Chapter 7

Standards and Methods for Evaluating the Success of Reclamation

Contents

List of Tables

List of Figures

Chapter 7

Standards and Methods for Evaluating the Success of Reclamation

CHAPTER OVERVIEW

Few aspects of the process for evaluating the success of reclamation have been firmly established under the Federal and State regulatory programs, leaving many uncertainties and issues. None of the five States examined during this assessment has established bond release criteria for Phases II and III. Most existing evaluation techniques and standards which the States could draw on to develop Phase II and III criteria have serious limitations. These limitations are particularly problematic in revegetation and hydrology–the two areas emphasized in the Surface Mining Control and Reclamation Act (SMCRA) performance standards.

To date, no method for evaluating revegetation adequately addresses both changes over time and spatial diversity over a large area. There is general agreement that revegetation standards should accommodate the climatic and temporal variations that affect all aspects of vegetation. However, the most widespread method for doing this–reference areas–assumes that vegetation on a few acres will vary in the same manner as, and thus can adequately represent, vegetation over thousands of acres.

Evaluation of hydrologic restoration is even more unclear. Although the SMCRA performance standards emphasize hydrology, most reclamation evaluations have focused on revegetation success. As a result, **neither operators nor regulatory authorities have much experience with applying hydrologic success standards, and the few standards currently in place are of questionable practicality.** The greatest uncertainties in evaluation of hydrologic restoration are insurmountable, and will simply have to be recognized in the evaluation process. The hundreds of years predicted to be necessary for resaturation of many spoils-aquifers in the West make it impractical to actually measure spoils water quality. Therefore, evaluations will have to be made with incomplete knowledge and available predictive tools. Similarly, some reconstructed surface drainage systems are unlikely to experience peak flow events during the liability period, and predictive techniques and design criteria must be used to evaluate these drainages.

There also is uncertainty about whether successful revegetation and hydrologic restoration are sufficiently reliable indicators of success for soils, overburden, and wildlife. Of particular concern is the time factor involved in spoils oxidation and the potential for deleterious overburden material to cause problems in the root zone after regraded spoils sampling.

Legal questions about liability under the mix of performance and design standards currently used by regulatory authorities are unresolved. If regulatory authorities require a certain reclamation design, and that design fails, are operators still liable for repairing the reclamation failure? A recent slump in Colorado (see below) raises this question.

In addition, there are practical questions about the relative effectiveness of performance and design standards. Performance standards better encourage innovation and selection of the most cost-effective reclamation methods. However, they also have a greater potential for reclamation failure if innovation is not conducted responsibly and if monitoring data are not routinely used to track and modify new practices. On the other hand, while design standards seem to provide greater protection against failures and operator irresponsibility, they can stifle innovation and may not ensure achievement of the desired performance.

PERFORMANCE BONDS AND THE BOND RELEASE PROCESS

SMCRA requires that surface mined lands be restored to a condition capable of supporting the premining land uses or to higher or better uses (24). All of the data collection and analysis conducted by operators and regulators described in the preceding chapters is directed toward meeting this requirement. This chapter examines the criteria and methods used to judge the success of reclamation efforts.

The Federal regulations define "reclamation" as "those actions taken to restore mined land as required by this chapter to a postmining land use approved by the regulatory authority"(l7). The basic reclamation requirements in the Federal regulations provide only **a** general outline of reclamation performance standards, however; they can rarely be applied without substantial interpretation and refinement by State regulatory authorities. This fits with the intent of SMCRA, that the primary governmental responsibility for regulating surface mining and reclamation should rest with the States (see ch. 4) (23).

In order to receive a surface mining permit under SMCRA, operators must put up a performance bond. A bond may either cover an entire permit area or may be filed in increments as the mine progresses. The amount of the bond is set by the regulatory authority and must be sufficient to pay for completion of the reclamation plan in the event of forfeiture. For the very large surface mines prevalent in the West, this usually means bonds of millions of dollars.

In practice, evaluation of reclamation success has become virtually synonymous with bond release. Therefore, the procedures for bond release outlined in SMCRA have shaped the way reclamation success is evaluated. Instead of keeping the entire bond until reclamation has been judged a complete success, which would be financially burdensome for an operator, the Act provides for a phased release of the bond in portions that reflect the operator's reclamation costs (25). The phases of bond release described in SMCRA are:

- phase I: When an operator completes the backfilling, regrading, and drainage control of a bonded area in accordance with the approved reclamation plan, he may apply for the release of up to 60 percent of the bond for that area. Topsoiling maybe required for the release of this phase, at the regulatory authority's discretion.
- Phase II: A second portion of the bond may be released after vegetation has been established on the regraded mined lands and those lands are not contributing suspended solids to streamflow or runoff outside of the permit area in excess of the regulatory requirements. The amount of this second release usually is 15 to 25 percent. The precise amount is left to the discretion of the State regulatory authority, which must retain a sufficient amount of the bond to cover the cost of hiring a third party to reestablish vegetation should the operator forfeit.
- Phase III: The remaining bond monies are released only after the operator has successfully completed all surface coal mining and reclamation activities in accordance with regulatory requirements and with his permit. SMCRA specifies that, in areas where the average annual precipitation is less than 26 inches (virtually all of the study area), the operator must assume responsibility and liability for successful revegetation for 10 years after the last year of augmented seeding, fertilizing, irrigating, or other work. Final success evaluation and final bond release cannot occur until this liability period has elapsed.

To date, none of the five State regulatory authorities has formulated criteria for all phases of bond release. Moreover, because permitting and bonding under SMCRA only began in the West in 1979 and 1980, very few operators are sufficiently advanced in their reclamation activities to apply for any type of bond release. There have been a few Phase I releases (discussed further below), but no Phase II or final releases of any bonds posted under SMCRA. In the next few years, however, more and more operators will be filing for release of various portions of their bonds. Regulatory authorities will then have to decide whether they need to develop more specific criteria for

evaluating reclamation. Preliminary indications are that criteria will differ significantly among the States, depending on environmental and mining conditions and regulatory philosophies.

The State regulatory authorities are drawing up standards for judging reclamation as those standards are needed. By waiting until applications for bond release are submitted, the regulatory authorities hope to incorporate more of the reclamation experience they are rapidly gaining into their criteria and evaluations. This means, however, that operators must proceed on the assumption that bond release criteria will be the same as the revegetation and other performance and design standards in SMCRA and the regulatory programs. Regulators' flexibility to establish more detailed criteria may be limited by approved reclamation plans that establish de facto criteria on a case-by-case basis.

STANDARDS AND METHODS USED TO JUDGE RECLAMATION SUCCESS

Without approved bond release criteria for reclamation parameters beyond Phase I backfilling and grading, and without any examples of Phase II or Phase III bond release, a definitive assessment of the bond release process cannot be undertaken. A preliminary assessment of the methods for evaluating reclamation success can be made, however, based on the Federal and State performance standards.

It is reasonable to assume that specific criteria for reclamation success will be based on the performance standards, and that the methods used to evaluate reclamation will be similar to those developed by technical specialists in the various reclamation disciplines for use in research and in the development of mining and reclamation plans. This section reviews the types of reclamation standards and success evaluation methods available, their advantages and disadvantages, and their use by the different State regulatory authorities. The following section describes the States' experience to date in applying these standards to actual bond release situations.

Types of Standards: Performance vs. Design

There are two broad categories of success standards—performance standards and design standards. Performance standards describe the features that must be present for reclamation to be considered a success and allow the operator to choose a means of achieving this success. Design standards dictate specific aspects or methods of mining and reclamation which, in the regulatory authority's view, must be used to avoid adverse health and safety or environmental impacts, A requirement that discharges of total suspended solids (TSS) from a mine site not exceed natural premining levels is a performance standard. Requiring TSS to be controlled with sediment ponds of a particular capacity built at specified points on the site constitutes a design standard.

SMCRA incorporates both performance and design standards. The latter generally are used either for dams and other engineered structures whose failure would pose a significant threat to public safety and the environment, or when the regulatory authorities' professional staff believe that a required level of performance can only be achieved with a particular design. Evaluation of compliance with design standards is simpler, because it is a straightforward engineering assessment of whether the design has been executed properly. However, reliance on design standards carries with it the risk, albeit small in most cases, that the mitigation designs specified by the regulatory authority might not prove adequate in all cases,

Federal and State Standards

Section 515 of SMCRA contains minimum general performance standards from which more specific success standards are being formulated and implemented by the States (see ch. 4). Table

7-1 lists the most important of these performance standards for Western reclamation. As the table indicates, SMCRA requires:

- restoration of the land's approximate original contour (AOC);[1]
- stabilization of the surface against erosion;
- salvage and protection of topsoil, with special requirements for prime farmlands;
- minimization of disturbance to the hydrologic balance, including maintenance of water quality, restoration of the essential hydrologic functions of alluvial valley floors **(AVFS), and restoration of aquifer recharge capacity;**
- **protecting revegetation and postmining water quality from acid-, alkaline- and toxic-forming overburden;**
- **establishment of a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area and capable of plant succession and regeneration; and**
- **assumption of responsibility for successful** revegetation for a period of 10 years after completion of work on the area.

The Federal regulations interpret and supplement these legislative requirements (see ch. 4). Many of the Federal regulations simply restate requirements in SMCRA. Additional performance and design standards in the regulations address: immediate topsoil replacement; design of hydrologic control structures; protection of wildlife, including threatened and endangered species; and slope stability.

Performance and design standards developed by the States must be at least as stringent as the Federal standards. In the Western States, they often are more stringent. In addition, the standards and criteria developed by State regulatory authorities have to fill in a number of gaps in the Federal regulations, which deliberately leave some important success evaluation decisions up to the States, particularly the revegetation standards.

[1]The act allows exceptions to this requirement for mines where it may not be compatible with the postmining land use, and for those with thin or thick overburden.

Table 7-1.—Selected Performance Requirements and Standards in SMCRA

General: Restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining, or higher or better uses of which there is reasonable likelihood.
AOC: Grade to approximate original contour (AOC) so that all highwalls, spoil piles, and depressions are eliminated (unless small depressions are needed in order to retain moisture to assist revegetation or as otherwise authorized.
Erosion: Stabilize and protect all surface areas and effectively control erosion and attendant air and water pollution.
Topsoil: Remove topsoil in a separate layer, replace it on a backfill area, or if not utilized immediately, segregate it in a separate pile from other spoil and maintain a successful cover by quick-growing pi ants or other means so that the topsoil is preserved from erosion and protected from contamination by acid or toxic material. (if topsoil is of insufficient quantity or of poor quality for sustaining vegetation, or if other strata can be shown to be more suitable for vegetation requirements, then the operator shall remove, segregate, and preserve in like manner such other strata best able to support vegetation.
Prime farmlands: For all prime farmlands, remove, segregate, and preserve the A soil horizon separately from the B and C horizons and replace the A horizon on top of the B and C horizons.
Hydrology: Minimize the disturbances to the prevailing hydrologic balance at the mine-site and in associated off site areas and to the quailty and quantity of water in surface and groundwater systems both during and after surface coal mining operations and during reclamation.
Acid or toxic drainage: Avoid acid or other toxic mine drainage by such measures as, but not limited to:
1. **preventing or removing water from contact with toxic producing deposits;**
2. **treating drainage to reduce toxic content which adversely affects downstream water upon being released to water courses;**
3. **casing, seailng, or otherwise managing boreholes, shafts, and wells and keep acid or other toxic drainage from entering ground and surface waters.**

Surface water quailty: Prevent as far as possible additional contributions of suspended solid to streamflow, or runoff outside the permit area. in no event shall contributions be in excess of requirements set by applicable State or Federal law. Siltation structures may be constructed for this purpose but they must be cleaned out and removed after areas are revegetated.
Aquifer recharge: Restore recharge capacity of the mine area to approximate premining conditions.
AVFS: Preserve throughout mining and reclamation the essential hydrologic functions of alluvial floors in the arid and semiarid areas of the country.
Revegetation: Estabilsh on the regraded areas and on all lands affected, a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected and capable of self-regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area; except, that introduced species may be used in the revegetation process where desirable and necessary to achieve the approved postmining land use plan.

Assume responsibility for successful revegetation for a period of 10 full years after the last year of augmented seeding, fertilizing, irrigation, or other work in areas where the annual average precipitation is 26 inches or less (5 years where annual precipitation is greater than 26 inches).

SOURCE: 30 CFR Parl 800.

The Federal and State standards emphasize revegetation and hydrologic restoration for several reasons. First, the standards are based on an assumption that success in these aspects of reclamation will provide indirect measurements of success in other areas. Successful revegetation can only be achieved if there is sufficient quantity and quality of soil material. Wildlife habitat will be reestablished if adequate revegetation is achieved and water quantity and quality are restored. Maintenance of acceptable water quality, particularly dissolved and suspended solids levels, indicates that the land surface has been stabilized and that erosion will not be a problem. Second, vegetation and surface water are the most accessible reclamation parameters, and therefore the easiest to measure. Third, in most cases, these are the parameters that most directly affect achievement of the postmining land use.

Revegetation Standards*

Because of the **emphasis on revegetation success—both historically and** in SMCRA—the Federal regulations include much more specific standards for revegetation than for other aspects of reclamation. In particular, the regulations require:

- use of statistically valid sampling techniques for measuring revegetation success, which must include criteria representative of unmined lands in the area;
- evaluation of revegetation cover and production by approved methods, such that these parameters are not less than 90 percent of the success standard;
- use of tree and shrub stocking and vegetative cover standards for evaluation of success on lands whose postmining land use is wildlife habitat; and
- achievement of the relevant vegetative success standard for at least the last 2 years of the 10-year responsibility period, without augmentation practices not expected to continue as part of the postmining land use.

State and Federal revegetation performance standards vary with land use (see table 7-2). For each use they must define: 1) what vegetation characteristics, such as cover, production, woody plant density and diversity, are to be evaluated; 2) what vegetation standard, such as a reference area or an historical data standard, is to be used to evaluate reclaimed areas; and 3) what level of statistical comparability must be established between the reclaimed area and the standard, such as considering cover equal if it is at least 90 percent of the standard with 90 percent statistical confidences

Most of the lands overlying strippable coal in the five-State region are native rangelands—lands that support predominantly native vegetation used to graze domestic livestock. Most of these lands also support a variety of wildlife and therefore are considered to be wildlife habitat as well. North Dakota is an exception in the study area because cropland and tame pastureland have replaced most natural habitats. Vegetation parameters usually considered in judging reclamation success on native rangelands are cover, production, diversity, and woody plant density. Other land uses, such as mown pasture and row cropland, are evaluated with some subset of these parameters. Methods used to collect data on these vegetation parameters, from which evaluations can be made, are discussed in chapter 5.

The permanence of revegetation is explicitly evaluated only in Montana.[4] In Montana, permanence is considered to have been achieved if the revegetated area is composed of at least 51 percent native species, based on production and canopy cover. This standard assumes that native communities are more likely to be self-sustaining than introduced species, which is generally true.

Revegetation evaluations emphasize these parameters because of their relevance to the postmining land use. Vegetative cover is an indicator of the stability of the soil resource. Permanence and net above-ground annual production are measures of the utility of the vegetation for livestock grazing and for wildlife. Vegetative diversity generally is considered to be a measure of

*Unless otherwise noted, material In this section is adapted from references 6 and 13.

[3]Many statistical standards of comparability were eliminated in the 1984 revisions to the Federal regulations, in effect making them standards of 100 percent with 100 percent confidence; see table 7-2.

[4]Use of a 10-year liability period addresses permanence indirectly, but it is not clear that this alone assures permanent revegetation.

Table 7.2.—Revegetation Performance Standards by Land Use Category and State

Federal 1979 PRP	Colorado	Montana	New Mexico	North Dakota	Wyoming
Native rangeland:					
For the last two consecutive years of the liability period: • Ground cover 90% of standard with 90% confidence or 80% confidence on shrublands; • Productivity 90% of standard with 90% confidence or 80% confidence on shrublands. Diverse, effective, and permanent cover of the same seasonal variety able to support postmining land use.	Cover and production same as PRP rangeland. Woody plant density same as PRP (see PRP wildlife). Diversity same as PRP wildlife.	Cover and production with same statistical measures as PRP rangeland, but comparison is to weighted cover and productivity (see text). Woody plant density same as PRP wildlife, Weighted diversity (see text) with same statistics as diversity in PRP rangeland. Permanence if 51% cover and production are native species.	Cover and production same as PRP. Woody plant density same as PRP (see PRP wildlife). Diversity same as PRP wildlife.	Cover and production same as PRP rangeland. Diversity same as PRP rangeland.	Cover and production same as PRP rangeland. Diversity same as PRP rangeland.
Wildlife habitat:					
Ground cover 70% of standard with 90% confidence. Woody plant stocking 90% of standard with 80% confidence. Ground cover diversity, seasonality, and regeneration to be evaluated.	Same as CO native rangeland.	Same as MT native rangeland.	Same as PRP wildlife.	Same as PRP wildlife. Trees same as stocking of PRB wildlife,	Same as WY native rangeland. Shrub density same as woody plant stocking in PRP wildlife.
Cropland:					
For the last two consecutive growing seasons of the liabilty period: • Production 90% of standard with 90% confidence.	Same as PRP cropland.	Same as PRP cropland.	Same as PRP cropland.	Same as PRP cropland.	Same as PRP cropland.
Tame pastureland:					
Same as PRP cropland.	Same as PRP cropland.	Same as PRP cropland.	Not applicable.	Cover and production same as ND and PRP rangeland.	Same as PRP cropland.
Revegetation standard system:					
Reference area or other approved standard.	Reference area or technical standard.	Reference area.	Reference area, technical standard, or historical record.	Reference area or other standard. A technical standard has also been accepted.	Reference area or control area.

NOTE: Only when statistical adequacy for a State is stricter than the Federal PRP is it entered in the table. Stocking has the same meaning as density. "PRP" means Permanent Regulatory Program.

SOURCE: Off Ice of Technology Assessment, from Federal and State regulatory programs.

ecological stability and an indicator of the land's capability for supporting wildlife. Woody plants contribute to habitat diversity, providing forage and reproduction sites, protective cover, and physical and spatial heterogeneity in the habitat. Therefore, woody plant diversity and density are considered a measure of reclamation success where wildlife habitat is a postmining land use.

Success standards for these vegetation parameters are set by different methods. Cover and production usually are judged according to standards that attempt to adjust for the climatic variations which affect these parameters. Woody plant density and species/lifeform diversity standards are usually compared with quantitative goals called technical standards, These are negotiated between the operator and the regulatory authority based on the postmining land use, premining conditions, and practical constraints.

Five different systems of revegetation standards have been developed that meet the Federal requirement for inclusion of criteria based on similar unmined lands **(22).** Each system has advantages and limitations that determine its usefulness for the different climatic regions of the West and for the different vegetative characteristics to be measured. **The primary limitation, common to all of the systems, is their inability to address both the temporal variations in environmental conditions and the spatial diversity that occurs over large areas. An additional concern is the lack of testing under actual land use conditions. For example, although the predominant land use in the study area is native rangeland, little test grazing has occurred on revegetated areas. Of the five States, only Montana has established guidelines** for test grazing plans and monitoring data collection.

Unadjusted Baseline.–This system uses the quantitative values for cover and production observed during the baseline vegetation study (see ch. **5)** as the revegetation standard. Thuse, there is no adjustment for natural variability due to environmental change. Rather, the unadjusted baseline method implicitly assumes that year-to-year fluctuations in the measured parameters are negligible. This approach has not been used widely except at existing (pre-SMCRA) small mines that do not have enough land for reference areas.

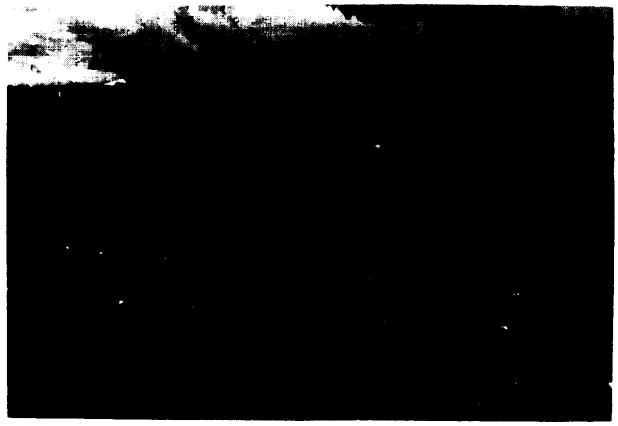


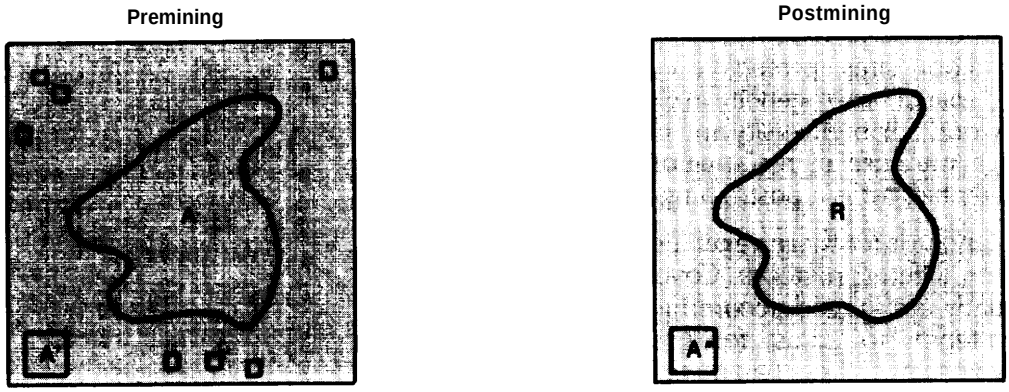
Photo credit: Jenifer Robison, OTA staff

Test **grazing may be conducted on native rangeland or pastureland at some mines for the last 2 years of the liability period in order to assess the success of revegetation under actual land use conditions.**

Reference Areas.–This method uses 2- to 3-acre plots of land, whose management can be controlled by the operator. The plots are chosen to be representative of one or more vegetation parameters (usually cover and production) on undisturbed lands similar to the area being reclaimed. The measured vegetation parameters on the reference areas constitute the success standard. The underlying assumptions of this method are that vegetative cover and production on the disturbed area should be equivalent to that on the reference area, and that the equivalency will hold over time and climatic variation. Vegetation on reclaimed areas is compared directly with the vegetation on the reference area at the close of the liability period. Baseline data are used only to establish comparability between the area to be disturbed and the reference area(s) during the baseline year, A premining demonstration of statistical equivalency between the reference area(s) and the proposed mining area is required (see fig. 7-l).

Operators must then demonstrate that cover and production of the reclaimed vegetation equals a prescribed percentage of the values in the reference area (often 90 or 100 percent) with a prescribed statistical level of confidence (usually 80 or 90 percent). The State regulatory au-

Figure 7-I.— Reference Area



Demonstrate A = A'

Assume AA' = AA

Demonstrate R≥A"

A = area to be mined of vegetation type A.
A' = reference area whose vegetation is representative of area A in baseline year.
R = area revegetated in vegetation type A.
A" = reference area in test year.

— **Purpose of collecting baseline data is to demonstrate similarity of A and A'.**

— Success **standards are the values in A".**

SOURCE: Modified from G.P. Kunkel and E.J. Hinzel, "Considerations in the Application of Standards for Revegetatlon Success," in E. Redente, et al., *Symposium on Western Coal Mining Regulatory issues: Land* **Use,** *Revegetation, & Management,* **Colorado State University Range Science Department, Science Series No. 35, August 1983, pp. 31-35.**

thorities prescribe levels of equivalence and statistical confidence, which may vary with land use or vegetation type. Reference areas are commonly used in all of the States except Wyoming,

Performance standards based on reference areas have the advantage of incorporating variations **in vegetation due to climatic conditions. Reference areas also have a number of limitations, however.** Most important is the underlying assumption that vegetation on a 2- to 3-acre plot can adequately represent the vegetation on an area many times larger (up to thousands of acres). Detailed ecological studies repeatedly demonstrate that vegetation is a mosaic of plant communities resulting from minor differences in the physical environment, localized population cycles of small mammals and insects, the natural growth and succession of individual plants and plant populations, and the cumulative effects of land use changes. Because cover and production also vary within this mosaic, a quantitative equivalency between a vegetation type on a reference area and a reclaimed area often is difficult or impossible to establish (see box 7-A).

Contro Areas.–Like reference areas, control areas are hosen to be representative of vegetation on an undisturbed area similar to the area being reclaimed. However, control areas are used differently to evaluate success. Vegetation parameters measured in control areas are not compared directly to the parameters on revegetated areas. Instead, vegetation samples from the control reference area in the test year are compared to values in the baseline year. The ratio of the test and baseline year samples is used to adjust the baseline data from the disturbed area for environmental and climatic changes over time. The adjusted baseline data are then used as the performance standard. Success is determined through a statistical comparison of the actual values in the

Box 7-A.—Use of Reference Areas

Extremely continental climates with erratic weather patterns, which are common in most parts of the West, make application of revegetation evaluation standards particularly difficult. Recent monitoring of revegetated grassland at a mine in east-central Montana illustrates the limitation on the use of small reference areas that results from variable vegetation response to changes in the distribution and amount of precipitation. One area of the monitored tract experienced a very dry winter and **early spring, but more adequate late summer rain. Cool-season grasses therefore did poorly, but warm-season grasses did well. The result was a shift in apparent species composition in the area. In addition, production varied across the area according to the amount of warm-season grass in each community. Production on other areas of the tract, which experienced different rainfall patterns, varied not just by a few percent, but by as much as several orders of magnitude (6).**

revegetated area and the adjusted baseline values (see fig. 7-2). Control areas are the preferred evaluation method in Wyoming.

Control areas share with reference areas both the advantage of incorporating variations in vegetation due to climatic conditions, and the disadvantage of assuming that the vegetation on a small control area can adequately represent the vegetation on a much larger area. The control area system, however, uses the control data only to formulate an adjustment factor for tract-wide baseline data. Therefore, it is somewhat less dependent on that assumption than the reference area method. But, it still assumes that vegetational response to climatic variation between the baseline and test years on the control area will be the same as the average across a vastly larger tract.

Control and reference areas also may be difficult to establish or maintain. Operators may not have land sufficiently similar to the mined land to set aside as reference or control areas. The small plots of vegetation can easily be disturbed or destroyed by changes in the mine plan, or by fire, insect infestation, and plant disease.

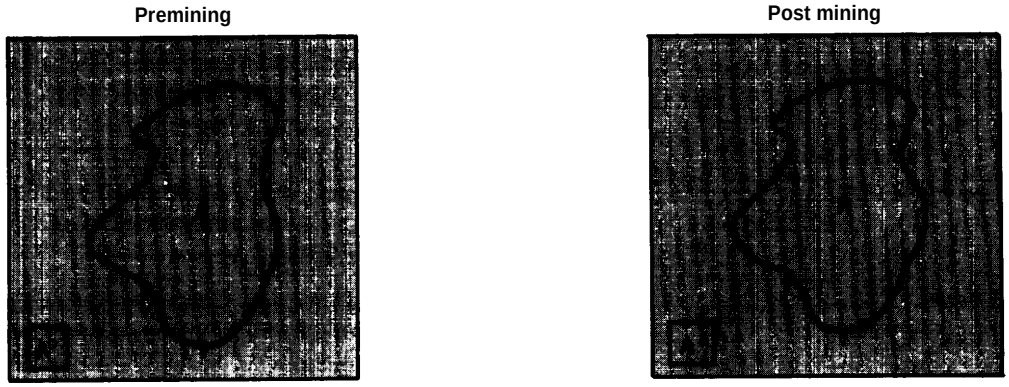
Historical Record.–Another method for addressing the temporal variations in vegetation parameters is to collect baseline data over a period considered to be one climatic cycle. Theoretically, this should bracket the potential variability in cover and production. In New Mexico, the only State in which the historical record approach has been used to a substantial extent, one climatic cycle typically has been regarded, albeit debatably, as at least 7 years,

Historical record data may be particularly useful **for mines that will eventually disturb all lands suitable for use as reference areas; for areas where several mines are located in the same region and so can share the cost of collecting data to establish the historical record, as is the case in northeastern New Mexico; and for measuring production where the postmining land use is cropland. Use of an historical record avoids many of the problems associated with reference areas: site selection, measure of similarity, and management conflicts. It could accurately reflect the natural range of temporal variation in vegetation by incorporating samples over a much longer period of time. The limitation of this standard,** however, is that the amount of data which must be collected in order to establish the record and the amount of time required to do this are both very large. Similarly, the most accurate evaluation method using the historical record requires a long period and a lot of sampling. For these reasons, it is not widely used outside of New Mexico. s

Moreover, it is not clear exactly how the accumulated data can best be used to judge revegetation success. One method developed jointly by the New Mexico Mining and Minerals Division (MMD) and the Office of Surface Mining (OSM) is to use the arithmetic mean of the historical record data as a technical guide with no associated variance term. With this approach, however, adequate revegetation could fail to meet the standards if it were evaluated in a drought year, and inadequate revegetation could be approved as successful if evaluated in a wet year. Another possible method would be to mon-

[5] For more information on use of the historical record standard in New Mexico, see reference 15.

Figure 7-2.—Control Area



A = area to be mined of vegetation type A.
A' = control area whose vegetation is representative of area A in baseline year.
R = area revegetated in vegetation type A.
A" = control area in test year.

- **Premining data are used to establish quantitative relationship between the control area and the disturbed area.**
- **Success standards are the baseline vegetation values for A adjusted by relationship between A' and A".**

SOURCE: Modified from G.P. Kunkel and E.J. Hinzel, "Considerations in the Application of Standards for Revegetation Success," In E. Redente et. al., *Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management,* **Colorado State University Range Science Department, Science Series No. 35, August 1983, pp. 31-35.**

itor the reclaimed area during a period comparable in length to the climatic cycle over which baseline data were collected. The means of the baseline and monitoring samples could then be compared with 90 percent confidence intervals. This would necessitate a longer period of sampling than the mandated 2 years at the end of the liability period, however.

Technical Standards.–Technical standards set quantitative goals for vegetative characteristics based either on the range of values for particular characteristics found on similar lands in the region, or on negotiations between the operator and the State regulatory authority that consider the requirements of the postmining land use, demonstrated success of revegetation practices in the region, and baseline vegetation values. Technical standards are most often used for cover and production when baseline conditions are unacceptable due to poor land management. Woody plant density and species/lifeform diversity are commonly judged with negotiated technical standards.

Realistic and fair selection of the technical standards that reasonably may be expected in an area require a substantial amount of data. Soil Conservation Service (SCS) or Bureau of Land Management (BLM) range site data maybe used for this purpose (see ch. 5), as may accumulated historical record data as it is developed in a region. For example, in Campbell County, Wyoming, most vegetation types have been sampled every year since 1977. **Therefore, sufficient data should now** be available to establish minimum regional performance standards for vegetative parameters, if such a standard were deemed desirable by the regulatory authority (6). However, differences in data-collection methods and cli-

matic conditions from site to site and year to year could make it difficult to translate these data into technical standards.

Similarly, because SCS range site data are from climax communities—a level of development that revegetation 9 or 10 years old might not be able to match–they can produce unreasonably high technical standards, Even where appropriate data are available, technical standards as currently used do not make adjustments for climatic conditions in the test year. Data used to derive technical standards often include ranges of production from most favorable to least favorable years, but a direct mathematical adjustment tied to climate is not available yet.

Technical standards may reduce costs of vegetation data collection by eliminating the need for reference or control area sampling. Technical standards also may be used to set higher standards than baseline conditions when the premining vegetation has been depleted by overgrazing. in addition, technical standards can be used in areas where reference areas are unavailable. As mentioned above, the most common present and potential use of technical standards, however, is for evaluation of woody plant density and species/lifeform diversity (see box 7-B).

80X 7-B.—A Proposed Technical Standard for shrub Density

Spatial heterogeneity of shrub cover greatly increases its contribution to wildlife habitat. However, baseline and reference area data usually record only the overall average of stems per acre. When such data are used as performance standards, the result is often a uniform distribution of shrubs to the required density, and the "clumping" of shrubs desirable for wildlife is lost. To address thisproblem, Wyoming has proposed a technical standard for shrub density which sstates that 10 percent of the reclaimed surface should have shrub densities of at least one stem per square meter (4,050 stems per acre). The remaining 90 percent of the area should have shrubs included in the seed mix, but there are no shrub density performance standards that must be met.

Hydrology Standards[8]

Although SMCRA emphasizes the hydrologic aspects of reclamation, performance and design standards, and bond release criteria for restoration of hydrologic systems, are not nearly so detailed as they are for revegetation. The regulatory authorities have not applied any hydrologic performance standards as yet (see below), with the exception of the restoration of surface drainage systems which are sometimes included in Phase I bond release. Evaluation of restored drainage systems is a straightforward comparison of regraded topography with the approved postmining topographic map. Other aspects of hydrologic evaluation will, however, require the regulatory authorities to formulate more specific directions about application of the standards. In none of the States and at none of the 20 mines reviewed for OTA are clear and complete hydrologic evaluation criteria in place.[7]

Surface Water.–Surface water standards in SMCRA deal with water quality and quantity, as well as drainage systems. The reclamation plan must include general information regarding backfilling and grading and a detailed description of the measures to be taken for the protection of surface water quality and quantity. The performance standards require operators to minimize disturbances to the quantity and quality of surface water and emphasize avoidance of deleterious materials and increased TSS and TDS levels. The standards also require operators to grade restored land so as to control erosion.

The Federal regulations include design criteria for the capacity of both "permanent diversions" (diversions of perennial and intermittent streams) and "diversions of miscellaneous flows" (ephemeral streams) (19). The regulations also specify design criteria for sedimentation ponds (21), and require that water discharged from these ponds be in compliance with the effluent limitations prom-

[6]Unless otherwise noted, material in this section is adapted from reference 14.

[7]Each of the case studies in reference 14 contains a discussion of the hydrologic evaluation criteria for that case study mine. In all cases, the criteria are at least vague and, occasionally, nonexistent.

ulgated by the Environmental Protection Agency (EPA) (1 7,19).

Bond release criteria for surface water are also quite general.[8] All States have regulations that require evaluation of: 1) whether pollution of surface water is occurring, whether such pollution is likely to occur in the future, and the estimated cost of abatement; and 2) whether lands are contributing suspended solids to streamflow or runoff outside the permit area in excess of requirements set by applicable State or Federal laws (see box 7-C). Although erosion is the primary contributor to elevated TSS levels, evaluation of sedimentation that affects surface water has not measured erosion rates. As discussed in chapter **8,** field data on sediment yields (the total amount of eroded material that reaches a control point) are needed to demonstrate that alternative methods of sediment control are as effective as sedimentation ponds.

[8]See reference 14, table 5, for a summary of references in the State regulations to hydrologic criteria for bond release.

Box 7-C.—Application of TSS Standards

It is not yet clear how regulatory authorities will apply the TSS performance standard. In Colorado and Wyoming, suspended solids requirements are set by premining or baseline levels of suspended solids. In North Dakota, Montana, and New Mexico, State and Federal authorities have established nonsite-specific standards of acceptable TSS for all perennial streams. Both types of standards have limitations. Adequate premining and baseline data on TSS levels are not always available and TSS standards have not been set for the small ephemeral streams which constitute the great majority of streams affected by mining in the West. In addition, no standards have been set on data collection methodologies to be used when evaluating TSS levels (see ch. 5). TSS levels vary greatly with the climatic changes that cause changes in flow rate and level, such as precipitation and snow melt events. TSS data may also vary greatly with the sampling methodology used and the point in the channel samples are taken from. These aspects of the evaluation procedure will have to be defined by regulatory authorities before suspended solids standards can be applied.

Compliance with an approved mining and reclamation plan provides regulatory authorities with the primary means to evaluate designs of restored surface drainage systems (see ch. 6). All designs submitted are evaluated during the permit application review and approval process, and progress on channel reconstruction is reviewed during compliance monitoring.

Groundwater. —There are no standards for evaluating restoration of spoils aquifer hydraulics and recharge, and no official numerical standards for evaluating postmining groundwater quality. Current bond release criteria for groundwater restoration are vaguely tied to whether or not pollution of subsurface water is occurring. However, "pollution" in this context is not defined quantitatively by any State program.

Due to the lack of numerical standards, groundwater quality impacts usually are analyzed with respect to use-suitability criteria established by EPA (see table 7-3). Spoils water is examined to determine if its quality is suitable for the same uses as premining groundwaters. Operators are concerned about one aspect of evaluation using these use-suitability criteria. An operation that disturbs water with TDS levels at the low end of the range of suitability for a particular use can add a large amount of solids without exceeding the criteria, but an operator affecting water at the high end of a range can add very little. For example, an operation disturbing an aquifer with premining TDS levels of 1,499 mg/1, which is unsuitable for domestic use but suitable for all

Table 7-3.—Maximum Recommended Total Dissolved Solids Concentrations in Water for Various Uses

Use	Maximum TDS concentration (ma/l)
Domestic	500 (recommended) 1,000 (maximum)
Livestock. , . . .	3,000 (for all classes of livestock) 5,000 (excluding poultry)
Irrigation	500 (for all crops and soils) 1,000 (for all but sensitive crops) 2,000 (may adversely affect some crops and requires careful management) 5,000 (only for salt-tolerant plants on permeable soils with careful management)

SOURCE: Western Water Consultanta, "Hydrologic Evaluation and Reclamation Technologies for Western Surface Coal Mining," contractor report to OTA, August 1985.

classes of livestock, can double TDS concentrations and remain within these criteria. An operation disturbing an aquifer with TDS levels of 2,999 mg/1, which is the top of the range suitable for livestock use, can add nothing to TDS concentrations, however.

Groundwater quantity and spoils-aquifer hydraulic characteristics usually are evaluated by determining whether the spoils will permit reestablishment of premining groundwater flow patterns, and whether they will provide water to wells in sufficient amounts to restore the uses supported by the premining coal and overburden aquifers. Because these wells typically supplied livestock and domestic uses, small well yields (less than 5 gpm) usually are adequate.

Mine operators must apply for permit renewals in 5-year intervals. if monitoring of spoils-water quality or aquifer testing of the spoils indicates that problems are developing, corrective measures can be worked out to forestall problems at bond release and final success evaluation (14).

Evaluation of groundwater restoration is often complicated by the very long periods of time required for spoils aquifer recharge in the West. Even after groundwater levels are reestablished in an aquifer, groundwater quality will remain variable for an indeterminate amount of time while chemical equilibrium is reestablished. Therefore, it is unclear whether application of quantitative evaluation standards for groundwater restoration will always be possible or reasonable.

Alluvial Valley Floors.–The general performance standard for AVFS in SMCRA is that essential hydrologic functions (EHFs) must be restored. Because these functions are described in detail in baseline studies (see chs. 5 and 6), the intensive premining data establish performance standards for AVF restoration. Thus, restoration of EHFs can be demonstrated by comparing data for the reconstructed AVF with the baseline standard. Reclamation of an AVF under SMCRA has not yet been completed in any of the five States, so details of the evaluation process have not been worked out. For example, no thresholds of statistical comparability have been established (e.g., the "90 percent with 90 percent confidence" standard established for vegetation) to define how close to the baseline the restored EHFs must be.

The timeframe within which restoration of EHFs must be judged also has not been specified in any State. As with many other aspects of surface and groundwater restoration, it may be many years after reclamation activities are complete before the hydrologic system achieves approximate steady-state conditions. One mine reviewed by OTA has taken special measures to hasten the resumption of subirrigation and other EHFs on a restored AVF to facilitate evaluation of their restoration (see ch. 3, box 3-K).[9]

Soils and Overburden Standards[10]

Standards for evaluating reclamation success for soils and overburden are very limited. Existing standards are based on approved designs; ''performance' of soils and overburden is assessed indirectly, through evaluation of revegetation and hydrologic restoration,

Soils.–In most cases, soil reconstruction is considered to be successful if the postmining soil is as thick as predicted in the baseline study, and the lifts (if required) are in the correct order. ' [11] Erosion must not exceed premining levels or contribute additional suspended solids to streamflow outside the permit area (see discussion of hydrology standards, above).

The regulatory authorities usually evaluate erosion of the redressed topsoil quantitatively, Two methods of erosion measurement used at mines reviewed by OTA are described in chapter 5, box 5-E. Federal and State regulations require that rills deeper than 9 inches on regraded and topsoiled areas be filled, graded, or otherwise stabilized.

The regulatory authority also will evaluate compliance with any special stipulations regarding soils. Several permit applications reviewed by OTA had stipulations regarding soil monitoring for salinity, sodium adsorption ratio, and pH. However, in some cases, the stipulations did not specify the value at which each of these parameters should be considered a problem. The stipulations also did not always say how problems should be treated if discovered.

---

[9] See reference 14, case study J.

[10] Unless otherwise noted, material for this section is adapted from reference 12,

[11] Montana and North Dakota both require two lifts.

Recent research on soil standards focuses on the reconstruction of a viable root zone. In North Dakota, researchers are developing methods for evaluating the properties of the reconstructed root zone that will help compensate for the shortcomings of reference areas. In addition, evaluation of soil parameters is an attractive method of gauging land productivity in areas where land is being reclaimed to cropland (e.g., in the Midwest and North Dakota), because of the variability in production due to climatic factors. However, methods to conduct such evaluations are still in their experimental stages and have not been accepted by the North Dakota regulatory authority (3).

Overburden.–Evaluations of overburden replacement emphasize prevention of problems because success is difficult to predict conclusively. Furthermore, cures for the inadvertent placement of material that may be detrimental to revegetation or postmining water quality may be prohibitively expensive because they involve removing and redistributing large amounts of material. Regulatory authorities therefore rely heavily on formulation of good spoils-handling plans in the permits to ensure proper handling of potentially deleterious spoils material, and on frequent inspection during mining to ensure compliance with approved plans.

As discussed in chapter **5,** it is fairly common in the West for operators to sample the surface of recontoured spoils to check for unsuitable material in the root zone (usually considered to be the top 4 feet of spoils). If a problem is found, steps can then be taken to treat or cover deleterious material. During bond release, each of the five States evaluates the data from these spoils samples by applying the same unsuitability criteria that they use for baseline evaluations of overburden suitability (see ch. **6).** Surficial spoils sampling for bond release is the norm in Montana and Wyoming. The North Dakota regulatory authority rarely requires spoils sampling because they require so much soil cover that unsuitable overburden usually will not be a problem. in Colorado, surficial spoils sampling is used to evaluate reclamation only if it is required in a permit stipulation because a potential problem was recognized before or during mining. In New Mexico, spoils sampling is not the norm, but in the two mines reviewed by OTA, baseline investigations showed all of the spoils to be unsuitable. Therefore, sampling the regraded material was considered unnecessary.

Where the surficial spoils are sampled, all State regulatory authorities consider a single round of sampling sufficient; nowhere are spoils routinely monitored over time. Consensus among the regulatory authorities is that monitoring following topsoiling should be required only if revegetation problems develop. This approach ignores the risk, however, of changes in spoils suitability, particularly in areas with potential for sodium migration.[12]

Wildlife Standards[13]

The regulatory agency personnel in the five States reported that they have no quantitative performance standards for judging the success of wildlife mitigation measures. Instead, regulatory authorities assess habitat restoration by evaluating the various habitat components, such as revegetation, topsoil placement, and water quality. Operators usually monitor wildlife use of restored habitats, but lack of confidence in wildlife data makes all parties reluctant to use monitoring data for quantitative evaluations (see ch. 5). Another obstacle to wildlife performance evaluations is the varying effect vegetation succession has on wildlife use of reclaimed land. Early- to mid-successional plant communities often benefit more—and different kinds of—wildlife than do late-successional and climax communities. Because floral succession through these vegetation stages often takes decades, wildlife use of reclaimed land will not reach premining levels of diversity and population density during the bond liability period.

Some wildlife mitigation measures must be evaluated with design standards; for example, range fencing that permits pronghorn passage, road underpasses and overpasses for wildlife, nesting structures, and raptor-safe power lines

[12] Recent work done in Montana increases cause for concern that sodium migration through spoils over time will not be detected through one-time spoil sampling programs (3).

[13] Unless otherwise noted, material in this section is adapted from reference 1.

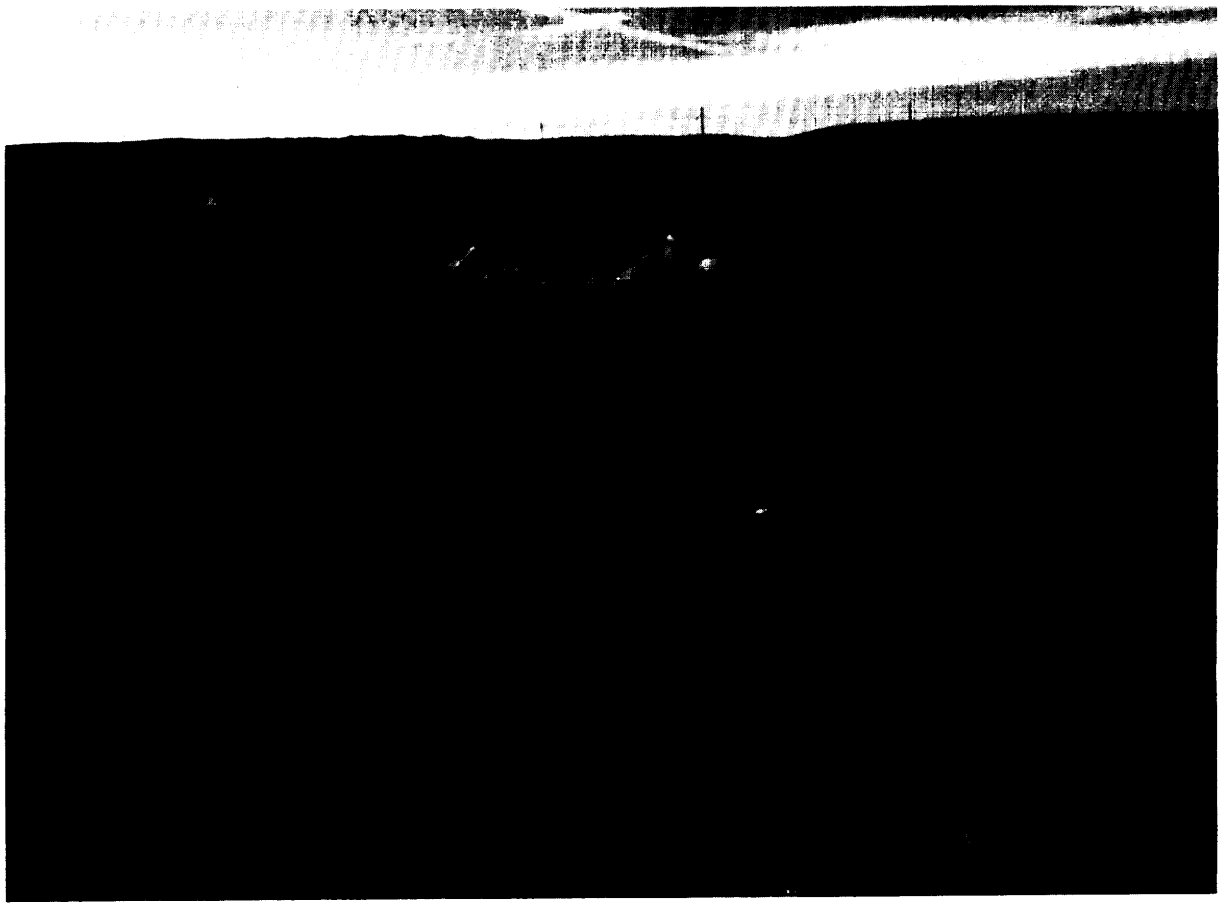


Photo credit: Jenifer Robison, OTA staff

Rockpiles are used to simulate surface features such as rock outcrops that are destroyed in mining. However, quantitative design standards to facilitate optimum establishment of features such as rockpiles have not been established.

(see ch. **3,** fig. 3-1 1). The U.S. Fish and Wildlife Service currently is developing design standards for raptor nest and highwall manipulations. However, design standards do not exist for many of the more commonly required habitat enhancement or replacement measures. There is general agreement that features such as rockpiles and shrub patches are beneficial to wildlife, but designs for optimum establishment of these features are less obvious. Lack of quantitative design standards for these features also make evaluation of compliance difficult for regulatory authorities. Questions that must be answered include: How big should these features be? How many of them should there be? In what configuration should they be placed over the landscape? Without some numerical parameters for constructing these features, it is difficult for operators to know how to install the mitigation features in a way that will satisfy the regulatory authority, and to have confidence in the usefulness of the habitat enhancement measures required in permitting.

STATE EXPERIENCE WITH RECLAMATION EVALUATION AND BOND RELEASE

Reclamation under SMCRA and the approved State programs is a relatively new activity in the West. While no mines have completed their 10-year liability period, a limited amount of experience has been gained in some States with release of Phase 1 bonds. Each of the five Western States studied has a slightly different approach to bond release and success evaluation. This section presents a brief overview of bond release activity and the development of bond release criteria in the study States.

North Dakota[14]

To protect the rich soil resource in its State, the Public Service Commission (PSC) in North Dakota divided the SMCRA Phase I release into two parts. To receive the initial **40** percent of the bond, operators must backfill, grade, and establish drainage control to the PSC'S satisfaction. After these activities have been judged successful, operators

[14]Unless otherwise noted, this discussion is based on reference 9.

Photo credit: Office of Surface Mining

Because of the predominance of cropland in North Dakota surface mining areas, the bond release procedures there emphasize reconstruction of the soil resource.

must topsoil the regraded surface to qualify for another 20 percent of their bond. Up to another 20 percent of the bond may be released after revegetation has been established. The PSC may only release the remaining 20 percent or more of the bond after the 10-year liability period has elapsed and it judges all reclamation activities to be successful.

North Dakota law establishes a Reclamation Advisory Committee to oversee the two final stages of bond release, The Committee consists of representatives from PSC, SCS, the North Dakota State agricultural extension service, and others knowledgeable about reclamation. When an operator wishes to start the 10-year liability clock, the committee inspects the reclaimed site. If the committee judges revegetation to have been reestablished successfully at that time, the initial revegetation portion of the bond is released and the 10-year liability period begins. During the liability period, the operator must manage the land with practices considered normal husbandry for the designated postmining land use. At the end of the 10 years, the committee reinspects the reclaimed site and decides whether the remainder of the bond should be released.

A few bonds have been partially released for grading and backfilling in North Dakota. Criteria used to judge success of these activities are fairly straightforward and usually are applied by mining engineers. Topographic maps are used to inspect for AOC and for adequate reconstruction of drainages according to approved reclamation plans. Sampling for deleterious material in the postmining root zone or water table is not routinely required. The regulatory authority generally relies on early identification of these materials from baseline data submitted with the permit application (see ch. 5), and on frequent inspections during mining and reclamation to ensure that any such materials have been handled properly. In addition, the requirement for 48 inches of soil cover over regraded spoils reduces concerns about deleterious overburden. Sampling may be required on a case-by-case basis if there is reason to believe that any material may be deleterious to plant growth.

The PSC is preparing guidelines for judging the reestablishment of revegetation. None of the mines studied has applied for the revegetation stages of bond release yet, although the first of these could be filed in 1986 if weather conditions are favorable.

Montana[15]

Montana has not released any phases of post-SMCRA bonds. At the time of this writing, however, the Department of State Lands (DSL) had two applications for Phase I release pending, and expected another application in June, 1986. One of the pending applications had been submitted twice, and both times was returned to the operator for further work. DSL has tried to formulate criteria for Phase I release (up to 60 percent), which in Montana covers backfilling, topsoiling, regrading, and drainage control. In this attempt, however, DSL found more exceptions than rules, and so is relying to a large extent on case-by-case evaluations of success,

In general, DSL inspects sites during Phase I release for obvious design features: AOC, stable drainage structures, adequate topsoil thickness as approved in the permit. If permit stipulations require sampling of recontoured spoi ls, the monitoring data must be submitted and evaluated prior to Phase I release. In addition, DSL uses the Phase I inspection to reexamine compliance with the mining and reclamation plan and to ensure that modifications—which are inevitable during the course of any mining operation—have been fully taken into account in the mine's long-range planning. In particular, DSL checks to ensure that, where an operator is seeking bond release on only a portion of the site, as is common at large Western mines, modifications made in the overall mine plan will not require the operator to redisturb the site.

DSL does not expect to receive any applications for Phase II bond release on revegetation for another 3 to 5 years. Unlike the other States, where Phase II revegetation is considered to be

[15]Unless otherwise noted, this discussion is based on reference 7.

only a preliminary surface stabilization measure, the Montana regulations require all of the revegetation success standards to be met prior to release of the Phase II bond (1 1). Montana also applies the lo-year liability clock on revegetation in Phase II rather than Phase [11. The regulations contain detailed standards for revegetation success in this second phase of bond release. These include:

- the use of reference areas under management practices similar to the revegetated area, and grazed at no more than **so** percent of capacity, as standards for judging reclamation success;
- evaluation of weighted productivity and weighted canopy cover by morphological class (the mathematical formulae to be used to calculate these are specified in the regulations);
- evaluation of weighted diversity by species (the mathematical formula to be used is specified in the regulations);
- evaluation of permanence and seasonality of vegetation; and
- analysis of potential toxicity of vegetation to animal consumers, where suspected.

Up to 25 percent of the bond may be released during Phase II_1 leaving 15 percent (or more, if less than the maximum was released in previous phases) to be released when the regulatory authority finds that all reclamation activities have been completed in accordance with the approved reclamation plan.

Wyoming[16]

Wyoming's bonding system differs slightly from the other States in that it is based on the intensive annual review the Wyoming Department of Environmental Quality (DEQ) conducts for each mine. Under Wyoming's system, each surface coal mining operation in the State has two different bonds. ' [7] The **area bond** covers only the cost of backfilling any portions of the pit that will remain unfilled during the coming year. The area bond is adjusted following annual DEQ review to reflect both progress in backfilling and progress of new disturbance. Therefore, if an operator backfills and disturbs at the same rate, his area bond will remain unchanged. Area bonds may only be adjusted upward—a protection for the regulatory authority to ensure that sufficient funds are available to cover default at any time.

The **incremental bond** covers all other features of reclamation; it is increased annually to reflect costs of reclaiming the amount of acreage that will be disturbed in the coming year. DEQ does not consider reclamation of previously disturbed acreage in the annual review of the incremental bond. Rather, release of the incremental bond follows a pattern similar to that outlined in SMCRA: 60 percent of the incremental bond may be released after regrading, topsoiling, and drainage control have been completed. Another portion of the bond (amount to be determined by the regulatory authority) may be released after initial revegetation, as determined by species composition, which must be similar to that of the approved seed mix. The remainder of the incremental bond may only be released after the operator has completed all reclamation activities in compliance with the permit, the regulatory program, and SMCRA.

Although DEQ has been reviewing and adjusting area bonds each year, no Wyoming operators have yet applied for release of any part of an incremental bond. Definite criteria for evaluation of the different phases have not yet been formulated. DEQ personnel do not anticipate much controversy or difficulty in the Phase I evaluation. As in other States, the criteria at this phase are fairly clear engineering design criteria.

DEQ inspects mine sites frequently during mining and reclamation to monitor the operators' progress. Moreover, after regrading an area, an operator may request that DEQ inspect it for acceptability of drainage topography, AOC, and

[16] Unless otherwise noted, this discussion is based on reference 16.

[17] The Federal regulations that allowed "phased bonding" of this type have recently been declared inconsistent with sec. 509(b) of SMCRA by the U.S. District Court because they do not require full bond for all aspects of reclamation for the duration of the mining and reclamation operation (5). The regulations have been remanded to the Department of the Interior, but until new Federal regulations are promulgated and, if challenged, are accepted by the courts, the State of Wyoming plans to continue to bond under its current system, as outlined in its approved permanent program (1 6).

presence of unsuitable spoil material at the surface. Before the inspection, operators supply data from recontoured spoils samples. This pre-topsoil inspection is not mandatory, but most operators request it because it can help identify problems in this expensive part of reclamation early so as to avoid the greater expense of fixing problems after topsoiling.

DEQ does not anticipate receiving any applications for Phase II release of the incremental bond for several years, but is working now on formulating criteria for this phase.

Colorado[18]

The Colorado Mined Land Reclamation Division (MLRD) has released one Phase I portion of a bond, and is reviewing two more applications for Phase I bond release. The Phase I release is for backfilling and grading only, and is based on standard engineering principles. However, MLRD's experience at the northwestern Colorado mine where Phase I release has been granted suggests that judging success for Phase I bond release may not be so straightforward as it appears.

MLRD's review of that Phase I bond release application concluded that all of the required criteria had been met. Therefore, MLRD was prepared to release 60 percent of the applicant's bond in the spring of 1984, when a major slump occurred on the regraded site. Much of the surface coal mining in northwestern Colorado occurs on fairly steep slopes, many of which contain mica shales dipping at angles semi-parallel to slope topography. The instability of these formations is well known and routinely taken into account in road and building construction, as well as in mining. Furthermore, precipitation had been much higher than normal during the years prior to the mine's application for Phase I release. Therefore, slumps were common in this area of Colorado, both in areas of little or no human activity and where the land had been disturbed (e.g., along highways).

Because MLRD determined that, at the time of application, the site met the criteria for bond release, MLRD released 60 percent of the bond on the area despite the slump. MLRD maintains, however, that the operator retains liability for the slump because it was the result of poor reclamation, and wants the operator to repair the damage. On the other hand, the operator argues that the slump was the result of unusual natural conditions unrelated to mining, and therefore is an act of God for which the operator may not held liable for repair. The remaining 40 percent of the bond is insufficient to repair the damage. The liability issue had not been resolved as of this writing.

One condition of MLRD's bond release was that the operator conduct a study of the reasons for the slump, to be submitted to MLRD in August 1985. Prior to the slump, the operator had been granted a permit to mine an adjacent area which contains similar steep formations. If the operator cannot diagnose the cause of the previous slump, and therefore cannot develop satisfactory mining and/or reclamation techniques to prevent another similar occurrence, MLRD feels it will be forced to withdraw this permit. Despite the operator's claim that the slump was unrelated to mining, the regulatory authority suspects that it may have occurred, at least in part, because of increased water infiltration into the spoils as a result of the mining methods used at this site. Revising the mine plan and/or draining the spoil might make mining on the adjacent similar areas possible. Detailed analysis of the problem must wait until the operator's report on the slump has been completed .19

In Colorado, the second phase of the bond is released after topsoiling and revegetation to a level sufficient to prevent erosion. The State has some Phase II applications pending and is in the process of formulating specific standards for evaluating them. Because MLRD views Phase II release as a judgment that the surface has been stabilized, these standards will emphasize vegetative cover to a specified level and a demonstration that sediment levels in water from reclaimed areas are not greater than baseline levels.

[18]Unless otherwise noted, this discussion is based on reference 2.

[19]Although the site discussed here originally was mined Prior to the passage of SMCRA, it was repermitted under Colorado's permanent program, bond was released according to SMCRA-mandated standards, and similar areas have been permitted for mining under SMCRA. For these reasons, the site is relevant to this study.

New Mexico[20]

The New Mexico Mining and Minerals Division (MMD) has not received any applications for bond release under its SMCRA program, and has not formulated standard criteria for release because it intends to judge applicants on a case-by-case basis to give proper consideration to the wide variability among surface coal mining sites in the State. MMD considers judging Phase I release, which includes backfilling, grading, drainage control, and topsoiling in New Mexico, to be a fairly straightforward engineering problem. Inspections for proper handling of acid- and alkaline-forming materials, which are very common in the overburden in New Mexico, will be conducted throughout the mining and reclamation process to ensure that potential problems are discovered and dealt with before bond release. By keeping in close contact with operators throughout the reclamation process, MMD does not anticipate any surprises at Phase I bond release inspect ion.

MMD expects judging success at the second phase of bond release to be more difficult, and their personnel are trying to formulate standards now. Because, historically, so much of the land in New Mexico has been poorly managed and overgrazed, baseline data often represent undesirable conditions. Therefore, suitable reference areas are difficult to find, and MMD is relying on a mix of methods while they try to formulate technical standards for cover, species diversity, shrub density and other vegetative parameters. At some sites, historical record evaluations can be used for the plant communities that are less likely to have been damaged by poor land management practices, particularly for evaluating woody plant density. At other sites, suitable reference areas may be available for some plant communities but not for others. For example, one mine has suitable reference areas for herbaceous communities, but not for woody plants because premining woody plant density was deemed too high to be compatible with the postmining land use. Technical standards will be used to judge success for woody plant communities. Thus, each mine is likely to have its own mix of evaluation methods and standards depending on peculiarities of the site.

[20]Unless otherwise noted, this discussion is based on reference 8.

CHAPTER 7 REFERENCES

1. Cedar Creek Associates, "Wildlife Technologies for Western Surface Coal Mining," contractor report to OTA, August 1985.
2. Colorado Mined Lands Reclamation Division, personal communication, 1985.
3. Doll, E. C., et al., "Planning and Evaluating Cropland Reclamation After Stripmining in North Dakota," *Minerals and Environment, vol. 6, 1984,* pp.121-126.
4. Dollhopf, D. J., et. al., "Chemical Amendment and Irrigation Effects on Sodium Migration and Vegetation Characteristics in 7-Year-Old Sodic Mine Spoils," Montana Agricultural Experiment Station, Montana State University at Bozeman, SR-17, January 1985.
5. *In re: Permanent Surface Mining Regulation Litigation,* Civil Action No. 79-1144, D.C.Cir., Oct. 11, 1984,
6. Kunkel, G. P., and Hinzel, E. J., "Considerations in the Application of Standards for Revegetation Success, " in E. Redente, et al., *Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, &Management,* Colorado State University Range Science Department, Science Series No. 35, August 1983, pp. 31-35.
7. Montana Department of State Lands, personal communication, 1985.
8. New Mexico Mining and Minerals Division, personal communication, 1985.
9. North Dakota Public Service Commission, personal communication, 1985.
10. Prodgers, R., "Circle West Vegetation Monitoring Study: Third Annual Report for the Period August 15-25, 1980, " Circle West technical report 7, MDNRC, Faculty Siting Div., Helena, MT, as discussed in G.P.Kunkel and E.J. Hinzel, ''Consider-

ations in the Applications of Standards for Revegetation Success, " in E. Redente, et. al., *Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management,* Colorado State University Range Science Department, Science Series No. 35, August 1983, pp. 31-35.
11. *Strip and Underground Mine Reclamation Rules and Regulations,* State of Montana, Apr. 1, 1980.
12. Walsh, James P., and Associates, "Soil and Overburden Management in Western Surface Coal Mine Reclamation, " contractor report to OTA, August 1985.
13. Western Resource Development Corp., and Jane Bunin, ''Revegetation Technologies and Issues at Western Surface Coal Mines, " contractor report to OTA, September 1985.
14. Western Water Consultants, "Hydrologic Evaluation and Reclamation Technologies for Western Surface Coal Mining, " contractor report to OTA, August 1985.
15. Wolfe, M. H., "Use of a Historical Data Base as a Revegetation Success Standard, " in E. Redente, et al., *Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management,* Colorado State University Range Science Department, Science Series No. 35, August 1983, pp. 31-35.
16. Wyoming Department of Environmental Quality, personal communication, 1985.
17.30 CFR 701.5.
18.30 CFR 816.42.
19.30 CFR 816.43.
20.30 CFR 816.46(c)B.
21, 30 CFR 816.46(c)C.
22.30 CFR 816.1 16(a)(2).
23.30 U.S.C. 1201 (f).
24.30 U.S.C. 1265(b)(2).
25.30 U.S.C. 1269(c).