: Surface Elevation: Boring Began: 9/19/02 Completed: 9/19/02
Encountered at: Caved at: Boring Method: Inspector: Thornton
At Completion: Hammer Wt. & Type: 140 lbs/Auto Hole Diameter: 4" Operator: Kingsley
After hrs Hammer Drop: 30 in. Rock Core Diam: Weather: Clear

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.3	AC **PAVEMENT**						
			Aggregate **BASE**						
		1.7	Loose to Medium dense, brown, medium **SAND** (dry)						
						J-1	1.6	7-12-13-11	●
				5		J-2	1.5	3-4-4-7	●
		6.0	Bottom of borehole at depth 6.0 feet.						
				10					
				15					
				20					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO 18(1) Boring No.: SR-2 Sheet: 1 of 1

Project Location: Cape Cod National Seashore Boring Location: Rt. 6A, Moors Rd.

Groundwater Depth:	Surface Elevation:	Boring Began:	9/19/02	Completed:	9/19/02
Encountered at:	Caved at:	Boring Method:		Inspector:	Thornton
At Completion:	Hammer Wt. & Type: 140 lbs/Auto	Hole Diameter:	4"	Operator:	Kingsley
After hrs	Hammer Drop: 30 in.	Rock Core Diam:		Weather:	Clear

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.4	AC **PAVEMENT**						
		2.0	Aggregate **BASE**						
			Loose to medium dense, brown, medium, **SAND** (dry)			J-1	1.0	7-14-15-13	●
				5		J-2	1.7	5-3-5-12	●
		6.0	Bottom of borehole at depth 6.0 feet.						
				10					
				15					
				20					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:

BORING LOG CACO 18(1).GPJ FHWA_VA.GDT 6/26/07

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO 18(1) | Boring No.: SR-3 | Sheet: 1 of 1

Project Location: Cape Cod National Seashore | Boring Location: Province Lands Road

Groundwater Depth: | Surface Elevation: | Boring Began: 9/19/02 | Completed: 9/19/02
Encountered at: | Caved at: | Boring Method: | Inspector: Thornton
At Completion: | Hammer Wt. & Type: 140 lbs/Auto | Hole Diameter: 4" | Operator: Kingsley
After hrs | Hammer Drop: 30 in. | Rock Core Diam: | Weather: Clear

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.8	AC **PAVEMENT**						
		1.5	Aggregate **Base**						
			Loose to medium dense, brown, medium **SAND** (dry)			J-1	1.4	9-12-15-16	●
				5		J-2	1.5	2-5-5-7	●
		5.5	Bottom of borehole at depth 5.5 feet.						
				10					
				15					
				20					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
The AC pavement included ground up old roadbed and the aggregate included crushed pavement.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO 18(1) Boring No.: SR-4 Sheet: 1 of 1

Project Location: Cape Cod National Seashore Boring Location: State Rt. 6

Groundwater Depth: Surface Elevation: Boring Began: 9/19/02 Completed: 9/19/02
Encountered at: Caved at: Boring Method: Inspector: Thornton
At Completion: Hammer Wt. & Type: 140 lbs/Auto Hole Diameter: 4" Operator: Kingsley
After hrs Hammer Drop: 30 in. Rock Core Diam: Weather: Clear

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit — Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.9	AC **PAVEMENT**						
		5.5	Medium dense, brown, medium **SAND** (dry)	5		J-1	1.6	6-10-13-15	●
						J-2	1.5	5-8-10-8	●
			Bottom of borehole at depth 5.5 feet.	10					
				15					
				20					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
AC pavement includes ground up old road bed.

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO 18(1) Boring No.: SR-5 Sheet: 1 of 1

Project Location: Cape Cod National Seashore Boring Location: State Rt. 6

Groundwater Depth: Surface Elevation: Boring Began: 9/19/02 Completed: 9/19/02
Encountered at: Caved at: Boring Method: Inspector: Thornton
At Completion: Hammer Wt. & Type: 140 lbs/Auto Hole Diameter: 4" Operator: Kingsley
After hrs Hammer Drop: 30 in. Rock Core Diam: Weather: Clear

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.8	AC **PAVEMENT**						
		1.2	Aggregate **BASE** (crushed stone)						
			Medium dense, brown, Medium **SAND** (dry)						
						J-1	1.6	10-10-14-16	●
				5		J-2	1.5	4-9-11-12	●
		6.0	Bottom of borehole at depth 6.0 feet.						
				10					
				15					
				20					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:

BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: CACO 18(1) Boring No.: SR-6 Sheet: 1 of 1

Project Location: Cape Cod National Seashore Boring Location: State Rt. 6

Groundwater Depth: Surface Elevation: Boring Began: 9/19/02 Completed: 9/19/02
Encountered at: Caved at: Boring Method: Inspector: Thornton
At Completion: Hammer Wt. & Type: 140 lbs/Auto Hole Diameter: 4" Operator: Kingsley
After hrs Hammer Drop: 30 in. Rock Core Diam: Weather: Clear

Elevation (feet)	Graphic Log	Layer Depth (ft)	MATERIAL DESCRIPTION Density, Color, Plasticity, Size, Proportions, Moisture	Depth Scale (ft)	SAMPLE Type	No.	Rec.	Blows per 6 in.	▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80
		0.4	AC **PAVEMENT**						
		2.4	Aggregate **BASE**						
		5.0	Medium dense, brown, medium **SAND** (dry)	5		J-1	1.6	7-8-7-6	●
			Bottom of borehole at depth 5.0 feet.	10					
				15					
				20					

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:

BORING LOG CACO 18(1).GPJ FHWA_VA.GDT 6/26/07

APPENDIX F – Photographs

Photo 1 – Route 12, Cracking and Rutting

Photo 2 – Route 12, Rutting

Photo 3 – Route 12, Transverse Cracking

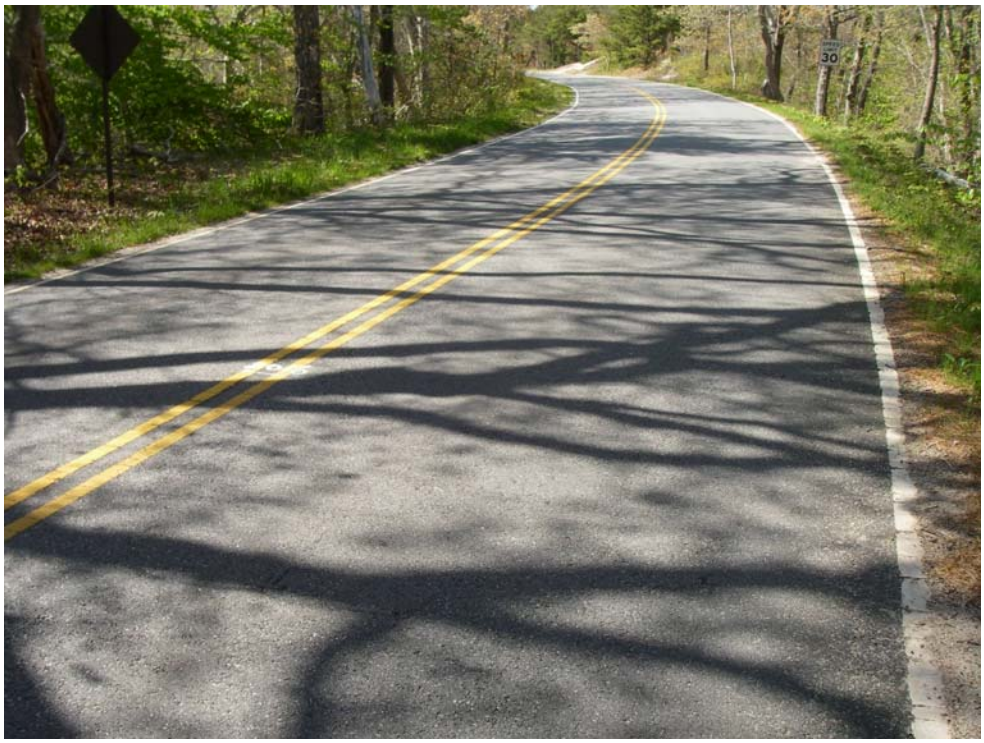

Photo 4 – Route 14, Typical

Photo 5 – US Route 6, Cracking