Topsoil Suitability Report

Portions of U.S. 212 (FH 4)
The Beartooth Highway
Park County, Wyoming

Prepared for—

Federal Highway Administration
Central Federal Lands Highway Division
555 Zang Street
Denver, Colorado 80025

Prepared by—

ERO Resources Corporation
1842 Clarkson Street
Denver, Colorado 80218

July 2001

ERO
Resources
Corporation

CONTENTS

TABLES

FIGURES

APPENDICES

TOPSOIL SUITABILITY REPORT

PORTIONS OF U.S. 212 (FH 4)
THE BEARTOOTH HIGHWAY
PARK COUNTY, WYOMING

Introduction

The Federal Highway Administration retained ERO Resources Corporation to prepare a report on soil suitability for revegetation for the proposed Beartooth Highway Reconstruction Project. The study area includes U.S. 212 (FH4) from KP 39.5 (MP 24.5) to the Montana/Wyoming state line at KP 69.4 (MP 43.1), Park County, Wyoming. The study area is generally about 30 m (100 ft.) on either side of the existing road centerline, but is wider in locations where potential road realignments may occur. This report provides an evaluation of the quality, depth, and suitability of topsoil for use in the reclamation and revegetation of cut and fill slopes, disturbed areas, and abandoned road segments following proposed road improvements. Included is an estimate of the volume of topsoil available for use in reclamation for each of the build alternatives under consideration.

Methods

Data Sources and Field Investigation

Information on soil resources in the study area was collected from several sources including soil survey data from Shoshone National Forest (undated), field investigations, and laboratory analysis of field samples. On September 18 to 20, 2000, Mark DeHaven of ERO Resources conducted a field reconnaissance of the study area. During the field survey, about 40 soil pits were hand-dug and 13 backhoe pits were excavated. Backhoe pits were excavated to a depth of about 1 m (3 ft.) to allow examination of the soil profile and collection of soil samples. Field notes from hand-dug and backhoe pits are included in Appendix A. Information on the area of construction disturbance for each build alternative was provided by Washington Infrastructure Services, Inc.

Laboratory Analysis

Soil samples were collected from the A horizon of 10 representative backhoe pits for laboratory analysis. The Colorado State University Soil, Water, and Plant Testing Laboratory in Fort Collins, Colorado conducted the analysis of soil samples. The laboratory analysis of soil samples included a determination of nutrients (nitrogen, phosphorus, potassium, zinc, iron, manganese, copper), electrical conductivity, pH, organic matter, and soil texture. Results of the lab analysis are included in Appendix B.

Topsoil Criteria

Topsoil is the uppermost layer of soil material, which includes the most active biological components, nutrients, and organic matter. Topsoil suitability criteria have been developed by several sources including Natural Resource Conservation Service (1993); Wyoming Soil Conservation Service (1981); Wyoming Department of Environmental Quality (1994); and Utah Department of Transportation (Hansen et al. 1991). Criteria include physical and chemical characteristics necessary for successful revegetation, such as soil texture, organic matter content, pH, and electrical conductivity. Additional constraints to soil suitability include the amount of rock fragments and slope. These factors are important because of the mechanical limitations in salvaging and reapplying soil with a high percentage of rock or working on steep slopes.

ERO developed criteria for topsoil suitability applicable to the Beartooth Highway from published sources and field evaluation of site conditions (Table 1). The applicability of these criteria and considerations for salvage of the native soil for the Beartooth Highway Reconstruction Project are discussed in the section on the *Characteristics of Soils in the Study Area.*

Table 1. Topsoil suitability criteria for revegetation along the Beartooth Highway.

Soil Property	Suitability		
	Good	Fair	Poor
Texture	sandy loam loam silt loam sandy clay loam	clay loam silty clay loam sandy clay loamy sand	clay silty clay silt sand
Rock fragments (percent by volume)	< 33	33-66	> 66
Organic matter	> 2 percent	0.5-2 percent	<0.5 percent
pH	6.0-8.4	5.0-6.0	<5.0; >8.4
Electrical conductivity (mmhos/cm)	0-4	4-8	8-16
Slope	< 8 percent	8-15 percent	>15 percent

Sources: NRCS (1993); Wyoming SCS (1981); Wyoming DEQ (1994); Hansen et al. (1991).

Surface Rock

The amount of rock on the soil surface is an approximate indicator of rock fragments in the soil profile, and hence the volume of soil available. The amount of surface rock (gravel, cobble, stones, or boulders) also will influence the techniques and types of equipment to use for salvaging soil during construction. Soils in the study area were divided into three classes of surface rock: Class I (low); Class II (medium); and Class III (high) to assist in the evaluation of the amount of soil available and the physical limitations in the salvage of soil material. Class I includes soils with less than 33 percent of the surface rock. Soils mapped as Class II contain from 33 to 66 percent surface rock. Soils mapped as Class III contain more than 66 percent surface rock. Maps of surface rock classes are included in Appendix C.

Soil Resources in the Study Area

The Beartooth Highway is located in the southeast portion of an area known as the Beartooth uplift (Woodward-Clyde 1998). The Beartooth uplift consists of granite and metamorphic rock overlain in places by sedimentary rock remnants. Glaciation and erosional processes are responsible for the majority of landscape forms currently present. Soils in the study area are the result of the slow weathering of primarily granitic and

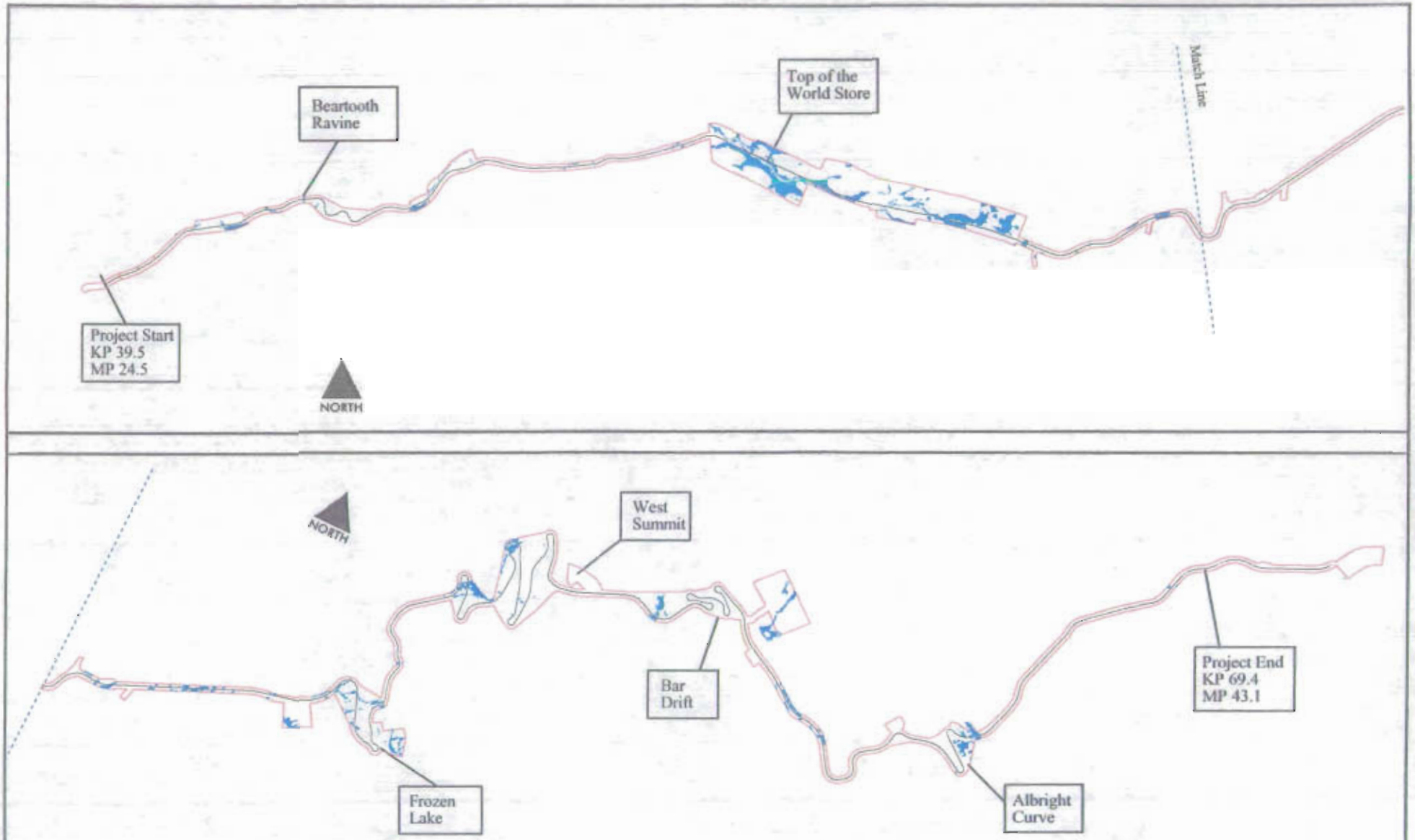
metamorphic rock, except where sedimentary material is present near the western end of the study area.

The Shoshone National Forest soil survey (undated), which includes the study area, was conducted at a broad level that includes map units containing a complex of soil series and soil taxonomic units. Soil series are named soil types with specific soil characteristics. Soil taxonomic units are based on soil morphology, soil horizons, and soil temperature and moisture regimes, and provide a more general description of the soil type. The soil series and taxonomic map unit descriptions described below are taken from Forest Service soil survey (undated).

Based on the Forest Service soil survey, seven major soil map units and three minor soil map units are found in the study area. A brief description of the soils in the study area follows. Soil map units are shown in Figure 1.

Major Soil Map Units

Map Unit 304 — Cryumbrepts-Cryochrepts-Cryorthents Complex. Map Unit 304 is located in alpine meadows on the eastern half of the study area (Figure 1). Soil types found in Map Unit 304 include 50 percent Cryumbrepts, 15 percent Cryochrepts, and 15 percent Cryorthents. Rock outcrop and other soil types comprise 20 percent of this map unit. Cryumbrepts have developed from granitic parent material and are moderately deep to deep. They typically have a 25-cm (10-in.) loam A horizon with about 15 percent gravel and 5 percent cobbles. The B horizon is a very gravelly sandy loam about 10 cm (4 in.) thick and includes 45 percent rock fragments. Cryochrepts have a 5-cm (2-in.) loam A horizon and a B horizon of gravelly to very gravelly loam or sandy loam. The B horizon has over 50 percent rock fragments. Cryorthents are moderately deep and have a very gravelly loam A horizon about 18 cm (7 in.) thick. The C horizon is less than 91 cm (36 in.) deep. Both the A and C horizons include 50 percent or more gravel and cobble.



ERO
ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1199

Wetland

Boundary of wetland study area

Centerline of existing road

Scale: 1:40,000

1/2 mile 0 1mile

1/2 km 0 1 kilometer

Figure 1

Wetlands in Project Area

July 2001

Source: 1:100,000 BLM topographic map (Cody)

rawwetmk2001.apr

Map Unit 305 —Cryumbrepts-Cryaquolls Complex. Map Unit 305 includes mountain meadows near Island Lake (Figure 1). This map unit includes 60 percent Cryumbrepts, similar to Map Unit 304 although soils are deeper and fewer rock fragments are present in Map Unit 305. Slopes in this portion of the study area are generally less than 10 percent. Cryaquolls are found in 20 percent of this map unit. Cryaquolls are somewhat poorly drained soils developed in alluvium along streams. These wetland soils include an organic horizon over silt loam to loamy soils. Some of these soils may qualify as fens. Other soil inclusions comprise 20 percent of the map unit.

Map Unit 306 —Sedbud-Mercetta Complex. Map Unit 306 is found on the western end of the study area in grassland and sagebrush habitats (Figure 1). Map Unit 306 includes 60 percent Sedbud soils and 20 percent Mercetta soils. Other soil inclusions comprise 20 percent of the map unit. Sedbud soils have a 8- to 23-cm (3- to 9-in.) A horizon of sandy loam. The B horizon is composed of gravelly to very gravelly sandy loam to about 102 cm (40 in.). Rock fragments in the B horizon increase with depth from about 15 percent to 55 percent. The Mercetta soil series has a 18-cm (7-in.) silt loam A horizon with few rock fragments. The B horizon is a very cobbly silt loam about 33 cm (13 in.) thick. Forty percent of the B horizon is rock fragments.

Map Unit 310 —Rock Outcrop-Taglake-Como Complex. Map Unit 310 is located on forested areas west of Beartooth Lake (Figure 1). This map unit includes 40 percent granitic rock outcrops, 30 percent Taglake soil series and 20 percent Como soil series. Included in this map unit are areas of steep rock outcrops west of the Beartooth Ravine area. The soil profile for a typical Como soil includes a 5-cm (2-in.) loamy A horizon with 10 percent gravel. The B horizon is about 43 cm (17 in.) thick and may include gravelly silt loams and very gravelly sandy loams. Gravels, cobbles and stones make up 20 to 55 percent of the soil profile in the B horizon. Taglake soils have a sandy loam A horizon from 5 to 15 cm (2 to 6 in.) over a 18- to 51-cm (7-to 20-in.) B horizon of gravelly to very gravelly sandy loam. Gravel and cobble in the A horizon are less than 20 percent. Rock fragments make up 50 percent of the B horizon.

Map Unit 311 —Rock Outcrop-Taglake-Cryumbrepts Complex. Map Unit 311 is found in alpine and subalpine areas where granitic rock outcrop dominates 75 percent of the landscape (Figure 1). Soils within Map Unit 311 are found in alpine meadows and in patches within fields of stones and boulders. The Taglake soil series is found in about 10 percent of this map unit. Taglake soils have a sandy loam A horizon from 5 to 15 cm (2 to 6 in.) over a 18- to 51-cm (7- to 20-in.) B horizon of gravelly to very gravelly sandy loam. Gravel and cobble in the A horizon are less than 20 percent. Rock fragments make up 50 percent of the B horizon. This map unit includes about 10 percent Cryumbrepts as described in Map Unit 304.

Map Unit 314 — Taglake-Buell Complex. Forested areas between the Top of the World Store and Beartooth Lake are included in Map Unit 314 (Figure 1). Map Unit 314 is composed of 45 percent Taglake soil series and 35 percent Buell soil series. Taglake soils have a sandy loam A horizon from 5 to 15 cm (2 to 6 in.) over a 18- to 51-cm (7- to 20-in.) B horizon of gravelly to very gravelly sandy loam. Gravel and cobble in the A horizon are less than 20 percent. Rock fragments make up 50 percent of the B horizon. The Buell soil series has a gravelly loam A horizon from 8 to 25 cm (3 to 6 in.) in depth. Gravels and cobbles average about 20 percent of the A horizon and increase to 30 to 55 percent in the sandy loam B horizon.

Map Unit 318 — Cryaquepts-Cryaquolls-Cryofibrists Complex. Map Unit 318 is found in wetland meadows near the Top of the World Store (Figure 1). Map Unit 318 includes 50 percent Cryaquepts, 15 percent Cryaquolls, and 15 percent Cryofibrists. Cryaquepts have a loamy 10-cm (4-in.) A horizon and a B horizon to 102 cm (40 in.) composed of layers of loam and sandy loam. The B horizon includes from 15 to 35 percent gravel and cobble. Cryaquolls are the same as described for Map Unit 305. Cryofibrists have a thick organic horizon of fibrous peat material and generally qualify as fens. Sandy clay loams are present in poorly drained Cryofibrists.

Minor Soil Map Units

Map Unit 204 — Cryoboralfs; Map Unit 302 — Cryaquepts-Cryaquolls-Cryofibrists; and Map Unit 319 — Cryumbrepts-Cryochrepts-Cryorthents. Three minor soil map units with limited distribution in the study area are also present (Figure 1). Map Unit 204 near Clay Butte includes fine-textured soils derived from limestone. Map Unit 302 near Little Bear Lake includes areas of wetland and fen soils similar to Map Unit 318. Map Unit 319 includes alpine soils and rock outcrop similar to Map Unit 304.

Characteristics of Soils in the Study Area

Physical Properties

Soil Texture. Soil texture is determined by the relative proportions of various sized soil particles. Sand is the largest-sized particle, clay the smallest; silt falls in between. Sandy loams have sand as the dominant soil particle; loams are a mixture of sand, silt, and clay sized particles.

Soil texture influences the permeability of soils to water and air and the amount of nutrients and water that a soil can hold. Coarse textured sandy soils are well drained, but have low nutrient and water holding capacities. Fine textured soils with a high clay content are poorly drained, but have high water and nutrient holding capacity. The rate of soil development at the high elevations present in the study area is limited because of the slow mechanical weathering of the hard, mostly granitic, parent material. Cold temperatures also inhibit the chemical reactions and biological activity necessary to develop soils (Brown et al. 1978).

Soil texture of the A horizon is similar throughout the study area. Sandy loam and loam surface textures are found in alpine meadows, forests, and montane meadows. Surface soil textures found throughout most of the study area are considered good for revegetation purposes (Table 1). Finer-textured clay loam soils are present near Clay Butte on the far west end of the project. Clay loams are rated fair for topsoil suitability (Table 1) because of the difficulty in handling clayey material, particularly if wet. The silt loam soils found in or near wetlands have good topsoil physical properties for wetland mitigation.

Chemical Properties

Organic Matter. Organic matter is an important characteristic that influences the structure, nutrient holding capacity, and biological activity of a soil. The incorporation of organic matter into soil aggregates is a slow process that may take up to 20 years (Staricka et al. 1992). Soils with high organic matter retain more moisture and nutrients and are more productive than soils low in organic matter. Organic matter also increases soil porosity, infiltration, and cation exchange capacity. The humus components of soils help cement soil particles together and contribute to the long-term aggregate stability. Because soils in the study area contain coarse textured soil material with low nutrient and water holding capacity, organic material is an essential component of these soils necessary for revegetation.

Laboratory analysis of A horizon soil material from the study area indicates a high organic matter content for all sampled locations (Appendix B). Percent organic matter ranges from 5.3 to over 8 percent. The slow decomposition of organic material at higher elevations accounts for the higher organic matter levels found in study area soils. The salvage of suitable soil material will include the incorporated organic material.

pH. Laboratory analysis of soil samples from the study area indicates very strongly to strongly acid soil reactions (Appendix B). Values for pH range from 4.6 to 5.4, with the exception of a pH of 6.1 near Clay Butte. The weathered granitic soils found in most of the study area have very low buffering capacities and carbonate concentrations. Although soils with pH values below 5.0 are generally considered poor for revegetation (Table 1), native plants in the study area are adapted to the acidic growing conditions. Use of the salvageable soil material present in the study area should not inhibit the establishment of native plant species tolerant of acidic soils.

Electrical Conductivity. Low electrical conductivity measurements indicate non-saline soils in the study area (Appendix B). Low salinity is a favorable condition for soil suitability (Table 1).

Nutrients. Nutrient concentrations for nitrogen, phosphorus, and potassium are very low for all of the soils tested in the study area (Appendix B). Low nutrient

concentrations are the result of several conditions including low nutrient holding capacity of coarse textured soils, low biological activity found at cold high elevation sites, and acidic soils. Most nitrogen available to plants is found within the soil organic matter. The removal, storage, and redistribution of soil during road construction and reclamation may deplete or alter nitrogen reserves due to the interruption of the chemical or biological processes in the nitrogen cycle (Munshower 1993). Soil phosphorus is complexed with organic matter and metals and is generally low in native soils with low pH. Potassium levels are low for all samples except for the clay loam soils near Clay Butte, which have moderately high potassium concentrations. Nutrient concentrations can be increased through fertilization.

Soil Micronutrients. Zinc, manganese and copper are low to medium for all sampled soils, but should not be a limiting factor for revegetation with native plants. Iron concentrations are very high for all soil samples. High iron concentration probably results from naturally occurring iron in the parent material and the solubility of iron in acidic soils.

Site Conditions

Rock Fragments. Rock fragments refer to the different sizes of rock within the soil profile or present on the soil surface. Categories of rock fragments defined by the Natural Resource Conservation Service (NRCS) (1993) are:

- Gravel = 2 mm to 75 mm (0.08 in. to 3 in.)
- Cobble = 75 mm to 250 mm (3 in. to 10 in.)
- Stone = 250 mm to 600 mm (10 in. to 24 in.)
- Boulder = > 600 mm (> 24 in.)

Rock fragments affect soil suitability primarily by the physical limitations in mechanical site preparation and planting equipment. The amount and sizes of rock fragments influence the ease of excavation, stockpiling, and respreading of soil. Because they are solid and inert, rock fragments also reduce nutrient retention and water holding capacity.

Soils in the study area with a high percentage of rock fragments are generally suitable for use as topsoil, if the soil material can be collected. The criteria used to distinguish

good, fair, and poor quality topsoil for the Beartooth Highway (Table 1) is based on a higher percentage of rock fragments than is used by the NRCS (1993). Typically, if the amount of rock fragments is greater than 25 to 35 percent, a soil is not considered suitable for topsoil due to the mechanical limitations in collecting the soil. However, because of the difficulty in revegetating disturbed areas at high elevations, it is important to salvage as much soil as practicable. For the study area, it is assumed that suitable soil can be collected if the amount of surface rock fragments is less than 66 percent. Above 66 percent, it becomes increasingly difficult to collect soil material and each specific site would need to be evaluated to determine the feasibility of salvaging soil.

The amount of rock fragments in the soil also affects seedling mortality. Mortality is generally slight when rock fragments are less than 50 percent, moderate between 50 and 75 percent, and severe above 75 percent (NRCS 1993).

The amount of rock fragments found within the soil profiles in the study area varies with landscape position and proximity to rock outcrops. As previously discussed, surface rock fragments in the study area were mapped into three classes according to the amount of surface rock present (Table 2). Surface rock provides an indication of the amount of rock present in the soil profile. In general, the A horizon has the lowest concentration of rock fragments. Gravels and cobbles are the most common rock fragments found in the A horizon. The percentage of rock fragments greatly increases below the A horizon and the amount of cobble-and stone-sized rocks increases with depth.

Table 2. Surface rock classes used to assess topsoil suitability.

Class	Surface Rock Fragments
I (Low)	0 to 33 percent
II (Medium)	33 to 66 percent
III (High)	66 to 100 percent

Slope. Slope affects the ability to collect soil. With some mechanized equipment, it is often difficult to strip soil when slopes are greater than 15 percent; however, much of the study area is located on moderate rolling to undulating slopes. The degree of slope should not be a major limitation in the collection of soil. Slope does limit the application

of soil to disturbed areas during reclamation; however, soil should not be applied to slopes greater than 1.75:1 because of the potential for erosion.

Results of Field Investigation

Hand-dug and backhoe excavations were used to collect site-specific data for the Beartooth Highway study area. Soil survey data (USFS undated) provides a broad overview of soil types present along the Highway, but does not include sufficient site-specific information to evaluate topsoil depth, rock content, and other physical and chemical properties. Information from the field investigation was used to establish four areas having similar topsoil characteristics. These areas correlated with the four vegetation zones. The four vegetation zones were alpine meadow, subalpine forest, montane meadow, and montane forest. These vegetation zones correspond with reclamation and revegetation measures that would vary by vegetation type. The following discussion provides an overview of soil characteristics for the four vegetation zones along the Beartooth Highway.

Alpine Meadow Zone (KP 55 to KP 69.4)

Soil characteristics in the high elevation (3,100 to 3,350 m [10,200 to 11,000 ft.]) alpine meadows are characterized by sandy loam and loam surface textures (Appendix D, Photo 1). Topsoil depth ranges from about 5 to 30 cm (2 to 12 in.) and averages about 20 cm (8 in.). Areas of rock outcrop with minimal soil are scattered throughout the alpine area. In the alpine meadow zone of the study area, Class I surface rock is found on about 40 percent the zone, Class II surface rock is found on 15 percent, and Class III surface rock is found on 45 percent (Table 3). Soil samples had an average pH of about 4.9. Collection of as much suitable soil as possible from alpine meadows would be important because of the difficulty in revegetating high-elevation sites.

Table 3. Distribution of surface rock classes and average topsoil depth by vegetation zone.

Vegetation Zone	Surface Rock Class Percentages in Study Area[†]			Average Topsoil Depth (cm/in.)
	I	II	III	
Alpine Meadow	40%	15%	45%	20/8
Subalpine Forest	36%	4%	60%	15/6
Montane Meadow	80%	5%	15%	25 to 30/10 to 12[‡]
Montane Forest	72%	3%	25%	20/8

[†]Class I = 0 to 33% rock; Class II = 33 to 66% rock; Class III = > 66% rock.
[‡]30 cm (12-in.) topsoil depth was used for meadow in KP 39.5 to 40.0

Subalpine Forest Zone (KP 51.5 to 55)

Soils in the subalpine forest portion of the study area include loam and sandy loam surface textures. Topsoil depth ranges from about 5 to 23 cm (2 to 9 in.) and average about 15 cm (6 in.). The depth to rock fragments greater than 50 percent of volume is generally less than 23 cm (9 in.). Large expanses of rock outcrop and Class III surface rock (60 percent) are present (Table 3). Class I surface rock is found on about 36 percent of the subalpine area and Class II surface rock on about 4 percent. The collection of soil from subalpine forests in the study area would require using equipment appropriate for extracting small pockets of suitable soil within a matrix of surface rock.

Montane Meadow Zone (KP 45 to 51.5)

Soil textures are primarily loam and sandy loam in montane meadows (Appendix D, Photo 2). Suitable soil material for use in revegetation is found in the surface horizon at depths from 20 to 30 cm (8 to 12 in.) and average 25 cm (10 in.). Rock fragments greater than 50 percent of soil volume are found at depths from 18 to 56 cm (7 to 22 in.). Wetland soils in the montane meadow zone are generally fine-textured silt loams with topsoil depths of 25 to 61 cm (12 to 24 in.). Sampled soils had an average pH of about 5.1. Class I surface rock is most common (80 percent) (Table 3). Class II surface rock is found in about 5 percent and Class III surface rock in about 15 percent of the zone. Gentle slopes found in montane meadows of the study area should facilitate collection and redistribution of soil. Soil salvage in the montane meadow zone should be maximized for possible use in other areas of the project.

Montane Forest Zone (KP 39.5 to 45)

Montane forest in the study area includes forested lands from the project start (KP 39.5) to west of the Top of the World Store. Surface soils include sandy loam, loam, and silt loams (Appendix D, Photo 3). Suitable topsoil averages about 20 cm (8 in.) and ranges from about 18 to 33 cm (7 to 13 in.). The depth to rock fragments greater than 50 percent of the soil volume is about 25 cm (10 in.). Large areas of rock outcrop are common west of Beartooth Lake and soil depths are generally shallower near areas of rock outcrop. Class I surface rock is found on about 72 percent of the area, Class II surface rock on about 3 percent, and Class III surface rock on about 25 percent (Table 3).

A small area of grassland meadow is included within the montane forest zone west of the Clay Butte Lookout Road (KP 39.5 to 40). Clay loam soils with rock fragments of less than 20 percent of the soil are present in this area. Suitable topsoil depth averages about 30 cm (12 in.). The finer textured soils found near Clay Butte have higher nutrient concentrations and are less acidic than other soils in the study area.

Topsoil Volume

Available topsoil for stripping and use in reclamation and revegetation of disturbed areas was estimated for the construction corridor. Topsoil volume estimates were based on the average depth of topsoil for each of the vegetation zones (Table 3). To account for rock fragments, volumes were reduced by 17 percent in Class I surface rock areas and by 50 percent in Class II areas. Topsoil was not considered salvageable in Class III surface rock areas. A preliminary estimate of soil application depths for use in revegetation was made using topsoil volume and the estimated reclamation area (Table 4). The reclamation area was based on the total area of new construction disturbance plus abandoned sections of road, less new road pavement that would not be reclaimed. Average topsoil replacement depth would be about 11 cm (4 in.). The difference between the alternatives in the average topsoil replacement depth is less than 5 percent.

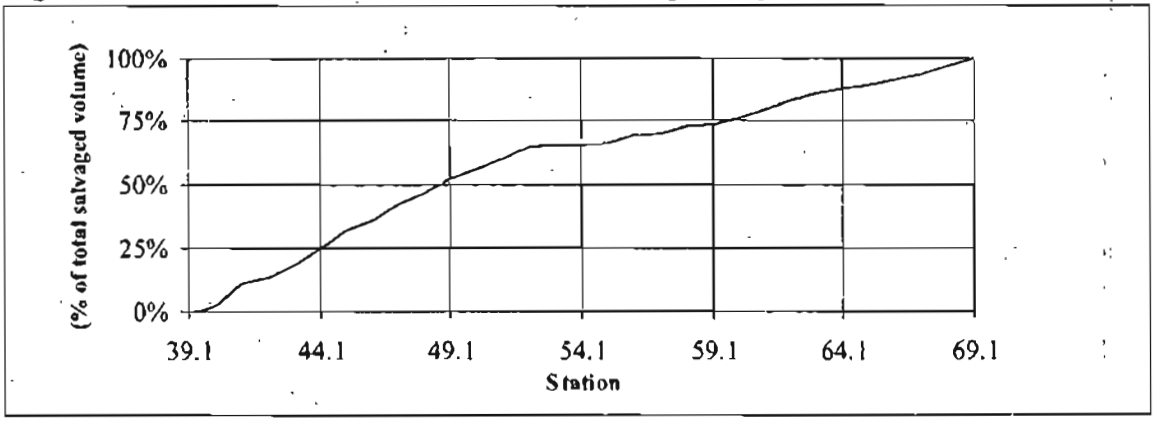
The volume of available topsoil varies over the corridor, with more topsoil available at lower elevations on the forested and mountain meadow zones and less available in the alpine meadow zone. Figure 2 presents a cumulative distribution of available topsoil by station. About 50 percent of the available topsoil is found in the first 10 km (6 mi.) of the

project. The middle and last 10-km (6-mi.) segments each have about 25 percent of the available topsoil.

Table 4. Available soil volumes.

	Alternative											
	1		2		3		4		5		6	
Volume Available (1,000 m^3/y^3)	0	0	67	88	61	80	66	86	63	82	68	89
Disturbed Area (ha/ac.)	0	0	91	225	84	209	87	214	83	206	89	220
Abandoned Sections (ha/ac.)	0	0	6	14	4	9	6	14	7	16	6	14
Proposed Paved Area (ha/ac.)	0	0	36	90	32	79	34	85	31	77	34	83
Reclaimed Area (ha/ac.)	0	0	60	149	56	139	58	143	59	145	61	151
Average Soil Depth (cm/in.)	0	0	11	4	11	4	11	4	11	4	11	4

Figure 2. Cumulative distribution of available topsoil by station.



A number of variables influence the actual amount of topsoil that is salvageable from the project site, including variations in topsoil depth, rock content, equipment limitations in stripping topsoil, and topsoil loss during excavation. Estimates of topsoil availability are expected to range within 20 percent of calculated amounts.

Topsoil volume was calculated for each of the build alternatives at 1-km (0.7-mi.) intervals (Tables 5 through 9). The volumes of topsoil available by kilometer post are not comparable by alternative because station numbering differs for each alternative;

however, the total volume of topsoil provides a comparison of the alternatives. Salvageable topsoil volumes range from about 60,000 cubic meters (78,500 cubic yards) for Alternative 3 to about 68,000 cubic meters (89,000 cubic yards) for Alternative 6.

Recommended topsoil salvage and replacement methods include windrowing topsoil at the limits of construction and pulling the soil back on slopes during reclamation. Available topsoil for use in reclamation ranges from about 0.7 cm (0.3 in.) to 22 cm (8.8 in.) per station (Figures 3 through 7). Shallow topsoil application depths are primarily the result of the amount of rock present. Increased soil stripping depths may be possible at some locations, but the percentage of rock fragments in the soil typically increases with depth.

A minimum topsoil application depth of 5 cm (2 in.) is recommended to provide a seed source, organic matter, and suitable physical and chemical properties for use in reclamation. Topsoil volumes are generally greater than 5 cm (2 in.) for all stations and all alternatives except between KP 52 to KP 55, where rock outcrops are common (Tables 5 through 9). Reclamation of these rocky areas is unlikely to include a uniform distribution of soil material, so sufficient soil would be available for selective revegetation. Transport of topsoil from nearby areas with a surplus of soil should be considered, but extensive soil stockpiling and relocation is not recommended. Reclamation of abandoned road segments would require transport of topsoil from nearby areas of soil salvage. If topsoil is stockpiled for use at another location, it should be applied within the same season. The fine textured soils present in the meadows near Clay Butte should not be moved to areas where coarse textured soils are found. Construction sequencing should consider the location of topsoil and the need for redistribution of topsoil.

Table 5. Alternative 2 — topsoil available for reclamation.

KMPOST	Reclamation Area		Topsoil Available		
	Area (sq. m)	Area (acres)	Volume (cu. m)	Depth (m)	Depth (in)
39.5-40.0	12,280	3.0	2,697	0.22	8.8
40.0-41.0	23,501	5.7	4,778	0.21	8.1
41.0-42.0	13,079	3.2	1,067	0.08	3.3
42.0-43.0	20,893	5.1	2,995	0.15	5.7
43.0-44.0	25,754	6.3	4,765	0.19	7.4
44.0-45.0	25,782	6.3	4,606	0.18	7.1
45.0-46.0	33,431	8.1	4,628	0.14	5.5
46.0-47.0	28,219	6.9	1,262	0.05	1.8
47.0-48.0	27,310	6.6	3,870	0.14	5.7
48.0-49.0	20,932	5.1	3,507	0.17	6.7
49.0-50.0	18,051	4.4	2,494	0.14	5.5
50.0-51.0	17,453	4.2	2,927	0.17	6.7
51.0-52.0	16,922	4.1	3,063	0.18	7.2
52.0-53.0	18,579	4.5	425	0.02	0.9
53.0-54.0	18,518	4.5	184	0.01	0.4
54.0-55.0	17,045	4.1	282	0.02	0.7
55.0-56.0	17,548	4.3	2,175	0.13	5.0
56.0-57.0	18,956	4.6	1,016	0.05	2.1
57.0-58.0	15,355	3.7	1,592	0.11	4.1
58.0-59.0	19,282	4.7	1,224	0.06	2.5
59.0-60.0	22,829	5.6	1,319	0.06	2.3
60.0-62.0	50,610	12.3	4,093	0.08	3.2
62.0-63.0	15,368	3.7	2,372	0.16	6.2
63.0-64.0	15,594	3.8	1,079	0.07	2.8
64.0-65.0	17,836	4.3	926	0.05	2.1
65.0-66.0	17,494	4.3	1,341	0.08	3.1
66.0-67.0	18,452	4.5	1,615	0.09	3.5
67.0-68.0	18,647	4.5	1,853	0.10	4.0
68.0-69.0	14,363	3.5	2,059	0.15	5.7
69.0-69.2	1,989	0.5	374	0.19	7.5
TOTAL	602,071	148.8	66,588		

Figure 3. Topsoil available for Alternative 2.

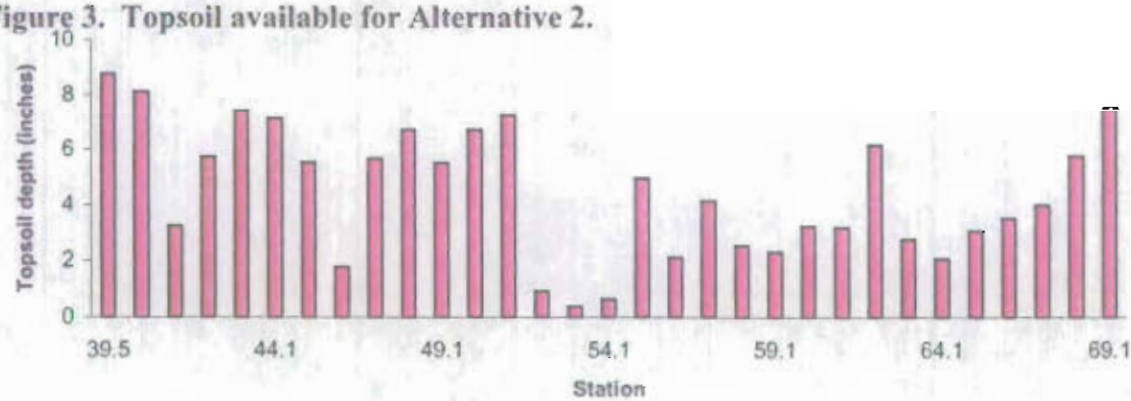


Table 6. Alternative 3 — topsoil available for reclamation.

KMPOST	Reclamation Area		Topsoil Available		
	Area (sq. m)	Area (acres)	Volume (cu. m)	Depth (m)	Depth (in)
39.5-40.0	11,795	2.9	2,394	0.21	8.1
40.0-41.0	23,272	5.7	4,343	0.19	7.5
41.0-42.0	12,787	3.1	1,008	0.08	3.2
42.0-43.0	21,331	5.2	2,923	0.14	5.5
43.0-44.0	23,484	5.7	4,187	0.18	7.1
44.0-45.0	26,507	6.5	4,500	0.17	6.8
45.0-46.0	20,648	5.0	2,418	0.12	4.7
46.0-47.0	18,488	4.5	3,381	0.19	7.3
47.0-48.0	15,724	3.8	2,945	0.19	7.5
48.0-49.0	20,693	5.0	3,243	0.16	6.3
49.0-50.0	18,863	4.6	2,260	0.12	4.8
50.0-51.0	16,666	4.1	2,690	0.16	6.4
51.0-52.0	17,131	4.2	2,485	0.15	5.8
52.0-53.0	18,367	4.5	398	0.02	0.9
53.0-54.0	16,837	4.1	107	0.01	0.3
54.0-55.0	17,469	4.3	447	0.03	1.0
55.0-56.0	18,051	4.4	1,825	0.10	4.0
56.0-57.0	17,779	4.3	817	0.05	1.8
57.0-58.0	14,791	3.6	1,544	0.11	4.2
58.0-59.0	19,098	4.6	817	0.04	1.7
59.0-60.0	20,980	5.1	1,346	0.07	2.6
60.0-62.0	51,223	12.5	3,914	0.08	3.1
62.0-63.0	14,376	3.5	2,159	0.15	6.0
63.0-64.0	16,029	3.9	921	0.06	2.3
64.0-65.0	17,952	4.4	772	0.04	1.7
65.0-66.0	16,008	3.9	1,405	0.09	3.5
66.0-67.0	20,186	4.9	1,480	0.07	2.9
67.0-68.0	17,485	4.3	1,813	0.11	4.1
68.0-69.0	13,183	3.2	1,736	0.13	5.3
69.0-69.1	1,004	0.2	182	0.18	7.2
TOTAL	558,206	138.5	60,461		

Figure 4. Topsoil available for Alternative 3.

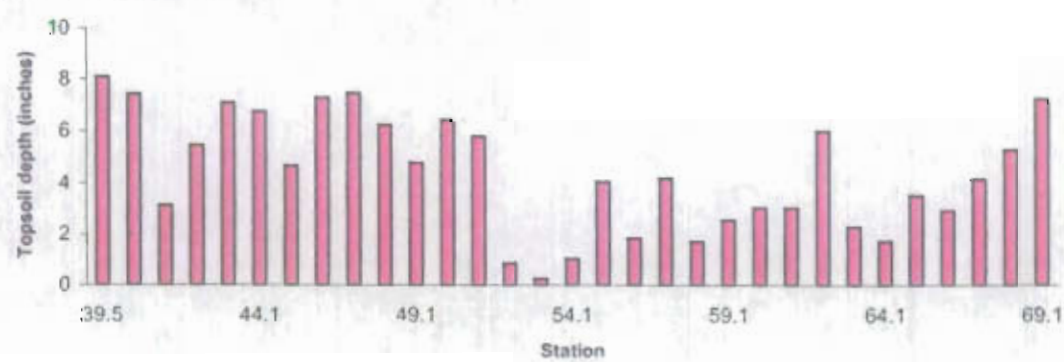


Table 7. Alternative 4 — topsoil available for reclamation.

KMPOST	Reclamation Area		Topsoil Available		
	Area (sq. m)	Area (acres)	Volume (cu. M)	Depth (m)	Depth (in)
39.5-40.0	12,297	3.0	2,700	0.22	8.8
40.0-41.0	23,764	5.8	4,662	0.20	7.8
41.0-42.0	14,936	3.6	1,333	0.09	3.6
42.0-43.0	23,036	5.6	3,538	0.16	6.1
43.0-44.0	25,248	6.1	4,595	0.18	7.3
44.0-45.0	25,561	6.2	4,610	0.18	7.2
45.0-46.0	19,979	4.9	2,571	0.13	5.1
46.0-47.0	19,767	4.8	3,900	0.20	7.9
47.0-48.0	16,903	4.1	3,210	0.19	7.6
48.0-49.0	19,541	4.8	3,475	0.18	7.1
49.0-50.0	21,221	5.2	2,439	0.12	4.6
50.0-51.0	14,192	3.5	2,896	0.21	8.2
51.0-52.0	18,674	4.5	2,625	0.14	5.6
52.0-53.0	18,149	4.4	387	0.02	0.9
53.0-54.0	23,239	5.7	381	0.02	0.7
54.0-55.0	19,928	4.9	777	0.04	1.6
55.0-56.0	18,522	4.5	1,769	0.10	3.8
56.0-57.0	16,603	4.0	873	0.05	2.1
57.0-58.0	18,654	4.5	1,985	0.11	4.3
58.0-59.0	23,667	5.8	965	0.04	1.6
59.0-60.0	16,165	3.9	1,431	0.09	3.5
60.0-62.0	53,735	13.1	5,153	0.10	3.8
62.0-63.0	14,933	3.6	1,436	0.10	3.8
63.0-64.0	17,463	4.3	970	0.06	2.2
64.0-65.0	25,495	6.2	1,358	0.05	2.1
65.0-66.0	18,096	4.4	1,659	0.09	3.7
66.0-67.0	19,125	4.7	1,755	0.09	3.7
67.0-68.0	14,451	3.5	2,089	0.15	5.8
68.0-68.3	2,473	0.6	442	0.18	7.1
TOTAL	575,815	142.5	65,985		

Figure 5. Topsoil available for Alternative 4.

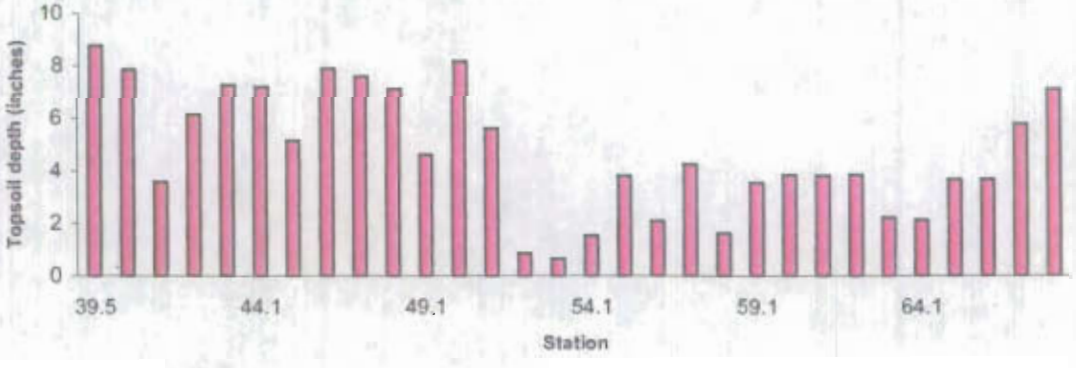


Table 8. Alternative 5 — topsoil available for reclamation.

KMPOST	Reclamation Area		Topsoil Available		
	Area (sq.m)	Area (acres)	Volume (cu. M)	Depth (m)	Depth (in)
39.5-40.0	11,803	2.9	2,396	0.21	8.1
40.0-41.0	23,435	5.7	4,378	0.19	7.5
41.0-42.0	13,873	3.4	1,219	0.09	3.5
42.0-43.0	23,073	5.6	3,319	0.15	5.7
43.0-44.0	23,354	5.7	4,088	0.18	7.0
44.0-45.0	26,513	6.5	4,535	0.17	6.8
45.0-46.0	35,214	8.6	4,077	0.12	4.6
46.0-47.0	29,296	7.1	3,337	0.12	4.6
47.0-48.0	18,752	4.6	3,867	0.21	8.2
48.0-49.0	21,536	5.2	3,401	0.16	6.3
49.0-50.0	19,922	4.9	2,510	0.13	5.0
50.0-51.0	17,354	4.2	2,651	0.16	6.1
51.0-52.0	16,902	4.1	2,574	0.15	6.1
52.0-53.0	18,538	4.5	414	0.02	0.9
53.0-54.0	17,118	4.2	143	0.01	0.3
54.0-55.0	17,569	4.3	360	0.02	0.8
55.0-56.0	17,701	4.3	1,885	0.11	4.3
56.0-57.0	18,252	4.4	846	0.05	1.9
57.0-58.0	14,329	3.5	1,427	0.10	4.0
58.0-59.0	18,644	4.5	954	0.05	2.0
59.0-60.0	22,219	5.4	1,260	0.06	2.3
60.0-62.0	51,941	12.6	4,599	0.09	3.5
62.0-63.0	14,846	3.6	1,409	0.10	3.8
63.0-64.0	17,914	4.4	1,169	0.07	2.6
64.0-65.0	18,848	4.6	621	0.03	1.3
65.0-66.0	14,007	3.4	1,827	0.13	5.2
66.0-67.0	21,670	5.3	1,125	0.05	2.1
67.0-68.0	15,131	3.7	2,160	0.14	5.7
68.0-68.6	6,907	1.7	865	0.13	5.0
TOTAL	586,663	145.0	63,416		

Figure 6. Topsoil available for Alternative 5.

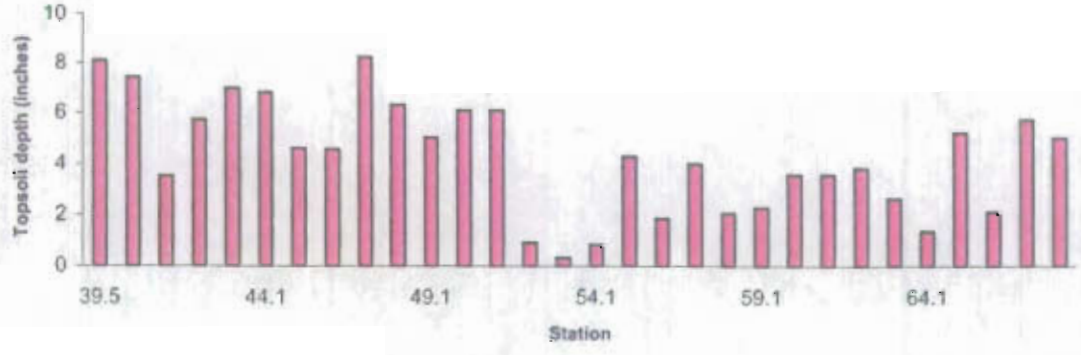
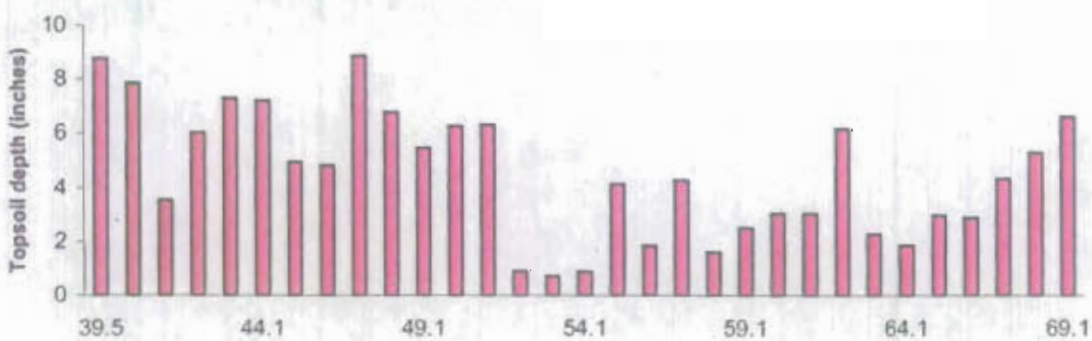


Table 9. Alternative 6 — Topsoil available for reclamation.

KMPOST	Reclamation Area		Topsoil Available		
	Area (sq. m)	Area (Acres)	Volume (cu. m)	Depth (m)	Depth (in)
39.5-40.0	12,287	3.0	2,697	0.22	8.8
40.0-41.0	23,451	5.7	4,616	0.20	7.9
41.0-42.0	14,769	3.6	1,311	0.09	3.5
42.0-43.0	22,867	5.6	3,446	0.15	6.0
43.0-44.0	25,370	6.2	4,629	0.19	7.3
44.0-45.0	25,753	6.3	4,640	0.18	7.2
45.0-46.0	34,046	8.3	4,221	0.13	5.0
46.0-47.0	29,633	7.2	3,589	0.12	4.8
47.0-48.0	18,519	4.5	4,110	0.23	8.9
48.0-49.0	21,845	5.3	3,696	0.17	6.8
49.0-50.0	19,631	4.8	2,690	0.14	5.5
50.0-51.0	17,136	4.2	2,692	0.16	6.3
51.0-52.0	17,030	4.1	2,691	0.16	6.3
52.0-53.0	18,320	4.5	412	0.02	0.9
53.0-54.0	22,388	5.5	400	0.02	0.7
54.0-55.0	21,551	5.2	479	0.02	0.9
55.0-56.0	18,313	4.5	1,892	0.10	4.1
56.0-57.0	17,855	4.3	830	0.05	1.9
57.0-58.0	14,911	3.6	1,604	0.11	4.3
58.0-59.0	19,207	4.7	776	0.04	1.6
59.0-60.0	21,348	5.2	1,347	0.06	2.5
60.0-62.0	51,493	12.5	3,930	0.08	3.0
62.0-63.0	14,367	3.5	2,218	0.16	6.2
63.0-64.0	16,016	3.9	911	0.06	2.3
64.0-65.0	16,368	4.0	766	0.05	1.9
65.0-66.0	26,363	6.4	1,954	0.08	3.0
66.0-67.0	20,738	5.0	1,498	0.07	2.9
67.0-68.0	16,591	4.0	1,803	0.11	4.3
68.0-69.0	13,039	3.2	1,723	0.13	5.3
69.0-69.1	796	0.2	131	0.17	6.6
TOTAL	612,003	151.2	67,704		

Figure 7. Topsoil available for alternative6.



References

Brown, R.W., R.S. Johnston, and K. Van Cleve. 1978. Rehabilitation problems in alpine and artic regions. In Reclamation of Drastically Disturbed Lands. American Society of Agronomy, Madison, WI.

Hansen, D., C.M. McKell, S.L. Clark, and L. Hobbs. 1991. Native plant establishment techniques for successful roadside revegetation. Utah Department of Transportation. Salt Lake City, UT.

Munshower, F.F. 1993. Practical Handbook of Disturbed Land Revegetation. CRC Press.

NRCS (Natural Resource Conservation Service), Soil Survey Staff. 1993. National Soil Survey Handbook, United States Department of Agriculture, title 430-VI, Washington D.C., U. S. Government Printing Office, November 1993.

Staricka, J.A., R.R. Allmaras, W.W. Nelson, and W.E. Larson. 1992. Soil aggregate longevity as determined by the incorporation of ceramic spheres. Soil Science Society of America Journal. 56:1591-1597.

USFS (U.S. Forest Service), Shoshone National Forest. Undated. Soil survey for Shoshone National Forest. Cody, WY.

Woodward-Clyde, Inc. 1998. Initial geohazards evaluation and geological study: Beartooth Highway, U.S. 212, Wyoming. Prepared for Federal Highway Administration, Central Federal Lands Highway Division, Lakewood, CO.

Wyoming DEQ (Department of Environmental Quality), Land Quality Division. 1994. Topsoil and overburden. Guideline No. 1. Cheyenne, WY.

Wyoming SCS (Soil Conservation Service). 1981. Wyoming Soil Interpretation Procedure Guide.

APPENDIX A: FIELD NOTES

Beartooth Highway

SOIL SURVEY DATA SHEET

DATE: 9/18/00 MBT

Wetland Mitigation Soil Pits

Site No: WMP 1		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-9	l	10g	g	stones + boulders 5%
B	9-18	l	20g, 15c	g	
C	18+	sl		f	

Notes: G+3 not drilled

excellent topsoil 0-9, good 9-18

Site No: WMP 2		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	l	5-10g	g	5% stone/ boulder
B	8-16+	sl	20g, 25c	f	

Notes: Excellent topsoil 0-8, >8 good but rocky

Site No: WMP3		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	scl	15g	g	5-8 b
C	8-16	scl	20g 15c	f	
	16+		25c 10g		

Notes: Excellent topsoil 0-16

CF = Coarse fragments - g-gravel, c-cobble, s-stone, b-boulder

OM - organic matter

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/18/00 MOD

Site No: WMP 4		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-14	l	10g	g	10b.
C	14-18+	scl	20g	f	
Notes: Excellent topsoil, large surface boulders					

Site No: WMP 6		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-10	l	10g	g	5b.
B	10-16	scl	15g	g	
Notes: large stones & boulders along streambank					
A-B good topsoil					

Site No: WMP 7		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-12	sl+	10g	g	5b.
B	12-16	sl-	15g 15c	f	
Notes: 0-16 good topsoil					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/18/00 MOD

Site No: WMP 11		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-11	scl	15 g	f	20 s+b
C	11-16	cl	20 g 15 c	p	

Notes: Top 16 good topsoil, high AWC
would require a large cut to create a wetland

Site No: WMP 12		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-5	l	15 g		15 s 10 b
C	5-14	scl	20 g 25 c		
C+	14+	rock			

Notes: top 14" good ts, rocky

Site No: WMP 14		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	sl	20 g 45 c	g	20 c
	8+	rocky			

Notes: rock content limitation

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/18/00 MER

Site No: WMP 16a		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-3	sl	3g	vg	<3c+5
B	3-16	sl +	20g 10c	g	
C	16-18+	l	20g 20c	f	
Notes: good topsoil 0-18+					

Site No: WMP 16b		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-4	sl	5g	vg	<5c
B	4-14	sl	20g 10c	g	
	14+	large cobbles			
Notes: 0-14 good topsoil, a lot of Carex - so likely high WT					

Site No: WMP 19		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-18	si l	0	vg	0
	10YR 2/2				
Notes: Exudent					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

Beartooth Highway
SOIL SURVEY DATA SHEET
Backhoe Pits

DATE: 9/19/00
MDT

Site No: BHP 1		Location: KP 45.8			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-6	sl lab	10g	5.5% lab / g	20s+b
B	6-9	cosl	15g 10c	f	
C1	9-17	sl+/scl	25g 20c	-	
C2	17-36	sl+/scl	30g 25c	-	
Notes: A good topsoil, B thin low AWC, C rocky, good texture					
Calcareous material in C					
Sample of A collected			Photo 19 pit, Photo 20 site		

Site No: BHP 2		Location: KP 46.580 on blue line			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	sl	10g 15c	g	20s+b
C1	8-14	cosl	30g, 25c, 10s	low	
C2	14-30	cosl/scl lenses	35g, 30c, 15s+b	low	
	1 large bedrock pit >24"				
Notes: A suitable topsoil, B low AWC + rock					
Similar to BHP 4					
			Photo 17 pit, Photo 18 site		

Site No: BHP 3		Location: KP 50.580			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	sl	15g 5c	g	5c
B	8-15	sl+/scl	20g 20c	low	10s
C	15-32+	cols	35g 35c	-	10b
Notes: A good TS, B rocky					
Sample from 4			Photo 15 pit Photo 16 site		

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/19/00 MW

Site No: BHP 4		Location: KP 51.580			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	l lab	10g	8+% lab vg	5c
B	8-22	10YR 4/4 cosl	15g 15c	low	10s 5b
C	22-32+	cosl	20g 25c	-	
Notes: A good TS, B suitable but low AWC, low om					
Sample A+B		Photo 13 pit Photo 14 site			

Site No: BHP 5		Location: KP 58.6			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-11	10YR 3/2 sl lab	10g 10c	8%+ lab vg	c 8
B	11-20	10YR 3/3 sl -	15g 25c 5s	g	s 8
C	20-34+	sl	10g 30c 10s	-	
Notes: 0-20" good TS, high rock in B					
Sample A		Photo-11 pit Photo 12-site			

Site No: BHP 6		Location: KP 60.78			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-10	sl lab	15g, 5c	5.5% lab g	20s+b
B	10-24	sl	25g 35c	f	
C	24-30	sl	30g 45c	-	
Notes: A good TS, B good soil but high rock content					
Sample A		Photo 9 pit Photo 10-site			

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/19/00
MBF

Site No: BHP 7		Location: KP 62.12			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-7	s/sl lab	20g 10c	8+% lab / vg	10 s+b
B	7-16	sl	25g 35c	f	
C	16-30	scl/sl+	30g 40c	-	
Notes: A good TS, B good but rocky					
Sample A				Photo 7 pit Photo 8 site	

Site No: BHP 8		Location: KP 64.16			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-9	ls lab	20g 15c	5.7% lab / vg	10g 10c 10s+b
B	9-18	sl	40g 20c	f	
C	18-35	scl	60g 20c		
Notes: A good, B rocky					
Sample A				Photo 5 pit Photo 6 site	

Site No: BHP 9		Location: KP 64.97 white alignment			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-7	sl	20g	vg	5-20 g/c
B	7-20	sl+	25g 15c	g	5-20 s
C	20-36	sl	40g 20c	-	
Notes: good topsoil to 20"					
Sample A				Photo 2 pit Photo 3 site	

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/19/00 MW1

Site No: BHP10		Location: Alpine 7m off road			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	sl lab	15g 5c	8+% lab vg	5 s+b
B	8-26	scl	20g 25c	g	
C	26-35+	scl	25g 25c	-	
Notes:					
Sample from A		Photo 1 pit Photo 2 setting			

Site No: BHP11 / WMP1		Location: KP 45.16 grassland			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	sl lab	15g	7.9% lab g	10 b
B	8-14	cosl	35g 20c	p	
C_1	14-27	cosc l	40g 30c	-	
C_2	27-38	cosc l+	30g 30c	-	
Notes:	A good topsoil, B poor - low AWC, rocky				
	WT >38" - moist in bottom				
Sample A					

Site No: BHP 12		Location: KP 43.56 forest			
Horizon	Depth	Texture	~~CF~~ OM ↔ ~~OM~~ CF		Surface Rock
A	0-7	sl lab	5.3% lab g	10g 10c	10 c 5 s 5 b
B	7-18	sl	p	20g 25c 10s	
C	18-24	sl	-	10g 35c 15s	
	large rock				
Notes:	A good TS, B low AWC, rocky				
Sample A		Photo 23 pit Site 24			

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/19/00 MOD

Site No: BHP 13		Location: KP 39.84			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-6	cl lab	10g	6.8% lab g	<5s
B_1	6-20	cl	15g 5c	g	
B_2	20-30	sicl	15g 10c	f	
C	30+				
Notes: 0-30" good soil material but high clay content may be hard to work					
Sample A/B mix		Roll 2 Photo 1 pit Phot 2 site			

Site No:		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
Notes:					

Site No:		Location:			
Horizon	Depth	Texture	CF	OM	Surface Rock
Notes:					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

Soil Pits

SOIL SURVEY DATA SHEET

DATE: 9/20/00

Beartooth Highway

MBG

Site No: SP-1		Location: Near Beer Lake			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-7	l	15g 5c	g	10 stb
B	7-15+	scl-	25g 20c	f	
Notes: Top 15" good TS					

Site No: SP2		Location:			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-7	l	15g 10c	g	20 g 5 c 5 stb
B	7-14	sl+	20g 25c	f	
Notes: Top 14 good TS					

Site No: SP3		Location:			Class II
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-7	l	5g 40c	g	10 c 20 s 10 b
		rock / cobble	on stone	-	
Notes: Rocky site suitable topsoil in surface horizon 7"+/-					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/20/00 MWD

Site No: SP 4		Location:			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-12	10YR 2/2 l +	10g 10c	vg	<5 st b
B	12-14+	l -	15g 25c	g	
Notes: Top 12" good TS - low rock >14 good soil rocky					

Site No: SP5		Location:			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-4	l	15g	g	5c +s
B	4-15	sl +	20g 20c	f	
Notes: good TS rocky below A					

Site No: SP6		Location:			Class II
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-5	l	25g 25c	g	15c
B	5-10+	sl +	40g 25c	f	25 st b
	10+ cobble/stone				
Notes: Suitable TS 0-10" but very rocky					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/20/00 MWD

Site No: SP 7		Location:			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-9	sl	20g 30c	g	15c 20s+b
C	9+	rocky			
Notes: shallow soil limited topsoil 0-9"					

Site No: SP 8		Location:			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-10	l	15g	g	10-15 c,s,b
B	10-16+	sl+r	20g 25c	g	
Notes: Good TS 0-11, rocky 10 b+ suitable 10"-16"					

Site No: SP 9		Location:			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-7	sl	25g	f	10-15 s+b
B	7-15	cosl	50g 10c	p	
Notes: Good TS 0-7, ~~good~~ fair but rocky 7-15 low AWC					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/20/00 MW

Site No: SP10		Location:			Class II/III
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	l	15g 45c	g	20c 20s+b
	>8	rocky			
Notes: 0-8" ok but rocky					

Site No: SP11		Location:			Class II
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-7	sl	10g 50c	g	20c 30s
	>7	rocky			
Notes: limited available TS - rocky					

Site No: SP12		Location:			Class III
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-2	sl	30g 20c	p	70g 20c
C	2-16	ls	50g 25c	p	
Notes: Poor TS due to rock content, low AWC					
Photo 3 on Fig 64 Class III boulders + s 75%					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/20/00

Site No: SP13		Location:			Class I +
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	sl	20g 40c	g	20c 10g 5s
	8+	rocky			
Notes: good soil material, but very rocky					
Photo 4					

Site No: SP14		Location:			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-10	sl	15g 10c		<5s
	10+				
Notes:					

Site No: SP15		Location:			Class II
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-11	l	10g 15c	g	40s+b
Notes:					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/20/00
MWD

Site No: SP16		Location:		Class I	
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-12	l	20	g	10 stb
Notes: good topsoil					

Site No: SP 17		Location:		Class I	
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-7	l	15g	vg	<5 s
B	7-16	sl+	15g 15c	g	
Notes: 0-16" good TS					

Site No: SP18		Location:		Class I	
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-9	l	10g		<5 stb
B	9-12+	sl	20g 25c		
	12+	cobbly			
Notes: 0-9 vg, 9-12 rocky					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/20/00

Site No: SP 19		Location: Class II			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-6	sl+	20g	vg	50 bts
B	6-12	sl-	25g 25c	g	
	>12	cobble			
Notes: 0-6" good >6" rocky					

Site No: SP 20		Location: Class I			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-4	l	15g	g	<5 b
B	4-9	sl	25g	f	
C	9-14	sl	35g 20c		
	7.5YR 4/4				
Notes: 0-9 good >9 rocky					

Site No: SP 21		Location: KP 46 on white/blue algn Class I			
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-8	l	10g 5c	g	5-10 bts
B	8-16+	scl-	20g 25c	f	
Notes:					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

SOIL SURVEY DATA SHEET

DATE: 9/30/00 MWD

Site No: SP22		Location: KP 45.5 white			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-13	si	10g	vg	<5 bts
	13+	rocky			
Notes: 0-13 ugood					

Site No: SP 23		Location: forest			Class I
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-9	l	20g 20c	g	10 stb
C	9-20+	sl-	25g 30c 20s	p	
Notes: Large cobbles + stone in road cut A horizon suitable v rocky below					

Site No: SP 24		Location: forest			Class II
Horizon	Depth	Texture	CF	OM	Surface Rock
A	0-4	sl+	10g	g	35 b
B	4-14	sl-	15g 30c	f	
Notes: 0-4 good 4-14 fair, - rock low AWC					

ERO Resources Corporation
1842 Clarkson Street, Denver, Colorado
303.830.1188

B

APPENDIX B: LABORATORY RESULTS OF SOIL ANALYSIS

[redacted]
Denver CO 80218

Soil, Water and Plant Testing Laboratory
Natural & Environmental Sciences Bldg - A319
Fort Collins, CO 80523

(970) 491-5061 FAX: 491-2930

DATE RECEIVED: 09-28-2000
DATE REPORTED: 12-12-2000

BILLING: SB1105

RESEARCH SOIL ANALYSIS

Lab #	Sample ID #	paste pH	paste EC mmhos/cm	Lime Estimate	% OM	AB-DTPA Extract ppm NO_3-N	P	K	Zn	Fe	Mn	Cu
R2515	BHP 1	5.4	0.2	Low	5.5	3.2	1.8	82.6	0.3	98.2	3.1	1.8
R2516	BHP 4	4.8	0.1	Low	+8.0	8.8	2.9	34.8	0.6	370	5.1	0.7
R2517	BHP 5	4.7	0.1	Low	+8.0	10.4	4.5	77.9	<0.1	886	3.8	<0.1
R2518	BHP 6	4.8	0.2	Low	5.5	5.2	2.8	26.4	1.1	365	2.3	0.2
R2519	BHP 7	5.2	0.1	Low	+8.0	5.4	1.2	61.1	<0.1	621	2.8	<0.1
R2520	BHP 8	4.6	0.2	Low	5.7	6.3	3.7	16.3	<0.1	262	0.5	1.1
R2521	BHP 10	5.3	0.2	Low	+8.0	4.6	1.7	39.2	0.2	336	3.5	1.9
R2522	BHP 11	4.7	0.1	Low	7.9	6.4	1.8	30.5	<0.1	369	0.7	<0.1
R2523	BHP 12	5.4	0.1	Low	5.3	3.3	2.8	57.1	1.9	220	8.4	1.8
R2524	BHP 13	6.1	0.4	Low	6.8	7.9	3.8	296	2.7	189	3.8	3.5

[redacted]
Denver-CO 80218

Soil, Water and Plant Testing Laboratory
Natural & Environmental Sciences Bldg - A319
Fort Collins, CO 80523

(970) 491-5061 FAX: 491-2930

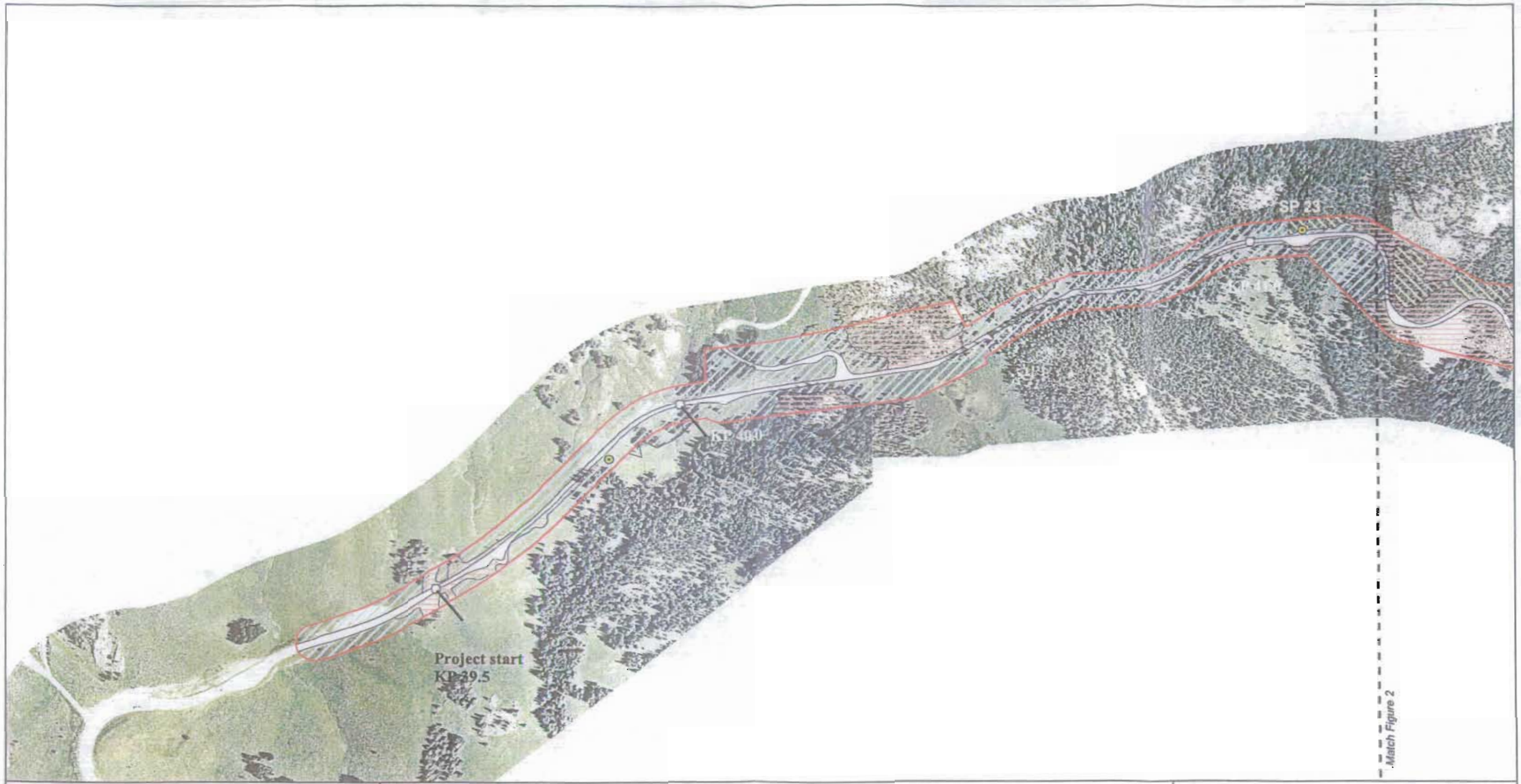
DATE RECEIVED: 09-28-2000
DATE REPORTED: 12-12-2000

BILLING:

RESEARCH SOIL ANALYSIS

Lab #	Sample ID #	%Sand	%Silt	%Clay	Texture	% very fine sand	crop to be grown	Irrigation	Fertilizer Suggestions lb/A N	P_2O_5	K_2O
R2515	BHP 1	59	31	10	Sandy Loam	9.0	native grasses	dryland	105	80	40
R2516	BHP 4	48	43	9	Loam	10.0	native grasses	dryland	105	80	60
R2517	BHP 5	57	38	5	Sandy Loam	12.2	native grasses	dryland	80	40	40
R2518	BHP 6	74	21	5	Sandy Loam	7.1	native grasses	dryland	80	80	60
R2519	BHP 7	46	47	7	Loam/Sandy Loam	8.6	native grasses	dryland	105	80	40
R2520	BHP 8	78	16	6	Loamy Sand	4.2	native grasses	dryland	105	40	60
R2521	BHP 10	56	37	7	Sandy Loam	6.5	native grasses	dryland	105	80	60
R2522	BHP 11	62	28	10	Sandy Loam	9.9	native grasses	dryland	105	80	60
R2523	BHP 12	53	33	14	Sandy Loam	9.5	native grasses	dryland	105	80	40
R2524	BHP 13	31	40	29	Clay Loam	6.4	native grasses	dryland	80	40	0

APPENDIX C: SURFACE ROCK MAPS



ERO
ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

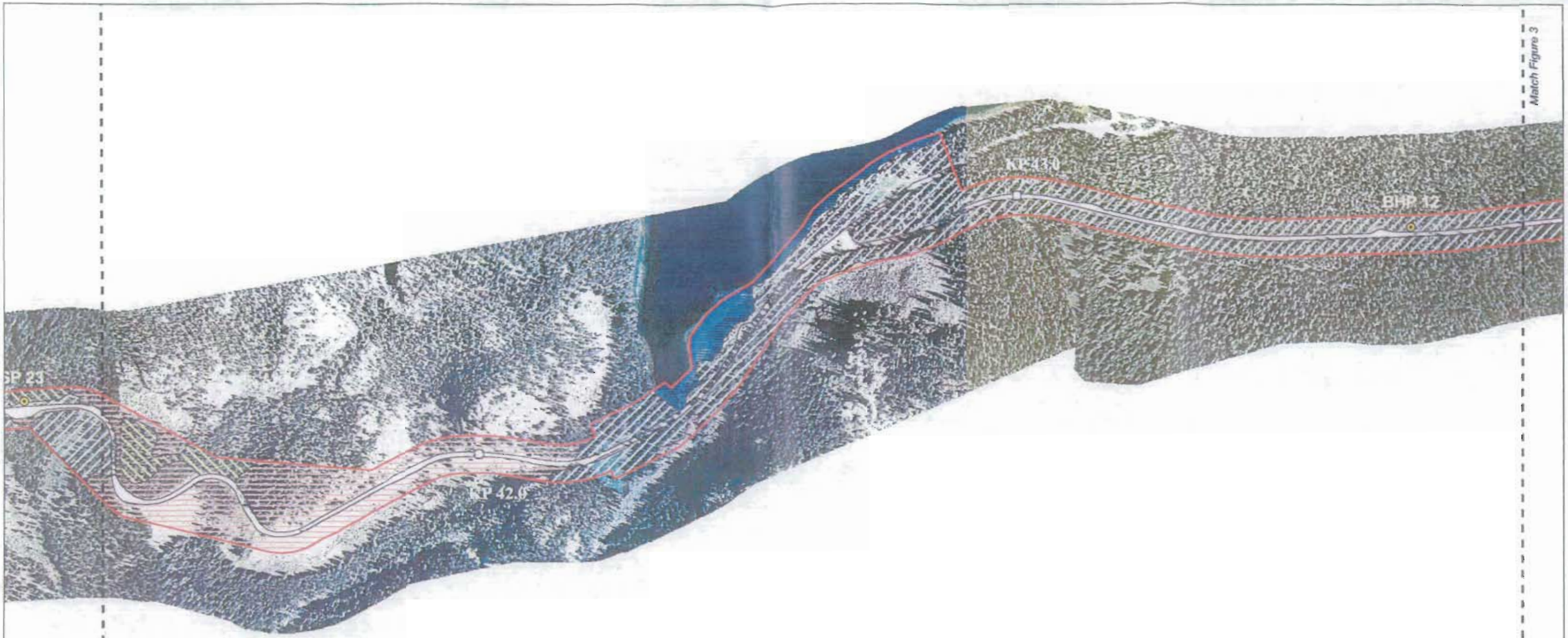
N

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6,000

Figure 1
Beartooth Highway Surface Rock Maps

June 2001



ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

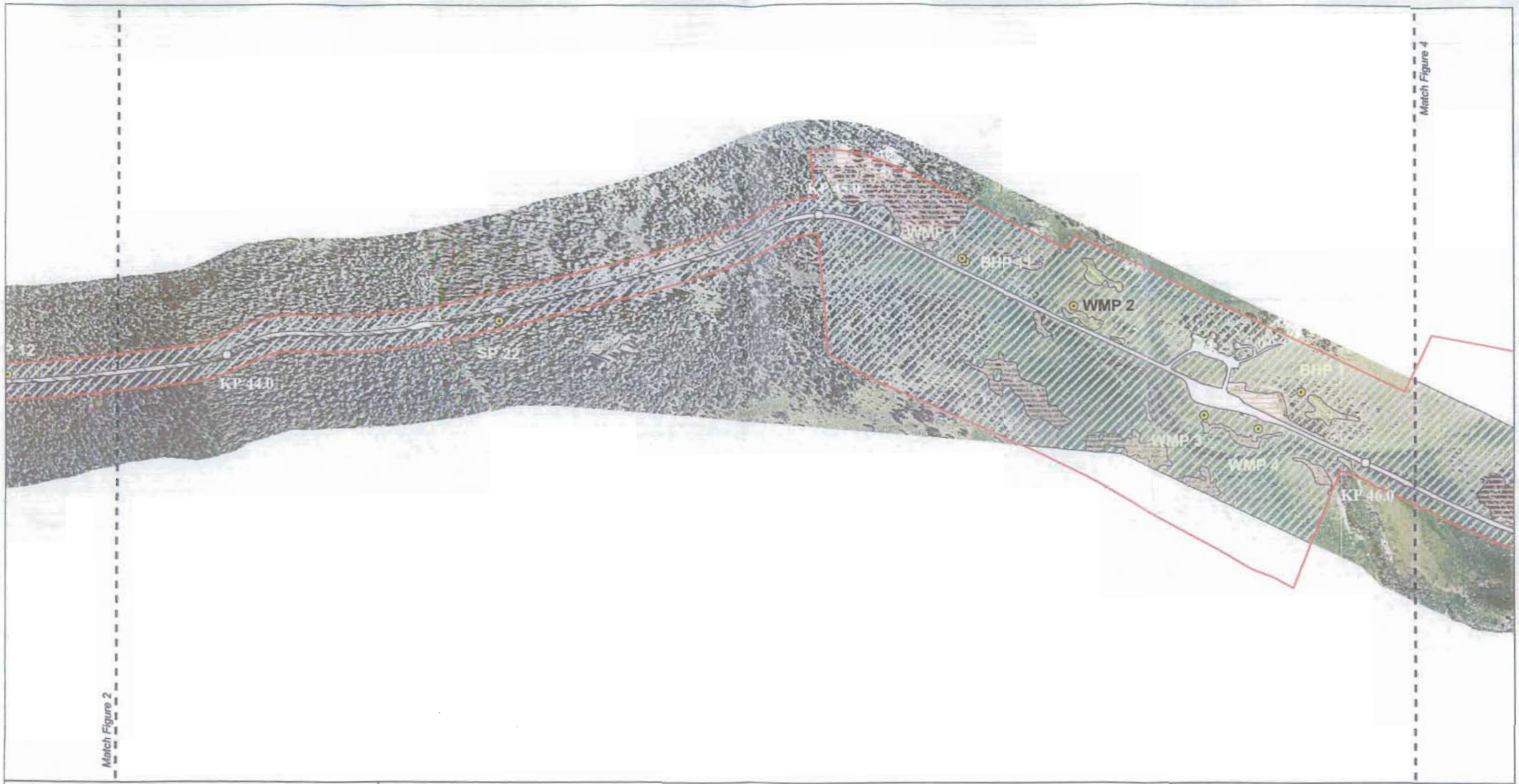
N

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 2
Beartooth Highway Surface Rock Maps

June 2001



ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

N

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 3
Beartooth Highway Surface Rock Maps

June 2001

ERO
ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

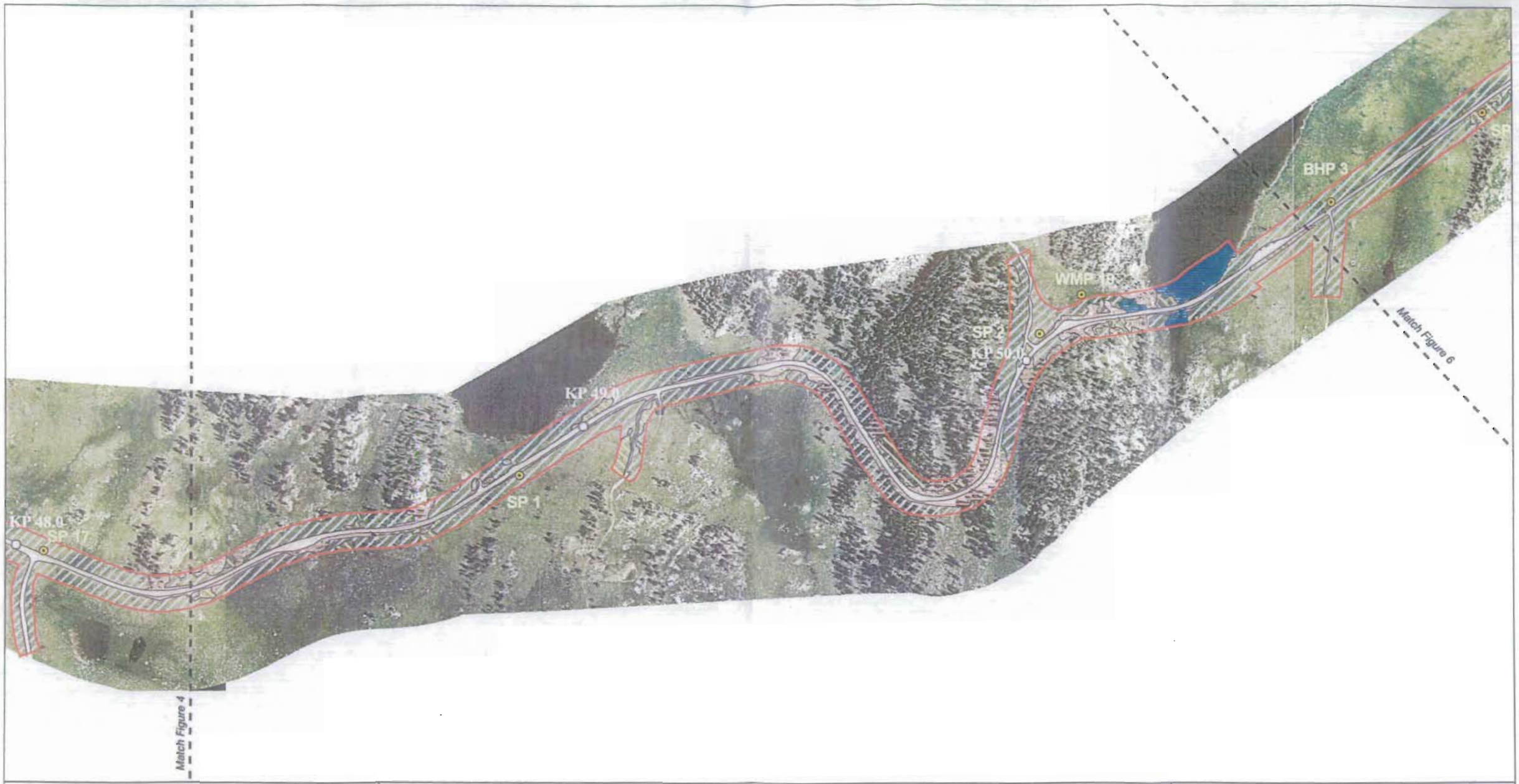
N

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 4
Beartooth Highway Surface Rock Maps

June 2001



ERO
ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

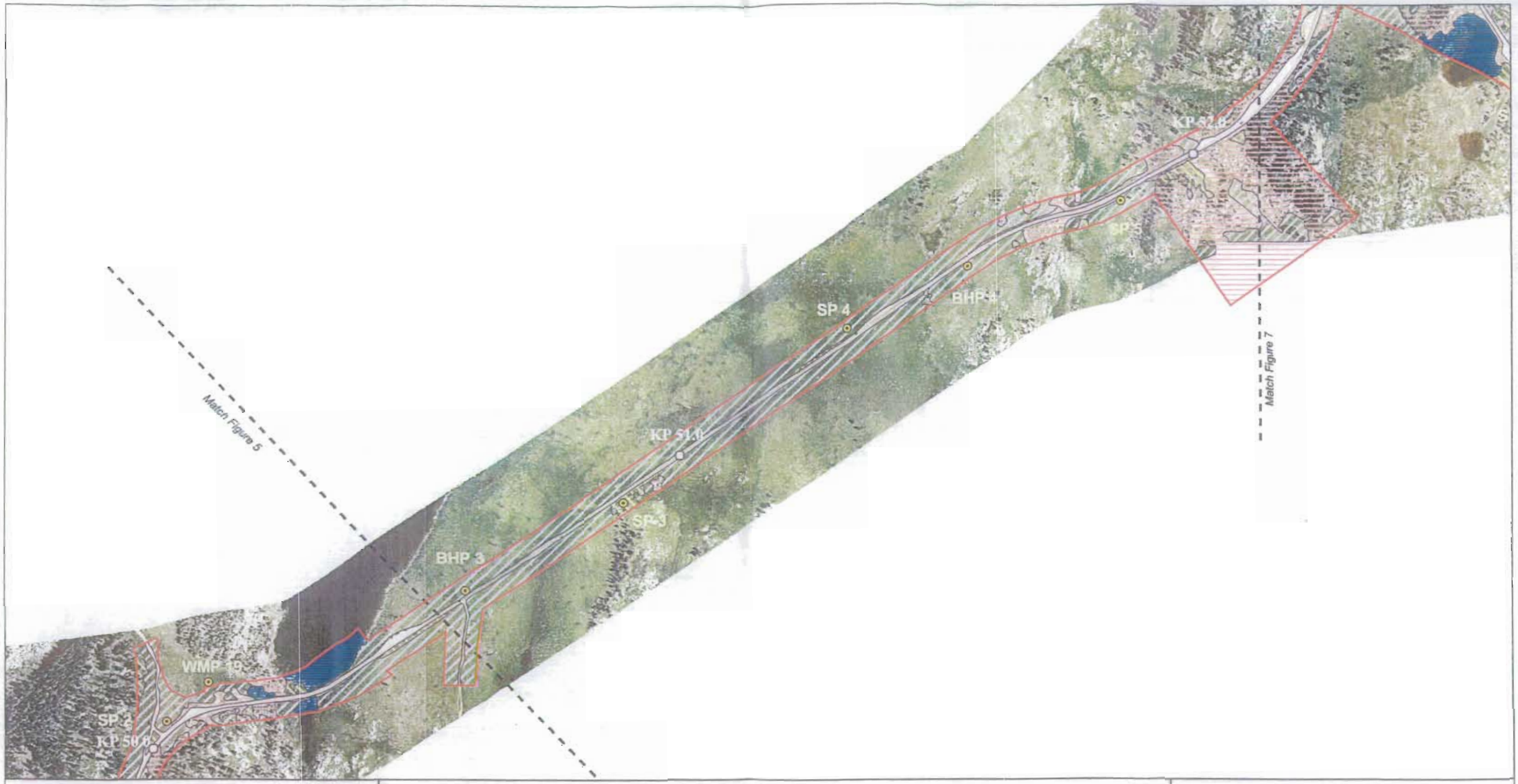
N

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 5
Beartooth Highway Surface Rock Maps

June 2001



ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

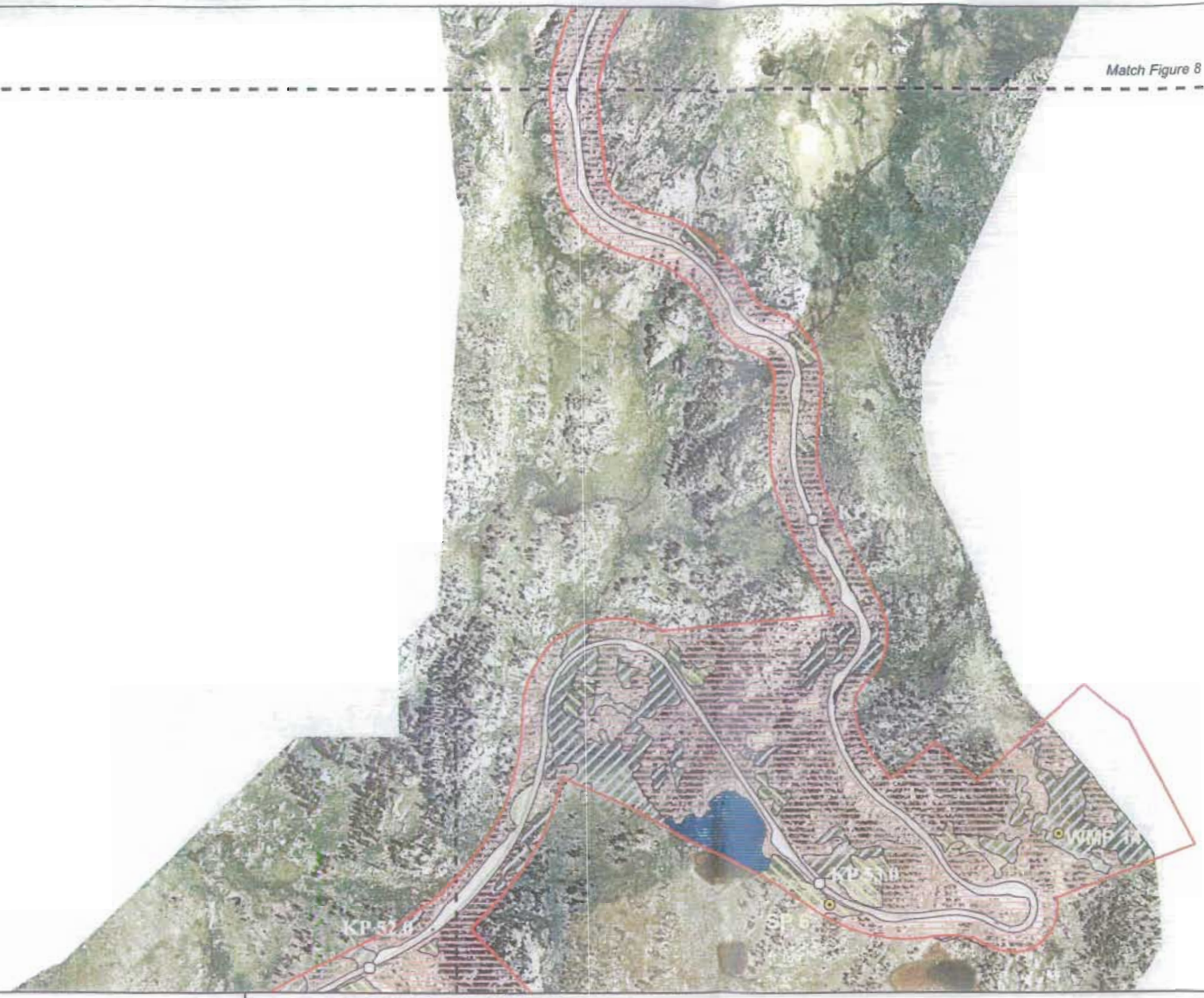
0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 6
Beartooth Highway Surface Rock Maps

June 2001

Match Figure 8



ERO
ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

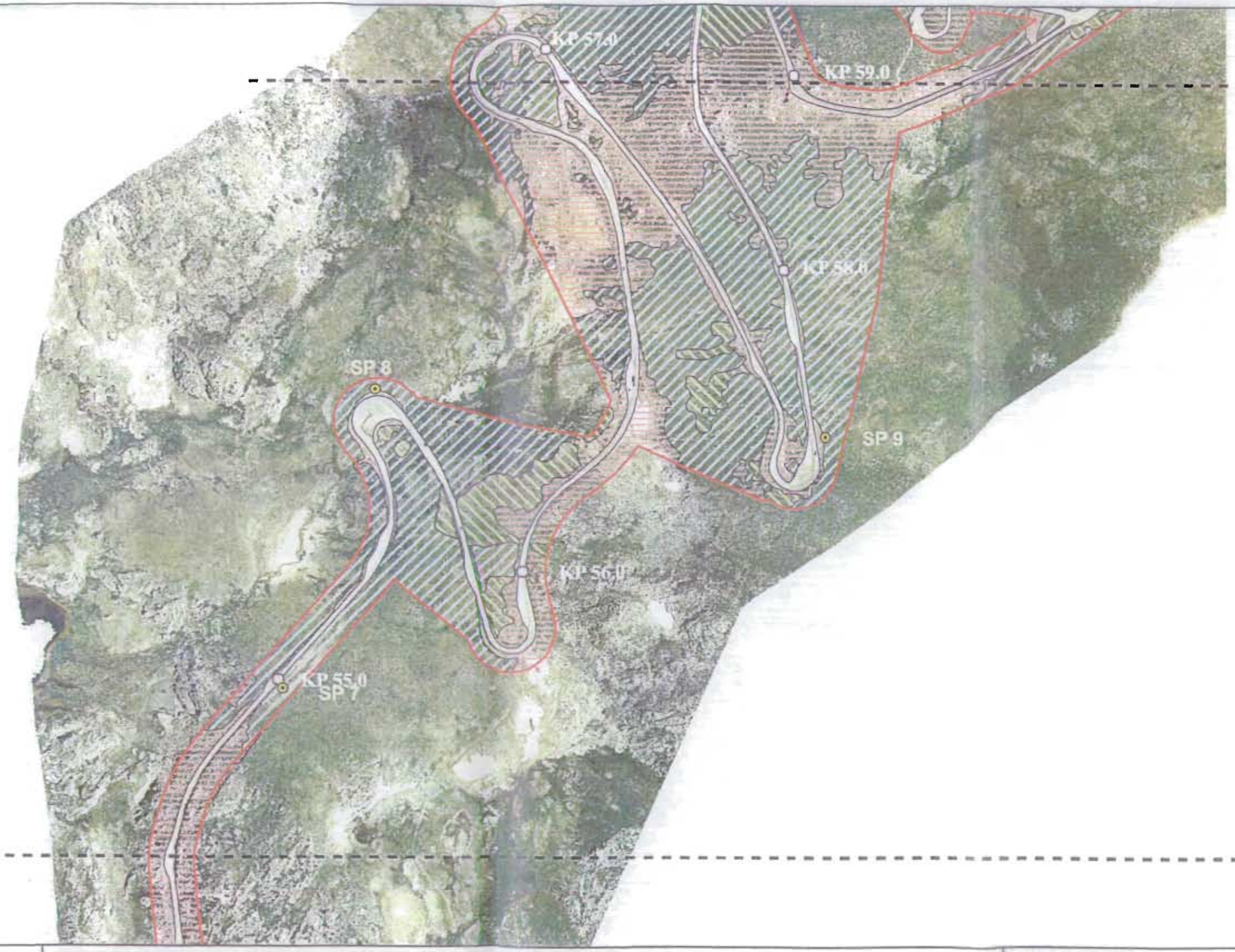
N

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 7
Beartooth Highway Surface Rock Maps

June 2001



ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

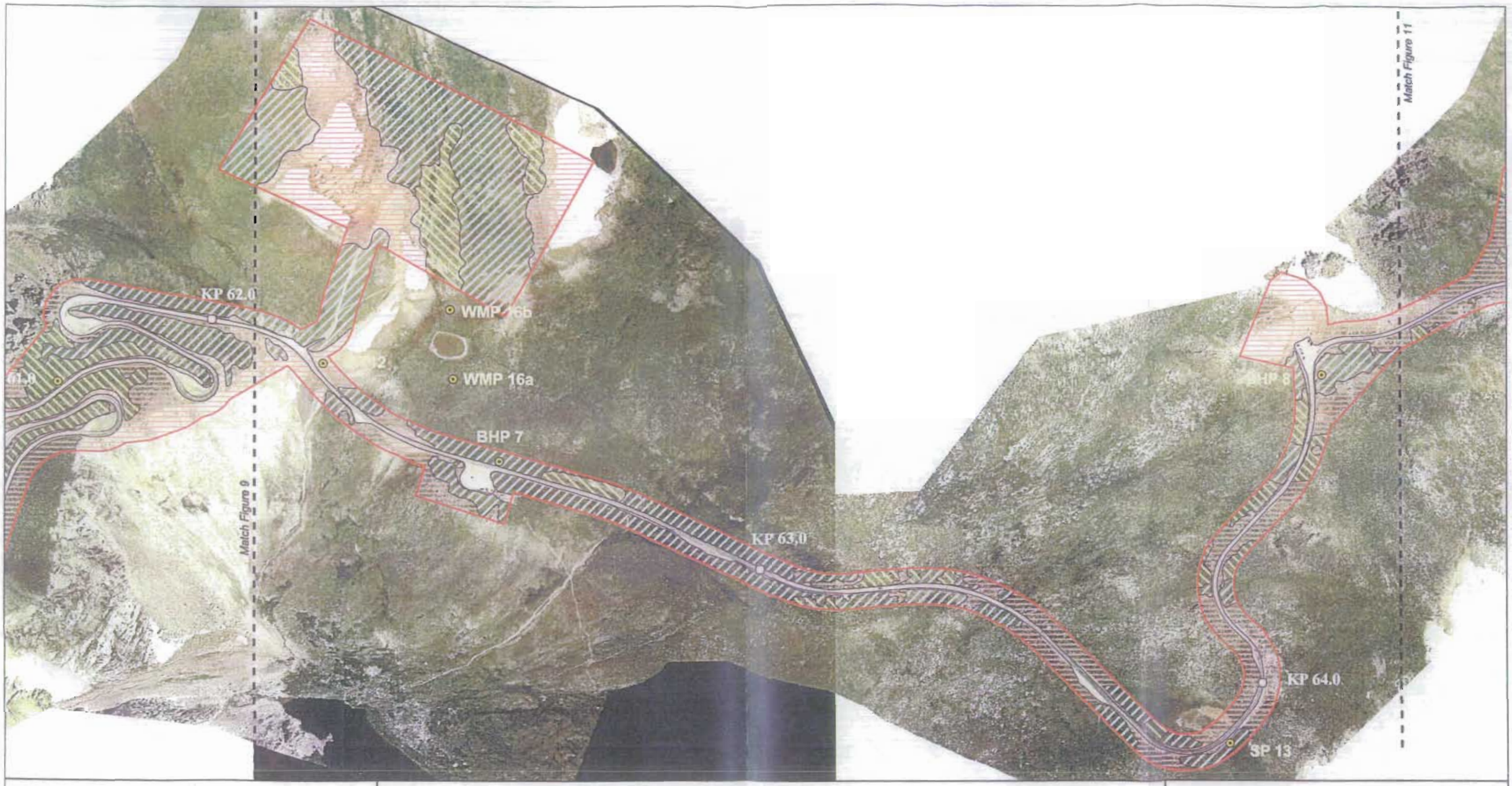
N

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 8
Beartooth Highway Surface Rock Maps

June 2001



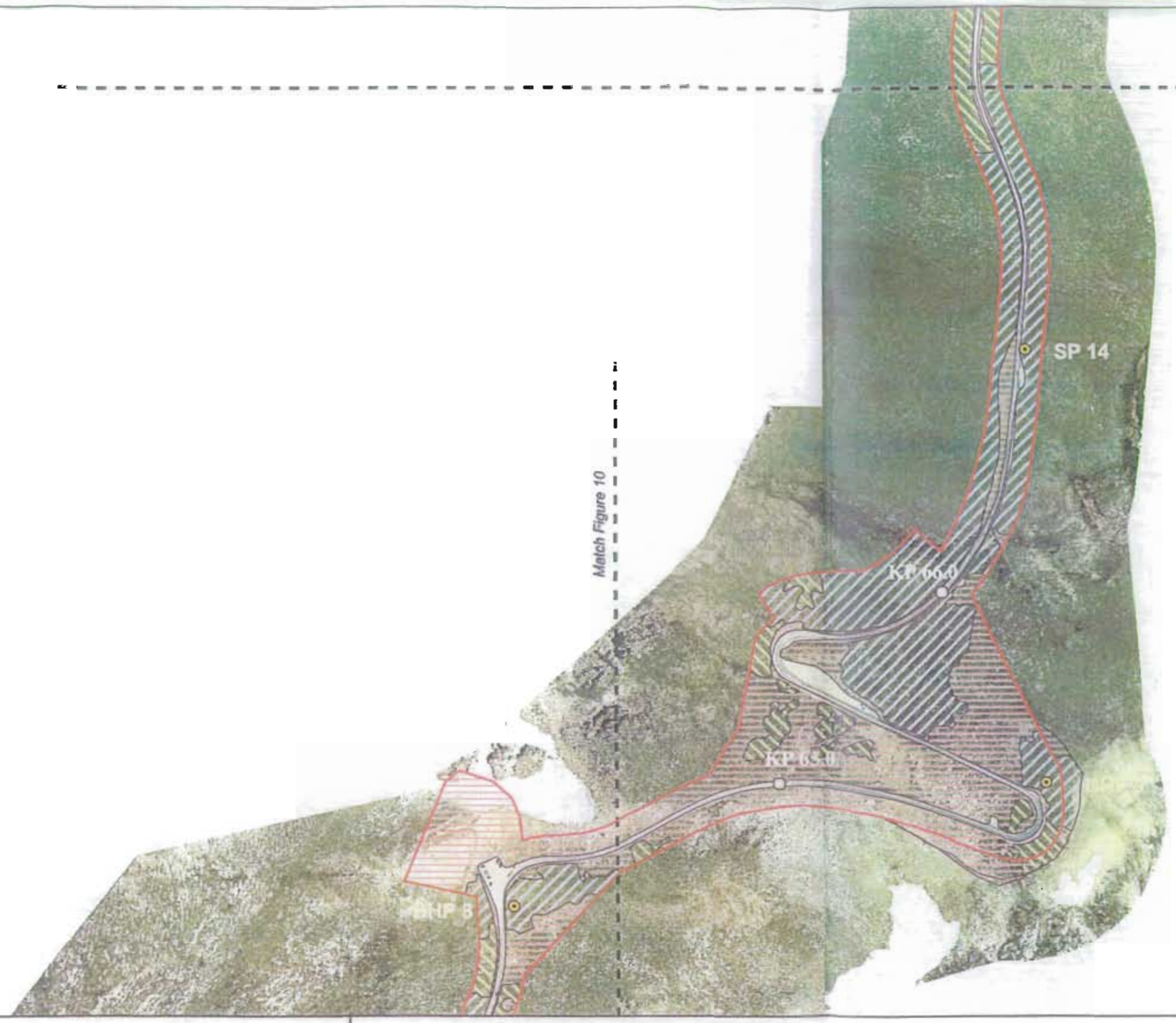
ERO
ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

0 50 100 150 Meters
0 250 500 Feet
Scale: 1:6000

Figure 10
Beartooth Highway Surface Rock Maps

June 2001



ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

N

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 11
Beartooth Highway Surface Rock Maps

June 2001

Match Figure 13

Match Figure 11

ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

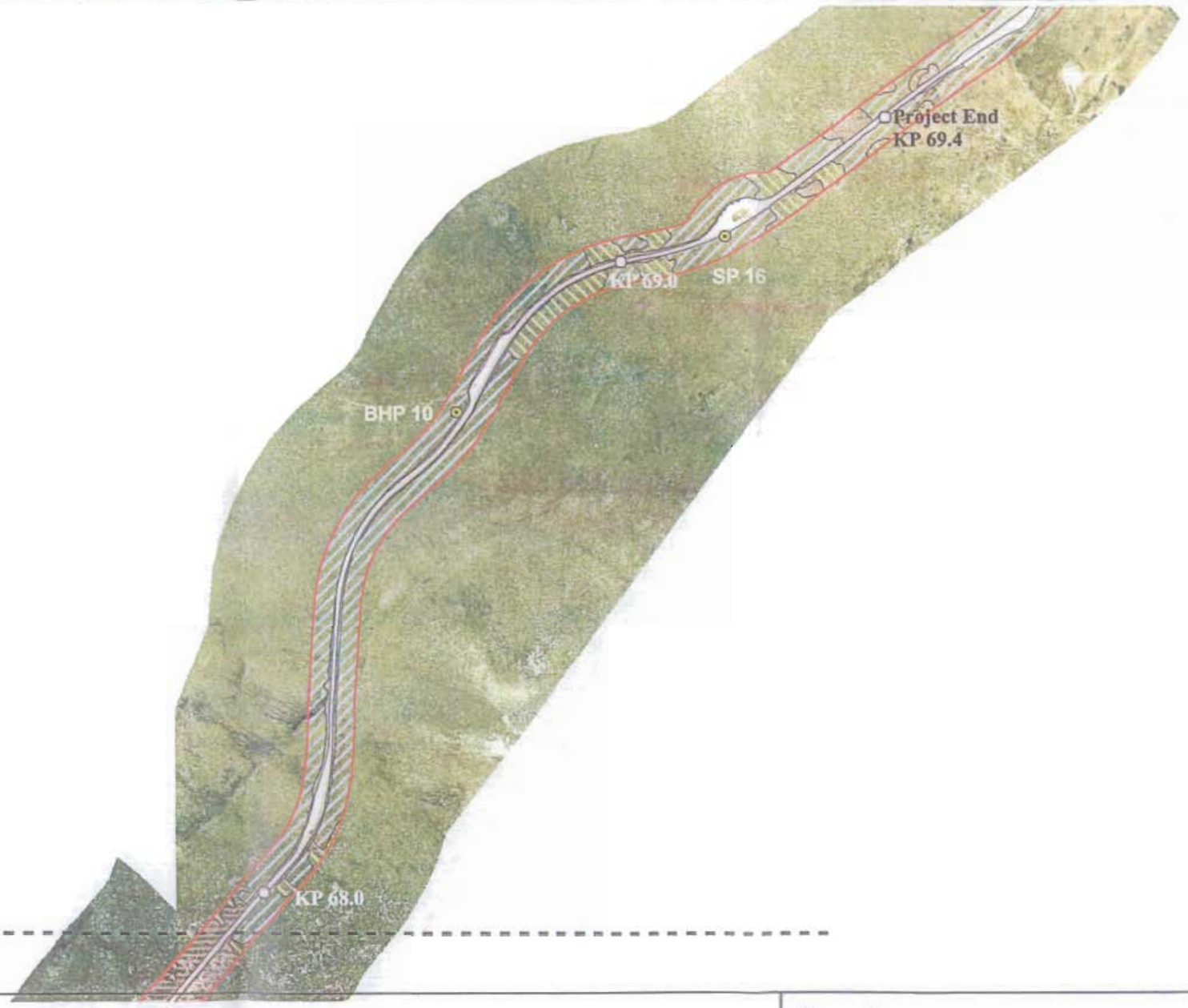
Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

0 50 100 150 Meters
0 250 500 Feet

Scale: 1:6000

Figure 12
Beartooth Highway Surface Rock Maps

June 2001



Match Figure 13

ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: 830-1188

Class I - <33% rock fragments
Class II - 33% - 66% rock fragments
Class III - >66% rock fragments
Water
Sample points
Figure match line
Kilometer post
Study area

N

0 50 100 150 *Meters*
0 250 500 *Feet*

Scale: 1:6000

Figure 13
Beartooth Highway Surface Rock Maps

June 2001

D

APPENDIX D: SOIL PROFILE PHOTOS

Photo 1 - Alpine meadow soil profile - Backhoe Pit No. 10

Photo 2 - Montane meadow soil profile - Backhoe Pit No. 3

Photo 3 - Montane forest soil profile - Backhoe Pit No. 12