2000 LONG-TERM REVEGETATION MONITORING REPORT

New World Mining District
Response and Restoration Project

Prepared for:

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1.0 INTRODUCTION

This Long-Term Revegetation Monitoring Report was prepared by Maxim Technologies, Inc. (Maxim) for the United States Department of Agriculture - Forest Service (USDA-FS). The USDA-FS is undertaking non-time-critical removal actions in the New World Mining District (District) to respond to and restore natural resources affected by historic gold, silver, copper, and lead mining. The District is located in a 40 square mile area surrounding Cooke City, Montana (Figure 1).

The objectives of revegetating disturbed areas are to provide an effective erosion control measure and to produce self-sustaining vegetative communities that reflect the natural conditions of the undisturbed, native communities in the District. The primary purpose of revegetation monitoring is to ensure that these objectives are being met and to provide a mechanism for corrective action if the objectives are not being met. A brief discussion of reclamation history, providing an overview of areas where this monitoring might apply, is also provided in the 1999 Revegetation Monitoring Report. Long term revegetation monitoring was first conducted in 1999. Results were published in a monitoring report (Maxim, 2000) that contains additional information on the site, reclamation history and revegetation history.

This report presents the results of area-wide monitoring and cover monitoring performed by Maxim in 2000 in accordance with the Long-Term Revegetation Monitoring Plan (Maxim, 1999). In 1999, monitoring was conducted on about 5.5 hectares (ha) of reclaimed disturbed areas and about 43.0 kilometers (km) of reclaimed roads that were initially identified in the District as of May 1999. Through review of reclamation history and field reconnaissance, an additional 1.9 ha of disturbed areas and 13.5 km of reclaimed roads were located and monitored in 2000 (Figure 2).

1.1 MONITORING ACTIVITIES

Personnel from Maxim, Larix Systems, Inc. (Larix), and Synergy Environmental (Synergy) conducted revegetation monitoring between July 24 and July 31, 2000. Activities included area-wide monitoring and cover monitoring, the details of which are provided in Section 2.0 and Section 3.0. Area-wide monitoring covered those disturbed areas initially monitored in 1999, additional disturbed areas located in 2000, and reclaimed roads in the upper and middle elevation strata that were not visited in 1999. Cover monitoring was conducted in strata within the reclaimed areas of the McLaren Pit, Como Basin, east Fisher Mountain, and along the same road segments that were selected and monitored in 1999.

Revegetation monitoring conducted in 2000 included some changes that were recommended based on 1999 monitoring results (Maxim, 2000). Several of these changes were incorporated into the Monitoring Plan and others were implemented in 2000 to address site-specific conditions, including the following:

- Areas reclaimed by Crown Butte Mining, Inc. (CBMI) that were not initially monitored in 1999 were field verified and included in revegetation monitoring in accordance with the Monitoring Plan. All known locations of CBMI revegetated areas were described in the 1999 Revegetation Monitoring Report.

- Locations and reclamation status of reclaimed areas presented in the 1999 Revegetation Monitoring Report were based largely on aerial photo interpretation (USDA-FS, 1999). Some of this information was field verified in 1999 and this effort continued in 2000. This involved a walking survey to record field observable reclamation. Location information of disturbed areas was updated using Global Positioning System (GPS) surveys, where possible.

- Observations made during 1999 area-wide monitoring were documented in field notebooks. These were difficult to review and consequently forms were developed for recordation in 2000.

- Because of transect layout used in the 1999 monitoring, there were conditions that were not adequately represented in the resulting data. Therefore, cover sample quadrats were located during 2000 sampling on a systematic grid, randomly placed within monitoring strata, that covered the entire reclaimed area.

- Because it will be many years before performance on reclaimed areas is expected to approach native conditions, sampling of native transects associated with the McLaren Pit, Como Basin, and reclaimed roads was deferred in the 2000 revegetation monitoring effort.

- Results of 1999 revegetation monitoring indicated that reclaimed areas at the McLaren Pit, Como Basin, and reclaimed roads showed sub-optimal revegetation performance. Because of this, vegetation monitoring was reduced in these areas to only record cover. Density was not measured in 2000.

Area-wide monitoring results are presented in Section 2.0. Cover monitoring results are presented in Section 3.0. Appendices provide field documentation (field notes and data sheets) as well as an assessment of data quality required by the Monitoring Plan. Corrective measures for maintaining revegetated areas and recommendations for 2001 revegetation monitoring are provided in Section 4.0.

Figure 1

Figure 2

2.0 AREA-WIDE MONITORING

This section presents area-wide monitoring data obtained during 2000. Activities were conducted on the major reclaimed areas (McLaren Pit, Como Basin and roads) to record the number, size, and location of revegetated areas bare of vegetation; record the presence, size, and extent of erosional features such as rills and gullies; and, to assess the cause(s) for the lack of vegetation. Criteria used to define barren areas were the following: 1) Areas that are approximately 10 percent or more of the monitoring strata; and, 2) Areas where reclamation treatment has clearly failed. For recording erosional features, a minimum size criterion did not apply; rather, erosional features were noted if they dominated the character of the reclaimed areas. Soil sampling was not conducted as part of area-wide monitoring in 2000. Field notes documenting area-wide monitoring activities can be found in Appendix A. Field recordation of barren areas and erosional features can be found in Appendix B.

2.1 METHODS

Area-wide monitoring included field verification of all CBMI reclaimed areas and verification of locations and reclamation status of reclaimed areas presented in the 1999 monitoring report (Maxim, 2000). Numerous additional reclaimed mine waste disturbed areas that were identified in 1999 were also visited in 2000. These new areas included those in Miller Creek, Glengarry Mine, Gold Dust Adit, and the east side of Fisher Mountain. Because the focus of revegetation monitoring is on reclaimed mine waste areas, exploration roads, exploration pads, and exploration trenches in these newly identified areas were not included the areas monitored for cover. Two new reclaimed mine waste areas, the Fisher Dumps and Fisher Trench, were added to the 2000 monitoring effort.

With the exception of the Fisher Dumps, the aerial extent of disturbed areas was field located using a Trimble ProXR GPS. Reclamation boundaries were surveyed based on field evidence of reclamation activities to a horizontal positional accuracy within 1 meter. For safety reasons (steep unstable slopes), the Fisher Dumps reclaimed area was not surveyed using a GPS; however, with minor adjustments using USDA-FS road data (1999), it was determined that existing boundary information was representative.

2.2 MCLAREN PIT

2.2.1 Field Verification

GPS survey of monitoring strata associated with the McLaren Pit yielded the following area determinations: McLaren Upper – 1.29 hectares (ha); McLaren Lower – 1.68 ha; and, McLaren Triangle – 0.35 ha. This represents an overall 16 percent net decrease in area represented in the 1999 Revegetation Monitoring Report. The greatest difference was evident in the McLaren Triangle monitoring stratum (45%) while the least percent difference was observed in McLaren Upper (5%). As field located boundaries were accurate to less than 1 meter, these areas represent improvements in project knowledge and should be carried forward in revegetation monitoring.

2.2.2 Barren Areas

Field monitoring in the McLaren Pit identified five barren areas meeting the criteria outlined above (Figure 3 and Figure 4). Barren areas delineated in 2000 more or less coincide with barren areas identified in 1999; however, their aggregate extent has almost doubled since 1999. Barren areas total about 0.41 ha, ranging in size from about 250 to 2,090 square meters (m^2). This represents about 12 percent of the total reclaimed area associated with the McLaren Pit. Key site limiting factors include: low soil pH (based on 1999 monitoring results); high rock content, subsurface and surface saturation; vehicle traffic; and post-seeding construction activities. Likely due to light snow and warm spring weather conditions, ponding and snow accumulation were not evident in 2000 as 1999. A general discussion of field conditions in each McLaren Pit area follow.

- ***McLaren Upper 1 through 3*** generally correspond to the McLaren Upper 1 barren area identified in the 1999 Revegetation Monitoring Report. These three areas total about 1,600 m^2 representing an increase of about 45 percent compared to 1999. Whereas in 1999 scattered grass tufts occurred within these areas, no vegetation was observed during 2000 monitoring. Site limiting factors appeared to vary among the three barren areas but, based on 1999 soil sampling results, it is likely that low soil pH is the most critical. McLaren Upper 1-3 barren areas are within the parcel that was excluded from lime amendment during reclamation. Other factors that were observed include rocky soil conditions (McLaren Upper 1 and McLaren Upper 2) and seeps discharging what is likely acidic water (McLaren Upper 2). As in 1999, minor erosion is occurring along the drain, with some small gullies forming at the lower end. A large rill feature within McLaren Upper 3 was noted during 2000 monitoring. No ATV use was evident.

- ***McLaren Lower 1*** encompasses about 2,100 m^2 representing a substantial increase (about 240 percent) from 1999 monitoring results. In 2000, this barren area runs along the entire base of the highwall and extends downslope 40 to 70 meters. McLaren Lower 1 is predominated by sparse, small grass vegetation, though there are several patches of vegetation scattered within. Along the highwall, it appears that the lack of vegetation is due to persistent snow, excess moisture, and construction activities observed in 1999. Below the highwall, chemical contamination continues to be the most likely site limiting factor. Based on visible evidence of slight rilling and water movement throughout the area, it is probable that chemical contamination results from overland flow from the highwall area, as well as from subsurface flow and in-place waste rock influences. Soil pH in the area below the highwall was very low (2.2 s.u.) in 1999 that, combined with the relatively high metal concentrations (especially copper and aluminum), severely inhibits plant establishment (Kabata-Pendias and Pendias, 1992).

- ***McLaren Triangle 1*** remains relatively unchanged compared to 1999 monitoring results. Total extent of this barren area in 2000 is about 390 m^2, a slight increase (about 15 percent) over 1999 approximations. McLaren Triangle 1 continues to be characterized by bare ground with sparse vegetation interspersed within. As in 1999, most of the barren portions are on steep slopes immediately downslope of an area reclaimed and covered with erosion blanket. In 2000, ATV use and other vehicular traffic was observed, which has further contributed to poor revegetation performance in these downslope areas. Vehicle traffic along with the lack of seed retention and lack of moisture retention capability appear to account for the lack of vegetation cover. The only erosion features evident were tire skid tracks, mostly occurring in the lower portion of the barren area.

Figure 3

Figure 4

2.2.3 Erosion Features

During 2000 monitoring, erosion noticeably increased in the McLaren Pit Area relative to observations made in 1999. In addition to rilling along the toe slopes of the surface drain at McLaren Upper 1 through 3, a prominent rill feature was observed in McLaren Upper 3. Minor rill erosion originally observed occurring near snow banks at McLaren Lower 1 has now been observed throughout the lower portions of the barren area described above. Finally, vehicle traffic has produced erosion features in the lower portion of the McLaren Triangle 1 barren area.

2.3 COMO BASIN

2.3.1 Field Verification

Field GPS survey of the reclaimed area within Como Basin resulted in a minor difference in the configuration and coverage reported in 1999 (Figure 5). Total area was measured to be 2.23 ha, which is about a 2 percent difference than originally presented. Much of the change in configuration occurred along the boundaries where road reclamation efforts have abutted the Como Basin proper. Delineation in 2000 more closely represents the extent of CBMI reclamation activities within the basin and reflects only those areas where treatment for contaminated soil had been applied.

2.3.2 Field Descriptions

Revegetation performance has noticeably declined throughout the entire reclaimed area (Figure 6). Visual estimation indicated approximately 60 percent of the Como Basin was mostly barren with sparse or no vegetation observed. Compared to 1999, there has been large scale die-back of grass west of the research plots and continued die-back extending most of the five barren areas originally described. Only small, scattered patches of green growth were evident in the entire area. In the upper portion of the reclaimed area, poor revegetation performance was originally attributed to poor seed retention on steep slopes prone to heavy overland water flow. Adverse soil conditions noted in 1999 (low pH, high metal concentrations, and high coarse fragment contents) are likely to have contributed to the continued decline in vegetation performance. As in the McLaren Pit, high soil moisture associated with ponding and snow accumulation were not evident this year. In the lower portion of the reclaimed area, the efficacy of lime amendment is probably diminishing. Consequently, the extent of low soil pH is probably increasing and accounting for the noticeable decline throughout the site. Increased ATV use, which bisects the reclaimed area north to southwest, has further influenced revegetation performance in the area.

2.3.3 Erosion Features

As in 1999, erosion in the Como Basin is a major concern to the stability of the revegetation of this area and is increasing via the decline in vegetation cover. Snowmelt at the top of the face of Fisher Mountain creates rills and gullies that continue to move through the basin. Although the drainage ditch along the southern boundary was re-armored after 1999 monitoring was conducted, field evidence indicated that snowmelt continues to overflow this control feature and create erosion along and below the berm. In 2000, gully erosion has extend from the middle upper basin to areas along the east and west boundaries and the lower basin. ATV traffic has contributed significantly to increased extent and severity of gully erosion. Left unchecked, impacts from ATV use are likely to increase as users continue to seek out uneroded areas to cross the basin.

2.4 RECLAIMED ROADS

2.4.1 Field Verification

Area-wide monitoring of reclaimed roads consisted primarily of field verification of all roads in the upper and middle monitoring strata that were not visited during 1999 revegetation monitoring. As in 1999, monitoring covered "present reclaimed roads" identified by the USDA-FS (1999); numerous roads were also covered that were not classified as "present reclaimed roads" but were determined in the field to have had recent reclamation activity. About 13.5 km of reclaimed roads were visited in 2000, of which 2.0 km were determined to be middle elevation roads and 0.2 km were upper elevation roads. Overall, combined with monitoring in 1999, almost all roads identified by the USDA-FS (1999) in the upper and middle elevation strata have been field verified (Figure 7).

2.4.2 Field Descriptions

As in 1999, roads monitored in the middle elevation stratum generally exhibited adequate cover and no erosion features were identified. Assessed in conjunction with 1999 monitoring results, key concerns regarding performance of reclaimed roads in the District are: 1) all upper elevation roads (barren areas); 2) middle elevation roads that have not been recontoured (erosion); and roads below the McLaren Pit (barren areas and erosion). Due to less extreme environmental conditions, reclamation of roads in the lower elevation monitoring stratum is generally not limited.

2.5 EAST FISHER MOUNTAIN

2.5.1 Field Verification

Based on historical evidence of CBMI reclamation activities and field indicators, two monitoring strata were identified on the east side of Fisher Mountain: the Fisher Dumps and the Fisher Trench (Figure 8). Reclamation history summarized in the 1999 Revegetation Monitoring Report described activities consisting of re-contouring, fertilizing, and reseeding that occurred in 1991. Additional reclamation in 1993 and 1994 involved similar practices on roads adjacent to and traversing the Fisher Dumps. Though the Fisher Dumps are not explicitly noted in CBMI's annual reports (Kirk, 1992; Kirk et al. 1993; Kirk et al. 1995), noticeable contouring activity and extant reclamation vegetation species led to the determination that some effort was made to reclaim the sites.

The Fisher Dumps stratum is comprised of Fisher Dumps 3 and 4 as referenced in CBMI reports. This reclaimed area is on the upper slope directly below the saddle between Henderson Mountain and Fisher Mountain. The area can be accessed by 4-WD truck via an un-reclaimed road that ties into the Daisy Pass Road just south of McLaren Pit. Two other roads, both reclaimed, also provide access from the Como Basin or the Homestake Mine. The segment from the Homestake Mine is passable only by foot. Growth media on the site are predominantly mine wastes, though areas of native material exist where roads crossing the site have been contoured. Slopes are extreme (100%+). Because of steep slopes and unstable soils, a field GPS survey was not conducted around the Fisher Dumps. Instead, the area reported changes by the USDA-FS (1999) was determined to be generally representative; however, minor changes were required to yield a consistent boundary with abutting roads and to incorporate reclaimed roads crossing the dump area. Total area within the Fisher Dumps monitoring strata totals 1.38 ha.

Figure 5

Figure 6

Figure 7

Figure 8

The Fisher Trench is a long, wide reclaimed area located north of the Fisher Dumps on a relatively gently sloped bench below the crest of Fisher Mountain. This site is best accessed either by foot from the Fisher Dumps or via the reclaimed road starting at lower Como Basin. Growth media on the site are typified by native coarse fragments with very low fine material content, containing exposed areas of what is apparently mine waste material scattered throughout the site. As noted, slopes are not excessive (10% to 20%), though steeper slopes exist in the southern third of the reclaimed area. This stratum is unique among all those monitored in that it contains characteristics of both reclaimed roads and mine waste areas encountered. Field GPS survey of the Fisher trench resulted in an area measurement of 0.51 ha. This is generally consistent with area originally represented by the USDA-FS (1999).

2.5.2 Field Descriptions

Revegetation performance at the Fisher Dumps is sparse to barren throughout the entire stratum (Figure 9). Only few scattered patches (less than 1 m^2) of reclamation species were found, more or less randomly distributed. Given the very steep slopes, it is most likely that poor seed retention was a major factor limiting initial establishment of reclamation vegetation. A large gully feature bisects the site from west to east and rilling was evident throughout the area. This indicates acute water runoff events that probably further contributed to poor seed retention in the absence of erosion controls. Plants germinating from remaining seed were most likely killed by acidic conditions in the mine waste material. Overall, the Fisher Dumps represent one of the poorest performing reclaimed areas in the District.

Revegetation performance within the Fisher Trench is also noticeably poor (Figure 9). Except for the northern quarter, only scattered patches of sedges (*Carex* spp.) and a few areas of drilled seed grass were found. The northern quarter of the site contained sedges, grasses, and forbs. It is likely that sedges were incidentally established from the adjacent native area via re-contouring activities. Otherwise, the Fisher Trench is essentially barren. Field evidence suggests the primary soil limiting factor is high coarse fragment content, comparable to that found on upper elevation roads. Insufficient nutrients and low soil pH are also likely inhibitors to plant establishment and growth on the site, though this has not been verified through soil sampling.

2.5.3 Erosion Features

Erosion within this reclaimed area is primarily confined to the gully and rill features noted within the Fisher Dumps stratum. Only a small area of very minor rill erosion was noted within the Fisher Trench. Erosion within the Fisher Dump area was also observed during 1999 revegetation monitoring, but because it was not acknowledged to be a reclaimed area it was reported only within the field notes of the 1999 Revegetation Monitoring Report. Compared to these initial observations, the amount of gullying has visually increased, as has the extent of rilling throughout the stratum. No noticeable ATV impacts were found in either stratum.

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Figure 9

Figure 9 back page

3.0 COVER MONITORING RESULTS

This section presents data obtained during the 2000 revegetation cover monitoring event. Revegetation cover monitoring activities were conducted at the McLaren Pit, Como Basin, reclaimed road, and east Fisher Mountain areas. Because of limited revegetation performance in those areas monitored in 1999, monitoring activities involved measuring vegetation cover by species on reclaimed areas. Density measurements were not made and native transects were not monitored. Two new strata identified in the east Fisher Mountain area, the Fisher Dumps and the Fisher Trench, were sampled for cover by species in native and reclaimed areas; however, for safety reasons, a reclaimed transect was measured for the Fisher Trench only. Density measurements were not made in these two strata. Species occurring within native quadrats were noted at Fisher Trench only. All field measurements used the point-quadrat method described in the Monitoring Plan. Field notes can be found in Appendix A and field data sheets in Appendix C.

3.1 METHODS

Location of point-quadrats within reclaimed strata differed from the approach used in 1999 cover monitoring. Although 1999 monitoring results generally represented vegetative cover conditions, use of the transect methods described in the long-term revegetation monitoring plan (Maxim, 1999) did not provide for thorough coverage of each stratum. Consequently, given the unique variability displayed within the reclaimed areas, there were conditions extant in the field that were not completely represented by the data. To resolve this, revisions to the draft Long-Term Monitoring Plan were made to use the point-quadrat method within each stratum on a systematic grid with a random start. Samples selected on this basis can be considered random, while resulting in improved coverage of the area sampled (Cochran, 1977).

Using the point quadrat method entailed: 1) calculation of a point-quadrat spacing based on stratum areas to achieve the desired sample size (50); 2) determination of grid orientation coinciding with the general aspect of the area; 3) establishment of a random start from a GPS surveyed tie-in point; and, 4) location of subsequent point-quadrat locations through compass and pacing in accordance with the determined orientation and spacing. For reclaimed roads, a similar procedure was implemented wherein: 1) spacing was determined based on the length of the road segment and a desired sample size of 10 quadrats per segment; 2) the random start was established from the beginning of the road segment as a tie-in point; 3) subsequent quadrats were located by pacing; and, 4) at each stop, the quadrat was located randomly within the road width.

3.2 DATA QUALITY

A complete discussion of data quality and validation, including results of cover measured on a subsample of monitoring locations using the 35mm slide method, is presented in Appendix D. Sight data verification resulted in the identification of 4 field tally errors that could not be fixed. Only one data entry error was identified that was resolved. Finally, a quadrat within a research area was partially tallied but excluded from further analysis.

Results from the 35mm Slide Method indicated a consistent bias that led to the conclusion that vegetation cover estimates based on the 2000 field data collection likely overstate the true vegetation cover within the McLaren Pit and Como Basin areas. A mathematical model was developed to adjust cover values resulting from point-quadrat measurements to provide a “better” representation of cover within these areas. Finally, sample size determinations based on sample variances indicated that adequate sampling was performed in most areas; however, 2000 sampling intensity was an order of magnitude or more lower than calculated sample sizes for the Fisher Dumps reclaimed area and the Fisher Trench native transect. Strata on the east side of Fisher Mountain also displayed higher variability than that encountered in other transects. Overall, the potential bias in cover estimates for the McLaren Pit and Como Basin presents the most significant concern for use and interpretation of 2000 monitoring results. None of these concerns were evident in the 1999 monitoring results. Corrective measures for data quality concerns are described in Section 4.0.

3.3 MCLAREN PIT

Table 1 summarizes cover monitoring results for the three strata within the McLaren Pit area. These results indicate that similar vegetative cover was observed within each reclaimed monitoring strata (16.8 percent to 20.8 percent). Species diversity was relatively low (Shannon's diversity index about 0.2) and *Poa alpina* (alpine bluegrass) and *Deschampsia caespitosa* (tufted hairgrass) were the dominant species present, accounting for 95 percent of the vegetative cover. Overall, quadrat vegetation cover measurements were low and, with the exception of barren areas, contiguously distributed. Over 80 percent of quadrats measured had 30 percent vegetation cover or less, about two thirds of which were 10 percent or less. Twenty percent of the samples had no vegetation cover measured. Areas of higher vegetation cover (40 percent or more) were limited to isolated patches within each monitoring stratum. Overall, there were significant areas (over 50% of the strata area) where there was little or no vegetation at all. These results are consistent with revegetation performance noted during area-wide monitoring.

Compared to 1999 cover monitoring results, 2000 estimates are higher. Cover of 16.6% to 20.8% was report in 2000 while lower estimates of 11.6% to 13.8% were reported in 1999. There are two facts to consider while interpreting these changes in cover. First, area-wide monitoring indicated large scale die back in areas monitored for cover in 1999 and 2000. Second, percent cover adjusted using the mathematical model described in Appendix D yielded far lower estimates. Furthermore, using the two-sample t-test for independent samples described in Elzinga et al. (1998), 2000 estimates for each of these strata (except McLaren Upper) were not statistically different from 1999 estimates at the 95% confidence level. Therefore, while there is an increase in vegetative cover estimates for 2000, this difference is refutable. Consequently, there is no basis to state whether revegetation performance improved or degraded since 1999. It is clear however, that vegetation cover and diversity remain low.

TABLE 1
Cover Monitoring Results – McLaren Pit
New World Mining District Response and Restoration Project
2000 Revegetation Monitoring

Species	Frequency	Percent Cover	Shannon's Diversity Index	Adjusted Percent Cover[1]
McLaren Upper Monitoring Stratum				
Poa alpina	76	15.20%	0.124	3.17%
Deschampsia caespitosa	24	4.80%	0.063	1.00%
Phleum alpinum	2	0.40%	0.010	0.08%
Phleum pratense	1	0.20%	0.005	0.04%
Trisetum spicatum	1	0.20%	0.005	0.04%
Vegetation	**104**	**20.80%**	**0.208**	**4.34%**
Litter	53	10.60%		
Rock	285	57.00%		
Bare Ground	58	11.60%		
McLaren Lower Monitoring Stratum				
Poa alpina	59	15.90%	0.127	3.32%
Phleum alpinum	8	2.16%	0.036	0.45%
Deschampsia caespitosa	7	1.89%	0.033	0.39%
Agropyron trachycaulum	1	0.27%	0.007	0.06%
Trisetum spicatum	1	0.27%	0.007	0.06%
Vegetation	**76**	**20.49%**	**0.209**	**4.27%**
Litter	31	8.36%		
Rock	210	56.60%		
Bare Ground	51	13.75%		
Moss	3	0.81%		
McLaren Triangle Monitoring Stratum				
Poa alpina	64	11.41%	0.108	2.38%
Deschampsia caespitosa	29	5.17%	0.067	1.08%
Vegetation	**93**	**16.58%**	**0.174**	**3.46%**
Litter	94			
Rock	319			
Bare Ground	33			
Moss	22			

1 Adjusted percent cover is explained in Appendix D.

3.4 COMO BASIN

Table 2 summarizes cover monitoring results for the Como Basin reclaimed area. As at the McLaren Pit, these results indicate that vegetative cover and diversity were relatively low, 17.14% and 0.2 respectively. *Poa alpina* (alpine bluegrass) and *Deschampsia caespitosa* (tufted hairgrass) were the dominant species present, accounting for almost all of the vegetative cover. Again, quadrat vegetation cover measurements were heavily skewed to the low end, but unlike the McLaren Pit, only a few isolated patches of significant vegetative cover existed. Over 80 percent of quadrats measured had 30 percent vegetation cover or less, about 85% of which were 10 percent or less. Over one-third of the samples (37%) had no vegetation cover measured. Overall, there were significant areas (over 67% of the strata area) where there was little or no vegetation at all. These results are generally consistent with revegetation performance noted during area-wide monitoring where the reclaimed area was classified as a barren area.

TABLE 2
Cover Monitoring Results – Como Basin
New World Mining District Response and Restoration Project
2000 Revegetation Monitoring

Species	Frequency	Percent Cover	Shannon's Diversity Index	Adjusted Percent Cover[1]
Poa alpina	65	13.27%	0.116	2.77%
Deschampsia caespitosa	16	3.27%	0.049	0.68%
Agropyron trachycaulum	1	0.20%	0.005	0.04%
Achillea millefolium	1	0.20%	0.005	0.04%
Phleum pratense	1	0.20%	0.005	0.04%
Vegetation	**84**	**17.14%**	**0.181**	**3.57%**
Litter	73			
Rock	212			
Bare Ground	118			
Moss	3			

1 Adjusted percent cover is explained in Appendix D.

Compared to 1999 monitoring results, 2000 vegetation cover estimate are almost double those initially reported, 17.4% versus 9.4%, which is statistically significant at the 95% confidence interval. Again there are two facts to consider in interpreting these results. First, area-wide monitoring indicated large scale die back in areas monitored for cover. Second, percent cover adjusted using the mathematical model described in Appendix D yielded far lower estimates. Therefore, as at McLaren Pit, this difference is refutable, and it is clear that vegetation cover and diversity remain relatively low within the Como Basin reclaimed area.

3.5 RECLAIMED ROADS

Table 3 summarizes cover monitoring results for the reclaimed roads strata monitored in 2000, the middle elevation stratum and the upper elevation stratum. The lower elevation reclaimed roads stratum was not monitored in 2000. Vegetative cover was higher in the middle elevation stratum (16.29%) compared to the upper elevation stratum where cover was extremely low (4.91%). Species diversity was relatively low (0.1 in the upper elevation stratum and 0.3 in the middle elevation) with *Poa alpina* (alpine bluegrass) and *Deschampsia caespitosa* (tufted hairgrass) as the dominant species present, accounting for about 40 percent of the vegetative cover. Notable cover was also contributed by *Carex paysonis* (Payson's sedge), *Epilobium alpinum* (alpine fireweed), *Agropyron trachycaulum* (slender wheatgrass), *Phleum alpinum* (alpine timothy), *Agoseris glauca* (pale agoseris), and *Juncus drummondii* (arrow grass). Overall, quadrat vegetation cover measurements were heavily skewed to the low end and, in the case of the upper elevation stratum, over 85 percent of quadrats measured had vegetative cover of 10 percent or less. Only about 55 percent of the quadrats measured in the middle elevation strata had little or no vegetation; however, over 90 percent had vegetation cover of 30 percent or less. These observations were consistent with area-wide monitoring conducted in 1999 and 2000 where middle elevation roads generally performed better than roads in the upper elevation stratum, all of which are considered barren areas.

TABLE 3
Cover Monitoring Results – Reclaimed Roads
New World Mining District Response and Restoration Project
2000 Revegetation Monitoring

Species	Frequency	Percent Cover	Shannon's Diversity Index
MIDDLE ELEVATION ROADS MONITORING STRATUM			
Deschampsia caespitosa	19	3.60%	0.052
Poa alpina	14	2.65%	0.042
Epilobium alpinum	8	1.52%	0.028
Agropyron trachycaulum	7	1.33%	0.025
Phleum alpinum	6	1.14%	0.022
Agoseris glauca	6	1.14%	0.022
Juncus drummondii	5	0.95%	0.019
Carex paysonis	4	0.76%	0.016
Arnica rydbergii	2	0.38%	0.009
Besseya wyomingensis	2	0.38%	0.009
Epilobium angustifolium	2	0.38%	0.009
Lupinus argenteus	2	0.38%	0.009
Luzula parviflora	2	0.38%	0.009
Mertensia cilliatum	2	0.38%	0.009
Phacelia hasta alpina	2	0.38%	0.009
Poa epilis	2	0.38%	0.009
Arenaria rubella	1	0.19%	0.005
Vegetation	**86**	**16.29%**	**0.307**
Litter	88		
Rock	232		
Bare Ground	122		
UPPER ELEVATION ROADS MONITORING STRATUM			
Deschampsia caespitosa	8	1.51%	0.027
Poa alpina	7	1.32%	0.025
Carex paysonis	5	0.94%	0.019
Agropyron trachycaulum	1	0.19%	0.005
Arnica latifolia	1	0.19%	0.005
Epilobium alpinum	1	0.19%	0.005
Luzula parviflora	1	0.19%	0.005
Oxyria digyna	1	0.19%	0.005
Sibbaldia procumbens	1	0.19%	0.005
Vegetation	**26**	**4.91%**	**0.102**
Litter	21		
Rock	422		
Bare Ground	61		

Compared to 1999 monitoring results, 2000 estimates are slightly higher than those initially reported (16.6% versus 10.4% for middle elevation roads and 4.9% versus 3.8% for upper elevation roads); however, only estimates between years for middle elevation roads are statistically significantly different at the 95% confidence level. Because of the extensive area of these roads and the limited coverage of sampling, it is difficult to state whether this represents a meaningful change. Consequently, there is limited basis to state whether revegetation performance improved or degraded since 1999. It is clear that vegetation cover and diversity remain relatively low, especially in the upper elevation roads stratum.

3.6 EAST FISHER MOUNTAIN

Table 4 summarizes cover monitoring results for Fisher Dumps and the Fisher Trench strata. Cover estimates for both strata indicated that the vegetation cover component was below 10 percent (7.50% within the Fisher Dumps and 8.33% at the Fisher Trench). Similarly, species diversity was relatively low (0.1) with *Deschampsia caespitosa* (tufted hairgrass) as the dominant species present, accounting for over 80 percent of the vegetative cover. Overall, quadrat vegetation cover measurements were heavily skewed to the low end and about 75 percent of quadrats measured had vegetative cover of 10 percent or less. Due to safety reasons (extreme slopes and poor footing), target sample size of 50 quadrats was not attained for the Fisher Dumps stratum. These results are generally consistent with revegetation performance noted during area-wide monitoring where both strata were generally classified as a barren areas.

Table 4 also summarizes cover monitoring results for the Fisher Trench native transect. Again, for safety reasons, quadrat monitoring of native transects for the Fisher Dumps was not attempted. While, it was also determined that this transect was under-sampled, this phenomenon was observed with native areas in 1999 and was addressed in the 1999 Revegetation Monitoring Report. Regardless, cover estimates for both strata indicated that the vegetation cover component was significantly greater than that in the reclaimed areas (33.16% versus 8.33%) at the 95 percent confidence level. Similarly, species diversity was relatively higher (0.3) with more taxa measured and noted on field data sheets.

TABLE 4
Cover Monitoring Results – East Fisher Mountain
New World Mining District Response and Restoration Project
2000 Revegetation Monitoring

Species	Frequency	Percent Cover	Shannon's Diversity Index
FISHER DUMPS MONITORING STRATUM			
Deschampsia caespitosa	6	5.00%	0.065
Poa alpina	2	1.67%	0.030
Spraguea umbellata	1	0.83%	0.017
Vegetation	**9**	**7.50%**	**0.112**
Litter	10		
Rock	83		
Bare Ground	18		
FISHER TRENCH MONITORING STRATUM – RECLAIMED TRANSECTS			
Deschampsia caespitosa	14	7.78%	0.086
Polygonum bistortoides	1	0.56%	0.013
Vegetation	**15**	**8.33%**	**0.099**
Litter	27		
Rock	100		
Bare Ground	38		
FISHER TRENCH MONITORING STRATUM – NATIVE TRANSECT			
Carex paysonis	47	24.74%	0.150
Deschampsia caespitosa	4	2.11%	0.035
Vaccinium scoparium	4	2.11%	0.035
Antenaria lanata	2	1.05%	0.021
Juncus drummondii	2	1.05%	0.021
Carex spp.	2	1.05%	0.021
Poa epilis	1	0.53%	0.012
Sibbaldia procumbens	1	0.53%	0.012
Vegetation	**63**	**33.16%**	**0.307**
Litter	59		
Rock	29		
Bare Ground	31		
Moss	8		

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4.0 DISCUSSION

Revegetation monitoring completed in 1999 and 2000 provided data to evaluate most of the CBMI reclaimed mining waste areas within the District and to define with relatively high accuracy the geographic location and extent of these reclaimed areas. Area-wide monitoring performed in 2000 identified two reclaimed waste areas that were not monitored in 1999. These new monitoring strata are the Fisher Dumps and the Fisher Trench. Several other candidate sites were identified from historical information and visited but it was determined that these sites were related to mining exploration activities and not reclamation of historic mine waste. Monitoring efforts also resulted in field verification of nearly all reclaimed roads in the middle and upper elevation monitoring strata that were initially monitored in 1999. A GPS survey of the reclaimed areas was performed based on field evidence of reclamation activities. Overall, the 2000 monitoring effort resulted in a monitoring frame that is representative, accurate, and complete.

As in 1999, revegetation monitoring in the District identified several areas where revegetation does not provide effective erosion control and/or has not produced a self-sustaining community that reflects natural conditions. In several instances, conditions have visually deteriorated from 1999. However, statistical analysis of cover monitoring data neither refutes nor supports this observation. Specific observations identified through vegetation cover and area-wide monitoring in 2000 include the following:

McLaren Pit Area
- Barren areas nearly doubled in size with increased associated erosion
- Over 50 percent of the strata area had little or no vegetation
- Vegetation cover and diversity remain relatively low, as in 1999

Como Basin Area
- Cover has visibly declined to where the entire basin is considered barren
- Erosion features have visibly increased due to water and ATV traffic
- Over 67 percent of the stratum area has little or no vegetation
- Vegetation cover and diversity remain relatively low as in 1999

Reclaimed Roads
- Continued absence of vegetation in the upper elevation stratum
- Continued low cover in the middle elevation monitoring stratum

East Fisher Mountain
- Vegetation is visibly lacking to where the strata are considered barren
- Significant erosion features were observed in the Fisher Dumps stratum
- About 75 percent of the strata area have little or no vegetation
- Native cover and diversity was notably higher than in reclaimed areas

The 1999 Revegetation Monitoring Report discussed several factors that could account for poor reclamation performance. Based on 2000 monitoring, it appears that these same factors continue to apply. These factors include:

- Low soil pH, high metals concentrations, low organic matter, and low nutrient levels in the McLaren Pit area

- Low soil pH, high metals concentrations, low organic matter, low nutrient levels, ATV use, erosion features, and poor seed retention in the Como Basin area

- Low organic matter, low nutrient levels, and poor seed retention on reclaimed roads

Similar factors are a likely cause of revegetation condition in the East Fisher Mountain Strata, although soil samples have not been collected to confirm these presumed conditions. As stated in the 1999 long-term revegetation monitoring report (Maxim, 2000), it is likely that restoration practices did not fully amend or treat limiting factors. Furthermore, based on the observations of large-scale die-back and overall increases in barren areas, it is possible that the efficacy of reclamation activities will continue to result in conditions intolerable to the remaining vegetation. Overall, this could lead to even lower vegetation performance and condition in the future.

5.0 RECOMMENDATIONS

Based on 2000 monitoring results, corrective measures described in the 1999 Long-Term Revegetation Monitoring Report are still applicable. That is, for reclaimed areas in the Como Basin and McLaren Pit, reapplication of prescriptions described in Brown and Amacher (1999) is recommended, prefaced by additional water control and erosion control measures. Given equally poor performance associated with reclaimed areas on the east side of Fisher Mountain, it is relevant to address the Fisher Dumps and Fisher Trench in a similar manner. Consideration should be given to re-evaluating lime requirements at the reclaimed waste sites to sustain a tolerable soil pH and avoid a large-scale die-back of vegetation, such as that observed in 2000. For reclaimed roads, developing a means to improve soil organic and nutrient conditions in upper elevation roads, and instituting some form of erosion control on uncontoured roads remain the appropriate recommended corrective measures. Any actions would have to be practical and cost-effective, and developed in the context of overall response and restoration efforts.

In terms of long-term revegetation monitoring, several recommendations can be derived from methods, results, and the level of confidence achieved with the 2000 revegetation monitoring. Overall, protocol modifications recommended in the 1999 Long-Term Revegetation Monitoring Report led to results that could be interpreted with a higher degree of confidence. However, several issues were identified through quality control that should be addressed in future monitoring events. These are the following:

- There were several instances where hits in the point-quadrat method were incorrectly tallied. This did not lead to a situation adversely affecting the quality of results. Nevertheless, data sheets should be field verified at each quadrat before traveling to the next sample location.

- Results from vegetation cover determinations using the 35mm slide method were consistently lower than those measured using the point-quadrat method in the McLaren Pit and Como Basin. This points to a potential bias that may have affected 2000 cover monitoring results in those areas. Some of this can be attributable to the low precision of the point-quadrat method but it also could be the result of "subconscious" bias associated with the method (Bonham, 1989 and Elzinga et al., 1998). The referenced literature outlines several procedures that should be considered for reducing bias.

- Because of safety concerns, cover monitoring of the Fisher Dumps could not be completed using the point-quadrat method due to the steepness of slopes. Although the changes made in the field at this site did not lead to excessive sampling error, other cover measurement procedures should be considered if future monitoring is performed. Several suitable methods are outlined in Elzinga et al. (1998) and Bonham (1989), including visual estimation in very small plots, line-intercept methods along transects, or single point measurement techniques.

In terms of future monitoring, consideration should be given deferring or reducing the frequency of the monitoring. Efforts of 1999 and 2000 monitoring have resulted in a practically complete monitoring coverage of reclaimed mine waste areas in the District. These results indicate relative low performance of revegetation resulting from reclamation activities conducted by CBMI. Most strata have been characterized with extensive areas of little or no vegetation and, in some cases, containing substantial erosion features. This has led to recommendations for restarting reclamation practices, including erosion and water control, at the McLaren Pit, Como Basin, and East Fisher Mountain sites. Overall, given the extent of reclamation knowledge, observations of generally poor revegetation performance, and possible future actions at these sites, it would be of limited value to continue monitoring on an annual basis. Therefore, it is recommended that future work plans address an appropriate reduced revegetation monitoring effort consistent with overall project goals and objectives.

6.0 REFERENCES

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APPENDIX A

FIELD NOTES
2000 Long-Term Revegetation Monitoring Report
New World Mining District
Response and Restoration Project

Area-Wide Monitoring

Cover Monitoring

APPENDIX B

AREA-WIDE MONITORING FIELD DATA SHEETS
2000 Long-Term Revegetation Monitoring Report
New World Mining District
Response and Restoration Project

APPENDIX C

COVER MONITORING FIELD DATA SHEETS
2000 Long-Term Revegetation Monitoring Report
New World Mining District
Response and Restoration Project

APPENDIX D

DATA QUALITY AND VALIDATION
2000 Long-Term Revegetation Monitoring Report
New World Mining District
Response and Restoration Project

APPENDIX D: DATA QUALITY AND VALIDATION

Data validation and quality was based on three assessments detailed in the Monitoring Plan. To ensure that data were correctly transferred from the field forms into the database, 10% of the data were independently checked and verified. Comparison of cover measurements was performed on a subsample of monitoring locations using the 35mm slide method to assess precision and potential bias. Finally, sample size determinations were calculated from sample variance for each stratum. Calculations used allowable error of +/-5% vegetation cover to provide a basis for comparison with sampling intensity in this monitoring event. Discussion of these results follows below for each assessment.

DATA ENTRY VERIFICATION

Ten percent of the data was selected for verification by randomly selecting one quadrat from each cover field data sheet (Appendix C). Because, in using a systematic grid, not all transects contained 10 quadrats, this resulted in a selection of slightly higher than 10% of the data. In total, data entry for 56 quadrats was verified against the data sheets, representing about 16% of the data. No transcription errors were noted; however, one quadrat was identified in which 11 hits were tallied in the field (versus 10 hits standard within the sample frame). As there was no basis for correcting this error, it was not modified. Given this error, an additional data verification procedure was performed, identifying quadrats that did not have 10 hits. This resulted in the discovery of 5 additional quadrats, of which one was determined to be a data entry error (which was resolved) and the remainder field tally errors for which only one had a basis for correction. Overall, these results indicate a data entry error rate of less than one-tenth of one percent and a field tally error rate of almost two-tenths of one percent. This error rate was not considered sufficient to significantly affect results; however, data verification by the crew boss in the field needs to be stressed in future events.

35MM SLIDE METHOD

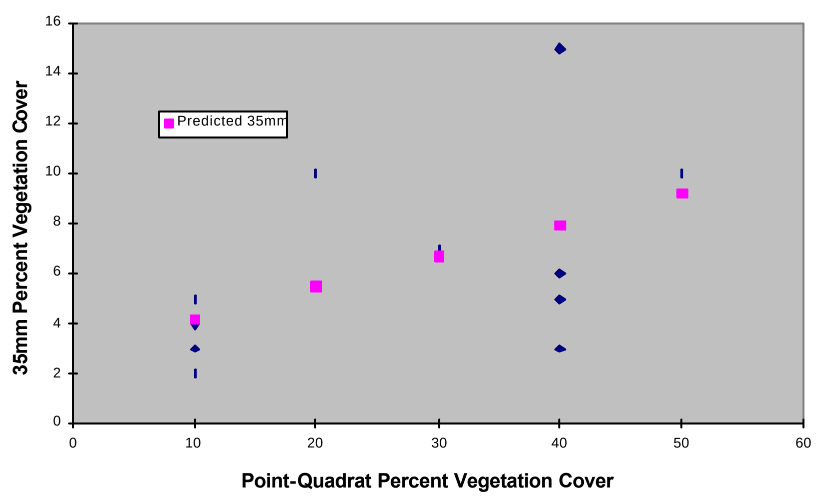
Field cover measurements using the point-quadrat method were compared against cover measurements obtained on a subset of quadrats using the 35mm Slide Method described in the Monitoring Plan and described by Chambers and Brown (1983). In total, 16 quadrats were randomly selected from quadrats tallied within the McLaren Pit, Como Basin, and East Fisher Mountain areas (Figures included in this appendix). Because of poor slide quality, two slides could not be interpreted. Overall, this resulted in about 6.3% of reclaimed area quadrats selected for comparison.

Vegetation cover was the key parameter of interest for comparisons using relative percent difference (RPD), the absolute percentage difference using the average of both cover measurements as a basis. RPD for vegetation cover in all reclaimed areas averaged about 118%, ranging from 57% to 200%. This is comparable to RPD values reported in the 1999 Revegetation Monitoring Report. Contrary to 1999 results, however, 2000 RPD values displayed a noticeable bias. With the exception of the east Fisher Mountain areas, vegetation measurements using the point-quadrat method were consistently higher than those obtained using the 35mm slide method. Furthermore, these differences displayed a noticeable relationship where, as percent cover measurements from the 35mm slide method increased, point-quadrat measurements increased at a proportional rate. Some of this can be attributed to the relatively lower precision of the point-quadrat method, but it also likely points to "subconscious" bias that is reported in use of this sampling procedure (Bonham, 1989 and Elzinga et al., 1998). This type of bias can be reduced through implementing corrective measures outlined in this literature. Overall, these results lead to the conclusion that vegetation cover estimates based on

2000 field data collection likely overstate the true vegetation cover within the McLaren Pit and Como Basin areas.

Given the visual evidence of potential bias in the point-quadrat data, an effort was made to model this error in developing a mathematical adjustment to point-quadrat measurements. This entailed performing a linear regression where vegetation measurements using the 35mm slide method formed the dependent variable reliant upon point-quadrat measurements. This approach is an appropriate use of subsample data (Cochran 1977); however, since this model relates one measurement method to another, the adjustment does not necessarily yield a "true" value in this instance. Nevertheless, the 35mm slide method provides total coverage of the sampling frame and is inherently more precise than the point-quadrat method. The result of this linear regression yields a slope coefficient of 0.209 that is significant at the 99% level. Simply interpreted, this result indicates that cover measurements from the point-quadrat method are about 5 times that from the 35mm slide method (Figure D-1). This factor is used in the reporting of "adjusted" cover values in Section 3.0 as a "better" representation of cover conditions within the McLaren Pit and Como Basin reclaimed areas.

Figure D-1. Predicted 35mm Slide Method Percent Vegetation Cover



SAMPLE SIZE DETERMINATIONS

Table D-1 presents descriptive statistics and sample size determinations for each monitoring strata sampled in 2000. Standard errors were generally within 15% of the mean for monitoring strata in the McLaren Pit and Como Basin. Standard error for the middle elevation road stratum was about 15 percent of the mean and about 25 percent of the mean for upper elevation roads. These relative errors are generally consistent with those encountered during 1999 revegetation monitoring; however, relatively larger sampling error was evident in the reclaimed areas east of Fisher Mountain (about 45% for the Fisher Dumps and 35% for the Trench), both initially sampled in 2000.

Though several strata contained less than 50 quadrats, sample size requirements to achieve an allowable error of +/-5% vegetation cover indicate adequate sampling was generally performed in most strata; however, 2000 sampling intensity was an order of magnitude or more lower than calculated sample size determinations for the Fisher Dumps reclaimed area and the Fisher Trench native area. Adequate sample size could not be achieved in the Fisher Dumps due to safety concerns and results within the native area are comparable to observations made for other native areas in the 1999 Revegetation Monitoring Report. Conversely, 2000 sampling intensity was an order of magnitude greater or more for two monitoring strata, the McLaren Triangle and the upper elevation roads. This knowledge could be used to reduce future monitoring efforts.

TABLE D-1
Descriptive Statistics and Sample Size Determinations
New World Mining District Response and Restoration Project
2000 Revegetation Monitoring

Monitoring Strata	Mean Percent Vegetation Cover	Standard Error	Sample Variance	Sample Size	Confidence Level (95%)	Sample Size Determination
MUR	0.208	0.025	0.032	50	0.051	49
MLR	0.203	0.032	0.038	37	0.065	59
MTR	0.164	0.018	0.018	56	0.036	28
CWR	0.171	0.027	0.035	49	0.053	54
FDR	0.075	0.035	0.015	12	0.077	23
FTR	0.083	0.027	0.013	18	0.057	21
FTN	0.374	0.057	0.062	19	0.100	67
RFR	0.166	0.023	0.028	53	0.045	43
RRR	0.049	0.012	0.008	53	0.025	13

NWRR-00MUR

NWRR-00MLR

NWRR-00MTR

NWRR-00CWR

NWRR-00FDR

NWRR-00FTR