U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division
12300 West Dakota Avenue
Lakewood, CO 80228

Memorandum

Subject: WY HPP 4-1(4) Beartooth Rehabilitation Project – Pavement Recommendations

Date: 8-29-08

From: Mike Voth
Pavement Discipline Leader
Lakewood, CO

To: Bert McCauley
Project Manager
Lakewood, CO

This project has potentially three different scopes / purposes as related to the pavement design and recommendations. (1) From Sta 50+770 to Sta 69+565 (11.75 miles) the intention is to complete a long-term performing pavement rehabilitation, and (2) from Sta 39+780 to 50+770 (6.9 miles) the intention is to complete patching, crack sealing, and a thin overlay to add short-term service life, and (3) from Sta 44+700 to 45+800 (0.7 miles) is bridge and roadway reconstruction. This last scope will not be addressed in this memo as pavement recommendations are to follow the guidance from a previous report (Report 98-16).

Pavement recommendations from Sta 50+770 to Sta 69+565 are as follows:

- 50 mm HACP
- 150 mm FDR-Pulverize
- SN = 1.60

All of the pavement design inputs are included in an attachment. To summarize a couple of the key inputs: the design subgrade resilient modulus value used (M_R) was 15,000 psi, and the amount of ESALs calculated for a 20-year period was about 110,000. This is based upon an AADT of 500 and 5% heavy vehicles. These traffic parameters were attained from engineering judgment as measured traffic data was not supplied. The required structural number (SN) is 1.65. The relatively high M_R value is based on R-values that are all well above 60 and most above 70.

It should be noted that a pavement structural section with an SN slightly less than 1.65 is being recommended. This will result in a calculated service life of about 17 years. However, given the limited project funding and the desire to rehabilitate as much of the roadway as

possible, the CFT agreed that it was acceptable to go forward with a less than 20-year design in the base schedule and employ a technical standard design exception. To help mitigate the performance risk of this nominal structural section, an option will be included in the contract to add an additional 25 mm of HACP, pending availability of funds.

Because the recommended pavement design in the base schedule includes only a thin 50 mm HACP surface without any conservativeness, achieving 95% compaction of the pulverized material and assuring there is a stable platform to pave on will be very important. Areas of pulverized material that are not properly compacted or properly maintained under traffic will result in premature fatigue cracking in the HACP surface.

It should also be noted that the boring information in Materials Report 98-16 indicates the presences of cobbles and possibly even boulders within the depth of the pulverized layer. A project specific SCR for section 303 was developed to address this issue. Report 98-16 is included as an attachment.

Pavement recommendations for Sta 39+780 to Sta 50+770 are as follows:

- 38 mm HACP overlay
- Pre-overlay repair: Sawcut and remove pavement in areas of moderate and high severity fatigue cracking; and backfill with base and HACP (per section 428). An acceptable alternative to this patching would be to allow the distressed area to be pulverized and re-compacted (per section 303) prior to overlay.
- Pre-overlay repair: Seal transverse and longitudinal cracks less than 25 mm and greater than 3 mm with a hot pour elastic sealant (AASHTO M 324, Type II); recommended that working cracks (i.e. thermal cracks) be routed. Fill cracks greater than 25 mm with a 404 or 417 type asphalt material.

The scope of the above recommendations is to preserve and add additional service life to the roadway at a minimal cost. Per the PDDM, no structural design is required when completing a preservation treatment. A chip seal would be an acceptable alternative to the thin overlay. However, given the very short construction season, cool summer temperatures of the project location, and the fact that HACP is already included in the project, it was anticipated that an HACP overlay would be most appropriate and cost effective.

Pavement Material Recommendations:

- HACP can be 401 Superpave or 402 Marshall. The grading should use a 12.5 mm nominal maximum size aggregate. Pavement roughness should be Type IV for segments, Sta 50+770 to Sta 69+565 and Sta 39+780 to Sta 50+770. The unit weight can be estimated at 2325 kg/m^3. The 50 mm and 38 mm depth HACP will be placed in 1 lift.
- Hydrated lime (Type III), at 1% of the unit weight of the HACP, will be the antistrip additive.
- The asphalt binder grade per the LTPPBind software program at 95% or greater reliability should be a PG 58-34. WFLHD's current *reconstruction* project on Beartooth is using a PG 58-34 graded binder. However, the scope of this project includes a thin overlay on a distressed pavement and a pavement rehabilitation on a segment that's closed to traffic and covered with snow (insulated) during the cold winter months. <u>As a result it is recommended</u>

to use a PG 58-28 graded binder. This is one of the common grades used in the area, and it will be cost effective. The CFT can decide to use a "higher" grade, but this most likely will result in higher costs that would be difficult to justify.

- A prime coat should be applied on the pulverized material prior to paving on the segment from Sta 50+770 to Sta 69+565. Bid item 41101-0000 should be used and the material should be a formulated to penetrate the surface at least 6 mm or it must be worked into the surface. The quantity can be estimated at 1.5 L/ m^2. A bid item for blotter material, 41105-0000, should also be included (at 8 kg/ m^2).
- A tack coat, bid item 41201-1000 should be included for the segment from Sta 39+780 to Sta 50+770. For estimating quantities use an application rate of 0.45 L/m^2. The emulsion type can be CSS-1, SS-1, CSS-1h, or SS-1h.
- Crack cleaning, sealing, and routing should be completed as discussed in the pavement recommendations above. An estimated linear quantity measured from a field visit should be used for plan quantities.

Attachments

cc:
Tech Services files
Acquisitions
Bill Hakala, COE

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

- 1000 ADT when route is open (closed half the year - used 500 ADT)
- Assume 5% heavy vehicles (using an RV as typical heavy vehicle)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	109,575
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	15,000 psi
Stage Construction	1
Calculated Design Structural Number	1.65 in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	500
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	5 %
Average Initial Truck Factor (ESALs/truck)	1
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	0 %
Growth	Compound
Total Calculated Cumulative ESALs	109,575

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	2	-	0.88
2	FDR-Pulverize	0.12	1	6	-	0.72
Total	-	-	-	8.00	-	1.60

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Calculate ESALs (perf life) on the as recommended section

Flexible Structural Design

Structural Number	1.6 in
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	15,000 psi
Stage Construction	1
18-kip ESALs Over Initial Performance Period	91,479

Five Closest Weather Stations For Latitude/Longitude= 45.084/109.972
Report Date: 7/21/2008
(LTPPBind V3.0 Alpha)

Three Closest WS Report Title

General	A=8 km	B=24 km	C=38 km	D=43 km	E=52 km
Station ID	MT1995	MT5961	WY9025	MT6190	MT3378
County/District	park	stillwater	yellowstone national	stillwater	park
Weather Station	cooke city 2 w	mystic lake	tower falls	nye 2	gardiner
Elevation, m	2113	1858	1774	1362	1494
Latitude, Longitude	45.02 ,109.97	45.23 ,109.75	44.92 ,110.42	45.43 ,109.8	45.03 ,110.68
Last Year Data Available	1997	1997	1997	1997	1997
Air Temperature	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)
High Temperature	26.7 (13,26)	27.5 (13,35)	29.8 (16,26)	31.3 (22,16)	33 (15,29)
Low Temperature	-35.2 (36,23)	-29.3 (40,35)	-36.8 (42,28)	-32.1 (45,16)	-29.1 (35,31)
Low Temperature Drop	29.5 (30,23)	27.8 (42,35)	32.2 (36,28)	32.4 (44,16)	27.4 (32,31)
Degree-Days > 10C	1439 (183,26)	1648 (170,35)	1960 (219,26)	2261 (227,16)	2494 (231,29)
PG	High Low Rel.	High Low Rel.	High Low Rel.	High Low Rel.	High Low Rel.
Pavement Temperature, C	41.4 -26.3	43.7 -22.1	47.0 -27.4	49.9 -24.2	52.1 -21.9
50% Reliability PG	46-28 (98,70)	46-28 (94,95)	52-28 (98,57)	52-28 (88,84)	58-22 (98,52)
>50% Reliability PG	46-34 (98,98)	52-28 (98,95)	52-34 (98,96)	52-34 (88,98)	58-28 (98,97)
=		52-34 (98,98)	52-40 (98,98)	58-34 (98,98)	58-34 (98,98)
=					
=					
=					

WYOMING
BEARTOOTH HIGHWAY
Mile Post 24.5 to Mile Post 43.1
Preliminary Materials Report

October 1998
REPORT 98-16

Investigation and Reported by:
Wayne Folkman, Materials Engineering Technician

Technical Services Branch
Central Federal Lands Highway Division
Federal Highway Administration
Denver, Colorado

Distribution

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10/5/98

DATE

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INTRODUCTION

The Beartooth Highway is a 110.5-kilometer (68.7-mile) route that begins at the northeast entrance to Yellowstone National Park near Silver Gate, Montana. It runs north easterly through Wyoming and Montana, and ends in Red Lodge, Montana. The first 13.5 kilometers (8.4 miles) of the route lies within Montana, passes through the communities of Silver Gate and Cooke City, and goes over Colter Pass. The next 55.8 kilometers (34.7 miles) of the route lies within Wyoming. It climbs from the Clark's Fork of the Yellowstone River to Beartooth Pass, which stands at 3,337 meters (10,947 feet) above sea level. The last 38.1 kilometers (23.7 miles) of the route lies within Montana. It descends from the Beartooth Plateau into Rock Creek valley and then ends in Red Lodge.

The Beartooth Highway is considered one of the most scenic routes in the United States, and from this highway travelers can see spectacular views of the Beartooth Mountain Range. The route is one of the highest highways in the country.

The Beartooth Highway serves as the northeast entrance to Yellowstone National Park. It is also known as the Red Lodge-Cooke City Highway and as the Beartooth Highway. It carries the US 212 number for its entire length, and the Forest Service recently designated it as the Beartooth Scenic Byway under the Forest Service Scenic Byway Program. The portion of the route within Montana is designated as Montana Forest Highway 59, and the portion of the route within Wyoming is designated as Wyoming Forest Highway 4. In addition to being a forest highway, the route carries a special designation as a National Park Approach Road. To avoid confusion, the route is referred to as the Beartooth Highway in this report.

The Beartooth Highway is classified as a rural minor arterial according to the *Policy on Geometric Design of Highways and Streets*. The American Association of State Highway and Transportation Officials (AASHTO) publishes this manual, and it is a nationally accepted guide for designing highways. The Beartooth Highway meets the definition of rural minor arterial because it links cities, larger towns, and other traffic generators (such as major resort areas) that attract visitors from distant places. Minor arterials usually provide for relatively high travel speeds and minimum interference to traffic flow. However, in the higher elevations on the Beartooth, the mountainous terrain dictates slower travel speeds, and design criteria that more closely follows lower roadway classifications such as rural collectors.

The route has been divided into seven segments for study purposes. These seven segments are shown on the map in Appendix A. Segment 1 stretches from the beginning of the route at the Yellowstone boundary (MP 0.0) to the Montana/Wyoming border (MP 8.4).

Segments 2, 3 and 4 make up the 55.8 kilometers (34.7 miles) within Wyoming. In the 1970s and the 1980s, the CFLHD reconstructed segments 2 and 3 to current standards, Segment 4 was rehabilitated and resurfaced in 1968 and 1969 but was not improved to any specific standards.

Segments 5, 6, and 7 make up the remaining 37.0 kilometers (23.0 miles) of the route and lie within Montana. The Montana Department of Transportation (MDT) is rehabilitating and resurfacing Segment 5, which includes making safety improvements. Segments 6 and 7 were reconstructed during the late 1970s and early 1980s to current standards.

Plans are to reconstruct Segment 4. Following is a description of this segment.

Segment 4 - Metric Stations 38+450 to 69+580 (MP 24.5 to MP 32.1)

Segment 4 was constructed in the early 1930s. In 1968, the pavement on the majority of this segment was rehabilitated and resurfaced to its original paved width which is 5.5 meters (18 feet). Many paved ditches were added when it was resurfaced and rehabilitated. The pavement has severe alligator cracking in may locations because of subsurface moisture and inadequate drainage. The pavement edges are raveling at many locations because the road is so narrow. The section from MP 28.1 to MP 29.5 has failed from subgrade moisture. Considerable maintenance work will to be required during the next few years to maintain a drivable surface.

The alignment and grade is the same as when it was built in the early 1930s. The design speed of the road is about 50 Km (30 mph), but the switchbacks over Beartooth Pass are exceptions to this design speed. The maximum grade is about 6.0 percent. Excessive superelevation creates hazardous conditions in certain locations when snow and ice are present.

Most of the pavement in Segment 4 is marked with a double solid yellow centerline, but it is striped as a passing zone near MP 31.5. It does not have white shoulder lines and there are delineators. The roadside clear zone varies from 0 to 1.2 meters (0 to 4 feet) from the edge of the pavement. A particularly hazardous area exists from MP 25.6 to 26.1 where the road is bordered by a high rock cliff on one side and a high steep rock talus slope on the other. Guardrail was installed at some of these hazardous locations in 1963, but the guardrail does not meet current standards. Signing is substandard, and this segment does not have mile post markers. There are curve warning signs and winding road signs in this segment, primarily from MP 32 to MP 41, with 40, 50, and 55 Km/h (20, 30 and 35 mph) advisory speed signs. Most of the switchbacks have an advisory speed of 40 Km/h (20 mph). The road does not have a posted speed limit and therefore defaults to the legal speed which is 90 Km/h (55 mph). The operating speed of this segment is 50 to 60 Km/h (30 to 35 mph).

There are many substandard turnouts throughout this segment that were created by drivers pulling off the road. These turnouts encourage unsafe traffic maneuvers because they are not paved and some are not properly located. Traffic flow is interrupted because vehicles slow to access these roadway turnouts. Additionally, the lack of turnouts and view points in certain areas causes vehicles to slow down while still on the road to view an area, which increases

the chances of accidents. More roadside turnouts that are properly located and defined are needed, particularly in the higher elevations where there are long-range views. The lower elevations of this segment is open range for cattle.

The four bridges in Segment 4 that were constructed during 1932 are too narrow and therefore do not meet current standards. The railing on these bridges is substandard, and they do not have approach guardrail. The useful life remaining for three of these bridges is between 15 and 20 years. The bridge over little Bear Creek at MP 28.2 has one abutment wing-wall that has completely failed, and the NPS says it has an insufficient waterway opening. The opening freezes solid with ice and snow, causing water to run over the road during spring runoff. There is also a settlement problem on one wing-wall at the bridge over Long Lake Outlet (MP 31.2).

The drainage facilities in Segment 4 are inadequate. Snow drifts in this segment average from 3.7 to 6.1 meters (12 to 20 feet) deep, and when all this snow melts in the spring, the ditches can't handle the volume of water. Some locations have no ditches, and the culverts are too small. During runoff periods, they can't handle the volume of water, and they often become plugged with debris. Many locations along the road in the higher elevations are plagued with wet ditches and subgrades. This leads to subgrade and base failures, alligator cracking and deterioration of the pavement. Weather conditions are severe, and snow and ice storms can occur during any month of the year. Excessive superelevation, combined with the grade and curvature of the road, presents serious problems and hazards in some locations when the road is icy. At one location, ice often builds as thick as 100 to 150 mm (4 to 6 inches), which causes NPS maintenance vehicles as well as tourist traffic to become stuck.

Segment 4 experiences high winds in many areas, which accelerates soil erosion. There also have been reports of winds so strong that they have peeled the asphalt pavement.

Segment 4 clearly has the worst conditions of any portion of the route. The narrow width of the road is the major deficiency, but the condition of the surface, inadequate drainage, lack of adequate roadside ditches and culverts, substandard signing and guardrail, lack of defined roadside turnouts, lack of snow storage area, and increasing bicycle use all indicate that serious consideration should be given to upgrading the road. A complaint of the NPS is that there is no place to store snow, and that the narrow width of the road presents a safety hazard during snow plowing operations. The 3.3-meter (11-foot) wide snowplow blades cannot fit within the 2.7-meter (9-foot) wide lanes, and have occasionally knocked mirrors off of oncoming vehicles.

MATERIALS INVESTIGATION ROADWAY

This investigation was conducted during the week of July 6 through 10, 1998, and consisted of the following:

1. Visual review of the existing roadway, and proposed cut and fill slopes.

2. Visual review of the existing pavement condition.

3. Visual review of the water related problems throughout the section.

4. Visual review of potential materials sources to provide materials for common borrow, select topping, crushed aggregate base, and bituminous surfacing.

5. Visual review to provide recommendations for interim maintenance needs.

6. Auger borings through the existing roadway.

Auger borings were drilled during the week of July 6 through 10, 1998. Borings were drilled by Braun Intertec, Billings, Montana. Traffic control was provided by Billings construction Supply. Borings were logged and samples obtained by FHWA personnel. Sample testing was conducted in the FHWA Materials Laboratory in Denver, Colorado.

All borings and other information in this report are referenced to the metric stationing marked on the roadway as of July 6 through 10, 1998.

Borings were drilled in the right lane going ahead on line at intervals of about 450 meters (1500 feet). In each boring the existing pavement and base depths were recorded and samples taken of the base and underlying subgrade materials to a depth of approximately 1.5 meters (5 feet). Sixty-seven (67) borings were drilled and sampled. Testing was done on 34 subgrade samples and 16 base samples.

AASHTO classification tests were run on the base along with classifications and resistance value tests of the subgrade materials. This information was used for structural pavement design.

Cut slope recommendations, along with shrink/swell factors, are provided in Appendix C, and are based on visual observations. A more detailed review should be made once the alignment and cross sections are available. Boring logs are provided in Appendix F.

There will be maintenance needs to provide a serviceable roadway for the next few years before reconstruction begins. Maintenance recommendations are provided in Appendix E.

Water problem areas are also addressed, and recommendations provided in Appendix D.

STRUCTURAL SECTION RECOMMENDATIONS

Based on the resistance values of the materials, the proposed project of 29.9 Km (18.6 miles) was broken into two sections.

Section No. 1 - Stations 39+450 to 48+000 (5.31 miles):

The existing pavement depths vary between 50 mm to 200 mm (2 inches to 8 inches) and average about 75 mm (3 inches) in depth. The base depths vary between 50 mm to 225 mm (2 and 9 inches), and average about 125 mm (5 inches). It was very difficult to visually distinguish between the base and subgrade materials. Resistance values through this section are somewhat lower than those in Section 2. There is more soil, clay/shale, and generally the area is through meadow areas consisting of silty and clayey soils mixed with sand, gravel, cobbles, boulders and fractured granite. R-values vary from 26 to 60 plus. An R-value of 35 was used for structural design.

Section No. 2 - Stations 48+000 to 69+580 (13.31 miles):

The existing pavement depths are thicker throughout this section, ranging from 50 mm to 200 mm (2 inches to 8 inches), averaging about 100 mm (4 inches) in depth. Base depth varies considerably but the average depth is approximately 125 mm (5 inches). It was very difficult to visually distinguish between the base and subgrade since both consists of broken granite. Resistance values are very high, all well above 60 and most above 70. The entire area consists of a subgrade constructed with granite and glacial deposits of sand, gravel, cobbles, and boulders, and the new construction will be the same. An R-value of 50 was used for structural design.

In both sections, there are several inches of pavement and base that can be salvaged (recycled) to use as a select topping. We recommend pulverizing the existing pavement and base to a depth of 150 mm (6 inches), then removing and stockpiling this material to use as a select topping. By removing and stockpiling 150 mm (6 inches) at the existing width of 5.5 m to 6.1 m (18 to 20 feet), there should be adequate material to provide for a depth of 75 mm (3 inches) on the new subgrade width of 9.1 m to 11.0 m (30 to 36 feet).

Since the roadway will generally be constructed with solid to fractured granite along with granite cobbles and boulders, it will be difficult to finish the subgrade within our normal specification of ± 30 mm for rock embankment. We recommend relaxing the specifications to ± 50 mm and doing the final grading to a ± 15 mm tolerance with recycled pavement and base at a 75 mm (3-inch) average depth, and another 75 mm (3-inch) depth of select borrow meeting the specifications of Section 704.07, Table 704-1, FP-96.

Structural section recommendations are as follows:

Section No. 1 - Stations 39+450 to 48+000 (5.31 miles):

Design R-value = 35
Structural number required for a 20-year design life = 2.32

Hot asphalt pavement		3 inches x .40	= 1.20
Crushed aggregate base		6 inches x .12	= .72
Recycled topping		3 inches x .08	= .24
Select borrow		3 inches x .08	= .24
	Total Depth	15 inches	2.40

Section No. 2 - Stations 48+000 to 69+580 (13.41 miles):

Design R-value = 50
Structural number required for a 20-year design life - 1.89

Hot asphalt pavement		3 inches x .40	= 1.20
Crushed aggregate base		3 inches x .12	= .36
Recycled topping		3 inches x .08	= .24
Select borrow		3 inches x .08	= .24
	Total Depth	12 inches	2.04

As you will note, both sections are slightly over-designed for a 20-year life expectancy. We feel this is advantageous due to the very harsh climate and wet conditions of the highway. Pavement structure work sheets are in Appendix H.

CULVERT RECOMMENDATIONS

Soils are not corrosive, all culvert types are acceptable. Imported material may be necessary for pipe backfill because the existing and newly excavated materials will be rocky.

MATERIALS SOURCES

Potential materials sources were reviewed with a report provided on August of 1998. This report and site map are is included in Appendix B.

APPENDIX A

Site Map Showing Entire Beartooth Highway

BEARTOOTH HIGHWAY

Scale in miles

Scale in kilometers

NORTH

PILOT CREEK TRAILHEAD
MP 12.6

TOP OF THE WORLD STORE
MP 28.3

JCT WYO 296

SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4
MP 0.0 – MP 8.4	MP 8.4 – MP 17.4	MP 17.4 – MP 24.5	
13.5km (8.4 miles)	14.5km (9.0 miles)	11.4km (7.1 miles)	29.9km (18.6 miles)

BEARTOOTH HIGHWAY

Scale in miles

0 1 2 3 4

Scale in kilometers

0 1 2 3 4

NORTH

CUSTER NATIONAL FOREST

Mt Hole-in-the-Wall

Shepard Mtn

Tempest Mtn

Mystic Mtn

Mt Peak

Glacier Pt

Mt Villard

Mt Wilson

Grass Mtn

RED LODGE RANGER STA

ROCK CREEK

Towne Pt

Pinerock Mtn

Mt Maurice

Mt Dewey

Summit Mountain

Snowbank Mtn

Castle Rock Mtn

Castle Mtn

Mt Lockhart

Whitetail Pk

Medicine Mtn

Mt Rosebud

Bald Knob

Middle Mtn

Orville Mtn

Thunder Mtn

Beartooth Mtn

Mt Beauguard

Black Pyramid Mtn

Tolman Mtn

Sheridan Pt

MOUNTAINS

BEARTOOTH

GALLATIN NATIONAL FOREST

PARK CO CARBON CO

Crazy Mtn

HISTORIC SITE

R15E R16E R17E R18E R19E R20E

Lonesome Mtn

Rock Island Butte

MONTANA

WYOMING

PARK CO

PARK CO

TOP OF THE WORLD STORE

MP 28.3

PILOT CREEK TRAILHEAD

MP 12.6

FOX CREEK

JCT WYO 296

Beartooth Butte

CLAY BUTTE

BEARTOOTH LAKE

BEAR CREEK

CLOSED

WINTER

Jim Smith Pk

Yellowstone

LAKE CREEK

Birdi Mtn

Tibbs Butte

Stacked Lake

LINE CREEK

SHOSHONE NATIONAL FOREST

Beartooth Highway Road Inventory and Needs Study 2-3

	SEGMENT 2	SEGMENT 3	SEGMENT 4	SEGMENT 5	SEGMENT 6	SEGMENT 7
MP	8.4 – 17.4	17.4 – 24.5	24.5 – 43.1BK	45.0AH – 60.0	60.0 – 64.2	64.2 – 68.7
	14.5km (9.0 miles)	11.4km (7.1 miles)	29.9km (18.6 miles)	24.1km (15.0 miles)	6.8km (4.2 miles)	7.2km (4.5 miles)

APPENDIX B

Materials Source Report of August 7, 1998
Site Map of Section 4 with Proposed Materials Sources

U.S. Department
of Transportation
**Federal Highway
Administration**

Central Federal Lands
Highway Division

555 Zang Street
P.O. Box 25246
Denver, Colorado 80225-0246

August 7, 1998

In Reply Refer To:

HTS-16.6

Brent Larson
District Ranger
204A Yellowstone Avenue
Cody, WY 82414

Subject: Beartooth Highway Materials Sources

Dear Mr. Larson:

During the week of July 6 through 10, Wayne Folkman conducted a materials investigation for the proposed Beartooth Highway Reconstruction, metric Stations 39+450 to 69+580 (18.7 miles). This section starts about 1/2 mile west of the road to the Clay Butte Lookout, and ends at the Wyoming/Montana state line.

During this investigation, possible sources for common borrow, select topping, crushed aggregate base, and bituminous pavement were reveiwed in the field.

Estimated quantities to complete the projects are as follows:

Common borrow	100,000 cu. yds.
Select toppings	115,000 cu. yds.
Crushed aggregate base/Bituminous surfacing	150,000 cu. yds.
Total	365,000 cu. yds.
	280,000 cu. meters (M^3)

Common borrow: Pit run sand and gravel used for grade raises, repair areas (subexcavation), etc.

Select topping: A crushed/screened material used to top out the completed subgrade. With the rock and boulders that will be used for constructing the roadway, it will be difficult to finish the grade to our current specifications. We recommend that the specification be relaxed, and select topping provided to finish the roadway and also decrease the base quantities.

Crushed aggregate base and bituminous pavement. A good quality crushed material used as needed to complete the final surfacing.

Sources that were reviewed are as follows with comments for each:

1. **Lily Lake:** This source has been used in the past. The source is approximately 9 miles from the start of the project. Our recommendations are not to consider this source unless the other sources do not work out. Field sampling and testing would be necessary to insure quality and quantity.

2. **Ghost Creek (Muddy Creek):** This source has been used for several projects in the past, and was called Muddy Creek at that time. The source is approximately 2-1/2 miles from the start of the project. Visually, this source looks acceptable for all materials needed. A field investigation would be required to insure quality and quantity.

3. **Metric Stations 46+700 to 46+900:** The right side of the roadway is a cut into the hillside. This area is just east of the bridge over Little Bear Creek and consists of sand, gravel cobbles, and boulders (glacial debris). It has been used in the past. Note the wide 20-foot to 30-foot ditch. There is evidence the area has been reseeded. This would be an ideal location to obtain common borrow that will be needed in this area for proposed grade raises through wet areas. The area could be widened and a parking area constructed.

4. **Metric Station 52+000 (7.8 miles into the project on right side or roadway):** This area is massive rock consisting of a Mafic dike and granite. A small area next to the road has been drilled and blasted with material removed from the dike. A false berm has been constructed along the roadway to hide the excavation from view. This materials (granite and dike) would make excellent crushed aggregate for base and bituminous pavement. Samples of this materials were taken for laboratory testing (results are not complete at this time). No other field sampling or testing would be required.

5. **Metric Station 53+300 (road to the right at switch back):** Old pit area next to roadway probably used for common borrow. Material is fractured granite over solid granite. Material would meet our needs but does not appear to be a good site, visually.

6. **Metric Station 62+140 (left of roadway, 14.1 miles into project):** There is a haul road left to an old source that was used for a project in 1968. Because of snow banks, we were unable to visually check this source. This source should be considered if it can be hidden visually. If this source would work out, it would save considerable haul costs. This area would have to be field sampled and tested.

Our preference would be to use Ghost Creek and the Mafic dike area at Station 52+000. It would also be very cost effective if the area at Station 46+700 to 46+900 and the old pit left of Station 62+140 could be used.

Please advise us as to your thoughts in this matter. We would like to finalize sampling and testing of sources next year.

Questions concerning this sources mentioned or others you fill may work should be directed to Wayne Folkman at (303) 716-2192.

Sincerely yours,

T. Samuel Holder, P.E.
Geotechnical Engineer

Attachments (2)

cc: Mark Taylor, HPD-16
Gary Strike, HPD-16
Wayne Folkman, HTS-16.6

END PROJECT, 69+580

62+140 SOURCE

53+300 SOURCE

52+000 SOURCE

46+800 SOURCE

GHOST CREEK SOURCE

START PROJECT, 39+450

LILY LAKE SOURCE

APPENDIX C

Summary of Soils Survey

Scale of Relative Rock hardness
Joint and Bedding Spacing Terms
Boring Log Legend and Terminology

SUMMARY OF SOIL SURVEY

Project: Wyoming PRP 04-1(2), Beartooth Highway — Date Performed: July 6 and 7, 1998

Notes per Stationing (km) marked on road as of July 8, 1998.

Beginning Reference Location: Start project, Station 39+450 (Mile Post 24.5) — Performed by: Wayne C. Folkman

Station to Station (metric)	Description of Soil or Rock	Recommended Slope Ratios (metric)	Shrink/Swell Factor	Water Problem Area (yes/no)	Remarks
39+450 to 40+240	Dark brown glacial debris and clay/shale.	1:2 (2:1) or flatter	10% shrink	Yes	Slide through road at 39+900 in clay shale material.
40+240 to 40+600	Tan granite, slightly to moderately weathered and medium hard, highly fractured. Moderately close to wide spacing. Dipping towards roadway in some areas.	4:1 (1/4:1) or flatter	10% swell	Possibly	Possibly some seeps will be encountered in this highly fractured granite.
40+600 to 41+100	Brown/tan glacial debris with some large boulders.	1:2 (2:1) or flatter	10% shrink	Yes	See Summary of Water Problems.
41+100 to 42+250	Tan granite, slightly to moderately weathered, medium hard, highly fractured, moderately close to wide spacing. Dipping toward roadway in some areas.	4:1 (1/4:1) or flatter	10% swell	Possibly-same as 40+200 to 40+600.	This is a very tight area to widen and will require further study once an alignment and x-sections are available. If cutting is done, rock bolts may be required. Look at other options in lieu of cutting - consider minor cutting at base of cliffs along with retaining walls right. At 41+340, fill settlement on high fill.
42+250 to 48+000	Brown/tan glacial debris, lots of granite boulders. Very wet. Grade needs to be raised in low areas.	1:2 (2:1) or flatter	10% shrink	Yes	Raise grade 45+000 to 47+000. Little Bear Creek is close to road on left. May require line shift right, or bank protection.

Station to Station (metric)	Description of Soil or Rock	Recommended Slope Ratios (metric)	Shrink/Swell Factor	Water Problem Area (yes/no)	Remarks
48+000 to 48+900	Heavy cut will be in rock. Shallow cuts rock and glacial debris. Rock will be tan granite, slightly to moderately weathered, medium hard, highly fractured, moderately close to wide spacing.	Glacial debris 2:1 or flatter. 4:1 (1/4:1) or flatter.	10% shrink 10% swell	Yes	See Summary of Water Problems.
48+900 to 51+700	Glacial debris, some ribs or rock, low area and very wet	1:2 (2:1) or flatter	5% swell	Yes	See Summary of Water Problems.
51+700 to 55+200	Brown/tan granite slightly to moderately weathered, medium hard, highly fractured, moderately close to wide spacing.	4:1 (1/4:1) or flatter	10% swell	Yes	See Summary of Water Problems.
55+200 to 67+500	Mostly shallow glacial debris over highly fractured granite - slightly to moderately weathered, medium hard, highly fractured, very close to moderately close joint spacing.	1:1 or flatter	5% swell	Yes	See Summary of Water Problems.
	Areas of glacial debris and highly fractured granite, shallow grading, keep flat. NOTE: 61+700 outside of fill is unstable, probably needs new retaining wall.	1:2 (2:1) or flatter	0% shrink/swell	Yes	See Summary of Water Problems.

Recommendations are very preliminary and will need to be finalized when alignment and cross sections are available.

Rock cuts will experience considerable rock fall. Because of this, we highly recommend wider ditches (subgrade width 6 ft. And 1 ft. Depth) to catch rock fall. These ditches could also be paved with concrete curb for durability.

REFERENCE FOR ROCK CLASSIFICATION
OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION, 1987

SCALE OF RELATIVE ROCK HARDNESS

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife. Scratched with finger nail.	100-1000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1000-4000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4000-8000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8000-16000 psi
Very Hard	R5	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16000 psi

SCALE OF RELATIVE ROCK WEATHERING

Designation	Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 inch into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

JOINT AND BEDDING SPACING TERMS

Spacing	Joint spacing Terms	Bedding/Foliation Spacing Terms
Less than 2 in.	Very close	Very thin (laminated)
2 in. - 1 ft.	Close	Thin
1 ft. - 3 ft.	Moderately close	Medium
3 ft. - 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick (massive)

BORING LOG LEGEND AND TERMINOLOGY

1. Color.
2. Soil Density (or Consistency).
3. Primary Constituent - Major grain size (IN CAPS)
4. Secondary Constituent:
   Coarse-grained - 30% to 50% of secondary coarse-grained constituent (i.e., sandy, gravelly).
   Fine-Grained - Based on plasticity and determined by Atterberg limits test (i.e. silty, clayey).
5. Additional Constituents:
   Coarse-grained - 'with some' - 10% to 30%; 'trace of' - less than 10%
   Fine-grained* - 'with some' - 5% to 12%; 'trace of' - less than 5%
6. Moisture Content - Dry (D), Moist (M), Wet (W).

* Index tests and/or plasticity tests are performed to determine whether the terms "silt" or "clay" are used.

SOIL DENSITY AND CONSISTENCY CORRELATED TO STANDARD PENETRATION TEST

Granular Soil		Cohesive Soil	
Blows	Density	Blows	Consistency
0 - 4	Very Loose	0 - 1	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 24	Medium Dense	5 - 8	Medium Stiff
25 - 50	Dense	9 - 15	Stiff
Over 50	Very Dense	16 - 30	Very Stiff
		31 - 60	Hard
		Over 60	Very Hard

PARTICLE SIZE

Millimeters (and above)	Inches (and above)	U.S. Standard Sieve No.	Soil Type	Abbreviation
			Boulder	Bldr
—305	12			
			Cobble	Cobb
— 76	3			
			Gravel	GR
— 5	3/16	4		
			Sand	SD
—0.074		200		
			Silt	SI
—0.002				
			Clay	CL

SYMBOLS FOR SAMPLE TYPES

AS - Auger Sample (disturbed sample) AASHTO T 203.
SPT - Standard Penetration Test (disturbed sample) AASHTO T 206.
CS - California Sample (brass liner).
ST - Shelby Tube Sample (undisturbed sample) AASHTO T 207.
CSS - Continuous Soil Sampler.
RCN - Nx/Nq Rock Core AASHTO T 225.
RCH - Hx/Hq Rock Core.

Federal Highway Administration, Central Federal Lands Highway Division
Materials Branch

Job:_____ Date:_____
Rev: 7/93

APPENDIX D

Summary of Water Problems

SUMMARY OF WATER PROBLEMS

Project: Wyoming PRP 04-1(2), Beartooth Highway Date Performed: July 6 and 7, 1998

Notes per Stationing (km) marked on road as of July 8, 1998.

Beginning Reference Location: Start project, Station 39+450 (Mile Post 24.5) Performed by: Wayne C. Folkman

Station to Station	Description of Problem	Recommendations
* 40+240	Water coming out of spring up Clay Butte Road, runs along main road for about 50 m, then into cross drain. Water presently ponds in ditch causing roadway distress.	With new construction, pave ditch to insure drainage.
40+400 to 40+800	Very wet on left.	Install under drain in left ditch line at 1-1/2 meter depth.
43+200 to 45+300 (Little Bear Creek)	Very wet on right.	Install under drain in right ditch line at 1-1/2 meter depth.
45+300 to 45+600	Roadway grade is low, wet both sides of road.	Raise grade with rock, construct to drain.
45+700 to 48+000	Very wet, road grade too low.	Needs to be reconstructed with rock to drain, and the grade raised.
48+000 to 48+450	Seepage left.	Install under drain in left ditch line at a 1-1/2 meter depth.
48+700 to 49+000	Very wet, seepage on right.	Install under drain in right ditch line at a 1-1/2 meter depth.
49+100 to 49+300	Low marshy area.	Raise grade, construct with rock to drain.
50+300	Bridge for outlet for Longs Lake. Wetlands both sides of bridge.	Raise grade and reconstruct with rock to drain.
50+400 to 51+600	Very wet across this area.	Needs to be reconstructed with rock to drain, and grade raised.
54+600 to 55+200	Very wet, seepage from right.	Install under drain in right ditch at a 1-1/2 meter depth.
56+900	Wet, along switchback.	Raise grade and construct with rock to drain.

Station to Station	Description of Problem	Recommendations
58+700 to 59+200	Wet, left side.	Install under drain in left ditch at a 1-1/2 meter depth.
60+000 to 60+400	Wet, left side.	Install under drain in left ditch at a 1-1/2 meter depth.
62+500 to 63+600	Wet, left side.	Install under drain in left ditch at a 1-1/2 meter depth.
64+400 to 64+600	Wet, right side.	Install under drain in right ditch at a 1-1/2 meter depth.
65+100 to 65+400	Wet, left side.	Install under drain in left ditch at a 1-1/2 meter depth.
67+500 to 68+500	Wet, right side.	Install under drain in right ditch at a 1-1/2 meter depth.
69+580	End of project.	

* Areas, as recommended, are preliminary. Further refinement will be needed once the alignment and cross sections are available.

APPENDIX E

Maintenance Needs

MAINTENANCE NEEDS
BEARTOOTH HIGHWAY
Per review of July 6 though 10, 1998

STATION	DESCRIPTION OF ROADWAY	RECOMMEN-DATIONS
39+450 to 39+600	Minor problems.	Okay
39+600 to 41+100	Patching, cracking, wet.	Overlay
41+100 to 45+000	Minor potholes, rutting, and cracking.	Okay
45+000 to 46+300	Potholes, alligator cracking, wet.	Overlay
46+300 to 46+950	Minor problems	Okay
46+950 to 48+300	Potholes, alligator cracking, wet.	Overlay
48+300 to 50+200	Minor problems.	Okay
50+200 to 51+300	Potholes, alligator cracking, wet.	Overlay
51+300 to 58+600	A small amount of potholes and alligator cracking.	Okay
58+600 to 59+000	Alligator cracking, potholes, wet.	Overlay
59+000 to 60+200	Minor problems.	Okay
60+200 to 66+300	Potholes, alligator cracking, rutting, wet.	Overlay
66+300 to 69+580	Minor problems.	Okay

There are areas that will need to be subexcavated and repaired during the reconstruction contracts along with subsurface drainage construction and installation. For interim maintenance measures, this should be kept to a minimum unless maintenance forces feel there are some areas that it is necessary. Grading of ditches to improve drainage would help in many areas, and is recommended before an overlay is constructed.

APPENDIX F

Boring Logs

BORING LOG
BEARTOOTH
(All borings in center of right lane going ahead on line.)

Boring	Stations (Metric)	Depths (mm)	Description
B-1	39+600	0 to 127 127 to 254 254 to 1219	Pavement. Base. Dark brown clayey silt, wet.
B-2	40+050	0 to 89 89 to 178 178 to 1524	Pavement. Base. Dark brown clayey silt, wet.
B-3	40+500	0 to 64 64 to 152 152 to 1219	Pavement. Base. Dark brown silty clay, wet.
B-4	40+950	0 to 64 64 to 152 152 to 1219	Pavement. Base. Dark brown sand and gravel, wet.
B-5	41+400	0 to 64 64 to 152 152 to 1219	Pavement. Base. Brown silty sand, gravel, and cobbles with large boulders, wet.
B-6	41+850	0 to 76 76 to 203 203 to 1219	Pavement. Base. Brown silty sand, gravel, and cobbles with large boulders, moist.
B-7	42+300	0 to 102 102 to 152	Pavement. Base. Hit boulder at 152 mm.
B-8	42+750	0 to 76 76 to 216 216 to 1219	Pavement. Base. Dark brown silty sand, gravel, cobbles, and large boulders, moist.
B-9	43+200	0 to 76 76 to 191 191 to 1219	Pavement. Base. Reddish brown silty sand, gravel, cobbles, and large boulders, moist.

Boring	Stations (Metric)	Depths (mm)	Description
B-10	43+650	0 to 89 89 to 229 229 to 1219	Pavement. Base. Reddish brown silty sand, gravel, cobbles, and large boulders, moist. Topsoil at 1219 mm (natural ground).
B-11	44+100	0 to 51 51 to 279 279 to 1219	Pavement. Base. Reddish brown silty sand and gravel, moist.
B-12	44+550	0 to 64 64 to 102 102 to 1219	Pavement. Base. Reddish brown silty sand, gravel, cobbles, and large boulders, moist.
B-13	45+000	0 to 64 64 to 191 191 to 914	Pavement. Base. Reddish silty sand and gravel, moist. Hit boulder at 914 mm.
B-14	45+450	0 to 89 89 to 229 229 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-15	45+900	0 to 89 89 to 140 140 to 279 279 to 1219	Pavement. Asphalt-treated base. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-16	46+350	0 to 89 89 to 140 140 to 1219	Pavement. Asphalt-treated base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-17	46+800	0 to 89 89 to 203 203 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-18	47+250	0 to 64 64 to 152 152 to 914	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.

Boring	Stations (Metric)	Depths (mm)	Description
B-19	47+700	0 to 76 76 to 178 178 to 914	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-20	48+000	0 to 76 76 to 152 152 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-21	48+600	0 to 102 102 to 203 203 to 914	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-22	49+050	0 to 127 127 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-23	49+500	0 to 102 102 to 203 203 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-24	49+950	0 to 127 127 to 254 254 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-25	50+400	0 to 203 203 to 305 305 to 1219	Pavement. Asphalt-treated base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-26	50+850	0 to 76 76 to 254 254 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-27	51+300	0 to 127 127 to 305 305 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.

Boring	Stations (Metric)	Depths (mm)	Description
B-28	51+750	0 to 127 127 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-29	52+200	0 to 102 102 to 203 203 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulderss, moist.
B-30	52+800	0 to 64 64 to 178 178 to 305	Pavement. Asphalt-treaded base. Brown silty sand, gravel, cobbles, and large boulderss, moist. Boulder at 305 mm.
B-31	53+100	0 to 76 76 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-32	53+550	0 to 178 178 to 305	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit boulder at 305 mm.
B-33	54+100	0 to 102 102 to 203 203 to 457	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit boulder at 457 mm.
B-34	54+450	0 to 102 102 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-35	54+900	0 to 127 127 to 305	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit rock at 305 mm.
B-36	55+350	0 to 127 127 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-37	55+800	0 to 152 152 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-38	56+250	0 to 165	Pavement. Hit boulder at 165 mm.

Boring	Stations (Metric)	Depths (mm)	Description
B-39	56+700	0 to 76 76 to 152 152 to 229	Pavement. Asphalt-treated base. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit rock at 229 mm.
B-40	57+150	0 to 178 178 to 381	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit rock at 381 mm.
B-41	57+600	0 to 152 152 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-42	58+050	0 to 165 165 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-43	58+500	0 to 76 76 to 914	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit rock at 914 mm.
B-44	58+950	0 to 76 76 to 203	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit rock at 203 mm.
B-45	59+400	0 to 203 203 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-46	59+000	0 to 76 76 to 914	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit rock at 914 mm.
B-47	60+300	0 to 127 127 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-48	60+750	0 to 89 89 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-49	61+200	0 to 127 127 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.

Boring	Stations (Metric)	Depths (mm)	Description
B-50	61+650	0 to 102 120 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-51	62+100	0 to 102 102 to 914	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist. Hit rock at 914 mm.
B-52	62+550	0 to 64 64 to 178 178 to 1219	Pavement. Asphalt-treated base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-53	63+000	0 to 51 51 to 152 152 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-54	63+450	0 to 51 51 to 203 203 to 1219	Pavement. Asphalt-treated base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-55	63+900	0 to 38 38 to 102 102 to 254 254 to 305	Pavement. Light brown base. Asphalt-treated base. Rock.
B-56	64+350	0 to 38 38 to 254 254 to 1219	Pavement. Light brown base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-57	64+800	0 to 51 51 to 203 203 to 1219	Pavement. Asphalt-treated base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-58	65+250	0 to 51 51 to 203 203 to 1219	Pavement. Asphalt-treated base. Brown silty sand, gravel, cobbles, and large boulders, moist.

Boring	Stations (Metric)	Depths (mm)	Description
B-59	65+700	0 to 51 51 to 255 255 to 1219	Pavement. Asphalt-treated base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-60	66+150	0 to 38 38 to 203 203 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-61	66+600	0 to 64 64 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-62	67+050	0 to 51 51 to 203 203 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-63	67+500	0 to 102	Pavement. Hit rock at 102 mm.
B-64	67+950	0 to 127 127 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-65	68+400	0 to 102 102 to 279 279 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-66	68+850	0 to 89 89 to 1219	Pavement. Brown silty sand, gravel, cobbles, and large boulders, moist.
B-67	69+300	0 to 89 89 to 254 254 to 1219	Pavement. Base. Brown silty sand, gravel, cobbles, and large boulders, moist.

* In borings where base is not shown, it was visually impossible to tell the difference between the base and subgrade materials.

APPENDIX G

Laboratory Test Results

FEDERAL HIGHWAY ADMINISTRATION
Central Federal Lands Highway Division

REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 04-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN
Date Reported: 8-31-98

Sample Number	Lab Number		98-465-RV	98-467-RV	98-469-RV	98-472-RV	98-473-RV
	Hole Number						
	Field Number		1	3	5	8	9
Sample Location	Station (meters) or Location		39+600	40+500	41+400	42+750	43+200
	Offset		Rt Lane				
	Depth (mm)		254 to 1219	152 to 1219	152 to 1219	216 to 1219	191 to 1219
AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm			100	100	
	1 1/2"	37.5 mm	100	100	98	98	
	1"	25.0 mm	98	99	95	96	100
	3/4"	19.0 mm	97	98	90	93	98
	1/2"	12.5 mm	96	97	84	85	95
	3/8"	9.5 mm	94	96	80	81	91
	#4	4.75 mm	89	91	72	69	81
	#8	2.36 mm					
	#10	2.00 mm	82	85	65	57	69
	#16	1.18 mm	79	79	60	49	61
	#30	600 µm					
	#40	425 µm	72	69	51	37	46
	#50	300 µm					
	#100	150 µm	64	58	41	27	32
	#200	75 µm	55.0	50.8	34.1	21.0	22.6
		2 µm					
		0.2 µm					
		0.1 µm					
	Moisture (%)						
AASHTO T 89 & 90	Liquid Limit		32	33	23	23	20
	Plasticity Index		8	10	4	4	2
Soil Classification	AASHTO M 145		A-4(2)	A-4(3)	A-2-4(0)	A-1-b(0)	A-1-b(0)
	ASTM D 2487		ML	CL	SC-SM	SC-SM	SM
AASHTO T 190	R-Value		35	26	35	51	NOT TESTED
AASHTO T 288	Min. Resistivity (ohm-cm)				6,100		
AASHTO T 289	pH				6.1		
AASHTO T Method:	Optimum Moisture (%)						
	Max. Dry Density (pcf)						

Distribution:
Materials 3 Copies

Geotechnical W. FOLKMAN

Remarks: ALL OF THE SAMPLES CONTAINED ASPHALT CONCRETE PARTICLES, RANGING FROM 5% TO 40% VISUALLY.

Reported by:
Ronald D Anderson for
Alan M. Held
Materials Specialist

Bob H. Welch, P. E.
Materials Engineer

FHWA 16-226

FEDERAL HIGHWAY ADMINISTRATION
Central Federal Lands Highway Division

REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN
Date Reported: 8-31-95

Sample Number	Lab Number		98-475-RV	98-477-RV	98-479-RV	98-480-RV	98-482-RV
	Hole Number						
	Field Number		11	13	15	16	18
Sample Location	Station (meters) or Location		44+100	45+000	45+900	46+350	47+250
	Offset		Rt. Lane				
	Depth (mm)		279 to 1219	191 to 914	279 to 1219	140 to 1219	152 to 914
AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm	100		100	100	
	1 1/2"	37.5 mm	98	100	99	97	100
	1"	25.0 mm	97	98	96	97	98
	3/4"	19.0 mm	95	95	94	94	97
	1/2"	12.5 mm	91	92	88	89	94
	3/8"	9.5 mm	89	90	84	87	92
	#4	4.75 mm	81	83	75	79	84
	#8	2.36 mm					
	#10	2.00 mm	71	73	65	71	76
	#16	1.18 mm	65	65	58	65	71
	#30	600 µm					
	#40	425 µm	54	51	44	53	60
	#50	300 µm					
	#100	150 µm	41	37	31	39	46
	#200	75 µm	27.1	29.4	23.2	25.9	32.5
		2 µm					
		0.2 µm					
		0.1 µm					
	Moisture (%)						
AASHTO T 89 & 90	Liquid Limit		22	NV	19	20	25
	Plasticity Index		3	NP	1	1	2
Soil Classification	AASHTO M 145		A-2-4(0)	A-2-4(0)	A-1-b(0)	A-2-4(0)	A-2-4(0)
	ASTM D 2487		SM	SM	SM	SM	SM
AASHTO T 190	R-Value		36	NOT TESTED	81	40	62
AASHTO T 288	Min. Resistivity (ohm-cm)					5,300	
AASHTO T 289	pH					6.3	
AASHTO T Method:	Optimum Moisture (%)						
	Max. Dry Density (pcf)						

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FHWA 19-220

FEDERAL HIGHWAY ADMINISTRATION
Central Federal Lands Highway Division

REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN **Date Reported:** 8-31-98

Sample Number	Lab Number	98-484-RV	98-486-RV	98-489-RV	98-491-RV	98-493-RV
	Hole Number					
	Field Number	20	22	25	27	29
Sample Location	Station (meters) or Location	48+000	49+050	50+400	51+300	52+200
	Offset	Rt. Lane				
	Depth (mm)	152 to 1219	127 to 1219	305 to 1219	305 to 1219	203 to 1219
AASHTO T 11, 27 & 88 (% Passing)	3" 75.0 mm		100	100	100	100
	1 1/2" 37.5 mm	100	93	99	99	96
	1" 25.0 mm	97	90	96	97	91
	3/4" 19.0 mm	91	86	91	93	88
	1/2" 12.5 mm	83	79	83	87	79
	3/8" 9.5 mm	78	75	78	83	74
	#4 4.75 mm	66	65	65	72	64
	#8 2.36 mm					
	#10 2.00 mm	54	54	52	58	50
	#16 1.18 mm	46	47	44	49	44
	#30 600 µm					
	#40 425 µm	33	35	30	34	33
	#50 300 µm					
	#100 150 µm	24	26	21	24	24
	#200 75 µm	20.0	20.6	17.1	20.1	18.8
	2 µm					
	0.2 µm					
	0.1 µm					
	Moisture (%)					
AASHTO T 89 & 90	Liquid Limit	NV	NV	NV	NV	NV
	Plasticity Index	NP	NP	NP	NP	NP
Soil Classification	AASHTO M 145	A-1-b(0)	A-1-b(0)	A-1-b(0)	A-1-b(0)	A-1-b(0)
	ASTM D 2487	SM	SM	SM	SM	SM
AASHTO T 190	R-Value	58	71	68	73	78
AASHTO T 288	Min. Resistivity (ohm-cm)			6,700		
AASHTO T 289	pH			6.4		
AASHTO T Method:	Optimum Moisture (%)					
	Max. Dry Density (pcf)					

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REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN **Date Reported:** 8-31-98

Sample Number	Lab Number		98-495-RV	98-497-RV	98-500-RV	98-501-RV	98-504-RV
	Hole Number						
	Field Number		31	33	36	37	40
Sample Location	Station (meters) or Location		53+100	54+000	55+350	55+800	57+150
	Offset		Rt. Lane				
	Depth (mm)		76 to 1219	203 to 457	127 to 1219	152 to 1219	178 to 381
AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm		100	100		
	1 1/2"	37.5 mm	100	97	94	100	100
	1"	25.0 mm	99	93	89	99	98
	3/4"	19.0 mm	96	89	84	98	93
	1/2"	12.5 mm	87	78	75	93	84
	3/8"	9.5 mm	81	73	69	90	77
	#4	4.75 mm	66	61	55	79	61
	#8	2.36 mm					
	#10	2.00 mm	52	52	41	60	48
	#16	1.18 mm	43	46	33	50	41
	#30	600 µm					
	#40	425 µm	28	34	22	35	31
	#50	300 µm					
	#100	150 µm	17	22	13	24	22
	#200	75 µm	12.0	16.8	10.2	21.9	18.3
		2 µm					
		0.2 µm					
		0.1 µm					
	Moisture (%)						
AASHTO T 89 & 90	Liquid Limit		NV	NV	NV	NV	NV
	Plasticity Index		NP	NP	NP	NP	NP
Soil Classification	AASHTO M 145		A-1-b(0)	A-1-b(0)	A-1-a(0)	A-1-b(0)	A-1-b(0)
	ASTM D 2487		SW-SM	SM	GW-GM	SM	SM
AASHTO T 190	R-Value		77	NOT TESTED	83	69	NOT TESTED
AASHTO T 288	Min. Resistivity (ohm-cm)				7,100		
AASHTO T 289	pH				6.0		
AASHTO T Method:	Optimum Moisture (%)						
	Max. Dry Density (pcf)						

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FHWA 10-226

FEDERAL HIGHWAY ADMINISTRATION
Central Federal Lands Highway Division

REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN **Date Reported:** 8-31-98

Sample Number	Lab Number		98-505-RV	98-507-RV	98-510-RV	98-512-RV	98-514-RV
	Hole Number						
	Field Number		41	43	46	48	50
Sample Location	Station (meters) or Location		57+600	58+500	59+000	60+750	61+650
	Offset		Rt. Lane	→	→	→	→
	Depth (mm)		152 to 1219	76 to 914	76 to 914	89 to 1219	102 to 1219
AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm			100	100	100
	1 1/2"	37.5 mm	100		91	96	94
	1"	25.0 mm	98	100	82	89	84
	3/4"	19.0 mm	97	97	76	84	77
	1/2"	12.5 mm	91	90	71	74	68
	3/8"	9.5 mm	88	86	68	69	63
	#4	4.75 mm	77	73	60	56	52
	#8	2.36 mm					
	#10	2.00 mm	62	57	51	46	44
	#16	1.18 mm	52	48	46	40	38
	#30	600 µm					
	#40	425 µm	39	32	36	30	28
	#50	300 µm					
	#100	150 µm	25	21	26	22	19
	#200	75 µm	17.8	16.2	22.0	19.8	14.5
		2 µm					
		0.2 µm					
		0.1 µm					
	Moisture (%)						
AASHTO T 89 & 90	Liquid Limit		NV	NV	NV	NV	NV
	Plasticity Index		NP	NP	NP	NP	NP
Soil Classification	AASHTO M 145		A-1-b(0)	A-1-b(0)	A-1-b(0)	A-1-b(0)	A-1-a(0)
	ASTM D 2487		SM	SM	GM	GM	GM
AASHTO T 190	R-Value		74	66	69	81	81
AASHTO T 288	Min. Resistivity (ohm-cm)				7300		
AASHTO T 289	pH				5.4		
AASHTO T Method:	Optimum Moisture (%)						
	Max. Dry Density (pcf)						

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Central Federal Lands Highway Division

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Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN
Date Reported: 8-31-98

Sample Number	Lab Number	98-516-RV	98-518-RV	98-520-RV	98-521-RV	98-523-RV
	Hole Number					
	Field Number	52	54	56	57	59
Sample Location	Station (meters) or Location	62+500	63+450	64+350	64+800	65+700
	Offset	Rt. Lane				
	Depth (mm)	178 to 1219	203 to 1219	254 to 1219	203 to 1219	255 to 1219
ASHTO T 11, 27 & 88 (% Passing)	3" 75.0 mm	100	100	100		
	1 1/2" 37.5 mm	97	98	99	100	100
	1" 25.0 mm	95	94	96	99	98
	3/4" 19.0 mm	92	88	93	98	96
	1/2" 12.5 mm	85	79	87	91	90
	3/8" 9.5 mm	81	73	82	84	86
	#4 4.75 mm	69	57	68	68	72
	#8 2.36 mm					
	#10 2.00 mm	55	44	56	52	59
	#16 1.18 mm	46	36	47	43	49
	#30 600 µm					
	#40 425 µm	31	24	32	29	32
	#50 300 µm					
	#100 150 µm	19	15	21	18	18
	#200 75 µm	15.7	13.1	17.0	14.8	12.9
	2 µm					
	0.2 µm					
	0.1 µm					
	Moisture (%)					
AASHTO T 89 & 90	Liquid Limit	NV	NV	NV	NV	NV
	Plasticity Index	NP	NP	NP	NP	NP
Soil Classification	AASHTO M 145	A-1-b(0)	A-1-a(0)	A-1-b(0)	A-1-b(0)	A-1-b(0)
	ASTM D 2487	SM	SM	SM	SM	SM
AASHTO T 190	R-Value	78	62	76	82	86
AASHTO T 288	Min. Resistivity (ohm-cm)				6,100	
AASHTO T 289	pH				6.4	
AASHTO T Method:	Optimum Moisture (%)					
	Max. Dry Density (pcf)					

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FEDERAL HIGHWAY ADMINISTRATION
Central Federal Lands Highway Division

REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN
Date Reported: 8-3-98

Sample Number	Lab Number		98-525-RV	98-526-RV	98-529-RV	98-531-RV
	Hole Number					
	Field Number		61	62	65	67
Sample Location	Station (meters) or Location		61+600	67+050	68+400	69+300
	Offset		Rt. Lane			
	Depth (mm)		64 to 1219	203 to 1219	279 to 1219	254 to 1219
AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm	100	100	100	100
	1 1/2"	37.5 mm	91	98	95	93
	1"	25.0 mm	88	94	89	85
	3/4"	19.0 mm	82	89	87	79
	1/2"	12.5 mm	74	78	79	72
	3/8"	9.5 mm	69	72	73	68
	#4	4.75 mm	56	59	60	59
	#8	2.36 mm				
	#10	2.00 mm	46	49	49	51
	#16	1.18 mm	40	42	42	44
	#30	600 µm				
	#40	425 µm	28	29	30	30
	#50	300 µm				
	#100	150 µm	17	19	21	21
	#200	75 µm	12.8	15.5	18.2	18.3
		2 µm				
		0.2 µm				
		0.1 µm				
	Moisture (%)					
AASHTO T 89 & 90	Liquid Limit		NV	NV	NV	29
	Plasticity Index		NP	NP	NP	3
Soil Classification	AASHTO M 145		A-1-a(0)	A-1-b(0)	A-1-b(0)	A-1-b(0)
	ASTM D 2487		GM	SM	SM	SM
AASHTO T 190	R-Value		69	79	72	60
AASHTO T 288	Min. Resistivity (ohm-cm)				7,600	
AASHTO T 289	pH				5.6	
AASHTO T Method:	Optimum Moisture (%)					
	Max. Dry Density (pcf)					

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FHWA 16-228

FEDERAL HIGHWAY ADMINISTRATION

Central Federal Lands Highway Division

REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY

Submitted By: WAYNE FOLKMAN

Date Reported: 8/13/98

Sample Number	Lab Number	98-532-SB	98-533-SB	98-534-SB	98-535-SB	98-536-SB
	Hole Number					
	Field Number	1	2	3	4	5
Sample Location	Station or Location (METERS)	39+600 EXISTING BASE COURSE	40+050	40+500	40+950	41+400
	Offset					
	Depth (MILLIMETERS)	127 - 254	89 - 178	64 - 152	64 - 152	64 - 152
AASHTO T 11, 27 & 88 (% Passing)	3" 75.0 mm					
	1 1/2" 37.5 mm					100
	1" 25.0 mm	NOT TESTED	NOT TESTED	NOT TESTED	100	95
	3/4" 19.0 mm				96	92
	1/2" 12.5 mm				86	86
	3/8" 9.5 mm				86	80
	#4 4.75 mm				73	67
	#8 2.36 mm				61	56
	#10 2.00 mm				57	54
	#16 1.18 mm					
	#30 600 µm				36	37
	#40 425 µm				32	32
	#50 300 µm				28	29
	#100 150 µm					
	#200 75 µm				14.5	17.1
	2 µm					
	% ASPHALT				15	20
	PARTICLES, VISUAL					
	Moisture (%)					
AASHTO T 89 & 90	Liquid Limit				NV	NV
	Plasticity Index				NP	NP
Soil Classification	AASHTO M 145				A-1-b(0)	A-1-b(0)
	ASTM D 2487				SM	SM
AASHTO T 190	R-Value					
AASHTO T 288	Min. Resistivity (ohm-cm)					
AASHTO T 289	pH					
AASHTO T Method:	Optimum Moisture (%)					
	Max. Dry Density (pcf)					

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Geotechnical WAYNE FOLKMAN

Remarks: DUE TO LARGE AMOUNT OF ASPHALT IN SAMPLES. SAMPLES WERE NOT TESTED 98-(532-534)-SB AND 98-(541, 545, 546)-SB. PER WAYNE FOLKMAN 8/7/98.

Reported by:

Ronald Anderson for
Alan M. Held
Materials Specialist

Bob H. Welch, P. E.
Materials Engineer

FHWA 19-226

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Central Federal Lands Highway Division

REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN
Date Reported: 8/13/98

Sample Number	Lab Number	98-537-SB	98-538-SB	98-539-SB	98-540-SB	98-541-SB
	Hole Number					
	Field Number	6	9	11	13	15
Sample Location	Station (METERS) or Location	41+850	43+200	44+100	45+000	45+900
		EXISTING BASE COURSE →				
	Offset					
	Depth (MILLIMETERS)	76-203	76-191	51-279	64-191	140-279
ASHTO T 11, 27 & 88 (% Passing)	3" 75.0 mm					
	1 1/2" 37.5 mm	100		100	100	NOT TESTED
	1" 25.0 mm	95	100	89	95	
	3/4" 19.0 mm	86	90	81	89	
	1/2" 12.5 mm	80	75	72	79	
	3/8" 9.5 mm	75	63	65	73	
	#4 4.75 mm	59	44	52	58	
	#8 2.36 mm	48	33	43	48	
	#10 2.00 mm	45	30	40	44	
	#16 1.18 mm					
	#30 600 µm	30	17	26	27	
	#40 425 µm	27	15	23	24	
	#50 300 µm	24	12	20	20	
	#100 150 µm					
	#200 75 µm	16.0	5.6	13.3	11.0	
	2 µm					
	% ASPHALT	20	15	10	20	
	PARTICLES, VISUAL					
	Moisture (%)					
AASHTO T 89 & 90	Liquid Limit	NV	NV	NV	NV	
	Plasticity Index	NP	NP	NP	NP	
Soil Classification	AASHTO M 145	A-1-b (0)	A-1-a (0)	A-1-a (0)	A-1-a (0)	
	ASTM D 2487	SM	GW-GM	GM	SW-SM	
AASHTO T 190	R-Value					
AASHTO T 288	Min. Resistivity (ohm-cm)					
AASHTO T 289	pH					
AASHTO T Method:	Optimum Moisture (%)					
	Max. Dry Density (pcf)					

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Remarks:

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FEDERAL HIGHWAY ADMINISTRATION
Central Federal Lands Highway Division

REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN
Date Reported: 8/13/98

Sample Number	Lab Number		98-542-SB	98-543-SB	98-544-SB	98-545-SB	98-546-SB
	Hole Number						
	Field Number		17	19	21	23	25
Sample Location	Station or Location	METERS	46+800	47+700	48+600	49+500	50+400
			EXISTING BASE COURSE →				
	Offset						
	Depth	MILLIMETERS	89-203	76-178	102-203	102-203	203-305
AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm					
	1 1/2"	37.5 mm	100	100			
	1"	25.0 mm	92	95	100	NOT TESTED	NOT TESTED
	3/4"	19.0 mm	83	89	96		
	1/2"	12.5 mm	76	83	88		
	3/8"	9.5 mm	68	79	82		
	#4	4.75 mm	53	69	69		
	#8	2.36 mm	43	58	57		
	#10	2.00 mm	40				
	#16	1.18 mm					
	#30	600 µm	26	37	37		
	#40	425 µm	23	31	32		
	#50	300 µm	20	27	28		
	#100	150 µm					
	#200	75 µm	11.5	10.5	11.4		
	% ASPHALT						
	PARTICLES VISUAL		20				
	Moisture (%) ASPHALT CONTENT (%)			3.4	3.8		
AASHTO T 89 & 90	Liquid Limit		NV	NT	NT		
	Plasticity Index		NP	NT	NT		
Soil Classification	AASHTO M 145		A-1-a (0)				
	ASTM D 2487		GW-GM				
AASHTO T 190	R-Value						
AASHTO T 288	Min. Resistivity (ohm-cm)						
AASHTO T 289	pH						
AASHTO T Method:	Optimum Moisture (%)						
	Max. Dry Density (pcf)						

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REPORT ON SOIL OR AGGREGATE TESTS

Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY

Submitted By: WAYNE FOLKMAN

Date Reported: 8/13/98

Sample Number	Lab Number		98-547-SB	98-548-SB	98-549-SB	98-550-SB	98-551-SB
	Hole Number						
	Field Number		29	54	57	60	62
Sample Location	Station or Location (METERS)		52 + 200 EXISTING BASE COURSE	62 + 550	64 + 800	66 + 150	67 + 050 →
	Offset						
	Depth (MILLIMETERS)		102 - 203	51 + 203	51 + 203	38 - 203	51 - 203
AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm					
	1 1/2"	37.5 mm				100	
	1"	25.0 mm	100			97	100
	3/4"	19.0 mm	98	100	100	95	94
	1/2"	12.5 mm	92	95	94	86	83
	3/8"	9.5 mm	81	90	85	78	72
	#4	4.75 mm	65	74	69	61	57
	#8	2.36 mm	52	60	56	49	46
	#10	2.00 mm				46	44
	#16	1.18 mm					
	#30	600 µm	32	37	37	30	31
	#40	425 µm	27	31	32	26	28
	#50	300 µm	23	27	28	23	24
	#100	150 µm					
	#200	75 µm	8.9	8.8	10.2	11.4	12.6
	% ASPHALT PARTICLES, VISUAL					15	20
	~~Moisture (%)~~ ASPHALT CONTENT (%)		4.2	3.4	2.4		
AASHTO T 89 & 90	Liquid Limit		NT	NT	NT	NV	NV
	Plasticity Index		NT	NT	NT	NP	NP
Soil Classification	AASHTO M 145					A-1-a (0)	A-1-a (0)
	ASTM D 2487					SW-SM	SM
AASHTO T 190	R-Value						
AASHTO T 288	Min. Resistivity (ohm-cm)						
AASHTO T 289	pH						
AASHTO T Method:	Optimum Moisture (%)						
	Max. Dry Density (pcf)						

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Project: WYOMING PRP 4-1(2) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN
Date Reported: 8/13/98

Sample Number	Lab Number		98-552-SB	98-553-SB			
	Hole Number						
	Field Number		65	67			
Sample Location	Station or Location (METERS)		68+400	69+300			
			EXISTING BASE COURSE				
	Offset						
	Depth (MILLIMETERS)		102-279	89-254			
AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm					
	1 1/2"	37.5 mm		100			
	1"	25.0 mm		90			
	3/4"	19.0 mm	100	75			
	1/2"	12.5 mm	95	66			
	3/8"	9.5 mm	85	59			
	#4	4.75 mm	66	51			
	#8	2.36 mm	54	44			
	#10	2.00 mm	51	42			
	#16	1.18 mm					
	#30	600 µm	36	30			
	#40	425 µm	32	27			
	#50	300 µm	27	23			
	#100	150 µm					
	#200	75 µm	15.6	13.9			
		2 µm					
	% ASPHALT						
	PARTICLES, VISUAL		20	15			
	Moisture (%)						
AASHTO T 89 & 90	Liquid Limit		NV	NV			
	Plasticity Index		NP	NP			
Soil Classification	AASHTO M 145		A-1-b (0)	A-1-a (0)			
	ASTM D 2487		SM	GM			
AASHTO T 190	R-Value						
AASHTO T 288	Min. Resistivity (ohm-cm)						
AASHTO T 289	pH						
AASHTO T Method:	Optimum Moisture (%)						
	Max. Dry Density (pcf)						

Distribution:
Materials 3 Copies

Geotechnical WAYNE FOLKMAN

Remarks:

Reported by:
Ronald Anderson for
Alan M. Held
Materials Specialist

Bob H. Welch, P. E.
Materials Engineer

FHWA 18-226

FEDERAL HIGHWAY ADMINISTRATION

Central Federal Lands Highway Division

REPORT OF SELECT, SUBBASE, BASE COURSE & SURFACE AGGREGATE TESTS

Project: WYOMING, PRP 4-1(12) BEARTOOTH HIGHWAY
Submitted By: WAYNE FOLKMAN

Date Reported: 8/24/98

Lab Number		98-554-PAGG	98-555-PAGG			
Field Number		1-A & B	2-A & B			
Source or Location	STATION	514+700 RIGHT IGNEOUS DIKE MAFIC	→ GRANITE			
Tested for: QUALITY FOR BASE & HOT MIX		BLASTED				
Item: ——— Grading: —		SURFACE MATERIAL	→			
Washed Sieve Analysis (% Passing)	Sieve Size	Specs.	T.V.	(D)		
Liquid Limit						
Plasticity Index						
Classification	AASHTO					
	Unified					
Moisture-Density Relationship T 180D	Optimum Moisture (%)					
	Maximum Dry Density (pcf)					
R-Value						
Los Angeles Abrasion, Grading B (% loss)		11	35			
Sodium Sulfate Soundness (% loss) -3/8" + #4		1	2			
Durability Index, AASHTO COARSE		90	87			
Fractured faces - One or more manufactured (%)						

Distribution:
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Q. A. Engineer
GEOTECHMICAL: W. FOLKMAN

Remarks: BOTH SAMPLES WERE CRUSHED TO 100% PASSING A 3/4" SIEVE TO PRODUCE ENOUGH MATERIAL TO RUN THE QUALITY TESTS

"(D)" indicates the allowable deviation from the target value.

Reported by:
Ronald D Anderson
Alan M. Held
Materials Specialist

Bob H. Welch, P. E.
Materials Engineer

APPENDIX H

Pavement Structure Work Sheets

Pavement Structure Layer Thickness Worksheet

Project: Wyo. Beartooth Highway Prepared By: Folkman

Section: 1 From: 39+450 To: 52+000 Date: 09/18/98

Traffic Analysis

	ADT	X	YEARS	X	DAYS	X	DDF	X	LDF	X	LF	=	DESIGN ESALs
Cars	636	X	20	X	365	X	0.60	X	1.00	X	0.00020	=	557
Trucks	20	X	20	X	365	X	0.60	X	1.00	X	1.00	=	86,133
											TOTAL	=	86,690
											DAILY	=	12

ADT = (1998 ADT + 2018 ADT)/2
= (555 + 756)/2
DAYS = Days/Year
YEARS = Design Life (Years)
DDF = Directional Distribution Factor

LDF = Lane Distribution Factor
LF = Load Factor (18 kip ESALs per Vehicle)
* Default Minimum ESALS of 5/day Have Been Used

Regional Factor

Precipitation (in/yr)	Over 24"	Pf	1.5
Avg. Elevation (ft.)	8,501' TO 9,500'	Ef	1
Drainage Condition	Poor	Df	1
		Total Rf	3.50

Soil Support Value

Description:		Classification:	
No. of Samples:	1	Test Value Range:	35
Type of Tests:	R Value	No. of Tests:	1
Percentile Value:	87.5	Percentile R:	35

Design R Value: 35
Design Soil Support Value: 5.37

Design Terminal Serviceability (Pt) 2.5

Required Structural Number (SN) 2.32

Required Pavement Structure

Layer Description	Coeff.	Thickness (in)	SN
Totals:		0.00	0.00

Pavement Structure Layer Thickness Worksheet

Project: Wyo. Beartooth Highway Prepared By: Folkman

Section: 2 From: 52+000 To: 69+580 Date: 09/28/98

Traffic Analysis

	ADT	X	YEARS	X	DAYS	X	DDF	X	LDF	X	LF	=	DESIGN ESALs
Cars	636	X	20	X	365	X	0.60	X	1.00	X	0.00020	=	557
Trucks	20	X	20	X	365	X	0.60	X	1.00	X	1.00	=	86,133
											TOTAL	=	86,690
											DAILY	=	12

ADT = (1998 ADT + 2018 ADT)/2
= (555 + 756)/2
DAYS = Days/Year
YEARS = Design Life (Years)
DDF = Directional Distribution Factor

LDF = Lane Distribution Factor
LF = Load Factor (18 kip ESALs per Vehicle)
* Default Minimum ESALS of 5/day Have Been Used

Regional Factor

Precipitation (in/yr)	Over 24"	Pf	1.5
Avg. Elevation (ft.)	8,501' TO 9,500'	Ef	1
Drainage Condition	Poor	Df	1
		Total Rf	3.50

Soil Support Value

Description:		Classification:	
No. of Samples:	1	Test Value Range:	50
Type of Tests:	R Value	No. of Tests:	1
Percentile Value:	87.5	Percentile R:	50

Design R Value: 50
Design Soil Support Value: 6.78

Design Terminal Serviceability (Pt) 2.5

Required Structural Number (SN) 1.89

Required Pavement Structure

Layer Description	Coeff.	Thickness (in)	SN
Totals:		0.00	0.00

APPENDIX I

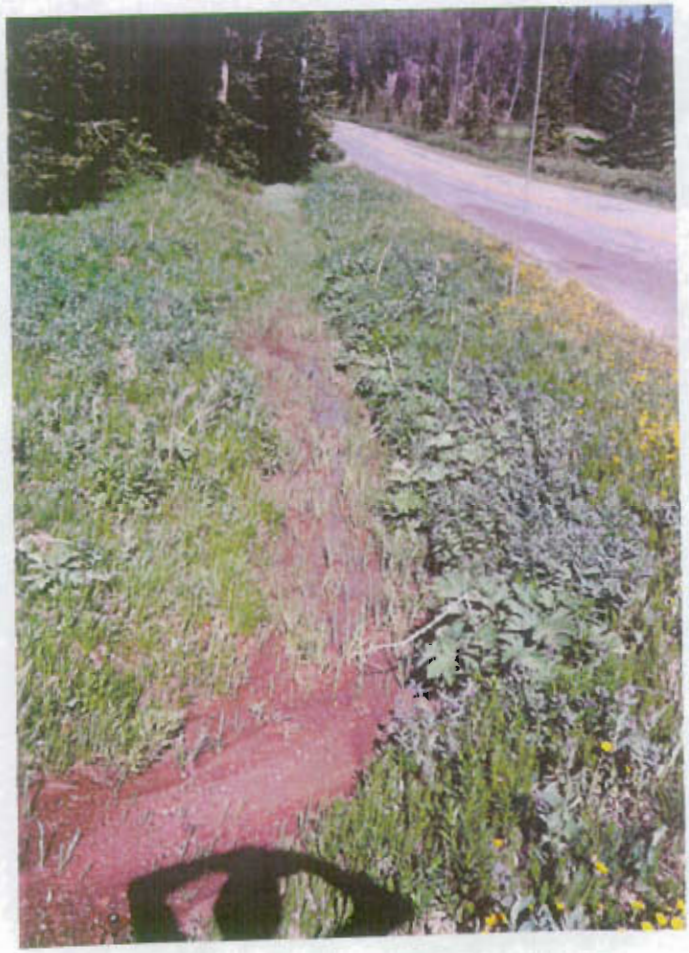
PHOTOGRAPHS

BEARTOOTH HIGHWAY
July 7, 1998

STATION 39+860
LOOKING AHEAD AT SLIDE. NOTE PATCH.

STATION 39+950
LOOKING BACK AT SLIDE, PATCH 50 METERS LONG.

STATION 40+240
CLAY BUTTE
LOOKOUT ROAD
SHOWING WATER
RUNNING FROM
SPRING.



STATION 40+240
STANDING ON CLAY
BUTTE LOOKOUT ROAD
SHOWING WATER
IN DITCH LEFT.
DITCH DOES NOT
DRAIN WELL.
NOTE PATCH
IN ROADWAY.

STATION 41+030
ON GRAVEL PULL-OUT LOOKING AHEAD AT NARROW SECTION.

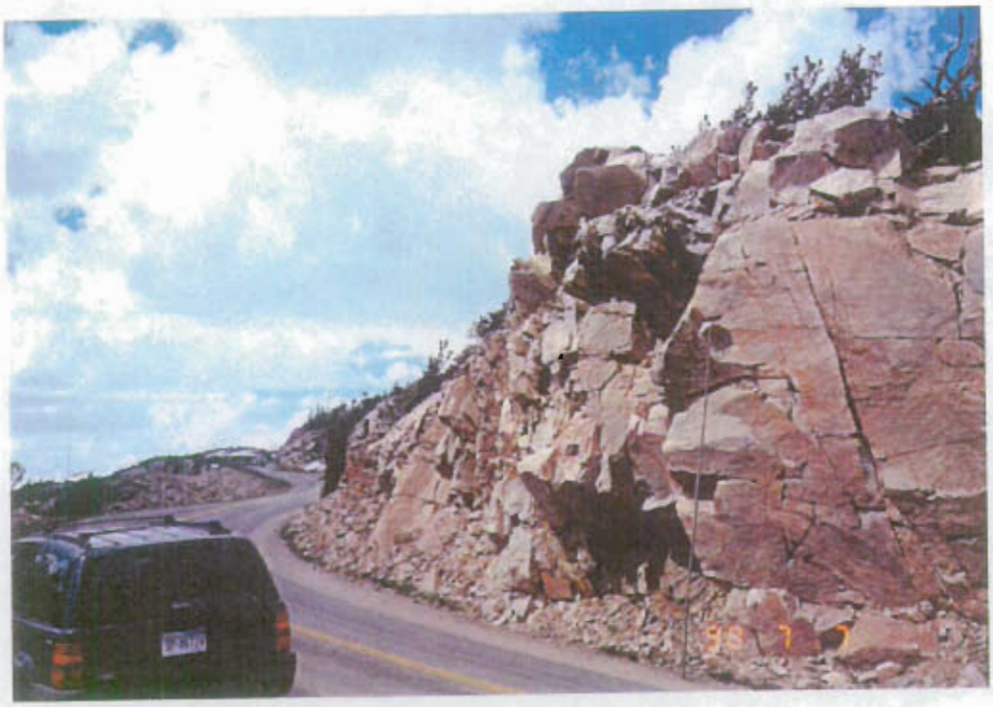
STATION 41+720
ON GRAVEL PULL-OUT ACROSS FROM FALLS
LOOKING BACK AT GRANITE CUTS.

STATION 41+720
LOOKING AHEAD AT GRANITE CUTS.

STATION 45+600
AT "TOP OF THE WORLD STORE" LOOKING BACK SHOWING AREA
NEEDING GRADE RAISE. WATER BOTH SIDES OF ROAD, MOSTLY RIGHT.

STATION 49+200
AT CENTER OF MASHY AREA LOOKING AHEAD AT GRANITE CUT ON LEFT.

STATION 52+000
AT GRAVEL PARKING AREA LEFT LOOKING AHEAD SHOWING GRANITE TERRAIN. ROAD CLOSURE GATE IN BACKGROUND AT STATION 52+250. NOTE ROAD SWITCH BACKING ABOVE.



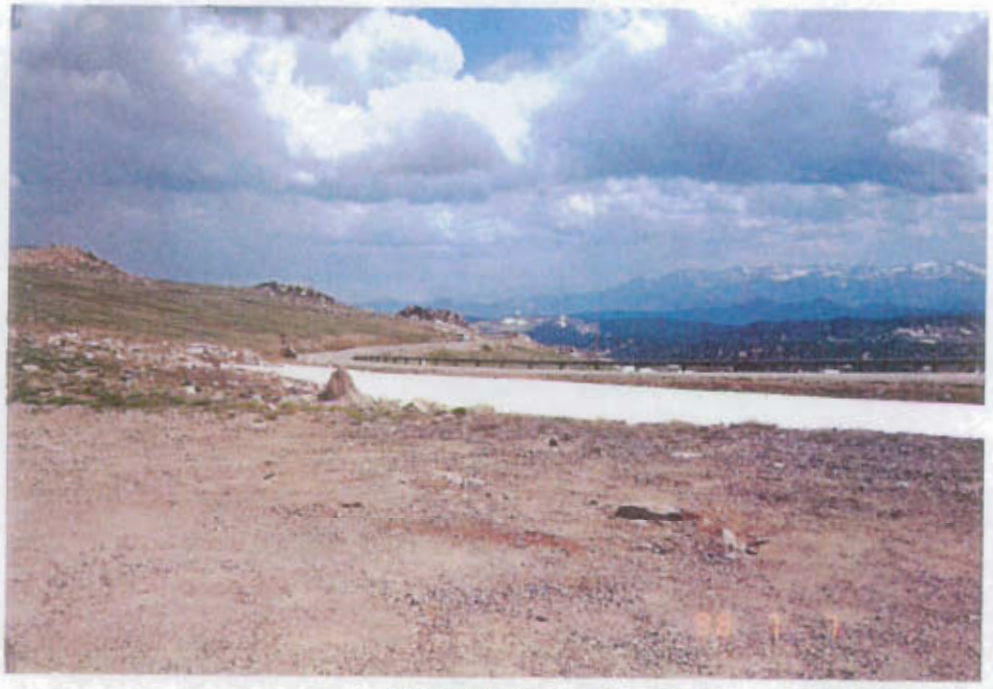
STATION 53+300
LOOKING AHEAD AT 25-FOOT GRANITE CUT.

STATION 57+300
LOOKING BACK AT ROAD TO OLD BORROW PIT.

STATION 55+200
LOOKING BACK. NOTE PATCH OVER CULVERT.

STATION 55+200
LOOKING AHEAD, VERY WET ON CUT SIDE.

STATION 57+400
LOOKING BACK SHOWING HILLSIDE OF GLACIAL DEBRIS OVER BEDROCK.
NOTE BOULDERS. NOTE SWITCHBACK IN BACKGROUND.



STATION 58+650
AT SWITCHBACK LOOKING BACK SHOWING TERRAIN OF GLACIAL DEBRIS.
FRACTURED GRANITE.

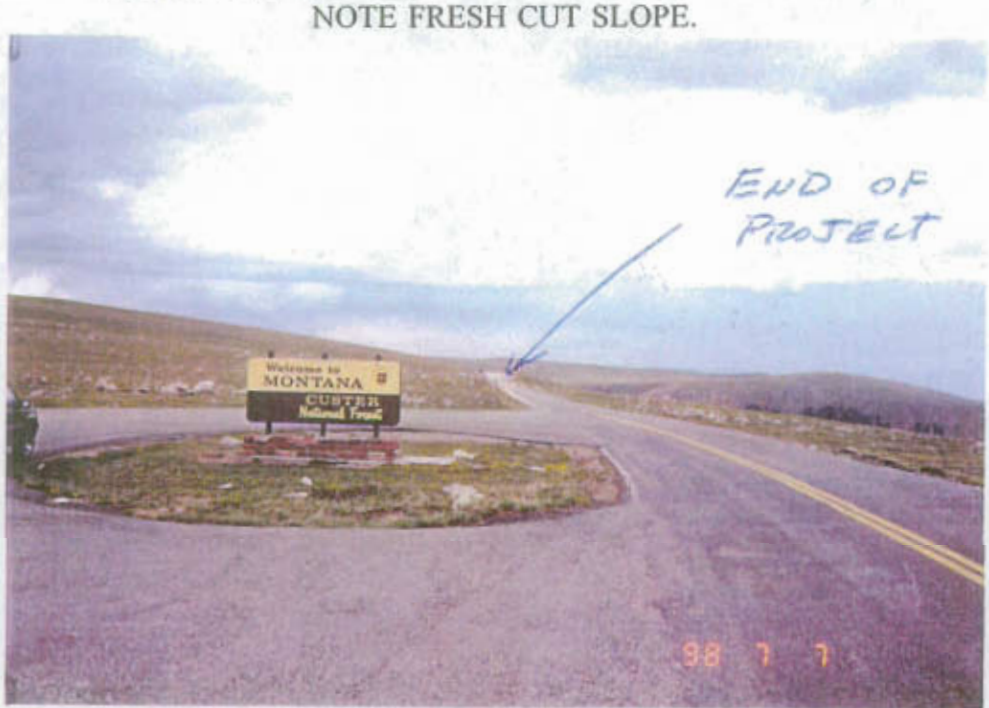
STATION 58+650
AT SWITCHBACK LOOKING AHEAD.

STATION 62+140
LOOKING AHEAD AT ROADWAY AND PARKING AREA ON RIGHT.

STATION 65+400
LOOKING AHEAD AT CURVE AT STATION 67+500.

STATION 67+300
LOOKING AHEAD AT RETAINING WALL REPAIR SITE.
NOTE FRESH CUT SLOPE.

STATION 67+550
LOOKING AHEAD AT RETAINING WALL REPAIR SITE.
NOTE FRESH CUT SLOPE.



STATION 69+210
LOOKING AHEAD AT WELCOME TO MONTANA SIGN
AND END OF PROJECT.

STATION 41+850
LOOKING AHEAD.

STATION 46+350
LOOKING BACK.

STATION 57+150
LOOKING AHEAD.

STATION 60+750
LOOKING AHEAD. NOTE BEARTOOTH IN BACKGROUND
AND ALLIGATORED PAVEMENT.

STATION 61+650
LOOKING BACK. NOTE CONDITION OF PAVEMENT
ALLEGATOR CRACKING DUE TO WET SUBGRADE.

STATION 65+700
LOOKING AHEAD.

STATION 66+600
LOOKING AT DRILL RIG.

BEARTOOTH HIGHWAY
METRIC STATIONING AS MARKED ON ROADWAY AS OF JUNE 3, 1998.
(Stationing is approximate)

PHOTO #1, STATION 67+500
LOOKING BACK, HIGHLY FRACTURED, BROKEN GRANITE. PROBABLY MORE SOLID AND LESS FRACTURING WITH DEPTH.

PHOTO #2, STATION 67+500
LOOKING AHEAD.

PHOTO #3, STATION 64+700
LOOKING AHEAD AT SKI TOE.

PHOTO #4, STATION 64+700
LOOKING BACK.

PHOTO #5, STATION 63+600
LOOKING AHEAD.

PHOTO #6, STATION 63+600
LOOKING BACK.

PHOTO #7, STATION 55+000
LOOKING AHEAD AT HEAVY CUT (20 to 30 feet) OF HARD,
HIGHLY FRACTURED GRANITE.

PHOTO #8, STATION 55+000
LOOKING BACK AT HEAVY CUT OF HARD, HIGHLY FRACTURED GRANITE.

PHOTO #9, STATION 53+000
LOOKING AHEAD AT GRANITE CUT (10 to 15 feet).
NOTE DIP TOWARDS ROAD.

PHOTO #10, STATION 53+000
LOOKING BACK.

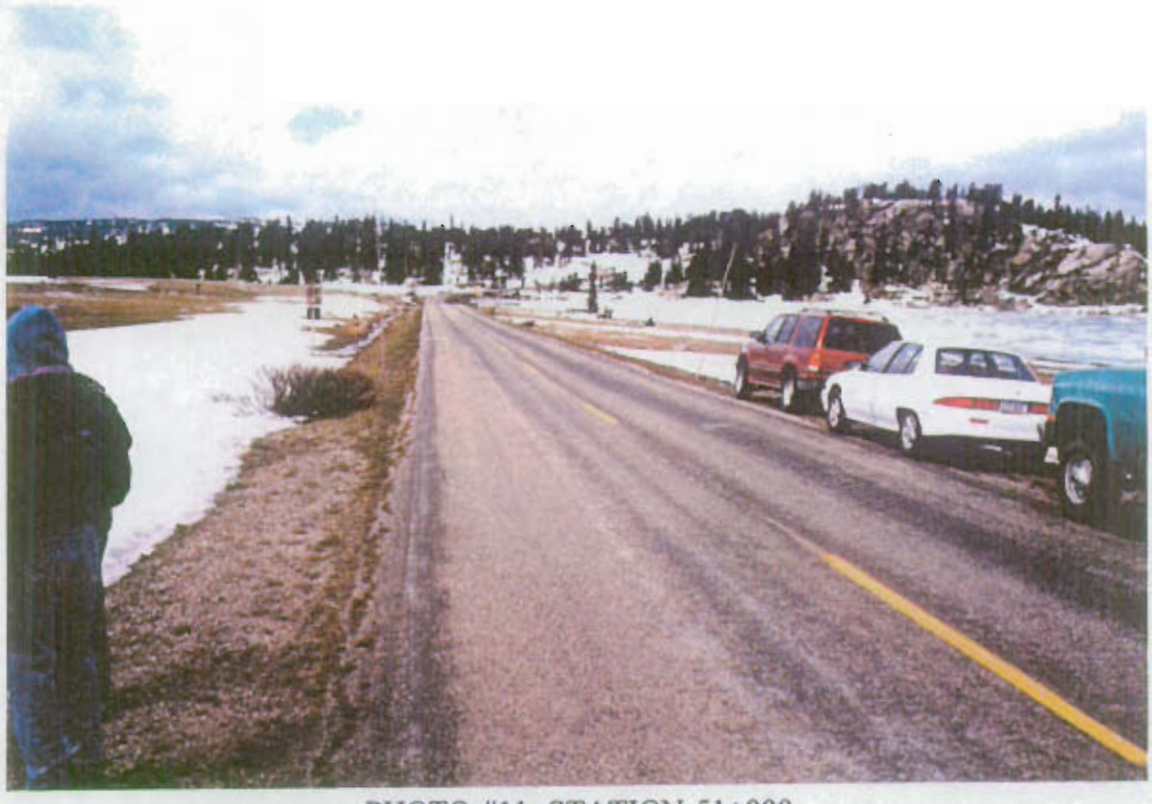


PHOTO #11, STATION 51+000
LOOKING BACK SHOWING OUTLET OF LONG LAKE.
VERY WET ON BOTH SIDES OF THE ROAD.

PHOTO #12, STATION 51+000
LOOKING AHEAD.

PHOTO #13, STATION 50+300
LOOKING AHEAD AT BRIDGE AT OUTLET OF LONG LAKE.

PHOTO #14, STATION 46+500
LOOKING AHEAD. NOTE WET AREA AND PATCHING.

PHOTO #15, STATION 46+500
LOOKING BACK.

PHOTO #16, STATION 46+500
LOOKING AHEAD AT LITTLE BEAR CREEK BRIDGE.

PHOTO #17, STATION 45+300
LOOKING AHEAD AT LITTLE BEAR CREEK BRIDGE.

PHOTO #18, STATION 43+800
LOOKING AHEAD.

PHOTO # 19, STATION 43+800
LOOKING BACK.

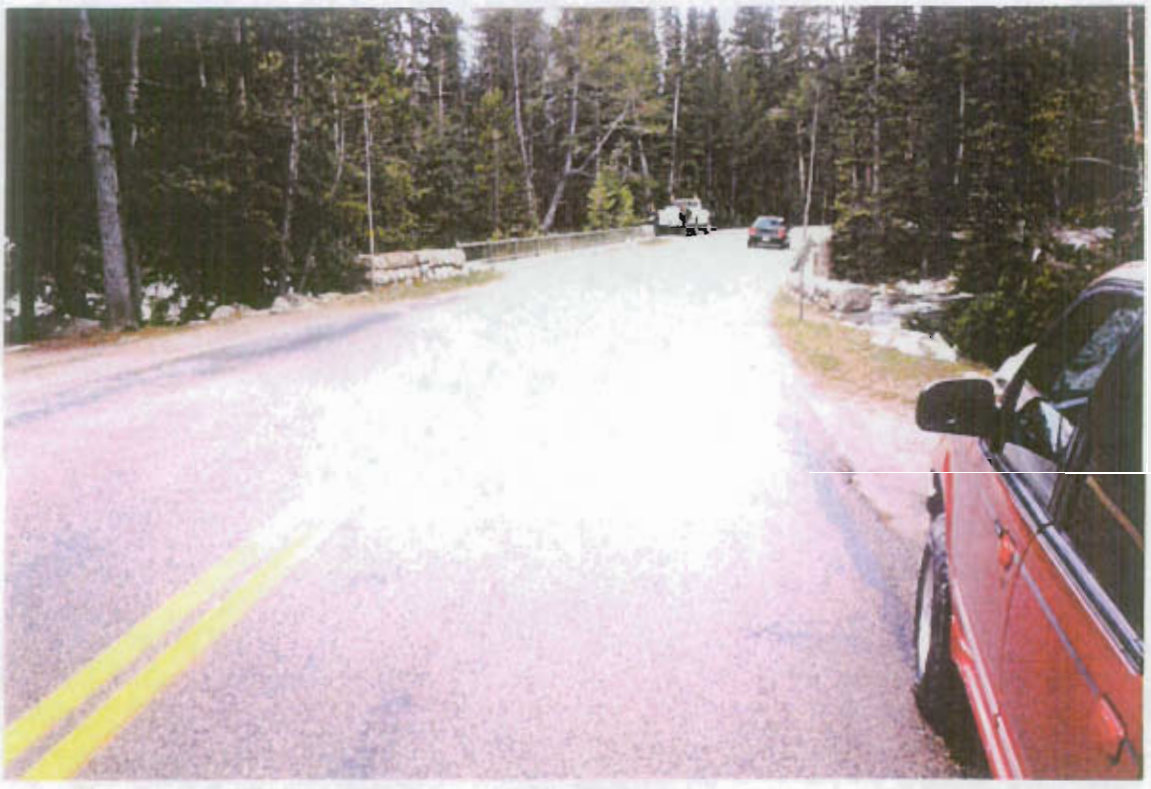


PHOTO # 20, STATION 42+500
LOOKING BACK AT BEARTOOTH LAKE OUTLET BRIDGE.

PHOTO #21, STATION 41+700
LOOKING AHEAD AT HEAVY CUT OF HIGHLY
FRACTURED GRANITE DIPPING TOWARDS ROAD.

PHOTO #22, STATION 39+900
LOOKING BACK AT SLUMP AREA THROUGH ROADWAY. NOTE PATCH.