Montana Department of Transportation

HWY 567 / PIPE CREEK ROAD
Libby North
CORRIDOR STUDY

Appendix B

Preliminary Geotechnical Corridor Study

PRELIMINARY GEOTECHNICAL CORRIDOR STUDY
11 KM NORTH OF LIBBY – NORTH
PROJECT STPS 567-1(4)7
CONTROL NO. 4789
LIBBY, MONTANA
TETRA TECH, INC.
PROJECT NO. 6570885

PRELIMINARY GEOTECHNICAL CORRIDOR STUDY
11 KM NORTH OF LIBBY – NORTH
PROJECT STPS 567-1(4)7
CONTROL NO. 4789
LIBBY, MONTANA
TETRA TECH, INC.
PROJECT NO. 6570885

Prepared for:

Parsons Brinckerhoff Quade & Douglas, Inc.
488 East Winchester Street, Suite 400
Murray, UT 84107

Prepared by:

Tetra Tech, Inc.
Consulting Geotechnical Engineers
2436 Dixon Avenue
Missoula, MT 59801

MONTANA
MARCO
FELLIN
NO. 12633PE
REGISTERED
PROF. ENGINEER - PROF. ENGINEER

December 2006

TETRA TECH, INC.

December 20, 2006

Mr. Stewart Lamb
Parsons Brinckerhoff Quade & Douglas, Inc.
488 East Winchester Street, Suite 400
Murray, UT 84107

SUBJECT: Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789
Libby, Montana

Dear Mr. Lamb:

At your request, we have completed our preliminary geotechnical corridor study for the Montana Department of Transportation (MDT) 11 km North of Libby – North Project referenced above. The report that follows describes in detail our study, summarizes our findings, and presents our Preliminary Geotechnical Evaluation (460).

If you have questions regarding this draft report, please contact us.

Respectfully submitted,

TETRA TECH, INC.

for Richard P. Dombrouski, P.E.
Senior Geotechnical Engineer

Jeremy Dierking, E.I.
Staff Geotechnical Engineer

TABLE OF CONTENTS

Page

1.0 PROJECT DESCRIPTION 1

2.0 PRELIMINARY GEOTECHNICAL EVALUATION (460) 1

2.1 SITE GEOLOGY 1

2.2 SITE VISIT 2

Existing Roadway 2
Aggregate Sources 3
Bridges 4
Cut and Fill Slopes 4
Seismic Assessment of Project Area 4

2.3 REVIEW OF PUBLISHED DATA 5

2.4 PRELIMINARY GEOTECHNICAL ANALYSIS 5

Retaining Walls 6
Rock Slopes 6

APPENDIX A
Figure 1 – Site Location Map
Figures 2 through 4 – Stereonet Projections

APPENDIX B
Project Photos (1 through 58)

1.0 PROJECT DESCRIPTION

The project is located along Secondary Route 567, approximately 11 kilometers (km) north of Libby, Montana. Secondary 567 is a low-volume, two-lane rural major collector on the state Secondary Highway System. The corridor is located in Lincoln County and the Kootenai National Forest and serves as a north-south corridor between Libby and Yaak. The road is also on the Forest Highway System, and is designated Forest Highway 67. It was originally built as a logging road with a gravel surface and segments later paved by the Forest Service through application of bituminous surface treatments, asphalt concrete pavement, and chip sealing. MDT, Lincoln County, and the Forest Service desire to improve the road to a modern, safe facility and are proposing to evaluate the feasibility of improving the roadway through development of a corridor plan. The project limits are from approximately Reference Post (RP) 6.7 at the Bobtail Jct. South [1244], north to the intersection with Turner Mountain Road at approximately RP 20.1. A topographic map of the project route is shown in Figure 1 noting the beginning and end points.

The purpose of the project is to develop a comprehensive, long-range plan for managing and improving the corridor. It will be a collaborative process with local jurisdictions, other agencies and the public in identifying transportation problems and the most efficient and effective solutions to them. The process will also provide a means for facilitating resolution of major issues before specific project programming and development begin.

The existing geometrics are challenging in terms of both vertical and horizontal alignments through a mountainous terrain and abutting Pipe Creek at various points along the route. Consequently, the corridor plan will evaluate the feasibility of improving the corridor including assessing a range of low-level safety type improvements through major reconstruction. Activities will include researching existing conditions; documenting existing and projected environmental, geotechnical and land use conditions; forecasting future growth; identifying goals and analyzing alternatives for the corridor from a constructability, financial feasibility, and public acceptance perspective; and recommending improvements and management strategies for the existing and long-term safety and operation of the corridor.

2.0 PRELIMINARY GEOTECHNICAL EVALUATION (460)

2.1 SITE GEOLOGY

The project is located along the Pipe Creek drainage in the Purcell Mountains north of Libby. Geology within the project area primarily consists of glacial and alluvial mixtures of boulders, cobbles, gravel, sand, silt and some clay overlying argillite bedrock of Precambrian age. The glacial and alluvial deposits generally consist of material scoured and eroded from the bedrock units, with areas in which alluvial processes have reworked the glacial deposits into mixtures of boulders, cobbles, gravel, sand, silt and occasional clay. In areas along the steep slopes adjacent to Pipe Creek, alluvial activity has also stripped the glacial and alluvial deposits and exposed the bedrock in outcrop. The underlying bedrock consists of calcareous or dolomitic sandy argillite and shale of the Wallace Formation of the Piegan Group within the Belt Supergroup (MBMG Bulletin 79, Geology and Mineral Deposits, Lincoln and Flathead Counties). The bedrock generally has joint patterns that are almost parallel and perpendicular to the bedding planes, which results in outcrop exposures having a rectangular blocky failure pattern and subsequent rockfall rectangular in shape.

The project is located in a forested canyon area and terrain varies from relatively flat to slightly sloping in the creek bottom transitioning to gently rolling or very steep in the mountainous terrain (Photo 1).

The majority of adjacent land is within the Kootenai National Forest boundaries, with occasional residential private parcels interspersed along the route.

Photo 1. Looking north at approximate RP 15.2, Pipe Creek to left, and Turner Mountain in background.

2.2 SITE VISIT

Tetra Tech performed a site visit and field reconnaissance on October 25 and 26, 2006. The field reconnaissance included walking and driving the entire length of the project to observe and evaluate site geology, topography, stability of natural and cut slopes, and surface drainage features/unusual drainage problems as they relate to geotechnical issues.

Existing Roadway

The road was originally constructed with a gravel surface which was later improved through application of bituminous surface treatments, asphalt concrete pavement, and chip sealing. In general, the existing roadway surface is in poor to fair condition respective to the age of the surface treatments, with areas of alligator cracking, occasional rutting and settlement features, potholes, patched areas, and raveling edges. Along the project route the road has minimal shoulders, minimal and deficient guardrail, and no traffic striping (Photos 1, 2, and 3). Several sections of roadway along the project length were recently overlayed with new asphalt concrete pavement, generally matching the former existing roadway width and with a maximum thickness of approximately 3 inches. The overlays varied in length from approximately 50 to 1500 feet and the existing pavement widths varied from approximately 15 to 26 feet. Drainage along borrow ditches appeared to be adequate evidenced by no standing water or severe erosion downcutting the ditch profile.

Photo 2. Looking northwest at approximately RP 19.5; example of pavement cracking and raveling.

Photo 3. Looking north at approximately RP 7.2; example of pavement surface raveling.

Aggregate Sources

An existing aggregate source was observed at approximate RP 15.8, northeast of the intersection with Forest Road 68X with several piles of stockpiled material (Photo 4). An existing aggregate source and hot mix plant was also observed south of the project area at approximate RP 1.0.

Photo 4. Stockpiled material at existing aggregate source near approximate RP 15.8.

Bridges

A single-span, concrete deck and steel girder bridge over Pipe Creek is located at approximate RP 7.6 and was observed to be in good condition (see Photographs 6 and 7, Appendix B). The bridge is approximately 34 feet wide and approximately 60 feet long. No other bridges were observed along the project route. Several culverts of varying type, size, and condition were observed at tributary drainage crossings (see Photographs 34, 50, and 51, Appendix B).

Cut and Fill Slopes

Existing cut slopes in the alluvial and glacial soil deposits were observed to have maximum slopes on the order of 2:1 with a maximum height of approximately 65 feet, and several of the slopes indicated surface raveling and erosion (Photo 5). Minor slope instability was observed on a large cut slope at approximate RP 19.7 (Photo 6). In our opinion, these types of slope instabilities are indicative of slopes consisting of granular soils standing at their angle of repose. Cut slopes within the weathered areas of the bedrock were also observed to have surface raveling and erosion. Measurements of strike and dip of the bedrock bedding planes and orientations of joint discontinuities were recorded at bedrock outcrop locations using a Brunton compass to determine their influences on the rock mass strength and slope stability. Fill slopes are vegetated with grass and weeds, and appeared to be in good condition and constructed of local materials.

Seismic Assessment of Project Area

According to the National Earthquake Hazard Reduction Program's recommendations for development of seismic regulations for the project area and the Probabilistic Earthquake Hazard Maps for the State of Montana prepared for the Montana Bureau of Mines and Geology 2005, parameters for this site include a Peak Ground Acceleration of 0.09, with a 90 percent probability of the ground motion not being exceeded in a 50-year period.

Photo 5. Looking north at cut slope at approximate RP 12.3.

Photo 6. Looking northwest at cut slope at approximate RP 19.7.

2.3 REVIEW OF PUBLISHED DATA

We have received copies of the preliminary geotechnical field review prepared by MDT and scoping meeting notes and a topographic site map of the project area along the entire project length prepared by Parsons Brinckerhoff (PB). These drawings indicate an overall project length of approximately 13.4 miles, with reference post increasing toward the north. Tetra Tech also attended a project kickoff meeting and a preliminary drive-through of the project corridor with personnel from Parsons Brinckerhoff in August 2006.

2.4 PRELIMINARY GEOTECHNICAL ANALYSIS

Several geotechnical issues were identified in the preliminary corridor study and will need to be evaluated and analyzed during a design level geotechnical investigation. Based on our observations, the key issues will include, but are not limited to the following:

- Several segments of the existing roadway encroach on Pipe Creek and are also flanked on the opposite side of the road by steep cut slopes in soil and/or in bedrock. Many of these slopes are composite slopes consisting of soil over bedrock.
- Cut slopes in the glacial and alluvial soil deposits and composite cut slopes consisting of overburden soil and weathered bedrock are typically standing at their angle of repose and therefore susceptible to shallow surface failure and erosion during heavy precipitation events, spring snow melt, or repetitive freeze-thaw cycles.
- Cut slopes in the bedrock exhibit rockfall hazards and wedge type slope failures in areas where the bedding and joint plane intersections daylight out of the slope face.
- Slope stability of existing and future cuts and fills along steep, winding section of roadway from approximate RP 19.0 to RP 20.1.
- Existing roadway alignment does not appear to meet current MDT geometric design standards.
- Possible slope improvements or treatments may include slope flattening or benching, slope revegetation or erosion fabric placement to prevent surface erosion, presplitting, and rockfall catchment ditches.

Retaining Walls

Retaining walls may be necessary for fill embankments constricted by Pipe Creek and steep adjacent slopes, and in the winding steep grade from RP 19.0 to 20.1 to achieve the desired roadway geometric design within existing right-of-way limits or to minimize encroachment outside of current limits. Retained fill embankments along the present travel way (PTW) should be analyzed for adequate foundation support and stability during the design phase of the project.

Rock Slopes

Discontinuities or weakness planes are those structural features that separate intact rock blocks within a rock mass. These features include faults, bedding planes, joints, and shear zones. Stress fields that develop as a result of forces during episodes of mountain building and other tectonic activity often create systems of discontinuities having approximately the same inclination and orientation. As a result of the processes involved in their formation, most discontinuities occur in families or discontinuity sets with preferred directions. A common method of analysis of such field data is through interpretation using stereographic projection.

Strike and dip orientations of bedrock bedding planes and major joint sets were recorded during our site reconnaissance at various outcrops along the existing alignment. Bedrock bedding inclinations were measured in the range of 45 to 89 degrees, generally dipping towards the southwest, with occasional areas dipping to the northeast, and an approximate strike range of N5° W to N70° W. The measured bedding planes have a mean strike and dip of N23° W, 62° SW, with the majority of the bedding planes having a mean strike and dip of N18° W, 70° SW. The respective pole populations of the bedding planes were plotted on an equal area stereonet and then statistically contoured (Figure 2).

The respective pole populations of the weakness planes were also plotted on an equal area stereonet and then statistically contoured (Figure 3). Contouring techniques identified three major systems of discontinuities (joint sets) having preferred orientations throughout the rock mass with the following mean strikes and dips:

Joint Set (J1), N 5° E, 41° SE

Joint Set (J2), N 74° E, 53° NW

Joint Set (J3), N 87° W, 87° NE

A small number of randomly oriented joints may occur outside of these mean strike ranges due to variances in the stress field. These discontinuities create weak zones in the parent argillite bedrock and partially control the inclination of the natural rock face as well as the dimensions and mechanics of the rock blocks in outcrop and in rock cuts along the present roadway alignment. The joint surfaces were generally clean, rough and slightly weathered to unweathered. On occasion, joint surfaces contained traces of lean clay or clayey sand infilling, which appear to be attributed to weathering and groundwater flow through the fracture system.

Based on observations and experience with similar slopes, two potential failure modes are possible; plane failure of a sliding block and wedge type failures. A plane failure occurs when a discontinuity (joints, bedding planes, etc.) nearly parallel to the slope face daylights out of the slope face at an angle greater than the friction angle of the plane. A wedge failure occurs in rock when two or more discontinuities form intersecting planes of weakness, in which the line of intersection daylights out of the slope face at an angle greater than the friction angle of the line of intersection, allowing blocks to slide from the slope face. Generally, for a plane or wedge failure to occur conditions must exist where the forces that cause sliding are greater than the frictional forces resisting movement.

A major area of potential rock slope instability was observed at approximate RP 11.0 (Deadman's Curve), which encroaches on Pipe Creek to the east (Photos 7 and 8). The rock cut slope is located on a tight curve west of centerline, with discontinuities forming a distinct block failure pattern along the length of the cut when viewed in outcrop exposure.

The respective pole populations of the weakness planes along the rock cut at Deadman's Curve were plotted on an equal area stereonet and then statistically contoured (Figure 4). Contouring techniques identified three major systems of discontinuities (bedding plane and joint sets) having preferred orientations throughout the rock mass with the following mean strikes and dips:

Bedding Plane (B1), N 21° W, 66° SW

Joint Set (J1), N 16° E, 43° SE

Joint Set (J2), N 76° W, 87° SW

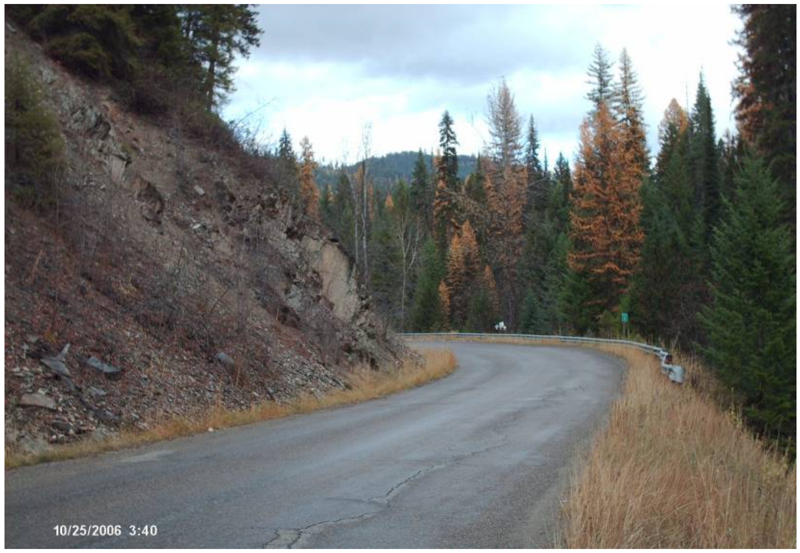


Photo 7. Looking north towards RP 11.0 (Deadman's Curve).

Photo 8. Rock cut at RP 11.0, note blocky pattern formed by discontinuities.

Stereographic analysis and field observation of the existing slope performance indicates a high probability of wedge type failures in the rock mass. Considering the fact that the rock slope at Deadman's Curve is located on a curve, the orientation of the cut slope changes through the curve, and a detailed analysis will need to be performed to design a safe slope configuration.

Slope stabilization and rockfall mitigation techniques will be required for rock cut slopes along the project. Such techniques may include slope flattening, rock bolting, rock netting, rockfall catchment ditches, and barrier fences. Actual placement and selection of the rockfall mitigation measures will depend on a complete field investigation and geotechnical study including stereographic and geomechanical analysis of potentially unstable slopes during the design phase.

APPENDIX A

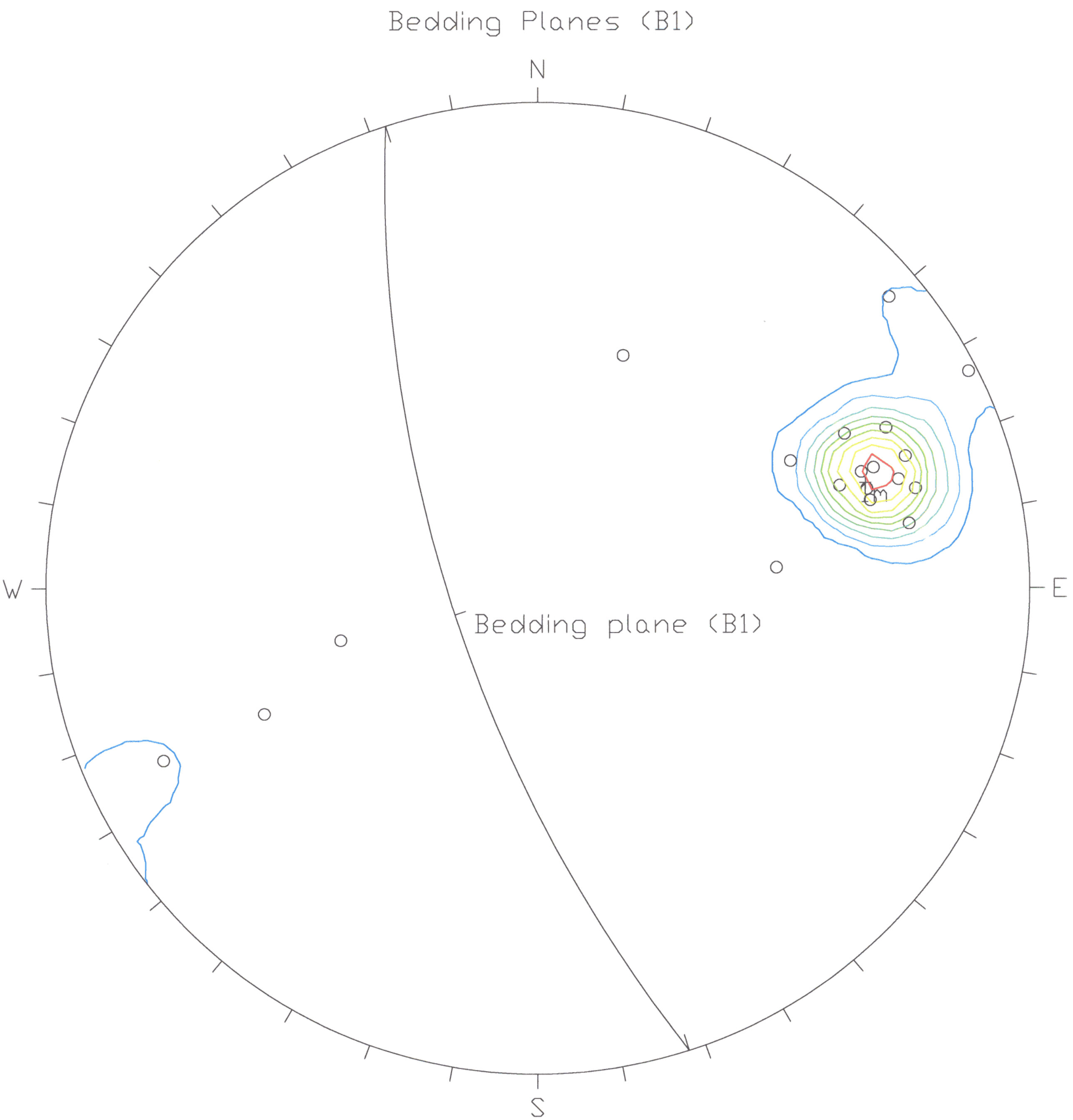
FIGURES

0 1.3
Miles

Drawn By:	
PAW	
Reviewed By:	
JD	

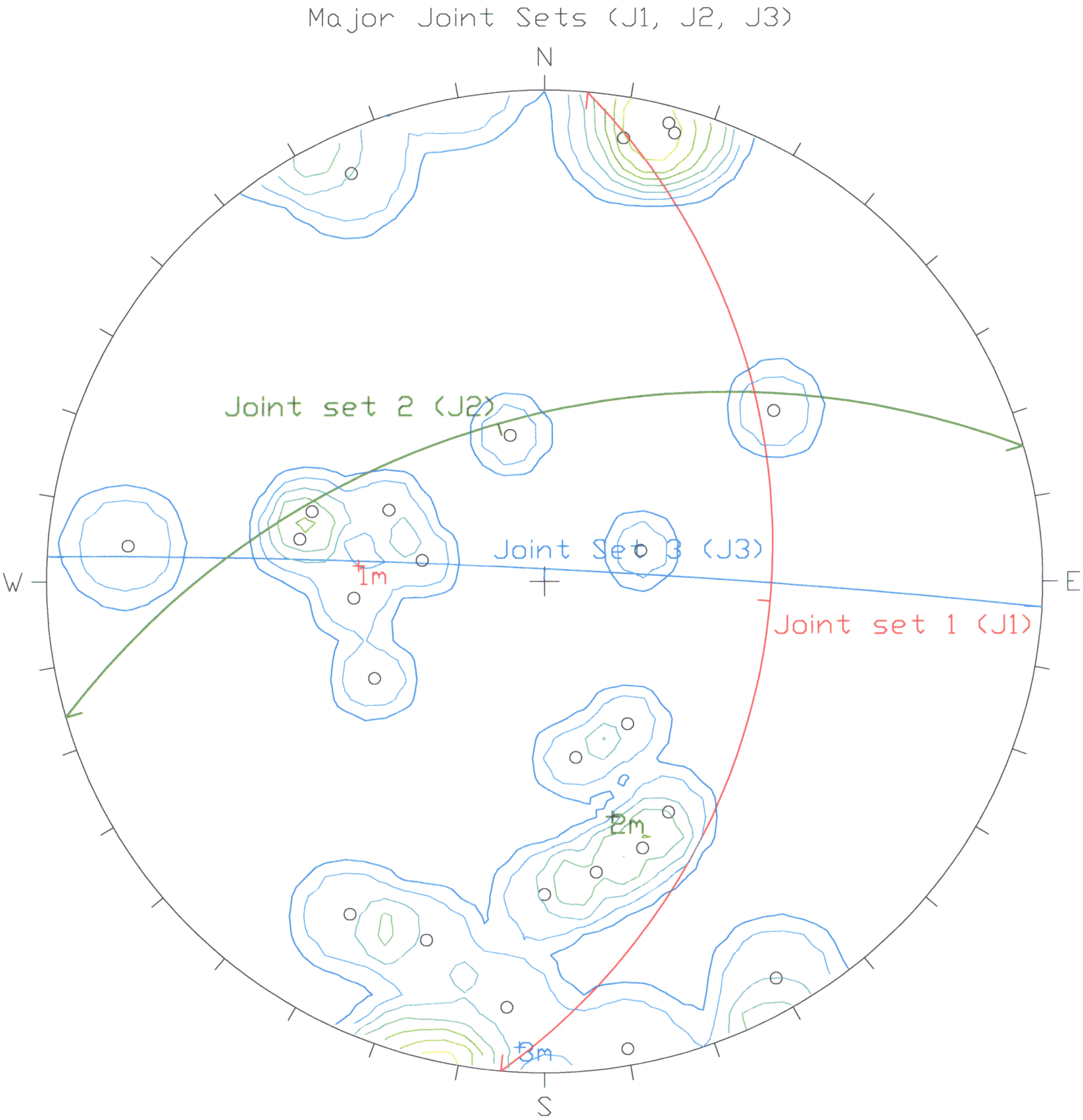
Site Location Map
Preliminary Geotechnical Corridor Study
11 km North of Libby - North
Project STPS 567-1(4)7, CN4789

Library\Brdreng3.dwg



Legend	Drawn By: JD	Equal Area, Lower Hemisphere Stereonet
○ Poles	Reviewed By: RD	Bedding Plane Pole Plot
Statisical Contours	Scale:	11 km North of Libby - North
		Project STPS 567-1(4)7, CN 4789

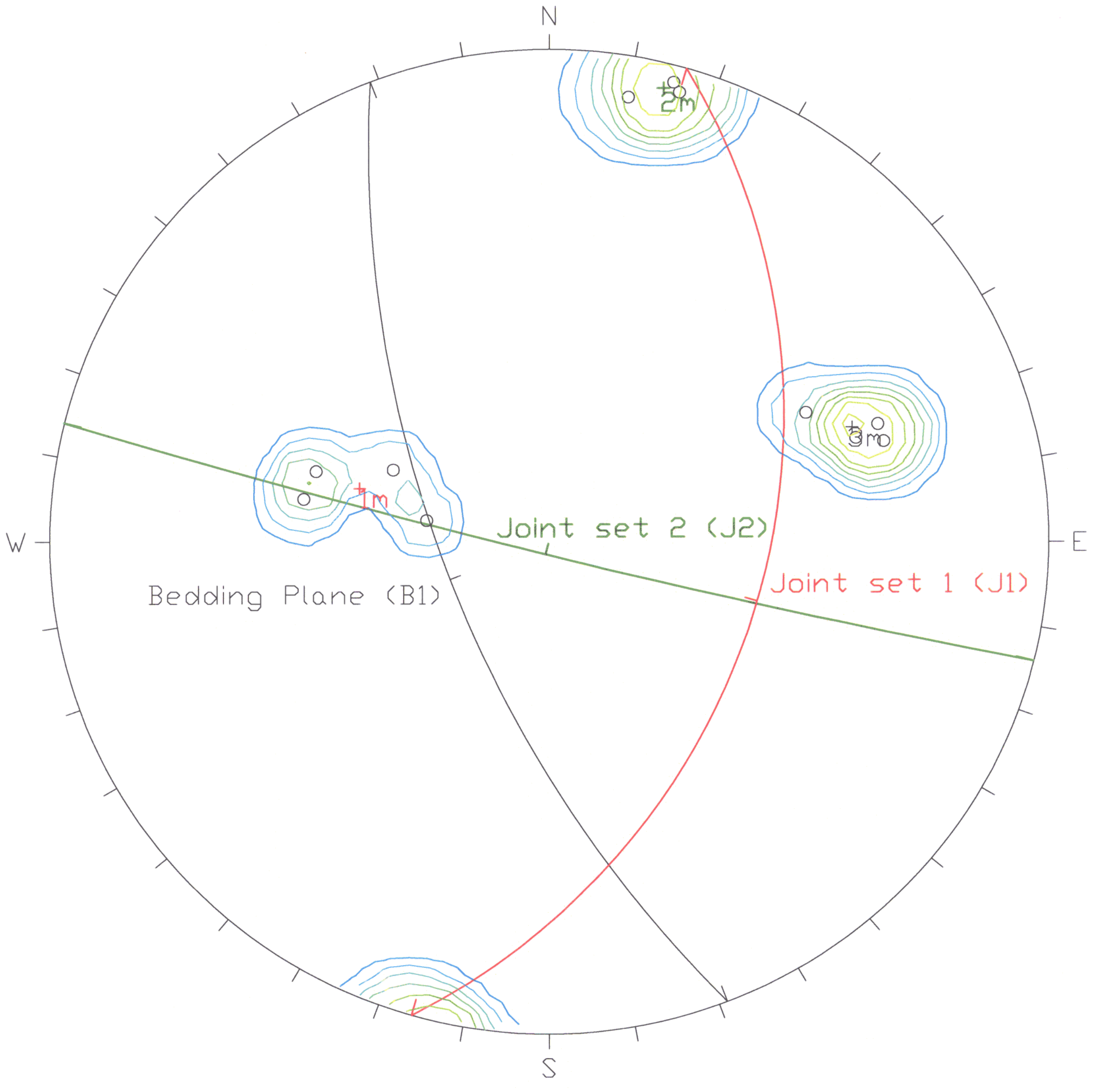
Library\Brdreng3.dwg



Legend	Drawn By: JD	Equal Area, Lower Hemisphere Stereonet
○ Poles	Reviewed By: RD	Joint Set Planes Pole Plot
Statisical Contours	Scale:	11 km North of Libby - North
		Project STPS 567-1(4)7, CN 4789

Library\Brdreng3.dwg

Deadman's Curve (RP 11.0) - bedding planes and joint sets



Legend	Drawn By: JD	Equal Area, Lower Hemisphere Stereonet
○ Poles	Reviewed By: RD	Bedding and Joint Sets Pole Plot - Deadman's Curve
Statisical Contours	Scale:	11 km North of Libby - North
		Project STPS 567-1(4)7, CN 4789

APPENDIX B

PROJECT PHOTOS

Project Photographs
Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789

PHOTOGRAPH 1 RP 7.0, looking west at end of good pavement.

PHOTOGRAPH 2 RP 7.0, looking north.

PHOTOGRAPH 3 RP 7.0, pavement cracking.

PHOTOGRAPH 4 RP 7.0, looking NE, at soil slope on east side of road.

PHOTOGRAPH 5 RP 7.2, looking north, pavement

PHOTOGRAPH 6 RP 7.6, looking north on west side of

Project Photographs
Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789

PHOTOGRAPH 7 RP 7.6, looking south on east side of bridge over Pipe Creek.

PHOTOGRAPH 8 RP 7.6, looking south across bridge over Pipe Creek.

PHOTOGRAPH 9 RP 7.9, looking southwest at soil slope on west side of road.

PHOTOGRAPH 10 RP 8.0, looking northwest at rock slope on west side of road.

PHOTOGRAPH 11 RP 8.0, looking north at rock slope on west side of road.

PHOTOGRAPH 12 RP 8.0, looking west at rock slope on west side of road.

Project Photographs

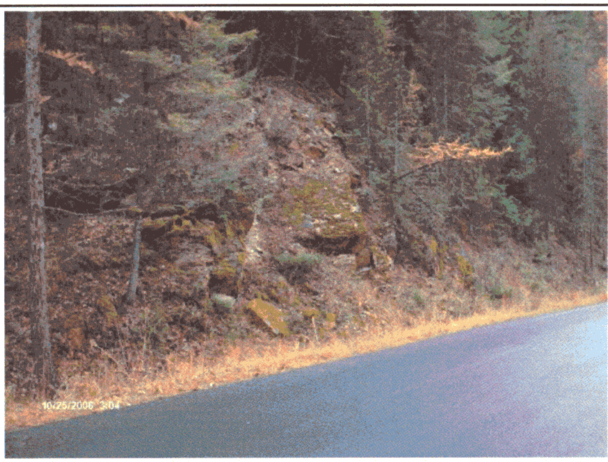
Preliminary Geotechnical Corridor Study

11 km North of Libby – North

Project STPS 567-1(4)7, CN 4789

PHOTOGRAPH 13 RP 8.6, looking northwest at soil slope on west side of road.

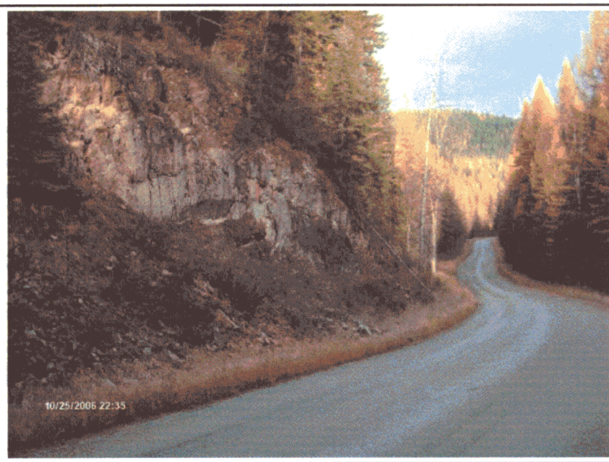
PHOTOGRAPH 14 RP 8.6, looking north at soil slope on west side of road.



PHOTOGRAPH 15 RP 8.7, looking northwest at rock outcrop on west side of road.

PHOTOGRAPH 16 RP 8.7, looking west at rock outcrop on west side of road.

PHOTOGRAPH 17 RP 9.7, looking northwest at rock outcrop on west side of road.



PHOTOGRAPH 18 RP 9.7, looking north at rock outcrop on west side of road.

Project Photographs

Preliminary Geotechnical Corridor Study

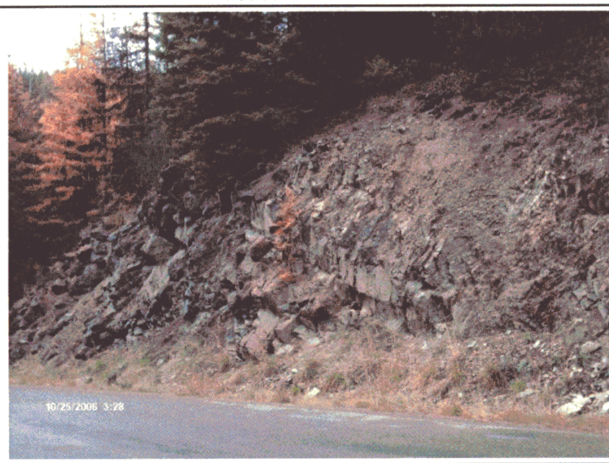
11 km North of Libby – North

Project STPS 567-1(4)7, CN 4789

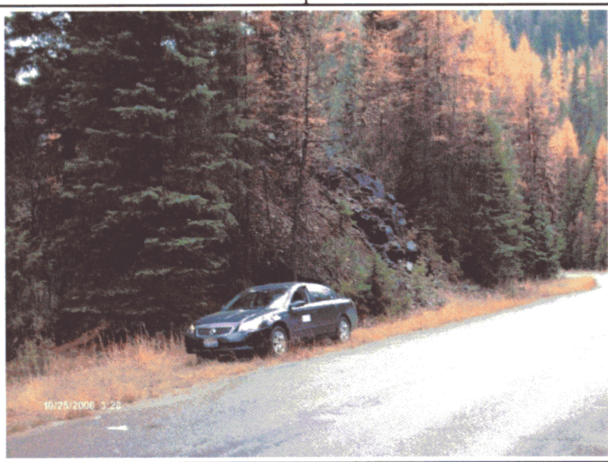
PHOTOGRAPH 19 RP 10.0, looking southwest at soil slope on west side of road.

PHOTOGRAPH 20 RP 10.3, looking southwest at weathered rock slope on west side of road.

PHOTOGRAPH 21 RP 10.6, looking west at weathered rock slope on west side of road.



PHOTOGRAPH 22 RP 10.9, looking west at rock slope on west side of road.



PHOTOGRAPH 23 RP 10.9, looking southeast at rock outcrop on east side of road.

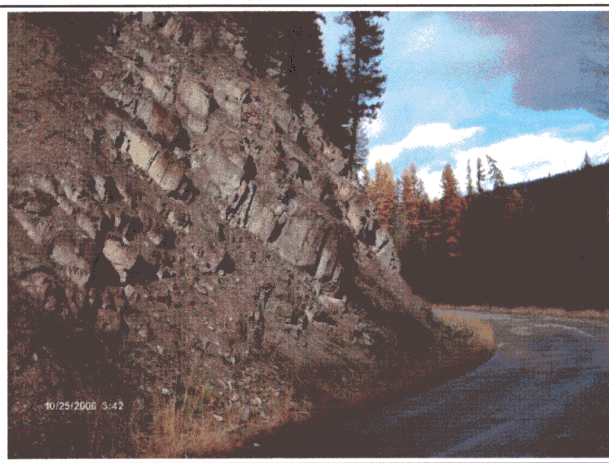
PHOTOGRAPH 24 RP 10.9, looking northeast towards RP 11.0, Deadmans Curve.

Project Photographs
Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789

PHOTOGRAPH 25 RP 11.0, looking west at rock slope on west side of road.

PHOTOGRAPH 26 RP 11.0, looking northeast towards Deadmans Curve.

PHOTOGRAPH 27 RP 11.0, looking north at rock slope on west side of road.

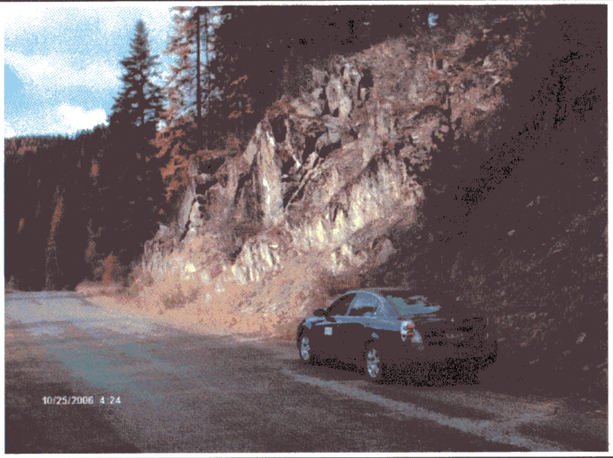


PHOTOGRAPH 28 RP 11.0, looking north at rock slope on west side of road.

PHOTOGRAPH 29 RP 11.0, looking north at rock slope on west side of road.

PHOTOGRAPH 30 RP 12.3, looking northeast at soil slope on east side of road.

Project Photographs
Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789



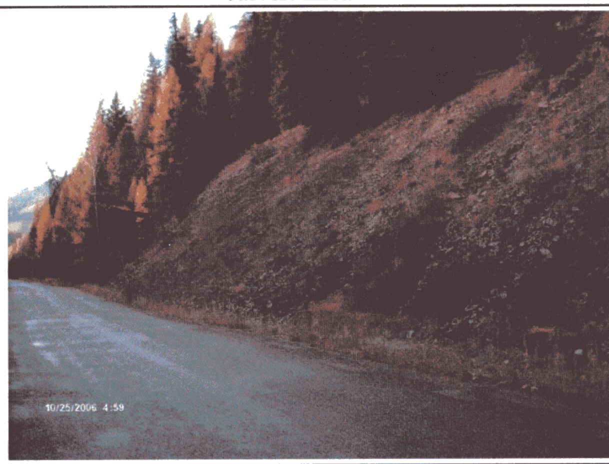
PHOTOGRAPH 31 RP 12.9, looking north at rock outcrop on east side of road.

PHOTOGRAPH 32 RP 13.2, looking south at rock slope on east side of road.

PHOTOGRAPH 33 RP 13.9, looking southeast at rock slope on east side of road.

PHOTOGRAPH 34 RP 14.2, Shafer Creek crossing, CSP culvert inlet.

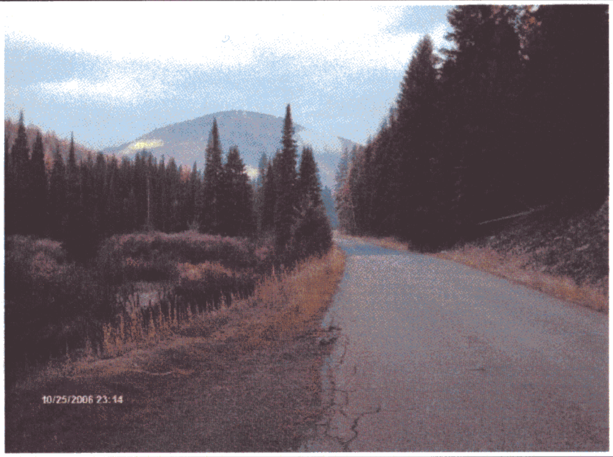
PHOTOGRAPH 35 RP 14.7, looking northeast at weathered rock slope on east side of road.



PHOTOGRAPH 36 RP 14.7, looking north at weathered rock slope on east side of road.

Project Photographs
Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789

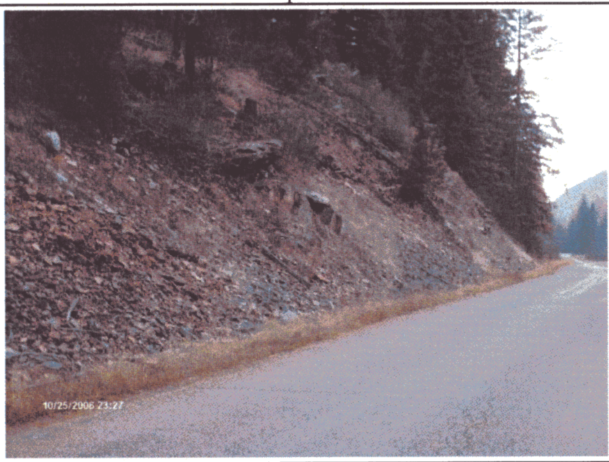
PHOTOGRAPH 37 RP 15.2, looking northeast at rock outcrop on east side of road.



PHOTOGRAPH 38 RP 15.2, looking north-northwest towards Turner Mountain (in background), Pipe Creek to left.

PHOTOGRAPH 39 RP 15.3, looking southeast at rock outcrop on east side of road.

PHOTOGRAPH 40 RP 15.3, looking south at rock outcrop on east side of road.

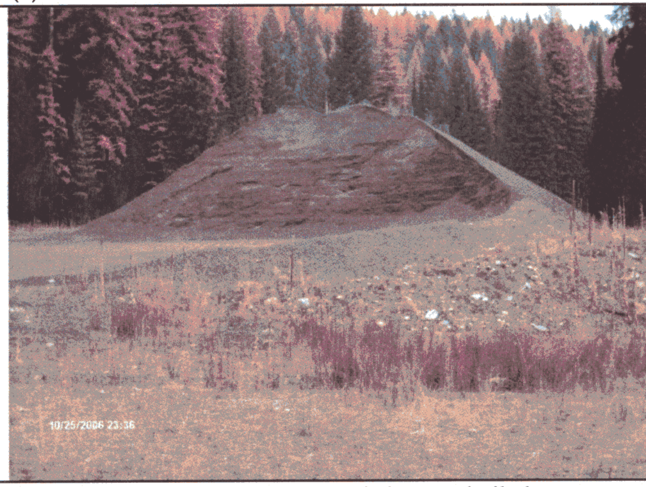


PHOTOGRAPH 41 RP 15.4, looking south at weathered, highly fractured rock outcrop on east side of road.

PHOTOGRAPH 42 RP 15.8, existing stockpiled crushed aggregate at source west of road on Forest Road 68X.

Project Photographs
Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789

PHOTOGRAPH 43 RP 15.8, existing stockpiled aggregate and cut slope at source west of road on Forest Road 68X.



PHOTOGRAPH 44 RP 15.8, existing stockpiled aggregate at source west of road on Forest Road 68X.

PHOTOGRAPH 45 RP 16.0, looking southeast at rock slope on east side of road.

PHOTOGRAPH 46 RP 16.0, looking north at rock slope on east side of road.

PHOTOGRAPH 47 RP 16.3, looking south at rock slope on

PHOTOGRAPH 48 RP 18.2, looking southeast at

Project Photographs
Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789

PHOTOGRAPH 49 RP 18.2, looking northeast at highly fractured rock slope on east side of road.

PHOTOGRAPH 50 RP 18.8, looking south at East Fork Pipe Creek crossing CSP inlet on east side of road.

PHOTOGRAPH 51 RP 18.9, looking northwest at Pipe Creek crossing CSP outlet on southwest side of road.

PHOTOGRAPH 52 RP 18.9, looking north at soil slope at intersection with two Forest Service Roads on eastside of road.

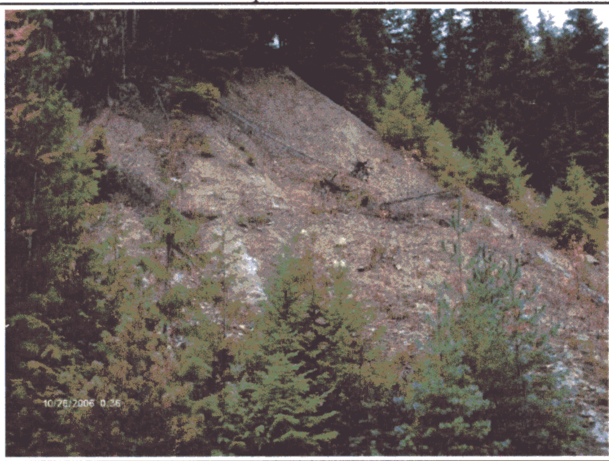
PHOTOGRAPH 53 RP 19.4, looking southwest at steep soil

PHOTOGRAPH 54 RP 19.5, looking northwest at

Project Photographs
Preliminary Geotechnical Corridor Study
11 km North of Libby – North
Project STPS 567-1(4)7, CN 4789

PHOTOGRAPH 55 RP 19.6, looking west at steep soil slope on southwest side of road.

PHOTOGRAPH 56 RP 19.7, looking west at steep soil slope on southwest side of road.



PHOTOGRAPH 57 RP 19.7, looking west at steep soil slope on southwest side of road.

PHOTOGRAPH 58 RP 19.7, looking west at steep soil slope on southwest side of road.