GOLDEN GATE NATIONAL RECREATION AREA

CA PRA GOGA 104 (1) 105 (2) BUNKER and MITCHELL ROADS

PAVEMENT REPORT

Report # 10-01

Pavement Section
May 2010

SIGNATURE SHEET

Report prepared by: ______________________________
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5/18/2010
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Date

Distribution
Project Management
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Materials

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I. INTRODUCTION

The Golden Gate National Recreation Area encompasses both ends of the Golden Gate Bridge that spans from San Francisco to the Marin Headlands at the north end. The area of focus for this report is this Marin Headlands that accesses Rodeo Beach and the Fort Cronkhite area. The Fort Cronkhite area includes National Park Service offices, the maintenance facilities, and the Marine Mammal Center that provides educational opportunities to school groups. The scope of CA PRA GOGA 104 (1) 105 (2) Bunker and Mitchell Roads is to rehabilitate Bunker Road from the bridge that crosses Rodeo Lagoon to the Fort Barry / Baker Tunnel, a distance of approximately 2 miles; prior to this, the first ½ mile of Bunker Road along with the ½ mile of Mitchell Road and the ¼ mile of Old Bunker Road will be re-constructed, including the 3-way intersection of those roadways. In addition, one paved parking area for the beach maybe re-constructed and a dirt overflow parking area eliminated and re-vegetated. Smith Road and a local route referred to as Rifle Range Bypass maybe rehabilitated for overflow parking with either an asphalt surfacing or reinforced grass surfacing; or these two routes maybe eliminated and re-vegetated.

II. CLIMATE AND THE EXISTING PAVEMENT, SOILS, & GEOLOGY

Climate

The Marin Headlands have a Mediterranean climate. This climate is typified with temperate wet winters that contrast with warm or dry summers. The distinct wet season, begins in October and will last through April or May, and then a dry season through September. Precipitation in January and February averages over 4 inches of rainfall for each month. The average high temperature ranges from 45° F to 65° F and the average low temperature ranging from 35° F to 45° F. The summer months typically have heavy fog in the morning that will burn off by mid to late morning so that the afternoons are pleasant. Fall is the warmest time of the year.

Existing Pavement

In 1972 the U.S. Army turned control of the Marin Headlands over to the NPS, becoming part of the Golden Gate National Recreation Area. Under NPS stewardship, the roads have not had a major rehabilitation. The pavement structural sections date to the U.S. Army which very likely did not perform road work in the years leading up to the turnover to the NPS. The pavement structural sections are then over 35 years old. The roads are actively maintained and patch. At least one surface treatment such as a slurry seal has been applied to the pavement. Patching or cracks at utilities were prevalent.

Table 1: Pavement Conditions for Bunker, Mitchell, & Old Bunker Roads

Stationing	HACP Depth	Pavement Conditions
Bunker Road B-12	115 mm (4.5 inches) average	High severity longitudinal cracks along utility, < 7 mm (¼ inch) settlement at utility right lane, left shoulder has utility-water patch.
Bunker Road B-9 to B-16	125 mm (5 inches) average	High severity alligator cracking 300 mm (12 inches) wide at centerline and high severity edge cracking. Both sets of cracking from old age and not load or fatigue stress.
Bunker Road B-17 to B-27	137 mm (5.5 inches) average	Moderate severity edge cracking, loss of surface fines, rough road texture. Left lane shows more distress than right lane and more distress in outer wheel line.
Bunker Road employee housing McCullogh Rd Intersection	150 mm (6 inches) to 215 mm (8.5 inches)	Speed plateau were built up with hot mix asphalt. No distress on plateau, past plateau high severity alligator cracking in outer wheel lines in both lanes. New sewer line cut right shoulder.
Bunker Road B-28 to B-29	115 mm (4.5 inches) averages	Right shoulder new 8 inches sewer line overlay. Minor to moderate severity alligator cracking left lane in wheel lines.
Mitchell Road Paved Parking (Surfer Parking)	75 mm (3") averages	2 high severity longitudinal cracks at the paving joints.
Mitchell Road B-4 to B-5	37 mm (1.5 inches) average	Surface treatment raveling. Pavement is oxidized with loss of surface fines. No loading or fatigue stress.
Mitchell Road B-6 to B-40	30 mm (1.25 inches) average	Not much of surface treatment left. High severity alligator cracking, with fines pumping. Utility overlay has > 25 mm (1 inch) settlement.
Old Bunker Road	65 mm (2.5 inches) average	High severity alligator cracking generally everywhere. Pavement is old oxidized and has loss of surface fines.

The borings to collect existing pavement thicknesses and subgrade samples were spaced approximately every 400 m (1/4 mile). Discrepancies may occur between borings, including areas of thicker or thinner HACP than listed in Table 1.

The following four charts provide the existing pavement thickness and the underlying material to a depth of 300 mm (12 inches). Note that at boring B-12, at 190 mm (7.5 inches), a hard packed cover material was encountered that could be protecting an utility line.

CA PRA GOGA 104 (1) 105 (2) BUNKER and MITCHELL ROADS

PAVEMENT & BASE COURSE THICKNESSES

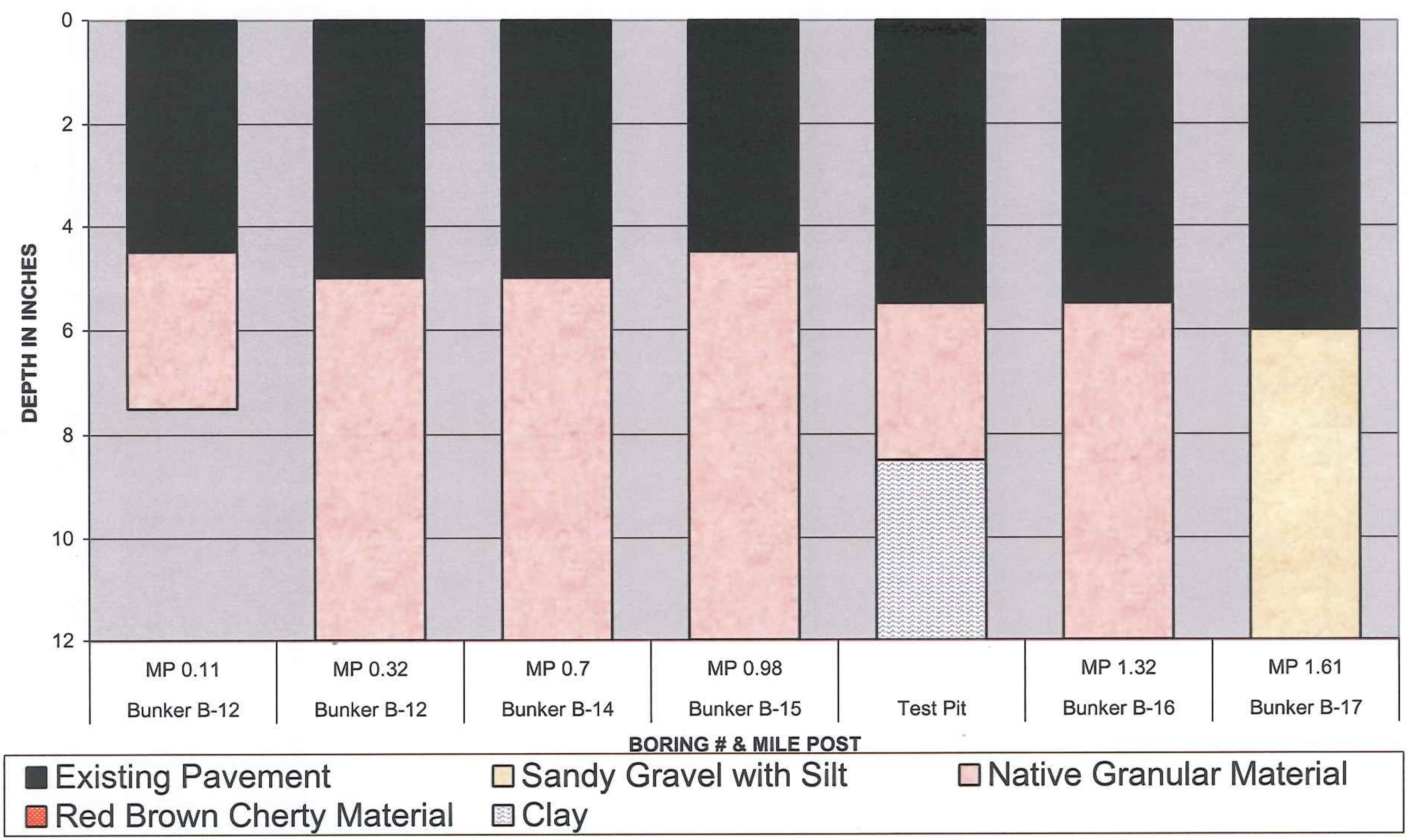


Chart 1

PAVEMENT & BASE COURSE THICKNESSES

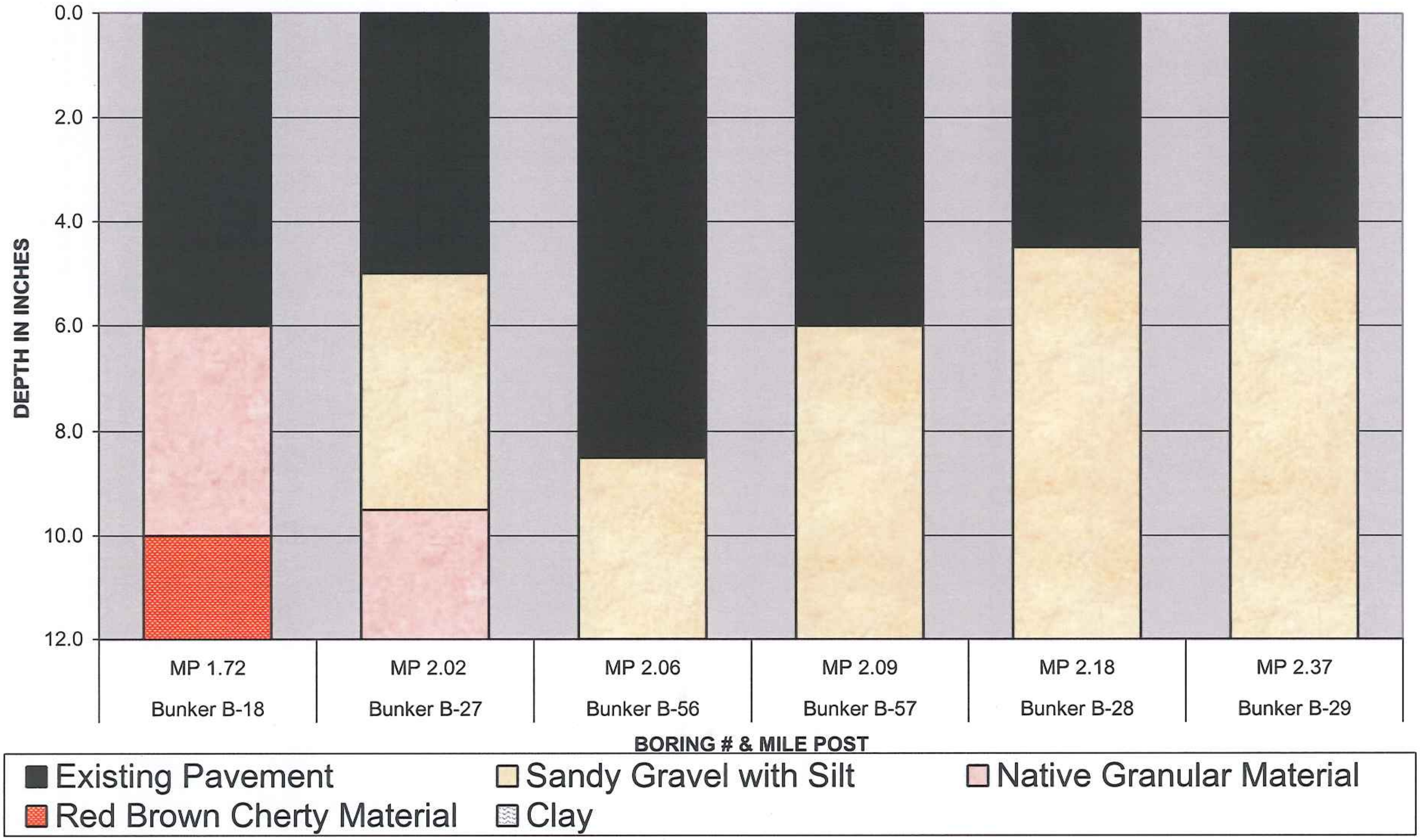


Chart 2

CA PRA GOGA 104 (1) 105 (2) BUNKER and MITCHELL ROADS

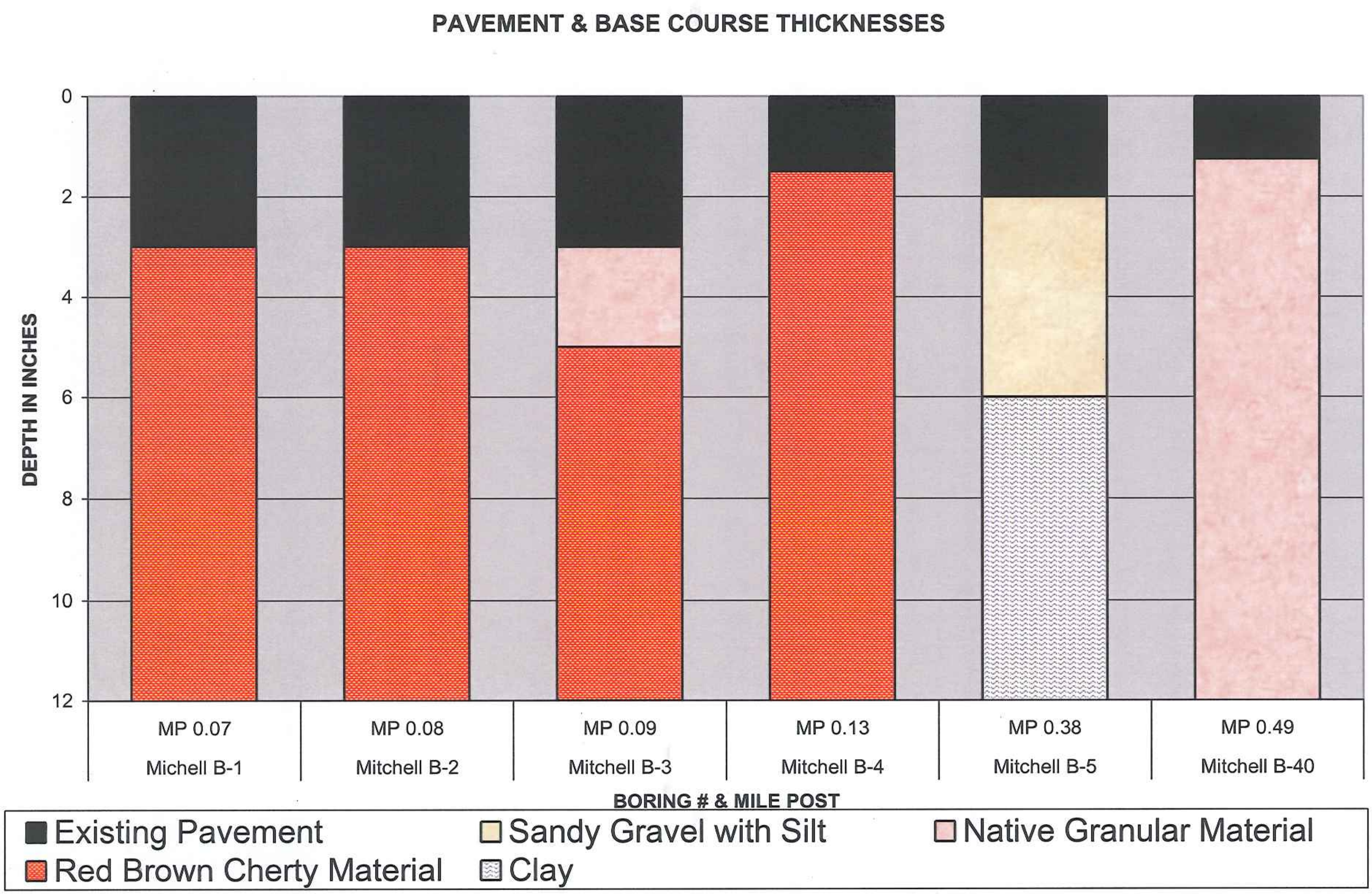


Chart 3

CA PRA GOGA 104 (1) 105 (2) BUNKER and MITCHELL ROADS

PAVEMENT & BASE COURSE THICKNESSES

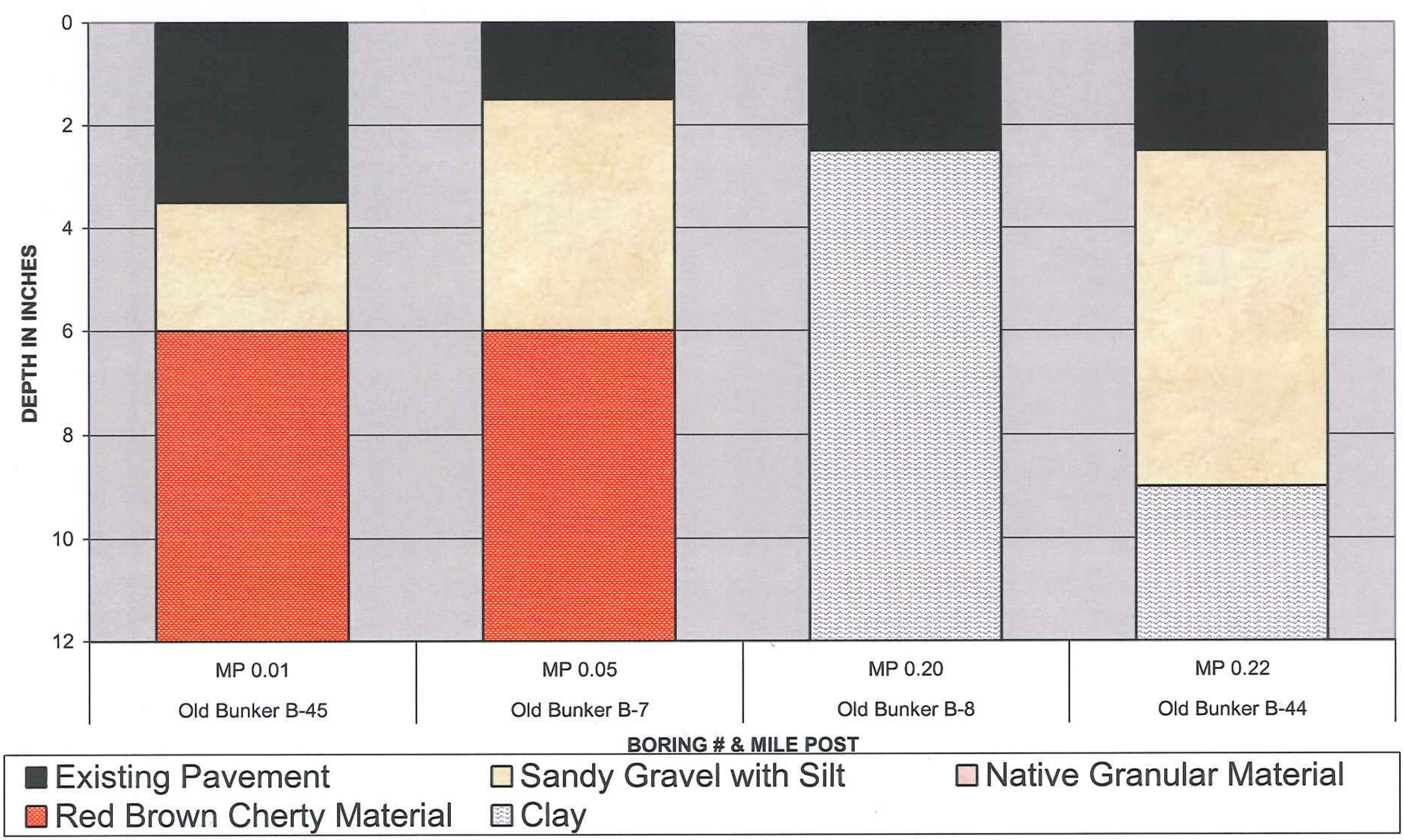


Chart 4

Geology & Soils
From http://www.nps.gov/goga/naturescience/geologicactivity.htm

The topographical relief of the park ranges from sea level to 2,300 feet above mean sea level near the top of Mt. Tamalpais. Hillslopes range from almost flat marine terraces and alluvial deposits to steep canyons above some creeks, and near verticals bluffs above some beaches. Most watersheds are less than one square mile in area, and flow through narrow V-shaped stream beds cut through bedrock. Stream channel gradients range from 3 percent, in Elk Creek to 35 percent, in steep tributaries on Bolinas Ridge.

Golden Gate is located in a seismically active area along a fault line. The Pacific Plate has been slowly creeping northward past the North American Plate at a rate of about one inch a year along the San Andreas Fault for the last 28 million years. The San Andreas Fault extends northward from near Fort Funston, and runs through Bolinas Lagoon and Tomales Bay. The San Andreas is the major fault in the area, but many smaller faults also exist. This movement is expressed as a violent earthquake occurring about once a century. Many earthquakes of lesser magnitude occur along the length of the fault.

Golden Gate also sits above a subduction zone where oceanic crust is moving under continental crust and being recycled. The rocks that compose the geologic foundations, or bedrock, of the Bay Area were formed along this subduction zone over 100 million years ago. Sandstone, Shale, Basalt, and Chert are among the bedrock types present. These rocks belong to the Franciscan Assemblage and were originally deposited on the ocean floor 80 to 140 million years ago. The rocks were greatly deformed and partly metamorphosed as the ocean floor was thrust under the western edge of the North American Plate, resulting in a landscape of easily eroded, sheared and crushed sandstone and shale, with occasional blocks of more resistant rock forming prominent outcrops.

III. EXPLORATION

A pavement and geotechnical investigation was conducted September 9th to the 11th, 2008. A truck mounted CME 45 drill rig from Technicon Engineering Services, Inc. of Fresno, CA at 1-559-276-9311 was used to drill either 300 mm (1 foot) in depth or 1.5 m (5 feet) in depth borings. The shallow borings were spaced 400 m (¼ mile) apart to determine pavement and aggregate base course thicknesses. The 1.5 m (5 feet) borings were to collect soil subgrade samples to identify soil classification and subgrade support values for traffic loading. All the borings were drilled within the roadway. CFLHD staff completed visual identification of the soils and logged the borings. Testing was performed at CFLHD's laboratory.

The pavement investigation began at the three way intersection of Old Bunker, Mitchell and Bunker Roads. This intersection is the beginning of Bunker Road. The investigation proceeded east to the Fort Barry / Baker Tunnel. The investigation then drilled Old Bunker Road and then Mitchell Road, including the paved parking area referred locally as Surfer Parking. Smith Road and Rifle Range Bypass were drilled only to determine existing pavement and aggregate base course thicknesses for determining recycling options. No samples from these two routes were collected. Additional drilling was then performed on Conzelman Road, the current construction project to supplement previous drilling information.

Typical pavement distresses were recorded and photos were taken to further document the condition of the pavement. Laboratory test results and photographs of the boring locations are provided in the appendices in the back of this report.

IV. TEST RESULTS

Table 2 provides a summary of the soil properties evaluated on 8 soil samples from Bunker, Mitchell, & Old Bunker Roads. Appendix B contains the full laboratory reports.

TABLE 2: Soil Summary for Bunker, Mitchell, & Old Bunker Roads

Boring/ Station	Sample Depth	AASHTO Classification	R-Value	Plasticity Index
Bunker Road B-14	450 mm – 760 mm (18 inches – 2.5 feet)	A-2-6(1)	25	17
Bunker Road B-16	140 – 760 mm (5.5 inches – 2.5 feet)	A-2-6 (1)	16	17
Bunker Road B-18	250 mm – 915 mm (10 inches – 3 feet)	A-2-6 (1)	20	18
Bunker Road B-27	125 mm – 915 mm (5 inches – 3 feet)	A-2-6 (0)	21	16
Bunker Road B-29	115 mm – 610 mm (4.5 inches – 2 feet)	A-2-6 (0)	31	15
Mitchell Road B-4	37 mm – 460 mm (1.5 inches – 1.5 feet)	A-2-6 (0)	-	11
Mitchell Road B-4	760 mm – 1525 mm (2.5 feet – 5 feet)	A-4 (0)	-	5
Old Bunker Road B-7	150 mm – 1525 mm (6 inches – 5 feet)	A-6 (4)	6	23

V. PAVEMENT RECOMMENDATIONS AND DISCUSSION

The NPS provided traffic counts from their consultants. In addition, traffic counts were taken by CFL using the High Star counters for the current construction project. Those counters were placed on McCullogh Road and Field Road, collectors for Bunker Road. The four sets of traffic counts were in general agreement and the information is in

Memorandum dated June 8, 2009 in Appendix F. The reported ADT and truck loading are low. The greatest loading and damage will come from the city buses and NPS heavy maintenance vehicles, or trucks servicing the Marine Mammal Center.

The existing asphalt pavements are at the end of their service life. The number of patches, severity and extent of cracking, and raveling from oxidation and over 35 years of exposure to a marine environment eliminates an overlay as cost effective option. The following are the pavement structural sections recommendations for the various routes.

Note: that milled or pulverized pavement meeting the requirements of SCR 303.08 can be used as aggregate base course.

Bunker Road:

Average existing pavement thickness was 125 mm (5 inches) with 120 mm (4.75 inches) of native granular material acting as a base course. Subgrade soil beneath Bunker Road is A-2-6 from 5 soil classifications samples. R-Values ranged from 16 to 31. Based on the 75% Reliability Index, the design R-Value is 20, or a soil resilient modulus of 5000 psi. For Bunker Road the calculated design structural number (SN) is 2.80.

The following structural section typical is **recommended** for **Bunker Road**:

> **115 mm** (4.5 inches) **HACP**
> **175 mm** (7 inches) **FDR – Pulverize** [125 mm (5 inches) HACP + 50 mm (2 inches) native granular soil]
> SN = 2.82
> Grade Raise = 4.5 inches

Mitchell & Old Bunker Roads:

Due to the potential need to re-configure the three way intersection and the resulting grade changes, these two short routes will be re-constructed which also will allow template changes to improve safety. Mitchell Road is more heavily distressed than Bunker Road with Old Bunker Road the most heavily distressed. Based on the design R-Value of 10 for Mitchell Road and the design R-Value of 6 for Old Bunker Road, and the heavier vehicles transiting Old Bunker Road to access the Marine Mammal Center or the NPS maintenance facility, the required SN for Mitchell Road is 3.26; and for Old Bunker Road the SN is 3.38. The existing pavement thickness for Mitchell Road ranges from 37 mm (1.5 inches) to 75 mm (3 inches), averaging 37 mm (1.5 inches); and for Old Bunker Road the existing pavement thickness ranges from 37 mm (1.5 inches) to 90 mm (3.5 inches), averaging 65 mm (2.5 inches). Aggregate base course for both roadways was too inconsistent to include in pavement structural section calculations.

The following structural section typical is **recommended** for **Mitchell Road** and **Old Bunker Road**:

> **100 mm** (4 inches) **HACP**
> **150 mm** (6 inches) **Aggregate Base Course**
> SN = 2.60

Although the SN is not met, the risk is manageable due to the control embankment during construction and low vehicle volume. Each road is receiving a significant enhanced pavement structural section.

Surfer Parking:

Informal name, the existing pavement has high severity cracking but this is not due to fatigue or traffic loading. All 3 borings recorded 3 inches of existing pavement on native clayey granular material. No analysis was performed. The following structural section typical is based on empirical observation and is **recommended** for **Surfer Parking**:

> **75 mm** (3 inches) **HACP**
> **150 mm** (6 inches) **Aggregate Base Course**

The overflow parking area adjacent to Surfer Parking will be re-vegetated. The surface gravel ranged from 3 inches to 6 inches of variable quality that may or may not be salvageable.

Smith Road and Rifle Range Bypass:

This area may be re-paved or turn back to nature, or the existing pavement removed and used as an overflow parking area. If the area is re-paved the following structural section typical is **recommended** for **Smith Road** and **Rifle Range Bypass**:

> **75 mm** (3 inches) **HACP**
> **150 mm** (6 inches) **Aggregate Base Course**

No analysis was performed but the recommendation is based on CFL's minimum typical section and is intended for passenger vehicles. If buses are to use Smith Road or Rifle Range Bypass, the above recommendations need to be re-evaluated.

If the intention of the project is to create at **Smith Road** and **Rifle Range Bypass** areas a more natural setting that will allow overflow parking, the following is **recommended**:

1. Remove the existing pavement and aggregate base course
2. Recondition the subgrade
3. Place 6 inches of a cellular confined aggregate
4. Top with 2 inches of Section 305 Aggregate Topsoil Course

Note: pavement milling or pulverized material will not be allowed under this option.

Pavement Materials

- The HACP should be Item 40201-4700, Hveem Test, Class B, Grading C or E, with Type IV Roughness level if the quantity is 4000 tons or more. If the quantity is less than 4000 tons, use item 40301-0000 HACP. The unit weight can be estimated at 2325 kg/m^3 (145.1 lb/ft^3).
- For antistrip additive, use Type III (Hydrated Lime) at 1%. Quantity for Item 40205-3000 can be estimated at 1% by weight of mix. Antistrip does not apply for Item 403.
- The asphalt cement should be PG 64-28PM. Estimate quantity at 6.5% by weight of mix. This is the binder that will be used on CA PRA GOGA 109(1), 107(1), 108(1), & 418(1). Do not specify the asphalt binder for Item 403.
- HACP thickness of 75 mm (3 inches) or greater shall be placed in two lifts.
- Tack coat is required between HACP lifts and should be estimated at 0.45 l/m^2 (0.10 gal/yd^2). Specify emulsion type to be either CSS-1, CSS-1h, SS-1, or SS-1h emulsion, Item 41201-1000.
- A fog seal bid item 409 should be included in the contract. For determining quantities use an application rate of 0.45 l/m^2 (0.10 gal/yd^2). Specify emulsion type to be either CSS-1, CSS-1h, SS-1, or SS-1h, Item 40920-1000.
- FDR - Pulverize should be Item 30306-3500 Pulverizing, 175 mm depth paid by the m^2. The unit weight can be estimated at 2260 kg/m^3 (141 lb/ft^3).
- A prime coat should be applied on the aggregate base course or pulverized base material prior to paving. The material type should be an emulsion formulated to penetrate. Estimate quantities at an application rate of 1.20 l/m^2 (0.30 gal/yd^2), Item 41101-3000.
- A bid item for blotter material should be included at 8.0 kg/m^2 (14.75 $lb.yd^2$), Item 41105-0000.

Drainage, Subexcavation, and other Issues

During the field investigation of September 2008, there were no major water or drainage problems that were evident concerning the roadbed. The soils for Mitchell & Old Bunker Roads are such that once the existing protective layer of pavement is removed and the subgrade is exposed to the elements such as rain and construction traffic, the subgrade will become muck and require subexcavation or drying. Construction should only be allowed in the dry summer months and no construction allowed from November through March. Provide as a contingency 380 cubic meters (500 cubic yards) of subexcavation & backfill material in the contract to be used at the discretion of the PE.

If subexcavation becomes necessary, Table 3 lists the recommended subexcavation depth based on plasticity index (PI) and liquid limit (LL). Based on soil classification testing, it appears most of the subgrade soil would fall into the 0.6 m depth category.

TABLE 3: Recommended Subexcavation Depth from PDDM, Chapter 11

Plasticity Index (PI)	Liquid Limit (LL)	Depth of Subecavation *
15 – 25	< 50	0.6 m (2 feet)
25 - 35	50 - 60	0.6 m – 1.2 m (2 – 4 feet)
> 35	> 60	1.2 m – 1.8 m (4 – 6 feet)

* Traffic volume, project significance, and results of AASHTO T 258 and T 92 should influence subexcavation depth.

For subexcavated areas, a geotextile separation fabric should be placed and the backfill material can consist of select borrow or millings. The pavement structural section should then match the mainline typical section. Positive drainage such as daylighting the select borrow out to the foreslope or installing an edge drain system should be included. The Pavements Section can be contacted for further details if subexcavating an area becomes an option.

APPENDICES

A – Location Map

B – Laboratory Test Results

C – Photographs

D – Pavement Design Calculations

E – Field Data Summary

F – Memo 6-8-09

APPENDIX A

LOCATION MAP

Hill 88
WOLF RIDGE
Miwok
GERBODE
Bobcat
Coastal
Marine Mammal Center
Old Bunker Rd
Rodeo Lake
Marin Headlands Visitor Center
Miwok
Rodeo Valley
McCullough Road
Bunker Road
Alexander Avenue
Bunker Rd
FORT BAKER
East Rd
Bay Area
Horseshoe Bay
Vista P
FORT CRONKHITE
Rodeo Beach
Mitchell Road
Rodeo Lagoon
FORT BARRY
Headlands Center for the Arts
Hostel
Coastal
Nike Missile Site
Field
Coastal
Conzelman Road
Hawk Hill
Begin one-way traffic
Conzelman Road
Kirby Cove
Kirby Cove
Battery Spencer
Lime Point
Golden Gate Bridge
Bicentennial
Bonita Cove
Bird Island
Bird Island Overlook
Mendel
Point Diablo
MARIN HEADLANDS
Point Bonita Lighthouse
Point Bonita

APPENDIX B

LABORATORY TEST RESULTS

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

U.S. Department of Transportation
Federal Highway Administration

Report of Soil or Aggregate Tests

AASHTO R18 ISO/IEC 17025

Project: California GOGA 104 (1) 105 (2) Rehab Bunker and Mitchell Roads
Submitted By: Steve Deppmeier
Date Reported: 11/4/2008

Sample Number	Lab Number		08-1104-RV	08-1105-RV	08-1106-RV	08-1107-RV	08-1108-RV
	Boring Number		B-7	B-14	B-16	B-18	B-27
	Field Number						
Sample Location	Road Name		Old Bunker	Bunker	Bunker	Bunker	Bunker
	Offset		Right	Left	Left	Left	Right
	Depth		6"-5'	18"-2.5'	5.5"-2.5'	10"-3'	5"-3'
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm					
	1 1/2"	37.5 mm					100
	1"	25.0 mm	100	100	100	100	99
	3/4"	19.0 mm	98	98	97	99	95
	1/2"	12.5 mm	96	92	91	91	87
	3/8"	9.5 mm	92	86	86	86	79
	#4	4.75 mm	80	71	70	72	58
	#8	2.36 mm					
	#10	2.00 mm	69	54	53	54	42
	#16	1.18 mm	63	46	45	46	36
	#30	600 µm					
	#40	425 µm	54	36	35	36	29
	#50	300 µm					
	#100	150 µm	46	28	27	29	22
	#200	75 µm	40	24	24	25	19
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		38	33	32	34	32
	Plasticity Index		23	17	17	18	16
Soil Classification	AASHTO M 145		A-6 (4)	A-2-6 (1)	A-2-6 (1)	A-2-6 (1)	A-2-6 (0)
	ASTM D 2487		SC	SC	SC	SC	GC
AASHTO T 190	R –Value		6	25	16	20	21
AASHTO T 288	Min. Resistivity, ohm-cm			1330			1860
AASHTO T 289	pH			7.5			7.6
AASHTO T 290	Sulfate Content, % / ppm			0.056 / 560			0.024 / 240
AASHTO T 291	Chloride Content, % / ppm			0.0034 / 34			0.0040 / 40

Distribution:	Num. / Project File
Laboratory	Darrell Harding
Pavements	Steve Deppmeier
Materials	1 Copy

Remarks: An FHWA consultant, Colorado Analytical Laboratories, performed the sulfate content and chloride content testing.

Stations or Mileposts were not furnished for the 17 samples.

Reported By:

Darrell Harding

Form FHWA 1702 Rev. 12/01

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

U.S. Department of Transportation
Federal Highway Administration

Report of Soil or Aggregate Tests

AASHTO R18 ISO/IEC 17025

Project: California GOGA 104 (1) 105 (2) Rehab Bunker and Mitchell Roads

Submitted By: Steve Deppmeier

Date Reported: 11/4/2008

Sample Number	Lab Number		08-1109-RV	08-1110-RV	08-1111-RV	08-1112-RV	08-1113-SB
	Boring Number		B-29	B-30	B-32	B-34	B-4
	Field Number						
Sample Location	Road Name		Bunker	Conzelman	Conzelman	Conzelman	Mitchell
	Offset		Right	Mid-Lane	Mid-Lane	Mid-Lane	Right
	Depth		4.5"-2'	1.5"-24"	1.5"-1.5'	2.5"-2.5'	1.5"-18"
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm					
	1 1/2"	37.5 mm	100	100	100		
	1"	25.0 mm	99	99	98		
	3/4"	19.0 mm	96	96	95		100
	1/2"	12.5 mm	84	84	85	100	96
	3/8"	9.5 mm	76	72	77	99	90
	#4	4.75 mm	57	44	54	97	71
	#8	2.36 mm					
	#10	2.00 mm	41	29	37	93	54
	#16	1.18 mm	35	25	29	90	46
	#30	600 µm					
	#40	425 µm	26	19	20	84	36
	#50	300 µm					
	#100	150 µm	20	14	14	68	26
	#200	75 µm	16	11	11	54	20
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %						7.6
AASHTO T 89 & T 90	Liquid Limit		30	31	31	27	28
	Plasticity Index		15	13	13	11	11
Soil Classification	AASHTO M 145		A-2-6 (0)	A-2-6 (0)	A-2-6 (0)	A-6 (3)	A-2-6 (0)
	ASTM D 2487		GC	GW-GC	GP-GC	CL	SC
AASHTO T 190	R –Value		31	46	48	10	
AASHTO T 288	Min. Resistivity, ohm-cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:	Num. / Project File
Laboratory	Darrell Harding
Pavements	Steve Deppmeier
Materials	1 Copy

Remarks: The moisture sample was taken from a sealed plastic bag.

Reported By:

Darrell Harding

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

U.S. Department of Transportation
Federal Highway Administration

Report of Soil or Aggregate Tests

AASHTO R18 ISO/IEC 17025

Project: California GOGA 104 (1) 105 (2) Rehab Bunker and Mitchell Roads

Submitted By: Steve Deppmeier

Date Reported: 11/4/2008

Sample Number	Lab Number		08-1114-SB	08-1115-SB	08-1116-SB	08-1117-SB	08-1118-SB
	Boring Number		B-4	B-14	B-14	B-16	B-30
	Field Number						
Sample Location	Road Name		Mitchell	Bunker	Bunker	Bunker	Conzelman
	Offset		Right	Left	Left	Left	Mid-Lane
	Depth		2.5'-5'	2.5'-3.5'	3.5'-5'	2.5'-3.5'	2'-8'
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm					
	1 1/2"	37.5 mm					100
	1"	25.0 mm					99
	3/4"	19.0 mm					98
	1/2"	12.5 mm					93
	3/8"	9.5 mm	100				88
	#4	4.75 mm	98				69
	#8	2.36 mm					
	#10	2.00 mm	94				58
	#16	1.18 mm	90				50
	#30	600 µm					
	#40	425 µm	77				36
	#50	300 µm					
	#100	150 µm	53				27
	#200	75 µm	40				22
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %		16.0	6.2	15.9	11.7	7.1
AASHTO T 89 & T 90	Liquid Limit		21				29
	Plasticity Index		5				11
Soil Classification	AASHTO M 145		A-4 (0)				A-2-6 (0)
	ASTM D 2487		SC-SM				SC
AASHTO T 190	R –Value						
AASHTO T 288	Min. Resistivity, ohm-cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:	Num. / Project File
Laboratory	Darrell Harding
Pavements	Steve Deppmeier
Materials	1 Copy

Remarks: Moisture samples were taken from sealed plastic bags.

Reported By:

Darrell Harding

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

Report of Soil or Aggregate Tests

AASHTO R18 ISO/IEC 17025

Project: California GOGA 104 (1) 105 (2) Rehab Bunker and Mitchell Roads

Submitted By: Steve Deppmeier

Date Reported: 11/4/2008

Sample Number	Lab Number		08-1119-SB	08-1120-SB			
	Boring Number		B-34	B-35			
	Field Number						
Sample Location	Road Name		Conzelman	Conzelman			
	Offset		Mid-Lane	Mid-Lane			
	Depth		2.5"-2.5'	2"-12"			
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm		100			
	1 1/2"	37.5 mm		97			
	1"	25.0 mm		96			
	3/4"	19.0 mm		92			
	1/2"	12.5 mm		82			
	3/8"	9.5 mm		75			
	#4	4.75 mm		56			
	#8	2.36 mm					
	#10	2.00 mm		41			
	#16	1.18 mm		33			
	#30	600 µm					
	#40	425 µm		23			
	#50	300 µm					
	#100	150 µm		16			
	#200	75 µm		13			
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %		10.6	5.8			
AASHTO T 89 & T 90	Liquid Limit			30			
	Plasticity Index			11			
Soil Classification	AASHTO M 145			A-2-6 (0)			
	ASTM D 2487			GC			
AASHTO T 190	R –Value						
AASHTO T 288	Min. Resistivity, ohm-cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:	Num. / Project File
Laboratory	Darrell Harding
Pavements	Steve Deppmeier
Materials	1 Copy

Remarks: Moisture samples were taken from sealed plastic bags.

Reported By:

Darrell Harding

APPENDIX C

PHOTOGRAPHS

MP 0.00 Bunker Road, B-43, Intersection with Mitchell & Old Bunker Roads

MP 0.02 Bunker Road, B-42 looking east

MP 0.11 Bunker Road, B-12 looking east

MP 0.32 Bunker Road, B-9 looking east

MP 0.70 Bunker Road, B-14 near the equestrian area, looking west

MP 1.32 Bunker Road, B-16 looking east

MP1.61 Bunker Road, B-17 looking east

MP 1.72 Bunker Road, B-18 looking east

MP 2.02 Bunker Road B-27 by Intersection with McCullough Road, looking east

MP 2.09 Bunker Road, B-57 looking east, note utility cut right

MP 2.18 Bunker Road, B-28 looking east, note utility cut right

MP 0.47 Mitchell Road, B-6, looking west

CA PRA GOGA 104 (1) 105 (1) BUNKER and MITCHELL ROADS

MP 0.08 Mitchell Road, informally called Surfer Parking, looking north

MP 0.25 Old Bunker Road, B-44 near Intersection with Mitchell & Bunker Roads, looking south

Smith Road Area , B-48

Smith Road Area, B-50

APPENDIX D

PAVEMENT DESIGN CALCULATIONS

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

BUNKER ROAD

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	185,473
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	5,000 psi
Stage Construction	1
Calculated Design Structural Number	2.80 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,487
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
2	98	0.7	0.0004	0	3,798
4	2	0	1	0	181,675
Total	100	-	-	-	185,473

Growth	Simple
Total Calculated Cumulative ESALs	185,473

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	4.5	-	1.98
2	FDR - PULVERIZE	0.12	1	7	-	0.84
Total	-	-	-	11.50	-	2.82

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

MITCHELL ROAD

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	168,842
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	3,500 psi
Stage Construction	1
Calculated Design Structural Number	3.16 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,264
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
2	98	0.7	0.0004	0	3,457
4	2	0	1	0	165,385
Total	100	-	-	-	168,842

Growth	Simple
Total Calculated Cumulative ESALs	168,842

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	4.5	-	1.98
2	New Base Course	0.14	1	4	-	0.56
3	FDR - PULVERIZE	0.12	1	6	-	0.72
Total	-	-	-	14.50	-	3.26

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

MITCHELL ROAD

Flexible Structural Design

Structural Number	2.6 in
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	3,500 psi
Stage Construction	1
18-kip ESALs Over Initial Performance Period	52,286

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,264
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
2	98	0.7	0.0004	0	3,457
4	2	0	1	0	165,385
Total	100	-	-	-	168,842

Growth	Simple
Total Calculated Cumulative ESALs	168,842

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	4.5	-	1.98
2	New Base Course	0.14	1	4	-	0.56
3	FDR - PULVERIZE	0.12	1	6	-	0.72
Total	-	-	-	14.50	-	3.26

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

OLD BUNKER ROAD

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	168,842
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	3,125 psi
Stage Construction	1
Calculated Design Structural Number	3.30 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,264
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
2	98	0.7	0.0004	0	3,457
4	2	0	1	0	165,385
Total	100	-	-	-	168,842

Growth	Simple
Total Calculated Cumulative ESALs	168,842

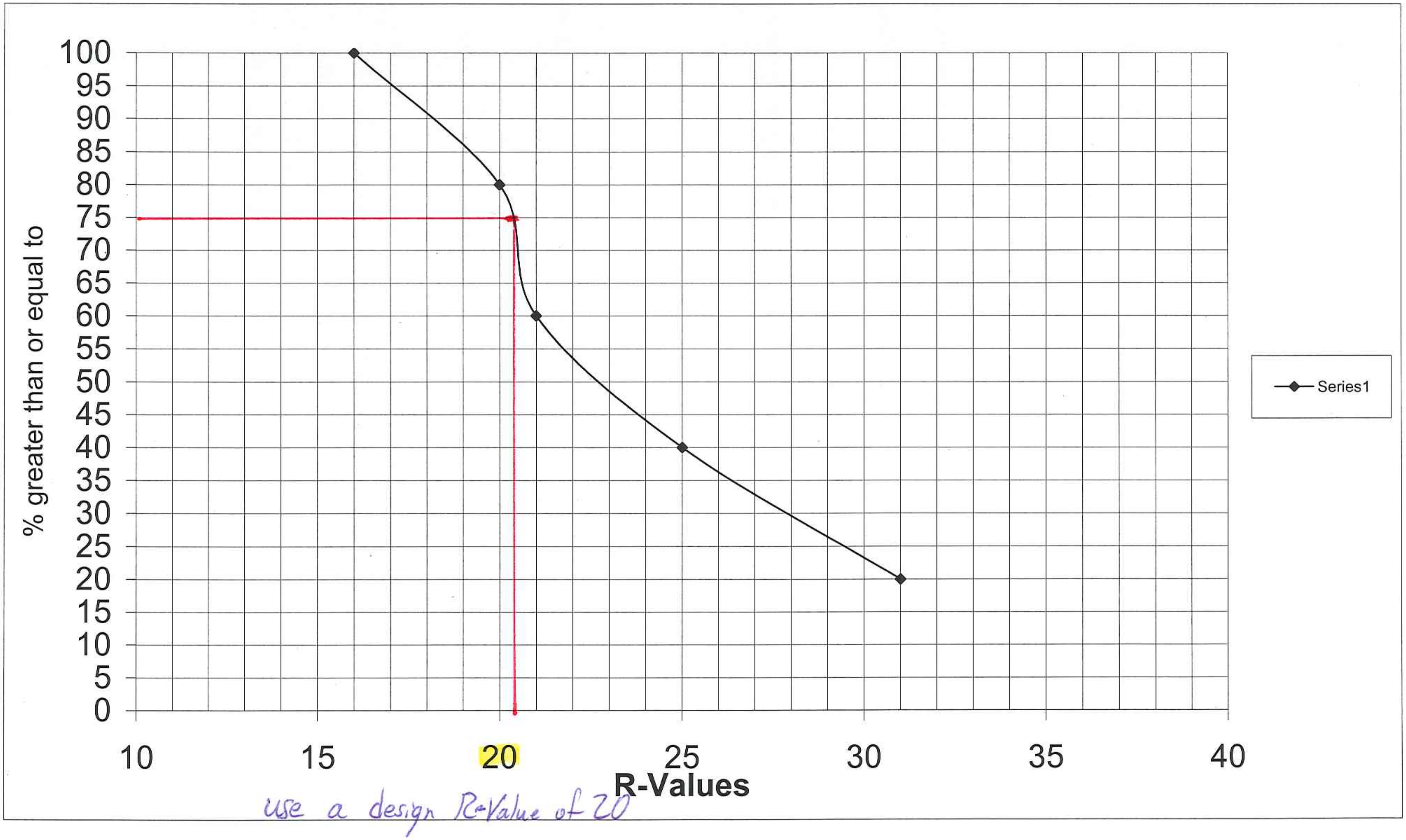
Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	4.5	-	1.98
2	Base Course	0.14	1	10	-	1.40
Total	-	-	-	14.50	-	3.38

CA PRA GOGA 104 (1) BUNKER ROAD

(A) - 5 RV's

31	20	20.0%
25	40	40.0%
21	60	60.0%
20	80	80.0%
16	100	100.0%



APPENDIX E

FIELD DATA SUMMARY

CA PRA GOGA 104(1) BUNKER, MITCHELL, & OLD BUNKER ROADS

	Boring		Log	Description	Note	AASHTO M 145	ASTM D 2487	R-Value	PI	#200	#4	MC %
Bunker Road												
MP 0.02	B-42	geotech	0 - 2.5" 2.5" - 5" 5" - 5'	HACP native clayey granular material acting as a base course red brown gravelly sandy clay								
MP 0.11	B-12		0 - 4.5" 4.5" - 5.5" 5.5" - 7.5" 7.5" -	HACP native clayey granular material acting as a base course silty/clayey Sand w/gravel (-1/2") hardpack cover material for utility(?); HACP cover(?)	At pullout to be re-vegetated Utilities galore, boring at centerline Severe longitudinal crack midlane for utilities, weeds growing in crack Right lane <1/4" settlement at utility Right lane has moderate cracking at utility every 5 feet, left lane has utility-water patch left shouler							
MP 0.10	B-46	dirt pullout	0 - 1' 1' - 2'	light red color silty/clayey gravel w/sand dark, to deep red/brown silty/clayey gravel w/sand, rock is - 3/8", [crusher fines]	Boring closest to chert cliff, -2" broken as opposed to crushed rock							
MP 0.12	B-47	dirt pullout	0 - 1' 1' - 2'	light red color silty/clayey gravel darker silty/clayey gravel w/sand [crusher fines] as at B-46								
	skipped B-10 & 11			B-10 & 11 at bridge approaches, skipped due to utilities & overheads								
MP 0.32	B-9		0 - 5" 5" - 12" 12"	HACP clayey/silty gravel w/sand, gray to dark, gravel rock is mixed of some broken or crushed -1" and native round -1/2" rock HACP and -2" cobbles	Left lane, midlane High alligator 1' wide at centerline, high edge, both sets of cracks from old age No load or fatigue stress Utilities galore							
	skipped B-13			B-13 skipped due to utilities & overheads								
MP 0.70	B-14		0 - 5" 5" - 6" 6" - 18" 18" - 2.5' 2.5' - 3.5' 3.5' - 5'	HACP Clayey gravel Light brown claye/silty gravel w/sand -1" non-crushed, broken as before Dark red brown cherty material Brown clayey/silty gravel w/sand Dark clay, moist	Left lane, midlane High severity utility longitudinal crack High severity centerline longitudinal cracking; no load or fatigue stress	A-2-6 (1)	SC	25	17	24	71	6.2 15.9
MP 0.98	B-15		0 - 4.5" 4.5" - 12" 12" - 18" 18" - 3' 3' - 4.5' 4.5' - 5'	HACP light gray clayey sand w/small gravel pieces -1/2" red brown cherty material three color changes, various clays dark moist high PI clay yellow moist high PI clay	Left lane, midlane High severity distresses @ utilities Patches raveling High severity alligator cracking							
MP 1.21	Test Pit	just before firing range @ Coastal Trail X	0 - 5.5" 5.5" - 8"	HACP base course, clayey gravel -1" fractured rock	at Coastal Trail 'X' Right lane, midlane Top mat 0 - 2.5"; bottom mat 2.5" - 5.5"							

CA PRA GOGA 104(1) BUNKER, MITCHELL, & OLD BUNKER ROADS

	Boring		Log	Description	Note	AASHTO M 145	ASTM D 2487	R-Value	PI	#200	#4	MC %
MP 1.32	B-16		0 - 5.5" 5.5" - 12" 12" - 2.5' 2.5' - 3.5' 3.5' - 5'	HACP light gray clayey sand w/gravel red brown cherty material reddish gravelly clay pea gravel size w/little fines, fines are high PI	Left lane, midlane High severity alligator cracking right lane, outer wheel line	A-2-6 (1)	SC	16	17	24	70	11.7
MP 1.61	B-17		0 - 6" 6" - 14"	HACP brown sandy gravel w/clay & silt -1" broken rock	Right lane, midlane Moderate severity edge cracking Loss of surface fines, everywhere too Rough road texture, no utility distress Left lane outer wheel line losing chipseal							
MP 1.72	B-18		0 - 6" 6" - 10" 10" - 5'	HACP light gray clayey sand reddish brown sandy gravel w/clay & silt -1" natural rock, fill material	Left lane, midlane; fill side, Right is cut High severity alligator cracking, left lane outer wheel line for 20' length High severity longitudinal centerline & outer wheel line cracking, Right lane has loss of surface fines	A-2-6 (1)	SC	20	18	25	72	
MP 2.02	B-27		0 - 5" 5" - 9.5" 9.5" - 2' 2' - 3' 3' - 5'	HACP gray sandy gravel, round rock red brown clayey gravel from driller, rock-chert layer black slightly moist to moist clay, high PI	moderate alligator right & left lanes, owl	A-2-6 (0)	GC	21	16	19	58	
MP 2.06 intersection w/ Lamoraux Dr Speed Plateau	B-56	on speed plateau	0 - 8.5" 8.5" - 11" 11" - 3' 3'	HACP gray sandy gravel more rocky - driller but it is the red brown cherty material just got soft drilling, terminated drilling	no distress on plateau, past plateau, high severity alligator owl both lanes sewer line cut right shoulder							
MP 2.09	B-57	just past plateau	0 - 6" 6" - 20" 20" - 3' 3'	HACP sandy gravel w/silt, -1.5", most -1" crushed smaller gravel, -3/8", sandy gravel w/silt drilling got soft, terminated drilling	moderate severity alligator, left lane owl 20' long, and 3' x 20' c.l. high alligator sewer line cut right shoulder to tunnel							
MP 2.18	B-28		0 - 4.5" 4.5" - 30" 30" - 4' 4'	HACP gray sandy gravel, NP, -1" crushed Red brown cherty material, got more clayey and more moist at 4', softer drilling, terminated boring at 4'	Right shoulder 8" sewer line overlay, minor to moderate alligator left lane inner & outer wheel lines							
MP 2.37	B-29		0 - 4.5" 4.5" - 24" 24" - 5'	HACP gray sandy gravel red brown cherty material, more moist & clay at 5'		A-2-6 (0)	GC	31	15	16	57	

CA PRA GOGA 104(1) BUNKER, MITCHELL, & OLD BUNKER ROADS

	Boring		Log	Description	Note	AASHTO M 145	ASTM D 2487	R-Value	PI	#200	#4	MC %
Mitchell Road												
MP 0.00	B-37	**dirt parking**	0 - 6" 6" - 12" 12" - 24"	chert gravel red brown clay dark clay, high PI, slightly moist to moist								
MP 0.01	B-38	**dirt parking**	0 - 3.5" 3.5" - 7.5" 7.5" - 12"	gravel chert layer red brown chert, ~ #4 rock size								
MP 0.01	B-39	**dirt Parking**	0 - 3" 3" - 12"	gravel yellow sandy clay, slightly moist	Overflow parking area							
MP 0.07	B-1	**Surfer Parking**	0 - 3" 3" - 18"	HACP red brown cherty material, mostly -3/8" but some 1" rock, but more clayey than B-2								
MP 0.08	B-2	**Surfer Parking**	0 - 3" 3" - 18"	HACP red brown cherty material, mostly -3/8" rock sandy/clayey gravel, loosely compacted	2 High severity longitudinal cracks, the paving joints, can pulverize 6" & pave							
MP 0.09	B-3	**Surfer Parking**	0 - 3" 3" - 5" 5" - 12"	HACP clayey gravel, -3/4" non-crushed natuarlly frac rock red brown gravelly clay, slighlty moist to moist								
MP 0.13	B-4		0 - 1.5" 1.5" - 18" 18" - 2.5' 2.5' 2.5' - 5'	HACP red brown cherty material sandy gravel w/clay, low PI, -1", mostly -1/2" rock Black, moist, High PI clay Layer of fine sand Black oozing High PI clay	slurry seal worn off, utility cracks no other distresses	A-2-6 (0) A-4 (0)	SC SC-SM	- -	11 5	20 40	71 98	7.6 16.0
MP 0.38	B-5	geotech At water 'X'	0 - 2" 2" - 6"	HACP Base course, real imported	Old oxidized, loss of surface fines, loss of slurry seal; No loading or fatigue stress. Utility patches at pipe okay, but a large filled in pothole 3' x 3' No rutting, need to peel shoulder - left bac so crown of roadway works							
MP 0.47	B-6	geotech	0 - 1.5" 1.5" - 5'	HACP No base course, dark red brown gravelly sandy clay Same as B-44								
MP 0.49	B-40	geotech	0 - 1.25" 1.25" - +20'	HACP clayey gravel fill	High severity alligator cracking, utility overly of sewer line >1" settlement Not much left of chip seal / slurry seal Low severity alligator, left lane outer wheel line w/fines pumping							

CA PRA GOGA 104(1) BUNKER, MITCHELL, & OLD BUNKER ROADS

	Boring		Log	Description	Note	AASHTO M 145	ASTM D 2487	R-Value	PI	#200	#4	MC %
Old Bunker Road												
MP 0.01	B-45	Marine Mammal	0 - 3.5" 3.5" - 6" 6" - 18"	HACP Base course, 'real' imported red brown cherty material, low to med PI mainly -3/8" but with some 1" rock	High alligator cracking everywhere, Patch, 1/3 length okay except for bottom 1/3 is high alligator cracked							
MP 0.05	B-7		0 - 1.5" 1.5" - 6" 6" - 18" 18" - 30" 30" - 5'	HACP Base course, 'real' imported, non-frac or round, -1/2" red brown cherty material dark clay sandy gravel w/silt, imported fill material	no loading or fatigue stresses High alligator cracking left & right shoulders, c.l., old oxidized, loss of fines	A-6 (4)	SC	6	23	40	80	
MP 0.20	B-8	geotech	0 - 2.5" 2.5" - 8"	HACP Base course, 'real' imported	High severity alligator cracking losing overlay, left lane outer wheel line							
MP 0.22	B-44	geotech	0 - 2.5" 2.5" - 9"	HACP Base course, 'real' imported	Right shoulder - grass area, higher than roadway							
Smith Road												
	B-48		0 - 4" 4" - 12"	HACP sandy/gravelly clay, red brown, med PI, slightly moist to moist								
skipped B-49 overhead wires	B-50		0 - 3.5" 3.5" - 12"	HACP red brown cherty material								
	B-51		0 - 4" 4" - 12"	HACP gravelly clay, med to high PI, slightly moist to moist	At 12" roots in with the clay							
Rifle Range Bypass												
	B-52		0 - 3" 3" - 12"	HACP, bottom seems to have an emulsion to chert material red brown cherty material, low PI to med PI, slightly moist to moist, the classic cherty material								
skipped B-53	B-54		0 - 3.5" 3.5" - 12"	HACP gravelly clay, red brown, med to high PI slighlty moist to moist								
	B-55		0 - 4.5" 4.5" - 12"	HACP gravelly clay, red brown, med to high PI, slighlty moist to moist	This road and Smith Road are old, oxidized and spent Chert material on shoulders							

APPENDIX F

MEMO 6-8-09

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: CA PRA GOGA 104(1) 105(2)
Rehab Bunker and Mitchell Roads
Pavement Recommendations

Date: June 8, 2009

From: Steve Deppmeier,
Pavements Engineer

To: Gary Strike
Project Manager

Jill Mathewson,
Lead Designer

The project consists of Bunker, Mitchell, & Old Bunker Roads that lie within Marin Headlands Unit of the Golden Gate National Recreation Area, Marin County, California. Grades are level except for the sharp rise for the intersection of the three roads. Bunker Road is 4.0 km (2.5 miles) in length, Mitchell Road is 0.8 km (0.5 miles) long, and Old Bunker Road is 0.4 km (0.25) miles long.

Design Assumptions:

- The ADT was provided in the Final Environmental Impact Statement, based on the Nelson\Nygaard 2001b report.
- Bunker Road's ADT is 2487, adjusted for 2011 construction year from ADT of 2319 in 2000 as noted from Nelson\Nygaard August 2000 & spring 2001 traffic counts. ESALs were then computed for 2011 to 2031.
- Mitchell and Old Bunker Roads ADT is 2264, adjusted for 2011 construction year from ADT of 2112 as noted from Nelson\Nygaard August 2000 & spring 2001 traffic counts. ESALs were then computed for 2011 to 2031.
- 0.7% ADT growth factor
- 50/50 traffic per traffic counts
- 24 buses or trucks at 1 ESAL apiece, or 2% of ADT. 98% of the vehicles are generating only 2% of the ESALs.

(Note: School buses during the pavement investigation were observed leaving the Marine Mammal Rescue Center and driving down Mitchell Road to picnic before leaving the area.)

The NPS Maintenance Facility is also located below the Marine Mammal Center so frequent trucks will also access the area.

The 20 year design life pavement typical sections are designed using the 1993 AASHTO Pavement Design.

Bunker Road

The existing typical section on Bunker Road is 125 mm (5 inches) of HACP and 120 mm (4.75 inches) of native granular material acting as a base course. Subgrade soil beneath Bunker Road is A-2-6 from 5 soil classifications samples. R-Values ranged from 16 to 31. Based on the 75% Reliability Index, the design R-Value is 20, or a soil resilient modulus of 5000 psi. Bunker Road has high severity longitudinal and alligator cracking throughout its length. For Bunker Road the calculated design structural number (SN) is 2.80.

The following structural section typical is **recommended** for **Bunker Road**:

115 mm (4.5 inches) **HACP**
175 mm (7 inches) **FDR-Pulverize** [125 mm (5 inches) HACP + 50 mm (2 inches) native granular soil]
SN = 2.82
Grade Raise = 4.5 inches

Mitchell Road

For Mitchell Road, the existing typical section is 37 mm (1.5 inches) HACP over a variable clayey granular material ranging from 100 mm (4 inches) to 450 mm (18 inches) in depth. Mitchell Road is more heavily distressed than Bunker Road. For Mitchell Road the subgrade soil is A-2-6 to 450 mm (18 inches) in depth, and then is classified at A-4, but with a moisture content of 16%. The design R-Value is 10, or a soil resilient modulus of 3500 psi. For Mitchell Road the SN is 3.26.

Old Bunker Road

Old Bunker Road existing typical section is 65 mm (2.5 inches) of HACP and 90 mm (3.5 inches) of imported base course. Old Bunker Road has high severity alligator cracking along with numerous other deficiencies. Old Bunker Road subgrade soil is classified as A-6. The design R-Value is 6, or a soil resilient modulus of 3125 psi. For Old Bunker Road the SN is 3.38.

The minimum Central Federal Lands typical section for re-construction is 75 mm (3 inches) HACP on 150 mm (6 inches) of aggregate base course. Due to the NPS maintenance facility and Marine Mammal Center at the end of Old Bunker Road, an extra inch of HACP is recommended.

The following structural section typcals is **recommended** for **Mitchell Road** and **Old Bunker Road**:

100 mm (4 inches) **HACP**
150 mm (6 inches) **Aggregate Base Course**
SN = 2.60
Grade Raise = as determined by geometric design

Pavement Materials

- The HACP should be Item 40201-4700 HACP, Hveem Test, Class B, Grading C or E, with Type IV Roughness level if the quantity is 4000 tons or more. If the quantity is less than 4000 tons, use Item 40301-0800 HACP, Grading C or E. The unit weight can be estimated at 2325 kg/m3 (145.2 lb/ft^3).
- For antistrip additive, use Type III (Hydrated Lime) with the quantity estimated at 1% by weight of mix. Antistrip does not apply for Item 403.
- The asphalt cement binder should be PG 64-28PM. Estimate quantity at 6.5% by weight of mix. This is the binder that will be used on CA PRA GOGA 109(1), 107(1), 108(1) & 418(1). Do not specify the asphalt binder for Item 403.
- HACP thicknesses of 75 mm (3 inches) or greater shall be placed in two lifts.
- Tack coat is required between HACP lifts and should be estimated at 0.45 l/m^2 (0.1 gal/yd^2). Specify emulsion type to be either CSS-1, CSS-1h, SS-1, or SS-1h.
- A fog seal bid item 409 should be included in the contract. For determining quantities use an application rate of 0.45 l/m^2 (0.10 gal/yd^2). Specify emulsion type to be either CSS-1, CSS-1h, SS-1, or SS-1h.
- FDR – Pulverize should be Item 303. The unit weight can be estimated at 2260 kg/m^3. (141 lb/ft^3).
- A prime coat should be applied on the aggregate base course or pulverized base material prior to paving. The material type should be an emulsion formulated to penetrate. Estimate quantities at an application rate of 1.20 l/m^2 (0.30 gal/yd^2).
- A bid item for blotter material should be included at 8.0 kg/m^2 (14.75 lb/yd^2).

No subexcavation areas were identified during the pavement investigation. Improved drainage features during construction will alleviate water related pavement distresses noted in the field notes in the attachment. Provide as a contingency 380 cubic meters (500 cubic yards) of subexcavation & backfill material in the contract for the discretion of the PE.

Attachments: Field Summary
June 25, 2007 e-mail
December 1, 2005 e-mail
Traffic Information from the Final Environmental Impact Statement

CC: Richard Duval, Pavements Lead Engineer
Ron Andresen, Staff Materials Engineer
Mike Peabody, Materials Engineer
Construction
Project Files

CA PRA GOGA 104(1) BUNKER, MITCHELL, & OLD BUNKER ROADS

	Boring		Log	Description	Note	AASHTO M 145	ASTM D 2487	R-Value	PI	-#200	-#4	MC %
Old Bunker Road												
	B-45	Marine Mammal	0 - 3.5" 3.5" - 6" 6" - 18"	HACP Base course, 'real' imported red brown cherty material, low to med PI mainly -3/8" but with some 1" rock	High alligator cracking everywhere, Patch, 1/3 length okay except for bottom 1/3 is high alligator cracked							
	B-7		0 - 1.5" 1.5" - 6" 6" - 18" 18" - 30" 30" - 5'	HACP Base course, 'real' imported, non-frac or round, -1/2" red brown cherty material dark clay sandy gravel w/silt, imported fill material	no loading or fatigue stresses High alligator cracking left & right shoulders, c.l., old oxidized, loss of fines	A-6 (4)	SC	6	23	40	80	
	B-8	geotech	0 - 2.5"	HACP	High severity alligator cracking losing overlay, left lane outer wheel line							
	B-44	geotech	0 - 2.5" 2.5" - 9"	HACP Base course, real imported	Right shoulder - grass area, higher than roadway							
	B-43	geotech										
Mitchell Road												
	B-37	dirt parking	0 - 6" 6" - 12" 12" - 24"	chert gravel red brown clay dark clay, high PI, slightly moist to moist								
	B-38	dirt parking	0 - 3.5" 3.5" - 7.5" 7.5" - 12"	gravel chert layer red brown chert, ~ #4 rock size								
	B-39	dirt Parking	0 - 3" 3" - 12"	gravel yellow sandy clay, slightly moist	Overflow parking area							
	B-1	Surfer Parking	0 - 3" 3" - 18"	HACP red brown cherty material, mostly -3/8" but some 1" rock, but more clayey than B-2								
	B-2	Surfer Parking	0 - 3" 3" - 18"	HACP red brown cherty material, mostly -3/8" rock sandy/clayey gravel, loosely compacted	2 High severity longitudinal cracks, the paving joints, can pulverize 6" & pave							
	B-3	Surfer Parking	0 - 3" 3" - 5" 5" - 12"	HACP clayey gravel, -3/4" non-crushed natuarlly frac rock red brown gravelly clay, slighlty moist to moist								

CA PRA GOGA 104(1) BUNKER, MITCHELL, & OLD BUNKER ROADS

Boring		Log	Description	Note	AASHTO M 145	ASTM D 2487	R-Value	PI	-#200	-#4	MC %
B-4		0 - 1.5"	HACP	slurry seal worn off, utility cracks	A-2-6 (0)	SC	-	11	20	71	7.6
		1.5" - 18"	red brown cherty material sandy gravel w/clay, low PI, -1", mostly -1/2" rock	no other distresses	A-4 (0)	SC-SM	-	5	40	98	16.0
		18" - 2.5' 2.5' 2.5' - 5'	Black, moist, High PI clay Layer of fine sand Black oozing High PI clay								
B-5	geotech At water 'X'	0 - 2" 2" - 6"	HACP Base course, real imported	Old oxidized, loss of surface fines, loss of slurry seal; No loading or fatigue stress. Utility patches at pipe okay, but a large filled in pothole 3' x 3' No rutting, need to peel shoulder - left bac so crown of roadway works							
B-6	geotech										
B-40	geotech	0 - 1.25" 1.25" - +20'	HACP clayey gravel fill	High severity alligator cracking, utility overly of sewer line >1" settlement Not much left of chip seal / slurry seal Low severity alligator, left lane outer wheel line w/fines pumping							
Bunker Road											
B-42	geotech										
B-12		0 - 4.5 4.5 - 5.5 5.5 - 7.5 7.5 -	HACP native clayey granular material acting as a base course silty/clayey Sand w/gravel (-1/2") hardpack cover material for utility(?); HACP cover(?)	At pullout to be re-vegetated Utilities galore, boring at centerline Severe longitudinal crack midlane for utilities, weeds growing in crack Right lane <1/4" settlement at utility Right lane has moderate cracking at utility every 5 feet, left lane has utility-water patch left shouler							
B-46	dirt pullout	0 - 1' 1' - 2'	light red color silty/clayey gravel w/sand dark, to deep red/brown silty/clayey gravel w/sand, rock is - 3/8", [crusher fines]	Boring closest to chert cliff, -2" broken as opposed to crushed rock							
B-47	dirt pullout	0 - 1' 1' - 2'	light red color silty/clayey gravel darker silty/clayey gravel w/sand [crusher fines] as at B-46								
skipped B-10 & 11		B-10 & 11 at bridge approaches, skipped due to utilities & overheads									
B-9		0 - 5" 5" - 12" 12"	HACP clayey/silty gravel w/sand, gray to dark, gravel rock is mixed of some broken or crushed -1" and native round -1/2" rock HACP and -2" cobbles	Left lane, midlane High alligator 1' wide at centerline, high edge, both sets of cracks from old age No load or fatigue stress Utilities galore							

CA PRA GOGA 104(1) BUNKER, MITCHELL, & OLD BUNKER ROADS

Boring	Log	Description	Note	AASHTO M 145	ASTM D 2487	R-Value	PI	#200	#4	MC %
skipped B-13		B-13 skipped due to utilities & overheads								
B-14	0 - 5" 5" - 6" 6" - 18" 18" - 2.5' 2.5' - 3.5' 3.5' - 5'	HACP Clayey gravel Light brown claye/silty gravel w/sand -1" non-crushed, broken as before Dark red brown cherty material Brown clayey/silty gravel w/sand Dark clay, moist	Left lane, midlane High severity utility longitudinal crack High severity centerline longitudinal cracking; no load or fatigue stress	A-2-6 (1)	SC	25	17	24	71	6.2 15.9
B-15	0 - 4.5" 4.5" - 12" 12" - 18" 18" - 3' 3' - 4.5' 4.5' - 5'	HACP light gray clayey sand w/small gravel pieces -1/2" red brown cherty material three color changes, various clays dark moist high PI clay yellow moist high PI clay	Left lane, midlane High severity distresses @ utilities Patches raveling High severity alligator cracking							
Test Pit just before firing range @ Coastal Trail X	0 - 5.5" 5.5" - 8"	HACP base course, clayey gravel -1" fractured rock	at Coastal Trail 'X' Right lane, midlane Top mat 0 - 2.5"; bottom mat 2.5" - 5.5"							
B-16	0 - 5.5" 5.5" - 12" 12" - 2.5' 2.5' - 3.5' 3.5' - 5'	HACP light gray clayey sand w/gravel red brown cherty material reddish gravelly clay pea gravel size w/little fines, fines are high PI	Left lane, midlane High severity alligator cracking right lane, outer wheel line	A-2-6 (1)	SC	16	17	24	70	11.7
B-17	0 - 6" 6" - 14"	HACP brown sandy gravel w/clay & silt -1" broken rock	Right lane, midlane Moderate severity edge cracking Loss of surface fines, everywhere too Rough road texture, no utility distress Left lane outer wheel line losing chipseal							
B-18	0 - 6" 6" - 10" 10" - 5'	HACP light gray clayey sand reddish brown sandy gravel w/clay & silt -1" natural rock, fill material	Left lane, midlane; fill side, Right is cut High severity alligator cracking, left lane outer wheel line for 20' length High severity longitudinal centerline & outer wheel line cracking, Right lane has loss of surface fines	A-2-6 (1)	SC	20	18	25	72	
B-27	0 - 5" 5" - 9.5" 9.5" - 2' 2' - 3' 3' - 5'	HACP gray sandy gravel, round rock red brown clayey gravel from driller, rock-chert layer black slightly moist to moist clay, high PI	moderate alligator right & left lanes, owl	A-2-6 (0)	GC	21	16	19	58	

CA PRA GOGA 104(1) BUNKER, MITCHELL, & OLD BUNKER ROADS

	Boring		Log	Description	Note	AASHTO M 145	ASTM D 2487	R-Value	PI	-#200	-#4	MC %
intersection w/ Lamoraux Dr Speed Plateau	B-56	on speed plateau	0 - 8.5" 8.5" - 11" 11" - 3' 3'	HACP gray sandy gravel more rocky - driller but it is the red brown cherty material just got soft drilling, terminated drilling	no distress on plateau, past plateau, high severity alligator owl both lanes sewer line cut right shoulder							
	B-57	just past plateau	0 - 6" 6" - 20" 20" - 3' 3'	HACP sandy gravel w/silt, -1.5", most -1" crushed smaller gravel, -3/8", sandy gravel w/silt drilling got soft, terminated drilling	moderate severity alligator, left lane owl 20' long, and 3' x 20' c.l. high alligator sewer line cut right shoulder to tunnel							
	B-28		0 - 4.5" 4.5" - 30" 30" - 4' 4'	HACP gray sandy gravel, NP, -1" crushed Red brown cherty material, got more clayey and more moist at 4', softer drilling, terminated boring at 4'	Right shoulder 8" sewer line overlay, minor to moderate alligator left lane inner & outer wheel lines							
	B-29		0 - 4.5" 4.5" - 24" 24" - 5'	HACP gray sandy gravel red brwn cherty material, more moist & clay at 5'		A-2-6 (0)	GC	31	15	16	57	

Deppmeier, Steve

From: Nedzesky, AJ
Sent: Monday, June 25, 2007 7:25 AM
To: Mathewson, Jill
Cc: Strike, Gary; Deppmeier, Steve; Daigler, Michael
Subject: GOGA counts

Jill,

I left a copy of the traffic counts I worked up over the weekend on your desk. **The numbers that are highlighted are the ones to use.** The values are a first cut and one or two of them may require further refinement (most notably, the number of vehicles on Conzelman after Hawk Hill). Take a look at the numbers and if you have any questions/concerns, send me an email (I'm out of the office most of today). One last thing about the numbers, I converted all of the different traffic counts to 2007 traffic but using the 0.7% growth factor we discussed on Friday; therefore, **all values on the sheet represent 2007 traffic.**

I didn't put any numbers down for buses. Trying to come with a number of passengers is a little tricky, and then I started thinking that if the buses are going to be GOGA shuttle buses, they will run on a set frequency (e.g., one bus per hour, two buses per hour, etc). If this is the case, then the volume of buses in independent of the number of passengers, so the volume would be based on frequency. If we assume a frequency of two buses/hr operating from 8am - 8pm, that comes out to 24 buses. Does this sound reasonable?

AJ

Deppmeier, Steve

From: Dave_Kruse@nps.gov
Sent: Thursday, December 01, 2005 9:05 AM
To: Paul_Bignardi@nps.gov
Cc: Deppmeier, Steve
Subject: Re: Truck Counts at Golden Gate NRA

Steve and Paul - what Paul has laid out below I agree with, except that I would add some allowance for say another 5-10 full size tour buses (e.g. Grey Line) per day on Conzelman Road between US 101 and the proposed roundabout at McCullough.

Dave Kruse
phone: (510) 817-1379 fax: (510) 817-1489

Paul Bignardi
11/30/2005 05:43 PM PST

To: Steve.Deppmeier@fhwa.dot.gov, Dave Kruse/OAKLAND/NPS@NPS
cc:
Subject: Re: Truck Counts at Golden Gate NRA(Document link: Dave Kruse)

November 30, 2005

Dear Steve:

For more information in this area I think you should speak with Dave Kruse at the Pacific West Region - NPS. Dave and I have shared project manager duties on the Marin Headlands-Fort Baker Transportation Plan, but he has more knowledge re. pavement issues and roadways than I do. He is also in tune with the funding aspects of this project much more than I am.

That said, your email did ask a couple of questions that I can respond directly to with answers. On East Road the average number of buses per day
-- that we are aware of that regularly go into Fort Baker is zero.
However, I would assume that school groups -- in buses, visit the Bay Area Discovery Museum at least a few times a week. Buses should be coming to the area (40 foot standard buses) in the next few years. The preferred alternative in the Marin Headlands-Fort Baker Transportation Plan does have about 15-20 buses per day, 7 days a week (I can get an exact number if
needed) operating along East Road, on Center Road, and on Bunker Road between Fort Baker and the intersection just before the Baker-Barry Tunnel.
This number can be split in half to get the number of buses by direction.
Once this service is in place at a future point in time (08?, 09?, later?) I would not expect the number to increase dramatically (e.g. double) for many years if it ever were to increase by that amount.

Conzelman, McCullough, Mitchell and Field Roads all have bus service (40 foot standard buses) - 14-16 trips per day, 1 day a week at the current time. At the current time these other roads do not have any regularly scheduled buses on other days, but do get an occasional tour group or school group that visits (one to a few times per week - especially in summer). Conzelman gets the most traffic - between McCullough and Highway 101, and Field Road probably gets the least. Heavy trucks do not regularly use these roads, and even an informal appearance is very rare. In the preferred alternative of the Marin Headlands-Fort Baker Transportation Plan these numbers are supposed to increase to 14-16 trips per day - 2 days a week, and possibly all 7 days a week. There is a small chance the service numbers could increase to 30 trips per day 2 days a week, but it is also not in the near term.

I hope this information has been helpful.

Paul Bignardi
Transportation Planner
National Park Service - Golden Gate NRA

"Deppmeier, Steve"
<Steve.Deppmeier@fhwa.dot.gov>

11/21/2005 10:11 AM MST

To: <paul_bignardi@nps.gov>
cc:
Subject: Truck Counts at Golden Gate NRA

Paul,
You sent me the traffic counts this summer. The data was collected before you arrived at GOGA. You were going to check on the number of buses per day, particularly for East Road. Has the museum(?) or other attractions gotten back to you on the number of buses that come in per day? How about the other roads, Conzelman, McCullough, or Field? Also truck counts. What I am looking for is heavy axle loads. 9600 passenger cars equal the wear of one truck. I need to confirm my pavement thickness design and would like to eliminate some assumptions. Thanks

Steve Deppmeier
Pavements Engineer
CFLHD
12300 West Dakota Ave, Suite 210
Lakewood, CO 80228-2683
720-963-3504

East Road. Unlike all other roads in this plan that are under the jurisdiction and control of the National Park Service, Alexander Avenue is under the joint jurisdiction and control of Golden Gate National Recreation Area, Caltrans, and the Golden Gate Bridge Highway and Transportation District because it is an approach road to the Golden Gate Bridge.

- *East Road* — a two-lane, two-way north-south roadway that runs between Alexander Avenue and the Fort Baker parade ground.
- *Bunker Road* — a two-lane road between Fort Cronkhite, Fort Barry, Rodeo Valley and Fort Baker. To the north, it provides access to the Marin Headlands through the one-lane Barry-Baker tunnel between Fort Baker and the Fort Barry area. Motor vehicle travel through the tunnel alternates between eastbound and westbound traffic and is controlled by traffic signals on each end of the tunnel. Four-foot-wide, striped Class 2 bicycle lanes are provided for several hundred feet on both sides of the tunnel.

As described in Chapter 2, several geometric improvements will be made to roads in Fort Baker as part of the *Fort Baker Plan Record of Decision.*

Traffic Volumes and Flow

Information on traffic volumes and flow is based on the results of a comprehensive data collection effort performed on a total of 14 days during the summer of 2000 and the spring of 2001. Traffic data were collected on all of the park's major roads and key intersections on weekdays and weekends during both seasons. Observations were also made of the transportation mode used by visitors to access the park (Nelson\Nygaard 2001b). This information is organized as follows: Marin Headlands and Fort Baker, Alexander Avenue, and U.S. 101. The future conditions anticipated from the proposed Fort Baker conference center are also discussed.

Traffic Volumes in the Marin Headlands

Vehicle counts on Conzelman Road (west of the U.S. 101 southbound on-ramp) and Bunker Road (west of the Barry-Baker tunnel) indicate that the total combined daily vehicle trips entering or exiting the Marin Headlands on both roads is approximately 4,000 during a spring weekday and 5,800 during a summer weekday (Nelson\Nygaard 2001b).

As shown in Table 3-1, the average daily traffic volumes on spring weekend days is 9,400, and on summer weekend days about 10,200. Average daily traffic volumes on weekends are about twice that on the weekdays during spring and summer.

For both spring and summer, about two-thirds of all inbound and outbound trips into the Marin Headlands are via Conzelman Road. The other one-third are made via the Barry-Baker tunnel.

TABLE 3-1. AVERAGE DAILY TRAFFIC VOLUMES ENTERING AND EXITING THE MARIN HEADLANDS

Location	Entering (Westbound)		Exiting (Eastbound)		Total In and Out	
	Summer 2000	Spring 2001	Summer 2000	Spring 2001	Summer 2000	Spring 2001
Weekday						
Bunker Road	915	774	1,150	914	2,065	1,688
Conzelman Road	1,808	1,306	1,934	1,039	3,742	2,345
Total	2,723	2,080	3,084	1,953	5,807	4,033
Saturday						
Bunker Road	1,768	1,155	1,175	1,661	2,943	2,816
Conzelman Road	3,520	3,813	3,709	2,764	7,229	6,577
Total	5,288	4,968	4,884	4,425	10,172	9,393
Sunday						
Bunker Road	1,703	1,469	1,261	1,975	2,964	3,444
Conzelman Road	3,655	3,608	3,519	2,464	7,774	6,072
Total	5,358	5,077	4,780	4,439	10,138	9,516
Daily Average						
Bunker Road	1,002	928	1,317	1,172	2,319	2,100
Conzelman Road	2,414	2,043	2,316	1,523	4,730	3,566
Total	3,416	2,971	3,633	2,695	7,049	5,666

SOURCE: Nelson\Nygaard 2001b.
NOTE: Summer 2000 volumes were collected between August 9 and August 15. Spring 2001 volumes were collected between April 19 and May 2. Bunker Road counts were taken west of the Barry-Baker tunnel. Conzelman Road counts were taken west of the U.S. 101 southbound on-ramp.

TABLE 3-6. TRANSPORTATION MODE OF ACCESS USED BY VISITORS TO THE MARIN HEADLANDS

	Volume		Visitors		Percentage of Total	
Mode	Summer 2000	Spring 2001	Summer 2000	Spring 2001	Summer 2000	Spring 2001
Data collected Friday, August 4, 2000, and Friday, April 27, 2001						
Vehicle	2,724	1,743	5,242	2,989	88.3%	91.0%
Pedestrian	1	2	1	2	0.0%	0.1%
Bicycle	116	100	116	100	2.0%	3.0%
Bus*	20	12	577	195	9.7%	5.9%
Total			5,936	3,286	100.0%	100.0%
Data collected Saturday, August 5, 2000, and Saturday, April 21, 2001						
Vehicle	4,184	5,300	8,927	11,807	90.5%	91.2%
Pedestrian	29	34	29	34	0.3%	0.3%
Bicycle	501	816	510	816	5.1%	6.3%
Bus*	12	11	406	286	4.1%	2.2%
Total			9,863	12,943	100.0%	100.0%
Data collected Sunday, August 6, 2000, and Sunday, April 22, 2001						
Vehicle	4,420	4,636	10,003	10,489	92.3%	91.7%
Pedestrian	14	23	14	23	0.1%	0.2%
Bicycle	351	679	351	679	3.2%	5.9%
Bus*	19	16	474	250	4.4%	2.2%
Total			10,842	11,441	100.0%	100.0%

SOURCE: Nelson\Nygaard 2001b.
*Bus includes school buses, private buses, chartered buses, and MUNI buses.

TABLE 3-7. TRANSPORTATION MODE OF ACCESS USED BY VISITORS TO FORT BAKER

	Volume		Visitors		Percentage of Total	
Mode	Summer 2000	Spring 2001	Summer 2000	Spring 2001	Summer 2000	Spring 2001
Data collected Friday, August 4, 2000, and Friday, April 27, 2001						
Vehicle	1,180	669	1,765	1,005	88.5%	86.9%
Pedestrian	32	7	32	7	1.6%	0.6%
Bicycle	28	10	28	10	1.4%	0.9%
Bus*	6	9	169	135	8.5%	11.7%
Total			1,994	1,157	100.0%	100.0%
Data collected Saturday, August 5, 2000, and Saturday, April 21, 2001						
Vehicle	1,144	1,076	2,214	2,034	93.2%	90.9%
Pedestrian	41	16	41	16	1.7%	0.7%
Bicycle	80	50	80	50	3.4%	2.2%
Bus*	2	6	40	138	1.7%	6.2%
Total			2,375	2,238	100.0%	100.0%
Data collected Sunday, August 6, 2000, and Sunday, April 22, 2001						
Vehicle	1,627	1,042	3,344	1,965	87.9%	91.0%
Pedestrian	36	55	36	55	0.9%	2.5%
Bicycle	34	49	34	49	0.9%	2.3%
Bus*	14	2	392	90	10.3%	4.2%
Total			3,806	2,159	100.0%	100.0%

SOURCE: Nelson\Nygaard 2001b.
*Bus includes school buses, private buses, chartered buses, and MUNI buses.

organism. Aside from the radiolaria, the only other known fossil in the vicinity was recovered from sandstone close to the Golden Gate Bridge and outside any areas proposed for change in this plan. The radiolaria is considered a very common fossil in the Marin Headlands because of its abundance (Elder, pers. comm. 2004; Murchey, pers. comm. 2004).

Soils

The Marin Headlands and Fort Baker are primarily covered with soils of the Cronkhite-Barnabe, Tamalpais-Barnabe, and Rodeo complexes. These soils are characterized by slow to moderate permeability, rapid stormwater runoff, and a high hazard of soil erosion, soil creep, and occasional land sliding (Natural Resources Conservation Service 1985). As previously discussed, trails, roadways, and parking areas have resulted in soil erosion. In some locations such as Conzelman Road, culvert improvement projects have been undertaken to control erosion. Although these projects have stopped gully erosion, the scarring remains. Smaller, less visible

Table 4-1 summarizes the results of the parking utilization analysis. The data for peak utilization was collected in July 2000 and refers to the maximum number of spaces that are used in a given parking area during a weekend day. The percentages for projected utilization in 2023 refer to the expected demand for parking spaces in relation to the planned number of parking spaces. Percentages greater than 100% indicate that demand will exceed available spaces. The assumed parking demand levels in 2023 were based on the parking utilization rates in 2000 adjusted by the projected traffic growth factors (1.175 for Alternatives 1 and 2, 1.169 for Alternative 3, and 1.156 for Alternative 4). Total parking changes under each alternative are shown in Appendix C.

A reduction in the demand for parking in relation to parking supply or an increase in parking supply relative to parking demand would be a beneficial impact. An increase in parking demand or a decrease in parking supply would be an adverse impact.

Impacts of Alternative 1 — No-Action Alternative

Impact Analysis

Traffic

Traffic Volume. Year 2023 traffic projections were calculated using an annual growth rate of 0.7% applied to the roadway segment traffic volumes calculated from existing counts. The expected traffic volumes from the *Fort Baker Plan* were added to the traffic forecasts for 2023 along Alexander Avenue, Bunker Road, and East Road. Because the roadway network, parking supply, and transit service would remain the same as existing, no other factors were applied to the traffic volumes on each roadway segment.

There would be no traffic volume changes in the Marin Headlands or Fort Baker as a result of this alternative. Therefore, there would be no traffic volume impacts. The estimated traffic volumes under each alternative are summarized in Figure 4.2.

Level of Service. An LOS analysis was performed for five intersections and two roadway segments. Peak-hour traffic at these locations was estimated based on existing peak-hour percentages and expected alternative traffic distributions. The Conzelman Road / McCullough Road, Bunker Road / Danes Drive, Alexander Avenue / Danes Drive, and Alexander Avenue / U.S. 101 northbound on-ramp intersections were analyzed as unsignalized T intersections. The Bunker Road / McCullough Road intersection was analyzed as the existing unsignalized Y intersection.

There would be no changes to the level of service at intersections within the Marin Headlands or Fort Baker under existing conditions, and proposed improvements are not anticipated to affect levels of service at park intersections.

Vehicular Safety

Roadway improvements would not be adopted under Alternative 1. Consequently, there would be no impacts to vehicular safety.

Parking Utilization

Parking supply would not be changed under Alternative 1, and there would be no actions that would change the demand for parking. There would be no impact on parking utilization.

Cumulative Impacts

Alternative 1 would have no direct impacts on traffic, vehicular safety, or parking utilization. As a result, there would be no cumulative impacts associated with this alternative.

Mitigation Measures

There would be no mitigation measures for this alternative.

Conclusion

There would be no long-term, short-term, or cumulative impacts to traffic, vehicular safety, or parking utilization as a result of this alternative.

Impacts of Alternative 3 — Preferred Alternative

Impact Analysis

Traffic

Traffic Volume. The reduction in automobile trips impacts under Alternative 3 were applied to the traffic volumes accessing the park and circulating within the park. Almost 17% of existing parking spaces within the Marin Headlands would be eliminated under this alternative. Some of the