



**WYOMING  
BEARTOOTH HIGHWAY  
MATERIALS SOURCE INVESTIGATION**

**SEPTEMBER 1999  
REPORT 99-14**

**Investigation and Reported by:  
Gene Folkman, Materials Engineering Technician**

**U.S. Department of  
Transportation**

**Federal Highway  
Administration**

**Central Federal Lands  
Highway Division**

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



Project Development)

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**Investigation and Reported by:  
Wayne Folkman, Materials Engineering Technician**

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

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9/25/99

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 many 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 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.

A preliminary investigation of the entire proposed reconstruction (Segment 4) was completed with a report distributed in October 1998 (Report No. 98-16).

When construction begins, materials sources will be needed for production of crushed aggregate base and asphalt pavement. Common borrow will also be needed for subexcavation and grade raises in low wet areas. Select borrow would also be ideal for this route to help with finishing operations due to the rocky subgrade material.

Several Sources of materials were reviewed in July of 1998 (see report dated August 7, 1998). Based on this review, two (2) sources for production of base and asphalt pavement were picked for further investigation and hopefully, approval by the Forest Service. A source for common borrow at Station 46+800 was also tested.

Another source that may be adequate for common borrow and select borrow is the old source used in 1968, which is left of station 62+140. This source has not been investigated but should be looked into at some point.

### INVESTIGATION AND RECOMMENDATIONS

#### **Ghost Creek Source: (Also called Muddy Creek in the past.)**

An investigation of the Ghost Creek source was conducted in July of 1999. A track-mounted Cat 322-L excavator and operator was furnished by Empire Sand and Gravel, Billings, Montana. Twenty-eight (28) test pits were dug in the area. The test pits were logged and samples taken by FHWA personnel, and samples tested in the Denver Central Laboratory.

This area has been used for production of gravel in the past, and consists of a glacial till (debris) deposit located along a ridge approximately 0.81 km (.50 miles) south of State Highway 212 (FH-4), along the east side of Forest Road 118. (See map in Appendix A.)

The area has been cleaned up fairly well with waste piles leveled out, topsoil placed, and the area seeded.

There are two areas along the ridge that have been worked in the past. We will call them the North Area and the South Area. There is an area between that has not been worked estimated to be a distance of approximately 300 meters ( $\pm$  1,000 feet). The South Area was outside of the present mapping. All excavations were marked with metal fence posts. Plans are to complete mapping of the area next year (2000). At this time, the excavation locations will be tied into the mapping.

Excavations were started in the South Area with BK-1 in the floor of the old excavation, BK-3 was also in the floor of the old excavation. Both showed waste material from previous work, crusher rejects, limbs, boulders, etc. BK-2 and BK-4 were in the face of the old excavation. Both showed sand and gravel on the fine side (mostly sand and small gravel). Excavation BK-5 showed sand and gravel on the sandy side, and BK-6 was mostly sand with large boulders.

We then moved to the North Area working up the ridge above the previously excavated area. BK-7 through BK-13 showed sand, gravel, cobbles, and boulders to depths as far as we could dig,  $\pm$  5 meters (16 feet).

BK-15 was very rocky (cobbles and boulders) to 1.2 meters ( $\pm$  4 feet), then fine sand and gravel. BK-14, BK-18, BK-19, BK-21, BK-22 and BK-23 were taken along the existing previously excavated cut face. The excavations all consisted of sand and gravel. Excavations BK-16, BK-17, and BK-20 all showed coarse sand (crusher rejects). In BK-20, sand and gravel was present under the rejects after 1.8 meters. The crusher rejects would be ideal material for pipe backfill. The natural material in a large majority of the route will be rock, pipe backfill will be needed.

We then excavated between the previously worked North and South areas. BK-25 showed mostly boulders to 1.83 meters (6 feet) and then sand to 4.27 meters (14 feet).

Excavations BK-26, BK-27, and BK-28 all showed sand and gravel. Please see excavation logs and test results for a more detailed description of the materials encountered.

There is a large quantity of material available in the area above the previously excavated North Area at a 6-meter (20-foot) depth estimated at 150,000 cubic meters (200,000 cubic yards). The sand and gravel is estimated to be much deeper and we recommend that borings (coring) be drilled as per the map in Appendix D. Depending on the depth of sand and gravel, the back slope can be steepened to a 1:2 (2:1), thus increasing the volume available, or a flatter slope can be excavated, but this will decrease the volume available. See cross section on map of Ghost Creek in Appendix D.

Once mapping and borings are completed, a excavation and reclamation plan can be designed for Forest Service approval.

#### **Station 52+000, Mafic Dike Area Materials Source:**

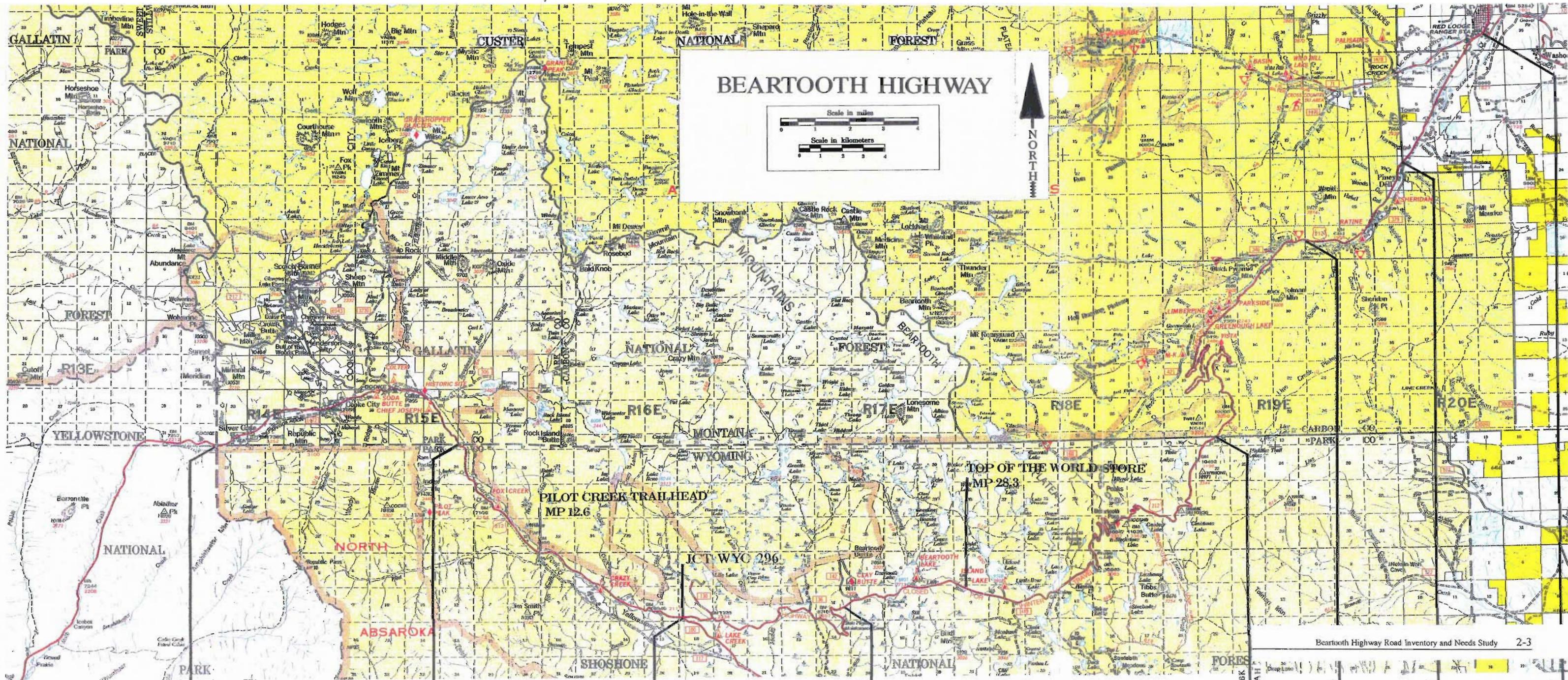
This area consists of a dark colored mafic dike surrounded by granite. (Mafic - an igneous rock composed chiefly of dark colored ferromagnesian minerals.) A small quarry excavation is next to the road and the material was used for road construction in the 1950's. The mafic material is very hard with an LA abrasion loss of 11 percent compared to the surrounding granite which has an LA abrasion loss of 35 percent. See test results in Appendix G of Materials Report 98-16. The material in this quarry site will be adequate for production of base and bituminous aggregate. The material will require blasting and crushing. The quantity of mafic material and granite available is only limited by the restrictions of the area that can be used per Forest Service approval.

A preliminary excavation plan is provided in Appendix F. A haul road could be constructed into the crusher and stockpile area from two directions. The area is wet, most if not all year, due to snow melt. Drainage ditches would need to be constructed, and the crusher and stockpile area would need to have the topsoil 0.60 meters ( $\pm$  2 feet) removed and the area plated with 0.90 meters ( $\pm$  3 feet) of rock. It is not necessary to use only the mafic material. The adjacent granite will meet our needs just as well.

**Station 46+800, Borrow Source:**

This area is adjacent to the roadway at preliminary metric Station 46+800. The proposed borrow area consists of a glacial till of sand, gravel, cobbles, and boulders. Two (2) samples of the material in the existing cut slope was sampled and tested. The material classified as an A-1-b. We would like to point out that the material sampled was only the minus 150 mm (6-inch) material. There will be cobbles and large boulders within this glacial till borrow area.

APPENDIX A  
LOCATION MAP



## BEARTOOTH HIGHWAY

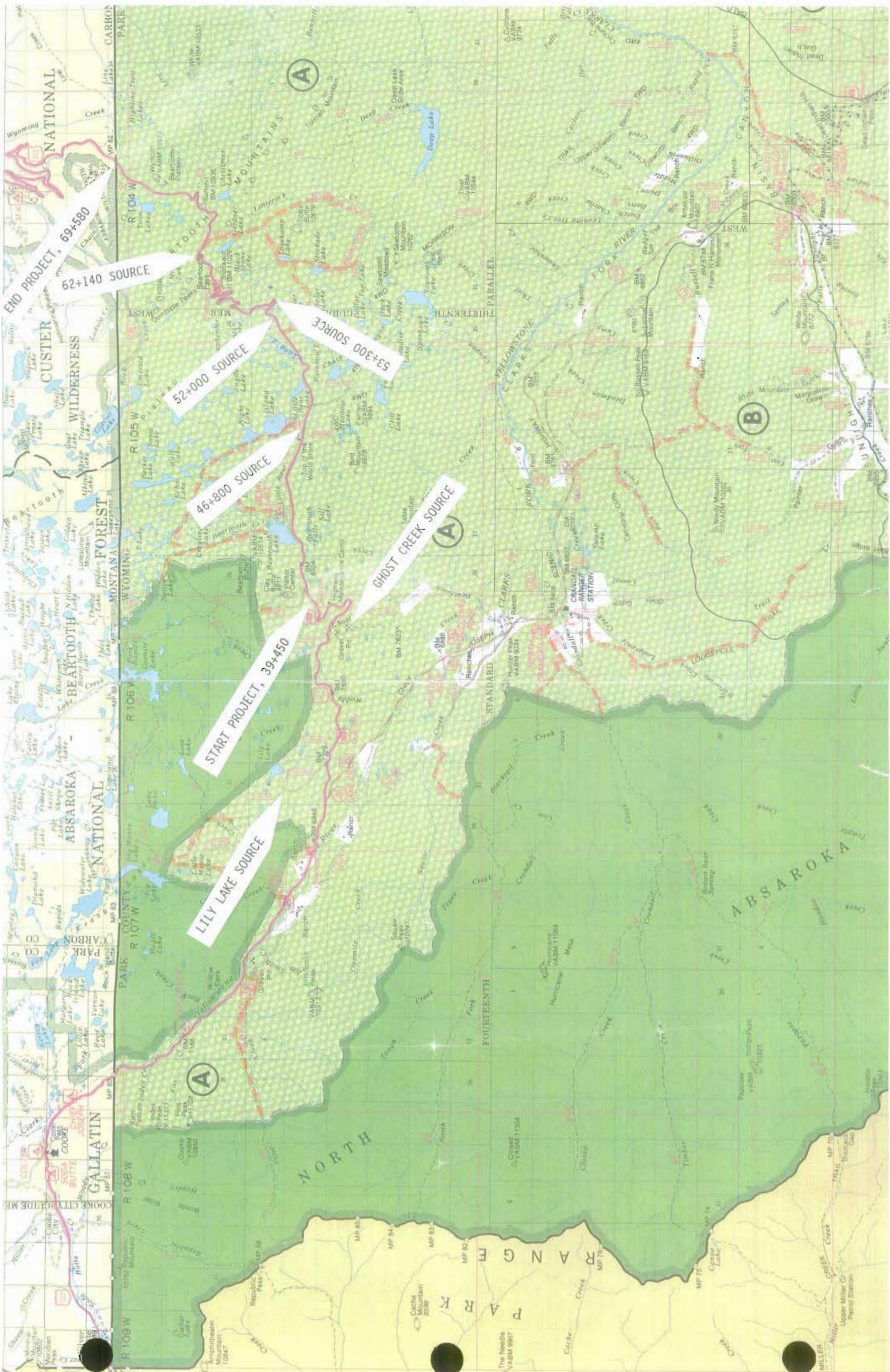
Scale in miles

Scale in kilometers

NORTH

Beartooth Highway Road Inventory and Needs Study 2-3

SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4	SEGMENT 5	SEGMENT 6	SEGMENT 7
MP 0.0	MP 8.4	MP 17.4	MP 24.5	MP 33.0	MP 42.2	MP 49.7
13.5km (8.4 miles)	14.5km (9.0 miles)	11.4km (7.1 miles)	29.9km (18.5 miles)	24.1km (15.0 miles)	6.8km (4.2 miles)	7.2km (4.5 miles)



END PROJECT, 69+580

62+140 SOURCE

52+000 SOURCE

53+300 SOURCE

46+800 SOURCE

GHOST CREEK SOURCE

START PROJECT, 39+450

LILY LAKE SOURCE

NATIONAL  
CUSTER  
WILDERNESS

BEARTOOTH  
NATIONAL  
FOREST

ABSAROKA  
NATIONAL  
PARK

GALLATIN  
NATIONAL  
PARK

(A)

(A)

(A)

(B)

MP 82

MP 83

MP 84

MP 85

MP 86

MP 87

MP 88

MP 89

MP 90

MP 91

MP 92

MP 93

MP 94

MP 95

MP 96

MP 97

MP 98

MP 99

R 104 W

R 105 W

R 106 W

R 107 W

R 108 W

R 109 W

R 110 W

R 111 W

R 112 W

R 113 W

R 114 W

R 115 W

R 116 W

R 117 W

R 118 W

R 119 W

R 120 W

R 121 W

THIRTEENTH

FOURTEENTH

FIFTEENTH

SIXTEENTH

SEVENTEENTH

EIGHTEENTH

NINETEENTH

Twentieth

Twenty-first

Twenty-second

Twenty-third

Twenty-fourth

Twenty-fifth

Twenty-sixth

Twenty-seventh

Twenty-eighth

Twenty-ninth

THIRTIETH

CLARK

COOK

COOK</

APPENDIX B  
LABORATORY TEST RESULTS

**REPORT ON SOIL OR AGGREGATE TESTS**

Project: WYOMING FS 4-1(O) BEARTOOTH HIGHWAY (ROUTE)  
Submitted By: WAYNE FOLKMAN

Date Reported: 8/13/99

Sample Number	Lab Number	99-846-AGG	99-847-AGG	99-848-AGG	99-849-AGG	99-850-AGG
	Hole Number					
	Field Number	7	8	10	11	12

Sample Location	Station or Location					
	Offset					
	Depth	5'-13'	5'-16'	2.5'-15'	4'-16'	8'-16'

ASHTO 11, 27 & 88 (% Passing)	3"	75.0 mm	95	100	100	81	95
	1 1/2"	37.5 mm	86	82	74	68	80
	1"	25.0 mm	80	75	69	62	77
	3/4"	19.0 mm	76	69	66	58	74
	1/2"	12.5 mm	71	63	62	53	70
	3/8"	9.5 mm	68	59	59	49	67
	#4	4.75 mm	58	49	51	40	58
	#8	2.36 mm	46	40	42	31	44
	#10	2.00 mm	42	37	39	29	40
	#16	1.18 mm					
	#30	600 µm	23	21	25	15	20
	#40	425 µm	18	16	22	12	16
	#50	300 µm	15	12	19	10	13
	#100	150 µm					
	#200	75 µm	7.7	4.1	12.3	4.7	6.4
		2 µm					
		0.2 µm					
	0.1 µm						
	Moisture (%)						
AASHTO T 89 & 90	Liquid Limit	NV	NV	22	NV	NV	
	Plasticity Index	NP	NP	NP	NP	NP	
Soil Classification	AASHTO M 145	A-1-a (o)					
	ASTM D 2487	SW-SM	GP	GM	GP-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)						

Distribution: Materials 3 Copies

Remarks: SAMPLES ARE FROM THE GHOST CREEK MATERIALS SOURCE

Reported by:  
*Ronald D. Andresen*  
Ronald D. Andresen  
Pavement Engineer

Bob H. Welch, P. E.  
Materials Engineer

Geotechnical ~~WAYNE FOLKMAN~~

**REPORT ON SOIL OR AGGREGATE TESTS**

**Project:**

**Submitted By:**

**Date Reported:** 8/13/99

Sample Number	Lab Number	99-851-AGG	99-852-AGG	99-853-AGG	99-854-AGG	99-855-AGG
	Hole Number					
	Field Number	13	14	18	20	21

Sample Location	Station or Location					
	Offset					
	Depth	2'-17'	0'-18'	0'-15'	6'-15'	1'-15'

AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm	89	91	85	80	91
	1 1/2"	37.5 mm	66	65	65	67	70
	1"	25.0 mm	58	59	59	64	64
	3/4"	19.0 mm	55	55	55	62	60
	1/2"	12.5 mm	50	50	49	57	53
	3/8"	9.5 mm	47	47	45	55	50
	#4	4.75 mm	40	40	36	46	41
	#8	2.36 mm	33	31	27	37	32
	#10	2.00 mm	31	28	24	34	30
	#16	1.18 mm					
	#30	600 µm	18	13	11	20	17
	#40	425 µm	14	10	9	17	13
	#50	300 µm	10	7	7	14	11
	#100	150 µm					
	#200	75 µm	3.2	3.0	2.6	6.8	5.0
		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-a (0)				
	ASTM D 2487		GP	GP	GP	SP-SM	GP-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

**Remarks:**

**Reported by:**

*Ronald D. Andresen*  
Ronald D. Andresen  
Pavement Engineer

Bob H. Welch, P. E.  
Materials Engineer

Geotechnical W. FOLKMAN

**REPORT ON SOIL OR AGGREGATE TESTS**

Project: WYOMING FS 4-1 (0) BEARTOOTH HIGHWAY (ROUTE)

Submitted By: WAYNE FOLKMAN

Date Reported: 8/13 '99

Sample Number	Lab Number	99-844-A66	99-845-A66		
	Hole Number				
	Field Number	1	2		

Sample Location	Station or Location	46 + 800 W	46 + 800 E		
		CUT SLOPE	CUT SLOPE		
	Offset	-	-		
	Depth	0-2'	0-2'		

AASHTO T 11, 27 & 88 (% Passing)	3"	75.0 mm	93	90	
	1 1/2"	37.5 mm	88	73	
	1"	25.0 mm	83	70	
	3/4"	19.0 mm	79	67	
	1/2"	12.5 mm	74	63	
	3/8"	9.5 mm	70	61	
	#4	4.75 mm	61	53	
	#8	2.36 mm	55	47	
	#10	2.00 mm	53	45	
	#16	1.18 mm			
	#30	600 µm	40	34	
	#40	425 µm	36	31	
	#50	300 µm	32	27	
	#100	150 µm			
	#200	75 µm	16.0	16.3	
		2 µm			
		0.2 µm			
	0.1 µm				
	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)				

Distribution:  
Materials 3 Copies

Remarks:

Reported by:  
*Ronald D. Andresen*  
Ronald D. Andresen  
Pavement Engineer

Bob H. Welch, P. E.  
Materials Engineer

Geotechnical W. Folkman

FEDERAL HIGHWAY ADMINISTRATION

Central Federal Lands Highway Division

REPORT OF SOIL OR AGGREGATE TESTS

Project : Wyoming FS 4-1 (0) Beartooth Highway (Route)

Submitted By : Wayne Folkman

Date Reported : 08/19/1999

Sample Number	Lab Number	99-956-AGG			
	Hole Number				
	Field Number				

Sample Location	Station or Location				
	Offset				
	Depth				

AASHTO T11, T27 & T88  Washed Sieve Analysis % passing	3 "	75.0 mm	90		
	1 - 1/2 "	37.5 mm	72		
	1 "	25.0 mm	66		
	3/4 "	19.0 mm	63		
	1/2 "	12.5 mm	57		
	3/8 "	9.5 mm	54		
	# 4	4.75 mm	45		
	# 8	2.36 mm	36		
	# 10	2.00 mm	33		
	# 16	1.18 mm			
	# 30	600 μm	18		
	# 40	425 μm	14		
	# 50	300 μm	11		
	# 100	150 μm			
	# 200	75 μm	4.8		
	20 μm				
	2 μm				
	1 μm				
AASHTO	Moisture, %				
AASHTO T89 & T90	Liquid Limit	NV			
	Plasticity Index	NP			
Soil Classification	AASHTO M145	A-1-a (0)			
	ASTM D 2487	GW-GC			
AASHTO T190	R -Value				
AASHTO T288	Min. Resistivity, ohm-cm				
AASHTO T289	pH				
AASHTO	Optimum Moisture, %				
	Max. Dry Density, pcf				

Distribution :

Materials 3 copies

Remarks :

Combined Samples: 99-(846-847,849-855)-AGG  
 Samples are from the Ghost Creek Materials Source.  
 Sand Equivalent Alternate Method 2: 71  
 Fine Durability Index: 69  
 Coarse Durability Index: 85  
 Los Angeles Abrasion, Grading B: 29%

Reported by :

*Ronald P. Andresen*  
 Ron Andresen  
 Materials Specialist  
 Bob Welch  
 Materials Engineer

WAYNE FOLKMAN

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 51+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: Materials 3 Copies

Q. A. Engineer  
GEOTECHNICAL: 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

FEDERAL HIGHWAY ADMINISTRATION  
Central Federal Lands Highway Division

**REPORT OF MISCELLANEOUS TESTS**

Laboratory Number : 99-956-AGG

Date Reported : 8/26/1999

Project : WYOMING FS 4-1(O) BEARTOOTH HIGHWAY (ROUTE)

Submitted By : WAYNE FOLKMAN

Material Type : AGGREGATE BASE

Material Source : GHOST CREEK MATERIAL SOURCE

Tested For : SODIUM SULFATE SOUNDNESS

Field Sample Number : N/A

**TEST RESULTS**

SODIUM SULFATE SOUNDNESS (-3/8 + #4) : 2 % LOSS

OTHER TEST RESULTS WERE REPORTED ON 8/19/1999

**Distribution :**

Materials 3 copies

Wayne Folkman Geotechnical

**Reported by :**

*Ronald D. Anderson*

Ron Andresen  
Materials Specialist

Bob Welch  
Materials Engineer

APPENDIX C  
EXCAVATION LOGS, GHOST CREEK

EXCAVATION LOGS  
GHOST CREEK MATERIALS SOURCE

LOGS BY: Wayne C. Folkman

Excavations made July 22-23, 1999, with a track-mounted CAT 322-L excavator.

BORING NO.	DEPTH	DESCRIPTION
BK-1 Previously excavated area	0 to 1.52	Waste material from previous work, fine sand (crusher rejects), tree limbs, boulders.
BK-2 Previously excavated area	0 to 1.82	In existing cut slope from previous excavation. Sand, gravel, cobbles and boulders. Not many boulders over 304 mm (12 inches).
	1.83 to 3.66	Sand and some gravel, mostly sand.
BK-3 Previously excavated area	0 to 1.83	Waste, clayey soil, boulders.
	1.83 to 3.05	Fine sand, probably crusher rejects.
BK-4 Previously excavated area	0 to 3.05	Sand with a small amount of gravel.
BK-5 Natural ground	0 to 0.61	Black topsoil.
	0.61 to 3.05	Light brown sand, gravel, and cobbles up to 254 mm (10 inches). Estimated 60 percent sand.
BK-6	0 to 0.61	Black topsoil.
	0.61 to 3.05	Mostly sand with large boulders up to 914 mm (36 inches) in diameter.
BK-7	0 to 0.61	Dark brown gravelly topsoil.
	0.61 to 1.52	Light brown sand with a small amount of gravel.
	1.52 to 3.96	Light brown sand, gravel, cobbles, and boulders up to 914 mm (36 inches). Sampled 152 mm (6-inch) minus. Estimated cobbles and boulders over 152 mm (6 inches) is 20 to 30 percent.

BORING NO.	DEPTH	DESCRIPTION
BK-8	0 to 0.76	Dark brown gravelly topsoil.
	0.76 to 1.52	Light brown sand and gravel, mostly sand with 20 to 30 percent gravel.
	1.52 to 4.88	Light brown sand, gravel, cobbles, and boulders. Sampled 152 mm (6 inches) minus. Estimated cobbles and boulders over 152 mm (6 inches) is 15 to 25 percent.
BK-9	0 to 0.61	Dark brown gravelly topsoil.
	0.61 to 2.44	Light brown sand intermixed with gravel, cobbles, and large boulders 305 to 914 mm (12 to 36 inches). Hard excavating, stopped at 8 feet. (No sample.)
BK-10	0 to 0.76	Dark brown gravelly topsoil.
	0.76 to 4.57	Light brown sand, gravel, cobbles, and boulders. Sampled 152 mm (6 inches) minus. Estimated cobbles and boulders above 152 mm (6 inches) is 20 to 30 percent.
BK-11	0 to 0.46	Dark brown topsoil.
	0.46 to 1.22	Light brown sand, cobbles, and boulders. Very bouldery. Boulders up to 762 mm (30 inches).
	1.22 to 4.88	Light brown sand, gravel, cobbles, and boulders. Sampled 152 mm (6 inches) minus. Estimated material 152 to 610 mm (6 to 24 inches) is 30 percent. Some boulders up to 914 mm (36 inches).
BK-12	0 to 0.61	Dark brown topsoil
	0.61 to 2.44	Light brown sand and gravel, mostly sand.
	2.44 to 4.88	Sand, gravel and cobbles. Sampled 152 mm (6 inches) minus. Material estimate 152 to 305 mm (6 to 12 inches) is 20 percent; 5 percent plus, 305 mm (12 inches).
BK-13	0 to 0.61	Dark brown topsoil.
	0.61 to 5.18	Light brown sand, gravel, cobbles, and boulders. Sampled 152 mm (6 inches) minus material. Estimated material 152 to 610 mm (6 to 24 inches) is 20 to 30 percent.

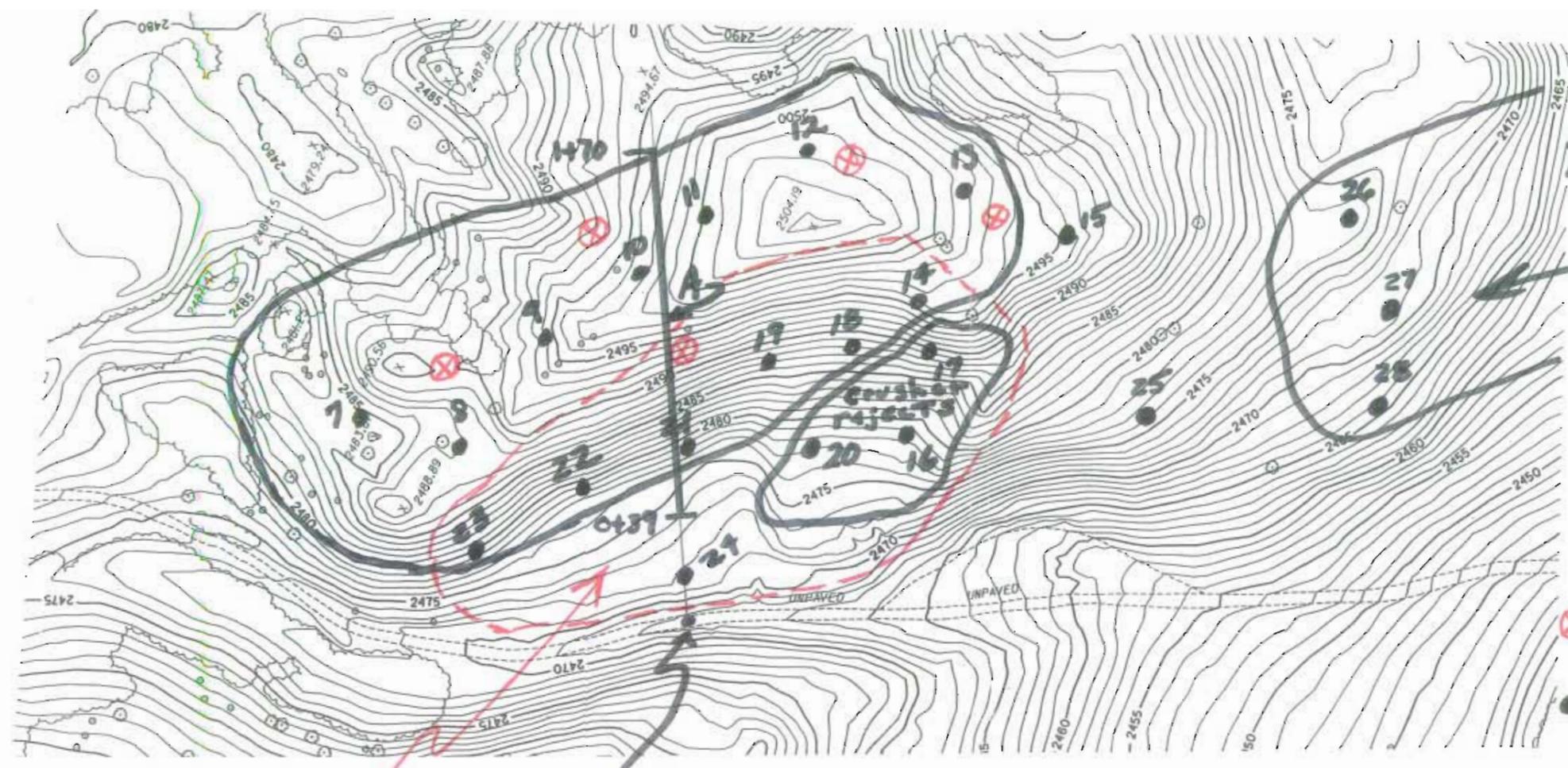
BORING NO.	DEPTH	DESCRIPTION
BK-14	0 to 5.49	No topsoil. Light brown sand, gravel, cobbles, and boulders. Sampled 152 mm (6-inches) minus material. Estimated material 152 to 762 mm (6 to 30 inches) is 20 to 30 percent.
BK-15	0 to 1.22	Very rocky cobbles and boulders.
	1.22 to 2.74	Sand and gravel, mostly sand. No sample taken.
BK-16	0 to 0.15	Dark brown topsoil.
	0.15 to 2.44	Sand, crusher rejects. No sample taken.
BK-17	0 to 3.05	Sand, crusher rejects. No sample taken.
BK-18	0 to 4.57	Light brown sand, gravel, cobbles, and boulders. Sampled 152 mm (6-inches) minus. Estimate material 152 to 762 mm (6 inches to 30 inches) is 20 to 30 percent.
BK-19	0 to 0.30	Dark brown topsoil.
	0.30 to 4.57	Light brown sand, gravel, cobbles, and boulders. No sample taken. Same as BK-18.
BK-20	0 to 0.30	Dark brown topsoil.
	0.30 to 1.83	Light brown sand, crusher rejects.
	1.83 to 4.57	Light brown sand, gravel, cobbles, and boulders. Sample taken, same as BK-18 and BK-19.
BK-21	0 to 0.30	Dark brown topsoil.
	0.30 to 4.57	Light brown sand, gravel, cobbles, and boulders. Sampled minus 152 mm (6 inches) material. Estimated material 152 to 610 mm (6 to 24 inches) is 20 to 30 percent.
BK-22	0 to 0.30	Dark brown topsoil.
	0.30 to 4.57	Light brown sand, gravel, cobbles, and boulders. No samples taken, same as BK-21.

BORING NO.	DEPTH	DESCRIPTION
BK-23	0 to 0.61	Dark brown topsoil.
	0.61 to 1.52	Light brown sand and gravel, mostly sand.
	1.52 to 3.05	Light brown sand, gravel, cobbles, and boulders. Same as BK-22. No sample taken. Becoming very bouldery, 914 mm (36 inches) plus boulders. End excavation.
BK-24	0 to 0.30	Dark brown topsoil.
	0.30 to 1.52	Dirty brown sand and gravel, materials from previous excavation.
	1.52 to 3.66	Dirty brown sand and gravel, not much rock. Becoming very bouldery at 3.05 m (10 feet).
BK-25	0 to 0.76	Dark brown topsoil.
	0.76 to 1.83	Light brown sand and large boulders up to 610 mm (24 inches), very little gravel and cobbles.
	1.83 to 4.27	Sand.
BK-26	0 to 0.46	Dark brown topsoil.
	0.46 to 1.83	Light brown sand and gravel, mostly 76 mm (3 inches) minus.
	1.83 to 4.57	Light brown sand, gravel, cobbles, and boulders. No sample taken.
BK-27	0 to 0.30	Dark brown topsoil.
	0.30 to 4.57	Light brown sand, gravel, cobbles, and boulders. No sample taken.
BK-28	0 to 0.46	Dark brown topsoil.
	0.46 to 3.66	Sand, gravel, cobbles and boulders. Very rocky. 50 percent estimated 152 to 610 mm (6 inches to 24 inches), becoming finer after 3.66 m to 4.27 m (12 feet to 14 feet).

APPENDIX D

PHOTO OF GHOST CREEK  
MAP OF GHOST CREEK MATERIALS SOURCE

REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
16	WY	FH 4 - 110) BEAR TOOTH HWY		



MATERIAL AVAILABLE IN THIS AREA

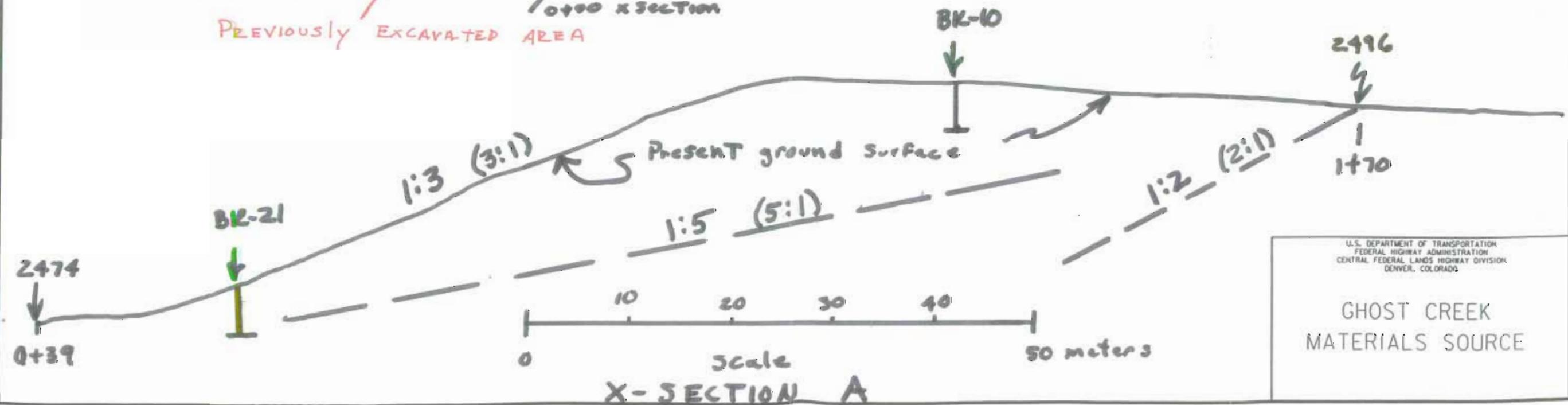
PREVIOUSLY EXCAVATED AREA. (OFF MAPPING)

⊗ RECOMMENDED CORING LOCATIONS

● EXCAVATIONS

PREVIOUSLY EXCAVATED AREA

0+39 X SECTION



U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL HIGHWAY ADMINISTRATION  
CENTRAL FEDERAL LANDS HIGHWAY DIVISION  
DENVER, COLORADO

GHOST CREEK  
MATERIALS SOURCE

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GHOST CREEK

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RB-98WY-273

1-1

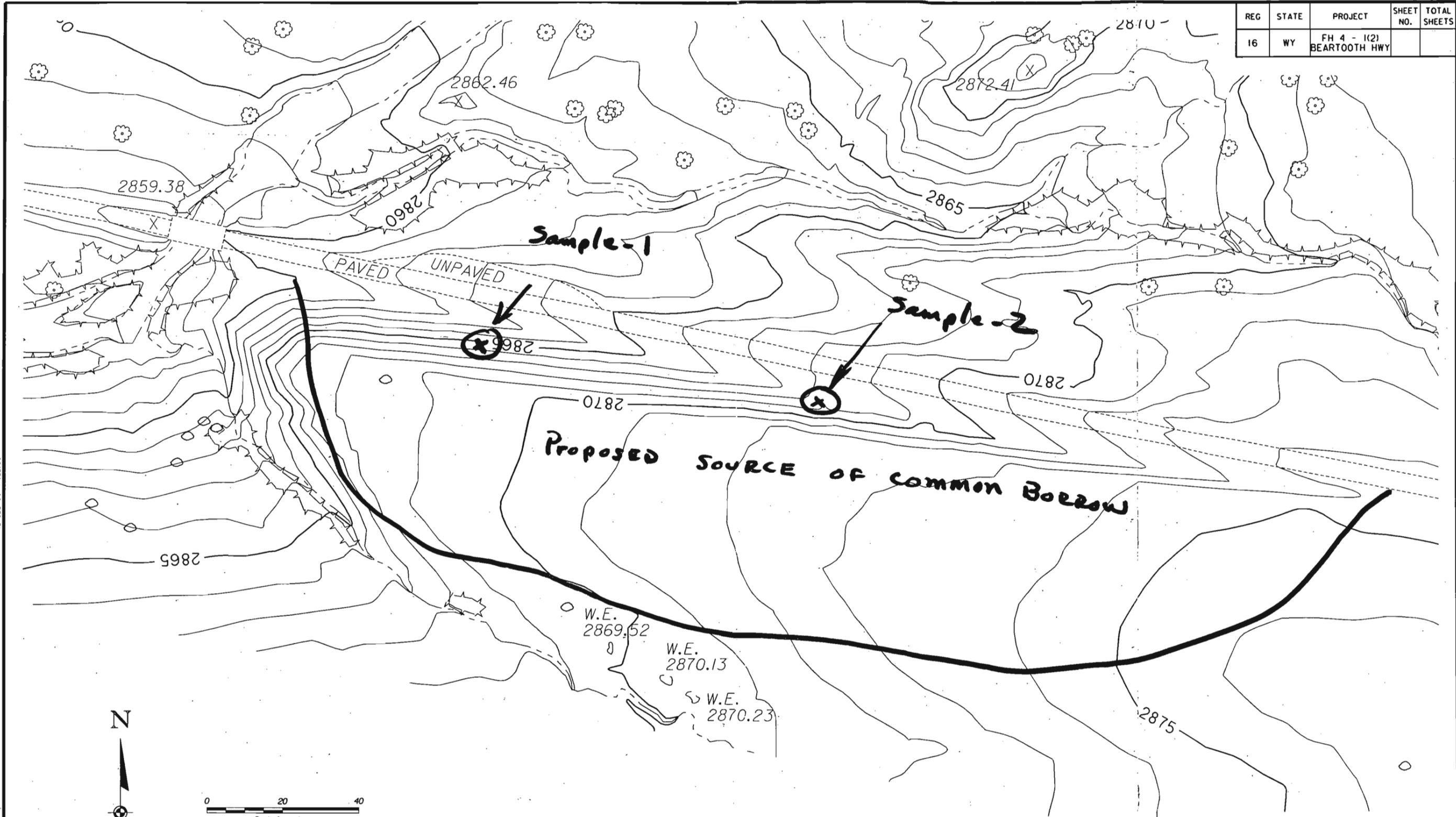


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APPENDIX E

MAP OF STATION 46+8000 MATERIALS SOURCE

REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
16	WY	FH 4 - (2) BEARTOOTH HWY		



U.S. DEPARTMENT OF TRANSPORTATION  
 FEDERAL HIGHWAY ADMINISTRATION  
 CENTRAL FEDERAL LANDS HIGHWAY DIVISION  
 DENVER, COLORADO

**STATION 46+800  
 MATERIALS SOURCE**

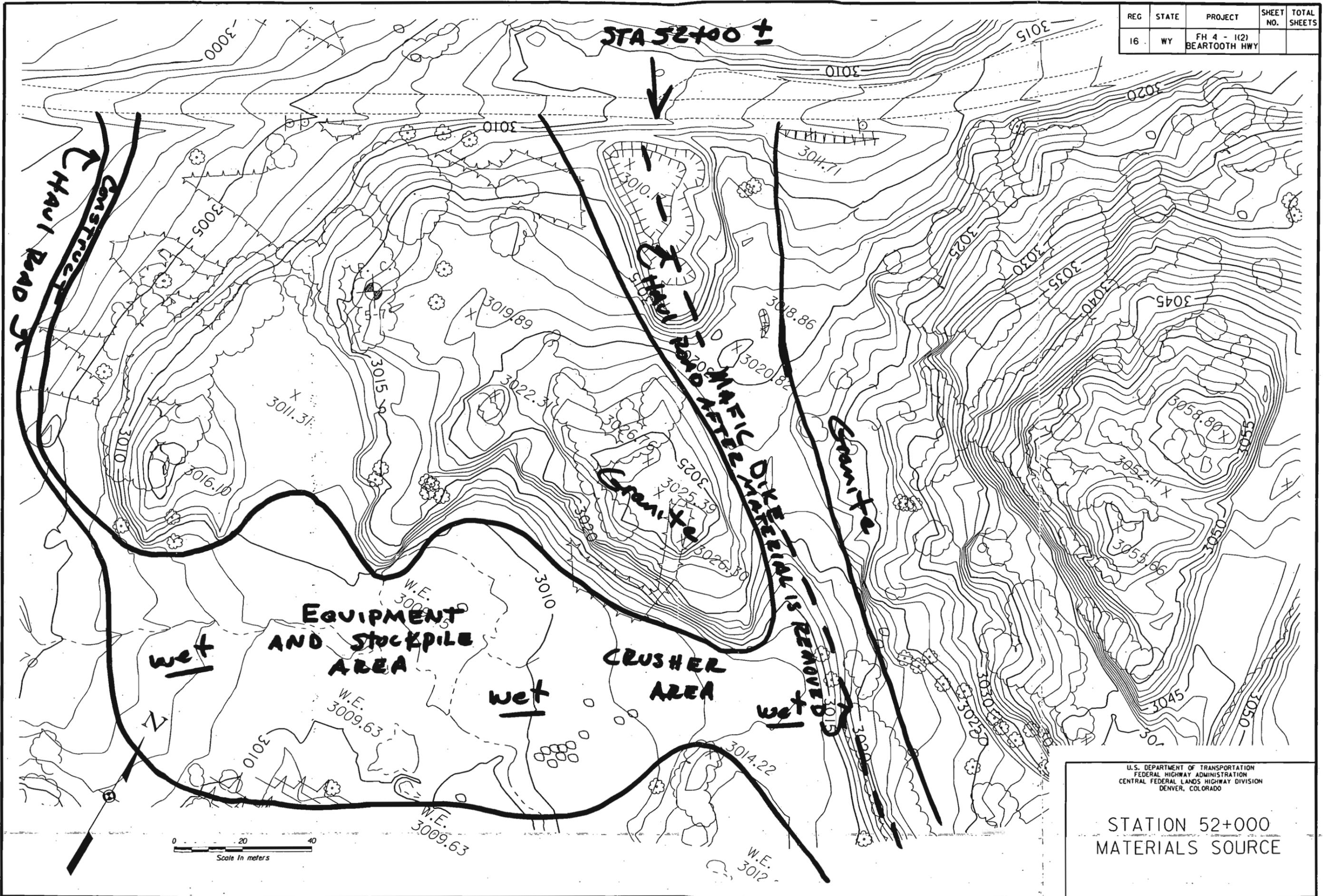
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APPENDIX F

MAP OF STATION 52+000 MATERIALS SOURCE

REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
16	WY	FH 4 - 1(2) BEARTOOTH HWY		



U.S. DEPARTMENT OF TRANSPORTATION  
 FEDERAL HIGHWAY ADMINISTRATION  
 CENTRAL FEDERAL LANDS HIGHWAY DIVISION  
 DENVER, COLORADO

STATION 52+000  
 MATERIALS SOURCE

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APPENDIX G

PHOTOS OF GHOST CREEK MATERIALS SOURCE

**GHOST CREEK  
MATERIALS SOURCE**



**PHOTO #1  
BK-1**



**PHOTO #2  
BK-2**



PHOTO #3  
BK-3



PHOTO #4  
BK-4



PHOTO #5  
BK-5



PHOTO #6  
BK-6



PHOTO #7  
BK-8, CLOSE UP.



PHOTO #8  
BK-10, CLOSE UP.



PHOTO #9  
BK-11, CLOSE UP.



PHOTO #10  
BK-13, CLOSE UP.



PHOTO #11  
BK-14, CLOSE UP.



PHOTO #12  
BK-14, LOOKING IN EXCAVATION.



PHOTO #13  
BK-15, CLOSE UP.



PHOTO #14  
BK-17, LOOKING DOWN AT BK-16.



PHOTO #15  
ABOVE BK-18, LOOKING DOWN AT BK-18, BK-17, AND BK-16.



PHOTO #16  
BK-19 AND BK-16.



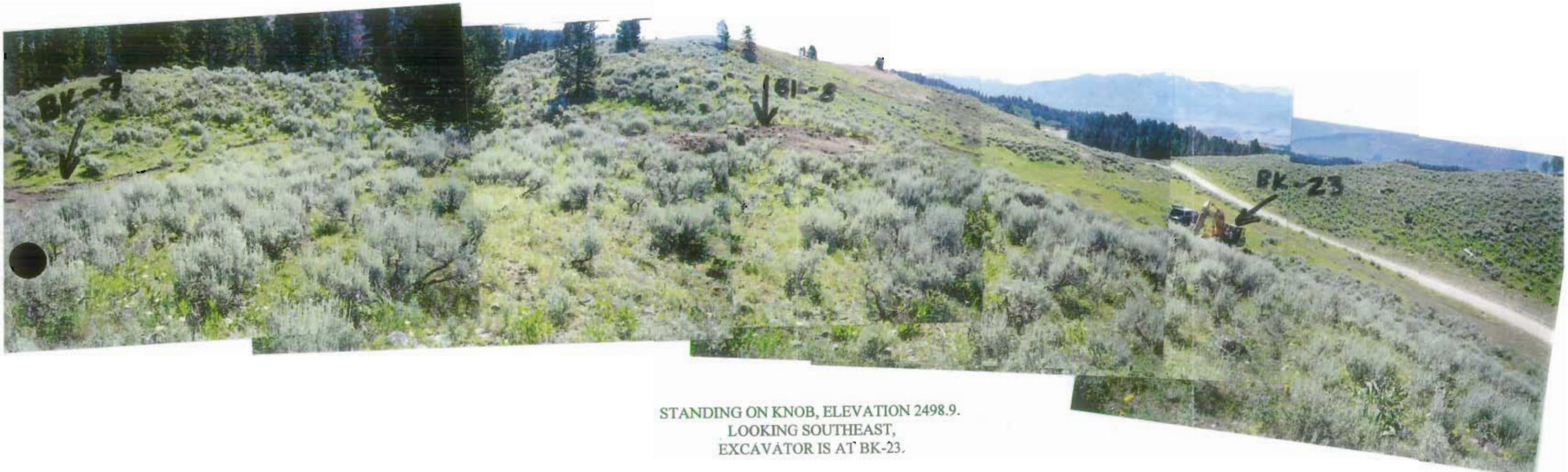
PHOTO #17  
BK-22



PHOTO #18  
T BK-23, LOOKING AT EXCAVATOR AT BK-22.



STANDING ON ROADWAY BELOW BK-28  
LOOKING NORTH.  
SHOWING RIDGE BETWEEN SOUTHERN AND NORTHERN OLD PIT AREAS.



STANDING ON KNOB, ELEVATION 2498.9.  
LOOKING SOUTHEAST,  
EXCAVATOR IS AT BK-23.



GHOST CREEK MATERIALS SOURCE

STANDING AT BK-14, LOOKING AT BK-15.  
LOOKING SOUTHEAST THEN SWINGING AROUND ON  
TOP OF RIDGE LOOKING AT OLD EXCAVATION AREA  
WITH ENDING PHOTO LOOKING SOUTH.