851 Bridger Drive Ste F
Bozeman, MT 59715

406.582.8780
FAX 406.582.8790

TECHNICAL MEMORANDUM

To: Bob Kirkpatrick

From: Allan Kirk

Date: November 21, 2001

Re: Revised and Final Report on Potential Rock and Soil Sources - McLaren Pit Capping System and Drainage Channels - New World Mining District Response and Restoration Project

CC:
M. B. Marks
F. Ehernberger
M. Cormier

Introduction

Under Delivery Order #12, Task #2, Maxim Technologies, Inc.® has identified a number of possible rock and soil sources for potential use as cover material in the McLaren Pit closure. Select soil source sites were studied in greater detail, which included: physical mapping, volume estimates, and the excavation of test pits. Test pits were designed to allow examination of subsurface materials and collection of material samples for laboratory analyses. Test pits were logged and information on soil profiles, grain size, and soil structures described. A preliminary analytical screen using acid-base accounting analyses was undertaken prior to conducting additional laboratory analyses. It was proposed that further suitability of near surface material for use as cover soil be evaluated by testing samples for the following parameters: sieve and texture analysis, organic matter content, pH, and electrical conductivity. To date, this second order testing has not been conducted on any of the samples collected. Procedures used to sample and analyze soil materials are further described in the Site-wide Sampling and Analysis Plan (Maxim, 1999).

During discussions with the US Forest Service Field and Construction Supervisor, Frank Ehernberger it became apparent that in addition to soil sources, quarry sites in the vicinity of the McLaren Pit would be desirable to provide suitable material for a cover drain layer and armoring for channels. Using existing US Geological Survey and Crown Butte Mining, Inc. geologic maps, a number of quarry and soil sites were identified (Figure 1). Sites identified are largely located in the Daisy and Miller Creek drainages to minimize haul distance to the McLaren Pit. Maxim assumed other sites available in the middle and lower portions of Fisher Creek offered no advantage over the sites proposed for use in the McLaren Pit proposed action EECA (i.e., soil source SB-4B(I) and rock quarry site (FHA quarry) sites in the Soda Butte Creek drainage.

The objectives in looking for other soil and quarry sites nearer to the McLaren Pit were to minimize the cost of hauling and handling materials and to minimize the amount of haul traffic on the Daisy Pass road. Given the large volume of tourist traffic on the Daisy Pass road, haul road safety issue are also a major concern. The preferred alternative selected for closure of the McLaren Pit (Alternative 3C) will require approximately 25,000 yards (1,500 truck loads @ 17 yds/truck) of quarried drain rock and armoring material, and some 44,000 yards of cover soil (2,600 truck loads @ 17 yds/load).

Maxim has calculated that quarrying rock and excavating soil materials closer to the McLaren Pit construction site could save between $250,000 to $500,000 in direct trucking costs, considerably reduce the amount of county road use, and minimize safety risks.

Possible sites identified for rock quarries and for soil excavation are shown on Figure 1. These sites are discussed below. Criteria used were apparent suitability of material, proximity to the McLaren Pit, land owner ship, confinement of all disturbances to the Daisy Creek drainage, and potential visual impact of quarry development or excavation of cover soil. Acid-Base Accounting (ABA) results are available for the limited number of samples submitted to date.

Conclusions

The soil and quarry sites identified in the McLaren EECA (SB-4B(I) and rock (FHA pit, respectively) are proven sources of suitable quality.

Another significant soil source that offers some advantages with respect to cost, haul traffic volume, and safety over the SB-4B(I)i site is the upper Daisy Creek moraine. The proximity of this source to the McLaren Pit and its ability to provide adequate amounts of soil material are two of its best features. This source does contain material that falls in range of acid base accounting values (ABA) that is uncertain with respect to acid generation; lime amendment is a distinct possibility to correct this deficiency. Lime amendment can be accomplished at a modest cost, about $15,000 (purchase, transport and mixing). Mixing of lime can likely be accomplished during screening or during placement of materials. Lime requirements are on the order of 15-32 tons of lime per 1000 tons of material (average 17 tons per 1000 tons). So, from an acid-rock drainage (ARD) point of view, the upper Daisy Creek morainal material can be amended such that there is almost no risk of generating acid from materials placed above the liner. There is ample space to set up stockpiling and screening, and, if necessary, crushing facilities. All of the impacts related to soil borrow could be confined to the upper Daisy Creek area. Visual impacts would be large during borrow operations and small over the long-term. The site proposed for borrow consists of a positive topographic feature, which and can be excavated and reclaimed relatively easily. Some white bark pines exist on the moraine and a small cultural resource site exists on the northeast corner of the moraine. The impact to the cultural resource could be avoided, and the impact to white bark pine minimized by selective development and production from the moraine. Obtaining soil from this morainal feature could represent a cost saving of as much as $500,000 over use of material from the SB-4i.

Most other potential soil sources evaluated may not contain suitable material and most can only provide a portion of the soil material needed. Each occurs at distances further from the McLaren Mine site than does the Daisy Creek moraine. Table C-1 presents a summary of characteristics of cover soil borrow areas evaluated.

Potentially acid-generating rock, screened from this soil material for use, as rock armoring for channels is, however, problematic. The ABA testing protocol calls for grinding the rock material before testing, so that the surface area of the material tested is greatly increased over the surface area of the actual size fraction proposed for use. Therefore, these ABA values are neither realistic nor representative of the actual surface area of rock material proposed for use. Regardless, rock clasts basically can't be amended because, without close and intimate contact between the acid generating material and the lime amendment, acid generation is not effectively buffered. Alternatively, rock needed for armor material could be quarried from a nearby granite or limestone sources.

Table C-1. Summary of Characteristics of Cover Soil Borrow Areas.

Site # - Feature	Drainage	Material		Distance McLaren Pit	Sampled	Land Status	Visual Impact	
		Suitability	Volume	Miles			Short Term	Long Term
#1 End. Moraine	Upper Daisy	Need Lime Amendment	OK	0.5	Yes	District	Large	Small
#2 Ground Moraine	Upper Miller	Probably Clayey Till	OK (?)	1.8	No	District Private and Nat'l Forest	Large	Small
#3 Ground Moraine	Lower Miller	Probably OK	Probably too small	2.7	No	District	Large	Small
#4 SB4i	Soda Butte	Good	More than adequate	5.0	Yes	Nat'l Forest	Large	Small

Most of the quarry sites evaluated offer both an adequate volume of rock of suitable or desirable quality (including limestone and/or dolomite sources). If rock were only quarried for channel and steep slope armoring, the size of the quarry can be greatly reduced over the size of a quarry needed to supply both rock for the drain layer of the cover and for channel armoring. Visual impacts would seem to create the biggest problem with quarrying from any of these sites. Therefore, the problem becomes one of the relative importance of visual impacts when weighed against cost, safety, and quality of construction material as factors. Probably the best example of this is the Pilgrim Limestone that out crops on the northwest flank of Fisher Mountain. In addition to being nearby, this material is durable, contains a significant amount of neutralization potential, and using this source for rock would confine impacts associated with obtaining material for the response action to the Daisy Creek drainage. However, the long-term visual impact of quarrying at this site is likely to be significant unless creative things are done with cliffs and benches.

Other nearby rock sources or potential quarry sites to the McLaren pit, the upper Daisy Creek Moraine and talus on Fisher Mountain, are potentially acid generating. Rock materials from each of these sites can not be adequately amended for use as rock armoring.

<u>Borrow and Quarry Sites Proposed for Use in the McLaren EECA</u>

The soil source identified and proposed for use in the McLaren Pit EECA (for the purposes of suitability and cost analysis) was the SB-4B(I) site, located in the Soda Butte Creek drainage about 1.5 miles north of US Highway 212 (Figure 1). For suitability and cost analysis purposes in the McLaren EECA, rock sources for use in the cover drain layer and armoring of channels in the McLaren Pit area were proposed to come from the Federal Highway Administration (FHA) rock quarry which is in Precambrian granite source located in the Soda Butte Creek drainage. This site is also located about 1.5 miles north of US

Highway 212 (Figure 1). Both the soil and quarry sites contain adequate volumes of suitable material for the designated construction purposes. Acid-Base Accounting (ABA) testing indicates that neither the soil nor the bedrock materials are at risk of generating acid (Maxim, 2001). The soil has considerable neutralization potential, 118-271 tons per thousand tons of material.

Roads have been upgraded and a new road constructed that would be suitable for hauling materials from these sites to staging areas in the vicinity of the McLaren pit. The primary issues concerning the use of these two identified sites are that they are both visible from US Highway 212 and are both about 5 miles away from the McLaren construction site, which add, significantly to haul costs, road usage, and road safety.

Possible Cover Soil Borrow Areas

1) End Moraine Upper Daisy Creek:

The feature proposed for excavation is a small glacial end moraine (ridge of sediments deposited at an intermediate stopping point at the downhill end of an active glacier) high in the Daisy Creek drainage (Figure 1). The moraine is a ridge-like topographic feature located in the upper Daisy Creek valley bottom immediately below Daisy Pass and about ¼ mile southwest of the McLaren Pit (Figure 3, Figures 3-16 are photographs at the end of the text). A number of White Bark Pine trees occur along the northern and southern edge of the ridge. A primitive drill road from the Lake Abundance road to the Daisy Creek valley bottom accesses the moraine. This road would need to be upgraded for hauling. This feature is a positive topographic feature that rises above the underlying valley floor.

This site was studied in some detail. It was mapped with tape and compass and elevations hand leveled at a number of locations around the perimeter of the moraine. The moraine is approximately 600 feet long and varies in width from 250 to 325 feet. Topographic relief varies from as little as 22 feet to as much as 70 feet. The computed volume of material from mapping is 177,000 cubic yards.

Four (4) test pits were excavated in the moraine: three along the ridge crest and one along the toe of the moraine in the middle of its north side (3). Two of the ridge top pits #1 and #2 are 16.4 feet and 15.1 feet deep, respectively. Test Pit #3 encountered silicified and skarn-altered Cambrian Park Shale bedrock from 9 to 11 feet (with minor visible sulfides, 1-2 percent). Test Pit #4 was extended into the north side of the deposit about 15.5 feet beginning at the elevation of the contact of the moraine with the valley floor, to determine the material type at the base of the moraine. All trenches had a moderate brown (5 YR ¾) silty-loam cover soil (weathered in place glacial till) with organic material and roots to varying depths. This cover soil ranges in thickness in the four pits from 12 to 36 inches (average about 20 inches). The remainder of the material in each of the pits is generally a light brown (5 YR 5/6) silty-loam material (glacial till) with moderate moisture content (holds form with compression in hand) (Figures 4-7). The pits contain various amounts of rock fragments of varying sizes. Almost all rock fragments are silicified and skarn altered Cambrian Park Shale that occurs as hard (silicified) blocky and angular fragments. Visual estimates of size and amount of material are shown in Table 1. Four or five photos were taken of each test pit that may be used for further size analysis of coarse rock material. The subject of each of the photos taken is listed by test pit in Appendix A. Electronic copies of the photos are available in Maxim Technologies Bozeman Office.

Table 1. Visual Estimates of Size and Amount

Pit #	Average Rock Fragment Size (inches)	Range of Rock Fragment Size (inches)	Visual Estimate of % Rock Fragments
1	1"	0.5-4"	5-10% (boulders 1%)
2	4"	0.5-16"	25-35% (boulders 3%)
3	1"	0.5-24"	5-10% (boulders 1%)
4	3"	0.5-14"	30-40% (boulders 5%)

More detailed descriptions of units and sub-units identified in each test pit are included in Appendix A of this report. Composited samples from each test pit (both a rock and a soil sample) were submitted to Northern Analytical for acid base account (ABA) analyses. The results of these analyses are presented in Table 2 below. Analysis of other physical and chemical parameters awaits a decision on whether this site is acceptable for use.

Figure 2 depicts graphically the relationship between acid generation potential and acid neutralization potential for soil and rock samples from the upper Daisy Creek moraine. On graphs of this type, samples that fall to the right of the ABA= +20 line are considered non-acid generating and samples that fall to the left of the ABA= -20 line are considered acid generating. For samples that fall between these two lines it is uncertain if acid will be generated. All of the rock and soil samples from the moraine fall in this zone of uncertainty accept for the rock sample from Test Pit #4 (at the base on the north side of the moraine), which appears to be acid generating. In order to address the question of whether these samples generate acid over time, it is likely that humidity cell testing would be required. Humidity cell testing places the samples in a simulated weathering environment and measures the actual acidity output over time.

Another means of evaluating acid generation or neutralization potential is also shown on Figure 2. Figure 2 shows the ratio between acid generation (AGP) and acid neutralization potentials (ANP) plotted as lines that have been derived mathematically and back-tested with empirical data. Samples with an ANP/AGP ratio of 1 have exactly enough neutralization potential to neutralize the acidity released by the acid generation potential. However, under empirical field conditions it has been shown that samples need an ANP/AGP ratio of 3:1 in order to insure that all of the acidity is neutralized. An ANP/AGP ratio of 3:1 has been adopted by the Bureau of Land Management (BLM) as the standard for evaluation of the potential for materials to generate acid. Sample from the Daisy Creek Moraine hover around the ANP/AGP 1/1 line and all of the samples have a ANP/AGP ratio of less than 3:1. This again suggests that the material may generate acid over time, in the weathering environment.

The risk of generating acid from these samples can be overcome by amending the material with lime to increase the neutralization potential. Table 2 presents both calculated and laboratory measured values for the amount of lime needed to amend these soils. The column labeled "Total Lime for (HNO_3 +Residual S = SMP)*1.25" is the calculated lime required to amend the materials. The column labeled "Total Lime needed as $CaCO_3$" is the amount of lime needed a determined by the laboratory. Both of the values are reported in tons of lime required to amend 1000 tons of material. As can be seen from table 2, the calculated values agree well with the laboratory data. The amount of lime needed to amend 1000 tons of material for soils from the Daisy Creek moraine ranges from 10.8 to 32.5 tons. The values for rock material range from 7.8 to 37.4). The average amount of lime required for all materials is about 18 tons of lime/1000 tons of material.

Table 2. Acid Base Accounting Data for soil and rock data from the Lower Daisy Creek Moraine.

Sample	SMP Lime Requirement tons/acre	AP tons/kton	HNO_3-S	HCl-S	Res S	recalc AP HNO_3 + Res S	NP	ABA	TOTAL Lime for (HNO_3 and Res S + SMP)*1.25	Tot S	Tot S AP	TOTAL Lime needed as $CaCO_3$
TP1-S	6.1	6	<0.1	<0.1	0.2	6.3	<1	-6	15.4	0.22	6.9	16.2
TP2-S	2.4	6	<0.1	<0.1	0.2	6.3	6	0	10.8	0.22	6.9	11.6
TP3-S	5.9	6	<0.1	<0.1	0.2	6.3	<1	-6	15.2	0.21	6.6	15.6
TP4-S	10.4	16	<0.1	<0.1	0.5	15.6	<1	-16	32.5	0.52	16.3	33.3
TP1-R	0	6	0.1	<0.1	0.1	6.3	11	5	7.8	0.24	7.5	9.4
TP2-R	0	6	0.1	<0.1	0.1	6.3	7	1	7.8	0.16	5	6.3
TP3-R	1.8	6	<0.1	<0.1	0.2	6.3	5	-1	10.1	0.37	11.6	16.7
TP4-R	1.8	28	0.3	<0.1	0.6	28.1	3	-25	37.4	0.93	29.1	38.6

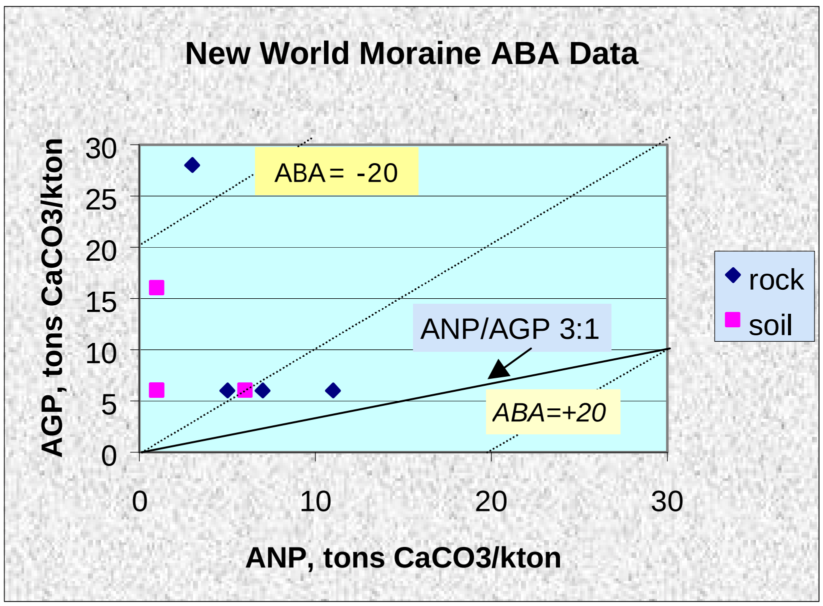

Figure 2. Graph of Acid Generation Potential vs. Acid Neutralization Potential for soil and rock samples form the Upper Daisy Creek Moraine.

These are very modest lime requirements and amendment of soil material from the Daisy Creek moraine should be relatively easily, assuming a good mix (during screening or during placement) can be established. However, rock screened from the moraine could not be amended, because close and intimate contact is required between the acid generating rock material and the lime amendment in order effectively buffer acid generation this is generally not possible for coarse rock fragments.

The Daisy Creek moraine is located on District property. The road distance to the McLaren Pit is about 0.5 miles. Disturbances associated with excavation would be confined to upper Daisy Creek. Visual impact during excavation will be significant, but because this is a positive topographic feature with abundant soil, reclamation should not be difficult. Long-term this excavation should have minimal visual impact except for the partial or complete removal of a topographic feature.

2) Ground Moraine Upper Miller Creek:

This potential borrow source consists of several small areas of thick glacial ground moraine (glacial till deposited at the sole (base) of an active glacier) high in the Miller Creek drainage (Figure 1). These morainal sediments (till) consist of a blanket-like deposit that occurs over much of the Miller Creek Valley floor. The small areas proposed for excavation occur in open meadow areas in the center of the valley, in the vicinity of the "plant nursery corral" and immediately north of Margaret Reeb's cabin. More extensive areas of ground moraine exist in the same general area, but are heavily tree covered. These deposits are known to be about 30-feet thick in monitor wells #5A and #5B, which were drilled within the area proposed for excavation.

Both of these monitor wells describe the till material as brown in color, consisting of 50-60% clay and 40-60% rock fragments. Rock fragments are predominantly brown dolomite and siltstone, with minor amounts of granitic and volcanic clasts. Monitor well 5A was drilled to a depth of 30.5 feet with 1.5 feet of soil material underlain by 7.5 feet of poorly sorted sandy loam soil with some coarse rock fragments (1.5-9 feet), followed by 18 feet of glacial till (9-27 feet), and 3.5 feet of bedrock at the bottom of the hole. Monitor well 5B was drilled just off the main stem of Miller Creek to a depth of 55 feet and targeted the Crown Butte Fault zone. This hole encountered soil to 0.5 feet, glacial till from 5-27 feet and bedrock from 27-55 feet. A significant water flow in excess of 15 gallons per minute (gpm) was encountered at 45 feet. During subsequent pump testing, this well could not be drawn down significantly at pumping rates of 400 gpm, and almost no draw down was seen in the adjacent observation well 5A. Material in both wells was damp or wet below 15 feet. These holes were drilled with air rotary methods and there was considerable difficulty drilling both the clayey till material and the rocks suspended in the clay.

Till material at this site is likely to be of unsuitable quality for borrow as soil cover due to the high clay content (50-60%), and high moisture content. Samples from this site have not been tested specifically for this use. No estimates have been made for material volume, but given the large aerial extent of these deposits that occur on unforested ground, and its estimated thickness, the area likely contains sufficient material to provide the necessary cover soil.

Land ownership in this area of upper Miller Creek is complex and the area underlain by ground moraine proposed for excavation occurs on District, private and National Forest property. The road distance to the McLaren Pit is about 1.8 miles, about 0.5 miles of which needs to be upgraded. Disturbances associated with the proposed borrow area would be confined to upper Miller Creek. Visual impact during excavation would be significant. This area contains abundant soil and long-term reclamation should not be difficult.

3) Ground Moraine Lower Miller Creek:

The area proposed for borrow consists of a small area of glacial ground moraine in the lower Miller Creek drainage (Figure 1). These morainal sediments consist of a blanket-like deposit that occurs over what is apparently a bedrock terrace adjacent to the steeply incised portion of the Miller Creek stream channel. The small area proposed for borrow occurs in a logged off area to the west of the Daisy Pass Road and to the east of Miller Creek. More extensive areas of ground moraine likely exist in the general area, but occur on steeper slopes that are extensively covered with burned trees. These deposits are of unknown thickness.

The material is likely to be of suitable quality for borrow as soil cover, but it has not been sampled or tested for suitability. No estimates have been made for material volume, but given the small aerial extent of these deposits that occur on unforested ground, it is unlikely that the area contains sufficient material to provide all of the required cover soil.

The unforested land underlain by ground moraine and proposed for soil excavation occurs on both District and National Forest property. The road distance to the McLaren Pit is about 2.7 miles, all of which except for the last 0.2 miles is suitable for hauling. Disturbances associated with the proposed excavation would be confined to lower Miller Creek. Visual impact during excavation will be significant, but this area contains abundant soil, and long-term reclamation should not be difficult.

4) Other Sites:

Most of the sites proposed as quarry sites below, will produce varying amounts of suitable cover soil material during the stripping of outcrops or the screening of unconsolidated rock-bearing material. In addition, some soil material may be obtained during the preparation of a lay-down or stockpile area for construction to be built at the McLaren site (probably immediately north of the junction of the Lulu Pass and Lake Abundance roads). One other possible major source of soil material that has not been evaluated lies in the large open portions of the Daisy Creek valley near its confluence with the Stillwater River. It is likely, however, that in these portions of the glaciated valley, a rather thin soil has developed as a veneer overlying shallow bedrock eroded into its present shape by glaciers (this hypothesis was recently tested in the upper part of the valley, where shallow piezometers installed along the flanks of Daisy Creek encountered bedrock at depths between 2 and 3 feet, and at depths of 8 feet on low lying terraces on the northeastern flank of Daisy Creek).

Table 3. Summary of Characteristics of Cover Soil Borrow Areas.

Site # - Feature	Drainage	Material		Distance McLaren Pit	Sampled	Land Status	Visual Impact	
		Suitability	Volume	Miles			Short Term	Long Term
#1 End. Moraine	Upper Daisy	Need Lime Amendment	OK	0.5	Yes	District	Large	Small
#2 Ground Moraine	Upper Miller	Probably Clayey Till	OK (?)	1.8	No	District Private and Nat'l Forest	Large	Small
#3 Ground Moraine	Lower Miller	Probably OK	Probably too small	2.7	No	District	Large	Small
#4 SB4i	Soda Butte	Good	More than adequate	5.0	Yes	Nat'l Forest	Large	Small

Possible Rock Quarry Sites

A) Landslide Block Upper Daisy Creek: A large landslide block lies at the base of the talus slope on the north side of Crown Butte in the upper Daisy Creek drainage (Figures 1 and 8). This block is approximately 850 feet long, about 50 feet high, and has a relatively flat surface, about 70 feet wide, that dips slightly back to the north into the talus slope of Crown Butte. The computed volume of material from mapping is 159,000 cubic yards. The surface of the landslide block appears to be comprised of about 70 percent rock material in a finer-grained, olive gray (5 Y 4/1) sandy soil matrix (30 percent of total material) (Figures 9 through 12). Rock fragments consist of limestone rock clasts and boulders (90 percent of total clasts material are limestone and dolomite) of the Cambrian Age Pilgrim Limestone and Snowy Range Formations and blocks and clasts of the Ordovician Bighorn Dolomite. In a localized area along the east end of the landslide, clasts, blocks, and boulders of the Lamar River and Cathedral Cliffs Formation (andesitic volcaniclastics and lava flows comprising 10 percent of total clast material) also occur admixed with the limestone and dolomite clasts. The average clast size is on the order of 4"-8," but the range of clasts is extremely variable, from 0.2 inch to 36 inches (one room-size clast (rock fall, Figure 13) was observed on the upper surface of the landslide block.

Two samples of rock material were collected as composites from four (4) traverses of the landslide's steep north facing slope. One sample consisted of limestone and dolomite clasts and boulders, the other of andesitic volcaniclastics and lava flow material. One test pit was excavated in this material (Appendix A) and no ABA testing has been done on the rock clasts samples collected from either the surface or from the test pit. In the test pit the matrix material of the landslide block was found to be a very wet silty-clay loam. Rock fragments are not as numerous as expected from the surface distribution of rocks. The upper 12 feet of material in the test pit is wet, clayey, and it only contains about 30% rock material. The total rock content of this upper 12 feet is so little and the matrix so wet and clayey that it is not suitable for crushing or as a rock source. The material below 12 feet, although it contains as much as 90% rock, this matrix is still very wet and clayey.

This feature is a positive topographic feature that rises above the underlying valley bottom and abuts adjacent talus slopes. This site was studied in some detail. It was mapped with tape and compass and elevations hand-leveled at a number of locations around the perimeter of the moraine (Figure 3). The total volume of material contained in the landslide block as calculated from mapping is about 159,000 cubic yards.

The land underlying this landslide block occurs on both private and National Forest property. The road distance to the McLaren Pit is about 0.6 mile, all of which needs to upgraded for hauling and needs to cross Daisy Creek. There is ample room on the site to set up a crusher. Disturbances associated with the proposed excavation would be confined to upper Daisy Creek. Visual impact during excavation will be significant, and the northern slope of Crown Butte is presently undisturbed. However, because this is a positive topographic feature with abundant soil, reclamation should not be difficult and long-term excavation should have minimal visual impact except for the partial or complete removal of a topographic feature. A few pine and fir trees occur at both ends of the landslide block in the potential borrow area.

B) Pilgrim Limestone NW Flank of Fisher Mountain: The Pilgrim Limestone outcrops on the northwest flank of Fisher Mountain just above the cabin remains at Lulu Pass (shown as the light gray material in the background on the flank of Fisher Mountain in Figure 3). The Pilgrim Limestone here lies in fault contact with the Fisher Mountain Intrusive and a dike of the Lulu Pass Dacite Porphyry that outcrops along the Crown Butte Fault. The outcrops here dip steeply to the west and stand prominently as steeply sloping and almost vertical cliffs. The limestone here consists of light to dark-gray, thick-bedded sequence of alternating massive, ripple laminated, bioturbated, and limestone pebble conglomerate units. The limestone is mildly silicified and very hard.

A composite rock sample of the limestone was collected. These rock samples have not been tested for ABA or crushing properties; however, the Pilgrim Limestone from this area is thought to be of desirable quality, in that it likely has a large neutralization potential. An adequate volume of material exists to meet all anticipated rock needs. These outcrops occur on District Property and disturbances would be confined to the Fisher Mountain area. The outcrops are about 0.4 mile from the McLaren Pit along the county road, which in this area would be suitable for hauling with minor upgrades. A crusher could be set up in the Lulu pass area. Both short- and long-term visual impacts would be significant, but the visual impact would likely only be visible from the north and northwest (Lulu Pass and Como Basin area and the Beartooth Absaroka Wilderness). The quarry highwall could be left as steep cliff resembling the existing topography.

C) Park Shale Outcrop South End of Henderson Mountain: Cambrian Park Shale outcrops are interlayered (?) with intrusive rocks of the Henderson Mountain Stock along a ridge on the southern end of Henderson Mountain (Figure 1). In this area the Park Shale is silicified and altered to an epidote-rich skarn-assemblage of predominantly Ca and Mg-bearing silicate minerals. The Henderson Mountain Stock is greenish-gray rhyodacite porphyry that exhibits some weak propylitic alteration. Both rock types are hard (rock samples of both lithologies were collected but not analyzed), and an adequate volume of rock exists. The ridge proposed for quarrying is accessible by a previously constructed drill road that takes off from the Daisy Pass county road. This portion of the Daisy Pass road (2.0 miles) is probably adequate for hauling with only minor upgrades, however the drill road (0.5 mile) would need to be realigned and reconstructed in order to access the quarry site for hauling. The total haul distance from the proposed quarry site to the McLaren Pit is 2.4 miles. The proposed quarry site would require the construction of a pad upon which to place a crusher (site is crowded and flat spaces are at a premium).

This proposed quarry site occurs on District Property and disturbances would be confined to the southern Henderson Mountain area. The status of adjacent patented claims is unclear, as there appears to be a discrepancy between existing maps. It will be difficult to restrict quarrying to this one claim, and adjacent claims are likely to be affected. If these adjacent claims are, in fact, privately owned, an arrangement for surface access, and perhaps mining, will need to be obtained. This will need to be checked. Short-term visual impacts would be small because of the isolated location of the site. Long-term visual impact would be moderate. This site occurs in a burn area (1988 fires) and there is a large number of standing dead trees that would need to be removed prior to quarrying operations. This quarry site is visible from US Highway 212 (one mile away); however, a screen of dead trees may be able to be left and reclamation of quarry benches may be able to minimize this visual impact. Alternatively, the quarry highwall could be left as steep cliffs resembling portions of the nearby topography.

D) Pilgrim Limestone and Snowy Range Fm. Outcrops South Flank of Crown Butte: Outcrops of the Cambrian Pilgrim Limestone and the Snowy Range Formations occur on the south flank of Crown Butte immediately east of Bull of the Woods Pass (Figure 1). Both of these units are largely medium to dark gray, medium to thick-bedded limestone and limestone clast conglomerates. The units are hard and resistant to erosion and stand as prominent rounded outcrops and cliffs in the vicinity of the proposed quarry. No samples were collected, but these lithologic units were sampled in the landslide block on the north flank of Crown Butte. Access is along a jeep road (0.6 mile) that takes off from Daisy Pass and traverses the southern flank of Crown Butte and ends at Bull of the Woods Pass. The total distance from

McLaren Pit to the proposed quarry site is 1.0 mile, at least 0.6 mile, which would need realignment and reconstruction for hauling. The proposed quarry site occurs on both District Property and Private property. There is ample room for stockpiles and a crusher site. The proposed quarry site occurs in undisturbed open areas of outcrop in the uppermost portion of the Miller Creek drainage and would have significant visual impacts both long- and short-term. Impacts would be visible along the portion of the Daisy Pass road that parallels upper Miller Creek.

E) Talus Material SW of Bull of the Woods Pass: Immediately to the south and west of Bull of the Woods Pass at the north end of Miller Mountain is a talus slope that is developed below rocks of Tertiary Lamar River and Cathedral Cliff Formations. These units are comprised of andesitic volcaniclastics rocks, lava flows and locally a light gray intrusive rock. Each of these rock types weathers to blocks, boulders and clasts of resistant and hard material to form the talus. No samples were collected, but these lithologic units were sampled in the landslide block on the north flank of Crown Butte. Access is along a jeep road (0.6 mile) that takes off from Daisy Pass and traverses the southern flank of Crown Butte and ends at Bull of the Woods Pass. The total distance from McLaren Pit to the proposed quarry site is 1.0 mile, at least 0.6 mile, which would need realignment and reconstruction for hauling. The proposed quarry site occurs on National Forest property. There is ample room for stockpiles and a crusher site. The proposed quarry site occurs on a talus slope that is blocked from view by a ridge in the foreground, and, therefore, long-term visual impacts should be small. Impacts would be restricted to the upper Miller Creek drainage.

F) Lulu Pass Rhyodacite Porphyry, Northwest of Scotch Bonnet Mountain: Northwest of Scotch Bonnet Mountain, the Lulu Pass Rhyodacite Porphyry outcrops over a rather extensive area. The weathering of this unit creates an unusual topography that is like subdued badlands with little vegetation (Figure 14). The rhyodacite porphyry is light gray and exhibits a weakly sericitized alteration. It contains phenocrysts of quartz and feldspar that exhibit a weakly developed spherulitic texture and biotite. The groundmass is largely comprised of fine-grained potassium feldspar with very few mafic minerals. The weathering of the potassium feldspar groundmass causes the rock to disintegrate into quartz-feldspar spherulites and weathered surfaces often contain abundant pea-gravel sized and shaped material. Two shallow test pits were excavated in this material (Appendix A, and Figures 15 and 16). The material was found to be very hard and resistant to excavation even with a tracked excavator. However, once excavated from the pit and struck with a hammer, this material was very friable and disintegrated into smaller clasts and eventually pea-gravel sized material. This suggests that the rock quality is likely not suitable for the proposed construction uses (above liner drainage layer and channel armor). However, this material may be highly desirable for road base or a bedding layer for the geosynthetic membrane. Rock was collected from both test pits but has not been analyzed or tested for material strength or ABA.

The proposed quarry site occurs on National Forest property. The outcrops at the quarry site form a low hill that could be excavated with only modest long-term visual impact. This quarry site lies about 1.3 miles from the McLaren Pit. Travel is along the Daisy Pass-Lulu Pass county road for about 0.8 mile and then along a 4-WD road for about 0.5 mile. The jeep road would require major realignment and reconstruction for use as a haul road. There is ample room for stockpiles and a crusher site.

G) Fisher Mountain Talus Material: Material has weathered from the crest and along the west side Fisher Mountain and accumulated as a large talus sheet along the west side of Fisher Mountain immediately above and to the north of the McLaren Pit. The talus material is known to be at lest 25 feet thick in the vicinity of where Crown Butte Mines quarried it. The talus material is comprised of weathered clasts of the Fisher Mountain Stock, a quartz "eye" rhyodacite porphyry. The talus material weathers into pinkish gray sub-angular clasts that range in size from 1 inch to about 14 inches (average size about 4-6 inches). "Run of the hill" talus material was used to line drainage ditches during reclamation by Crown Butte Mines and the material was of a size that prevented wash outs and slope failure in all but one of the steepest spots in the McLaren Pit area. A composite rock chip sample was collected from the slopes of Fisher Mountain; it has not been analyzed or tested. Two samples collected by Furniss in 1996 of Fisher Mountain Intrusive talus (FCSI-96-10 and 12) from this same area, on the west flank of Fisher Mountain suggest that it could be acid generating (Table 4). Sample FCSI-96-13 is from soil material adjacent and admixed with the Fisher Mountain talus (Table 4).

Table 4. Acid Base Accounting Data for soil and talus material from the talus deposits on the west flank of Fisher Mountain..

Sample	SMP Lime Requirement tons/acre	HNO_3-S	HCl-S	Res S	recalc AP HNO_3 + Res S	NP	TOTAL Lime for (HNO_3 and Res S + SMP)*1.25	TOTAL Lime for (Total S + SMP)*1.25	Tot S	Tot S AP	TOTAL Lime needed as $CaCO_3$
FCSI-96-10	5.74	<0.1	<0.1	0.1	3.1	0.3	11.1	8.3	0.03	0.9	11
FCSI-96-12	1.78	0.1	<0.1	0.2	9.4	9	13.9	12.8	0.27	8.4	15
FCSI-96-13	10.59	<0.1	<0.1	0.4	12.5	0.3	28.9	26.9	0.35	10.9	33

Table 4 indicates that the Fisher Mountain talus could be acid generating because they have almost no neutralization potential and modest acid generation potential that likely results from unweathered sulfides disseminated in the Fisher Mountain Intrusive. From the samples collected previously the required lime amendment would range from 11-33 tons per 1000 tons and average 18.5 tons per 1000 tons. While this is not a large lime requirement, it is difficult to add a lime amendment to rock materials because intimate contact of the amendment with the sulfides can not be generally be obtained. Therefore, it is unlikely that this material can be used for rock armor in channels or in the cover drain layer in the McLaren pit area.

The proposed talus excavation lies on District Property. It may be risky to use this material, when other non-acid generating materials sources are available. If we would like to evaluate this material further, I would suggest multiple sampling sites in the talus to test and see if the median of samples collected were acid generating or not, or alternatively run a humidity cell test on the material. The quarry site is less that 0.1 mile from the McLaren Pit, but because it occurs on rather steep talus slope there is little room for a quarry and stockpile site in the immediate vicinity. Other nearby sites do, however, exist for these facilities. Short- and long-term visual impact will likely be large, but visible only from Daisy Pass, Daisy Creek and small portions of the Beartooth Absaroka Wilderness.

H) Talus South Flank Scotch Bonnet Mountain: Along the southern flank of Scotch Bonnet Mountain and adjacent to the Lulu Pass road are talus deposits weathered from the Scotch Bonnet Diorite. The Scotch Bonnet Diorite is a dark gray, medium grained (but locally porphyritic) intrusive rock that comprises the mass of Scotch Bonnet Mountain. Talus deposits are distributed all along the southern flank of the mountain and the talus blocks range in size from 1-16 inches (average 8-10 inches). The rock is extremely hard and durable. A composite sample was collected from talus martial distributed along the Lulu Pass road. Although the deposits are laterally extensive, they are likely relatively thin and obtaining the required amount of material may require removing much of the talus present. The proposed talus excavation site is located about 1.3 miles from the McLaren Pit. This entire road has been upgraded for hauling, but the part over Lulu Pass to the east is steep. Removal of the talus material would likely result in large short- and long-term visual impacts.

Other Sites Examined but Not Carried Forward

I) Meager Limestone East Side of Miller Mountain: The Cambrian Meagher Limestone outcrops along the road on the east side of Miller Mountain, west of Miller Creek (Figure 1). The limestone rock is likely suitable and there is an adequate volume of material. This site occurs in a heavily wooded (large trees), undisturbed area with very poor access. Miller Creek must be crossed to access the site. No samples were collected. For these reasons, the site was not carried forward in detailed analysis.

J) Talus north of Bull of Woods Pass: On the north side of Bull of the Woods Pass, two talus cones extend partway down both the east and west slopes of the cirque basin (Figure 1). The talus material on the east is Cambrian Snowy Range Formation and on the west is Tertiary Lamar River and Cathedral Butte Formation. Both rock types should be suitable material and adequate volumes exist. No samples were collected, but both rock types have been sampled elsewhere (landslide A, above). Access to both sites is very difficult, as steep slopes must be crossed in order to reach the cirque basin from the Daisy Creek drainage. This area also is relatively undisturbed and visual impacts of excavation would be seen from Bull of the Woods Pass and areas to the north in the Daisy Creek drainage and the Beartooth Absaroka Wilderness.

K) Flathead Sandstone Outcrops North of Scotch Bonnet Mountain: Outcrops of Cambrian Flathead Sandstone (quartzite) occur in the unnamed basin north of Lulu Pass and Scotch Bonnet Mountain (Figure 1). Although the rock initially appeared suitable, it was found to contain 2-4 percent pyrite disseminated within the quartzite. This material was not sampled.

L) Precambrian Granite outcrops north of Scotch Bonnet Mountain: Outcrops of Precambrian Granite occur in the unnamed basin north of Lulu Pass and Scotch Bonnet Mountain (Figure 1) at the north end of the road, near the Goose Creek Canyon overlook. This rock type is the same as that proposed for use from the quarry site just north of US Highway 212 in the lower Fisher Creek drainage. The material has not been tested but is probably suitable and an adequate volume exists for all the anticipated needs. Long- and short-term visual impacts would be significant, but the area can only be seen from the basin immediately north of Scotch Bonnet Mountain and perhaps (?) the north side of the Goose Creek canyon. This material was not sampled. The Precambrian Granite outcrops occur on both private and National Forest land, and it is the complex land situation and the visual impacts that prevented this site from being carried forward.

Table 5, on the following page, presents a summary of various characteristics of the possible rock quarries.

Table 5. Summary of Characteristics of Rock Quarry sites.

Site # - Feature	Drainage	Material		Distance McLaren Pit	Sampled *	Land Status	Visual Impact	
		Suitability	Volume	Miles			Short Term	Long Term
#A. Landslide Block	Upper Daisy Creek	Probably Good Limestone and dolomite	OK	0.6	RC TP	Private and Nat'l Forest	Large	Small
#B Limestone Outcrop	NW Flank Fisher Mt	Good Pilgrim Limestone	OK	0.4	RC	District	Large	Moderate
#C Outcrop Henderson Mt.	Lower Miller	Probably Good Silicified Park Shale	OK	2.4	RC	District and Private (?)	Small	Small
#D Outcrop Bull of the Woods	Upper Miller	Good Pilgrim Limestone	OK	1.0	No	District and Private	Large	Large
#E Talus Bull of the Woods	Upper Miller	Probably Good Volcanics	OK	1.0	No	Nat'l Forest	Small	Small
#F Outcrop NW Lulu Pass	Lower Daisy	Poor (?) Friable Intrusive	OK	1.3	RC TP	Nat'l Forest	Moder ate	Small
#G Talus	Fisher Mountain	Good Mildly Acidic Needs Amend	Prob. OK	0.1	RC	District and Nat'l Forest	Large	Large
#H Talus Scotch Bonnet	Upper Fisher Creek	Good Intrusive Diorite	Poss. OK Small	0.8	RC	District and Nat'l Forest	Large	Large
#I Meagher Limestone	Miller Creek	Good Meagher Limestone	Prob. OK	2.7	NS	Private and Nat'l Forest	Large	Large (?)
#J Talus Bull of the Woods	Upper Daisy	Good (?) Limestone and Volcanics	OK	2.0	RC	Private and Nat'l Forest	Large	Large
#K Flathead Sandstone	Goose Creek	Poor Acidic Sandstone	Too Small (?) and scattered	1.4	NS	Private and Nat'l Forest	Large	Large (?)
#L Precambrian Granite	Goose Creek	Good Precambrian Granite	Prob. OK	1.8	NS	Private and Nat'l Forest	Large	Moderate (?)

*RS = Rock Types Sampled
TP = Test Pits
NS = Not Sampled

References

Maxim Technologies, Inc., 2001, Selective Source Response Action Engineering Evaluation / Cost Analysis, New World Mining District Response and Restoration Project, Prepared for the USDA Forest Service, Northern Region, Missoula, Montana. January 2001.

APPENDIX A
Summary of Test Pit Data:

Summary of Daisy Creek Moraine Test Pit Data:

Test Pit #: 1	**Daisy Creek Moraine**
Location	Top of lower east end of moraine, south side of Daisy Creek Moraine, 25 feet in elevation above colluvial surface.
Dimensions	16.4 feet deep, one 4 foot wide excavator bucket
Description	
Surface	Soil and rock-strewn surface, 10% angular rock fragments, Park Shale (CP) skarn
0 - 2.3 feet	Organic rich, dark yellowish brown (10 YR 4/2) silty-loam, root depth max = 2.8 feet, with approximately 10% angular rock fragments of Cp skarn (avg. 1 inch)
2.3 - 16.4 feet	Light brown (5 YR 5/6) silty loam with 5-10% angular rock fragments of Cp skarn and Meagher (Cm) limestone, rock fragments 0.5 - 4.0 inches, average 1 inch, soil moisture content material will compress and retain shape when released but will not ball-up
Rock types	Silicified and skarn altered Park shale, blocky and angular clasts, very hard and silicified range of clast sizes as above
Photos	Four (Roll 1, 8-11) (site, pit wall, 2-materials)
Sample	01-DC-TP-1 (5 gallon bucket)
Other	

Test Pit #: 2	**Daisy Creek Moraine**
Location	Top center: along the south edge of the Daisy Creek Moraine, about 50 feet in elevation above the colluvial surface
Dimensions	15.1 feet deep, one 4-foot wide excavator bucket
Description	
Surface	Soil and rock strewn surface, about 5% angular rock fragments, Park Shale (CP) skarn, about 1-2% large boulders scattered about on surface
0 – 1.5 feet	Organic rich, dark yellowish brown (10 YR 4/2) silty loam, maximum root depth ~ 2.0 feet, with approx. 15% rock chips, which are angular rock fragment of Park Shale silicified and skarn altered.
1.5 – 15.1 feet	Light brown (5YR, 5/6) silty loam soil; with approx 25-30% angular rock fragments of Park Shale; rock chips range in size from .5 inches to 1.3 feet; largest one being ~ 2.0 feet and average size of rock class are ~ 4 inches; soil moisture content is such that material will compress and retain the shape upon release of pressure but does not ball up; some iron oxide staining in soil at depth with test pit and appear to be regularly shaped blotches, 1-2 feet on side
Rock types	Silicified and skarn altered Park shale, blocky and angular clasts, very hard and silicified range of clast sizes as above
Photos	Five (Roll 1, 12-16) site (1), pit (2), materials (3)
Sample	01-DC-TP-2 (5 gallon bucket)
Other	

Open Cut	**Daisy Creek Moraine**
Location	Base of slope at east end of moraine, above cabin
Dimensions	
Description	
Surface	Pine tree-covered slope on the uphill end of the dozer-cut
0 - .5 feet	6 inch sandy loam soil cover
.6 – 15 feet	Cat-cut (open trench); Light brown silty loam with 10-15% rock fragments, mostly Park Shale, averaging 3 inches in size with range of clast from .5 inches to 2.0 feet
Rock types	Park Shale, silicified and angular clasts
Photos	None
Sample	None
Other	

Test Pit #: 3	**Daisy Creek Moraine**
Location	Top of moraine on the northeast end of ridge; located 150 feet below open cut described above; 13 feet of elevation between top of moraine and colluvial slope
Dimensions	11.0 feet deep, one 4-foot wide excavator bucket
Description	
Surface	Soil and rock strewn surface, 20-30% of 1-inch rock chips, 1-2% boulders; rock is Park Shale and silicified and skarn altered; boulder up to 2.0 feet in diameter
0 – 3.0 feet	Organic rich, dark yellowish brown (10 YR, 4/2) silty loam, maximum root depth ~ 24 inches containing ~ 2% rock fragments
3.0 feet – 9.0 feet	Light brown (5 YR 5/6) silty loam with 5-10% angular rock fragments of Park Shale, silicified with epidote and minor pyrite, less than 1%
9 – 11.0 feet	Bedrock (?), Park Shale silicified with epidote and minor sulfide, pyrite content 1-3%; angular, breaking into blocks, chips
Rock types	As above 9-11 feet, very hard and silicified
Photos	Six (Roll 1, 17-22); site (2), pit (1), materials (3)
Sample	01-DC-TP-3 (5 gallon bucket); 200# bulk samples of rock collected
Other	

Test Pit #: 4	**Daisy Creek Moraine**
Location	Northwest side of moraine; at the toe or break in slope of the ridge; 0 feet in elevation above colluvial surface, extends downward for total depth of 11 feet
Dimensions	11.0 feet, one 4-foot wide excavator bucket
Description	
Surface	Soil and rock strewn at break in slope with colluvium and north edge of moraine, at ~ 20° angle
0 - .3 feet	dark yellowish brown 10YR4/2, silty loam soil; maximum root depth ~ 1.0 feet
1 – 11.1 feet	Below valley bottom; material light brown (5 YR 5/6) silty loam, 30-40% angular rock fragments of Park Shale, average size ~ 3 inches; from .5 – 14 inches; few very large clasts > 24 inches (about 1% of total material)
Rock types	Silicified and skarn altered Park Shale, blocky and angular clasts, very hard and silicified: trace of visible sulfide
Photos	Six (Roll 1, 23-24; Roll 2, 1-4) site (2), pit (1), materials (3)
Sample	01-DC-TP-4 (5 gallon bucket)
Other	Excavated for potential bedrock in place at toe of moraine, although very rocky material encountered, no obvious bedrock was found in place to 11 feet

Summary of the Lulu Pass Quartz Dacite Quarry Data:

Test Pit #: 5	**Lulu Pass Quarry Site**
Location	Northwest of Scotch Bonnet Peak, east end of ridge, northwest of Lulu Pass
Dimensions	4.0 feet deep; one 4-foot wide excavator bucket
Description	
Surface	Soil covered with irregular outcrops of Lulu Pass Quartz Dacite
0 – 1.0 feet	dark yellowish brown 10YR4/2, silty loam soil, 10% Quartz Dacite porphyry (Tdlp) rock fragments
1.0 – 2.0 feet	Tdlp, soft, weathered in place to pea-gravel size material, contains abundant clay alterations, rock fragments are very crumbly and weathered
2.0 = 4.0 feet	Tdlp, very hard, breaks into .3 – 1.0 foot boulders and blocks of Tdlp
4.0 feet +	Very hard Tdlp; excavator refused to dig with rippers and full weight of excavator on teeth
Rock types	Tdlp weathers to pea gravel at surface and very hard silicified clasts and blocks at depth
Photos	Four (Roll 2, 9-12) site (1) pit (3)
Sample	01-DC-TP-5 (2 - 12.x24 bags) 1 ea: pea gravel, large blocky rock fragment
Other	

Test Pit #: 6	**Lulu Pass Quartz Dacite Quarry**
Location	West end of same ridge, north of Scotch Bonnet Peak and NW of Lulu Pass
Dimensions	
Description	Blocky material 4-6 inches, medium gray porphyritic intrusive with 0.5 – 1 cm feldspar phenocrysts in dark gray matrix with biotite and minor quartz
Surface	Mixed soil, rock outcrop surface with mostly soil and irregular and only localized outcrops of Tdlp
0 - .75 feet	Soil, dark yellowish brown 10YR4/2, silty loam with 20% Tdlp rock fragment
.75 – 2.0 feet	Tdlp, very hard digging, such that lifted excavator off ground while digging material; refusal to dig at 2.0 feet; upon raking teeth over material, it crumbled into pebble size pea gravel, interpret to mean it is chemically weathered with abundance of clay material in the matrix despite that fact very hard to dig, breaks up fairly easily once loosened; clasts up to 6 inches but crumbly and can be hand crumbled out of ground
Rock types	As described above
Photos	Three (Roll 2, 13-5) site (2), pit (1)
Sample	01-DC-TP-2 (5 gallon bucket)
Other	

Outcrop of the Lulu Pass dacite porphyry (Tdlp)

OUTCROP	**Outcrop Tdlp Porphyry**
Location	In-between Test Pits #5 and #6; bedrock outcrop ~ 2 feet in elevation above the surrounding surface
Dimensions	
Description	Light gray Tdlp outcrop about 18” above surrounding soil cover
Surface	Tried to rip outcrop using the tract excavator; lifted excavator off ground with same result as above; extraordinarily (very, very hard) digging and ripping, but once out of ground, became crumbly when struck with hammer into pea size gravel, silty, sandy kind of matrix
Rock types	Tdlp as above
Photos	Two (Roll 2, 16-17) before and after on outcrop
Sample	None
Other	

Crown Butte Landslide Block

Test Pit #: 7	**Crown Butte Landslide Block**
Location	North flank of Crown Butte at base of talus slope; large rotated landslide block
Dimensions	15.4 feet, 1 4-foot wide excavator bucket
Description	
Surface	Largely rock covered flats with rocks of many different sizes; soil as matrix material; rock clasts make up ~ 40-50% of entire surface, ½ inch - 2.0 feet
0 – 0.5 feet	Soil, dark yellowish brown 10YR4/2, silty loam, with maximum root depth up to 18 inches; abundant rock material in silty loam, as much as 30% rock clasts
0.5 – 12.0 feet	Upper material is a dark chocolate brown silty loam with 30-40% rock fragments; angular and consist of numerous different lithologies; suspended in the silty-clay loam material; silty-clay loam matrix material has very high moisture content and balls up when squeezed and can be rolled into small balls which maintain their shape
12.0 – 15.4 feet	As above, with 90% rock fragments; from 0.5-1.5 feet, appear to have a bi-model distribution with average of 1.5 inches and another ~ 5 inches
Rock types	Rock fragments are ~ 50/50 mix of Cambrian Snowy Range formation and Ordovician Big Horn Dolomite; in addition there are 5-10% andesite clasts probably with Tertiary volcanic material from above the Heart Mountain detachment fault; most rock fragments are hard, angular in shape.
Photos	Three: site (1), materials (2); numerous photos taken of landslide block during traverses to measure the size and shape
Sample	01-DC-TP-7 (2, 12"x24" sample sacks)
Other	The matrix material in the landslide block is very, very wet; rock fragments are not as numerous as expected from the surface distribution of rocks; appears that the upper 12 feet of material is so wet that not suitable for crushing; it only contains 30% rock material whereas the below 12 feet, although as much as 90% rock material, the matrix still remains very wet and clayey.

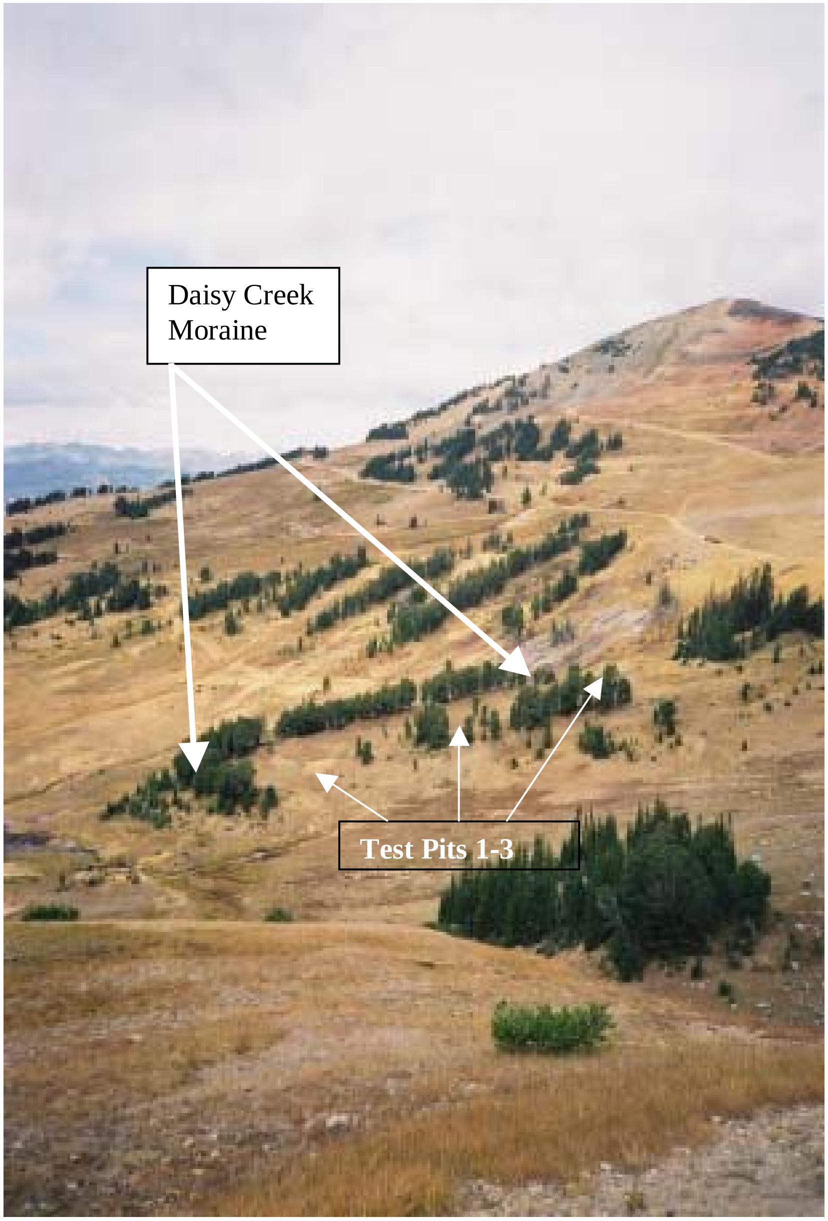

Figure 3. Daisy Pass Moraine Overview (between arrows, looking north from Daisy Pass)


Figure 4. Upper Daisy Creek Moraine TP #1 (west end of moraine)

Figure 5. Upper Daisy Creek Moraine TP #2 (middle of moraine)

Figure 6. Upper Daisy Creek Moraine TP 3 (east end of moraine near cabin)


Figure 7. Upper Daisy Creek Moraine TP 4 (north side of moraine at base or valley bottom level)

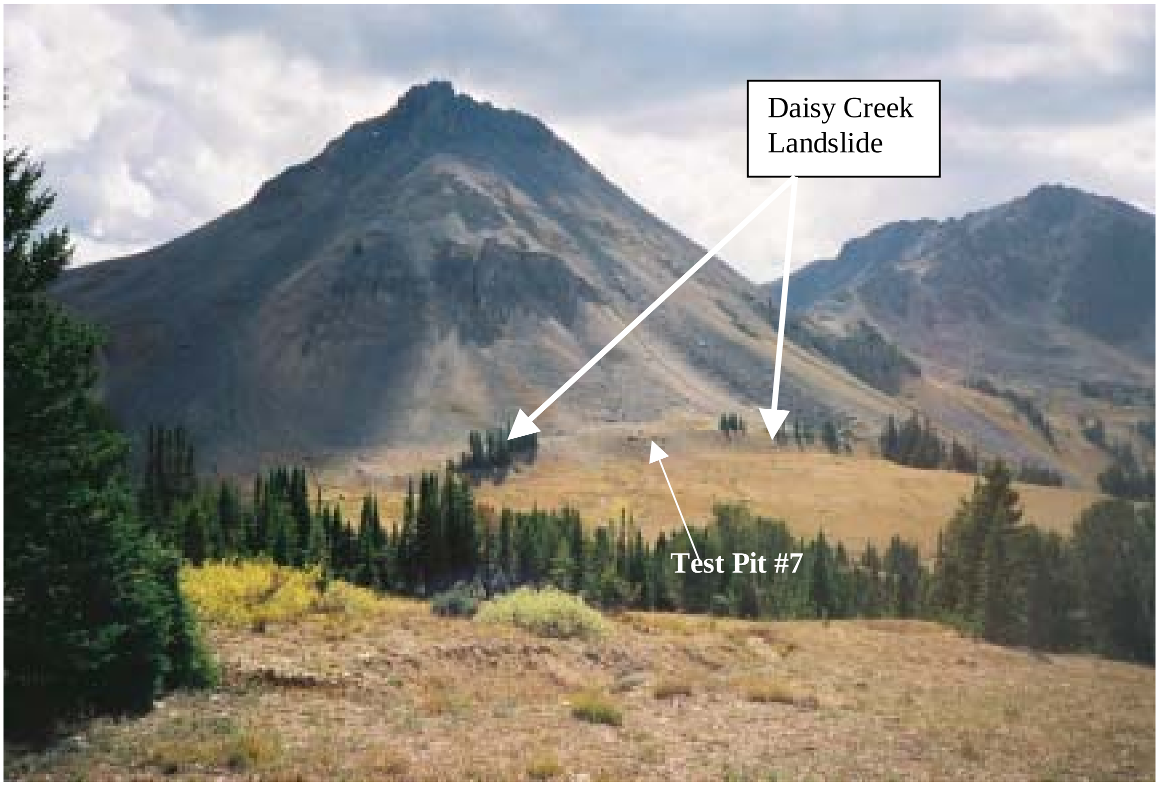

Figure 8. Overview of Upper Daisy Creek Landslide Block (looking SW toward Crown Butte from Daisy Creek Valley Bottom)

Figure 9. Daisy Creek Landslide (looking east on east end, north facing slope of landslide)

Figure 10. Daisy Creek Landslide Block (looking east at north facing slope of landslide from middle traves across block)

Figure 11. Daisy Creek Landslide Block (looking south across upper top surface of landslide on middle traverse)

Figure 12. Daisy Landslide Block (looking east at upper top surface of landslide block on western end of landslide, western traverse)

Figure 13. Daisy Creek Landslide upper surface western end showing unusually large boulder (orange box about 8")

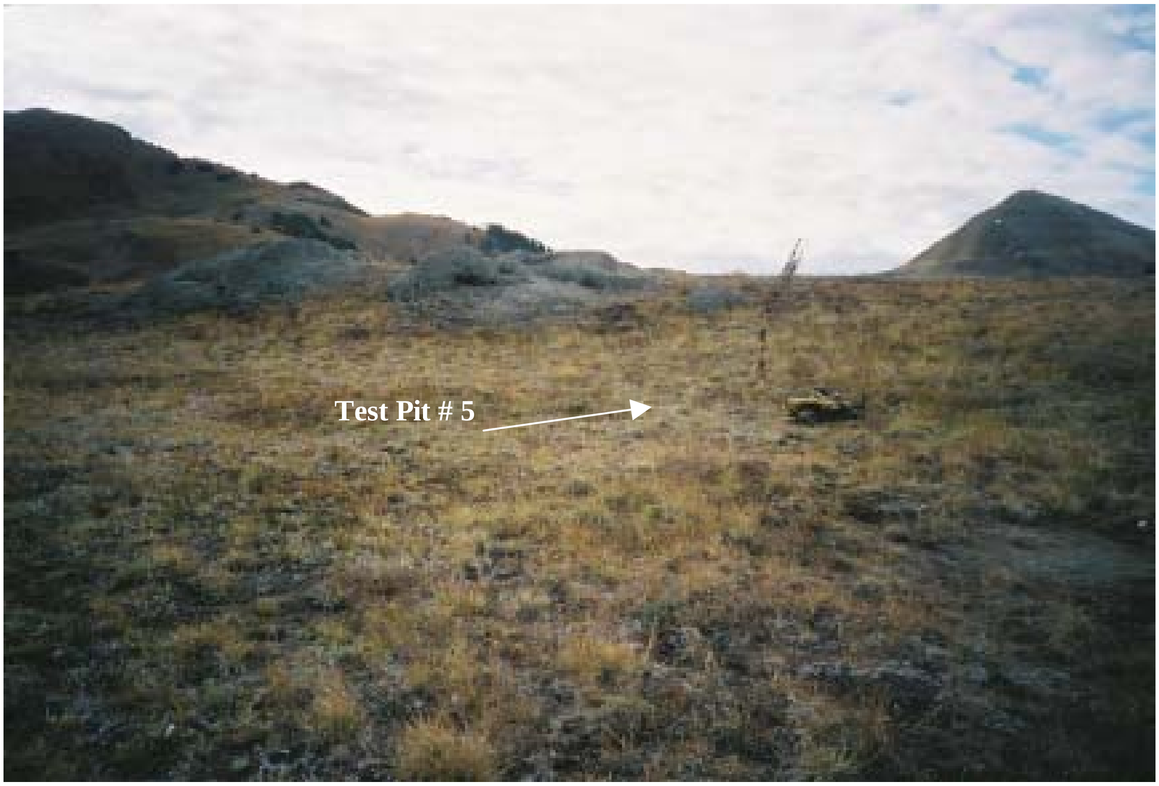

Figure 14. Tdlp Quarry Site (Moonscape, location shown on Figure 1)

Figure 15. Tdlp Quarry site TP #5, note scrape makes from excavator teeth, very hard digging, but friable material once excavated. Has to do with the formation of spherulites of relatively hard quartz and feldspar minerals in an altered clay and fine-grained mafic matrix. Material is probably unsuitable for use as a drain rock at McLaren but excellent for road base.


Figure 16. Tdlp Quarry Site, excavator worked very hard trying to rip this outcrop (front of machine off ground while digging this very hard material, but again friable once excavated).