APPENDIX A

VEGETATION SAMPLING METHODS AND RECLAMATION SUCCESS STANDARDS FOR SURFACE COAL MINING OPERATIONS

Introduction

Procedures specified in this document are required for surface coal mining operators per its reference in Chapter 2, Section 2(a)(vi)(C) of the WDEQ/LQD Rules and Regulations. Permission for significant departures from this Appendix should be requested by formal proposal to the Division. Proposed alternatives will be evaluated by the state and federal authorities prior to approval and implementation. Alternative methods which are equally acceptable to those recommended in this Appendix will be given due consideration.

This document outlines acceptable procedures for generation, analysis and presentation of vegetation data and revegetation practices to assist a permit applicant with respect to the permit application requirements of W.S. § 35-11-406(a)(vii), (b)(i) and (b)(iii), Sections 2(a)(vi)(A) & (B), 2(a)(vi)(C), and 2(b)(iv)(C) of Chapter 2 of LQD Rules and Regulations and Sections 2(a)(i), 2(a)(ii), 2(d)(i) through (xiv) of Chapter 4 of LQD Rules and Regulations. The description of lands not previously permitted should be in accordance with methods specified in this document or in accordance with an approved alternative. Renewal applications may utilize vegetation baseline data collected using earlier approved methods if the results are part of the currently approved mine permit.

Some of the introduction is revised and included in Chapter 2 Section 3(a).

The type and amount of vegetation information required for mining permit applications may be modified depending upon:

a. The type of land disturbed and/or the type and acreage of disturbance.

b. The size of the permit area.

This information is revised and included in Chapter 2 Section 3(b)

~~This document outlines acceptable procedures for:~~

~~A. Designing and executing premining baseline vegetation inventories.~~

~~B. Documenting the premining land uses and the capability of the existing plant communities to support those uses.~~

~~C. Establishing and evaluating appropriate postmining land uses.~~

~~D. Formulating a sound revegetation plan by choosing appropriate plant species and plant community types which will support the postmining land uses.~~

~~E. Establishing quantitative and qualitative vegetation parameters which serve as reclamation success standards for purposes of final bond release.~~

~~F. Preparing sections of Appendices D-1, D-8, and D-11 and the Reclamation Plan.~~

~~G. Evaluating the success of revegetation efforts and for eventual request of full bond release.~~

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I. General Inventory Procedures

These procedures constitute an acceptable premining vegetation inventory. Other methods and types of inventories may be acceptable if they meet or exceed the objectives of this appendix. Failure to receive prior approval for alternative procedures may cause significant delays during permit review, and rejection of the sampling methods and procedures if these do not result in an equivalent data base. WDEQ/LQD strongly encourages cooperative interactions among the regulatory authority, prospective applicants and consultants to prospective applicants during the design and execution of baseline inventories and preparation of permit applications.

This section is moved, with revision, to Chapter 2 Section 3(a).

A. Mapping of Plant Communities

The plant communities or vegetation types of the entire permit area shall be delineated on an aerial mosaic photograph or topographic base map. The mapping should be extended to adjacent areas (0.8 km) on all sides of the permit area boundary or study area boundary. This suggested extension beyond the permit area applies only to mapping of community types. This suggestion does not refer to sampling of areas outside the permit area.

The LQD does not recommend the use of SCS range sites for the mapping of premining plant communities. The range site concept does not facilitate practical units for reclamation purposes.

The map scale should be between 1:4,800 and 1:10,000 (approximately 1 inch equal to 400-700 feet).

The vegetation map should clearly and accurately show all appropriate legend information outlined under the heading "Maps" in WDEQ/LQD Guidelines No. 6 or 6A. In addition, the vegetation map should identify all sample locations, accurately locate all Control Areas (CONA) (See Glossary), identify and describe the type and extent of all existing disturbances and identify all areas to be affected by mining and associated activities, including access roads, railroad spurs, etc.

This section is moved with revision to Chapter 2 Section 3(c).

~~B. Sampling of Plant Communities~~

~~Each defined plant community of the permit area and all CONAs should be sampled for the following parameters:~~

1. % vegetation cover by species
2. % total cover (= sum of all species)
3. % total ground cover (= vegetation + litter + rock)
4. % bare ground
5. herbaceous production by species
6. total herbaceous production
7. density and distribution of full shrubs (and subshrubs when appropriate)
8. density of trees
9. species diversity and species composition

The LQD prefers that these vegetation parameters be estimated by vegetation type, considering the entire permit area as a single unit, i.e. without a distinction between affected and non-affected areas. The LQD feels that sampling the entire permit area will:

1. facilitate the derivation of more accurate quantitative and qualitative revegetation success standards;
2. provide the operator greater flexibility in planning the location and progression of pits and the location of mining facilities.

However, the applicant should also consider their chosen method of evaluating revegetation success (Sections III.B. and VIII.B.) when deciding whether to distinguish between affected and non-affected areas for sampling purposes.

Both absolute and relative values for % species cover, % vegetation cover, % total ground cover, herbaceous production by species and total herbaceous production should be provided. The absolute values of % vegetation cover, % total cover and total herbaceous production constitute the quantitative revegetation success goals, as per Chapter 4, Section 2(d)(x), for evaluation of full bond release. The relative values of cover and production are used to evaluate the representative nature of the CONAs and may be used in evaluating postmining species diversity and species composition as per Chapter 4, Section 2(d)(x).

Please see the Glossary for definitional distinctions between absolute and relative values.

C. Establishing and Sampling Control Areas or Reference Areas

The applicant should establish a Control Area (CONA) or Reference Area (REFA) for each vegetation type, in excess of 10 acres, which will be disturbed (or a greater area approved by the Division) unless the Division has agreed that reestablishment of the vegetation type will not be required. For the sake of brevity, this guideline will generally use only the term CONA. However, all applicants should clearly understand that either the CONA or REFA concept is an acceptable procedure for the evaluation of revegetation success under provisions of Chapter 4, Section 2(d)(x).

Sections III.B. and VIII.B. describe the conceptual distinctions between the use of CONAs or REFAs. Applicants may develop, propose and request approval for alternatives to CONAs or REFAS for the evaluation of revegetation success.

Each CONA should be marked on the vegetation map, should be permanently marked in the field, and should be managed in a fashion equivalent to all other non-affected lands within the permit area. By definition the land units chosen as CONAs should remain unaffected by mining and associated activities over the life of the mine, and they cannot be moved without resampling the entire type they represent.

The applicant should present vegetation data on each community type and each CONA in a fashion which facilitates evaluation of the representative nature of each CONA. A tabular summary might best achieve this comparison (see Appendix V, Table 3).

D. Describing the Plant Communities

Each plant community and the representative CONA should be verbally described. The description should include the general vegetation composition, the dominant plant species, characteristic topography, soil types, average slope, aspect and interspersion with or relationship to other community types. The quantitative and qualitative vegetation information may be best presented in a tabular format (Appendix V, Table 2).

If noxious (designated) or declared weeds (see Appendix I) comprise more than 25% of the vegetation cover on three (3) or more contiguous acres, these areas should be mapped as distinct vegetation types and identified on the vegetation map. These weedy species should be noted in the species list; their presence in any of the mapped community types should also be noted. Quantitative sampling should not be performed on noxious weed mapping units.

The presence of selenium indicators (Appendix III) should also be noted and their distribution discussed.

The applicant should present the following information in a tabular format (see Appendix V, Table 1):

1. Total acreage of each vegetation type on the permit area.
2. Total acreage of each vegetation type sampled on the study area, if the study area is larger than the permit area.
3. Total acreage of each vegetation type affected by mining and associated activities.
4. % of each vegetation type affected by mining and associated activities.
5. Total acreage of each CONA.
6. Total acreage of all other mapping units, e.g. reservoirs, cropland, pastureland, hayland, existing disturbed areas.

A 3 1/2" x 5" (or larger) photograph or a 2-3 frame panoramic sequence showing the general features of each community type and its representative CONA should be provided in the vegetation report. Photocopies of photographs are not acceptable. The location of all photographs should be noted on the vegetation map.

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This section is moved with revision to Chapter 2 Section 3(j)(iv).

E. Compiling a Plant Species List

The applicant should compile a list of the vascular plants of the permit area, including plant species observed but not actually recorded during sampling. The species list should be field checked and updated at least once a month from April through September during the field season when baseline sampling is performed. Regional and seasonal phenological processes should determine the actual compilation time period.

The plant species should be listed by scientific binomial and common name under life-form categories. Suggested categories include annual grasses, perennial grasses, grass-like species, forbs, succulents, full shrubs, subshrubs and trees.

The applicant should list the literature and/or personnel contacted for identification of plant species and note the location of any herbarium samples collected during the baseline inventory. A specimen of the following may be requested to confirm its occurrence:

1. any plant of special concern (Appendix IV).
2. any species which is similar to a plant of special concern;
3. any species not previously recorded in Wyoming.
4. any species out of its known range.

The applicant should specifically note any plants of special concern (Appendix IV) which occur on or adjacent to the permit area.

This section is moved with revision to Chapter 2 Section 3(i).

~~F. Sample Adequacy~~

~~The applicant should attain formula-based sample adequacy or achieve the maximum sample size for each of the following vegetation parameters in each vegetation type and each CONA:~~

1. ~~% vegetation cover (absolute value only).~~
2. ~~% total ground cover (absolute value only).~~
3. ~~Total herbaceous production (absolute value only).~~

Section IV of this appendix outlines procedures for calculating sample adequacy and lists maximum and minimum sample sizes.

II. Detailed Qualitative and Quantitative Sampling Procedures

A. Choice of Sample Locations

All sample locations must be chosen by random or systematic procedures. Random procedures are discussed in most standard statistical texts. The selection of sample locations must be done objectively in the lab or office, not in the field. Grid line intervals (when used) should be no more than 65 meters on the ground. After the sample locations are selected, pacing from easily identifiable land marks is sufficiently accurate to locate them in the field.

Systematic sampling is described in Cochran (1977), Chapter 8. Systematic samples are acceptable only if each vegetation type is entirely covered. Calculations for systematic samples may be done by assuming the sample is random.

Sample locations must not be discarded because they are located on areas which are barren or otherwise seem atypical. However, sample locations which fall within recognizable and distinct inclusions within a given vegetation type, on obvious ecotones between types or on areas obviously disturbed by human activities or for land management practices, may be excluded during actual sampling. The applicant should carefully note and report in the permit application, Appendix D-8, all such occurrences.

The same procedures should be used for choosing sample locations in CONAs as in the permit area as a whole. These procedures should be clearly described in the permit application, Appendix D-8.

B. Choosing Sampling Methods

The quantitative vegetation data requested in this appendix can be gathered using the basic methods of quadrants and/or transects. The choice of methods lies with the applicant. The choice should be based upon:

1. The specific parameter being measured.
2. The degree of statistical accuracy desired.
3. Operator knowledge of the permit area and its plant communities.
4. Operator experience in using a given technique.

The methods discussed in this guideline have been widely used in plant communities of Wyoming. In general, they have provided sufficiently detailed and accurate information to meet the permit application requirements of W.S. § 35-11-406 and Chapters 2 and 4 of LQD Rules and Regulations. In particular, the methods discussed in this appendix have consistently provided the type, quantity and quality of data necessary to:

1. document the highest previous use of the land within a permit area.
2. document that the regional plant communities can or cannot support the prevailing land uses.
3. develop sound reclamation and revegetation methods.
4. establish sound quantitative and qualitative revegetation success goals.

Investigators have devised numerous study designs, sampling regimes and sampling methods for, vegetation analysis. Some of these procedures variously known as two-stage sampling, double sampling, cluster sampling, stratified sampling, etc., have been used for baseline vegetation inventories in Wyoming. However, in general these methods have not proven satisfactory for attaining adequate baseline information. Operationally, the large variance terms associated with these sampling methods have caused serious difficulties in attaining the sample adequacy tests of this appendix. The LQD does not recommend use of these procedures.

The references listed in Appendix VI may provide useful information regarding sampling methods.

1. Use of Quadrats

All of the required vegetation parameters can be estimated using quadrants. However, a single quadrant size and shape may not be appropriate for all parameters. Furthermore, there is no absolute, universal method for determining quadrant size or shape. Quadrant size and shape should be selected to reduce variance and thereby reduce the number of samples needed. The quadrant should be sufficiently large so that:

a. Separation, counting and measurement of the individual plants can be performed with relative ease.
b. Sampling efficiency is as high as possible.
c. The largest plant within the quadrant does not fill the quadrant.
d. All quadrants enclose some vegetation.

2. Use of Line Transects

All transects should be at least 50 meters in length. If a transect runs out of a given vegetation community, select a new random orientation, at the point where the transect leaves the vegetation type, which will return the transect to the same vegetation type.

If quadrants are spaced along a transect, no fewer than five (5) quadrants should be placed along each transect. If point-intercept methods are employed along a 50-meter transect, no fewer than fifty (50) sample points should be evenly spaced along each transect.

Independent of the method, each transect comprises a sample size (N) of one (1).

C. Suggested Sampling Procedures for Specific Vegetation Parameters

1. Cover Parameters

Chapter 1 of LQD Rules and Regulations defines "cover," as vegetation, litter and rock over the soil which intercept rainfall. This definition describes % total ground cover. Operationally, vegetation cover is the vertical projection of the general outline of plants (ignoring minor gaps between branches and holes in the canopy) to the ground surface expressed as a percent of a surface reference unit.

The applicant should collect data for the following categories:

1. % vegetation cover by species
2. % total vegetation cover (=sum of all species)
3. % total ground cover (=vegetation + litter + rock)
4. % bare ground

The original absolute cover values for individual species should be manipulated to provide relative cover values.

For sampling purposes rock may be considered any stone or mineral matter at least one (1) square centimeter in size. Litter is any plant part, lying on the ground surface, whose structural integrity remains recognizable.

a. Quadrat Methods

Species cover, vegetation cover and total ground cover can be determined from appropriately sized quadrants by ocular estimation. The considerations for determining quadrat size and shape discussed earlier clearly apply to cover sampling.

b. Line Transect Methods

Species cover, vegetation cover and total cover can be determined from procedures based on line transects. The point intercept method has been frequently and successfully applied in Wyoming plant communities. Point samples may be determined using the following tools: sharpened rod or pin or an ocular siting device projected vertically downward to the sample location on the transect.

When estimating % cover by species, only the first hit on each species should be recorded and used in the calculations. If one projection intercepts the same species more than once, record only the "first hit" on that species. If one

projection intercepts more than one species, separate hits should be recorded for each on each species.

When estimating % total vegetation cover, the first "hit" per projection should be used.

In general, the line transect should be at least fifty (50) meters long; Point samples should be collected at one (1) meter intervals. Each transect constitutes a sample size (N) of one (1).

2. Total Herbaceous Production

In this appendix, the term production will describe an estimate of the total herbaceous standing crop biomass which is measured at or near the expected peak of the standing crop. Herbaceous production by species and total herbaceous production should be estimated for each community type and its representative CONA.

a. Grazing Exclosures

All production estimates should be taken from within grazing exclosures. Random sample points (exclosure locations) should be established before the growing season. The exclosures should be placed in the field on or before April 15th or as soon after snowmelt as field conditions permit. Cages should be placed at this time to avoid possible data complications from snow accumulation through the winter.

The number of cages needed can be estimated from preliminary sampling, from results of previous vegetation sampling on-site or from other vegetation surveys in similar vegetation types in the area. All permit applications and approved permits for mining in Wyoming are public documents and open to review. Analysis of existing data from applicable documents should be an integral part of all study designs for a baseline vegetation inventory. Applicants should establish several extra exclosures in each vegetation type and CONA to accommodate possible loss of some exclosures due to destruction by cattle, inaccessible locations, placement in an inclusion, etc.

The cage size and quadrant size must be chosen with each other in mind. The exclosure must be sufficiently large to accommodate the sample quadrant and to provide a buffer area which reduces the potential for serious edge effects.

All exclosures should be removed when the inventory is complete.

b. Field Methods

~~The standing crop biomass of all herbaceous species should be harvested in each quadrant. Full shrubs, succulents, annual grasses, annual forbs, Yucca spp., noxious weeds, cushion plants and trees should not be harvested. The seasonal growth of subshrubs should be harvested (see Appendix II) when accurate density data are unattainable. If annual grasses and/or annual forbs are major community components, these life forms should be clipped.~~

~~The vegetation should be clipped by species in each vegetation type and each CONA. The minor or remaining species can be harvested by life form category (Section I.E.).~~

~~All biomass should be carefully dried in an oven to a constant weight and recorded to the nearest 0.1 gram. Data should be reported in grams per square meter.~~

~~c. Data on Cropland, Hayland or Pastureland~~

~~Land units which have experienced special management such as cropland or pastureland (see definitions under "cropland and pastureland", respectively) should be delineated and identified on the vegetation map. Best available information on the current and historical management of these lands and their production must be provided. The applicant should consult appropriate land owners or managers for these data. All sources for this information should be identified in the text. Harvest data should be presented in units of grams per square meter, if possible.~~ Cropland need not be sampled for any of the vegetation parameters outlined in Section I.B. However, some vegetation sampling of pasturelands and haylands may be appropriate. It is strongly recommended that the applicant contact LQD during the initial planning stages of the proposed vegetation inventories to discuss appropriate sampling procedures relative to these land units.

This section is moved with revision to Chapter 2 Section 3(m).

~~In general, CONAs or REFAs need not be established for these land units. The premining production data, similar undisturbed management units or average area agricultural statistics information may serve as reclamation success standards per Chapter 4, Section 2(d)(x)(I). However, given site specific conditions it may be appropriate to establish CONAs or REFAs for haylands and pasturelands. The need to establish CONAs or REFAs should be discussed with the LQD during the initial planning stages of the vegetation inventory.~~

~~3. Shrub Habitat Characteristics~~

~~The postmining density, composition and distribution of shrubs shall be based upon site specific evaluation of the premining vegetation and wildlife use. Except where a~~

~~lesser density is justified from premining conditions, at least 20 percent of the eligible land shall be restored to shrub patches supporting an average density of one shrub per square meter (Chapter 4, Section 2(d)(x)(E)). Thus, the baseline vegetation inventory shall include premining shrub distribution data, to include an estimation of the distribution and areal extent of shrub clumps or patches. Shrub density and cover data shall be components of the shrub distribution information.~~

~~When shrub density data are estimated, they shall be gathered from each community, but not from CONAs, REFAS OR MINIMUM EXREFAS. Shrubs shall be divided into woody species (full shrubs) and suffrutescent species (subshrubs) for sampling purposes (see Appendix II).~~

~~Shrub density counts shall be performed within a 50 square meter area using a plot shape appropriate to the community.~~

~~Data shall be recorded by species and then manipulated to formulate full shrub and subshrub density values for each community type. The data shall be reported as number per square meter and number per acre. The growth characteristics of certain subshrub species under various environmental conditions may prohibit accurate density counts. Under these circumstances, consultation with LQD may provide for the collection of seasonal growth biomass as a substitute method of characterizing these plant species.~~

~~All shrub density data collected after August 6, 1996 shall be subject to sample adequacy tests specified in Section IV. of this Appendix. However, all shrub density data collected prior to August 6, 1996 shall not be subject to sample adequacy tests unless that shrub density data is being used to fulfill the 20% standard. In general, when sampling is conducted which is not subject to sample adequacy, the number of shrub density sample points should correspond to the number of cover samples in each community type.~~

~~4. Tree Distribution~~

~~Chapter 4, Section 2(d)(x)(E) requires that trees be returned to a density equal to the pre-mining conditions on all surface mining operations.~~

~~Plotless distance, methods and direct counts have been used to estimate tree densities in Wyoming plant communities. Because of the patterns of distribution and general paucity of tree species on lands affected by mining in Wyoming, direct count methods may be the most accurate and efficient. Depending upon community characteristics, plant distribution, plant size and availability of source materials, direct counts may be made by field reconnaissance or from aerial photographs. If plotless methods are used, 15-20 randomly chosen sample points should be sampled. Some estimate of height and/or age distribution should also be provided.~~

Tree density data are not required for CONAs. Tree density data are not subject to sample adequacy tests.

The general locations or concentrations of trees should be illustrated on the vegetation map.

5. Species Composition and Species Diversity

Chapter 1 of LQD Rules and Regulations defines species composition as the "...number, kinds, amount and quality of species" and species diversity as the "...number of species per unit area". Chapter 4, Section 2(d)(x) establishes suitable postmining species diversity and composition as revegetation success goals for all operators.

The concept of species diversity is complex. Some researchers suggest that species diversity can be measured by indices of diversity. Though numerous indices of diversity have been developed, no standard index exists and no single index is necessarily better than another.

The applicant should collect premining data which can be manipulated to document the species composition and species diversity of premining plant communities.

D. Recording of Sample Methodology

All sampling procedures must be presented clearly in the text of Appendix D-8. The applicant should use the same procedures for sampling vegetation types and CONAS.

III. Establishing Revegetation Success Goals

A. Quantitative and Qualitative Vegetation Standards

Chapter 4, Section 2(a)(i) requires that reclamation restore the land to a condition equal to or greater than the "highest previous use". Chapter 4, Section 2(d)(x) outlines specific vegetation parameters which constitute revegetation success goals when reclaimed lands are considered for full bond release.

These qualitative and quantitative vegetation parameters which constitute revegetation success goals include:

1. % vegetation cover (absolute value).
2. % total ground cover (absolute value).
3. Total production for herbaceous species (absolute value).
4. Density of full shrub and subshrub species (in mosaics according to the applicable goal or standard).
5. Areal extent of shrub mosaics according to the applicable goal or standard.
6. Total number of trees.

7. Species diversity and species composition.
8. Attainment of these parameters for the last two consecutive years for those mines using reference areas, or for those mines using an approved technical standard., two out of four years beginning no sooner than year eight of the bonding period

The premining values of these parameters, estimated from the vegetation types actually affected by mining and/or from other undisturbed portions of the same type which are representative of the affected vegetation types, are used to generate the postmining revegetation success goals.

The baseline vegetation inventory should generate a single quantitative or qualitative value for parameters 1, 2, 3, 5 and 6 from each vegetation type and its representative CONA. Each quantitative and qualitative goal should be clearly presented in the permit application, Appendix D-8, and at least referenced in the Reclamation Plan.

B. Establishing Land Units for Use in Evaluating Revegetation Success for Full Bond Release

As noted above, Chapter 4 specifies the vegetation parameters which constitute revegetation success goals for full bond release and requires the LQD Administrator to specify methods for evaluating attainment of these goals. At this time, all approved success evaluation methods must be based upon analysis of an undisturbed land unit, i.e. a control area or reference area. As discussed more fully in Section VIII, several methods of evaluating revegetation success exist. Each of the methods conceptually share several common features:

1. During the baseline inventory, the applicant delineates portions of vegetation types which will remain undisturbed and which are biotically and abiotically representative of vegetation types affected by mining activities.

2. During the baseline inventory, standard sampling methods are used to estimate the premining values of the vegetation parameters (outlined above in Section III.A.) on each affected vegetation type and an undisturbed portion of the same vegetation type. These premining data are used to document the representative nature of the undisturbed unit.

3. At least two (2) years prior to the desire for full bond release, the revegetation success parameters are again estimated on the revegetated areas and the undisturbed units.

The applicant should choose which conceptual framework is appropriate for the evaluation of revegetation success under the conditions expected to exist on the mine site. Alternate success standards for evaluating reclamation success may be submitted for approval by the Administrator. The applicant must establish at least one land unit,

~~within an undisturbed portion of a vegetation type, which is representative of each vegetation type that will experience ten (10) acres or more of disturbance (or a greater area if approved by the Division).~~

~~The following types of undisturbed land units may be established for use in evaluating revegetation success. The land units themselves and the conceptual framework within which they are used are not interchangeable. The applicant should consistently establish one type of land unit from the following:~~

Control Area means a land unit which is representative, in terms of physiography, soils, vegetation and land use history, of a plant community affected by mining activities. The representative nature of the Control Area is verified by subjective (nonstatistical) comparison of its qualitative and quantitative characteristics to similar information from the plant community it typifies.

Quantitative premining and postmining vegetation data from the Control Area are used to mathematically adjust premining affected area data for climatic change. These adjusted data are directly compared by statistical procedures (confidence level of 80%, $\alpha = 0.2$) to data from a reclaimed vegetation type when evaluating revegetation success for full bond release. Qualitative data are compared by standard procedures agreed to by the applicant or permittee and LQD.

The definition for Control Area is relocated to chapter 1, listed as a subsection under the definition for "Reference Area".

Reference Area means a land unit which is representative, in terms of physiography, soils, vegetation and land use history, of a plant community affected by mining activities. The representative nature of the Reference Area is verified by statistical comparison (confidence level of 90%, $\alpha = 0.1$) of its absolute values of % vegetation cover, % total ground cover and total herbaceous production to similar data from the plant community it typifies. Species composition and species diversity are subjectively (nonstatistically) evaluated.

Quantitative postmining vegetation data from the Reference Area are directly compared, by standard statistical procedures (confidence level of 80%, $\alpha = 0.2$), to data from a reclaimed vegetation type when evaluating revegetation success for full bond release. Qualitative data are compared by standard procedures agreed to by the applicant or permittee and LQD.

The definition for Reference Area is relocated to chapter 1.

Note: The following is a special kind of reference area that can be utilized by the operator.

Extended Reference Area means all the undisturbed portions of a vegetation type which has experienced disturbance by mining activities. The representative nature of the Extended Reference Area is verified by evaluation of vegetation mapping procedures, the adequacy of premining vegetation data, soils data, physiography and land use history information.

Postmining quantitative vegetation data from the Extended Reference Area are directly compared by standard statistical procedures (confidence level of 80%, $\alpha = 0.2$), to data from a reclaimed vegetation type when evaluating revegetation success for full bond release. No mathematical adjustment for climatic change is made. Qualitative data are compared by standard procedures agreed to by the applicant or permittee and LQD.

The definition for Extended Reference Area is relocated to chapter 1, listed as a subsection under the definition for "Reference Area".

~~A Control Area (CONA) or Reference Area (REFA) should be at least two (2) acres in size. Larger land units are preferred, whenever possible, for the following reasons: 1) to reduce the variability (in terms of the abiotic and biotic characteristics) between the CONAs or REFAs and the communities they typify; and 2) to reduce the potential adverse impacts to the CONAs or REFAs due to intensive sampling at the time of bond release, which becomes more critical when successive units of reclaimed lands are being evaluated for revegetation success.~~

~~All CONAs or REFAs should remain undisturbed by mining activities and should be managed in a fashion which will not cause significant, management-related changes in the vegetation parameters used to evaluate revegetation success. Permittees should contact LQD if they perceive the need to relocate a previously established CONA or REFA.~~

~~Section VIII.B. further outlines operational differences among the CONA and REFA concepts when evaluating the success of revegetation.~~

~~For existing mining operations where vegetation data were not collected prior to disturbance, another type of land unit may be established for purposes of evaluating revegetation success.~~

Comparison Area means a land unit which is representative, in terms of physiography, soils, vegetation and land use history, of a premining plant community from which no vegetation data were collected prior to disturbance. The representative nature of the Comparison Area may be validated by a subjective field reconnaissance of the site or by subjective evaluation of vegetation data generated by a sampling program. The establishment procedures should be agreed to by the permittee or applicant and the LQD prior to establishment.

Postmining quantitative data from the comparison area are directly compared, by standard statistical procedure (confidence level of 80%, $\alpha = 0.2$), to data from a reclaimed vegetation type when evaluating revegetation success for full bond release. No mathematical adjustment for climatic change is made. Qualitative data are compared by standard procedure agreed to by the permittee or applicant and LQD.

A Comparison Area should be at least two (2) acres in size and should be managed in a fashion which will not cause significant changes in the vegetation parameters used to evaluate revegetation success. The permittee or applicant should establish and request approval of the Comparison Area at least two (2) years prior to an anticipated request for full bond release.

The definition for Comparison Area is relocated to chapter 1, listed as a subsection under the definition for "Reference Area".

~~IV. Estimating Adequate Sample Size~~

~~A. General Considerations~~

~~The applicant must achieve sample adequacy or execute the maximum sample size for each CONA and for each vegetation type.~~

~~The applicant must achieve sample adequacy for each of the following parameters independently in each CONA and each vegetation type.~~

1. ~~% vegetation cover (absolute cover).~~
2. ~~% total ground cover (absolute cover).~~
3. ~~Total herbaceous production~~.

~~B. Procedures~~

~~The applicant should sample at least the minimum number of sample locations as outlined by Table 2. below. The following formula should then be used in an incremental and iterative fashion to estimate sample adequacy:~~

$$n_{\min} = \frac{2(sz)^2}{(d\bar{x})^2}$$

~~where:~~

~~n_{min} = the number of sample points needed in a given vegetation type~~
~~sample standard deviation = S~~

$$S = \sqrt{\frac{\sum x_i^2 - \left(\sum x_i\right)^2 / n}{n-1}}$$

z = the z statistic

d = acceptable amount of inherent variability to be identified between the sample mean and the true population mean; See Table 1 below for d and z values.

θ = sample mean for cover or production

If sample adequacy is not met in an incremental fashion, the sample adequacy test should be applied until the maximum number of samples, as outlined by Table 2, is reached. Alternatively, the applicant may simply establish and sample the maximum number of samples presented in Table 2.

The applicant should always present analyses of sample adequacy using the n_{min} formula. These analyses are best presented in a tabular format (see Appendix V, Table 4). In order that LQD personnel may check these data, all parameters of the formula must be clearly presented.

If the calculated n_{min} exceeds the maximum sample size of Table 2, the applicant should indicate the confidence level (d value) achieved by solving for z (assuming n actual = n_{min}). The applicant should also present a brief explanation of why the sample was unusually variable and thus formula adequacy was not achieved.

C. Determining d and z values

The community composition determines the d and z values for assessment of sample adequacy for total herbaceous production. Two arbitrary community types are defined as follows:

1. A grassland community is a vegetation type where the contribution of the cover of full shrubs and subshrubs comprises less than 20% of the total cover of all species.

2. A shrubland community is a vegetation type where the contribution of the cover of full shrubs and subshrubs comprises more than 20% of the total cover of all species.

These definitions are based upon analyses of existing premining vegetation data. Their derivation is available from LQD upon request.

After making this operational distinction based upon sampling data, choose the appropriate parameters from Table 1 below. The parameters used for evaluation of % vegetation cover and % total ground cover do not vary with community type. Consult Table 1 for appropriate parameters.

Table 1. z and d values for use in the sample adequacy formula

Vegetation parameter	z	d
% vegetation cover, grassland & shrubland	1.28	0.1

% total ground cover, grassland & shrubland	1.28	0.1
total herbaceous production, grassland	1.28	0.1
total herbaceous production, shrubland	0.84	0.2
50 m^2 shrub density plots	0.84	0.2

D. Determining Minimum and Maximum Sample Sizes

Table 2. Minimum and maximum sample sizes for various sampling methods

Sampling Method	sample size	
	minimum	maximum
1. In Control or Reference Areas		
quadrats	10	30
transects with quadrats	5	30
intercept transects	15	30
2. In Vegetation Types		
quadrats	15	50
transects with quadrats	7	30
intercept transects	20	50
50 m^2 shrub density plots	15	*

* if sample adequacy can not be achieved after sampling 50 shrub density plots, the operator shall contact the LQD for guidance

The maximum and minimum sample sizes for CONAs also apply to vegetation types which cover fewer than 30 ha (80 acres) or vegetation types which will experience fewer than 4 ha (10 acres) of disturbance. The applicant should consult LQD for direction in such situations.

The maximum and minimum sample sizes were constructed with the following qualifications:

1. cover, production and density are being estimated using appropriately sized quadrats.
2. line transects are 50m long with 50 evenly spaced estimation points.
3. all sample points are randomly or systematically chosen.
4. vegetation types are accurately and professionally delineated, mapped and sampled.
5. a permit area no larger than 10,000 acres. If a permit area exceeds 10,000 acres it may require a larger sample size. The applicant should consult LQD for direction in such situations.
6. shrub density is estimated using a 50 square meter plot

Compromise of any of these criteria may result in serious difficulties with sample adequacy requirements and may compromise acceptability of the baseline vegetation inventory.

V. Suggested Timetable for Components of the Vegetation Inventory

Design vegetation study	Any time - discuss with DEQ/LQD well in advance of field sampling season
Map vegetation types of entire permit area	Any time - field check during growing season, prior to baseline sampling.
Describe each vegetation type	Any time - confirm dominant species during and after field sampling.
Construct species list	Field check at least once a month from April through September (actual period is determined by regional and seasonal phenology).
Place grazing exclosures in field	Before April 15 or following snowmelt.
Sample for vegetation parameters including tree and full shrub density. CONAs or REFAs and vegetation types should be sampled at the same time to permit valid comparisons of data.	July through September - actual sampling period is determined by regional and seasonal phenology.

VI. General Format for Appendix D-8 of the Permit Application

The following is a suggested outline for organization of Appendix D-8.

A. Table of Contents - A summary of the major entries, including lists of figures, tables, and maps.

B. Introduction - A description of the location and general features of the permit area and the personnel (or firm) conducting the baseline inventory.

C. Methods - A description of all procedures used in the baseline inventory, which includes:

1. delineation and mapping of vegetation types and other land units.
2. general sampling design for the permit area.

a. selection of sample points
b. plot size and shape, transect characteristics, etc.
c. specific calendar dates of all sampling

3. general sampling design for the Control or Reference Areas.
4. establishment, marking and management of CONAs or REFAs.
5. evaluation of sample adequacy.
6. compilation of species list.

D. Results and Discussion – A presentation and interpretation of the vegetation data, to include:

1. description of the Vegetation Map and each vegetation type or other land unit.
2. description of each CONA or REFA and discussion of its representative nature.
3. tabular summary of the areal extent of each mapping unit and acreage affected by mining (see Table 1, Appendix V).
4. summarized vegetation parameters for the permit area (see Tables 2 and 5, Appendix V).
5. summarized vegetation parameters for the CONAs (see Tables 3 and 5, Appendix V).
6. comparison of vegetation data between each vegetation type and its representative CONA (see Table 3, Appendix V).
7. evaluation of sample adequacy for each vegetation type and its representative CONA (see Table 4, Appendix V).
8. species list, selenium indicators, species of special concern and noxious (designated) or declared weeds (see Appendices I, III and IV).

E. Literature Cited

F. Raw Data

VII. Developing a Revegetation Plan

A. General Considerations

A postmining revegetation plan should incorporate information from the premining baseline vegetation inventory, to include:

1. Input and concurrence from the "resident or agricultural landowner" regarding the applicant's proposed reclamation plan (as per W.S. § 35-11-406(b)(xi)).

2. The premining land uses and the plant species which supported those land uses.

3. The type, number, size and distribution of premining plant communities, croplands or pasturelands.

4. The major plant species from each premining plant community, cropland or pastureland.

5. ~~The growth form (bunch or sod-forming) and seasonal variety (cool or warm season) of the dominant grass species.~~

6. ~~Type and distribution of full shrubs, subshrubs and trees. General proposed locations of shrub mosaics including the areas which are expected to be most conducive to shrub establishment should be shown on a map of the postmining landscape.~~

   ~~The applicant should consider returning the major vegetation types, major plant species and growth forms in numbers and configurations which will support the postmining land uses (see definitions).~~

B. Seed Mixtures

After choosing the postmining land uses and considering the dominant postmining topographic features and landowner desires, the applicant should develop different seed mixes which will accommodate the postmining land uses and differences in soils, moisture conditions, exposures etc. on the postmining landscape. Also, considering seed availability, growth form, seasonal variety and prevailing dominant species, each proposed seed mixture should:

Requirements for seed mixtures are in Chapter 2 Section 6(b)(iii)(E).

1. contain no fewer than four (4) herbaceous species, unless a proposed land use (e.g. managed hayland or pastureland) requires fewer species;
2. contain the native dominant herbaceous species which support the postmining land uses;
3. if needed, contain additional species native to the region which support the postmining land uses;
4. contain naturalized, introduced species only if additional herbaceous species are needed, or if suitable, native species are a unavailable or if naturalized species are superior for a specialized land use (e.g. managed hayland or pastureland);

   This section is moved with revision to Chapter 2 Section 6(b)(iii)(E)(V).

5. contain full shrub and/or subshrub species when these species will support the postmining land uses. To increase postmining species diversity and establish shrub mosaics, shrub mixtures should be developed and seeded separately from the herbaceous mixtures (see Coenenberg, 1982);

   This section is moved with revision to Chapter 2 Section 6(b)(iii)(E)(VII).

6. contain native forb species if natural reinvasion of forbs will be limited by site-specific conditions.

For coal operators, seed mixtures for all postmining communities which will be jointly used by livestock and wildlife should include full shrub and/or subshrub species.

The proposed postmining location of each seed mixture should be illustrated on a postmining contour map.

This section is relocated to Chapter 4 Section 6(b)(iii)(E)(IX).

~~Seed mixtures for temporary stabilization of sites, stockpiles or other special uses should also be developed considering site-specific characteristics. The LQD strongly discourages the use of aggressive introduced plant species, particularly crested wheatgrass, on topsoil stockpiles. The concern lies in the possible carry over of such species to postmine lands during the replacement of stockpiled topsoil, which could ultimately result in problems (on the applicant's part) in meeting species diversity requirements at the time of bond release due to the predominance of the above mentioned introduced species. The LQD feels that other vigorous, rhizomatous species are readily available for such uses.~~

~~C.~~ ~~Seeding Practices~~

~~In general, all seed mixtures should total at least 14 lbs. PLS (Pure Live Seed) per acre when drill seeded. Seeding depth should be 1/4 to 1/2 inch when drilled. However, small seeded species (e.g. big sagebrush, blue grama, etc.) establish best when the seed is broadcast and lightly covered. Drill seeding should occur on the contour or across the prevailing wind direction. If seed mixtures are broadcast, the rate of application should be doubled and the seed should be lightly covered.~~

~~The LQD strongly recommends that the applicant consider staggered seeding methods to facilitate the establishment of warm season grasses and shrubs and/or to revegetate areas with poor quality substrates, (e.g. see Coenenberg, 1982; DePuit, 1982). Similarly, direct backhaul of live topsoil has proven very beneficial to establishment of diverse postmining plant communities (DePuit, 1984).~~

~~In general, the most appropriate seeding times are after October 15th or before April 15th. The soil should not be frozen or snowcovered. An extension to May 15th entails minimal risk of failure in most years. The actual choice of seeding time should be based on regional climatic conditions, site-specific environmental conditions, operator preference and operator experience.~~

~~Chapter 2, Section 2(b)(iv)(C) and Chapter 4, Section 2(d)(iv) require the use of mulch on all reclaimed lands,~~ unless specific permission is granted for not using mulch. ~~The LQD considers a seeded cover crop/stubble mulches as an acceptable alternative to crimped (hay or straw) mulch. In fact, research (Schuman,~~ ~~et. al.~~ ~~1980) has shown that cover crop/stubble mulch have several advantages over the use of crimped hay or straw mulch including:~~

Chapter 2, Section 6(b)(iii)(F) retains the provision that operators may request approval from the Administrator to eliminate mulching from specific areas.

~~1. decreased operation and application costs.~~
~~2. better wind and water erosion control.~~
~~3. increased water infiltration.~~
~~4. increased weed control.~~
~~5. less temperature fluctuation at shallow soil depths.~~

~~In the event that a crimped mulch is utilized, weed free native hay is preferred over the use of domestic hay or straw mulch. This reduces the chances of introducing noxious weeds onto the reclaimed area and can promote the introduction of desirable native species.~~
~~In general, the LQD does not recommend hydromulching as a permanent revegetation practice. Hydromulching has proven useful only for temporary reclamation activities.~~

D. Husbandry Practices

The applicant should clearly discuss the postmining husbandry practices it expects to use on revegetated communities. The bonding period usually begins after the permittee has completed fertilizing, seeding, irrigation or other work to ensure revegetation, Chapter 4, Section 2(d)(x); W.S. § 35-11-423(a).

Chapter 4, Section 2(d)(xiii) requires that newly seeded areas must be protected from livestock grazing for a minimum of two (2) years or until the plant community is capable of renewing itself under proper management practices. The newly seeded areas may be protected by fencing or other management practices which meet the intent of this statutory provision.

> *Acceptable husbandry practices are described in detail in Chapter 4 Section 2(d)(i)(M).*

~~E. Postmining Grazing Practices~~

~~Chapter 4, Section 2(d)(xiii) states that the LQD, the permittee and the landowner or land managing agency will mutually determine if and when domestic livestock grazing will be introduced on revegetated areas.~~

~~The Reclamation Plan shall include some discussion of the above point.~~

~~F. Restoration of Shrubs, Subshrubs and Trees~~

~~On coal mined lands, the postmining density, composition, and distribution of shrubs shall be based upon site-specific evaluation of the premining vegetation and wildlife use. Efforts to achieve the density standard shall be conducted through the application of best~~

technology currently available. Except where a lesser density is justified from premining conditions, at least 20 percent of the eligible land shall be restored to shrub patches supporting an average density of one shrub per square meter (Chapter 4, Section 2(d)(x)(E)).

For coal operators, tree species shall be returned to a postmining density equal to the premining density. The application should detail the age or size of transplants, the nature of the stock (bareroot, tubelings, etc.), the transplanting procedures and methods of protecting the transplanted stock from large and small herbivores.

G. Literature

Literature in Appendix VI may provide additional information for construction of revegetation plans. Specific acceptable revegetation practices may be found in permits approved by DEQ/LQD; additional proposed practices occur in pending permit applications. Both these sources are public documents. Applicants are encouraged to consult these sources and/or DEQ/LQD for further information.

VIII. Testing Adequacy of Reclamation

The Reclamation Plan should contain a discussion of the applicant's proposed methods for evaluation of revegetation success. The discussion should address all qualitative and quantitative success standards.

The operator is required to submit a plan for measurement of revegetation success in the Reclamation Plan. The details of these requirements are in Chapter 2 Section 6(b)(iv).

A. Reclamation Success Standards

Chapter 2, Section 2(b)(xiv) of the LQD Rules and Regulations requires that the applicant clearly define the postmining land uses. Livestock grazing and wildlife habitat are the most commonly proposed postmining land uses. Chapter 4, Section 2(d)(x) defines the following success goals for all operators:

1. Postmining cover equal to premining cover;
2. Postmining production equal to premining production;
3. Species composition and species diversity capable of supporting the postmining land uses;
4. Attainment of all the above for two consecutive years immediately prior to full bond release for those mines using reference areas, or two out of four years beginning no sooner than year eight of the bonding period for those mines using an approved technical standard.

B. Land Units Used for Evaluating Revegetation Success

The vegetation parameters which are compared between the Control Area (CONA) or

Reference Area (REFA) or Extended Reference Area (EXREFA) and the reclaimed area (RECA) are identical. However, the methods used to compare the vegetation parameters differ intrinsically among the methods. These intrinsic differences are explained in Sections 1, 2 and 3 below.

1. Procedures Using a Control Area

The CONA concept involves the use of a mathematical adjustment for climatic changes which may have occurred between the dates that the premining and postmining data were collected.

The CONA concept is used to test the attainment of the success goals of % vegetation cover, % total ground cover and total herbaceous production. The operator should use the same methods in premining and postmining sampling to generate the following parameters:

Premining

Affected Area	Control Area
$\bar{x}_1$ = percent cover or production	$\bar{y}_1$ = percent cover or production
$S\bar{x}_1^2$ = variance of mean	$S\bar{y}_1^2$ = variance of mean

Postmining

Reclaimed Area	Control Area
$\bar{x}_2$ = percent cover or production	$\bar{y}_2$ = percent cover or production
$S\bar{x}_2^2$ = variance of mean	$S\bar{y}_2^2$ = variance of mean

Where: $S\bar{x}_2^2$ & $S\bar{y}_2^2$ = variance of mean = $\dfrac{\sum \bar{x}_i^2 - \left(\sum x_i\right)^2 / n}{n(n-1)} = \dfrac{(S)^2}{n}$

If the value of $\bar{y}_1$ is statistically equal (confidence level = 90%, $\alpha = 0.1$) to $\bar{y}_2$, $\bar{x}_1$ should be directly compared (confidence level = 80%, $\alpha = 0.2$) to $\bar{x}_2$.

If $\bar{y}_1$ is not statistically equal to $\bar{y}_2$, an additional parameter, $\hat{\bar{x}}$, is generated in the following fashion:

$\hat{\bar{x}}$ = the cover or production goal adjusted for climatic change

$$\hat{\bar{x}} = \left(\bar{y}_2 / \bar{y}_1 \right) \bullet \bar{x}_i$$

Reclamation will be considered adequate for % total ground cover, % vegetation cover and total production when the following inequality has been satisfied for two (2) consecutive growing seasons:

$$\bar{x}_2 = \hat{\bar{x}} + z_{0.8}\sqrt{S\bar{x}_2^2 + S\hat{\bar{x}}^2} \geq 0$$

where $S\hat{\bar{x}}^2$ = the estimated variance of {overline x} calculated by

$$\left(\frac{\bar{x}_1^2}{\bar{y}_1^2}\right) \bullet S\bar{y}_2^2 + \bullet Sr^2 + \bullet S\bar{y}_2^2 \bullet Sr^2$$

where:

$$Sr^2 \cong \left(\frac{\bar{x}_1^2}{y_1^2}\right)\left(\frac{S\bar{x}_1^2}{\bar{x}_1^2} + \frac{S\bar{y}_1^2}{\bar{y}_1^2}\right)$$

If $\bar{x}_2 > \hat{\bar{x}}$, the above inequality is met and the lengthy variance calculations are unnecessary.

An example calculation is available upon request for the entire bond release comparison outlined above.

2. Procedures Using a Reference Area

The REFA concept does not incorporate the use of a mathematical adjustment for climatic change. If climatic change has influenced the vegetation, it is assumed that the individual species and species assemblages of the REFA and RECA will have responded similarly.

The REFA concept is used to test the attainment of the success goals of % vegetation cover, % total ground cover and total herbaceous production. The operator should use the same methods to sample the REFA and RECA for the last two (2) consecutive years after the minimum bonding period and after the operator considers revegetation successful.

For each year's data set, the data from the REFA are directly compared, by standard statistical procedure (confidence level = 80%, α = 0.2), to the RECA data. The goals of equal cover and production must be achieved for each quantitative parameter for the last two (2) consecutive years of the bonding period.

3. Procedures Using an Extended Reference Area

The EXREFA concept is identical to the REFA concept in its statistical comparisons. The intrinsic difference between the EXREFA and REFA concept lies in the postmining sampling of all of the undisturbed area of a given vegetation type, versus the sampling of a small, representative unit, the REFA.

C. Evaluation of Species Diversity and Species Composition

The postmining plant communities must have sufficiently diverse species composition (numbers and types of individual species and life forms) and sufficient species diversity (a measure of the variability of the species composition) to support the postmining land uses.

Appendix D-8 should contain a discussion of premining species composition and species diversity. The discussion should include the value (e.g. browse, shelter, grazing, soil protection) of the major species and communities as a whole. A major species is defined as having relative cover equaling or exceeding two (2) percent. This discussion should be documented by applicable literature.

The Reclamation Plan should include a discussion of projected postmining species composition and species diversity, and the ability of the species to support the postmining land uses. The composition of reclamation seed mixes and/or special plantings, known species characteristics and life form distribution should form the basis of this discussion.

The applicant should also include in the Reclamation Plan a conceptual outline of how it proposes to evaluate species diversity and composition when bond release is requested. This outline may include:

1. a discussion of the species of the reclaimed community and their ability to support and maintain the postmining land uses;

2. the role of these species in secondary succession;

3. a direct qualitative comparison of the species composition of the premining and postmining communities;

4. a direct qualitative comparison of the life forms of the premining and postmining communities using an appropriate index of similarity or other assessment method agreeable to the LQD.

An index of similarity (Mueller-Dombois and Ellenberg, 1974) may be used to compare the premining and postmining communities. However, such indices should not constitute the sole criterion for evaluation of species diversity.

DEQ/LQD has developed a suggested format and procedures for evaluation of species composition and species diversity. These documents are available upon request; alternative methods may be appropriate.

D. Evaluation of Restored Cropland or Pastureland

~~Unless specifically approved in a Reclamation Plan, the areal extent of specially managed land units, such as croplands, haylands or pasturelands, should not significantly exceed their areal extent on the premining landscape. If a coal operator desires significant changes in postmining land uses, e.g. a significant increase in croplands, the proposal must be justified and approved as per Chapter 2, Section 2(b)(xiv).~~

~~As per Chapter 4, Section 2(d)(x)(I), postmining restoration of cropland is deemed complete when their "productive capability" is equivalent, for at least two (2) consecutive crop years, to premining conditions. Premining cropland production data should be considered in judging restored croplands, whenever said data are available. The equivalency can be assessed by direct comparison of postmining production data to accurate premining production data. Alternatively, the permittee may identify a premining cropland unit whose production capacity will be used as a success standard. Clearly the premining cropland unit must remain unaffected by mining activities, should be managed in an appropriate manner and should accurately represent the disturbed premining croplands. Alternative methods of evaluating cropland may be approved by the Administrator.~~

~~The LQD Rules and Regulations do not specifically address procedures for evaluating revegetation success on post-mining pasturelands and haylands. The procedures agreed to by the applicant and LQD should be clearly presented in the Reclamation Plan.~~

E. Evaluation of Shrub Density

This section on the shrub density standard is moved to Chapter 4, Appendix 4-2.

Introduction

All land affected after August 6, 1996, excluding cropland, pastureland or treated grazingland as defined in Chapter 1 shall be considered eligible land subject to the standard. Except where a lesser density is justified by premining conditions, at least 20 percent of the eligible land shall be restored to shrub patches supporting an average density of one shrub per square meter (Chapter 4, Section 2(d)(x)(E)).

The postmining areal extent of shrub patches and specific shrub density(ies) shall be based on the original premining shrub densities in each vegetation community and the percentage each community contributes to the total eligible land existing in the original permit area and any lands added to the permit area through the amendment process.

Premine community(ies) identified and sampled during the baseline studies shall serve as the target for bond release unless otherwise approved by the Administrator.

For bond release purposes, the average postmine total density and species specific density(ies) shall be at least 90 percent of the calculated criteria for the applicable standard.

CALCULATING THE REQUIRED POSTMINE DENSITY AND SPECIES COMPOSITION

In order to calculate density and composition, the following must be identified:

1. Areal extent and premining total density of eligible land by vegetation community;

2. Relative density for each species;

3. Dominant premine species which then becomes the target postmine species;

4. Density of target postmine species using the formula D[1/(N + 1)]; *

5. Allowable density of postmining residual species; and

6. Acceptable residual species.

* D is the postmining total shrub density. When D is less than 1.00, the density of the target postmining species is reduced proportionately. N is the number of primary premining shrub or subshrub species.

Table 3: Identification of available options

Option	Identification	PREMINE
I	Reduced permit-wide full shrub standard	< 20% @ $\geq$ 1/M^2
II	Permit-wide full shrub standard	$\geq$ 20% @ $\geq$ 1/M^2
III	Community-specific full shrub standard	No restrictions
IV	Community-specific full and subshrub standard	No restrictions - add subshrubs

The operator shall select one option only for bond release purposes within each permit or amendment area.

Option I: Permit-wide full shrub density standard; reduction in areal extent; composition based on premining full shrub density only (see Figure 1 for an illustration of this Option). For bond release purposes, no more than two separate acreage/density standards shall be used.

1. Reductions in areal extent and shrub density shall be appropriate when the premining vegetation community(ies) supporting at least one shrub per square meter comprised less than 20 percent of the eligible land. The percentage this community contributed to the total eligible land would then become the percentage of the postmining landscape that is required to support one shrub per square meter. The remainder of the postmining 20 percent areal extent of shrub patches shall be required to support shrubs at a density equalling the next highest density existing in a premining community.

2. Compute the relative premining dominance of full shrub species based on a weighted average of the percent areal extent of all vegetation communities and their associated full shrub species present within the eligible land. In this instance, one shrub patch seed mixture will be developed for the entire 20 percent areal extent.

3. From the information calculated in step 2. above, identify the dominant premine full shrub species. This species then becomes the target postmine species within the postmine shrub patches.

4. Compute the minimum density that the postmining target shrub (identified in step 3. above) must meet in order to achieve bond release under the standard. This is accomplished by applying the following equation:

   $$D[1/(N + 1)]$$

   D is the postmining total shrub density (D is always $\leq$ 1.00). N is the number of primary shrub species existing in the premining communities as identified in step 2. above. Primary shrub species shall be defined as full shrub species which comprise at least 10 percent of the relative density of full shrubs.

   All primary shrub species shall be included in the shrub patch seed mixture.

5. The postmining residual density is calculated by subtracting the minimum required density of the target species from the total required density.

6. Residual density may be comprised of any premining primary species and any other approved full shrub species. In addition, the following subshrub species may be counted towards up to one half of the residual density.

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat
Artemisia pedatifida	birdfoot sagewort
Artemisia spinescens	bud sagewort

For a hard copy of Figure 1: Tables 1 and 2 please refer to the copy on file with the Secretary of State or with the Wyoming Department of Environmental Quality.

For an electronic copy of these tables please contact the Land Quality Division at 777-7757.

For a hard copy of Figure 1: Table 3 please refer to the copy on file with the Secretary of State or with the Wyoming Department of Environmental Quality.

For an electronic copy of this table, please contact the Land Quality Division at 777-7757

Option II: Permit-wide full shrub density standard, no reduction in areal extent or density, composition based on premining full shrub density only (see Figure 2 for an illustration of this Option).

1. If 20 percent or more of the premine eligible land supports at least 1 shrub per square meter, no reduction in shrub density or areal extent shall be permitted.

2. Compute the relative premining density of full shrub species based on a weighted average of the percent areal extent of all vegetation communities and their associated full shrub species present on eligible land. In this instance, one shrub patch seed mixture will be developed for the entire 20 percent areal extent.

3. From the information calculated in step 2. above, identify the dominant premine full shrub species. This species then becomes the target postmine species within the postmine shrub patches.

4. Compute the minimum density that the postmining target shrub (identified in step 3. above) must meet in order to achieve bond release under the standard. This is accomplished by applying the following equation:

   $$D[1/(N + 1)]$$

   D is the postmining total shrub density (D is always $\leq$ 1.00). N is the number of primary shrub species existing in the premining communities as identified in step 2. above. Primary shrub species shall be defined as full shrub species which comprise at least 10 percent of the relative density of full shrubs.

   All primary shrub species shall be included in the shrub patch seed mixture.

5. The postmining residual density is calculated by subtracting the minimum required density of the target species from 1.00.

6. Residual density may be comprised of any premining primary species and any other approved full shrub species. In addition, the following subshrub species may be counted towards up to one half of the residual density.

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat
Artemisia pedatifida	birdfoot sagewort
Artemisia spinescens	bud sagewort

For a hard copy of Figure 2: Tables 1 and 2 please refer to the copy on file with the Secretary of State or with the Wyoming Department of Environmental Quality, Land Quality Division.

For an electronic copy of Tables 1 and 2, please contact the Land Quality Division at 777-7757.

For a hard copy of Figure 2: Table 3 please refer to the copy on file with the Secretary of State or with the Wyoming Department of Environmental Quality, Land Quality Division.

For an electronic copy of Table 3, please contact the Land Quality Division at 777-7757.

Option III: Community-specific full shrub density standard (see Figure 3 for an illustration of this Option)

1. Each eligible premining vegetation community serves as the basis for developing the required postmine density and areal extent. The percentage each community contributes to the total eligible land is multiplied by 20 percent to establish the number of acres required on the postmining landscape. The average number of full shrubs each community supported premine serves as the postmine average density for that particular community.

2. Compute the relative premining dominance of all full shrub species within each eligible vegetation community. In this instance, one shrub patch seed mixture will be developed for each eligible vegetation community.

3. From the information calculated in step 2. above, identify the dominant premine full shrub species within each eligible vegetation community. This species then becomes the target postmine species within a particular shrub patch corresponding to a specific vegetation community.

4. Compute the minimum density that the postmining target shrub (identified in step 3. above) must meet in order to achieve bond release under the standard. This is accomplished by applying the following equation:

   $$D[1/(N + 1)]$$

   D is the postmining total shrub density (D is always $\leq$ 1.00). N is the number of primary shrub species existing in the premining communities as identified in step 2. above. Primary shrub species shall be defined as full shrub species which comprise at least 10 percent of the relative density of full shrubs.

   All primary shrub species shall be included in the respective shrub patch seed mixtures.

5. The postmining residual density is calculated by subtracting the minimum required density of the target species within each vegetation community from the total required density for that community.

6. Residual density may be comprised of any premining primary species and any other approved full shrub species. In addition, the following subshrub species may be counted towards up to one half of the residual density within each community.

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat
Artemisia pedatifida	birdfoot sagewort
Artemisia spinescens	bud sagewort

For a hard copy of Figure 3: Tables 1 and 2 please refer to the copy on file with the Secretary of State or with the Wyoming Department of Environmental Quality, Land Quality Division.

For an electronic copy of Tables 1 and 2, please contact the Land Quality Division at 777-7757.

Option IV: Community-specific full shrub and approved subshrub density standard (see Figure 4 for an illustration of this Option)

1. Each eligible premining vegetation community serves as the basis for developing the required postmine density and areal extent. The percentage each community contributes to the total eligible land is multiplied by 20 percent to establish the number of acres required on the postmining landscape. The average number of full shrubs and approved subshrubs each community supported premine serves as the postmine average density for that particular community.

   The following are the approved subshrubs which shall be included in calculating the premining density within each community:

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat

2. Compute the relative premining dominance of full shrub and approved subshrub species within each eligible vegetation community. In this instance, one shrub patch seed mixture will be developed for each eligible vegetation community.

3. From the information calculated in step 2. above, identify the dominant premine full shrub or approved subshrub species within each eligible vegetation community. This species then becomes the target postmine species within a particular shrub patch corresponding to a specific vegetation community.

4. Compute the minimum density that the postmining target shrub/approved subshrub (identified in step 3. above) must meet in order to achieve bond release under the standard. This is accomplished by applying the following equation:

   $$D[1/(N + 1)]$$

   D is the postmining total shrub density (D is always $\leq$ 1.00). N is the number of primary shrub/approved subshrub species existing in the premining communities as identified in step 2. above. Primary shrub/approved subshrub species shall be defined as full shrub/approved subshrub species which comprise at least 10 percent of the relative density of full shrubs. However, in order to be considered a primary species, fringed sagewort must comprise at least 20 percent of the relative shrub/approved subshrub composition.

   All primary shrub/approved subshrub species shall be included in the respective shrub patch seed mixtures.

5. The postmining residual density is calculated by subtracting the minimum required density of the target species within each vegetation community from the total required density for that community.

6. Residual density may be comprised of any premining primary full shrub/approved subshrub species and any other approved full shrub species. In addition, the following subshrub species may be counted towards up to one half of the residual density within each community.

Artemisia frigida	fringed sagewort
Atriplex gardneri/gordonii	Gardners saltbush
Ceratoides lanata	winterfat
Artemisia pedatifida	birdfoot sagewort
Artemisia spinescens	bud sagewort

For a hard copy of Figure 4: Tables 1 and 2 please refer to the copy on file with the Secretary of State or with the Wyoming Department of Environmental Quality, Land Quality Division.

For an electronic copy of Tables 1 and 2, please contact the Land Quality Division at 777-7757.

A complete proposal for evaluation of postmining shrub density should include:

1. A commitment to provide a brief history of the methods employed to implant shrubs and the husbandry practices specifically related to shrub establishment and maintenance.

2. Methods to identify shrub patches and to determine their areal distribution and extent.

3. Proposed sampling methods for the determination of shrub density within the patches. This discussion should include number of samples.

4. Proposed methods for documenting the presence and distribution of shrub species on all other lands jointly used by livestock and wildlife.

F. Summary

The major components of a complete proposal for evaluation of revegetation success shall be presented in the Reclamation plan and shall include:

The required components for evaluation of revegetation success are detailed in Chapter 2 Section 6(iv). Parts of this section are retained in Chapter 2.

1. A commitment to provide a brief discussion of the reclamation practices used on each reclaimed area, including the seed mix applied, any husbandry practices used (e.g., interseeding, biocide application, grazing practices, etc.) and the land management practices applied.

2. A commitment to describe the procedures used to define the boundaries of each reclaimed area, including any combinations of different age classes of reclaimed areas.

3. Presentation of the methods used to define the vegetational composition of each reclaimed area, such that the proper CONA may be chosen. Two approaches seem apparent:

    a. The composition may be determined by a thorough, qualitative field reconnaissance. Qualitative means the use of methods which do not involve point sampling procedures as discussed in Section II.A.

    b. The composition may be determined by standard, point sampling techniques. These data would subsequently be used in the direct evaluation of revegetation success.

4. Specification of the actual methods employed for each vegetation parameter. The sampling procedures should use standard methods and should be based upon standard

procedures for the choice of sample locations. Clearly, the same methods must be used on the reclaimed areas and CONA or REFA.

5. Specification of the number of samples to be taken for each parameter from the reclaimed areas and CONA. Several options are available:

    a. The applicant may employ the sample adequacy procedures of Appendix A, as qualified by maximum and minimum sample numbers.

    b. The applicant may employ other standard, statistical tests for assessing sample adequacy.

6. Specification of the statistical methods proposed for the comparison of quantitative vegetation parameters.

7. Specification of qualitative or quantitative (or a combination thereof) methods to assess the success standard that species diversity and species composition are capable of supporting the postmining land uses.

8. Specification of methods to assess the establishment of suitable postmining wildlife habitat, including assessment of the quantitative and qualitative aspects of wildlife habitat.

Appendix I

List of Prohibited and Restricted Noxious (Designated) Weeds for the State of Wyoming.

This list has been compiled from the appropriate laws governing the control of noxious (designated) weeds in the State of Wyoming (i.e. The Weed and Pest control Act of 1973 and The Wyoming Seed Laws). County Weed Control supervisors should be contacted for additional lists of declared weeds.

Prohibited Noxious (Designated) Weeds

Compositae - Sunflower Family

- Arctium minus - common burdock
- Carduus acanthoides - plumeless thistle
- Carduus nutans - musk thistle
- Centaurea masulosa - spotted knapweed
- Centaurea repens - Russian knapweed
- Chrysanthamum leucanthemum - ox-eye daisy
- Cirsium arvense - Canada thistle
- Franseria discolor = Ambrosia tomentosa - skeletonleaf bursage
- Onopordum acanthium - Scotch thistle
- Sonchus arvensis - perennial sowthistle

Convolvulaceae - Morning Glory Family

- Convolvulus arvensis - field bindweed

Cruciferae - Mustard Family

- Cardaria draba - hoarycress
- Cardaria pubescens - hoarycress
- Isatis tinctoria - Dyer's woad
- Lepidium latifolium - perennial pepperweed

Boraginaceae - Borage Family

- Cynoglossum officinale - hound's tongue

Euphorbiaceae - Spurge Family

- Euphorbia esula - leafy spurge

Gramineae - Grass Family
- Agropyron repens - quackgrass

Scrophulariaceae - Figwort Family

- Linaria dalmatica - Dalmation toadflax
- Linaria vulgaris - yellow toadflax

Restricted Noxious (Designated) Weeds

Compositae - Sunflower Family

- Ambrosia psilostachya - perennial ragweed
- Centaurea diffusa - diffuse knapweed
- Centaurea solstitialis - yellow starthistle
- Iva axillaris - poverty weed
- Lactuca pulchella - blue-flowering lettuce
- Tanacetum vulgare -tansy

Convolvulaceae - Morning Glory Family

- Cuscuta species - dodder

Cruciferae - Mustard Family

- Descurainia pinnata - tansymustard
- Chorispora tenella - blue mustard

Gramineae - Grass Family

- Avena fatua - wild oat

Leguminosae

- Glycyrrhiza lepidota - wild licorice
- Sphaerophya salsula - Austrian peaweed

Plantaginaceae - Plantain Family

- Plantago lanceolata - buckhorn plantain

Zygophyllaceae - Caltrop Family

- Tribulus terrestris - Puncture vine

See glossary for definition of the following terms: noxious (designated) weeds, prohibited noxious (designated) weeds, restricted noxious (designated) weeds and declared weeds.

Appendix II - Subshrubs

This list was prepared from literature sources and permit documents on file with DEQ/LQD. Nomenclature follows Dorn (1977).

Amorpha canescens
Arctostaphylos uva-ursi
Artemisia frigida
Artemisia longifilia
Artemisia ludoviciana
Artemisia pedatifida
Artemisia spinescens
Atriplex falcata
Atriplex gardneri (= A. nuttallii = A. gordonii)
Brickellia eupatorioides
Ceratoides lanata
Eriogonom brevicaule
Eriogonum effusum
Eriogonum jamesii
Eriogonum microthecum
Eriogonum pauciflorum
Gutierrezia sarothrae (= Xanthocephalum sarothrae)
Kochia americana
Leptodactylon caespitosum
Leptodactylon pungens
Mahonia repens (=Berberis repens)
Sphaeromeria argentea
Yucca glauca

Appendix III - Primary Selenium Indicator Plants

This list was developed from Beath (1982). Nomenclature follows Dorn (1977).

Astragalus bisulcatus
Astragalus flavus
Astragalus grayi
Astragalus pectinatus
Astragalus racemosus
Haplopappus multicaulis
Haplopappus wardii
Stanleya pinnata
Stanleya tomentosa
Stanleya viridiflora
Xylorhiza glabriuscula

Appendix IV – Plant Species of Special Concern

One plant species in Wyoming is currently listed as Threatened (T) and another is listed as Endangered (E) under the federal Endangered Species Act. Two other species are candidates (C) for potential listing. These plants are noted by their assigned ranking in parentheses. However, there are many additional species occurring within Wyoming which may be considered for formal listing in the future. State and federal agencies have historically afforded these species special consideration until their status is accurately assessed.

Presented below are those species currently (as of January, 2001) listed as Threatened (T), Endangered (E), or Candidates (C). In addition to this list, the Administrator will compile a list of those species that deserve special consideration. This list will be made available to the public and will be updated as determined by the Administrator.

Gaura neomexicana ssp. coloradensis (C)
Penstemon haydenii (E)
Spiranthes diluvialis (T)
Yermo xanthocephalus (C)

Appendix V - Suggested Tabular Format for Data Presentation

Table 1. Areal extent and percent of total area for each of the vegetation types and other mapping units

	Affected Area		Unaffected Area		Entire Permit Area		Control Areas
Mapping Units	Total Acres	% of Area	Total Acres	% of Area	Total Acres	% of Area	Total Acres
1. Upland grassland	1697.8	51.9	580.8	44.2	2278.6	49.7	2.5
2. Streamside meadow	31.4	0.9	58.4	4.4	89.8	1.9	3.0
___.							
___.							
___.							
8.Agricultural areas	424.9	12.9	60.0	4.5	484.9	10.6	--
9.Disturbed areas	102.7	3.1	5.9	0.4	108.6	2.4	--
10.Reservoirs	1.3	0.1	0.1	0.1	1.4	0.1	--
TOTAL	3271.3		1315.6		4586.9		15.5

Table 2. Summary of life form vegetation sampling data for the Control Area for the Streamside Meadow Grassland Community. All values are means.

	Vegetation Cover (%)		Herbaceous Prod.(g/m^2)	
	Absolute	Relative	Absolute	Relative
Perennial Grasses & Grass-like Species				
Agropyron smithii	44.7	85.6	180.0	90.9
Agropyron trachycaulum	0.4	0.8	0.2	0.1
Bouteloua gracilis	1.1	2.1	3.1	1.6
Stipa comata	0.1	0.2	0.4	0.8
Stipa viridula	3.0	5.7	10.5	5.3
Sub-Total*	49.3	94.4	194.2	98.0
Annual Grasses				
Bromus japonicus	0.1	0.2	0.2	0.1
Forbs				
Achillea lanulosa	0.3	0.6	0.5	0.3
Aster adscendens	0.1	0.2	0.2	0.1
Taraxacum officinale	0.8	1.5	1.1	0.5
Unknown Rosette	0.1	0.2	0.1	0.1
Sub-Total*	1.3	2.5	1.9	1.0
Subshrubs & Succulents				
Artemisia ludoviciana	0.7	1.3	1.8	0.9
Ceratoides lanata	0.1	0.2	---	---
Gutierrezia sarothrae	0.4	0.8	---	---
Sub-Total*	1.2	2.3	1.8	0.9
Full Shrubs				
Artemisia tridentata	0.1	0.2	---	---
Atriplex canescens	0.2	0.4	---	---
Sub-Total*	0.3	0.6	---	---
TOTALS	52.2	100.0	198.1	100.0

*sub-total across all species within a given life form category

NOTE: A similar table should summarize data for each community type and each control area or reference area.

Table 3. Quantitative Comparison of major species in the Control Area and Affected Area for the Streamside Meadow Grassland Community. All values are means.

	Affected Area		Control Area	
	Absolute Cover (%)	Herbaceous Production (g/m^2)	Absolute Cover %	Herbaceous Production (g/m^2)
PERENNIAL GRASSES AND GRASS-LIKE SPECIES				
Agropyron smithii	9.0	66.6	44.7	180.1
Poa pratensis	6.7	16.6	1.2	4.9
Bouteloua gracilis	5.7	8.5	1.1	3.1
Distichlis stricta	5.1	13.7	42.3	—
Stipa comata	3.0	4.7	0.1	0.5
Carex spp.	4.9	18.4	0.1	1.2
Sub-Total*	45.5	160.8	51.6	208.1
FORBS				
Taraxacum officinale	4.5	—	0.8	—
Aster falcatus	2.4	—	—	—
Aster adscendens	1.8	—	0.1	—
Achillea lanulosa	0.7	—	0.3	—
Sub-Total*	13.6	41.3	2.2	7.4
SUB-SHRUBS				
Artemisia ludoviciana	5.5	—	0.7	—
Artemisia frigida	1.0	3.5	—	—
Sub-Total*	6.7	3.6	1.1	1.1
SHRUBS				
Artemisia tridentata	0.1	—	0.1	—
Rosa woodsii	0.5	—	—	—
Atriplex canescens	—	—	0.2	—
Sub-Total*	0.6	—	0.3	—
TOTALS	66.4	206.4	55.3	217.4

*** Sub-Total across all species within a life form category**

NOTE: a similar table should summarize data for each community type and each control area or reference area

Table 4. Summary of sample adequacy calculations for % vegetation cover using the formula of Appendix A

	Vegetation Cover (%) x+1 S.D.	Actual Sample Size	Computed Adequate Sample Size	Computed* z value	Confidence Level Achieved
AFFECTED AREA Grasslands					
1. Streamside Meadow	66.4 ± 7.3	26	4	N/A	N/A
2. Upland Grassland	20.4 ± 8.6	29	58	0.90	81.6
5. Scoria Grassland	51.0 ±13.5	33	23	N/A	N/A
Shrublands					
1. Big Sagebrush	28.1 ± 6.9	25	20	N/A	N/A
2. Silver Sagebrush	63.4 ±19.8	21	32	1.04	85.1
CONTROL AREA Grasslands					
1. Streamside Meadow	55.3 ±11.1	15	14	N/A	N/A
2. Upland Grassland	33.8 ±19.3	20	107	0.55	70.9
5. Scoria Grassland	52.7 ±14.9	29	27	N/A	N/A
Shrublands					
1. Big Sagebrush	21.6 ± 3.5	15	9	N/A	N/A
2. Silver Sagebrush	53.3 ±15.6	15	29	0.94	82.6

*** These values should be calculated only if the computed sample size exceeds the actual sample size and the actual sample size is less than the maximum required sample size.**

NOTE: A similar table should summarize data for % total cover and herbaceous production

Table 5. Summary cover and production data from Affected Area and Control Area sampling. All values are means ± one standard deviation. These data constitute the premining values for use in the Control Area concept for the evaluation of revegetation success

	Affected Area			Control Area		
	Absolute Vegetation Cover	**Absolute Total Cover %**	**Herbaceous Vegetation Cover (g/sq m)**	**Absolute Vegetation Cover (%)**	**Absolute Total Cover (%)**	**Herbaceous Production (g/sq m)**
Grasslands* 1. Streamside Meadow	**66.4± 7.3**	**95.7±18.1**	**206.4±81.9**	**55.3±11.1**	**74.0±16.1**	**217.4±78.6**
2. Upland Grassland	**20.4± 8.6**	**78.4±13.2**	**60.4± 6.3**	**33.8±19.3**	**80.3±11.0**	**83.3±23.4**
□						
□						
□						
5. Scoria Grassland	**51.0±13.5**	**95.0± 9.0**	**70.5±20.9**	**52.7±14.0**	**91.7± 9.2**	**66.9±17.4**
Shrublands* 1. Big Sagebrush	**28.1± 6.9**	**81.1±20.1**	**34.7±14.9**	**21.6± 3.5**	**78.9±15.1**	**26.9±12.0**
2. Silver Sagebrush	**63.4±19.8**	**84.1±19.3**	**116.0±50.7**	**53.3±15.6**	**75.8±11.6**	**117.5±52.8**

*** As defined by Appendix A**

Appendix VI - References

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~~"Absolute Cover" is the determination of % cover of a given cover category in a fashion which is operationally independent of the other categories. Thus the sum of absolute cover categories (e.g. vegetation and litter/rock and bare ground) may be less than, equal to or greater than 100% (see Relative Cover).~~

~~"Affected Land" (Affected Area) means the area of land from which overburden is removed, or upon which overburden, development waste rock or refuse is deposited, or both, access roads, haul roads, mineral stockpiles, mill tailings, impoundment basins, and all other lands whose natural state has been or will be disturbed as a result of the operations.~~

"Adjacent Areas" means land located outside the permit area upon which air, surface water, groundwater, fish, wildlife, or other resources protected by the Act may reasonably be expected to be adversely impacted by mining or reclamation operations. Unless otherwise specified by the Administrator, this area shall presumptively be limited to lands within one-half mile of the proposed permit area.

This definition is already in Chapter 1.

"Baseline Vegetation Inventory" is a vegetation sampling program executed prior to any significant surface disturbance caused by proposed mining activities. The inventory will provide a verbal and mental picture of the prevailing plant communities and will quantitatively and qualitatively classify the different plant communities to the specifications of Wyoming State Law.

This definition moved to Chaper 1.

"Comparison Area" means a land unit which is representative, in terms of physiography, soils, vegetation and land use history, of a premining plant community from which no vegetation data were collected prior to disturbance. The representative nature of the Comparison Area may be validated by a subjective field reconnaissance of the site or by subjective evaluation of vegetation data generated by a sampling program. The establishment procedures should be agreed to by the permittee or applicant and LQD prior to establishment.

Postmining quantitative data from the Comparison Area are directly compared, by standard statistical procedures (confidence level of 80%, $\alpha = 0.2$), to data from a reclaimed vegetation type when evaluating revegetation success for full bond release. No mathematical adjustment for climatic change is made. Qualitative data are compared by standard procedures agreed to by the applicant or permittee and LQD.

A Comparison Area should be at least two (2) acres in size and should be managed in a fashion which will not cause significant changes in vegetation parameters used to evaluate revegetation success.

The definition for comparison area is moved to Chapter 1, as a subsection under the definition for "Reference Area".

"Control Area" means a land unit which is representative in terms of physiography, soils, vegetation and land use history, of a plant community affected by mining activities. The representative nature of the Control Area is verified by subjective (non-statistical) comparison of its quantitative and qualitative characteristics to similar information from the plant community it typifies.

Quantitative premining and postmining vegetation data from the Control Area are used to mathematically adjust premining affected area data for climatic change. These adjusted data are directly compared by statistical procedures (confidence level = 80%, $\alpha = 0.2$) to data from a reclaimed vegetation type when evaluating revegetation success for full bond release. Qualitative data are compared by standard procedures agreed to by the applicant or permittee and LQD.

A Control Area should be at least two (2) acres in size and should be managed in a fashion which will not cause significant changes in the vegetation parameters used to evaluate revegetation success.

The definition for control area is moved to Chapter 1, as a subsection under the definition for "Reference Area".

"Cool-Season Plant" is a species which grows and flowers during the spring. Its growth usually slows or becomes dormant during the hotter, drier portions of the summer, but the species may resume growth in the fall with the advent of cooler temperatures and available soil moisture.

This definition moved to Chapter 1.

"Cover" is the proportion of the ground surface cloaked by a vertical projection of objects on or above that ground surface. Cover is expressed as a percentage of a surface reference unit. The following cover categories are of interest to LQD:

1. % litter and rock cover is the proportion of the ground surface overlain by dead plant material and rock (defined as any stone or mineral matter at least one (1) square centimeter in size).

2. % vegetation cover is the vertical projection of the general outline of plants (ignoring minor gaps between branches and holes in the canopy) to the ground surface.

3. % total ground cover is the sum of the cover values for % vegetation, % litter and % rock.

4. % bare ground is the proportion of the ground surface occupied by unvegetated mineral soil.

This definition moved with revision to Chapter 1.

"Cropland" means land used for the production of adapted crops for harvest, along or in a rotation with grasses and legumes, and includes row crops, small grain crops, hay crops, nursery crops, orchard crops, and other similar specialty crops.

This definition moved to Chapter 1, and included under the "Land Use" definition.

"Density" is the number of individuals per unit area.

This definition moved to Chapter 1.

"Dominant" refers to the species with the greatest density relative to all other species sampled.

This definition moved to Chapter 1.

"Extended Reference Area" means all the undisturbed portion of a vegetation type which has experienced disturbance by mining activities. The representative nature of the Extended Reference Area is verified by evaluation of vegetation mapping procedures, the adequacy of premining quantitative and qualitative vegetation data, soils data, physiography and land use history information.

Postmining quantitative vegetation data from the Extended Reference Area are directly compared by standard statistical procedures (confidence level of 80%, $\alpha = 0.2$) to data from a reclaimed vegetation type when evaluating revegetation success for full bond release. No mathematical adjustment for climatic change is made. Qualitative data are compared by standard procedures agreed to between the permittee and LQD.

An Extended Reference Area should be managed in a fashion which will not cause significant changes in vegetation parameters used to evaluate revegetation success.

The definition for extended reference area is moved to Chapter 1, as a subsection under the definition for "Reference Area".

"Forestry" means land used or managed for the long-term production of wood, wood fiber, or wood derived products.

This definition moved to Chapter 1.

"Full Shrub" is a perennial woody plant which differs from a tree by normally being shorter in height and by often having several stems arising near the base.

This definition moved to Chapter 1.

"Grazing Exclosure" is a fence or other device utilized to prevent grazing by large herbivores in order to more accurately estimate production of a land unit.

This definition moved to Chapter 1.

"Grazingland" includes rangelands and forest lands where the indigenous native vegetation is actively managed for grazing, browsing, or may occasionally be cut for hay production.

This definition moved to Chapter 1, listed under the definition for "Land Use"..

"Land Use" refers to the specific uses or management-related activities which a given unit of land experiences. Land use is directly supported by, but not directly defined by the existing plant communities. See definitions of cropland, pastureland, grazingland, forestry, or appropriate discussion in LQD Rules and Regulations, Chapter 1, under "land use."

This definition moved to Chapter 1.

"Life Form" is a category of growth morphology which appears to have some adaptive significance. Examples of life forms include trees, full shrubs, sub-shrubs, perennial grasses, annual forbs, succulents, cushion plants, etc.

This definition moved to Chapter 1.

~~"Line Intercept" is a cover estimation method based upon the measurement of the proportion of a line transect intercepted by the vertical projection of plant parts. Absolute cover, when using the line intercept method, is defined by the formula~~

$$\text{~~\% cover of A~~} = \frac{\text{~~sum of all segments intercepted by A~~}}{\text{~~total length of the line transect~~}} \times 100$$

"Litter" means any recognizable plant parts or structures which are lying on the ground surface. Decomposing organic matter which has lost its structural integrity or which is no longer a recognizable plant part is not litter.

This definition moved to Chapter 1.

"Noxious Weeds" are agriculturally unuseful or troublesome plants whose seeds are totally prohibited from or severely limited in any amounts in commercial crop seed offered for sale. These designations are made by State law.

This definition moved to Chapter 1.

~~"Prohibited noxious" (designated) weeds are those species whose seed is not allowed in the seed of crops under any amounts. Restricted noxious (designated) weeds are those species~~

~~whose seed is tolerated in the seed of crops only under small amounts. Declared weeds are those species which are of a particular concern to a specific county which may or may not be considered noxious (designated) under State law.~~

"Pastureland" is land used primarily for the long-term production of adapted, domesticated forage plants to be grazed by livestock or occasionally cut and cured for livestock feed.

This definition moved to Chapter 1, under the definition for "Land Use"..

"Permit Area" means the area of land and water within the boundaries of the approved permit or permits during the entire life of the operation and includes all affected lands and water.

This definition is already in Chapter 1.

~~"Plant Community" (Vegetation Type) is a relatively homogeneous combination of individual plants existing under common environmental conditions.~~

"Plotless Sampling" means estimation of vegetation parameters without the use of two-dimensional areal reference units.

This definition moved to Chapter 1.

"Point Intercept" is a cover estimation method based upon the lowering of a "pin" through the vegetation at objectively established sampling points. The "pin" may be an ocular siting device (e.g. crosshairs), a sharpened rod or a series of sharpened rods. Absolute cover, when using the point intercept method, is defined by the formula:

$$\% \text{ cover of A} = \frac{\text{number of hits on A}}{\text{total number of hits}} \times 100$$

This definition moved to Chapter 1.

"Primary shrub species" means all full shrub species which comprise at least 10 percent of the relative density of full shrubs. However, if an operator selects Option IV, the community-specific full shrub and approved subshrub density standard, then "primary shrub species" means all full shrub and approved subshrub species which comprise at least 10 percent of the relative density of full shrubs. It is further provided under Option IV that in order to be considered as a "primary shrub species", fringed sagewort must comprise at least 20 percent of the relative shrub and approved subshrub species composition.

This definition moved to Chapter 1.

"Production" is an estimate of the total standing crop biomass of herbaceous species (grass, grass-like, forb and some subshrub species). The estimate is made at a time near the expected peak of the current year's growth and is reported on a per unit area basis.

This definition moved to Chapter 1.

"Quadrat" is a two-dimensional areal unit which is superimposed on the ground surface for the purposes of estimating one or more vegetation parameters.

This definition moved to Chapter 1.

"Reference Area" means a land unit which is representative, in terms of physiography, soils, vegetation and land use history, of a plant community affected by mining activities. The representative nature of the Reference Area is verified by statistical comparison (confidence level of 90%, $\alpha = 0.1$) of its absolute values of % vegetation cover, % total ground cover and total herbaceous production to similar data from the plant community it typifies. Species composition and species diversity are also subjectively (non-statistically) evaluated.

Postmining quantitative vegetation data from the Reference Area are directly compared by standard statistical procedures (confidence level of 80%, $\alpha = 0.2$), to data from a reclaimed vegetation type when evaluating revegetation success for full bond release. No mathematical adjustment for climatic change is made. Qualitative data are compared by standard procedures agreed to between the permittee and LQD.

A Reference Area should be at least two (2) acres in size and should be managed in a fashion which will not cause significant changes in the vegetation parameters used to evaluate revegetation success.

This definition moved to Chapter 1.

~~"Relative Cover" is the expression of any number of cover categories e.g.vegetation + litter/rock + bare ground) in relation to each other, such that the sum of the relative cover values for those categories totals 100%. Relative Cover is calculated by the formula:~~

$$\text{~~\% Relative Cover of A =~~} \frac{\text{~~Absolute Cover of A~~}}{\text{~~Sum of the Absolute Cover of categories A + B + ...n~~}} \text{~~x 100~~}$$

~~"Selenium Indicator Plants" are plant species which may selectively concentrate selenium in their tissue and/or be tolerant of high selenium concentrations in the soil. These species, when grazed by cattle or sheep, may produce toxic reactions known as selenium poisoning.~~

"Shrub Mosaic" is a pattern of shrub patches designed to achieve maximum habitat interspersion and edge effect. The boundary of a mosaic encompasses the areal extent of shrub patches and other vegetation types occupying the area between the patches.

This definition moved to Chapter 1.

"Shrub Patch" refers to a continuous surface of varying shape and size (no less than 0.05 acres) that is intensively managed to support a high density of shrubs.

This definition moved to Chapter 1.

"Species Composition" means number, kinds, amount, and quality of species.

This definition moved to Chapter 1.

"Species Diversity" means number of species per unit area.

This definition moved to Chapter 1.

"Study Area" means the full extent of the surface area which was sampled during the baseline vegetation inventory. The study area may coincide with or exceed the permit area.

This definition moved to Chapter 1.

"Subshrub" is a perennial plant which is partly woody, usually at the base, but also partly herbaceous. The individual plant generally dies back to the woody tissue after each year's growth.

This definition moved to Chapter 1.

"Transect" is a sampling method which involves the establishment of a long, continuous line or strip. The starting point and orientation of the line should be randomly established.

This definition moved to Chapter 1.

"Warm-Season Plant" is a species which produces most or all of its growth during the late spring and summer, subsequently flowering in the late summer or autumn.

This definition moved to Chapter 1.