

Castle Gate Holding Company  
Castle Gate Mine  
C/007/0004

Partial Phase III Bond Release  
Application  
Hardscrabble and Sowbelly Canyons

July 2012

C007/0004 Incoming

CASTLE GATE HOLDING COMPANY

# 4153  
OK

Castle Gate Mine  
P.O. Box 30  
Helper, Utah 84526  
Office Phone (435) 472-4737  
Cell Phone (435) 650-2951

July 30, 2012

Mr. Daron Haddock  
Utah Division of Oil, Gas and Mining  
1594 West North Temple, Suite 1210  
P.O. Box 145801  
Salt Lake City, Utah 84114-5801

Re: Partial Phase III Bond Release, Hardscrabble and Sowbelly Canyons, Castle Gate Holding Company, Castle Gate Mine, C/007/0004

Dear Mr. Haddock:

Please find enclosed three copies and the Partial Phase III Bond Release Application for Hardscrabble and Sowbelly Canyons. This application includes all the required documentation for phase III bond release including the C1 and C2 forms, reclamation history, vegetation information, sediment yield information, a proposed public notice, landowner and government agency notification letters, reclamation certification and bond calculations.

Please review the public notice and inform me of any requested changes as soon as possible in order that I can deliver it to the local paper for publication. Also, please schedule the onsite inspection as soon as practical.

If you have any questions please give me a call.

Sincerely,



Dennis N. Ware  
Company Representative

Enclosures

File in:  
 Confidential  
 Shelf  
 Expandable

Date Folder: 080212, C0070004  
Incoming

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AUG 02 2012

DIV. OF OIL, GAS & MINING

## APPLICATION FOR COAL PERMIT PROCESSING

Permit Change  New Permit  Renewal  Exploration  Bond Release  Transfer

Permittee: CASTLE GATE HOLDING COMPANY

Mine: CASTLE GATE MINE

Permit Number:

C/007/0004

Title: PARTIAL PHASE III BOND RELEASE APPLICATION, HARDCRABBLE AND SOWBELLY CANYONS

Description, Include reason for application and timing required to implement:

PHASE II BOND RELEASE

**Instructions:** If you answer yes to any of the first eight questions, this application may require Public Notice publication.

- |   |   |
|---|---|
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 1. Change in the size of the Permit Area? Acres: _____ Disturbed Area: _____ <input type="checkbox"/> increase <input type="checkbox"/> decrease. |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 2. Is the application submitted as a result of a Division Order? DO# _____  |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?                                     |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 4. Does the application include operations in hydrologic basins other than as currently approved?   |
| <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?   |
| <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | 6. Does the application require or include public notice publication?   |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 7. Does the application require or include ownership, control, right-of-entry, or compliance information?   |
| <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?   |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 9. Is the application submitted as a result of a Violation? NOV # _____   |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 10. Is the application submitted as a result of other laws or regulations or policies?  |

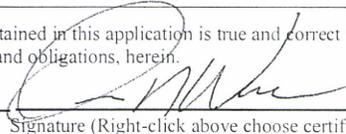
Explain: \_\_\_\_\_

- |   |  |
|---|--|
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 11. Does the application affect the surface landowner or change the post mining land use?                          |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2) |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 13. Does the application require or include collection and reporting of any baseline information?                  |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?            |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 15. Does the application require or include soil removal, storage or placement?                                    |
| <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | 16. Does the application require or include vegetation monitoring, removal or revegetation activities?             |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 17. Does the application require or include construction, modification, or removal of surface facilities?          |
| <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | 18. Does the application require or include water monitoring, sediment or drainage control measures?               |
| <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | 19. Does the application require or include certified designs, maps or calculation?                                |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 20. Does the application require or include subsidence control or monitoring?                                      |
| <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | 21. Have reclamation costs for bonding been provided?  |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?               |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 23. Does the application affect permits issued by other agencies or permits issued to other entities?              |
| <input type="checkbox"/> Yes <input type="checkbox"/> No            | 24. Does the application include confidential information and is it clearly marked and separated in the plan?      |

**Please attach three (3) review copies of the application. If the mine is on or adjacent to Forest Service land please submit four (4) copies, thank you.** (These numbers include a copy for the Price Field Office)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

Dennis N. Ware                      Company Representative                      07/30/2012  
 Print Name                                      Position                                      Date

  
 Signature (Right-click above choose certify then have notary sign below)

Subscribed and sworn to before me this 30 day of July, 2012

Notary Public: Ruanne LeeFlang, state of Utah.

My commission Expires: 6-30-13

Commission Number: 579452

Address: 25 No. Main

City: Orangeville State: Ut Zip: 84537

SS:



For Office Use Only:

Assigned Tracking Number:

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**Castle Gate Holding Company  
Castle Gate Mine  
C/007/0004**

**Partial Phase III Bond Release  
Application  
Hardscrabble and Sowbelly Canyons**

**July 2012**

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CASTLE GATE MINE  
Partial Phase III Bond Release Application  
Hardscrabble and Sowbelly Canyons  
Permit Number C/007/0004

Introduction

The Castle Gate Mine permit area is located approximately 10 miles north of Price, Utah and in the Wasatch Plateau coal fields in Carbon County. The complex consists of various separate areas including: the Hardscrabble Canyon No.3 and 4 mine facilities; the Sowbelly Gulch No.5 Mine facilities; and the Price Canyon Adit No.1 Mine. The post mining land use is Wildlife and Grazing. This area has a history of various mining operations producing coal since the 1880's, when Teacum Pratt opened the first operation for house coal. Mining activities were consolidated in 1971 under the Braztah Corporation, which in turn became the Price River Coal Company in 1979, then Castle Gate Coal Company in 1986, Amax Coal Company in 1991, Amax Coal Holding Company in 1996, and Castle Gate Holding Company in 1998.

The permit was renewed on December 24, 2009 and expires on December 24, 2013. The current performance bond for the Castle Gate Mine is \$490,100. This partial phase III bond release application will result in a bond release of \$263,500 after which the remaining bond amount will be \$226,600 in 2014 dollars

Reclamation History

Hardscrabble Canyon

Hardscrabble Canyon contains approximately 39 acres within the disturbed area boundary. By the end of 1999, 38.28 acres in Hardscrabble Canyon not including the 0.72 acres associated with the substation had been reclaimed. Hardscrabble reclamation began in 1984 with reclamation of the Goose Island refuse pile followed by reclamation of the No.3 and 4 Mine areas during the years of 1993 through 1999. The road through the disturbed area was altered but left in place for the post mining land use. In 1997, AMAX Coal Company, Castle Gate Holding Company's predecessor, received an Earth Day Award from the Board of Oil, Gas and Mining for "outstanding final reclamation and site restoration". The company was commended for enhancing the post mining land use by restoring the canyon to a more natural configuration and paying particular attention to wildlife habitat while providing better

downstream water quality. Phase I bond release, not including the substation, was incorporated into the Permit in May of 2000 (see the Castle Gate Permit Section 3.3 for reclamation as-built information). Phase II bond release, not including the substation, was incorporated into the Permit in January of 2003 (see the Hardscrabble Canyon Phase II Bond Release, a stand-alone document). In 2003, the Hardscrabble Canyon site was nominated by the Division of Oil, Gas and Mining for an "Excellence in Surface Coal Mining Reclamation Award" and was selected by the Department of Interior's Office of Surface Mining as one of the "National Award" winners and went on to win the "Best of the Best" award. In 2008 Mt. Nebo Scientific, Inc. performed a year-9 vegetation study and in 2009 year-10 vegetation monitoring was conducted to demonstrate vegetation success in preparation for Phase III bond release.

Reclamation work on 0.72 acres associated with the substation in Hardscrabble Canyon was completed in the fall of 2002. Phase I bond release was approved in October of 2005. In 2007 Mt. Nebo Scientific, Inc. performed a year-4 revegetation study on the substation area in Hardscrabble Canyon. The Hardscrabble Canyon substation is not included in this Phase III bond release application.

#### Sowbelly Gulch/Canyon

Sowbelly Canyon contains approximately 21 acres within the disturbed area boundary. Reclamation in Sowbelly Canyon began in 1992 and by the end of 1995, the 19.16 acres in Sowbelly Canyon, not including the 1.84 acres associated with the substation, had been reclaimed. Phase I bond release, not including the substation, was incorporated into the Permit in January of 1997 (see the Castle Gate Permit Section 3.2 for reclamation as-built information). Phase II bond release, not including the substation, was incorporated into the Permit in January of 2003 (see the Sowbelly Gulch Phase II Bond Release, a stand-alone document). In 2004 Mt. Nebo Scientific, Inc. performed a year-9 vegetation study and in 2005 year-10 vegetation monitoring was conducted to demonstrate vegetation success in preparation for Phase III bond release.

Reclamation work on 1.84 acres associated with the substation in Sowbelly Canyon was completed in the fall of 2002. In September of 2004 Phase I bond release was approved. In 2007 Mt. Nebo Scientific, Inc. performed a year-4 revegetation study on the substation area in Sowbelly Canyon. The Sowbelly Canyon substation is not included in this Phase III bond release application.

#### Adit No. 1

The Adit No. 1 contains 3.0 acres within the disturbed area boundary. Reclamation work at the Adit No. 1 was performed during the fall of 2002. In September of 2005 Phase I bond release was approved. In 2007 Mt. Nebo Scientific, Inc. performed a year-4 revegetation study at the Adit No. 1. The Adit No. 1 is not included in this Phase III bond release application.

#### Vegetation

In Hardscrabble Canyon Mt. Nebo Scientific, Inc. conducted the year-9 and year-10 vegetation studies during the growing seasons of 2008 and 2009. In Sowbelly Canyon Mt. Nebo Scientific, Inc. conducted the year-9 and year-10 vegetation studies during the growing seasons of 2004 and 2005. These vegetation studies are included in this bond release application as Appendix 1. The results of these vegetation studies show that the reclaimed areas have met or exceeded the requirements of R645-301-350.

#### Sediment Yields

There are no remaining sediment control structures (ponds, silt fences, straw bales or diversion) to be removed. EarthFax Engineering prepared sediment yield calculations for Hardscrabble and Sowbelly Canyons in 2012, these calculations are included in this bond release application as Appendix 2. The results show that the reclaimed lands are contributing less sediment to the stream flow than the pre-disturbance condition.

#### Other

The proposed Public Notice, the Landowner and Government Agency Notification Letters, the Reclamation Certification and the Bond Release Calculation are included in the bond release application as Appendices 3, 4, 5 and 6 respectively.

#### One Final Note:

The Permittee began the application for Phase III bond release in 2010 following the year-ten vegetation study in Hardscrabble Canyon conducted in 2009. During the preparation of the bond release application the Permittee discovered that one of the requirements for Phase III bond release was the removal of all subsidence monuments. This project to remove the subsidence monuments took two summer seasons to complete at considerable expense to the Permittee. The time and cost of this project was primarily due to the initial lack of GPS location data and the difficult terrain above the Castle Gate Mine workings. The Permittee is happy to report that all subsidence monuments have been removed.

#### Summary

The information included with this application provides documentation as required by Directive Number: Tech-006 and the R645-301-800 Utah Coal Regulations. The Permittee has successfully completed Phase III reclamation on

the 57.44 acres covered in this Phase III bond release application. This application covers all the lands in Hardscrabble Canyon and Sowbelly Canyons except for the substations. Following approval of this Phase III bond release the only remaining lands in the Castle Gate Permit will be the Hardscrabble Canyon substation area (0.72 acres), the Sowbelly Canyon substation area (1.84 acres) and the Adit No. 1 area (3.0 acres) leaving a total of 5.56 acres in the permit.

**Appendix 1**

**Vegetation Monitoring  
For Phase III Bond Release  
Sowbelly and Hardscrabble Canyons  
Years 9 and 10**

**VEGETATION MONITORING  
FOR PHASE III BOND RELEASE  
IN SOWBELLY CANYON**

**YEAR TWO  
2005**



Prepared by

***MT. NEBO SCIENTIFIC, INC.***

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by

Patrick Collins, Ph.D.

for

***PLATEAU MINING CORPORATION***

847 Northwest Highway 191

Helper, Utah 84526



February 2006

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**VEGETATION MONITORING  
FOR PHASE III BOND RELEASE  
IN SOWBELLY CANYON**

**YEAR TWO  
2005**

**INTRODUCTION**

This document contains the second-year results of vegetation sampling that has been conducted for the past two consecutive years in Sowbelly Canyon. Sowbelly Canyon (also known as Sowbelly Gulch) is an area that was once mined for coal. An earlier report that included sampling results for first-year monitoring in the study area was prepared and submitted to Plateau Mining Corporation. This report was called:

**VEGETATION MONITORING  
FOR PHASE III BOND RELEASE  
IN SOWBELLY CANYON  
YEAR ONE  
2004**

The disturbances to the land surface from the mining activities have been reclaimed and reseeded to an approximate "natural" condition with the goal to blend in with the native plant communities of the surrounding areas.

Plateau Mining Corporation will apply to the State of Utah, Division of Oil, Gas and Mining (DOGM) to receive final bond release on this mined property. In order to do this, the process requires at least 10 years of time to pass following revegetation activities, called the

“responsibility period”. This time period usually allows enough time for the plants in the reclaimed areas to become established and hopefully provide a vegetative cover that is “*diverse, effective and permanent.*” During the final two years of this responsibility period, the vegetation of the reclaimed land can be monitored to determine whether or not the area has met pre-determined standards for revegetation success. This document was prepared to address vegetation sampling results for **Year 2**, or the last year required for monitoring for final bond release.

### Brief History

Sowbelly Canyon is located within the Wasatch Plateau approximately 4 miles west-northwest of the city of Helper, Utah. This canyon has been the site of mining activities for nearly 100 years. Spring Canyon Coal Company was one of the first mining companies in the canyon, conducting their operations between 1890 and 1970. Subsequently, McCulloch Oil purchased the site followed by Franklin Real Estate, Price River Coal and Castle Gate Coal Company. Plateau Mining Corporation currently owns the property. In recent years the disturbed areas of Sowbelly Canyon have been reclaimed with the final seeding accomplished in Fall 1995. Preliminary vegetation sampling has been conducted since that time to monitor the early establishment of the revegetated plant communities.

## General Site Description

The average elevation of the Reclaimed and Reference Areas of Sowbelly Canyon is approximately 7,000 ft above sea level. The canyon sides are dominated by pinyon-juniper and Gambel's oak/grass plant communities. Most of the Reclaimed Areas are located near the canyon bottoms that, prior to disturbance, were probably once dominated by Gambel's oak, sagebrush and grass communities. During reclamation activities, a drainage channel was re-created at the canyon bottoms. The Reclaimed Areas were seeded with native plant species. In addition, containerized plant species such as serviceberry (*Amelanchier utahensis*), chokecherry (*Prunus virginiana*), willows (*Salix* spp.), and Wood's rose (*Rosa woodsii*) have been transplanted along the channel in the valley bottom.

## Reference Area

A general Reference Area to be used as a standard for final revegetation success was chosen at a much earlier date. The Mining and Reclamation Plan (MRP) stated that "*the AML Reference Areas shown on Exhibit 9-6 will be used to evaluate previously mined areas*". Because the AML (Abandoned Mined Lands) areas were relatively extensive, at least for use as one Reference Area, biologists from DOGM along with representatives from Plateau Mining Corporation, chose a smaller portion of the AML areas as a Reference Area for Sowbelly Canyon. This Reference Area was located down-canyon (or south) and very close to the Reclaimed Areas.

## METHODS

For Year 2, quantitative and qualitative data were recorded from the vegetation of the Reclaimed and Reference Areas in Sowbelly Canyon using virtually identical methodologies as were employed in Year 1. Sampling in 2005 was conducted in late-July. Methodologies used for sampling were performed in accordance with the guidelines provided by DOGM.

### Transect and Quadrat Placement

Random/regular placement of sample quadrats were designed as an attempt to provide unbiased accuracy of the data compiled. This was accomplished by establishing several long transect lines along the entire length of the Reclaimed Areas. These lines were placed in the lowest portion of the reclaimed drainage system. At regular intervals along the drainage transect lines, random numbers were generated and used to measure distances at right angles from the drainage and to determine sample locations. Whether these random numbers were odd or even determined which side of the drainage (east or west) a given quadrat was placed. The random numbers selected could be high enough to place quadrats to the lateral limits of the Reclaimed Areas and all areas in-between. This insured that the sample quadrats were placed randomly over the entire study area in an attempt to adequately address and represent the site as a whole.

### Cover, Frequency and Composition

Cover estimates were made using ocular methods with meter square quadrats. Species composition and relative frequencies were also assessed from the quadrats. Additional information recorded on the raw data sheets were: estimated precipitation, slope, exposure, grazing use, animal disturbance and other appropriate notes. Plant nomenclature follows "A Utah Flora" (Welsh et al. 2003).

### Sample Size & Adequacy

Sampling adequacy was calculated using formula given below.

$$nMIN = \frac{t^2 s^2}{(dx)^2}$$

where,

- nMIN* = minimum adequate sample
- t* = appropriate confidence t-value
- s* = standard deviation
- x* = sample mean
- d* = desired change from mean

The values used for "t" and "d" insured that sample adequacy was met with 90% confidence within a 10% deviation from the true mean.

## Diversity & Similarity Indices

There are several well-documented methods to assess diversity and similarities in plant communities. The "Motyka Index" is a modified form of the "Sorenson Index", both similarity indices. This index was used on the data and the equation is shown below:

$$IS_{MO} = \left( \frac{2MW}{MA+MB} \right) \times 100$$

where,

MW =  $\sum$  of the smaller quantitative values of species of two communities,  
MA =  $\sum$  of the quantitative values of all species in one community,  
MB =  $\sum$  of the quantitative values of all species in another community.

A diversity index has been reported in this document for the Reclaimed and Reference Areas. MacArthur's Diversity Index is an effective diversity measurement and is computed using the following equation:

$$1/\sum pi^2$$

where,

$pi$  is the proportion of sum frequency contributed by the  $i$ th species in the sample area of concern.

The proportional contribution of each species is then squared and the values for all species in the sample areas are summed. This index integrates the number of species and the degree to which frequency of occurrence was equitably distributed among those species.

## Photographs

Color photographs of the sample areas were taken at the time of sampling and submitted with this report.

## Raw Data

The raw data for total cover, cover by species, frequency and composition were also submitted in the Appendix of this report which should facilitate future scrutiny of the data and further statistical testing if desired. Specific sample areas are shown on the raw data sheets.

# RESULTS

## Reclaimed Areas

The total living cover for the combined data of the Reclaimed Areas in Sowbelly Canyon was 52.38% (Table 1-A). Grasses were the dominant lifeform in these areas comprising 68.28% of the total living understory cover, followed distantly by shrubs at 17.75% and forbs at 13.96% (Table 1-B).

The dominant plant species in the reclaimed areas were thickspike wheatgrass (*Elymus lanceolatus*), Western wheatgrass (*Elymus smithii*), rubber rabbitbrush (*Chrysothamnus nauseosus*), and blueleaf aster (*Aster glaucodes*). For a list of all plant species present in the

sample quadrats along with their cover and frequency values, refer to Table 2.

### Reference Area

The Reference Area, or area chosen to be used for revegetation success standards, had a total living cover of 49.00% (Table 3-A). Like the Reclaimed Areas, grasses were the dominant lifeform and comprised 61.23% of the total living cover. Forbs at 21.21% and shrubs at 17.56% followed the grasses in the proportion of the total living cover (Table 3-B).

The plant species that dominated the Reference Area were thickspike wheatgrass, cheatgrass (*Bromus tectorum*), and rubber rabbitbrush. For cover and frequency values by species refer to Table 4.

### Data Set Comparisons

Comparisons were made in the 2005 data sets between the Reclaimed and Reference Areas. To also compare Year 1 and Year 2, results from the 2004 data sets were included in the figures of this 2005 report.

**FIG. 1. STUDENT'S T TEST - A Total Living Cover Comparison Between the Reclaimed and Reference Areas at Sowbelly Canyon.**

**2004**

Reclaimed Area:  $\bar{x}=54.00$ ;  $s=11.74$ ;  $n=80$   
Reference Area:  $\bar{x}=49.50$ ;  $s=12.46$ ;  $n=50$   
 $t = 2.077$ ;  $df = 128$ ,  $SL= p<.05$

**2005**

Reclaimed Area:  $\bar{x}=52.38$ ;  $s=12.45$ ;  $n=80$   
Reference Area:  $\bar{x}=49.00$ ;  $s=12.88$ ;  $n=50$   
 $t = 1.486$ ;  $df = 128$ ,  $SL= N.S.$

First, statistical tests were implemented to compare the total living plant cover of the two areas.

A "Student's t-test" analysis suggested the Reclaimed Areas were not significantly different for total living cover when compared to the Reference Area in 2005 (Fig. 1). In 2004, the Reclaimed Areas cover was greater than the Reference Area.

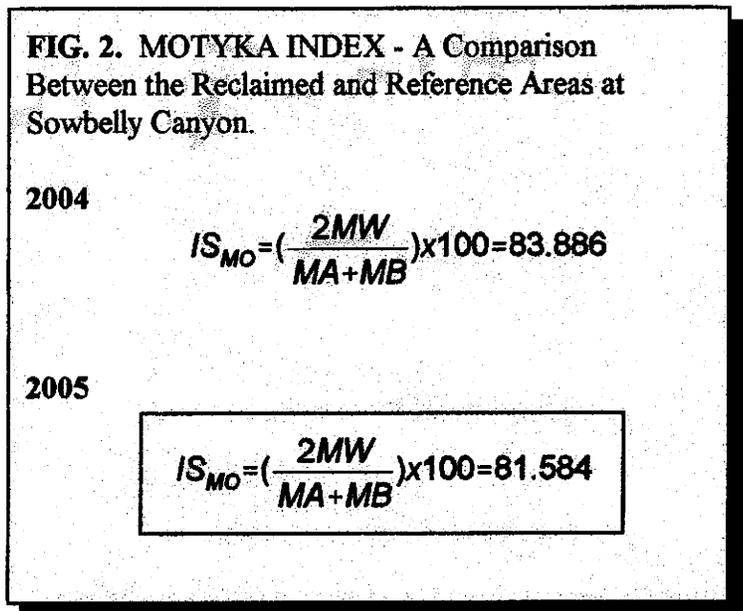
Next, similarity and diversity indices were computed and the areas were compared.

The Motyka Index was recommended to be used to compare species diversity in the Mining and Reclamation Plan (MRP). Although this index is more of a *similarity index* than a *diversity index*, it has been employed to compare the data sets. The MRP assigned the following categories to be used for comparisons in the Motyka Index:

- Non-Weedy Shrub Cover,
- Weedy Shrub Cover,
- Native Perennial Grass Cover,
- Introduced Perennial Grass Cover,
- Non-Weedy Forb & Grass Cover,
- Weedy Forb & Grass Cover.

When using the above categories and employing the Motyka Index, the 2004 similarity value for the two communities was 83.89%; in 2005 it was 81.58% (Fig. 2).

MacArthur's Diversity Index was also employed to the data sets of the Reclaimed and Reference Areas. This comparison suggests that the total diversity of the Reclaimed Areas was greater than



that of the Reference Area in 2004 and 2005 (Fig. 3).

## DISCUSSION

Plateau Mining Corporation and State of Utah, Division of Oil, Gas and Mining (DOG M) worked together formulating revegetation success standards in the MRP for Sowbelly Canyon. Because the area was disturbed by mining operations prior to the current revegetation regulations and requirements, standards for revegetation success were modified. State

regulation R645-301-356.250 states that: *“for areas previously disturbed by mining that were not reclaimed to the requirements of R645-200 through R645-203 and R645-301 through R645-302 and that are remined or otherwise redisturbed by coal mining and reclamation operations, at a minimum, the vegetative ground cover will be not less than the ground cover existing before redisturbance and will be adequate to control erosion”*.

The Sowbelly Canyon area was continuously mined since the time it was first disturbed by mining activities. Because of this there was no vegetative cover data “existing before redisturbance” as mentioned above in the state regulation. Therefore, DOGM and Plateau agreed that upon final reclamation the standards for revegetation success would be determined using a specific

**FIG. 3. MacARTHUR'S INDEX - A Comparison Between the Reclaimed and Reference Areas at Sowbelly Canyon.**

$$1/\sum p_i^2 =$$

**2004**

Reclaimed Area: 12.250

Reference Area: 10.354

**2005**

Reclaimed Area: 11.662

Reference Area: 8.757

Reference Area – but success parameters would be dictated more from the species present, diversity, and similarity indices rather than strictly by cover, productivity and woody species density as the more recent regulations would dictate. Erosion control (as stated in the regulation above) should also be considered for a successful revegetation standard.

With the above considerations, sampling quantitatively for cover would still be necessary in the Reclaimed and Disturbed Areas to adequately address the success standards. That said, and even though such a comparison was not necessary here, the total living cover of the Reclaimed Areas was as good as or better than the Reference Area in 2004 and 2005. Moreover, the plant species present in the quadrats in the Reclaimed Areas were comprised almost exclusively of “desirable” rather than “weedy” species. Not only does this suggest successful revegetation from a cover perspective, but it also suggests that erosion control is probably better in the Reclaimed Area when compared to the Reference Area.

In addition, as shown in the RESULTS section above, diversity and similarity indices revealed favorable results for the Reclaimed Areas in Sowbelly Canyon when compared to the Reference Area. In other words, the Reclaimed Areas were more diverse than the Reference Area, but the two areas were still quite similar.

The vegetation monitoring data sets for 2 consecutive years (2004 and 2005), along with statistical analyses and other methods to compare the Reclaimed Areas with the Reference Area in Sowbelly Canyon show that Phase III Bond Release may be warranted.

**TABLE 1:** Total cover and composition summary for the Reclaimed Areas in Sowbelly Canyon (2005).

---

<b>A. TOTAL COVER</b>	<b>% MEAN COVER</b>	<b>STANDARD DEVIATION</b>	<b>SAMPLE SIZE</b>
Total Living	52.38	12.45	80
Litter	14.25	8.83	80
Bareground	14.83	10.12	80
Rock	18.55	12.36	80

---

**B. COMPOSITION**

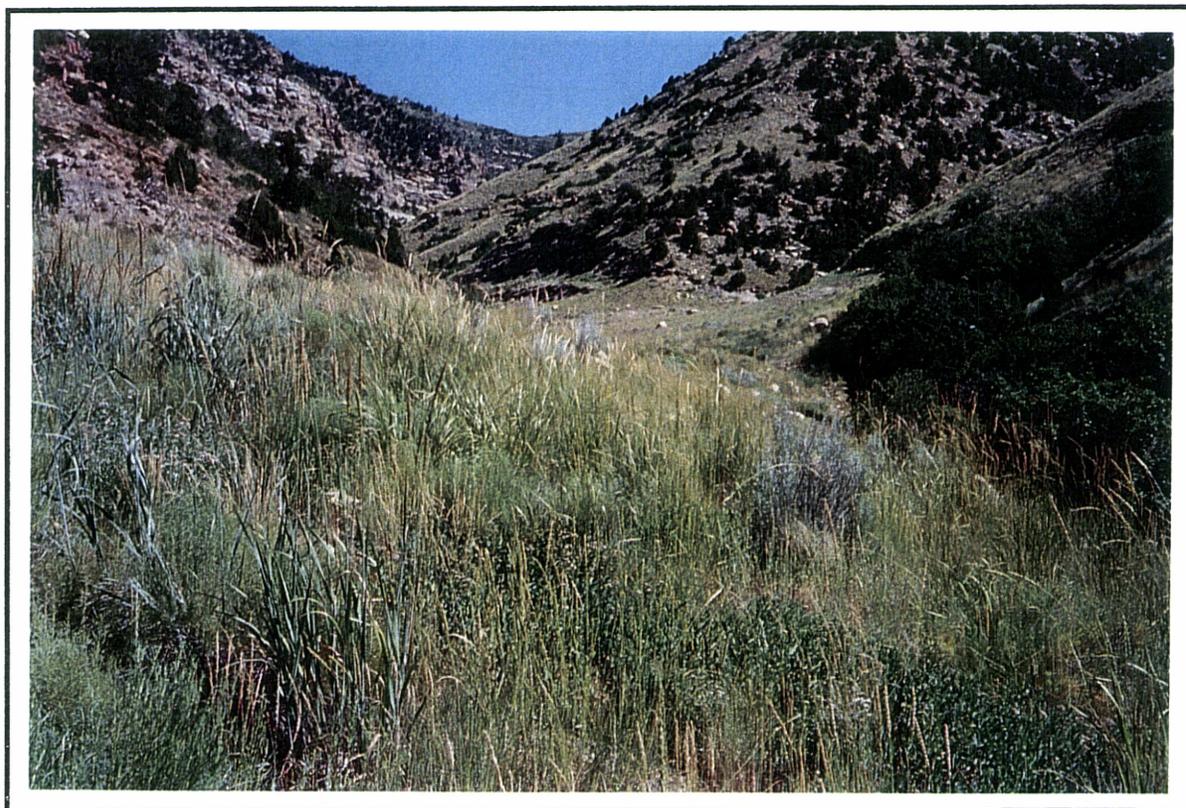
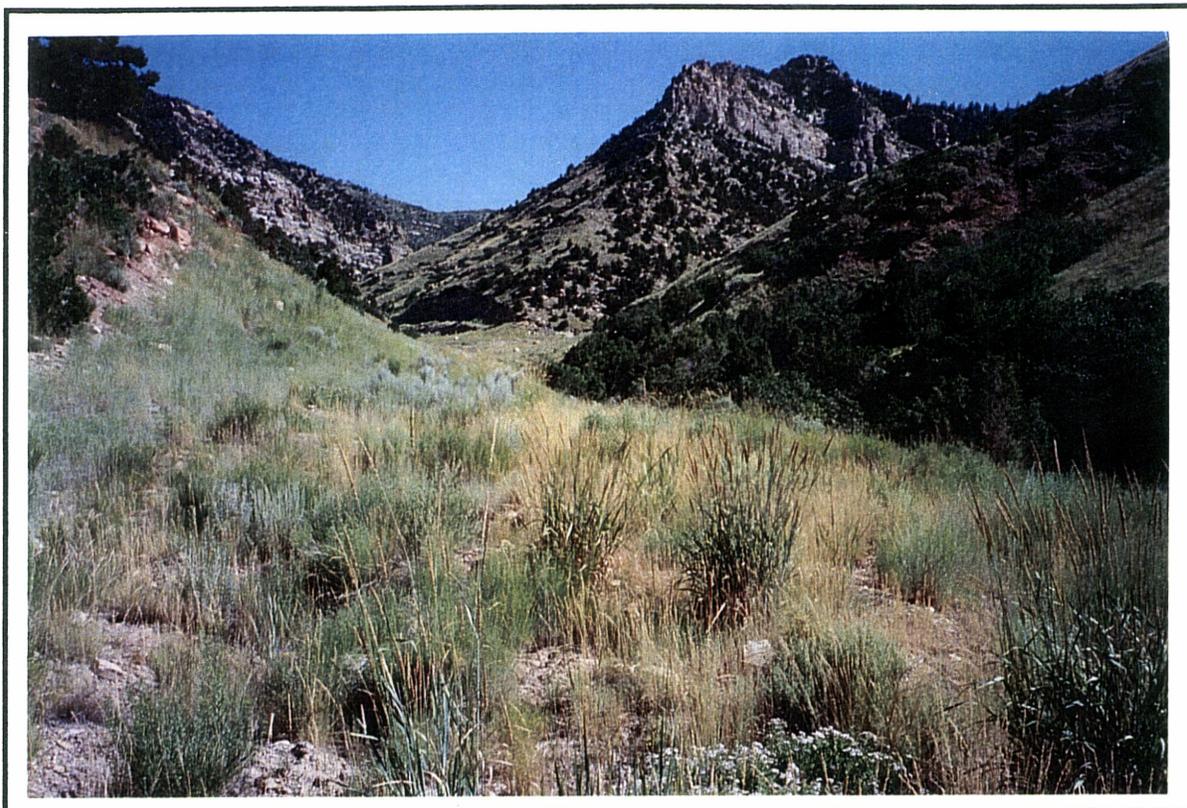
Shrubs	17.75	24.26	80
Forbs	13.96	17.79	80
Grasses	68.28	26.81	80

---

**TABLE 2:** Species cover and frequency summary for the Reclaimed Areas in Sowbelly Canyon (2005).

<b>SPECIES</b>	<b>% MEAN COVER</b>	<b>STANDARD DEVIATION</b>	<b>SAMPLE SIZE</b>	<b>RELATIVE FREQUENCY</b>
<b>TREES &amp; SHRUBS</b>				
<i>Artemisia tridentata</i>	1.81	6.67	80	10.00
<i>Atriplex canescens</i>	0.50	4.44	80	1.25
<i>Ceratoides lanata</i>	0.25	1.63	80	2.50
<i>Chrysothamnus nauseosus</i>	6.84	12.12	80	37.50
<i>Gutierrezia sarothrae</i>	0.28	1.83	80	2.50
<b>FORBS</b>				
<i>Artemisia dracunculus</i>	0.15	0.95	80	2.50
<i>Aster glaucodes</i>	6.24	10.96	80	36.25
<i>Hedysarum boreale</i>	0.19	1.67	80	1.25
<i>Linum lewisii</i>	0.60	1.79	80	11.25
<i>Melilotus officinalis</i>	0.55	1.78	80	10.00
<i>Penstemon palmeri</i>	0.13	1.11	80	1.25
<b>GRASSES</b>				
<i>Agropyron cristatum</i>	1.19	4.35	80	10.00
<i>Bromus carinatus</i>	0.91	3.66	80	7.50
<i>Bromus tectorum</i>	1.40	3.39	80	18.75
<i>Dactylis glomerata</i>	0.13	1.11	80	1.25
<i>Elymus cinereus</i>	3.50	6.53	80	30.00
<i>Elymus hispidus</i>	3.19	11.27	80	10.00
<i>Elymus lanceolatus</i>	7.74	10.84	80	45.00
<i>Elymus salinus</i>	0.56	2.74	80	5.00
<i>Elymus smithii</i>	7.38	11.88	80	43.75
<i>Elymus spicatus</i>	5.36	9.05	80	37.50
<i>Hordeum jubatum</i>	0.06	0.56	80	1.25
<i>Poa secunda</i>	2.06	6.36	80	12.50
<i>Stipa hymenoides</i>	1.38	6.32	80	5.00

**COLOR PHOTOGRAPHS**  
Reclaimed Areas  
[Sample Area A (beginning south to north)]







(Sample Areas B and C)



Reference Area  
[Sample Area (beginning south to north)]





**APPENDIX**

Raw Data

PLATEAU MINING

Sowbelly

Reclaimed Area

Exposure: Variable

1 thru 60 Transect "A"

Slope: Variable

Sample Date: 27-28 July 2005

1.00 2.00 3.00 4.00 5.00 6.00 7.00

TREES & SHRUBS

<i>Artemisia tridentata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Atriplex canescens</i>	0.00	40.00	0.00	0.00	0.00	0.00	0.00
<i>Ceratoides lanata</i>	0.00	7.00	0.00	0.00	0.00	0.00	0.00
<i>Chrysothamnus nauseosus</i>	0.00	0.00	30.00	0.00	0.00	0.00	0.00
<i>Gutierrezia sarothrae</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FORBS

<i>Artemisia dracunculus</i>	0.00	0.00	0.00	7.00	0.00	0.00	0.00
<i>Aster glaucodes</i>	0.00	0.00	0.00	0.00	7.00	20.00	35.00
<i>Hedysarum boreale</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Linum lewisii</i>	0.00	0.00	0.00	0.00	0.00	5.00	5.00
<i>Melilotus officinalis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Penstemon palmeri</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

GRASSES

<i>Agropyron cristatum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Bromus carinatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Bromus tectorum</i>	0.00	5.00	5.00	0.00	0.00	0.00	15.00
<i>Dactylis glomerata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus cinereus</i>	0.00	0.00	0.00	0.00	10.00	0.00	0.00
<i>Elymus hispidus</i>	0.00	0.00	0.00	35.00	15.00	0.00	0.00
<i>Elymus lanceolatus</i>	20.00	13.00	0.00	0.00	0.00	45.00	0.00
<i>Elymus salinus</i>	0.00	0.00	0.00	0.00	0.00	0.00	10.00
<i>Elymus smithii</i>	10.00	0.00	0.00	10.00	0.00	0.00	0.00
<i>Elymus spicatus</i>	10.00	0.00	0.00	3.00	18.00	0.00	0.00
<i>Hordeum jubatum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Poa secunda</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Stipa hymenoides</i>	0.00	0.00	30.00	0.00	0.00	0.00	0.00

COVER

Total Living Cover	40.00	65.00	65.00	55.00	50.00	70.00	65.00
Litter	10.00	10.00	10.00	15.00	10.00	10.00	10.00
Bareground	35.00	10.00	10.00	20.00	25.00	10.00	15.00
Rock	15.00	15.00	15.00	10.00	15.00	10.00	10.00

% COMPOSITION

Shrubs	0.00	72.31	46.15	0.00	0.00	0.00	0.00
Forbs	0.00	0.00	0.00	12.73	14.00	35.71	61.54
Grasses	100.00	27.69	53.85	87.27	86.00	64.29	38.46

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
0.00	0.00	0.00	0.00	0.00	20.00	0.00	15.00	0.00	25.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	13.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	55.00	10.00	5.00	0.00	0.00	8.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30.00	7.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	15.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	8.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	7.00
0.00	0.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	5.00	0.00	0.00	10.00	10.00	0.00	0.00	5.00	30.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	10.00	10.00	20.00	0.00	5.00	15.00	0.00	0.00	0.00
0.00	10.00	0.00	0.00	0.00	0.00	10.00	30.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00
65.00	40.00	65.00	40.00	65.00	45.00	35.00	45.00	35.00	70.00
10.00	5.00	10.00	10.00	25.00	15.00	10.00	15.00	5.00	10.00
15.00	30.00	15.00	30.00	5.00	10.00	15.00	15.00	35.00	5.00
10.00	25.00	10.00	20.00	5.00	30.00	40.00	25.00	25.00	15.00
0.00	0.00	0.00	32.50	84.62	66.67	14.29	33.33	0.00	47.14
46.15	17.50	38.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53.85	82.50	61.54	67.50	15.38	33.33	85.71	66.67	100.00	52.86

18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00	5.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	0.00	0.00	0.00	0.00	10.00	10.00	10.00	15.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.00	23.00	25.00	0.00	0.00	0.00	0.00	20.00	5.00	20.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	20.00	10.00	5.00	25.00	0.00	0.00	20.00
10.00	0.00	0.00	10.00	15.00	40.00	0.00	15.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75.00	35.00	25.00	70.00	25.00	60.00	35.00	45.00	35.00	55.00
10.00	5.00	10.00	20.00	10.00	20.00	25.00	25.00	10.00	10.00
5.00	35.00	35.00	5.00	10.00	10.00	30.00	10.00	20.00	10.00
10.00	25.00	30.00	5.00	55.00	10.00	10.00	20.00	35.00	25.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.09
13.33	5.71	0.00	35.71	0.00	0.00	0.00	0.00	0.00	0.00
86.67	94.29	100.00	64.29	100.00	100.00	100.00	100.00	100.00	90.91

28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	15.00	0.00	30.00	40.00	7.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	10.00	0.00	7.00	0.00	0.00	18.00	0.00	0.00	15.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	5.00	0.00	5.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	5.00	5.00	0.00	5.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	10.00	15.00	20.00	0.00	0.00	0.00	10.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	5.00	15.00	5.00	5.00	0.00
15.00	0.00	10.00	8.00	0.00	0.00	5.00	10.00	10.00	15.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	20.00	0.00	0.00	15.00	0.00	0.00	0.00	30.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.00	50.00	45.00	55.00	55.00	50.00	50.00	35.00	45.00	35.00
5.00	15.00	40.00	20.00	10.00	5.00	10.00	10.00	35.00	20.00
5.00	10.00	10.00	5.00	5.00	35.00	15.00	15.00	15.00	5.00
50.00	25.00	5.00	20.00	30.00	10.00	25.00	40.00	5.00	40.00
0.00	0.00	33.33	0.00	54.55	80.00	14.00	28.57	0.00	0.00
37.50	30.00	0.00	30.91	9.09	10.00	46.00	0.00	0.00	42.86
62.50	70.00	66.67	69.09	36.36	10.00	40.00	71.43	100.00	57.14

38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	0.00	0.00	0.00	10.00	0.00	60.00	0.00	15.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	30.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	0.00	0.00	0.00	10.00	35.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	0.00
0.00	5.00	15.00	15.00	0.00	15.00	15.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	15.00	0.00	10.00	10.00	15.00	0.00	0.00	0.00	65.00
0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70.00	55.00	30.00	50.00	60.00	65.00	75.00	70.00	50.00	65.00
15.00	10.00	10.00	15.00	30.00	10.00	23.00	5.00	7.00	15.00
5.00	25.00	25.00	5.00	5.00	10.00	1.00	10.00	35.00	10.00
10.00	10.00	35.00	30.00	5.00	15.00	1.00	15.00	8.00	10.00
57.14	36.36	0.00	0.00	0.00	0.00	0.00	64.29	0.00	0.00
21.43	18.18	16.67	20.00	16.67	0.00	80.00	21.43	30.00	0.00
21.43	45.45	83.33	80.00	83.33	100.00	20.00	14.29	70.00	100.00

48.00	49.00	50.00	51.00	52.00	53.00	54.00	55.00	56.00	57.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	40.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	15.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	0.00	10.00	0.00	10.00	25.00	0.00	0.00	5.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	10.00	70.00	15.00	0.00	50.00	0.00	0.00	0.00
0.00	20.00	30.00	0.00	0.00	0.00	0.00	8.00	0.00	15.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	25.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	15.00
35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	40.00	0.00
60.00	55.00	50.00	70.00	65.00	65.00	50.00	40.00	60.00	50.00
10.00	20.00	5.00	5.00	10.00	15.00	10.00	5.00	15.00	15.00
25.00	15.00	30.00	15.00	20.00	15.00	25.00	10.00	5.00	30.00
5.00	10.00	15.00	10.00	5.00	5.00	15.00	45.00	20.00	5.00
0.00	9.09	0.00	0.00	61.54	0.00	0.00	30.00	25.00	0.00
33.33	0.00	20.00	0.00	15.38	38.46	0.00	0.00	8.33	10.00
66.67	90.91	80.00	100.00	23.08	61.54	100.00	70.00	66.67	90.00

61 thru 70 Transect "B"

58.00	59.00	60.00	61.00	62.00	63.00	64.00	65.00	66.00	67.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	20.00	10.00	10.00	0.00	5.00	20.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	15.00	40.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	15.00	10.00
0.00	0.00	5.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	20.00	0.00	0.00	10.00	25.00	0.00
10.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00
0.00	20.00	10.00	45.00	15.00	0.00	0.00	30.00	0.00	10.00
5.00	15.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45.00	65.00	55.00	65.00	40.00	40.00	30.00	55.00	65.00	60.00
10.00	15.00	5.00	10.00	10.00	10.00	5.00	20.00	10.00	20.00
20.00	15.00	25.00	15.00	5.00	20.00	45.00	10.00	15.00	5.00
25.00	5.00	15.00	10.00	45.00	30.00	20.00	15.00	10.00	15.00
33.33	30.77	18.18	15.38	0.00	12.50	66.67	0.00	0.00	0.00
22.22	0.00	0.00	0.00	0.00	37.50	33.33	0.00	23.08	66.67
44.44	69.23	81.82	84.62	100.00	50.00	0.00	100.00	76.92	33.33

71 thru 80 Transect "C"

68.00	69.00	70.00	71.00	72.00	73.00	74.00	75.00	76.00	77.00
0.00	0.00	0.00	10.00	20.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	0.00	0.00	0.00	5.00	40.00	0.00	20.00	5.00	15.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00
0.00	0.00	0.00	15.00	0.00	5.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	25.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	20.00	5.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	15.00	0.00	0.00	10.00	30.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	25.00	0.00	0.00	0.00	0.00	0.00	45.00	0.00	0.00
20.00	0.00	10.00	35.00	0.00	0.00	0.00	0.00	10.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	35.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45.00	50.00	50.00	70.00	60.00	60.00	40.00	65.00	55.00	40.00
5.00	30.00	30.00	20.00	30.00	5.00	35.00	15.00	15.00	50.00
5.00	10.00	10.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
45.00	10.00	10.00	5.00	5.00	30.00	20.00	15.00	25.00	5.00
55.56	0.00	0.00	14.29	41.67	66.67	0.00	30.77	9.09	50.00
0.00	0.00	0.00	21.43	0.00	8.33	25.00	0.00	0.00	12.50
44.44	100.00	100.00	64.29	58.33	25.00	75.00	69.23	90.91	37.50

PLATEAU MINING

Sowbelly

Reclaimed Area

Exposure: Variable

Slope: Variable

Sample Date: 27-28 July 2005

78.00	79.00	80.00	Mean	SDev	Freq	
<hr/>						TREES & SHRUBS
0.00	0.00	0.00	1.81	6.67	10.00	<i>Artemisia tridentata</i>
0.00	0.00	0.00	0.50	4.44	1.25	<i>Atriplex canescens</i>
0.00	0.00	0.00	0.25	1.63	2.50	<i>Ceratoides lanata</i>
25.00	5.00	7.00	6.84	12.12	37.50	<i>Chrysothamnus nauseosus</i>
0.00	0.00	0.00	0.28	1.83	2.50	<i>Gutierrezia sarothrae</i>
<hr/>						FORBS
0.00	0.00	0.00	0.15	0.95	2.50	<i>Artemisia dracunculus</i>
0.00	0.00	0.00	6.24	10.96	36.25	<i>Aster glaucodes</i>
0.00	0.00	0.00	0.19	1.67	1.25	<i>Hedysarum boreale</i>
3.00	5.00	0.00	0.60	1.79	11.25	<i>Linum lewisii</i>
7.00	0.00	0.00	0.55	1.78	10.00	<i>Melilotus officinalis</i>
0.00	0.00	0.00	0.13	1.11	1.25	<i>Penstemon palmeri</i>
<hr/>						GRASSES
0.00	10.00	0.00	1.19	4.35	10.00	<i>Agropyron cristatum</i>
0.00	0.00	8.00	0.91	3.66	7.50	<i>Bromus carinatus</i>
0.00	0.00	0.00	1.40	3.39	18.75	<i>Bromus tectorum</i>
0.00	0.00	0.00	0.13	1.11	1.25	<i>Dactylis glomerata</i>
0.00	0.00	0.00	3.50	6.53	30.00	<i>Elymus cinereus</i>
0.00	0.00	0.00	3.19	11.27	10.00	<i>Elymus hispidus</i>
15.00	30.00	25.00	7.74	10.84	45.00	<i>Elymus lanceolatus</i>
0.00	0.00	0.00	0.56	2.74	5.00	<i>Elymus salinus</i>
0.00	0.00	0.00	7.38	11.88	43.75	<i>Elymus smithii</i>
0.00	0.00	5.00	5.36	9.05	37.50	<i>Elymus spicatus</i>
0.00	0.00	0.00	0.06	0.56	1.25	<i>Hordeum jubatum</i>
0.00	0.00	0.00	2.06	6.36	12.50	<i>Poa secunda</i>
0.00	0.00	0.00	1.38	6.32	5.00	<i>Stipa hymenoides</i>
<hr/>						COVER
50.00	50.00	45.00	52.38	12.45		Total Living Cover
15.00	10.00	10.00	14.25	8.83		Litter
5.00	25.00	10.00	14.83	10.12		Bareground
30.00	15.00	35.00	18.55	12.36		Rock
<hr/>						% COMPOSITION
50.00	10.00	15.56	17.75	24.26		Shrubs
20.00	10.00	0.00	13.96	17.79		Forbs
30.00	80.00	84.44	68.28	26.81		Grasses

PLATEAU MINING  
 Sowbelly Reference Area  
 Exposure: Variable  
 Slope: Variable

Sample Date: 27-28 July 2005	1.00	2.00	3.00	4.00	5.00	6.00	7.00
<b>TREES &amp; SHRUBS</b>							
<i>Artemisia tridentata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Atriplex canescens</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Chrysothamnus nauseosus</i>	40.00	40.00	5.00	5.00	0.00	20.00	75.00
<i>Gutierrezia sarothrae</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>FORBS</b>							
<i>Artemisia ludoviciana</i>	5.00	8.00	0.00	5.00	0.00	0.00	0.00
<i>Aster glaucodes</i>	0.00	0.00	45.00	0.00	20.00	0.00	0.00
<i>Medicago sativa</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Penstemon palmeri</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Sisymbium altissimum</i>	0.00	2.00	0.00	0.00	0.00	0.00	0.00
<i>Tragopogon dubius</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>GRASSES</b>							
<i>Bromus inermis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Bromus tectorum</i>	5.00	5.00	0.00	0.00	0.00	0.00	0.00
<i>Dactylis glomerata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus hispidus</i>	0.00	0.00	15.00	0.00	0.00	0.00	0.00
<i>Elymus lanceolatus</i>	0.00	0.00	0.00	12.00	40.00	35.00	0.00
<i>Elymus salinus</i>	0.00	5.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus smithii</i>	5.00	0.00	0.00	13.00	0.00	0.00	0.00
<i>Stipa hymenoides</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>COVER</b>							
Total Living Cover	55.00	60.00	65.00	35.00	60.00	55.00	75.00
Litter	10.00	30.00	15.00	15.00	35.00	35.00	15.00
Bareground	10.00	5.00	5.00	5.00	4.00	5.00	5.00
Rock	25.00	5.00	15.00	45.00	1.00	5.00	5.00
<b>% COMPOSITION</b>							
Shrubs	72.73	66.67	7.69	14.29	0.00	36.36	100.00
Forbs	9.09	16.67	69.23	14.29	33.33	0.00	0.00
Grasses	18.18	16.67	23.08	71.43	66.67	63.64	0.00

28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	20.00	15.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	10.00
0.00	0.00	0.00	0.00	0.00	10.00	5.00	0.00	0.00	5.00
0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	5.00	10.00	15.00	0.00	20.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	30.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
30.00	0.00	5.00	10.00	50.00	5.00	10.00	0.00	0.00	30.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00
0.00	30.00	0.00	0.00	0.00	0.00	0.00	30.00	5.00	0.00
0.00	0.00	0.00	5.00	0.00	10.00	0.00	0.00	0.00	0.00
50.00	35.00	55.00	35.00	55.00	30.00	35.00	55.00	60.00	65.00
35.00	10.00	15.00	10.00	5.00	5.00	5.00	10.00	25.00	5.00
5.00	10.00	25.00	10.00	10.00	35.00	5.00	30.00	5.00	20.00
10.00	45.00	5.00	45.00	30.00	30.00	55.00	5.00	10.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.18	0.00	0.00
20.00	14.29	36.36	57.14	0.00	33.33	42.86	0.00	8.33	23.08
80.00	85.71	63.64	42.86	100.00	66.67	57.14	81.82	91.67	76.92

38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	15.00	0.00	15.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	5.00	15.00	5.00	15.00	15.00	35.00	35.00
0.00	25.00	35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	10.00	0.00
0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	30.00	30.00	55.00	50.00	15.00	5.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	10.00	5.00	0.00	0.00	0.00	10.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	10.00	5.00
0.00	0.00	0.00	5.00	0.00	3.00	5.00	0.00	0.00	20.00
40.00	65.00	70.00	70.00	65.00	40.00	40.00	40.00	55.00	60.00
10.00	5.00	20.00	20.00	15.00	45.00	10.00	50.00	25.00	25.00
15.00	10.00	5.00	5.00	5.00	5.00	35.00	5.00	5.00	10.00
35.00	20.00	5.00	5.00	15.00	10.00	15.00	5.00	15.00	5.00
0.00	0.00	0.00	0.00	0.00	37.50	0.00	37.50	0.00	0.00
25.00	38.46	50.00	14.29	23.08	17.50	37.50	37.50	81.82	58.33
75.00	61.54	50.00	85.71	76.92	45.00	62.50	25.00	18.18	41.67

PLATEAU MINING  
 Sowbelly Reference Area  
 Exposure: Variable  
 Slope: Variable  
 Sample Date: 27-28 July 2005

48.00	49.00	50.00	Mean	SDev	Freq	
<hr/>						TREES & SHRUBS
0.00	0.00	0.00	0.14	0.98	2.00	<i>Artemisia tridentata</i>
0.00	0.00	0.00	0.80	3.22	6.00	<i>Atriplex canescens</i>
0.00	5.00	7.00	7.06	13.58	40.00	<i>Chrysothamnus nauseosus</i>
0.00	0.00	0.00	0.16	0.81	4.00	<i>Gutierrezia sarothrae</i>
<hr/>						FORBS
0.00	15.00	8.00	5.94	8.14	54.00	<i>Artemisia ludoviciana</i>
0.00	0.00	0.00	3.60	10.15	12.00	<i>Aster glaucodes</i>
0.00	0.00	0.00	0.40	1.69	6.00	<i>Medicago sativa</i>
0.00	0.00	0.00	0.40	1.69	6.00	<i>Penstemon palmeri</i>
0.00	0.00	0.00	0.44	1.70	8.00	<i>Sisymbium altissimum</i>
0.00	0.00	0.00	0.04	0.28	2.00	<i>Tragopogon dubius</i>
<hr/>						GRASSES
0.00	0.00	0.00	0.50	3.50	2.00	<i>Bromus inermis</i>
0.00	20.00	0.00	8.00	12.08	52.00	<i>Bromus tectorum</i>
0.00	0.00	0.00	1.10	5.32	6.00	<i>Dactylis glomerata</i>
0.00	0.00	0.00	3.00	7.55	18.00	<i>Elymus hispidus</i>
0.00	0.00	0.00	10.42	15.26	50.00	<i>Elymus lanceolatus</i>
0.00	0.00	0.00	1.10	7.02	4.00	<i>Elymus salinus</i>
70.00	0.00	25.00	4.66	11.78	28.00	<i>Elymus smithii</i>
0.00	0.00	0.00	1.24	3.42	18.00	<i>Stipa hymenoides</i>
<hr/>						COVER
70.00	40.00	40.00	49.00	12.88		Total Living Cover
15.00	5.00	5.00	15.20	11.53		Litter
5.00	15.00	5.00	11.28	9.33		Bareground
10.00	40.00	50.00	24.52	17.64		Rock
<hr/>						% COMPOSITION
0.00	12.50	17.50	17.56	24.27		Shrubs
0.00	37.50	20.00	21.21	20.33		Forbs
100.00	50.00	62.50	61.23	24.85		Grasses

**VEGETATION MONITORING  
FOR PHASE III BOND RELEASE  
IN SOWBELLY CANYON**

**YEAR ONE  
2004**

**FOR  
PLATEAU MINING CORPORATION**



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**VEGETATION MONITORING  
FOR PHASE III BOND RELEASE  
IN SOWBELLY CANYON**

**YEAR ONE  
2004**

**INTRODUCTION**

Sowbelly Canyon (also known as Sowbelly Gulch) is an area that was once mined for coal. The disturbances to the land surface from the mining activities have been reclaimed and reseeded to an approximate "natural" condition with the goal to blend in with the native plant communities in the surrounding areas. In order for the mining company to receive final bond release on the mined property, the State of Utah, Division of Oil, Gas and Mining (DOGGM) requires at least 10 years of time to pass following revegetation activities. This time period usually allows enough time for the plants in the reclaimed areas to become established and hopefully provide a vegetative cover that is "diverse, effective and permanent." During the final two years of this *responsibility period*, the vegetation of the reclaimed land can be monitored to determine whether or not the area has met pre-determined standards for revegetation success. This document was prepared to address vegetation sampling results for **Year 1** of the two years required for final monitoring.

## Brief History

Sowbelly Canyon is located within the Wasatch Plateau approximately 4 miles west-northwest of the city of Helper, Utah. This canyon has been the site of mining activities for nearly 100 years. Spring Canyon Coal Company was one of the first mining companies in the canyon, conducting their operations between 1890 and 1970. Subsequently, McCulloch Oil purchased the site followed by Franklin Real Estate, Price River Coal and Castle Gate Coal Company. Plateau Mining Corporation currently owns the property. In recent years the disturbed areas of Sowbelly Canyon have been reclaimed with the final seeding accomplished in Fall 1995. Preliminary vegetation sampling has been conducted since that time to monitor the early establishment of the revegetated plant communities.

## General Site Description

The average elevation of the Reclaimed and Reference Areas of Sowbelly Canyon is approximately 7,000 ft above sea level. The canyon sides are dominated by pinyon-juniper and Gambel's oak/grass plant communities. Most of the Reclaimed Areas are located near the canyon bottoms that, prior to disturbance, were probably once dominated by Gambel's oak, sagebrush and grass communities. During reclamation activities, a drainage channel was re-created at the canyon bottoms. The Reclaimed Areas were seeded with native plant species. In addition, containerized plant species such as serviceberry (*Amelanchier utahensis*), chokecherry (*Prunus virginiana*), willows (*Salix* spp.), and Wood's rose (*Rosa woodsii*) have been transplanted along

the channel in the valley bottom.

### Reference Area

A general Reference Area to be used as a standard for final revegetation success was chosen at a much earlier date. The Mining and Reclamation Plan (MRP) stated that "*the AML Reference Areas shown on Exhibit 9-6 will be used to evaluate previously mined areas*". Because the AML (Abandoned Mined Lands) areas were relatively extensive, at least for use as one Reference Area, biologists from DOGM along with representatives from Plateau Mining Corp., chose a smaller portion of the AML areas as a Reference Area for Sowbelly Canyon. This Reference Area was located down-canyon (or south) and very close to the Reclaimed Areas.

## **METHODS**

Quantitative and qualitative data were taken from the vegetation of the Reclaimed and Reference Areas in Sowbelly Canyon. Sampling was conducted in mid-August, 2004. Methodologies used for sampling were performed in accordance with the guidelines provided by DOGM.

### Transect and Quadrat Placement

Random/regular placement of sample quadrats were designed as an attempt to provide unbiased accuracy of the data compiled. This was accomplished by establishing several long transect lines along the entire length of the Reclaimed Areas. These lines were placed in the lowest portion of the reclaimed drainage system. At regular intervals along the drainage transect lines, random numbers were generated and used to measure distances at right angles from the drainage and to determine sample locations. Whether these random numbers were odd or even determined which side of the drainage (east or west) a given quadrat was placed. The random numbers selected could be high enough to place quadrats to the lateral limits of the Reclaimed Areas and all areas in-between. This insured that the sample quadrats were placed randomly over the entire study area in an attempt to adequately represent the site as a whole. The sample points that were placed randomly in the drainage bottom (or potential riparian area) were marked on the raw data sheets so they could be studied separately if desired.

### Cover, Frequency and Composition

Cover estimates were made using ocular methods with meter square quadrats. Species composition and relative frequencies were also assessed from the quadrats. Additional information recorded on the raw data sheets were: estimated precipitation, slope, exposure, grazing use, animal disturbance and other appropriate notes. Plant nomenclature follows "A Utah Flora" (Welsh et al. 2003).

## Sample Size & Adequacy

Sampling adequacy was calculated using formula given below.

$$n_{MIN} = \frac{t^2 s^2}{(dx)^2}$$

where,

$n_{MIN}$	=	minimum adequate sample
$t$	=	appropriate confidence t-value
$s$	=	standard deviation
$x$	=	sample mean
$d$	=	desired change from mean

The values used for “t” and “d” insured that sample adequacy was met with 90% confidence within a 10% deviation from the true mean.

## Diversity & Similarity Indices

There are several well-documented methods to assess diversity and similarities in plant communities. The “Motyka Index” is a modified form of the “Sorenson Index”, both similarity indices. This index was used on the data and the equation is shown below:

$$IS_{MO} = \left( \frac{2MW}{MA+MB} \right) \times 100$$

where,

$MW$	=	$\sum$ of the smaller quantitative values of species of two communities,
$MA$	=	$\sum$ of the quantitative values of all species in one community,
$MB$	=	$\sum$ of the quantitative values of all species in another community.

A diversity index has been reported in this document for the Reclaimed and Reference Areas. MacArthur's Diversity Index is an effective diversity measurement and is computed using the following equation:

$$1/\sum p_i^2$$

where,

$p_i$  is the proportion of sum frequency contributed by the  $i$ th species in the sample area of concern.

The proportional contribution of each species is then squared and the values for all species in the sample areas are summed. This index integrates the number of species and the degree to which frequency of occurrence was equitably distributed among those species.

### Photographs

Color photographs of the sample areas were taken at the time of sampling and submitted with this report.

### Raw Data

The raw data for total cover, cover by species, frequency and composition were also submitted in the Appendix of this report which should facilitate future scrutiny of the data and further statistical testing if desired.

## RESULTS

### Reclaimed Area

The total living cover for the combined data of the Reclaimed Areas in Sowbelly Canyon was 54.00% (Table 1-A). Grasses were the dominant lifeform in these areas comprising 61.30% of the total living understory cover, followed next by shrubs at 20.53% and forbs at 18.16% (Table 1-B).

The dominant plant species in the reclaimed areas were rubber rabbitbrush (*Chrysothamnus nauseosus*), thickspike wheatgrass (*Elymus lanceolatus*), blueleaf aster (*Aster glaucodes*) and Western wheatgrass (*Elymus smithii*). For a list of all plant species present in the sample quadrats along with their cover and frequency values, refer to Table 2.

### Reference Area

The Reference Area, or area chosen as revegetation success standards, had a total living cover of 45.50% (Table 3-A). Like the reclaimed areas, grasses were the dominant lifeform and comprised 63.53% of the total living cover. Shrubs and grasses were nearly identical in their proportion of the total living cover (Table 3-B).

The plant species that dominated the Reference Area were thickspike wheatgrass, Western

wheatgrass, rubber rabbitbrush and cheatgrass (*Bromus tectorum*). For cover and frequency values by species refer to Table 4.

### Data Set Comparisons

Comparisons were made between the data of the Reclaimed and Reference Areas. First, statistical tests were implemented comparing the total living plant cover of the two areas. A “Student’s t-test” analysis suggested the Reclaimed Areas were significantly higher for total living cover when compared to the Reference Area (Fig. 1).

**FIG. 1. STUDENT’S T TEST - A Total Living Cover Comparison Between the Reclaimed and Reference Areas at Sowbelly Canyon (2004).**

Reclaimed Area:  $\bar{x}=54.00$ ;  $s=11.74$ ;  $n=80$

Reference Area:  $\bar{x}=49.50$ ;  $s=12.46$ ;  $n=50$

$t = 2.077$ ;  $df = 128$ ,  $SL = p < .05$

Next, similarity and diversity indices were computed and the areas were compared. The Motyka Index was recommended to be used to compare species diversity in the Mining and Reclamation Plan (MRP). Although this index is more of a ‘similarity index’ than a ‘diversity index’, it has been employed to compare the data sets. The MRP assigned the following categories to be used for comparisons in the Motyka Index:

Non-Weedy Shrub Cover,  
Weedy Shrub Cover,  
Native Perennial Grass Cover,  
Introduced Perennial Grass Cover,  
Non-Weedy Forb & Grass Cover,  
Weedy Forb & Grass Cover.

When using the above categories and employing the Motyka Index, the similarity value for the two communities was 83.89% (Fig. 2).

**FIG. 2. MOTYKA INDEX - A Comparison Between the Reclaimed and Reference Areas at Sowbelly Canyon (2004).**

$$IS_{MO} = \left( \frac{2MW}{MA+MB} \right) \times 100 = 83.886$$

MacArthur's Diversity Index was also employed

to the data sets of the Reclaimed and Reference Areas. This comparison suggests that the total diversity of the Reclaimed Area was greater than that of the Reference Area (Fig. 3).

## DISCUSSION

Plateau Mining Corporation (PMC) and State of Utah, Division of Oil, Gas and Mining (DOG M)

**FIG. 3. MacARTHUR'S INDEX - A Comparison Between the Reclaimed and Reference Areas at Sowbelly Canyon (2004).**

$$1/\sum p_i^2 =$$

Reclaimed Area: 12.250

Reference Area: 10.354

worked together formulating revegetation success standards for the Mining and Reclamation Plan in Sowbelly Canyon. Because the area was disturbed by mining operations prior to the current revegetation regulations and requirements, standards for revegetation success were modified. State

regulation R645-301-356.250 states that: *"for areas previously disturbed by mining that were not reclaimed to the requirements of R645-200 through R645-203 and R645-301 through R645-302 and that are remined or otherwise redisturbed by coal mining and reclamation operations, at a minimum, the vegetative ground cover will be not less than the ground cover existing before*

*redisturbance and will be adequate to control erosion”.*

The Sowbelly Canyon area was continuously mined since the time it was first disturbed by mining activities. Because of this there was no vegetative cover data “existing before redisturbance” as mentioned above in the state regulation. Therefore, DOGM and PMC agreed that upon final reclamation the standards for revegetation success would be determined using a specific Reference Area – but success parameters would be dictated more from the species present, diversity and similarity indices rather than strictly by cover, productivity and woody species density as the more recent regulations would dictate. Erosion control (as stated in the regulation above) should also be considered for a successful revegetation standard.

With the above considerations, sampling quantitatively for cover would still be necessary in the Reclaimed and Disturbed Areas to adequately address the success standards. That said, and even though such a comparison was not necessary here, the total living cover was significantly greater statistically when compared to the Reference Area. Moreover, the plant species present in the quadrats were comprised almost exclusively of “desirable” rather than “weedy” species. Not only does this suggest successful revegetation from a cover perspective, but it also suggests that erosion control is probably better in the Reclaimed Area when compared to the Reference Area.

In addition, as shown in the RESULTS section above, diversity and similarity indices revealed favorable results for the Reclaimed Areas in Sowbelly Canyon when compared to the Reference Area. In other words, the Reclaimed Areas were more diverse than the Reference Area, but the

two areas were still quite similar.

The vegetation monitoring data show that if bond release were based on this sample period (the first of a two-year vegetation monitoring plan), Phase III Bond Release may be warranted.

However, final bond release is to be based on two consecutive sample years. Therefore, the area should be re-sampled in 2005 to determine whether or not the same results apply.

**TABLE 1:** Total cover and composition summary for the Reclaimed Areas in Sowbelly Canyon (2004).

<b>A. TOTAL COVER</b>	<b>% MEAN COVER</b>	<b>STANDARD DEVIATION</b>	<b>SAMPLE SIZE</b>
Overstory Living	0.31	2.78	80
Understory Living	53.69	12.03	80
Litter	15.13	9.91	80
Bareground	15.46	11.54	80
Rock	15.73	10.55	80
<b>Total Living Cover</b>	<b>54.00</b>	<b>11.74</b>	<b>80</b>
<b>B. COMPOSITION</b>			
Shrubs	20.53	28.37	80
Forbs	18.16	23.97	80
Grasses	61.30	31.66	80

**TABLE 2:** Species cover and frequency summary for the Reclaimed Areas in Sowbelly Canyon (2004).

<b>SPECIES</b>	<b>% MEAN COVER</b>	<b>STANDARD DEVIATION</b>	<b>SAMPLE SIZE</b>	<b>RELATIVE FREQUENCY</b>
<b>OVERSTORY</b>				
<i>Acer grandidentatum</i>	0.31	2.78	80	1.25
<b>TREES &amp; SHRUBS</b>				
<i>Amelanchier utahensis</i>	0.06	0.56	80	1.25
<i>Artemisia tridentata</i>	0.81	3.30	80	8.75
<i>Atriplex canescens</i>	1.63	6.26	80	7.50
<i>Ceratoides lanata</i>	0.94	4.41	80	5.00
<i>Chrysothamnus nauseosus</i>	7.66	16.38	80	27.50
<i>Gutierrezia sarothrae</i>	0.13	0.78	80	2.50
<i>Symphoricarpos oreophilus</i>	0.69	6.11	80	1.25
<b>FORBS</b>				
<i>Achillea millefolium</i>	0.04	0.33	80	1.25
<i>Artemisia drucunculus</i>	0.38	1.73	80	5.00
<i>Aster glaucodes</i>	6.38	12.25	80	36.25
<i>Grindelia squarrosa</i>	0.46	1.75	80	10.00
<i>Hedysarum boreale</i>	0.06	0.56	80	1.25
<i>Iva axillaris</i>	0.50	4.44	80	1.25
<i>Linum lewisii</i>	0.61	2.66	80	7.50
<i>Machaeranthera canescens</i>	0.44	1.62	80	7.50
<i>Melilotus officinalis</i>	0.31	1.99	80	2.50
<i>Salsola pestifer</i>	0.13	1.11	80	1.25
<b>GRASSES</b>				
<i>Agropyron cristatum</i>	1.13	5.24	80	7.50
<i>Bromus tectorum</i>	0.50	1.87	80	7.50
<i>Dactylis glomerata</i>	0.06	0.56	80	1.25
<i>Elymus cinereus</i>	4.81	11.22	80	25.00
<i>Elymus hispidus</i>	0.38	2.06	80	3.75
<i>Elymus junceus</i>	0.19	1.24	80	2.50
<i>Elymus lanceolatus</i>	7.56	10.90	80	48.75
<i>Elymus salinus</i>	1.56	6.96	80	6.25
<i>Elymus smithii</i>	6.16	9.56	80	43.75
<i>Elymus spicatus</i>	4.69	13.13	80	13.75
<i>Elymus trachycaulus</i>	0.56	4.03	80	2.50
<i>Poa pratensis</i>	0.44	2.52	80	3.75
<i>Poa secunda</i>	4.13	11.67	80	17.50
<i>Stipa hymenoides</i>	0.31	2.28	80	2.50

**TABLE 3:** Total cover and composition summary for the Reference Area in Sowbelly Canyon (2004).

---

<b>A. TOTAL COVER</b>	<b>% MEAN COVER</b>	<b>STANDARD DEVIATION</b>	<b>SAMPLE SIZE</b>
Total Living	45.50	12.46	50
Litter	18.60	14.39	50
Bareground	11.80	8.76	50
Rock	24.10	17.51	50

---

**B. COMPOSITION**

Shrubs	18.44	23.61	50
Forbs	18.04	20.59	50
Grasses	63.53	26.25	50

---

**TABLE 4:** Species cover and frequency summary for the Reference Area in Sowbelly Canyon (2004).

<b>SPECIES</b>	<b>% MEAN COVER</b>	<b>STANDARD DEVIATION</b>	<b>SAMPLE SIZE</b>	<b>RELATIVE FREQUENCY</b>
<b>TREES &amp; SHRUBS</b>				
<i>Artemisia tridentata</i>	0.50	3.50	50	2.00
<i>Atriplex canescens</i>	3.24	7.81	50	20.00
<i>Chrysothamnus nauseosus</i>	4.60	7.93	50	36.00
<i>Gutierrezia sarothrae</i>	0.40	1.69	50	6.00
<b>FORBS</b>				
<i>Artemisia ludoviciana</i>	1.96	3.44	50	34.00
<i>Aster glaucodes</i>	3.70	8.30	50	32.00
<i>Chenopodium sp.</i>	0.10	0.70	50	2.00
<i>Grindelia squarrosa</i>	0.26	1.05	50	6.00
<i>Machaeranthera grindelioides</i>	1.04	2.72	50	16.00
<i>Melilotus officinalis</i>	0.10	0.70	50	2.00
<i>Penstemon palmeri</i>	0.90	4.32	50	8.00
<b>GRASSES</b>				
<i>Bromus inermis</i>	2.30	7.63	50	20.00
<i>Bromus tectorum</i>	4.70	9.61	50	30.00
<i>Dactylis glomerata</i>	0.20	1.40	50	2.00
<i>Elymus lanceolatus</i>	10.30	12.47	50	62.00
<i>Elymus salinus</i>	0.20	1.40	50	2.00
<i>Elymus smithii</i>	9.10	13.18	50	42.00
<i>Poa secunda</i>	0.20	0.98	50	4.00
<i>Stipa hymenoides</i>	1.70	3.55	50	22.00

# COLOR PHOTOGRAPHS

## Reclaimed Areas

(Walking North to South)







Reference Area



**APPENDIX**

Raw Data

PLATEAU MINING

Sowbelly

Reclaimed Area

R = Riparian

Exposure: Variable

Slope: Variable

Sample Date: 17 Aug 2004

R  
1.00 2.00 3.00 4.00 5.00 6.00 7.00

OVERSTORY

*Acer grandidentatum* 0.00 0.00 0.00 0.00 0.00 0.00 0.00

TREES & SHRUBS

*Amelanchier utahensis* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Artemisia tridentata* 0.00 0.00 5.00 0.00 0.00 0.00 0.00  
*Atriplex canescens* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Ceratoides lanata* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Chrysothamnus nauseosus* 0.00 0.00 0.00 0.00 0.00 0.00 15.00  
*Gutierrezia sarothrae* 0.00 5.00 0.00 0.00 0.00 0.00 0.00  
*Symphoricarpos oreophilus* 0.00 0.00 0.00 0.00 0.00 0.00 0.00

FORBS

*Achillea millefolium* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Artemisia drucunculus* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Aster glaucodes* 0.00 0.00 0.00 8.00 4.00 10.00 3.00  
*Grindelia squarrosa* 0.00 0.00 2.00 0.00 0.00 1.00 0.00  
*Hedysarum boreale* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Iva axillaris* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Linum lewisii* 0.00 0.00 0.00 7.00 1.00 4.00 2.00  
*Machaeranthera canescens* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Melilotus officinalis* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Salsola pestifer* 0.00 0.00 0.00 0.00 0.00 0.00 0.00

GRASSES

*Agropyron cristatum* 0.00 0.00 0.00 10.00 30.00 0.00 35.00  
*Bromus tectorum* 0.00 5.00 0.00 0.00 0.00 0.00 0.00  
*Dactylis glomerata* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Elymus cinereus* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Elymus hispidus* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Elymus junceus* 0.00 0.00 0.00 0.00 0.00 10.00 0.00  
*Elymus lanceolatus* 25.00 25.00 10.00 0.00 0.00 40.00 0.00  
*Elymus salinus* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Elymus smithii* 20.00 5.00 18.00 0.00 10.00 0.00 10.00  
*Elymus spicatus* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Elymus trachycaulus* 0.00 0.00 0.00 10.00 0.00 0.00 0.00  
*Poa pratensis* 0.00 5.00 0.00 0.00 0.00 0.00 0.00  
*Poa secunda* 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
*Stipa hymenoides* 0.00 0.00 0.00 5.00 0.00 0.00 0.00

COVER

Overstory 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
 Total Living Cover 45.00 45.00 35.00 40.00 45.00 65.00 65.00  
 Litter 30.00 20.00 5.00 15.00 30.00 25.00 20.00  
 Bareground 15.00 5.00 35.00 30.00 15.00 5.00 10.00  
 Rock 10.00 30.00 25.00 15.00 10.00 5.00 5.00

% COMPOSITION

Shrubs 0.00 11.11 14.29 0.00 0.00 0.00 23.08  
 Forbs 0.00 0.00 5.71 37.50 11.11 23.08 7.69  
 Grasses 100.00 88.89 80.00 62.50 88.89 76.92 69.23

Overstory + Understory 45.00 45.00 35.00 40.00 45.00 65.00 65.00

	R		R				R	R	
8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45.00	0.00	40.00	0.00	5.00	5.00	13.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	25.00	2.00	0.00	0.00	5.00
0.00	0.00	0.00	2.00	0.00	0.00	0.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	15.00	0.00	0.00	45.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	20.00	20.00	10.00	5.00	0.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	45.00	0.00	0.00	0.00
0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	20.00
0.00	35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60.00	50.00	65.00	40.00	65.00	45.00	60.00	40.00	35.00	35.00
30.00	15.00	10.00	10.00	20.00	35.00	10.00	20.00	10.00	15.00
5.00	20.00	5.00	10.00	10.00	10.00	20.00	5.00	10.00	15.00
5.00	15.00	20.00	40.00	5.00	10.00	10.00	35.00	45.00	35.00
75.00	0.00	61.54	0.00	7.69	11.11	21.67	0.00	0.00	14.29
0.00	0.00	0.00	12.50	0.00	55.56	3.33	25.00	0.00	28.57
25.00	100.00	38.46	87.50	92.31	33.33	75.00	75.00	100.00	57.14
60.00	50.00	65.00	40.00	65.00	45.00	60.00	40.00	35.00	35.00













PLATEAU MINING  
 Sowbelly  
 Reclaimed Area  
 Exposure: Variable  
 Slope: Variable  
 Sample Date: 17 Aug 2004

78.00	79.00	80.00	Mean	SDev	Freq	
<hr/>						OVERSTORY
0.00	0.00	0.00	0.31	2.78	1.25	<i>Acer grandidentatum</i>
<hr/>						TREES & SHRUBS
0.00	0.00	0.00	0.06	0.56	1.25	<i>Amelanchier utahensis</i>
0.00	0.00	0.00	0.81	3.30	8.75	<i>Artemisia tridentata</i>
0.00	0.00	0.00	1.63	6.26	7.50	<i>Atriplex canescens</i>
0.00	0.00	0.00	0.94	4.41	5.00	<i>Ceratoides lanata</i>
0.00	0.00	0.00	7.66	16.38	27.50	<i>Chrysothamnus nauseosus</i>
0.00	0.00	0.00	0.13	0.78	2.50	<i>Gutierrezia sarothrae</i>
0.00	0.00	0.00	0.69	6.11	1.25	<i>Symphoricarpos oreophilus</i>
<hr/>						FORBS
0.00	0.00	0.00	0.04	0.33	1.25	<i>Achillea millefolium</i>
0.00	0.00	0.00	0.38	1.73	5.00	<i>Artemisia drucunculus</i>
0.00	0.00	0.00	6.38	12.25	36.25	<i>Aster glaucodes</i>
0.00	0.00	0.00	0.46	1.75	10.00	<i>Grindelia squarrosa</i>
0.00	0.00	0.00	0.06	0.56	1.25	<i>Hedysarum boreale</i>
0.00	0.00	0.00	0.50	4.44	1.25	<i>Iva axillaris</i>
0.00	0.00	20.00	0.61	2.66	7.50	<i>Linum lewisii</i>
0.00	0.00	0.00	0.44	1.62	7.50	<i>Machaeranthera canescens</i>
0.00	0.00	0.00	0.31	1.99	2.50	<i>Melilotus officinalis</i>
0.00	0.00	0.00	0.13	1.11	1.25	<i>Salsola pestifer</i>
<hr/>						GRASSES
0.00	0.00	0.00	1.13	5.24	7.50	<i>Agropyron cristatum</i>
0.00	0.00	5.00	0.50	1.87	7.50	<i>Bromus tectorum</i>
0.00	0.00	0.00	0.06	0.56	1.25	<i>Dactylis glomerata</i>
5.00	0.00	0.00	4.81	11.22	25.00	<i>Elymus cinereus</i>
0.00	0.00	0.00	0.38	2.06	3.75	<i>Elymus hispidus</i>
0.00	0.00	0.00	0.19	1.24	2.50	<i>Elymus junceus</i>
0.00	0.00	5.00	7.56	10.90	48.75	<i>Elymus lanceolatus</i>
0.00	0.00	0.00	1.56	6.96	6.25	<i>Elymus salinus</i>
0.00	0.00	10.00	6.16	9.56	43.75	<i>Elymus smithii</i>
50.00	0.00	0.00	4.69	13.31	13.75	<i>Elymus spicatus</i>
0.00	0.00	0.00	0.56	4.03	2.50	<i>Elymus trachycaulus</i>
0.00	0.00	0.00	0.44	2.52	3.75	<i>Poa pratensis</i>
10.00	40.00	5.00	4.13	11.67	17.50	<i>Poa secunda</i>
0.00	0.00	0.00	0.31	2.28	2.50	<i>Stipa hymenoides</i>
<hr/>						COVER
0.00	0.00	0.00	0.31	2.78		Overstory
65.00	40.00	45.00	53.69	12.03		Total Living Cover
20.00	20.00	10.00	15.13	9.91		Litter
10.00	10.00	30.00	15.46	11.54		Bareground
5.00	30.00	15.00	15.73	10.55		Rock
<hr/>						% COMPOSITION
0.00	0.00	0.00	20.53	28.37		Shrubs
0.00	0.00	44.44	18.16	23.97		Forbs
100.00	100.00	55.56	61.30	31.66		Grasses
<hr/>						Overstory + Understory
65.00	40.00	45.00	54.00	11.74		

PLATEAU MINING  
 Sowbelly Reference Area  
 Exposure: Variable  
 Slope: Variable  
 Sample Date: 18 Aug 2004

1.00      2.00      3.00      4.00      5.00      6.00      7.00

OVERSTORY

TREES & SHRUBS

<i>Artemisia tridentata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Atriplex canescens</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Chrysothamnus nauseosus</i>	30.00	15.00	5.00	5.00	0.00	0.00	0.00
<i>Gutierrezia sarothrae</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FORBS

<i>Artemisia ludoviciana</i>	0.00	5.00	0.00	0.00	0.00	5.00	0.00
<i>Aster glaucodes</i>	5.00	10.00	0.00	50.00	5.00	0.00	5.00
<i>Chenopodium sp.</i>	0.00	0.00	0.00	0.00	0.00	5.00	0.00
<i>Grindelia squarrosa</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Machaeranthera grindelioides</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Melilotus officinalis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Penstemon palmeri</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

GRASSES

<i>Bromus tectorum</i>	0.00	0.00	0.00	0.00	0.00	10.00	5.00
<i>Dactylis glomerata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Bromus inermis</i>	5.00	10.00	0.00	5.00	0.00	0.00	0.00
<i>Elymus lanceolatus</i>	15.00	5.00	30.00	5.00	5.00	5.00	0.00
<i>Elymus salinus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus smithii</i>	0.00	0.00	30.00	0.00	35.00	5.00	5.00
<i>Poa secunda</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Stipa hymenoides</i>	0.00	0.00	0.00	0.00	5.00	0.00	10.00

COVER

Overstory	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Living Cover	55.00	45.00	65.00	65.00	50.00	30.00	25.00
Litter	15.00	35.00	20.00	25.00	35.00	50.00	20.00
Bareground	15.00	10.00	10.00	5.00	5.00	10.00	10.00
Rock	15.00	10.00	5.00	5.00	10.00	10.00	45.00

% COMPOSITION

Shrubs	54.55	33.33	7.69	7.69	0.00	0.00	0.00
Forbs	9.09	33.33	0.00	76.92	10.00	33.33	20.00
Grasses	36.36	33.33	92.31	15.38	90.00	66.67	80.00

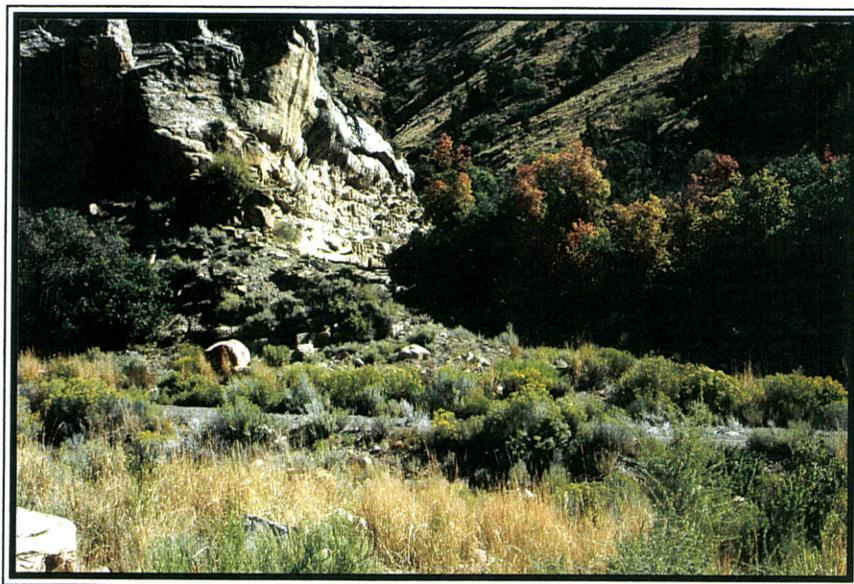
Overstory + Understory	55.00	45.00	65.00	65.00	50.00	30.00	25.00
------------------------	-------	-------	-------	-------	-------	-------	-------

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00
0.00	0.00	35.00	25.00	0.00	0.00	20.00	0.00	0.00	0.00
10.00	0.00	15.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00
5.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	5.00	5.00	30.00	10.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	25.00	15.00	35.00	5.00	25.00	0.00	0.00	30.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45.00	25.00	65.00	65.00	35.00	40.00	25.00	30.00	50.00	50.00
35.00	5.00	15.00	20.00	15.00	10.00	65.00	60.00	10.00	45.00
5.00	5.00	5.00	5.00	5.00	10.00	5.00	5.00	5.00	15.00
15.00	65.00	15.00	10.00	45.00	40.00	5.00	5.00	35.00	-10.00
22.22	0.00	76.92	46.15	14.29	12.50	80.00	0.00	0.00	70.00
22.22	0.00	0.00	0.00	28.57	0.00	0.00	0.00	20.00	0.00
55.56	100.00	23.08	53.85	57.14	87.50	20.00	100.00	80.00	30.00
45.00	25.00	65.00	65.00	35.00	40.00	25.00	30.00	50.00	50.00



VEGETATION MONITORING  
FOR PHASE III BOND RELEASE  
IN HARDSCRABBLE CANYON, UTAH  
2008 - 2009

FOR THE  
CASTLE GATE HOLDING COMPANY



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February 2010

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## INTRODUCTION

### Objectives for Monitoring

Hardscrabble Canyon, once the site of early coal mining activities, has been reclaimed and restored to native plant communities similar to those that existed prior to the disturbance by mining. Enough time has passed that the “*Responsibility Period*” for the site has been achieved.

This means that the vegetation has been established for a time period long enough that specific parameters can be compared to those pre-set as standards for final revegetation success. If revegetation is deemed successful, an application for *final* or **Phase III Bond Release** can be submitted through the State of Utah, Division of Oil, Gas and Mining (DOGGM).

This report has been prepared to supplement the bond release application. Phase III Bond Release requires a more intensive vegetation sampling regime than was required for Phase II Bond Release; it also requires two consecutive years of quantitative datasets. Consequently, vegetation sampling was conducted in 2008, and again in 2009. This report describes the *complete* methods and results for the quantitative sampling conducted in 2009 (Year 2 of the required two sample years), however, it also incorporates some summary information from the 2008 sample period (Year 1) to facilitate comparisons. For the *complete* report for 2008, refer to the earlier document called *Vegetation Monitoring for Phase III Bond Release in Hardscrabble Canyon, Year 1: 2008*.

## General Site Description

Hardscrabble Canyon is located in Carbon County, Utah and has a rich history in coal mining activities. Those areas previously disturbed by the mining activities have been reclaimed and reseeded with the final seed mixture, most of which were native plant species.

The average elevation of the Reclaimed Areas in Hardscrabble Canyon was approximately 6,700 ft above sea level. The canyon sides are dominated by pinyon-juniper and Gambel's oak/grass plant communities. Most of the Reclaimed Areas were located near the canyon bottoms that, prior to disturbance, were probably once dominated by Gambel's oak, sagebrush and grass communities.

## Reference Area

A Reference Area to be used as standards for final revegetation success was chosen at a much earlier date by representatives of the mining company and DOGM. The Mining and Reclamation Plan (MRP) states that "the AML Reference Areas shown on Exhibit 9-6 will be used to evaluate previously mined areas". Because the AML (State of Utah, Division of Oil, Gas & Mining, Abandoned Mined Lands Program) areas were relatively extensive, at least to be sampled as one Reference Area, a biologist from DOGM along with a representative from Plateau Mining Corporation, chose a smaller portion of the AML areas that would be appropriate to be used as the Reference Area for the revegetation at Hardscrabble Canyon. This area was located in a

nearby area called Sowbelly Canyon. More specifically, the Reference Area was located down-canyon (or south) and very close to the previously disturbed mined areas that have also been reclaimed in Sowbelly Canyon. In fact, it is the same Reference Area that was used for a standards for revegetation success in the Reclaimed Areas of Sowbelly Canyon, another area once disturbed by early mining activities.

## METHODS

Quantitative and qualitative data were taken from the vegetation of the Reclaimed Areas in Hardscrabble Canyon and the Reference Area in Sowbelly Canyon. Sampling was conducted in September 2009. Methodologies used for sampling were performed in accordance with the *Vegetation Information Guidelines* supplied by DOGM. (Note: Neither woody species density nor annual biomass production measurements were not required parameters for final bond release in Hardscrabble Canyon).

### Transect and Quadrat Placement

Random/regular placement of sample quadrats were designed in an attempt to provide unbiased accuracy of the data compiled. This was accomplished by establishing one long transect line along the entire length of the Reclaimed Areas. This line was placed in the lowest portion of the reclaimed drainage system. At regular intervals along the drainage transect line, random numbers were generated and used to measure distances at right angles from the drainage and to

determine sample locations. Whether these random numbers were odd or even determined which side of the drainage a given quadrat was placed. The random number selected would be high enough to place quadrats to the lateral limits of the Reclaimed Areas and all areas in-between. This insured that the sample quadrats were placed randomly over the entire study area in an attempt to adequately represent the site as a whole.

### Cover, Frequency and Composition

Cover estimates were made using ocular methods with meter square quadrats. Species composition and relative frequencies were also assessed from the quadrats. Additional information recorded on the raw data sheets were: estimated precipitation, slope, exposure, grazing use, animal disturbance and other appropriate notes. Plant nomenclature follows "A Utah Flora" (Welsh et al. 2003).

### Sample Size & Adequacy

Sampling adequacy was calculated using the formula given below.

$$n_{MIN} = \frac{t^2 s^2}{(dx)^2}$$

where,

$n_{MIN}$  = minimum adequate sample  
t = appropriate confidence t-value  
s = standard deviation  
x = sample mean  
d = desired change from mean

The values used for “t” and “d” insured that sample adequacy was met with 90% confidence within a 10% deviation from the true mean.

### Diversity & Similarity Indices

There are several well-documented methods to assess diversity and similarities in plant communities. The “Motyka Index” is a modified form of the “Sorenson Index”, both similarity indices. This index was used on the data and the equation is shown below:

$$IS_{MO} = \left( \frac{2MW}{MA+MB} \right) \times 100$$

where,

MW =  $\sum$  of the smaller quantitative values of species of two communities,  
MA =  $\sum$  of the quantitative values of all species in one community,  
MB =  $\sum$  of the quantitative values of all species in another community.

Two diversity indices have been reported in this document for the Reclaimed and Reference Areas. MacArthur's Diversity Index is an effective diversity measurement and is computed using the following equation:

$$1/\sum p_i^2$$

where,

$p_i$  is the proportion of sum frequency contributed by the  $i$ th species in the sample area of concern.

The proportional contribution of each species is then squared and the values for all species in the sample areas are summed. This index integrates the number of species and the degree to which frequency of occurrence was equitably distributed among those species.

Another diversity measurement was provided that shows the average number of species encountered at each quadrat, providing a value for species diversity.

### Photographs

Color photographs of the study areas were taken at the time of sampling and submitted with this report.

### Raw Data

The raw data for total cover, cover by species, frequency and composition were also submitted in the Appendix of this report which should facilitate future scrutiny of the data and further statistical testing if desired.

## RESULTS

### Reclaimed Areas

In 2009, sampling results of the Reclaimed Areas in Hardscrabble Canyon showed the most common shrub species for cover and frequency were rubber rabbitbrush (*Chrysothamnus nauseosus*), fourwing saltbush (*Atriplex canescens*) and big sagebrush (*Artemisia tridentata*). The most common forbs were Pacific aster (*Aster ascendens*), Palmer penstemon (*Penstemon palmeri*) and tarragon (*Artemisia dracunculus*). Finally, the most common grasses were bluebunch wheatgrass (*Elymus spicatus*), Gt. Basin wildrye (*E. cinereus*) and western wheatgrass (*E. smithii*). For a list of all species present in the sample quadrats by cover and frequency, refer to Table 1.

The total living cover for the Reclaimed Areas in Hardscrabble Canyon in 2009 was 53.70% (Table 2-A), of which 45.44% of this cover were comprised of grasses, 39.39% from shrubs and 15.17% from forbs (Table 2-B).

### Reference Area

As noted previously, the Reference Area chosen to represent revegetation success standards for the Reclaimed Areas in Hardscrabble Canyon was located in Sowbelly Canyon. In 2009, the most common shrub species in the Reference Area were rubber rabbitbrush and fourwing saltbush. The most common forbs were Louisiana sagewort (*Artemisia ludoviciana*) and blue-

leaf aster (*Aster glaucodes*). The most common grasses were western wheatgrass, thickspike wheatgrass (*Elymus trachycaulus*) and cheatgrass (*Bromus tectorum*). For a complete list of all species present in the sample quadrats by cover and frequency, refer to Table 3.

The total living cover for the Reference Area was 39.90% (Table 4-A). All of this cover was represented in the understory cover; it was comprised of 59.25% grasses, 21.39% forbs and 19.37% shrubs (Table 4-B).

#### Dataset Comparisons

Comparisons were made between the data of the Hardscrabble Canyon Reclaimed Areas and its Reference Area. To begin, statistical tests were implemented comparing the total living plant cover of the two areas. A

Student's t-test suggested that the Reclaimed

Areas' total living cover was significantly greater statistically when it was compared to the

Reference Area for both the 2008 and 2009 datasets (Figure 1). [NOTE: As mentioned above, some results from the 2008 study have been included in this document for comparison purposes].

Next, the Motyka Index was recommended to be used to compare species diversity in the Mining and Reclamation Plan (MRP). Although this index is more of a *similarity index* than a *diversity*

**FIGURE 1. STUDENT'S T TEST - A Comparison Between the Reclaimed Areas at Hardscrabble Canyon and its Reference Area (2008-2009).**

**2008**

Reclaimed Areas:  $\bar{x}=53.95$ ;  $s=12.17$ ;  $n=100$

Reference Area:  $\bar{x}=42.50$ ;  $s=8.85$ ;  $n=50$

$t = 5.913$ ;  $df = 148$ ,  $SL= p<0.01$

**2009**

Reclaimed Areas:  $\bar{x}=53.70$ ;  $s=13.94$ ;  $n=100$

Reference Area:  $\bar{x}=39.90$ ;  $s=9.57$ ;  $n=50$

$t = 6.293$ ;  $df = 148$ ,  $SL= p<0.01$

*index*, it has been employed here to compare the datasets. Language in the MRP assigned the following categories to be used for comparisons with the Motyka Index:

- Non-Weedy Shrub Cover,
- Weedy Shrub Cover,
- Native Perennial Grass Cover,
- Introduced Perennial Grass Cover,
- Non-Weedy Forb & Grass Cover,
- Weedy Forb & Grass Cover.

When using the above categories and employing the Motyka Index, the similarity value between the two communities was 85.120% in 2008 and 89.135% in 2009 (Figure 2).

**FIGURE 2. MOTYKA INDEX - A Comparison Between the Reclaimed Areas at Hardscrabble Canyon and its Reference Area (2008-2009).**

**2008**

$$IS_{MO} = \left( \frac{2MW}{MA+MB} \right) \times 100 = 85.120$$

**2009**

$$IS_{MO} = \left( \frac{2MW}{MA+MB} \right) \times 100 = 89.135$$

MacArthur's Diversity Index was also employed to the datasets of the Reclaimed and Reference Areas. This comparison suggested that the total diversity of the Reclaimed Areas was greater than that of the Reference Area by quite a wide margin for both years (Figure 3).

**FIGURE 3. MacARTHUR'S INDEX - A Comparison Between the Reclaimed Areas at Hardscrabble Canyon and its Reference Area (2008-2009).**

$$1/\sum p_i^2 =$$

**2008**

Reclaimed Areas: 16.933

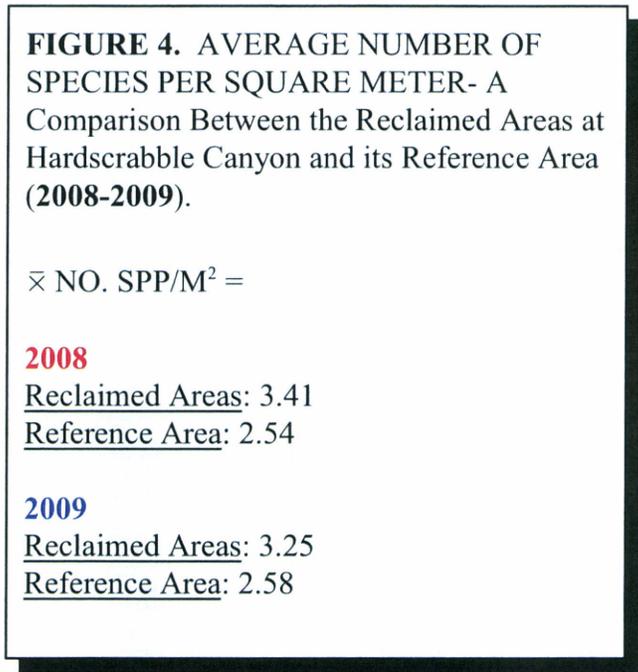
Reference Area: 10.507

**2009**

Reclaimed Areas: 16.104

Reference Area: 8.809

Another method of comparing species diversity of the two areas is to simply calculate the mean number of species present in the sample quadrats. Results from this method in 2008 and 2009 also suggested that the Reclaimed Areas were more diverse with respect to species when compared to the Reference Area (Figure 4).



## SUMMARY & CONCLUSIONS

Quantitative sampling was conducted in the Reclaimed Areas in Hardscrabble Canyon in 2008 and 2009. Additionally, sampling was conducted in a Reference Area that had been chosen previously to represent revegetation success. This report provides the complete methods and results for the 2009 study. It also provides summary results for the 2008 study to facilitate

comparisons between the two years.

The results for total living cover, similarity and diversity in 2008 and 2009 all suggest that the reclaimed site has met or exceeded the revegetation standards set by the Reference Area. Also worth mentioning is that most of the species present in the sample quadrats were “desirable” plant species, and not “weedy” exotics.

The state regulations (R645-301-353) require that the reclaimed plant cover should be “*diverse, effective and permanent*” and should “*at least equal in extent of cover to the natural vegetation of the area*”. The same regulations also state that the plant species will “*be compatible with the approved postmining land use*” and should “*have the seasonal characteristics of growth as the original vegetation*”. Finally, they should “*be capable of self-regeneration and plant succession*” and well as “*be compatible with the plant and animal species of the area*”.

In conclusion, results from quantitative sampling in 2008 and 2009 suggest that the reclaimed plant communities in Hardscrabble Canyon could be considered for final or Phase III Bond Release.

**SUMMARY TABLES**

**Table 1: Hardscrabble Canyon Area. Living Cover and Frequency by Plant Species (2009).**

<b>Reclaimed Areas</b>			n=100
	Mean Percent	Standard Deviation	Percent Frequency
<b>TREES &amp; SHRUBS</b>			
<i>Artemisia nova</i>	1.80	6.42	12.00
<i>Artemisia tridentata</i>	3.90	9.61	20.00
<i>Atriplex canescens</i>	4.05	10.86	16.00
<i>Ceratoides lanata</i>	1.20	7.28	3.00
<i>Chrysothamnus nauseosus</i>	9.60	17.37	34.00
<i>Gutierrezia sarothrae</i>	0.55	2.64	6.00
<i>Rhus aromatica</i>	0.30	2.98	1.00
<i>Suaeda torreyana</i>	0.65	5.55	2.00
<b>FORBS</b>			
<i>Achillea millefolium</i>	0.15	1.11	2.00
<i>Artemisia dracuncululus</i>	1.30	4.16	13.00
<i>Aster ascendens</i>	3.90	11.35	19.00
<i>Hedysarum boreale</i>	0.95	3.65	8.00
<i>Machaeranthera canescens</i>	0.20	1.40	2.00
<i>Medicago sativa</i>	0.05	0.50	1.00
<i>Penstemon palmeri</i>	1.30	4.22	14.00
<b>GRASSES</b>			
<i>Agropyron cristatum</i>	2.25	6.02	21.00
<i>Bromus tectorum</i>	0.95	3.98	8.00
<i>Elymus cinereus</i>	4.20	10.62	23.00
<i>Elymus hispidus</i>	0.45	4.48	1.00
<i>Elymus lanceolatus</i>	3.65	7.10	28.00
<i>Elymus salinus</i>	0.80	6.27	20.00
<i>Elymus smithii</i>	3.10	7.03	25.00
<i>Elymus spicatus</i>	5.25	10.87	27.00
<i>Poa secunda</i>	1.75	8.47	9.00
<i>Stipa hymenoides</i>	1.40	5.70	10.00

**Table 2: Hardscrabble Canyon Area. Total Cover and Composition (2009).**

<b>Reclaimed Areas</b>		n=100
<b>A. TOTAL COVER</b>	Mean Percent	Standard Deviation
Total Living Cover	53.70	13.94
Litter	11.07	4.92
Bareground	11.19	6.54
Rock	24.04	11.98
<b>B. % COMPOSITION</b>		
Shrubs	39.39	32.58
Forbs	15.17	22.74
Grasses	45.44	32.57

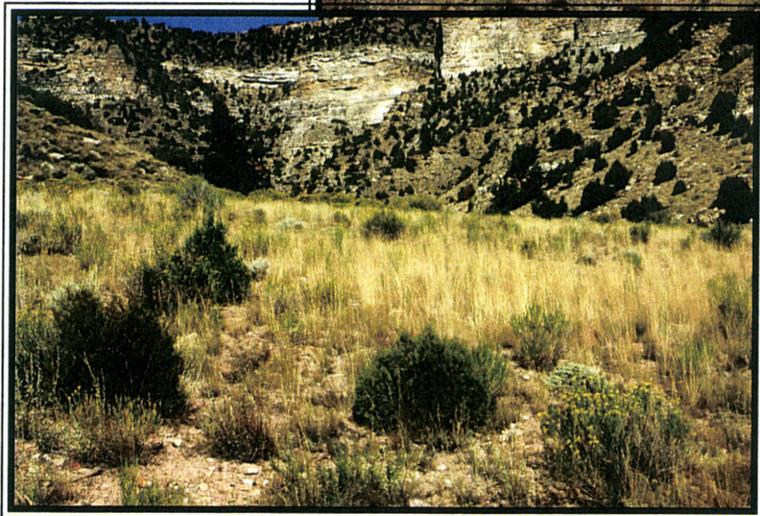
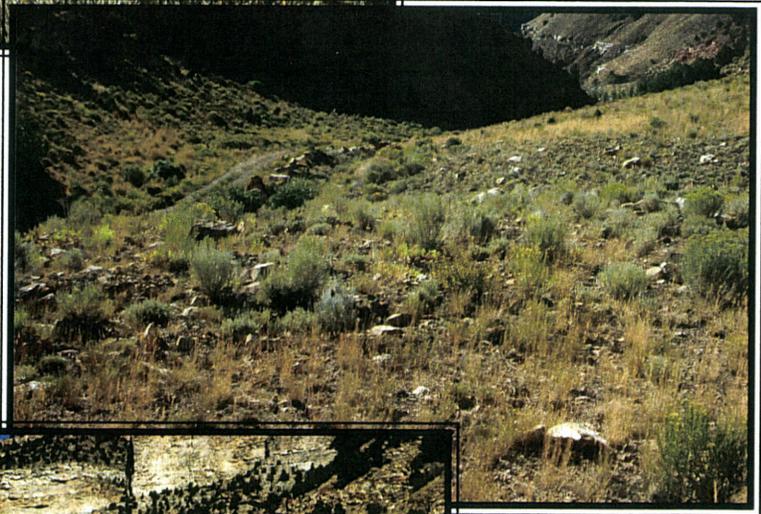
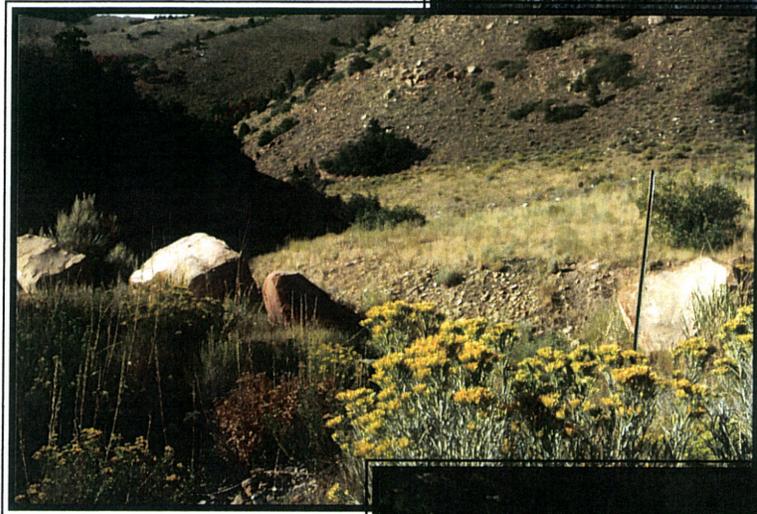
**Table 3: Hardscrabble Reference Area (located in Sowbelly Canyon). Living Cover and Frequency by Plant Species (2009).**

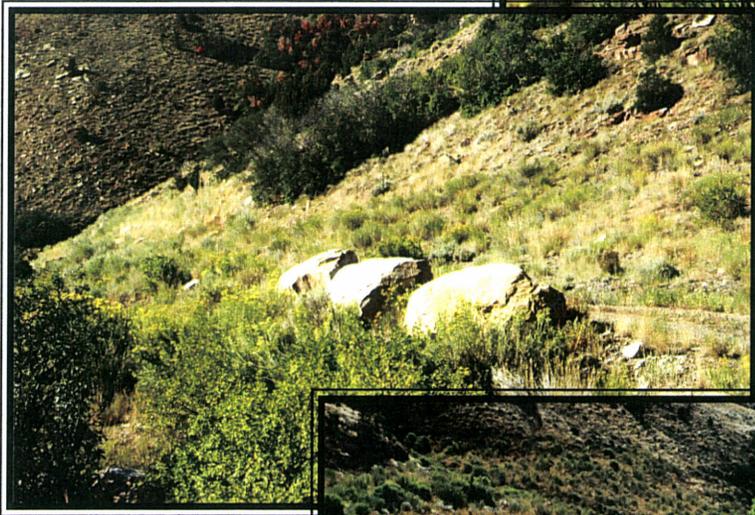
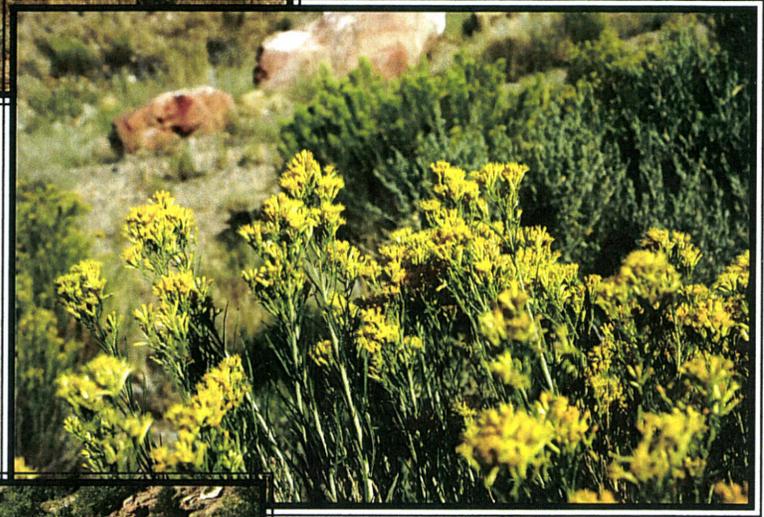
Reference Area			n=50
	Mean Percent	Standard Deviation	Percent Frequency
<b>TREES &amp; SHRUBS</b>			
<i>Atriplex canescens</i>	2.30	4.92	20.00
<i>Chrysothamnus nauseosus</i>	5.20	10.00	28.00
<i>Gutierrezia sarothrae</i>	0.50	1.80	8.00
<b>FORBS</b>			
<i>Artemisia ludoviciana</i>	4.80	7.68	36.00
<i>Aster glaucodes</i>	3.50	6.02	30.00
<i>Medicago sativa</i>	0.20	1.40	2.00
<i>Solidago sp.</i>	0.20	1.40	2.00
<b>GRASSES</b>			
<i>Bromus inermis</i>	0.20	1.40	2.00
<i>Bromus tectorum</i>	2.80	7.15	16.00
<i>Dactylis glomeratus</i>	0.60	2.15	8.00
<i>Elymus hispidus</i>	0.60	4.20	2.00
<i>Elymus lanceolatus</i>	5.90	9.52	38.00
<i>Elymus salinus</i>	1.10	5.94	4.00
<i>Elymus smithii</i>	10.10	12.90	46.00
<i>Poa secunda</i>	0.30	2.10	2.00
<i>Stipa hymenoides</i>	1.60	4.18	14.00

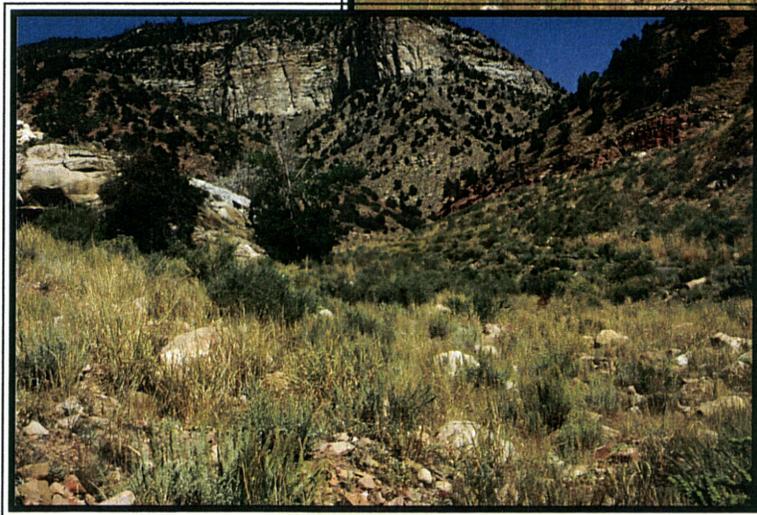
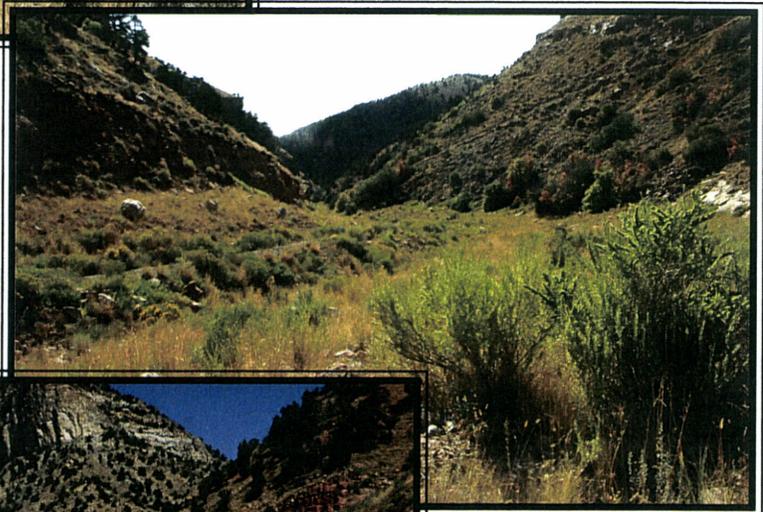
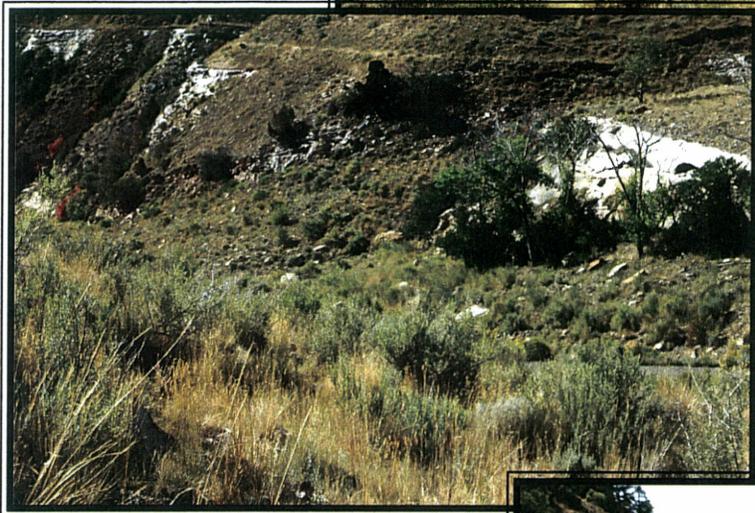
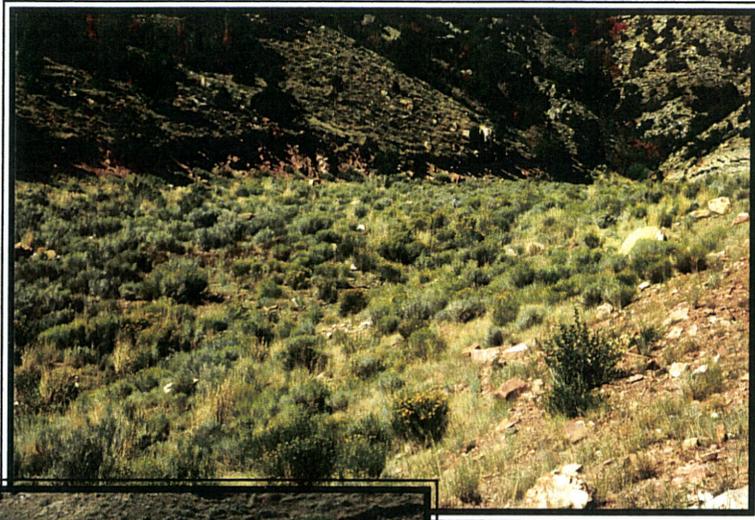
**Table 4: Hardscrabble Canyon Area. Total Cover and Composition (2009).**

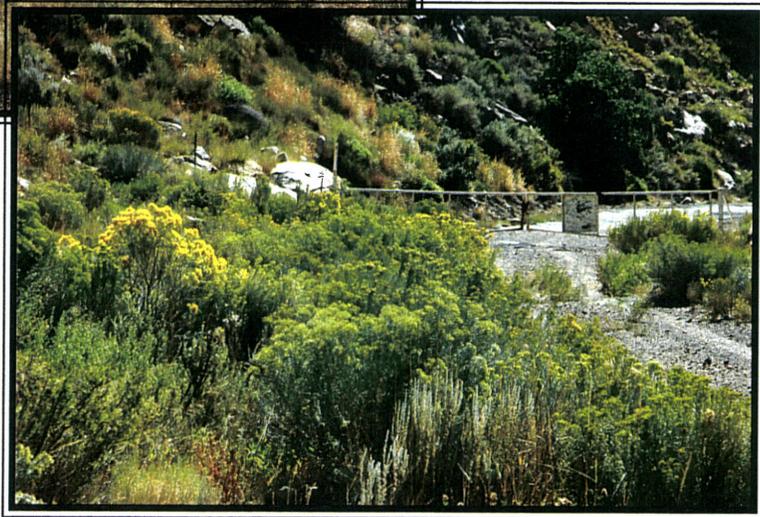
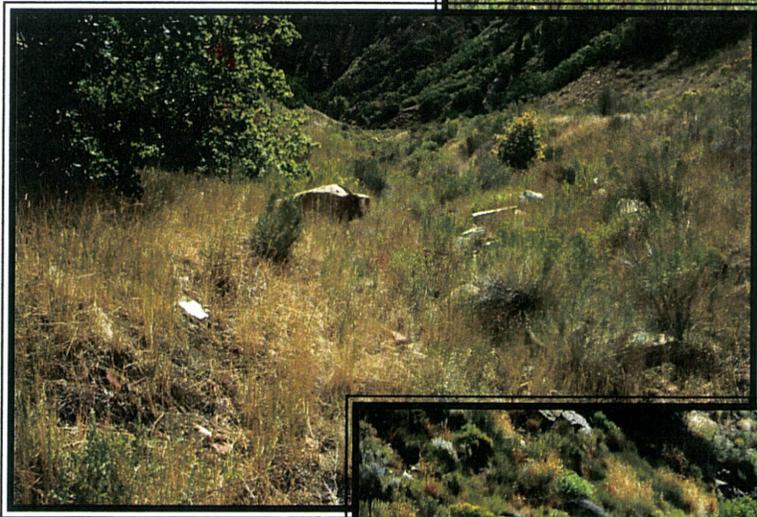
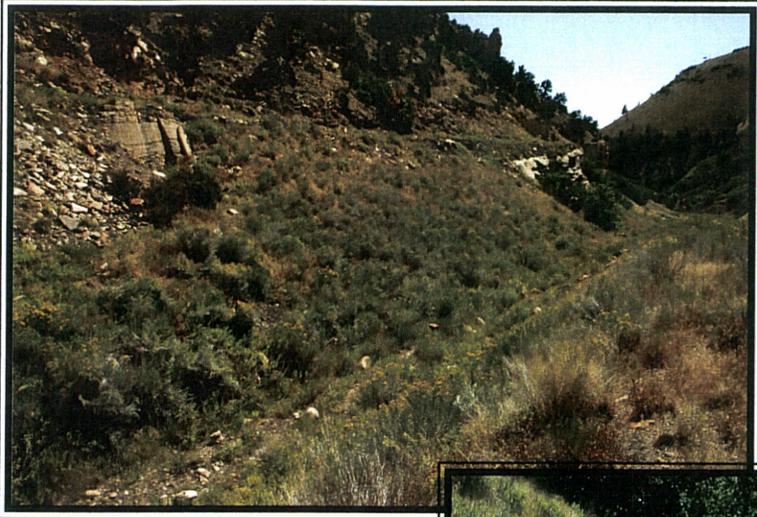
Reference Area		n=50
	Mean Percent	Standard Deviation
<b>A. TOTAL COVER</b>		
Total Living Cover	39.90	9.57
Litter	28.30	13.25
Bareground	8.50	6.73
Rock	23.30	15.51
<b>B. % COMPOSITION</b>		
Shrubs	19.37	25.89
Forbs	21.39	19.32
Grasses	59.25	27.36

**COLOR PHOTOGRAPHS  
OF THE  
SAMPLE AREAS**









**APPENDIX**

**Hardscrabble Reclaimed**

Exposure: Variable

Slope: Variable

Sample Date: 10-12 Sept 2009

1.00      2.00      3.00      4.00      5.00      6.00      7.00

**TREES & SHRUBS**

<i>Artemisia nova</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Artemisia tridentata</i>	10.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Atriplex canescens</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ceratoides lanata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Chrysothamnus nauseosus</i>	15.00	0.00	40.00	25.00	75.00	15.00	40.00
<i>Gutierrezia sarothrae</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rhus aromatica</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Sueda torreyana</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**FORBS**

<i>Achillea millefolium</i>	0.00	5.00	10.00	0.00	0.00	0.00	0.00
<i>Artemisia dracunculus</i>	0.00	0.00	0.00	0.00	0.00	0.00	25.00
<i>Aster ascendens</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Hedysarum boreale</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Machaeranthera canescens</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Medicago sativa</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Penstemon palmeri</i>	5.00	5.00	0.00	0.00	0.00	0.00	0.00

**GRASSES**

<i>Agropyron cristatum</i>	0.00	0.00	0.00	15.00	0.00	0.00	0.00
<i>Bromus tectorum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus cinereus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus hispidus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus lanceolatus</i>	15.00	25.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus salinus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus smithii</i>	10.00	0.00	10.00	0.00	0.00	20.00	0.00
<i>Elymus spicatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Poa secunda</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Stipa hymenoides</i>	0.00	15.00	5.00	0.00	0.00	10.00	0.00

**COVER**

Total Living Cover	55.00	50.00	65.00	40.00	75.00	45.00	65.00
Litter	15.00	10.00	5.00	10.00	10.00	10.00	25.00
Bareground	20.00	10.00	5.00	15.00	5.00	25.00	5.00
Rock	10.00	30.00	25.00	35.00	10.00	20.00	5.00

**% COMPOSITION**

Shrubs	45.45	0.00	61.54	62.50	100.00	33.33	61.54
Forbs	9.09	20.00	15.38	0.00	0.00	0.00	38.46
Grasses	45.45	80.00	23.08	37.50	0.00	66.67	0.00

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	0.00	15.00
5.00	5.00	0.00	0.00	0.00	0.00	5.00	0.00	40.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	35.00	45.00	70.00	5.00	0.00	25.00	0.00	0.00	0.00
5.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	5.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	5.00	0.00	20.00	20.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	0.00	0.00	5.00	0.00	0.00	5.00	0.00	5.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	20.00	0.00	0.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00
35.00	50.00	65.00	75.00	30.00	40.00	35.00	45.00	65.00	35.00
10.00	10.00	10.00	5.00	10.00	10.00	5.00	10.00	10.00	10.00
35.00	15.00	10.00	5.00	15.00	10.00	10.00	10.00	10.00	15.00
20.00	25.00	15.00	15.00	45.00	40.00	50.00	35.00	15.00	40.00
28.57	80.00	69.23	93.33	33.33	0.00	85.71	88.89	69.23	57.14
14.29	0.00	0.00	0.00	0.00	0.00	0.00	11.11	7.69	14.29
57.14	20.00	30.77	6.67	66.67	100.00	14.29	0.00	23.08	28.57













78.00	79.00	80.00	81.00	82.00	83.00	84.00	85.00	86.00	87.00
0.00	10.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60.00	0.00	20.00	15.00	0.00	0.00	70.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	5.00	0.00	10.00	0.00	15.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	0.00	0.00	10.00	0.00	15.00	0.00	10.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	10.00	70.00	10.00
0.00	15.00	0.00	0.00	45.00	0.00	0.00	0.00	0.00	0.00
70.00	40.00	40.00	50.00	65.00	35.00	70.00	35.00	70.00	35.00
5.00	10.00	10.00	10.00	15.00	10.00	25.00	25.00	15.00	20.00
5.00	10.00	10.00	20.00	5.00	20.00	4.00	10.00	5.00	5.00
20.00	40.00	40.00	20.00	15.00	35.00	1.00	30.00	10.00	40.00
0.00	50.00	25.00	70.00	0.00	57.14	0.00	0.00	0.00	0.00
85.71	0.00	50.00	30.00	0.00	14.29	100.00	28.57	0.00	42.86
14.29	50.00	25.00	0.00	100.00	28.57	0.00	71.43	100.00	57.14

88.00	89.00	90.00	91.00	92.00	93.00	94.00	95.00	96.00	97.00
0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	10.00	25.00	45.00	0.00	25.00	0.00	0.00	0.00
0.00	0.00	25.00	0.00	0.00	60.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	55.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50.00	15.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	5.00	0.00	10.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	25.00	0.00	10.00	0.00	25.00	0.00	60.00	0.00
10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60.00	55.00	70.00	40.00	65.00	70.00	50.00	55.00	60.00	60.00
20.00	20.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
5.00	10.00	10.00	10.00	10.00	5.00	10.00	10.00	10.00	15.00
15.00	15.00	10.00	40.00	15.00	15.00	30.00	25.00	20.00	15.00
0.00	54.55	64.29	62.50	69.23	85.71	50.00	100.00	0.00	66.67
83.33	27.27	0.00	25.00	15.38	0.00	0.00	0.00	0.00	0.00
16.67	18.18	35.71	12.50	15.38	14.29	50.00	0.00	100.00	33.33

**Hardscrabble Reclaimed**

Exposure: Variable

Slope: Variable

Sample Date: 10-12 Sept 2009

98.00	99.00	100.00	Mean	SDev	Freq	
<hr/>						<b>TREES &amp; SHRUBS</b>
0.00	0.00	0.00	1.80	6.42	12.00	<i>Artemisia nova</i>
0.00	0.00	0.00	3.90	9.61	20.00	<i>Artemisia tridentata</i>
10.00	0.00	0.00	4.05	10.86	16.00	<i>Atriplex canescens</i>
0.00	35.00	0.00	1.20	7.28	3.00	<i>Ceratoides lanata</i>
0.00	0.00	25.00	9.60	17.37	34.00	<i>Chrysothamnus nauseosus</i>
0.00	0.00	0.00	0.55	2.64	6.00	<i>Gutierrezia sarothrae</i>
0.00	0.00	0.00	0.30	2.98	1.00	<i>Rhus aromatica</i>
0.00	0.00	10.00	0.65	5.55	2.00	<i>Sueda torreyana</i>
<hr/>						<b>FORBS</b>
0.00	0.00	0.00	0.15	1.11	2.00	<i>Achillea millefolium</i>
0.00	0.00	0.00	1.30	4.16	13.00	<i>Artemisia dracunculus</i>
0.00	0.00	0.00	3.90	11.35	19.00	<i>Aster ascendens</i>
0.00	0.00	0.00	0.95	3.65	8.00	<i>Hedysarum boreale</i>
0.00	0.00	0.00	0.20	1.40	2.00	<i>Machaeranthera canescens</i>
0.00	0.00	0.00	0.05	0.50	1.00	<i>Medicago sativa</i>
0.00	0.00	0.00	1.30	4.22	14.00	<i>Penstemon palmeri</i>
<hr/>						<b>GRASSES</b>
0.00	0.00	0.00	2.25	6.02	21.00	<i>Agropyron cristatum</i>
0.00	0.00	0.00	0.95	3.98	8.00	<i>Bromus tectorum</i>
0.00	0.00	0.00	4.20	10.62	23.00	<i>Elymus cinereus</i>
0.00	0.00	0.00	0.45	4.48	1.00	<i>Elymus hispidus</i>
10.00	0.00	10.00	3.65	7.10	28.00	<i>Elymus lanceolatus</i>
0.00	0.00	0.00	0.80	6.27	20.00	<i>Elymus salinus</i>
10.00	0.00	10.00	3.10	7.03	25.00	<i>Elymus smithii</i>
10.00	10.00	20.00	5.25	10.87	27.00	<i>Elymus spicatus</i>
0.00	0.00	0.00	1.75	8.47	9.00	<i>Poa secunda</i>
0.00	0.00	0.00	1.40	5.70	10.00	<i>Stipa hymenoides</i>
<hr/>						<b>COVER (reclaimed)</b>
40.00	45.00	75.00	53.70	13.94		Total Living Cover
5.00	10.00	5.00	11.07	4.92		Litter
5.00	5.00	15.00	11.19	6.54		Bareground
50.00	40.00	5.00	24.04	11.98		Rock
<hr/>						<b>% COMPOSITION</b>
25.00	77.78	46.67	39.39	32.58		Shrubs
0.00	0.00	0.00	15.17	22.74		Forbs
75.00	22.22	53.33	45.44	32.57		Grasses

PLATEAU MINING

**Hardscrabble/Sowbelly Reference Area**

Exposure: Variable

Slope: Variable

Sample Date: 10-11 Sept 2009

1.00      2.00      3.00      4.00      5.00      6.00      7.00

TREES & SHRUBS

<i>Atriplex canescens</i>	0.00	0.00	0.00	0.00	0.00	15.00	0.00
<i>Chrysothamnus nauseosus</i>	35.00	35.00	10.00	30.00	30.00	10.00	0.00
<i>Gutierrezia sarothrae</i>	5.00	0.00	0.00	0.00	0.00	0.00	0.00

FORBS

<i>Artemisia ludoviciana</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Aster glaucodes</i>	0.00	0.00	20.00	10.00	0.00	0.00	0.00
<i>Medicago sativa</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Solidago sp.</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

GRASSES

<i>Bromus inermis</i>	10.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Bromus tectorum</i>	0.00	0.00	10.00	0.00	0.00	0.00	25.00
<i>Dactylis glomeratus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus hispidus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus lanceolatus</i>	0.00	0.00	0.00	20.00	0.00	25.00	0.00
<i>Elymus salinus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus smithii</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Poa secunda</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Stipa hymenoides</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

COVER

Total Living Cover	50.00	35.00	40.00	60.00	30.00	50.00	25.00
Litter	30.00	10.00	10.00	30.00	55.00	35.00	10.00
Bareground	10.00	45.00	5.00	5.00	5.00	5.00	5.00
Rock	10.00	10.00	45.00	5.00	10.00	10.00	60.00

% COMPOSITION

Shrubs	80.00	100.00	25.00	50.00	100.00	50.00	0.00
Forbs	0.00	0.00	50.00	16.67	0.00	0.00	0.00
Grasses	20.00	0.00	25.00	33.33	0.00	50.00	100.00

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
5.00	10.00	30.00	0.00	10.00	0.00	0.00	15.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	20.00	0.00	0.00	0.00	10.00	0.00	0.00
10.00	20.00	15.00	0.00	0.00	10.00	20.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	10.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	30.00	20.00	15.00	30.00	40.00	5.00	0.00	35.00	30.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.00	60.00	65.00	35.00	45.00	50.00	45.00	35.00	35.00	40.00
20.00	30.00	25.00	15.00	40.00	40.00	40.00	5.00	25.00	45.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
40.00	5.00	5.00	45.00	10.00	5.00	10.00	55.00	35.00	10.00
14.29	16.67	46.15	0.00	33.33	0.00	0.00	42.86	0.00	25.00
28.57	33.33	23.08	57.14	0.00	20.00	44.44	42.86	0.00	0.00
57.14	50.00	30.77	42.86	66.67	80.00	55.56	14.29	100.00	75.00

18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00
10.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	10.00	10.00	10.00	10.00	0.00	0.00	10.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	10.00	5.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	25.00	0.00	20.00	25.00	30.00	10.00	15.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	15.00	0.00	0.00	0.00	20.00	15.00	0.00	20.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00
40.00	35.00	35.00	30.00	35.00	40.00	40.00	35.00	35.00	50.00
50.00	20.00	15.00	20.00	25.00	25.00	30.00	35.00	35.00	10.00
5.00	10.00	10.00	10.00	20.00	10.00	10.00	10.00	5.00	10.00
5.00	35.00	40.00	40.00	20.00	25.00	20.00	20.00	25.00	30.00
25.00	28.57	28.57	0.00	0.00	0.00	0.00	0.00	0.00	10.00
0.00	0.00	28.57	33.33	28.57	25.00	25.00	14.29	28.57	30.00
75.00	71.43	42.86	66.67	71.43	75.00	75.00	85.71	71.43	60.00

28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00
0.00	10.00	0.00	0.00	15.00	0.00	5.00	0.00	0.00	20.00
0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	0.00	5.00	0.00	20.00	0.00
10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	0.00	40.00	35.00	0.00	30.00	10.00	10.00	0.00	20.00
0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
30.00	50.00	40.00	35.00	35.00	30.00	30.00	30.00	30.00	40.00
40.00	10.00	25.00	55.00	20.00	55.00	40.00	25.00	10.00	40.00
10.00	10.00	5.00	5.00	10.00	5.00	10.00	10.00	5.00	10.00
20.00	30.00	30.00	5.00	35.00	10.00	20.00	35.00	55.00	10.00
0.00	50.00	0.00	0.00	42.86	0.00	16.67	33.33	0.00	50.00
33.33	20.00	0.00	0.00	28.57	0.00	16.67	33.33	66.67	0.00
66.67	30.00	100.00	100.00	28.57	100.00	66.67	33.33	33.33	50.00

38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00
10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	15.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	25.00	0.00	0.00	0.00	5.00	0.00	25.00	10.00
0.00	0.00	0.00	0.00	0.00	15.00	10.00	0.00	0.00	0.00
10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	5.00	5.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	5.00	0.00	0.00	5.00	0.00	10.00	0.00	0.00	40.00
0.00	0.00	0.00	40.00	0.00	0.00	0.00	0.00	15.00	0.00
5.00	15.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	0.00	10.00	10.00	0.00	10.00
35.00	30.00	50.00	40.00	35.00	35.00	40.00	30.00	40.00	60.00
45.00	25.00	30.00	20.00	40.00	20.00	25.00	10.00	45.00	30.00
10.00	25.00	10.00	5.00	5.00	5.00	5.00	10.00	5.00	5.00
10.00	20.00	10.00	35.00	20.00	40.00	30.00	50.00	10.00	5.00
28.57	0.00	0.00	0.00	28.57	42.86	0.00	0.00	0.00	0.00
28.57	33.33	50.00	0.00	0.00	42.86	37.50	0.00	62.50	16.67
42.86	66.67	50.00	100.00	71.43	14.29	62.50	100.00	37.50	83.33

PLATEAU MINING  
**Hardscrabble/Sowbelly Reference Area**

Exposure: Variable  
 Slope: Variable

Freq Sample Date: 10-11 Sept 2009

48.00	49.00	50.00	Mean	SDev	Freq	
-----						
TREES & SHRUBS						
0.00	0.00	0.00	2.30	4.92	20.00	<i>Atriplex canescens</i>
0.00	0.00	0.00	5.20	10.00	28.00	<i>Chrysothamnus nauseosus</i>
0.00	0.00	0.00	0.50	1.80	8.00	<i>Gutierrezia sarothrae</i>
FORBS						
0.00	10.00	30.00	4.80	7.68	36.00	<i>Artemisia ludoviciana</i>
0.00	0.00	0.00	3.50	6.02	30.00	<i>Aster glaucodes</i>
0.00	0.00	0.00	0.20	1.40	2.00	<i>Medicago sativa</i>
0.00	0.00	0.00	0.20	1.40	2.00	<i>Solidago sp.</i>
GRASSES						
0.00	0.00	0.00	0.20	1.40	2.00	<i>Bromus inermis</i>
20.00	20.00	30.00	2.80	7.15	16.00	<i>Bromus tectorum</i>
0.00	0.00	0.00	0.60	2.15	8.00	<i>Dactylis glomeratus</i>
0.00	0.00	0.00	0.60	4.20	2.00	<i>Elymus hispidus</i>
10.00	10.00	0.00	5.90	9.52	38.00	<i>Elymus lanceolatus</i>
0.00	0.00	0.00	1.10	5.94	4.00	<i>Elymus salinus</i>
0.00	0.00	0.00	10.10	12.90	46.00	<i>Elymus smithii</i>
0.00	0.00	0.00	0.30	2.10	2.00	<i>Poa secunda</i>
0.00	10.00	0.00	1.60	4.18	14.00	<i>Stipa hymenoides</i>
-----						
COVER						
30.00	50.00	60.00	39.90	9.57		Total Living Cover
40.00	10.00	25.00	28.30	13.25		Litter
20.00	5.00	5.00	8.50	6.73		Bareground
10.00	35.00	10.00	23.30	15.51		Rock
-----						
% COMPOSITION						
0.00	0.00	0.00	19.37	25.89		Shrubs
0.00	20.00	50.00	21.39	19.32		Forbs
100.00	80.00	50.00	59.25	27.36		Grasses
-----						

**VEGETATION MONITORING  
FOR PHASE III BOND RELEASE  
IN HARDCRABBLE CANYON  
YEAR 1: 2008**

**FOR THE  
CASTLE GATE HOLDING COMPANY**



*Prepared by*

***MT. NEBO SCIENTIFIC, INC.***

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*by*

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*for*

***CASTLE GATE HOLDING COMPANY***

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May 2009

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## INTRODUCTION

### Objectives for Monitoring

This report describes the findings of quantitative sampling in 2008, or nine years after this site was reclaimed and seeded so that final revegetation establishment could occur. Hardscrabble Canyon has been reclaimed for enough time now that the "Responsibility Period" of the owner will soon be completed. This means that enough time has passed for vegetation establishment on reclaimed land before an application for bond release can be initiated. Because of this, Castle Gate Holding Company may submit the application for *final* or Phase III Bond Release relatively soon. Consequently, sampling in 2008 was conducted with this in mind. Because sample adequacy and statistical analyses meet the required levels, this dataset can be used as "Year 1" of the two consecutive years of vegetation monitoring required to apply for Phase III Bond Release.

Vegetation in the reclaimed areas was also sampled in the growing season of 2001 as a means to monitor the success of revegetation for Phase II Bond Release. Following that sample period, Phase II Bond Release was granted by submitting applications with the appropriate information including that vegetation monitoring dataset. The application was submitted through the State of Utah, Division of Oil, Gas and Mining (DOGGM).

A Reference Area, or an area previously chosen to be a standard of success for the revegetation in this area has also been sampled for comparisons with the reclaimed areas.

### General Site Description

Hardscrabble Canyon is located in Carbon County, Utah and has a rich history in coal mining activities. Those areas previously disturbed by the mining activities have been reclaimed and reseeded with the 'final' seed mixture, most of which were native plant species.

The average elevation of the Reclaimed Area of Hardscrabble Canyon was approximately 6,700 ft above sea level. The canyon sides are dominated by pinyon-juniper and Gambel's oak-grass plant communities. Most of the Reclaimed Area were located near the canyon bottoms that, prior to disturbance, were probably once dominated by Gambel's oak, sagebrush and grass communities.

### Reference Area

A general Reference Area to be used as a standard for final revegetation success standards was chosen at a much earlier date by representatives of the mining company and DOGM. The Mining and Reclamation Plan (MRP) states that "the AML Reference Areas shown on Exhibit 9-6 will be used to evaluate previously mined areas". Because the AML (State of Utah, Division of Oil, Gas & Mining, Abandoned Mined Lands Program) areas are relatively extensive, at least to be sampled as one Reference Area, a biologist from DOGM along with an official from Plateau Mining Corporation, chose a subset portion of the AML areas that would be representative and therefore be used as the Reference Area. This area was located in a nearby area called Sowbelly

Canyon. More specifically, the Reference Area was located down-canyon (or south) and very close to the previously disturbed mined areas that have also been reclaimed in Sowbelly Canyon. In fact, it is the same Reference Area that was used for a standard for revegetation success of the reclaimed areas in Sowbelly Canyon.

## METHODS

Quantitative and qualitative data were taken from the vegetation of the Reclaimed Area in Hardscrabble Canyon and the Reference Area in Sowbelly Canyon. Sampling was conducted in the first week of September 2008. Methodologies used for sampling were performed in accordance with the *Vegetation Information Guidelines* supplied by DOGM.

### Transect and Quadrat Placement

Random/regular placement of sample quadrats were designed in an attempt to provide unbiased accuracy of the data compiled. This was accomplished by establishing one long transect line along the entire length of the Reclaimed Area. This line was placed in the lowest portion of the reclaimed drainage system. At regular intervals along the drainage transect line, random numbers were generated and used to measure distances at right angles from the drainage and to determine sample locations. Whether these random numbers were odd or even determined which side of the drainage a given quadrat was placed. The random number selected would be high enough to place quadrats to the lateral limits of the Reclaimed Area and all areas in-

between. This insured that the sample quadrats were placed randomly over the entire study area in an attempt to adequately represent the site as a whole. The sample points that were placed randomly in the drainage were marked on the raw data sheets so they could be studied separately if desired.

### Cover, Frequency and Composition

Cover estimates were made using ocular methods with meter square quadrats. Species composition and relative frequencies were also assessed from the quadrats. Additional information recorded on the raw data sheets were: estimated precipitation, slope, exposure, grazing use, animal disturbance and other appropriate notes. Plant nomenclature follows "A Utah Flora" (Welsh et al. 2003).

### Sample Size & Adequacy

Sampling adequacy was calculated using the formula given below.

$$nMIN = \frac{t^2 s^2}{(dx)^2}$$

where,

*nMIN* = minimum adequate sample  
t = appropriate confidence t-value  
s = standard deviation  
x = sample mean  
d = desired change from mean

The values used for “t” and “d” insured that sample adequacy was met with 90% confidence within a 10% deviation from the true mean.

### Diversity & Similarity Indices

There are several well-documented methods to assess diversity and similarities in plant communities. The “Motyka Index” is a modified form of the “Sorenson Index”, both similarity indices. This index was used on the data and the equation is shown below:

$$IS_{MO} = \left( \frac{2MW}{MA+MB} \right) \times 100$$

where,

MW =  $\sum$  of the smaller quantitative values of species of two communities,  
MA =  $\sum$  of the quantitative values of all species in one community,  
MB =  $\sum$  of the quantitative values of all species in another community.

Two diversity indices have been reported in this document for the Reclaimed and Reference Areas. MacArthur's Diversity Index is an effective diversity measurement and is computed using the following equation:

$$1/\sum pi^2$$

where,

$pi$  is the proportion of sum frequency contributed by the  $i$ th species in the sample area of concern.

The proportional contribution of each species is then squared and the values for all species in the sample areas are summed. This index integrates the number of species and the degree to which frequency of occurrence was equitably distributed among those species.

Another diversity measurement was provided that shows the average number of species encountered at each quadrat, providing a value for species diversity.

### Photographs

Color photographs of each sample area were taken at the time of sampling and submitted with this report.

### Raw Data

The raw data for total cover, cover by species, frequency and composition were also submitted in the Appendix of this report which should facilitate future scrutiny of the data and further statistical testing if desired.

## **RESULTS**

### Reclaimed Area

The Reclaimed Area in Hardscrabble Canyon was dominated by the following most common

shrub species as indicated by cover and frequency were big sagebrush (*Artemisia tridentata*) and rubber rabbitbrush (*Chrysothamnus nauseosus*); the most common forbs were Pacific aster (*Aster ascendens*), northern sweetvetch (*Hedysarum boreale*) and tarragon (*Artemisia dracunculus*); the most common grasses were Gt. Basin wildrye (*Elymus cinereus*), bluebunch wheatgrass (*E. spicatus*) and western wheatgrass (*E. smithii*). For a list of all species present in the sample quadrats by cover and frequency, refer to Table 1.

The total living cover of the Reclaimed Area in Hardscrabble Canyon was 53.95% (Table 2-A), of which 45.75% of this cover were comprised of grasses, 31.57% from shrubs and 22.69% from forbs (Table 2-B).

#### Reference Area

As noted previously, the Reference Area chosen to represent revegetation success standard for the reclaimed areas in Hardscrabble Canyon was located in Sowbelly Canyon. The most common shrub species in the Reference Area were rubber rabbitbrush and fourwing saltbush (*Atriplex canescens*); the most common forbs were Louisiana sagewort (*Artemisia ludoviciana*) and blue-leaf aster (*Aster glaucodes*); the most common grasses were western wheatgrass, intermediate wheatgrass (*Elymus hispidus*) and Indian ricegrass (*Stipa hymenoides*). For a complete list of all species present in the sample quadrats by cover and frequency, refer to Table 3.

The total living cover for the Reference Area was 42.50% (Table 4-A). Most of this cover was from the understory cover (there was only 0.20% cover that consisted of overstory). The understory cover was comprised of 58.61% grasses, 23.20% forbs and 19.93% shrubs (Table 4-B).

### Dataset Comparisons

Comparisons were made between the data of the Reclaimed Areas at Hardscrabble Canyon and its Reference Area. To begin, statistical tests were implemented comparing the total living plant cover of the two areas. A “Student’s t-test” analysis suggested that the Reclaimed Area’s total living cover was significantly greater statistically when it was compared to the Reference Area (Fig. 1).

Next, the Motyka Index was recommended to be used to compare species diversity in the Mining and Reclamation Plan (MRP). Although this index is more of a ‘similarity index’ than a ‘diversity index’, it has been employed here to compare the datasets.

Language in the MRP assigned the

following categories to be used for comparisons with the Motyka Index:

**FIG. 1. STUDENT’S T TEST - A Comparison Between the Reclaimed Area at Hardscrabble Canyon and its Reference Area (2008).**

Reclaimed Area:  $\bar{x}$ =53.95; s=12.17; n=100

Reference Area:  $\bar{x}$ =42.50; s=8.85; n=50

t = 5.913; df = 148, SL= p<0.01

**FIG. 2. MOTYKA INDEX - A**  
 Comparison Between the Reclaimed Area at  
 Hardscrabble Canyon and its Reference  
 Area (2008).

$$IS_{MO} = \left( \frac{2MW}{MA+MB} \right) \times 100 = 85.120$$

Non-Weedy Shrub Cover,  
 Weedy Shrub Cover,  
 Native Perennial Grass Cover,  
 Introduced Perennial Grass Cover,  
 Non-Weedy Forb & Grass Cover,  
 Weedy Forb & Grass Cover.

When using the above categories and employing the Motyka Index, the similarity value between the two communities was 85.120% (Fig. 2).

MacArthur's Diversity Index was also employed to the data sets of the Reclaimed and Reference Area. This comparison suggested that the total diversity of the Reclaimed Area was greater than that of the Reference Area by quite a wide margin (Fig. 3).

Another method of comparing species diversity of the two areas is to simply calculate the mean number of species present in the sample quadrats. Results

**FIG. 3. MacARTHUR'S INDEX - A**  
 Comparison Between the Reclaimed Area at  
 Hardscrabble Canyon and its Reference  
 Area (2008).

$$1/\sum p_i^2 =$$

Reclaimed Area: 16.933

Reference Area: 10.507

from this method also suggested that the Reclaimed Area was more diverse with respect to species when compared to the Reference Area (Fig. 4).

**FIG. 4. AVERAGE NUMBER OF SPECIES PER SQUARE METER- A Comparison Between the Reclaimed Area at Hardscrabble Canyon and its Reference Area (2008).**

$\bar{x}$  NO. SPP/M<sup>2</sup> =

Reclaimed Area: 3.41

Reference Area: 2.54

## SUMMARY & CONCLUSIONS

According to the results of sampling the vegetation in 2008, or the ninth year following final reclamation of the disturbed areas in Hardscrabble Canyon, the area could soon be considered for Phase III Bond Release. The results herein could be considered for **Year 1** of the two consecutive years required for the application to the State of Utah, Division of Oil, Gas & Mining (DOGM) for the bond release.

In summary, the 2008 sampling results for total living cover, similarity and diversity all suggests that the reclaimed site has established an adequate plant community to soon be considered for final bond release. (Note: woody species density nor annual biomass production measurements were not required parameters for final bond release in Hardscrabble Canyon). Vegetation sampling for Year 2, or the second of the two consecutive years required for final bond release, should be accomplished in the growing season of 2009.

**Table 1: Hardscrabble Canyon Area. Living Cover and Frequency by Plant Species (2008).**

Hardscrabble Reclamation			n=100
TREES & SHRUBS	Mean Percent	Standard Deviation	Percent Frequency
<i>Artemisia nova</i>	1.27	4.94	9.00
<i>Artemisia tridentata</i>	4.80	10.65	23.00
<i>Atriplex canescens</i>	4.05	10.92	15.00
<i>Ceratoides lanata</i>	0.30	1.85	3.00
<i>Chrysothamnus nauseosus</i>	5.15	10.09	31.00
<i>Gutierrezia sarothrae</i>	1.70	6.97	11.00
<i>Suaeda torreyana</i>	0.45	4.48	1.00
<b>FORBS</b>			
<i>Achillea millefolium</i>	0.05	0.50	1.00
<i>Artemisia dracunculus</i>	2.23	5.28	19.00
<i>Aster ascendens</i>	3.70	11.04	11.00
<i>Grindelia squarrosa</i>	0.15	1.49	1.00
<i>Hedysarum boreale</i>	2.57	8.60	15.00
<i>Machaeranthera canescens</i>	0.75	2.17	12.00
<i>Melilotus officinalis</i>	0.15	1.49	1.00
<i>Penstemon palmeri</i>	1.68	4.40	19.00
<i>Sisymbrium altissimum</i>	0.20	1.40	2.00
<i>Sphaeralcea coccinea</i>	0.45	2.25	4.00
<b>GRASSES</b>			
<i>Agropyron cristatum</i>	1.87	4.64	18.00
<i>Bromus tectorum</i>	0.35	1.77	4.00
<i>Elymus cinereus</i>	5.20	10.79	29.00
<i>Elymus elymoides</i>	0.60	4.43	2.00
<i>Elymus hispidus</i>	0.90	5.72	3.00
<i>Elymus lanceolatus</i>	2.67	5.86	24.00
<i>Elymus salinus</i>	0.35	2.03	3.00
<i>Elymus smithii</i>	4.38	8.86	31.00
<i>Elymus spicatus</i>	4.65	9.65	26.00
<i>Poa secunda</i>	1.40	5.83	8.00
<i>Stipa hymenoides</i>	1.93	6.16	15.00

**Table 2: Hardscrabble Canyon Area. Total Cover and Composition (2008).**

Hardscrabble Reclamation			n=100
A. TOTAL COVER	Mean Percent	Standard Deviation	
Total Living Cover	53.95	12.17	
Litter	12.75	6.98	
Bareground	11.05	7.05	
Rock	22.25	12.93	
<b>B. % COMPOSITION</b>			
Shrubs	31.57	30.53	
Forbs	22.69	27.22	
Grasses	45.75	31.56	

**Table 3: Hardscrabble Reference Area (located in Sowbelly Canyon). Living Cover and Frequency by Plant Species (2008).**

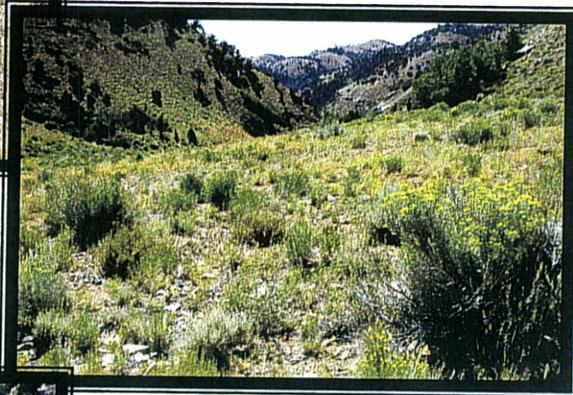
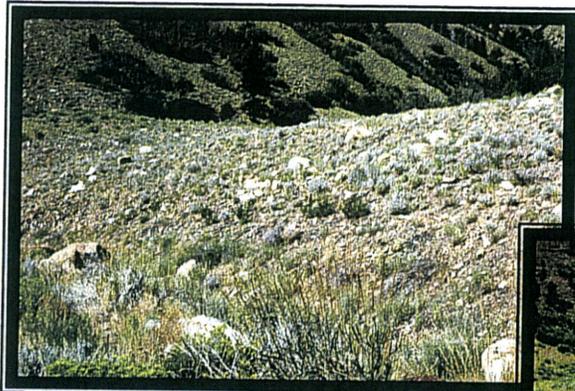
Hardscrabble Reference Area			n=50
OVERSTORY COVER	Mean Percent	Standard Deviation	Percent Frequency
<b>TREES &amp; SHRUBS</b>			
<i>Quercus gambelii</i>	0.20	1.40	2.00
<b>UNDERSTORY COVER</b>			
<b>TREES &amp; SHRUBS</b>			
<i>Artemisia tridentata</i>	0.40	1.96	4.00
<i>Atriplex canescens</i>	2.00	6.86	12.00
<i>Chrysothamnus nauseosus</i>	6.50	12.62	32.00
<i>Quercus gambelii</i>	0.50	3.50	2.00
<b>FORBS</b>			
<i>Artemisia ludoviciana</i>	4.16	9.59	26.00
<i>Aster glaucodes</i>	4.00	8.37	28.00
<i>Machaeranthera canescens</i>	0.10	0.70	2.00
<i>Medicago sativa</i>	0.54	1.92	8.00
<i>Penstemon palmeri</i>	0.20	1.40	2.00
<i>Solidago sp.</i>	0.10	0.70	20.00
<i>Viguiera multiflora</i>	0.20	1.40	2.00
<b>GRASSES</b>			
<i>Bromus inermis</i>	0.60	2.15	2.00
<i>Bromus tectorum</i>	1.60	5.70	10.00
<i>Dactylis glomeratus</i>	0.80	5.60	2.00
<i>Elymus hispidus</i>	4.10	9.78	20.00
<i>Elymus lanceolatus</i>	3.30	9.14	16.00
<i>Elymus smithii</i>	9.60	13.37	42.00
<i>Stipa hymenoides</i>	3.60	8.00	22.00

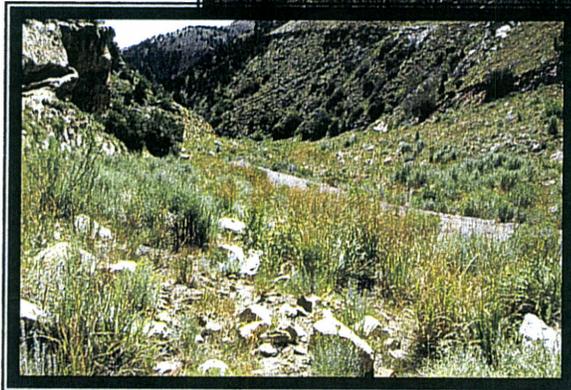
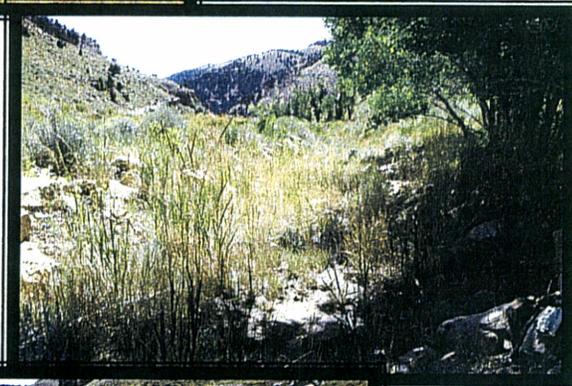
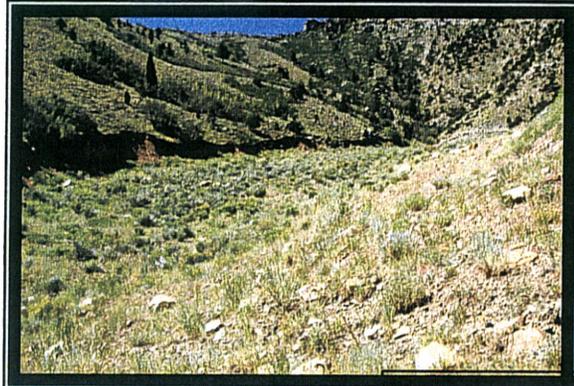
**Table 4: Hardscrabble Reference Area (located in Sowbelly Canyon). Total Cover and Composition (2008).**

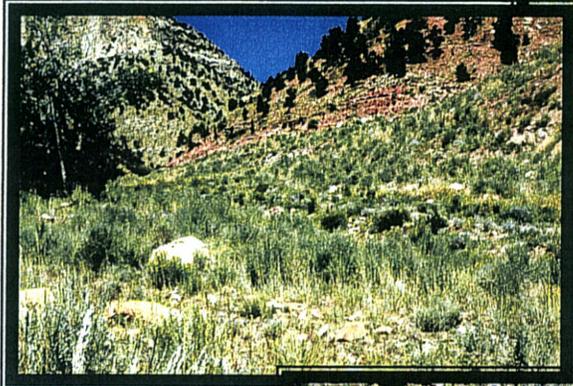
Hardscrabble Reference Area		n=50
A. TOTAL COVER	Mean Percent	Standard Deviation
Overstory Cover (o)	0.20	1.40
Understory Cover (u)	42.30	8.56
Litter	25.70	13.15
Bareground	11.30	6.15
Rock	20.70	12.77
o+u	42.50	8.85
<b>B. % COMPOSITION</b>		
Shrubs	19.93	27.26
Forbs	23.20	31.06
Grasses	58.61	30.93

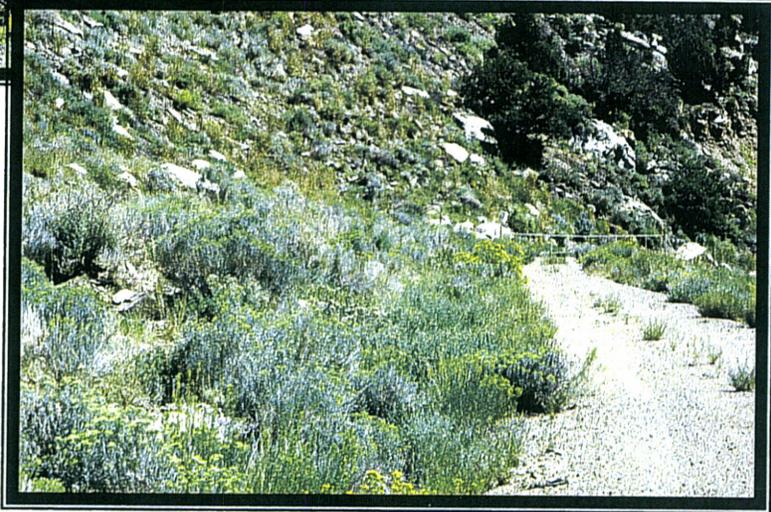
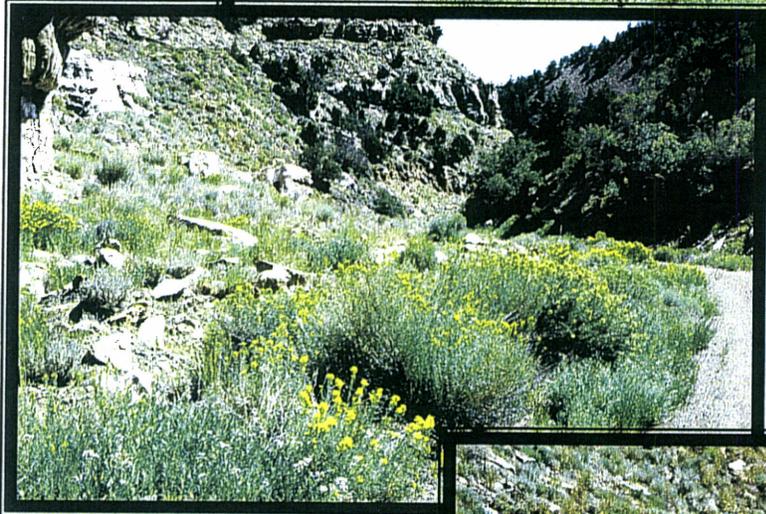
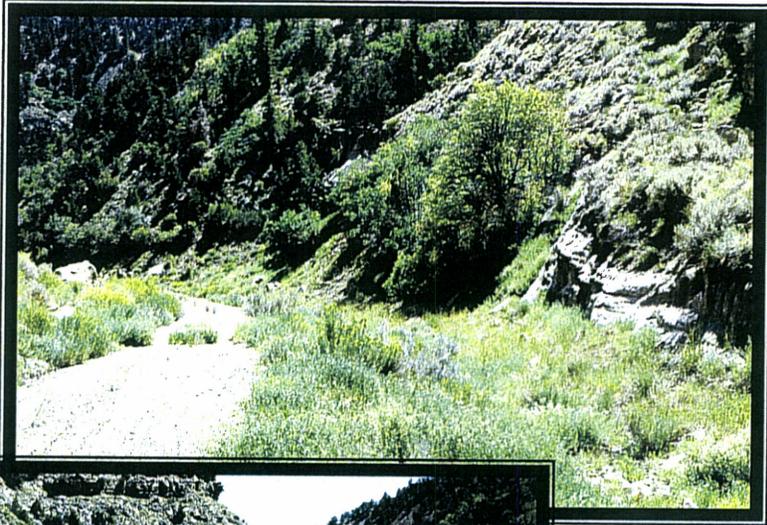
**COLOR PHOTOGRAPHS  
OF THE  
SAMPLE AREAS**

**RECLAIMED AREAS  
IN  
HARDSCRABBLE CANYON  
(From North to South)**

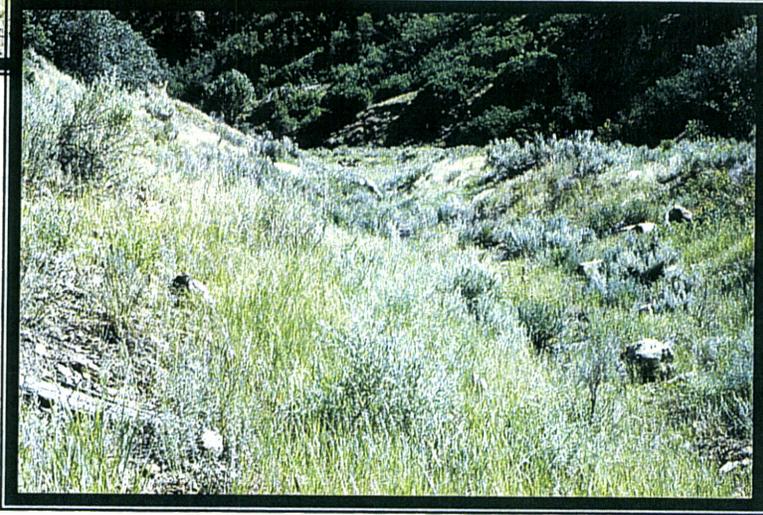
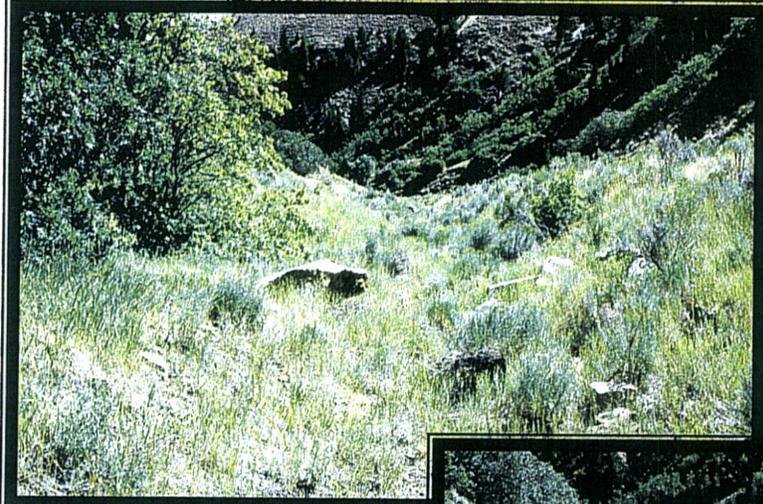








**HARDSCRABBLE CANYON REFERENCE AREA**  
(Located in Sowbelly Canyon)



**APPENDIX**

**Hardscrabble Reclamation**

Exposure: Variable

Slope: Variable

Sample Date: 2-5 Sept 2008

1.00      2.00      3.00      4.00      5.00      6.00      7.00

**TREES & SHRUBS**

<i>Artemisia nova</i>	0.00	7.00	0.00	25.00	0.00	0.00	0.00
<i>Artemisia tridentata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Atriplex canescens</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ceratoides lanata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Chrysothamnus nauseosus</i>	0.00	10.00	10.00	15.00	0.00	0.00	0.00
<i>Gutierrezia sarothrae</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Suaeda torreyana</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**FORBS**

<i>Achillea millefolium</i>	0.00	0.00	5.00	0.00	0.00	0.00	0.00
<i>Artemisia dracunculus</i>	0.00	10.00	5.00	0.00	0.00	0.00	20.00
<i>Aster ascendens</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Grindelia squarrosa</i>	0.00	0.00	0.00	0.00	0.00	15.00	0.00
<i>Hedysarum boreale</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Machaeranthera canescens</i>	10.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Melilotus officinalis</i>	15.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Penstemon palmeri</i>	0.00	15.00	0.00	0.00	0.00	0.00	0.00
<i>Sisymbrium altissimum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Sphaeralcea coccinea</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**GRASSES**

<i>Agropyron cristatum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Bromus tectorum</i>	0.00	0.00	0.00	0.00	0.00	0.00	10.00
<i>Elymus cinereus</i>	0.00	0.00	15.00	0.00	35.00	0.00	0.00
<i>Elymus elymoides</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus hispidus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus lanceolatus</i>	0.00	0.00	0.00	0.00	20.00	10.00	5.00
<i>Elymus salinus</i>	0.00	0.00	10.00	0.00	0.00	0.00	0.00
<i>Elymus smithii</i>	0.00	0.00	0.00	0.00	10.00	10.00	5.00
<i>Elymus spicatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Poa secunda</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Stipa hymenoides</i>	10.00	13.00	10.00	0.00	0.00	0.00	0.00

**COVER**

Total Living Cover	35.00	55.00	55.00	40.00	65.00	35.00	40.00
Litter	20.00	10.00	25.00	5.00	15.00	20.00	10.00
Bareground	5.00	10.00	5.00	5.00	10.00	5.00	20.00
Rock	40.00	25.00	15.00	50.00	10.00	40.00	30.00

**% COMPOSITION**

Shrubs	0.00	30.91	18.18	100.00	0.00	0.00	0.00
Forbs	71.43	45.45	18.18	0.00	0.00	42.86	50.00
Grasses	28.57	23.64	63.64	0.00	100.00	57.14	50.00



18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00
0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	10.00	0.00	10.00	25.00	0.00
0.00	0.00	0.00	0.00	10.00	35.00	0.00	15.00	0.00	30.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	10.00	0.00	0.00	10.00	5.00	0.00	0.00	0.00	0.00
15.00	20.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	25.00	0.00	5.00	0.00	0.00	10.00	0.00	15.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	15.00	0.00	0.00	10.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	20.00	10.00	5.00	0.00	60.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	10.00	0.00	0.00	0.00	0.00	10.00	0.00
0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	10.00	10.00	0.00	0.00	0.00	10.00	25.00
0.00	0.00	0.00	15.00	15.00	20.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50.00	65.00	65.00	65.00	65.00	70.00	70.00	65.00	65.00	65.00
10.00	10.00	20.00	15.00	10.00	15.00	15.00	10.00	10.00	10.00
10.00	5.00	10.00	10.00	10.00	5.00	5.00	10.00	10.00	10.00
30.00	20.00	5.00	10.00	15.00	10.00	10.00	15.00	15.00	15.00
50.00	46.15	30.77	23.08	30.77	71.43	0.00	38.46	38.46	46.15
20.00	38.46	23.08	7.69	23.08	0.00	14.29	30.77	30.77	0.00
30.00	15.38	46.15	69.23	46.15	28.57	85.71	30.77	30.77	53.85



38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	20.00	0.00	5.00	25.00	0.00
60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	10.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00
0.00	10.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	45.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	20.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	7.00	20.00	0.00	0.00	0.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	8.00	0.00	0.00	0.00	45.00	35.00	0.00	25.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00
60.00	55.00	30.00	55.00	50.00	70.00	45.00	60.00	50.00	45.00
5.00	10.00	10.00	25.00	10.00	10.00	10.00	10.00	10.00	10.00
25.00	15.00	45.00	10.00	20.00	10.00	10.00	10.00	10.00	10.00
10.00	20.00	15.00	10.00	20.00	10.00	35.00	20.00	30.00	35.00
100.00	0.00	0.00	0.00	0.00	28.57	0.00	8.33	50.00	0.00
0.00	0.00	50.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00
0.00	100.00	50.00	100.00	100.00	71.43	100.00	66.67	50.00	100.00



58.00	59.00	60.00	61.00	62.00	63.00	64.00	65.00	66.00	67.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00
35.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	35.00	0.00	25.00	25.00	60.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	5.00	5.00	0.00	0.00	5.00
0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00
0.00	0.00	0.00	10.00	40.00	10.00	0.00	10.00	0.00	0.00
0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55.00	65.00	65.00	65.00	70.00	50.00	50.00	70.00	40.00	35.00
10.00	25.00	10.00	15.00	20.00	15.00	10.00	5.00	10.00	10.00
5.00	5.00	5.00	10.00	5.00	5.00	5.00	20.00	25.00	35.00
30.00	5.00	20.00	10.00	5.00	30.00	35.00	5.00	25.00	20.00
63.64	7.69	0.00	69.23	0.00	50.00	50.00	85.71	75.00	0.00
0.00	69.23	100.00	15.38	42.86	10.00	50.00	0.00	25.00	42.86
36.36	23.08	0.00	15.38	57.14	40.00	0.00	14.29	0.00	57.14

68.00	69.00	70.00	71.00	72.00	73.00	74.00	75.00	76.00	77.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	15.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	20.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	5.00	0.00
40.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	45.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	10.00	0.00	0.00	0.00	0.00	0.00	30.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	10.00	0.00	25.00	0.00	20.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	10.00	0.00	0.00	35.00	0.00	0.00	0.00
5.00	10.00	20.00	10.00	25.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
65.00	55.00	55.00	50.00	45.00	45.00	60.00	60.00	75.00	60.00
10.00	10.00	10.00	10.00	25.00	40.00	10.00	5.00	5.00	10.00
10.00	25.00	10.00	10.00	20.00	10.00	20.00	15.00	15.00	10.00
15.00	10.00	25.00	30.00	10.00	5.00	10.00	20.00	5.00	20.00
61.54	0.00	27.27	20.00	22.22	0.00	0.00	100.00	33.33	66.67
7.69	18.18	18.18	0.00	0.00	100.00	0.00	0.00	40.00	0.00
30.77	81.82	54.55	80.00	77.78	0.00	100.00	0.00	26.67	33.33

78.00	79.00	80.00	81.00	82.00	83.00	84.00	85.00	86.00	87.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.00	25.00	0.00	0.00	55.00	25.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00
0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	15.00	15.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	5.00	5.00	10.00	0.00	0.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	0.00	0.00	10.00	10.00	0.00	5.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	10.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	10.00	10.00
0.00	25.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00
60.00	50.00	40.00	15.00	70.00	50.00	35.00	40.00	55.00	70.00
5.00	10.00	10.00	10.00	15.00	15.00	5.00	15.00	10.00	10.00
20.00	25.00	10.00	10.00	5.00	5.00	10.00	10.00	5.00	5.00
15.00	15.00	40.00	65.00	10.00	30.00	50.00	35.00	30.00	15.00
66.67	50.00	25.00	0.00	78.57	50.00	71.43	37.50	9.09	57.14
8.33	0.00	75.00	33.33	7.14	30.00	0.00	12.50	54.55	0.00
25.00	50.00	0.00	66.67	14.29	20.00	28.57	50.00	36.36	42.86



**Hardscrabble Reclamation**

Exposure: Variable

Slope: Variable

Sample Date: 2-5 Sept 2008

98.00	99.00	100.00	Mean	SDev	Freq	
<hr/>						
<b>TREES &amp; SHRUBS</b>						
0.00	0.00	0.00	1.27	4.94	9.00	<i>Artemisia nova</i>
0.00	0.00	0.00	4.80	10.65	23.00	<i>Artemisia tridentata</i>
0.00	0.00	0.00	4.05	10.92	15.00	<i>Atriplex canescens</i>
0.00	0.00	0.00	0.30	1.85	3.00	<i>Ceratoides lanata</i>
0.00	0.00	0.00	5.15	10.09	31.00	<i>Chrysothamnus nauseosus</i>
0.00	0.00	0.00	1.70	6.97	11.00	<i>Gutierrezia sarothrae</i>
0.00	0.00	0.00	0.45	4.48	1.00	<i>Suaeda torreyana</i>
<b>FORBS</b>						
0.00	0.00	0.00	0.05	0.50	1.00	<i>Achillea millefolium</i>
0.00	0.00	0.00	2.23	5.28	19.00	<i>Artemisia dracunculus</i>
45.00	10.00	30.00	3.70	11.04	11.00	<i>Aster ascendens</i>
0.00	0.00	0.00	0.15	1.49	1.00	<i>Grindelia squarrosa</i>
0.00	0.00	10.00	2.57	8.60	15.00	<i>Hedysarum boreale</i>
10.00	0.00	0.00	0.75	2.17	12.00	<i>Machaeranthera canescens</i>
0.00	0.00	0.00	0.15	1.49	1.00	<i>Melilotus officinalis</i>
0.00	30.00	0.00	1.68	4.40	19.00	<i>Penstemon palmeri</i>
0.00	0.00	0.00	0.20	1.40	2.00	<i>Sisymbrium altissimum</i>
0.00	0.00	0.00	0.45	2.25	4.00	<i>Sphaeralcea coccinea</i>
<b>GRASSES</b>						
0.00	0.00	0.00	1.87	4.64	18.00	<i>Agropyron cristatum</i>
0.00	0.00	0.00	0.35	1.77	4.00	<i>Bromus tectorum</i>
0.00	0.00	15.00	5.20	10.79	29.00	<i>Elymus cinereus</i>
0.00	0.00	0.00	0.60	4.43	2.00	<i>Elymus elymoides</i>
0.00	0.00	0.00	0.90	5.72	3.00	<i>Elymus hispidus</i>
0.00	0.00	0.00	2.67	5.86	24.00	<i>Elymus lanceolatus</i>
0.00	0.00	0.00	0.35	2.03	3.00	<i>Elymus salinus</i>
0.00	0.00	0.00	4.38	8.86	31.00	<i>Elymus smithii</i>
0.00	0.00	0.00	4.65	9.65	26.00	<i>Elymus spicatus</i>
0.00	0.00	0.00	1.40	5.83	8.00	<i>Poa secunda</i>
0.00	0.00	0.00	1.93	6.16	15.00	<i>Stipa hymenoides</i>
<hr/>						
<b>COVER</b>						
55.00	40.00	55.00	53.95	12.17		Total Living Cover
5.00	10.00	30.00	12.75	6.98		Litter
25.00	5.00	5.00	11.05	7.05		Bareground
15.00	45.00	10.00	22.25	12.93		Rock
<hr/>						
<b>% COMPOSITION</b>						
0.00	0.00	0.00	31.57	30.53		Shrubs
100.00	100.00	72.73	22.69	27.22		Forbs
0.00	0.00	27.27	45.75	31.56		Grasses

**Hardscrabble Reference Area**

at Sowbelly

Slope: Variable

Sample Date: 2-5 Sept 2008

	1.00	2.00	3.00	4.00	5.00	6.00	7.00
<b>OVERSTORY COVER</b>							
<i>Quercus gambelii</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>TREES &amp; SHRUBS</b>							
<i>Artemisia tridentata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Atriplex canescens</i>	0.00	0.00	5.00	0.00	0.00	0.00	0.00
<i>Chrysothamnus nauseosus</i>	20.00	25.00	35.00	30.00	15.00	30.00	0.00
<i>Quercus gambelii</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>FORBS</b>							
<i>Artemisia ludoviciana</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Aster glaucodes</i>	10.00	0.00	0.00	10.00	10.00	0.00	0.00
<i>Machaeranthera canescens</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Medicago sativa</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Penstemon palmeri</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Solidago sp.</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Viguiera multiflora</i>	0.00	0.00	0.00	0.00	0.00	10.00	0.00
<b>GRASSES</b>							
<i>Bromus inermis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Bromus tectorum</i>	0.00	0.00	10.00	0.00	0.00	0.00	0.00
<i>Dactylis glomeratus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus hispidus</i>	20.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Elymus lanceolatus</i>	0.00	5.00	0.00	0.00	5.00	0.00	0.00
<i>Elymus smithii</i>	0.00	0.00	0.00	10.00	0.00	0.00	45.00
<i>Stipa hymenoides</i>	0.00	0.00	0.00	0.00	15.00	10.00	0.00
<b>COVER</b>							
Overstory Cover (o)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Understory Cover (u)	50.00	30.00	50.00	50.00	45.00	50.00	45.00
Litter	40.00	50.00	30.00	30.00	10.00	15.00	35.00
Bareground	5.00	10.00	10.00	10.00	10.00	10.00	10.00
Rock	5.00	10.00	10.00	10.00	35.00	25.00	10.00
<b>% UNDERSTORY COMPOSITION</b>							
Shrubs	40.00	83.33	80.00	60.00	33.33	60.00	0.00
Forbs	0.00	0.00	20.00	20.00	22.22	0.00	33.33
Grasses	40.00	16.67	20.00	20.00	44.44	20.00	100.00
<b>TOTAL LIVING COVER (o+u)</b>							
	50.00	30.00	50.00	50.00	45.00	50.00	45.00

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	5.00	0.00	0.00	35.00	0.00
0.00	10.00	25.00	0.00	0.00	0.00	0.00	10.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	5.00	0.00
15.00	5.00	40.00	0.00	0.00	5.00	25.00	10.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	50.00	0.00	5.00	25.00	0.00	15.00	0.00
0.00	0.00	0.00	0.00	30.00	0.00	0.00	0.00	0.00	0.00
0.00	20.00	0.00	0.00	0.00	10.00	0.00	10.00	0.00	25.00
0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.00	35.00	65.00	50.00	35.00	35.00	50.00	40.00	60.00	35.00
45.00	20.00	25.00	35.00	45.00	55.00	30.00	10.00	25.00	50.00
10.00	5.00	5.00	10.00	10.00	5.00	10.00	10.00	5.00	5.00
10.00	40.00	5.00	5.00	10.00	5.00	10.00	40.00	10.00	10.00
28.57	28.57	38.46	0.00	14.29	14.29	0.00	25.00	66.67	0.00
14.29	114.29	0.00	0.00	14.29	71.43	40.00	12.50	16.67	0.00
28.57	57.14	0.00	100.00	85.71	71.43	50.00	25.00	25.00	71.43
35.00	35.00	65.00	50.00	35.00	35.00	50.00	40.00	60.00	35.00

18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00
0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	15.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	5.00
10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	35.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	15.00
10.00	0.00	20.00	0.00	10.00	20.00	20.00	35.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00
40.00	35.00	40.00	35.00	35.00	50.00	45.00	40.00	40.00	30.00
35.00	30.00	20.00	25.00	10.00	20.00	35.00	30.00	10.00	10.00
10.00	10.00	10.00	20.00	30.00	5.00	10.00	5.00	5.00	10.00
15.00	25.00	30.00	20.00	25.00	25.00	10.00	25.00	45.00	50.00
0.00	0.00	50.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00
0.00	0.00	25.00	42.86	14.29	50.00	11.11	0.00	12.50	83.33
100.00	100.00	50.00	71.43	57.14	40.00	44.44	87.50	100.00	83.33
40.00	35.00	40.00	35.00	35.00	60.00	45.00	40.00	40.00	30.00

28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	65.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	0.00	0.00
0.00	25.00	0.00	10.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.00	10.00	25.00	0.00	35.00	40.00	0.00	0.00	40.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60.00	35.00	50.00	35.00	40.00	40.00	35.00	40.00	40.00	65.00
5.00	40.00	30.00	15.00	35.00	50.00	10.00	10.00	25.00	25.00
20.00	5.00	10.00	15.00	15.00	5.00	10.00	15.00	10.00	5.00
15.00	20.00	10.00	35.00	10.00	5.00	45.00	35.00	25.00	5.00
0.00	0.00	50.00	0.00	0.00	0.00	14.29	0.00	0.00	100.00
0.00	0.00	50.00	14.29	0.00	0.00	0.00	0.00	0.00	7.69
58.33	100.00	50.00	28.57	87.50	100.00	85.71	100.00	100.00	0.00
60.00	35.00	50.00	35.00	40.00	40.00	35.00	40.00	40.00	65.00

38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	10.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	8.00	0.00	0.00	55.00	25.00	15.00	0.00	25.00	0.00
0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	35.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00
0.00	20.00	20.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	35.00	15.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.00	35.00	45.00	35.00	55.00	40.00	45.00	45.00	40.00	35.00
20.00	35.00	25.00	10.00	15.00	25.00	30.00	5.00	40.00	25.00
10.00	15.00	15.00	30.00	20.00	10.00	10.00	10.00	10.00	20.00
30.00	15.00	15.00	25.00	10.00	25.00	15.00	40.00	10.00	20.00
25.00	0.00	55.56	57.14	0.00	0.00	22.22	0.00	0.00	0.00
37.50	0.00	11.11	157.14	45.45	37.50	0.00	55.56	0.00	42.86
62.50	57.14	44.44	28.57	0.00	37.50	44.44	100.00	37.50	100.00
40.00	35.00	45.00	35.00	55.00	40.00	45.00	45.00	40.00	35.00

**Hardscrabble Reference Area**

Exposure: Variable

Slope: Variable

Sample Date: 2-5 Sept 2008

48.00	49.00	50.00	Mean	SDev	Freq	
<hr/>						<b>OVERSTORY COVER</b>
0.00	0.00	0.00	0.20	1.40	2.00	<i>Quercus gambelii</i>
<hr/>						<b>TREES &amp; SHRUBS</b>
0.00	0.00	0.00	0.40	1.96	4.00	<i>Artemisia tridentata</i>
0.00	0.00	0.00	2.00	6.86	12.00	<i>Atriplex canescens</i>
0.00	0.00	0.00	6.50	12.62	32.00	<i>Chrysothamnus nauseosus</i>
0.00	0.00	0.00	0.50	3.50	2.00	<i>Quercus gambelii</i>
<hr/>						<b>FORBS</b>
15.00	10.00	10.00	4.16	9.59	26.00	<i>Artemisia ludoviciana</i>
0.00	0.00	0.00	4.00	8.37	28.00	<i>Aster glaucodes</i>
0.00	0.00	0.00	0.10	0.70	2.00	<i>Machaeranthera canescens</i>
0.00	0.00	0.00	0.54	1.92	8.00	<i>Medicago sativa</i>
0.00	0.00	0.00	0.20	1.40	2.00	<i>Penstemon palmeri</i>
0.00	0.00	0.00	0.10	0.70	20.00	<i>Solidago sp.</i>
0.00	0.00	0.00	0.20	1.40	2.00	<i>Viguiera multiflora</i>
<hr/>						<b>GRASSES</b>
0.00	0.00	5.00	0.60	2.15	2.00	<i>Bromus inermis</i>
0.00	0.00	0.00	1.60	5.70	10.00	<i>Bromus tectorum</i>
0.00	0.00	0.00	0.80	5.60	2.00	<i>Dactylis glomeratus</i>
0.00	0.00	0.00	4.10	9.78	20.00	<i>Elymus hispidus</i>
0.00	0.00	0.00	3.30	9.14	16.00	<i>Elymus lanceolatus</i>
0.00	0.00	0.00	9.60	13.37	42.00	<i>Elymus smithii</i>
15.00	25.00	30.00	3.60	8.00	22.00	<i>Stipa hymenoides</i>
<hr/>						<b>COVER</b>
0.00	0.00	0.00	0.20	1.40		Overstory Cover (o)
30.00	35.00	45.00	42.30	8.56		Understory Cover (u)
10.00	20.00	5.00	25.70	13.15		Litter
25.00	20.00	5.00	11.30	6.15		Bareground
35.00	25.00	45.00	20.70	12.77		Rock
<hr/>						<b>% UNDERSTORY COMPOSITIO</b>
0.00	0.00	0.00	19.93	27.26		Shrubs
33.33	28.57	20.67	23.20	31.06		Forbs
50.00	71.43	77.78	58.61	30.93		Grasses
<hr/>						<b>TOTAL LIVING COVER (o+u)</b>
30.00	35.00	45.00	42.50	8.85		

**Appendix 2**

**Sediment Yield Calculations  
For Phase III Bond Release  
Sowbelly and Hardscrabble Canyons**

**Sediment Yield Calculations**  
**Sowbelly Canyon Phase III Bond Release**  
**Plateau Mining Corporation**



June 2012

Prepared by

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## **Sediment Yield Calculations**

### **Sowbelly Canyon Phase III Bond Release Plateau Mining Corporation**

#### **Summary**

The Revised Universal Soil Loss Equation (RUSLE) was used to calculate sediment yields from the former Sowbelly Canyon Mine area under both pre-disturbance and post-reclamation conditions. Details regarding this methodology and the associated references are provided on the following pages. Under the pre-disturbance condition, slopes were taken as 100 feet long. Deep gouging was used in reclaimed areas, thereby limiting the post-reclamation slope length to approximately 3 feet. The changes in sediment yields resulting from revegetation of the site were also accounted for by comparing plant growth in the reclaimed area to the growth in an undisturbed reference area. The following calculations indicate that sediment yields for the reclaimed condition are 0.70 ton/acre/year, while those from the pre-disturbance condition are 0.78 tons/acre/year. Hence, sediment yields are estimated to be less after reclamation than before the area was disturbed by mining.

### Sediment Yield Calculation

	R	K	LS	C	P	A (t/ac/yr)
Sowbelly Canyon Substation (Pre-Disturbance)	11	0.05	24.74	0.057	1	0.78
Sowbelly Canyon Substation (Post Reclamation)	11	0.15	7.32	0.058	1	0.70

Notes:

1.  $A = R K L S C P$ , where A is the annual sediment yield (tons/acre/year). This is the Revised Universal Soil Loss Equation (RUSLE). Each of the coefficients is explained below.
2. R = Rainfall-Runoff Erosivity Factor (unitless) = 11 from Map 7 (Israelsen et al., 1984). R is identical for both the pre-disturbed and post-reclamation conditions.
3. K = Soil Erodibility Factor (unitless). According to the NRCS Web Soil Survey (<http://websoilsurvey.nrcs.usda.gov/app/>), K = 0.05 for surficial soils throughout Sowbelly Canyon. Therefore, this value was accepted as the K factor for the pre-disturbance condition. Since most of the mine-related disturbance was pre-law, topsoil was generally not stockpiled. As a result, subsoil was used to reclaim most of the disturbed area, and a K value of 0.15 was assumed (equivalent to the K value for subsurface soils in the canyon bottom, according to the NRCS Web Soil Survey).
4. LS = Length-Slope Factor (unitless), taken from the following LS Calculation Table
5. C = Cover Management Factor (unitless), taken from the following Determination of C Factor Table.
6. P = Support Practice Factor (unitless). Since during both the pre-disturbance and reclamation conditions the site is left undisturbed, this factor does not apply. Thus, it will be taken as 1.

References:

1. Israelsen, C. Earl, Joel E. Fletcher, Frank W. Haws, and Eugene K. Israelsen, 1984. *Erosion and Sedimentation in Utah: A Guide for Control*. Hydraulics and Hydrology Series UWRL/H-84/03. Utah Water Research Laboratory, College of Engineering, Utah State University, Logan, Utah.
2. Jensen, E.H. and J.W. Borchert, 1988. *Soil Survey of Carbon Area, Utah*. U.S. Natural Resources Conservation Service, Salt Lake City, Utah.

### LS Calculation Table

Location	s	l	m	LS
Sowbelly Canyon Substation (Pre-Disturbance)	63	100	0.5	24.74
Sowbelly Canyon Substation (Post Reclamation)	100	3	0.5	7.32

#### Notes:

1. s = slope angle (%). The steepest slopes at the Sowbelly Canyon substation site (100%) were used for the post-reclamation condition. Since pre-disturbance topography is unknown, the slopes were conservatively assumed to be 63%, based on surrounding topography.
2. l = slope length (ft). This value is defined as the distance from the origin of overland flow to the point of deposition or channelized flow. Slope lengths rarely exceed 400 feet, and in this case, the presence of rocks, trees, and roads are conservatively estimated to limit the pre-disturbance slope length to 100 feet. Post-reclamation slope lengths are taken as 3 feet, which is the average distance from the top to the bottom of a deep gouge.
3. m = a factor in the LS equation which is 0.5 for slopes steeper than 5%.
4.  $LS = ((65.41s^2/(s^2+10,000)) + 4.56s/(s^2+10,000)^{0.5} + 0.065) / (1/72.6)^m$  (Israelsen et al., 1984)

#### References:

1. Israelsen, C. Earl, Joel E. Fletcher, Frank W. Haws, and Eugene K. Israelsen, 1984. *Erosion and Sedimentation in Utah: A Guide for Control*. Hydraulics and Hydrology Series UWRL/H-84/03. Utah Water Research Laboratory, College of Engineering, Utah State University, Logan, Utah.

### Determination of C Factor

The cover and management factor (C) was determined using tabulated values provided by Haan et al. (1994). The vegetative cover at the site was taken from Tables 7 and 10 of a vegetation monitoring report for the site performed in July 2007 (Mt. Nebo Scientific, Inc., 2008). These tables present the percentages of vegetative growth in both a reference area (pre-disturbance) and the reclaimed area. The total ground cover at each area was taken as the sum of the percentages covered by trees, shrubs, forbs, and grasses. Note that litter was not included in the ground cover calculation, since its presence is implicit in the tabulations provided by Haan et al. (1994). The C values were determined as shown below.

#### Percent cover from site surveys (Mt. Nebo Scientific, 2008)

Reference Area (Pre-Disturbance)					Sowbelly Canyon Substation (Post Reclamation)				
%Shrubs/ Trees	%Forbs/ Grasses	%Litter	%Ground Cover	C	%Shrubs/ Trees	%Forbs/ Grasses	%Litter	%Ground Cover	C
14.75	40.00	19.50	54.75	0.057	13.25	41.25	10.25	54.50	0.058

#### References:

1. Haan, C. T., B.J. Barfield, and J.C. Hayes. 1994. Design *Hydrology and Sedimentology for Small Catchments*. Academic Press, San Diego, California.
2. Mt. Nebo Scientific, Inc., 2008, *Revegetation Monitoring on Sites Reclaimed in 2002 at the Castle Gate Mine*. prepared by Patrick Collins, Ph.D. for Plateau Mining Corporation.

**Sediment Yield Calculations**

**Hardscrabble Canyon Phse III Bond Release  
Plateau Mining Corporation**



June 2012

Prepared by

EarthFax Engineering, Inc.  
7324 South Union Park Avenue  
Midvale, Utah 84047

## **Sediment Yield Calculations**

### **Hardscrabble Canyon Phase III Bond Release Plateau Mining Corporation**

#### **Summary**

The Revised Universal Soil Loss Equation (RUSLE) was used to calculate sediment yields from the former Hardscrabble Mine area under both pre-disturbance and post-reclamation conditions. Details regarding this methodology and the associated references are provided on the following pages. Under the pre-disturbance condition, slopes were taken as 100 feet long. Deep gouging was used in reclaimed areas, thereby limiting the post-reclamation slope length to approximately 3 feet. The changes in sediment yields resulting from revegetation of the site were also accounted for by comparing plant growth in the reclaimed area to the growth in an undisturbed reference area. The following calculations indicate that sediment yields for the reclaimed condition are 0.02 ton/acre/year, while those from the pre-disturbance condition are 0.06 tons/acre/year. Hence, sediment yields are estimated to be less under current, post-reclamation conditions than under natural conditions before the area was disturbed by mining.

### Sediment Yield Calculation

	R	K	LS	C	P	A (t/ac/yr)
Hardscrabble Canyon (Pre-Disturbance)	11	0.05	1.80	0.057	1	0.06
Hardscrabble Canyon (Post Reclamation)	11	0.15	0.31	0.046	1	0.02

Notes:

1.  $A = R K L S C P$ , where A is the annual sediment yield (tons/acre/year). This is the Revised Universal Soil Loss Equation (RUSLE). Each of the coefficients is explained below.
2. R = Rainfall-Runoff Erosivity Factor (unitless) = 11 from Map 7 (Israelsen et al., 1984). R is identical for both the pre-disturbed and post-reclamation conditions.
3. K = Soil Erodibility Factor (unitless). According to the NRCS Web Soil Survey (<http://websoilsurvey.nrcs.usda.gov/app/>), K = 0.05 for surficial soils throughout Hardscrabble Canyon. Therefore, this value was accepted as the K factor for the pre-disturbance condition. Since most of the mine-related disturbance was pre-law, topsoil was generally not saved. As a result, subsoil was used to reclaim most of the disturbed area, and a K value of 0.15 was assumed (equivalent to the K value for subsurface soils in the canyon bottom, according to the NRCS Web Soil Survey).
4. LS = Length-Slope Factor (unitless), taken from the following LS Calculation Table.
5. C = Cover Management Factor (unitless), taken from the following Determination of C Factor Table.
6. P = Support Practice Factor (unitless). Since during both the pre-disturbance and reclamation conditions the site is left undisturbed, this factor does not apply. Thus, it will be taken as 1.

References:

1. Israelsen, C. Earl, Joel E. Fletcher, Frank W. Haws, and Eugene K. Israelsen, 1984. *Erosion and Sedimentation in Utah: A Guide for Control*. Hydraulics and Hydrology Series UWRL/H-84/03. Utah Water Research Laboratory, College of Engineering, Utah State University, Logan, Utah.

### LS Calculation Table

Location	s	l	m	LS
Hardscrabble Canyon Substation (Pre-Disturbance)	12	100	0.5	1.80
Hardscrabble Canyon Substation (Post Reclamation)	12	3	0.5	0.31

#### Notes:

1. s = slope angle (%). Because pre-disturbance topography is unknown, the steepest slope in the reclaimed area (12%) was used for both the post-reclamation and pre-disturbance conditions.
2. l = slope length (ft). This value is defined as the distance from the origin of overland flow to the point of deposition or channelized flow. Slope lengths rarely exceed 400 feet, and in this case, the presence of rocks, trees, and roads are conservatively estimated to limit the pre-disturbance slope length to 100 feet. Post-reclamation slope lengths are taken as 3 feet, which is the average distance from the top to the bottom of a deep gouge.
3. m = a factor in the LS equation which is 0.5 for slopes steeper than 5%.
4.  $LS = ((65.41s^2/(s^2+10,000)) + 4.56s/(s^2+10,000)^{0.5} + 0.065) / (1/72.6)^m$  (Israelsen et al., 1984)

#### References:

1. Israelsen, C. Earl, Joel E. Fletcher, Frank W. Haws, and Eugene K. Israelsen, 1984. *Erosion and Sedimentation in Utah: A Guide for Control*. Hydraulics and Hydrology Series UWRL/H-84/03. Utah Water Research Laboratory, College of Engineering, Utah State University, Logan, Utah.

### Determination of C Factor

The cover and management factor (C) was determined using tabulated values provided by Haan et al. (1994). The vegetative cover at the site was taken from Tables 1 through 12 of a recent vegetation monitoring report for the site performed by Mt. Nebo Scientific, Inc. (2008). These tables present the percentages of vegetative growth in both reference areas (pre-disturbance) and reclaimed areas. The total ground cover at each area was taken as the sum of the percentages covered by trees, shrubs, forbs, and grasses. Note that litter was not included in the ground cover calculation, since its presence is implicit in the tabulations provided by Haan et al. (1994). The C values were determined as shown

#### Percent cover from site surveys (Mt. Nebo Scientific, 2008):

Reference Area (Pre-Disturbance)					Hardscrabble Canyon Substation (Post Reclamation)				
%Shrubs/ Trees	%Forbs/ Grasses	%Litter	%Ground Cover	C	%Shrubs/ Trees	%Forbs/ Grasses	%Litter	%Ground Cover	C
14.75	40.00	19.50	54.75	0.057	19.75	39.00	7.75	58.75	0.046

#### References:

1. Haan, C.T., B.J. Barfield, and J.C. Hayes. 1994. *Design Hydrology and Sedimentology for Small Catchments*. Academic Press, San Diego, California.
2. Mt. Nebo Scientific, Inc., 2008, *Revegetation Monitoring on Sites Reclaimed in 2002 at the Castle Gate Mine*. prepared by Patrick Collins, Ph.D. for Plateau Mining Corporation.

**Appendix 4**

**Landowner and Government Agency Notification  
Phase III Bond Release**

CASTLE GATE HOLDING COMPANY

July 30, 2012

Mark Stilson, Regional Engineer  
State of Utah  
Division of Water Rights  
319 Carbonville Rd. Suite B  
Price, Utah 804501

Re: **Notification of Application for Partial Phase III Bond Release, Castle Gate Holding Company, Castle Gate Mine, C/007/0004, Carbon County, Utah**

Dear Mr. Stilson,

Castle Gate Holding Company, P.O. Box 30, Helper, Utah 84526, has filed an application with the Utah Department of Natural Resources, Division of Oil, Gas and Mining pursuant to R645-301-880 for Phase III bond release for portions of the Castle Gate Mine Permit C/007/0004. The Phase III bond release applies to the 57.44 acres in Hardscrabble and Sowbelly Canyons which were reclaimed between the years 1984 and 1999. Castle Gate Holding Company has completed phase III of the approved reclamation plan for portions of the Castle Gate Mine in Hardscrabble and Sowbelly Canyons based on meeting the requirements for phase III reclamation in accordance with the approved reclamation plan.

In accordance with the provision of R645-301-880, of the State of Utah R645 Coal Mining Rules, notice is hereby given that Castle Gate Holding Company is applying for partial release of the performance bond posted for this property. The surety bond posted for the Castle Gate Mine is \$490,100; Castle Gate Holding Company is seeking release of \$263,500 which will reduce the bond to \$226,600.

The permit area is shown on the Standardville, Utah, U.S. Geological Survey 7.5-minute quadrangle map. The portion of the permit area that is affected contains a total of 57.44 acres and is located on the following described lands:

Township 13, Range 9 East, SLB&M, Utah  
Sec. 3: SE1/4SW1/4  
Sec. 10: NW1/4NW1/4, NE1/4NW1/4, SE1/4NW1/4, NW1/4NE1/4, SW1/4NE1/4, SE1/4NE1/4  
Sec. 4: NW1/4SW1/4, SW1/4SW1/4  
Sec. 9: NW1/4NW1/4

Comments concerning Phase III bond release from the legal or equitable owner of record of the surface areas to be affected and from the Federal, Utah and local government agencies which would have to initiate, implement, approve or authorize the proposed use of the land following reclamation should be mailed to: Castle Gate Holding Company, P.O. Box 30 Helper, Utah 84526.

Sincerely,

Dennis Ware  
Company Representative  
(435) 472-4737  
dware@alphanr.com

Mailed to:

Carbon County Planning and Zoning  
120 East Main Street  
Price, Utah 84501

Director Land Management  
Blackhawk Coal Company  
700 Morrison Road  
Gahanna, Ohio 43230-6642

Carbon County Commissioners  
120 East Main Street  
Price, Utah 84501

Mr. Steven Rigby  
Bureau of Land Management  
125 South 600 West  
Price, Utah 84501

Director  
School and Institutional Trust Lands Administration  
675 East 500 South, Suite 500  
Salt Lake City, Utah 84102-2818

Eric Larson, Regional Supervisor  
State of Utah  
Division of Wildlife Resources  
319 North Carbonville, Rd. Suite A  
Price, Utah 84501

Mark Stilson, Regional Engineer  
State of Utah  
Division of Water Rights  
319 Carbonville Rd. Suite B  
Price, Utah 804501

Dr. Phil Notorianni, Jr., Director  
State Historic Preservation Office  
300 Rio Grande  
Salt Lake City, Utah 84101

Eric Larson, Regional Supervisor  
State of Utah  
Division of Wildlife Resources  
SOUTHEASTERN REGION  
319 North Carbonville Road, Suite A  
Price Utah 84501

**Appendix 5**

**Reclamation Certification  
Phase III Bond Release**

Castle Gate Holding Company  
Castle Gate Mine  
C/007/0004

Partial Phase III Bond Release for Hardscrabble and Sowbelly Canyons on 57.44 acres of land which is in Castle Gate Mine Permit C/007/0004.

I hereby certify to the best of my information and belief all the information contained in this application for phase III bond release is true and correct and that all applicable reclamation activities have been accomplished in accordance with the requirement of the Act, the regulatory program and the approved reclamation plan.

Dennis N. Ware  
Print Name

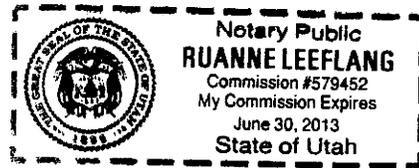
Company Representative  
Position

Dennis N. Ware      7/30/2012  
Signature, Date

Subscribed and sworn to before me this 30<sup>th</sup> day of July, 2012

Ruanne Leeflang  
Notary Public

My Commission Expires: 6-30, 2013  
Attest: State of Utah  
County of Emery



## **Appendix 6**

### **Bond Release Calculation Phase II Bond Release**

**Castle Gate Holding Company  
Castle Gate Mine. C/007/0004  
Partial Phase III Bond Release  
Bond Calculation**

Castle Gate Holding Company is filing for a partial Phase III bond release on portions of the Castle Gate Permit. The segments of the permit for which Phase III is being filed are the Hardscrabble and Sowbelly Canyons not including the substations. The Hardscrabble and Sowbelly Substations and the Adit #1 will remain in Phase I.

In order to determine the amount of bond to be released the current bond amount must be broken down in segments identifying those segments that will receive phase III bond release and those segments that will remain in phase I. Further, the remaining bond amount must be escalated from 2011 dollars to 2014 dollars.

The table below shows the bond amount prior to the last bond release (\$680,154) which occurred in March of 2006, the March 2006 phase I bond release for the Substations in Hardscrabble and Sowbelly Canyons as well as the Adit #1 (\$190,054), the current bond amount in 2006 dollars (\$490,100), the amount of bond that will remain following this Partial Phase III Bond Release in 2006 dollars (\$218,600) and the amount that will remain after this Partial Phase III Bond Release escalated to 2014 dollars (\$226,600) and the amount of this Partial Phase III Bond Release (\$263,500).

	Bond Prior to March 2006 Bond Release	March 2006 Phase I Bond Release	March 2006 Bond In 2011 Dollars	Remaining after Partial <u>Phase III</u>
Hardscrabble Canyon	\$179,500	\$0	\$179,500	\$0
Sowbelly Canyon	\$92,000	\$0	\$92,000	\$0
Hardscrabble Substation	\$138,500	-\$51,000	\$87,500	\$87,500
Sowbelly Substation	\$141,000	-\$65,000	\$76,000	\$76,000
Adit #1	<u>\$129,154</u>	<u>-\$74,054</u>	<u>\$55,100</u>	<u>\$55,100</u>
Totals	\$680,154	-\$190,054	\$490,100	\$218,600
				Escalate to 2012 dollars @1.2%
				\$221,223
				Escalate to 2013 dollars @1.2%
				\$223,878
				Escalate to 2014 dollars @1.2%
				\$226,564
				Bond in 2014 \$ Rounded
				\$226,600
				Current Bond
				\$490,100
				Bond Remaining after Phase III
				<u>\$226,600</u>
				Bond Amount to be Released
				\$263,500