Montana Department of Environmental Quality
Permitting and Compliance Division
Industrial and Energy Minerals Bureau
Helena, Montana 59620

SOIL, OVERBURDEN AND REGRADED SPOIL GUIDELINES
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A. Introduction

In order to protect the valuable soil resources which are designated for disturbance by coal mining operations and to enhance the potential of achieving successful reclamation, premining soil surveys and soil handling methodologies must meet the requirements and objectives of the law and the pursuant rules and regulations[1] (see Appendix C for list of rules pertaining to soils). The goals of the premining soil survey are as follows:

(1) to characterize the soils occurring within the proposed permit area;

(2) to determine the salvage depths and volumes of suitable[2] soil[3] and specific soil consociations and complexes available for salvage within the proposed permit area;

(3) to determine whether soil and specific soil consociations and complexes are available in an adequate quantity and quality for use in reclamation; and

(4) to define the need for special handling techniques of specific soil types that will facilitate specific reclamation needs.

Companies are requested to consult with the Department in the development of soil survey plans.

B. Specifications of Soil Inventory and Maps

All specifications as herein described should be followed in accordance with procedures of SCS National Soil Survey Handbook (1993) and SCS Soil Survey Manual (1993).

(1) Companies should conduct a detailed soil survey by phases of soil series that is oriented toward the use of soils for reclamation. Soil survey specifications for the purpose of a permit application are:

Mapping units:	consociations and complexes
Map scale:	1:4800 or as otherwise approved consistent with other permit application maps

(a) Phases

Phases of soil series should be based on factors important to suitability, salvage, and reclamation potential. These factors

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[1] Reference: 82-4-222(1)(j) MCA, ARM 17.24.304(11), ARM 17.24.324, and ARM 17.24.701(1).

[2] See soil suitability criteria in Appendix A.

[3] For ease of communication, the term "soil", as used here and throughout the guidelines, refers to the A, E, B, and C horizons. Users of these guidelines are reminded that in the Montana Strip and Underground Mine Reclamation Act, the term "topsoil" refers to the A, E, B, and C horizons.

include, but are not limited to texture, erodibility, slope, rock fragment content, rockiness, sodium and soluble salt content, and depth to bedrock (paralithic or lithic contact).

(b) Consociations

In a consociation, delineated areas are dominated by a single soil taxon (or miscellaneous area) and similar soils. As a rule, at least 50 percent of the pedons in each delineation of a consociation are of the same soil component providing the name for the map unit. Most of the remainder of the delineation consists of soil components so similar to the named soil that major interpretations for reclamation are not affected significantly. The total amount of dissimilar inclusions of other components in a map unit generally does not exceed about 15 percent if limiting and 25 percent if nonlimiting. The amount of dissimilar inclusions in an individual delineation of a map unit can be greater than this if no useful purpose would be served for reclamation by defining a new map unit.

A consociation named for a kind of miscellaneous area (such as a rock outcrop) is dominated by the kind of area for which it is named to the extent that any inclusions do not significantly affect the use of the map unit. Generally, this means that less than about 15 percent of such a delineation are soils or less than about 25 percent are other kinds of miscellaneous areas. Percentages may vary, depending on the kind of miscellaneous area and the kind, size, and pattern of the inclusions.

(c) Complexes

Complexes consist of two or more dissimilar taxa components or miscellaneous areas occurring in a regularly repeating pattern. The major components of a complex cannot be mapped separately at a scale of about 1:4,800. The major taxa components are sufficiently different in morphology or behavior that the map unit cannot be called a consociation. In each delineation of a complex, all of the major components are normally present, though their proportions may vary appreciably from one delineation to another. The total amount of inclusions that are dissimilar to any of the major components does not exceed about 15 percent if limiting and 25 percent if nonlimiting in a map unit.

The first part of the name of a soil complex is formed by using names of taxa, usually soil series joined by hyphens. If a miscellaneous area is an extensive component, its name is used as though it were the name of a taxon. The names of two or three taxa, rarely four, may be used to name a complex, followed by the surface texture phase term if the surface texture of all major components is the same; otherwise the taxa are followed by the word "complex." The name of the most extensive component is given first. Examples: Sharkey-Alligator clays; Skaggs-Duncan-Hughesville complex; Travessila-Rock outcrop complex; Gem-Springerville complex, 0 to 5 percent slopes.

(d) Similar components occur together in landscapes, are alike or much alike in most properties, and share limits of those diagnostic properties in which they differ. Differences are beyond the limits of the reference taxon or phase class but generally are within or slightly beyond normal errors of observation. Because only a few limits are shared or the range is small, interpretations for most common uses are alike or reasonably similar and the interpretive purity of a map unit is not affected.

Dissimilar components on the other hand, differ appreciably in chemical or physical properties, and the differences generally are great enough to affect major interpretations for reclamation use. Some dissimilar components are limiting, while others are nonlimiting relative to the interpretations being considered. The minimum area of dissimilar soils mapped should be one (1) acre.

Soils that cannot be used feasibly for the same reclamation purposes as the surrounding soil are especially critical. They are delineated separately if the map scale permits it and if showing them will improve the usefulness of the map for major anticipated reclamation uses. If such areas are less than one (1) acre in size, they should be identified and located on the map by spot symbols. If two kinds of soils lie in small areas in a consistent repeating pattern and affect use or management differently, they are mapped together as a complex.

There commonly are different interpretive purities of a map unit depending on the specific use interpretation. For the purpose of mine permit application soil surveys, mapping units should be interpreted for their use in reclamation.

(2) S.C.S. soil surveys may be used, but refinement and additional information should be supplied to meet the standards discussed in (1) above.

(3) Soil pedon descriptions

The soil pedon description submitted for each soil sample site should include the following attributes: the kind, thickness, and arrangement of horizons; their structure, color, texture, rock fragment content, content of carbonates and other salts; abundance and diameter of roots; and consistence and plasticity.

C. Description and Characterization of Soils

(1) A soil survey narrative should be submitted and consist of:

(a) a description of each soil series by depth, drainage class, parent material, physiographic location, precipitation, typical horizon and profile characteristics, infiltration, permeability, effective rooting depth, surface runoff, and wind and water erosion hazard;

(b) a description of each mapping unit by slope (dominant slope and range), SCS rangeland soil-group (USDA, SCS Montana Grazing Guides), kinds of soils and the percent of each kind of soil in the mapping unit, whether or not the soils are typical for the series, their limitations for use in reclamation, the position of the soils in the landscape, the typical vegetation associated with the soils (from the SCS rangeland soil-group (USDA, SCS Montana Grazing Guides));

(c) soil pedon descriptions in accordance with B(3) above; and

(d) chemical and physical characteristics of the soils at each soil sample site (see D below).

(2) Maps

The soils information should be presented to the Department on a set of maps which meet the following criteria:

(a) Aerial photographs or topographic maps at a scale of 1:4800 or as otherwise approved (see B(1)) should be used as the map base.

(b) All maps should be oriented to the north with a north arrow on each map. All maps should have section corners, townships and ranges clearly delineated and labeled. In addition, clear representation of coordinates based upon the 1000-meter Universal Transverse Mercator system or other established coordinate systems, as approved by the Department, should be included on the maps;

(c) Soil sample locations, including proposed presalvage (operational) sampling sites (if appropriate), should be shown on the maps;

(d) The maps should clearly show the boundaries of all proposed disturbance areas from which soils will be salvaged;

(e) The maps should clearly show all soil mapping unit boundaries and assigned numbers;

(f) A soil survey legend should be included on the soil maps and should consist of a listing of all mapping units and their symbols.

D. Sampling

(1) Vertical Distribution

(a) Representative soil profiles of each major soil taxon in a mapping unit should be sampled to a depth of 84 inches (213 centimeters) or to a lithic or paralithic (bedrock) contact, whichever occurs first. Sampling of paralithic materials may be desirable depending upon the available soil resource and the proposed mining and reclamation plan.

(b) After the profile has been exposed and described, representative continuous 2-quart ~(2-liter) (top to bottom of each horizon) samples should be collected from each specific genetic horizon. Two-quart ~(2-liter) samples should provide an adequate amount of soil material for analysis and for sample splits or duplicate or additional analysis that may be requested.

(c) Layers or horizons less than 3 inches (7 centimeters) thick may be combined with an adjacent layer for sampling purposes. Horizons or layers greater than 24 inches (60 centimeters) thick should be split so that no sample represents a layer exceeding 24 inches (60 centimeters) in thickness.

(2) Horizontal Distribution

(a) The precise number and location of sampling sites required for each soil taxon should be based on a site-specific evaluation of what is needed to adequately characterize the qualitative and quantitative nature of the soils.

(b) Companies are encouraged to contact the Department before and during a soil survey regarding problems or questions about sampling adequacy.

(c) As a general guideline, the Department requests that profile descriptions and sampling for analysis be conducted for at least three (3) representative sample locations for the major soil taxa providing the names for the mapping units.

(d) The Department may request more samples if, after reviewing the initial results of the survey, it becomes evident that additional information is needed.

(3) Sampling techniques

(a) The most important consideration in sampling and transport is to prevent contamination and changes in chemical and physical properties of the soils to the maximum extent possible.

(b) Soil samples should be placed into clean polyethylene plastic bags and transported to the laboratory as soon as possible. The samples should not be exposed to extremes of temperature during transport. If the soils require shipping or storage for extended periods of time, they should be air-dried at room temperature (not greater than 35□ C) or frozen.

(4) Sample Site Location

A legal description of the sample site should be part of the profile description. This should be in metes and bounds, e.g.: 100 ft. N, 200 ft. W from the SW corner Section 26, T1N, R5E (any □ corner or section corner may serve as a reference point) or other established coordinate system, as approved by the Department.

E. Analysis

(1) Quality Assurance/Quality Control

The accuracy of the laboratory needs to be substantiated by providing results of the laboratory's analysis of standard samples or an equivalent analysis program.

In order to substantiate the precision of the laboratory analysis, duplicate analyses on 5 percent of the total samples and on field-split blind duplicate samples should be run at the primary laboratory facility.

(2) Required Analytical Parameters

Each soil sample should be prepared and analyzed for the following parameters using the indicated procedures:

Parameters	Procedures
(a) (i) Preparation of soil samples for analysis	Air dry samples at less than or equal to 35^{o} C. Break up clods for disaggregation of sample (less than or equal to □ inch). Pick out and set aside rock fragments (gravel, pebbles, etc.) for further analysis [see (m) below]. Disaggregate sample material until it just passes a 10-mesh (2-mm) sieve (avoid grinding coarse fragments). Rock fragments left on the sieve after disaggregation should be set aside for further analysis [see (m) below]. A rubber pestle in an agate mortar, a roller, or a motorized disaggregator should be used to disaggregate samples. During the entire sample preparation procedure, excessive disaggregation of sample material must be avoided.
(ii) Subsampling of sieved (<2 mm) soil materials for analysis	U.S.D.A. Handbook 60, 1954 - Diagnosis and Improvement of Saline and Alkali Soils, pp. 83-84. Or use standard sample splitter to obtain the specified sample size.
(b) Preparation of saturation extract and saturation percentage determination. Endpoint of saturation may be difficult to determine in montmorillonitic-dominated materials.	U.S.D.A. Handbook 60, Methods 2 and 3a, pp. 84 and 88, and Method 27a, p. 107 or A.S.A Monograph #9, 1982 Methods of Soil Analysis Part 2, Method 10-2.3.1, p. 169.
(c) pH (determination using saturated paste)	U.S.D.A. Handbook 60, Method 21a, p. 102 or A.S.A Monograph #9, 1982 Methods of Soil Analysis Part 2, Method 10-3.2, p. 171 and Method 10-2.3.1, p. 169.
(d) Conductivity of saturation extract in dS/m (mmhos/cm) at 25EC	
U.S.D.A. Handbook 525, 1978, Laboratory Methods Recommended for Chemical Analysis of Mined-Land Spoils and Overburden in Western United States, Method 1, pp. 22-24 or A.S.A. Monograph #9, 1982 Methods of Soil Analysis Part 2, Method 10-3.3, pp. 172-173.	Analysis by atomic absorption spectrometry (AAS), U.S.D.A. Handbook 525, Method 2, pp. 24-25, or by inductively coupled plasma optical emission spectrometry (ICP-OES), A.S.A. Monograph #9, Part 2, 2nd ed., 1982, Method 3-5.4, pp. 57-59 or A.S.A. Monograph #9, 1982 Methods of Soil Analysis Part 2, Method 10-3.4, pp. 173-174.
(e) Calcium content in the saturation extract in meq/l	
(f) Magnesium – same as for calcium	Same as for calcium.
(g) Sodium - same as for calcium	Same as for calcium.
(h) SAR (sodium adsorption ratio)	U.S.D.A. Handbook 60, p. 26. Use concentrations from e, f, and g above.
(i) Boron (ppm of soil)	Hot water soluble extract, A.S.A. Monograph #9, 1982 Methods of Soil Analysis Part 2, Method 25-9.1, pp. 443-444. Analysis of extract by azomethine-H (Method 25-5, pp. 435-436 in same reference) or by ICP-OES (see Calcium above).
(j) Selenium - The occurrence, density, and distribution of primary and secondary selenium-accumulating plant	

	Parameters	Procedures
	species (Rosenfeld and Beath, 1964; Fisher et al, 1987) on the proposed mine plan area should be noted and described as part of the vegetative survey. The Department, in consultation with the company, will then determine a testing and evaluation program, if necessary, for soils in question.	
(k)	Particle size analysis. Report as % sand, % silt, and % clay, as well as the U.S.D.A. textural classification.	Hydrometer Method. A.S.A. Monograph #9, 1986, 2nd ed., Part 1, Method 15-5, pp. 404-408.
(l)	Percent organic matter (soil only). To be used in determining first lift salvage depths. Analyze samples of the A and upper B horizons.	Loss on Ignition at 375°C in a muffle furnace for 24 hours (adapted from Davies, 1974).
(m)	Percent rock fragments by volume.	Calculate % by weight and convert to % by volume, U.S.D.A., Soil Survey Investigations Report No. 42, 1992 - Soil Survey Laboratory Methods Manual, Methods 3B1b and 3B2, pp. 79-81.

If a company prefers to utilize different procedures, it should contact the Department prior to any analysis. Other tests may be requested by the Department, depending on the nature of the soils.

The analytical data should be reviewed by the company or its consultant to verify, modify, or reject the initial mapping unit and soil series designations and field mapping. Changes should be made as necessary.

II. Soil Salvage and Redistribution

A. Soil Volumetrics

(1) The soil survey and laboratory information should be utilized by the company in a discussion of the suitability of each mapping unit for salvage. The company should present the proposed depths (first and second lifts), acreage, and volumes of the soils to be salvaged for each mapping unit within the areas proposed for disturbance. This information should be listed and summarized in tabular form.

(2) Estimated salvage depths for consociation mapping units should be determined from the information collected for the dominant soil taxa.

(3) Estimated salvage depths for mapping units that are complexes should be determined by a weighted average salvage depth of the major soil taxa in the complex.

B. Soil Replacement Depth

The company should present the proposed soil replacement depth(s) and needed volumes for the whole disturbed area. This is for the purpose of determining the balance between soil salvage and soil replacement.

C. Selective Soil Handling

The proposed soil handling program should take into consideration selective soil salvage and replacement which would promote the reestablishment of the desired plant communities and would minimize erosion and stability problems. Selective handling techniques could include the use of variable soil depths, the selection and use of soils with specific chemical and/or physical properties, and the placement of certain soils in specific topographic positions. For example, special handling techniques have been utilized in salvaging alluvium and colluvium for drainage reconstruction and sandy and skeletal soils for use as tree and shrub root media (Wendtland et al, 1992).

In cases where there is a documented shortage of soil materials with specific attributes essential to the establishment of a particular plant community, the permittee may consider soil substitution alternates (ARM 17.24.703) in developing the soil handling plan. This may include, but is not limited to, reconstruction of the plant rooting profile using selectively salvaged coarse-textured subsoil material in reclaimed areas designated for tree and shrub planting. In addition, regraded spoil may be considered a viable soil substitute for the establishment of tree and shrub species, if, for instance, the material has a high percentage of sand and/or rock fragments. These types of plant growth media (coarse-textured soil and spoil) generally have enhanced soil permeability properties and reduce competition from herbaceous species due to limited moisture holding capacity in the upper portion of the reconstructed profile.

D. Soil Islands

During each phase of the soil salvage operations, the Department recommends that small undisturbed areas of soil (soil islands) representing each mapping unit delineation be left in place until the Department has had a reasonable opportunity to inspect the islands. A stake on each soil island can be used to show the salvage depth of the soil represented.

E. Direct Haul of Soil Materials

Direct haul replacement of soil to regraded areas is preferred to stockpiling and should be implemented whenever possible. This soil handling technique has several advantages, other than the obvious economic advantage, including reduction in impact to soil aggregation, organics, and microorganism populations, and enhanced establishment of viable plant propagules.

F. Soil Compaction

The proposed soil reconstruction should be designed to minimize the compaction of soil and regraded spoil. Operations should not be conducted under wet conditions. Vehicle traffic on the regraded spoil and replaced soil should be minimized.

G. Soil and Regraded Spoil Scarification

Regraded spoils must be tilled or scarified (ripped, subsoiled, or plowed) to a depth of at least 12 inches (30 centimeters)(ARM 17.24.702(4)). Respread soil should be laid down in the thickest lifts possible. The entire respread soil thickness should be tilled or scarified to relieve compaction. This activity should be conducted in phases if the soil thickness exceeds the effective depth of the implement being used. It is recommended that when tilling or scarifying the respread soil, the implement also penetrate the regraded spoil surface.

H. Mitigation of Erosion Features

Rill and gully erosion developing in reclaimed areas must be remediated pursuant to ARM 17.24.721. Depending on the magnitude of erosion damage, repairs may include importation of soil materials to fill-in erosion features and reseeding, emplacement of straw bales (keyed-in and anchored), installation of erosion control matting, tree and shrub planting, etc.. The permittee may benefit from consulting the Department prior to implementing mitigation measures.

III. Overburden - Premining

A. Introduction

The rationale for a premining overburden assessment is to identify overburden which is not suitable for placement in the rooting zone or which may degrade the quality of surface water or groundwater. The identification of such material is necessary in order to devise and evaluate a mining and reclamation plan with respect to the requirements of the Montana Strip and Underground Mine Reclamation Act and rules.

Companies should include in the permit application a detailed evaluation of overburden characteristics, including data and narrative, in the context of the above concerns.

Companies are encouraged to consult with the Department when designing and implementing a drilling, sampling, and analysis program. All boreholes must be permitted and drilled in compliance with Subchapter 10 (ARM), and must be abandoned in compliance with ARM 17.24.632 and with appropriate sections of Subchapter 10 (ARM).

B. Drilling Methods

(1) One method of sampling will probably not be suited for use in an entire drilling program. Careful planning in the use of appropriate methods, which will yield non-contaminated, representative samples, is necessary.

(2) The Department recommends the following methods for overburden drilling:

(a) Continuous core drilling using air, an air-water mist, or water (non-contaminating, low in salts) as the drilling medium. Other drilling media, such as mud, should be avoided (Sandoval and Power, 1976). To circumvent the use of mud, an operator may choose to drill an alternate hole. The alternate hole should be in close proximity to the original hole. Plugging down to a core point which corresponds to the point abandoned in the original hole would be allowed at the alternate location. If the use of drilling mud is essential, the core samples should be carefully cleaned before analysis.

(b) Rotary drilling for chip samples using conventional circulation of air as the drilling medium. Hole wall erosion and subsequent mixing of strata from cave-in is generally not a concern even in the weakly consolidated sandstones and shales encountered in the Fort Union Formation of southeastern Montana (Dollhopf, D.J., personal communication, 1994). However, excessive air pressure should be avoided as it can fracture formations and give erroneous samples through erosion of the hole. The use of water should be avoided, unless required where overburden is wet or the holes are too deep for the cuttings to be lifted. The use of other drilling media is to be avoided.

(c) Rotary recirculation drilling for chip samples using air as a drilling medium. A cyclone separator may be used in conjunction with this drilling method if the separator is cleaned thoroughly between sample intervals. The use of water should be avoided, unless required where overburden is wet or the holes are too deep for the cuttings to be lifted.

(d) Thin-wall tubes, split barrel samplers, or other drive or press devices to sample unconsolidated materials (Sutton et al., 1981).

(3) Drill stem joint lubricants which may contaminate the overburden samples should not be used. Potentially contaminating lubricants include those with certain metal additives (zinc, lead, copper, molybdenum) (Dollhopf et al., 1981).

(4) Companies should specify the drilling methods, drilling media, and joint lubricants used for each hole. This must include laboratory analysis of media and lubricants used. This requirement may, in certain cases, be satisfied by submittal of lubricant constituent data provided by the supplier.

C. Sampling

(1) Samples should be collected, logged, and labeled in the field under the direction of a qualified geologist or other qualified specialist as approved by the Department. Core recovery should be recorded and included with the drill log. Experienced drillers should be used, especially when collecting samples by rotary drilling.

(2) Overburden sampling recommendations are as follows:

(a) Surface Coal Mines

Sampling of the test holes should be conducted on all overburden (including soil), interburden, partings, top and bottom of seam to be mined, and coal that is to be spoiled (rider seams, thin stringers, etc.) down to 2 feet (60 centimeters) below the last coal seam proposed for mining. Composite samples should be taken of the total thickness of each stratum or increment in not greater than 10-foot (3-meter) intervals and not less than 2-foot (60-centimeter) intervals. For instance, if a sandstone stratum is 30 feet (9 meters) thick, then three (3) samples of 10-foot (3-meter) lengths should be taken. Furthermore, if several alternating beds are together within a 2-foot (60-centimeter) interval, then only one (1) composite sample is necessary for that interval. When either coring or chip sampling, an attempt should be made to break the sampling intervals if an obvious change in chroma, rock type, or weathering occurs or if an anomalous or carboniferous zone appears. The Department recognizes that the ease of accomplishing this may occur in the following descending order of sample types: core, dry chip, wet chip. Each stratum or sample interval should be designated by thickness and depth. Chip samples should be adequately mixed before splitting.

(b) Underground Coal Mines

Sampling should be conducted in order to physicochemically characterize overburden, roof and floor materials, interburden and coal. Where applicable, all sampling should be conducted as described in (2)(a) above. Specifically, the following samples should be collected/analyzed:

(i) overburden expected to collapse or fracture above the mined out seam;
(ii) samples from the first ten feet of strata overlying the coal seam;
(iii) sample(s) of the first five feet of the stratum underlying the last coal seam proposed for mining;
(iv) samples of interburden;
(v) samples of parting material;
(vi) samples of coal to be spoiled.

Overburden materials encountered in the face-up area must be characterized in accordance with criteria indicated in (2)(a) above.

(3) Geologic logs of each overburden hole should be kept and submitted as part of the application. The logs should include a header and a lithologic description. The header should include the date the hole was drilled, driller's name, drill hole location in established coordinate systems (i.e., metes and bounds description, UTM coordinates, company specific coordinates, or state plane coordinates), collar elevation, total depth drilled, and a brief description of any particulars such as depth of lost circulation, depth in which water was encountered or injected as a drilling medium. The lithologic log should include depth intervals, stratigraphy, lithology, lithologic constituents, and color. Lithologic logs of coal exploration and groundwater monitoring well holes should be retained for possible use.

(4) Hand sampling of highwalls and outcrops may be used to supplement drill hole sampling for surface coal mines and face-up areas associated with underground coal mines (Sutton et al., 1981). Samples must be taken from freshly exposed surfaces.

(5) Sample material should not be dropped onto the ground or handled with contaminating equipment such as grease- or oil-covered gloves (Sutton et al., 1981). As samples are taken in the field, they should be placed in polyethylene bags for transport. Moist or wet samples should be immediately frozen or spread to air dry at room temperature (not greater than 35 C) on a waterproof material and stored in closed, water resistant, non-contaminating containers until analyzed (Sandoval and Power, 1978).

D. Drill Hole Location and Analysis

(1) Overburden drill holes should be located to characterize all strata proposed for disturbance including highwall reduction material and the subsequent exposed overburden surfaces.

(2) A two (2) phase approach to overburden sampling is recommended: Phase 1 - initial drilling and overburden characterization and Phase 2 - additional drilling to delineate potential problem areas. The following strategy is recommended for surface and underground coal mines.

(a) Phase 1.

(i) At a minimum, the Department recommends initial drilling on approximately 1900-foot (580-meter), square-grid centers. This design gives an effective coverage of approximately eighty (80) acres (32 hectares) per hole.
(ii) Drill holes should be relatively evenly spaced in the area to be characterized with a minimum of 8 holes drilled per section.
(iii) Holes should reasonably conform to the grid system, but at the same time be located to adequately represent the lithology and topography of the area to be disturbed.
(iv) An analysis of the parameters previously listed for soils (Section I-E), except for organic matter, and of the parameters specific for overburden (see section (4)(b) below) should be conducted on the samples.

(b) Phase 2.

(i) If there are materials shown to be of concern as a result of Phase 1 sampling or a need to locate and delineate suitable materials for reclamation purposes, then those areas of suspect overburden should be delineated. The Department, in consultation with the company, may request that additional drilling and sampling be conducted to more thoroughly delineate suspected problem areas or locations of suitable materials.
(ii) Parameters to be analyzed for in this phase will be those found in Phase 1 which exceed the suspect levels.

(3) Hole spacing and location may be modified on the basis of site-specific geologic and/or topographic conditions.

(4) Analysis

(a) As a means of quality control, duplicate analyses on 5 percent of the total samples and on field-split blind duplicate samples should be run at the primary laboratory facility.

(b) In addition to the parameters listed for soils (I-E above), except for organic matter, each overburden sample should be prepared and analyzed for the following parameters using the indicated procedures:

Parameter			Procedure
(i)	a.	Preparation of overburden samples for analysis.	Air dry samples at less than or equal to 35□C. Break up cores or chips for disaggregation of sample (less than or equal to □ inch). Disaggregate sample materials until they just pass a 10-mesh (2-mm) sieve. A rubber pestle in an agate mortar, a roller, or a motorized disaggregator should be used for disaggregating samples. Excessive disaggregation of samples must be avoided.
	b.	Subsampling of sieved (< 2mm) overburden materials for analysis.	U.S.D.A. Handbook 60, 1954 - <u>Diagnosis and Improvement of Saline and Alkali Soils</u>, pp. 83-84. Or run sample through a standard sample splitter until the desired sample size is obtained.
(ii)	Nitrate-Nitrogen (NO_3-N) of the saturation extract (ppm of overburden).		Analysis of the saturation extract by the phenoldisulfonic acid method, A.S.A. Monograph #9, Part 2, 1965 ed., Method 84-5, pp. 1212-1219.
(iii)	Molybdenum (ppm of overburden) Ammonium oxalate extraction. A.S.A. Monograph #9, 1965 ed., Part 2, Method 74-2, pp. 1054-1057; analysis of extract by ICP-OES (A.S.A. Monograph #9, Part 2, 1982 ed., Method 3-5.4, pp. 57-59), or by graphite furnace AAS (Neuman, 1975).		
(iv)	Selenium (ppm of overburden)		Hot water extractable selenium, A.S.A. Monograph, #9, 1965, Part 2, Method 80-3.2.2, p. 1122. Analyze by hydride generation for AAS or ICP-OES (A.S.A. Mono. #9, Part 2, 1982 ed., Method 3-5.5, pp. 59-61).

(c) Additional analysis such as for sulfate, total alkalinity, ammonium-nitrogen, certain trace elements, acid-base potential, simulated weathering test, pyritic morphology identification (i.e., via electron microscopy), and clay mineralogy may be requested depending on the proposed mine area and the nature of the overburden material. Desired deviations from the recommended analysis procedures should be discussed with the Department prior to analysis.

(d) Plant growth tests may be requested by the Department on selected samples after data from soil and overburden analyses have been reviewed by the Department.

IV. Sampling of Regraded Spoils

A. Introduction

A sampling and testing program should be conducted on the regraded spoil surface to determine if spoil handling procedures have been effective, and if premining overburden information adequately predicted the nature of the regraded material. Sampling of the regraded spoils for analysis and the opportunity for Departmental review should be made prior to resoiling and revegetation activities.

B. Sampling

(1) Each area which has been regraded should be tested. Highwall reduction areas, facility and pond areas, and roads should also be tested.

(2) Spoil sampling should be conducted to a depth of 8 feet (2.4 meters) or as otherwise approved by the Department. The Department recommends that the spoil samples be divided into two (2) equal increments for analysis. Sample increment thickness may vary, if distinctive layers of clayey, coaly or otherwise suspect materials are encountered during sampling.

(3) Regraded spoils should be sampled on approximately 300-foot (91-meter) centers or as otherwise approved by the Department. Sample locations should be relatively evenly spaced. Additional delineation of problem spoil areas may be required. A map showing sample locations and a delineation of the regraded area under consideration should be submitted with the analysis.

(4) These sampling guidelines may vary based on site-specific conditions and permitting decisions.

C. Analysis

(1) All techniques referred to previously in the careful handling of soils and overburden to prevent contamination, etc. are applicable here. In addition to the sample preparation and subsampling procedures and parameters listed for soils (I-E above), except for organic matter, regraded spoil samples should be analyzed for the following parameters using the indicated procedures:

Parameters		Procedures
(a)	Acid potential (AP)* (reported as % sulfur)	US EPA, EPA-600/2-78-054. 1978. Field and Laboratory Methods Applicable to Overburden and Minesoils, Method 3.2.6, pp. 60-62.
(b)	Neutralization potential (NP)* (reported as tons of $CaCO_3$ equiv./1000 tons of material)	US EPA, EPA-600/2-78-054. 1978. Field and Laboratory Methods Applicable to Overburdens and Minesoils, Method 3.2.3, pp. 47-50.
(c)	Acid-Base Potential (ABP)* (reported as tons $CaCO_3$ equiv./1000 tons of material)	Calculated: ABP = NP - AP

* Required for regraded spoil material consisting of a high percentage of coal fragments or carbonaceous shale.

(2) Certain of the analyses may be deleted on a site-specific basis depending on the overburden analysis or on experience with the spoils in question.

(3) The Department may require that additional samples be analyzed or that different or additional tests be conducted, depending on results of overburden analysis or permit requirements.

D. Mitigation of Unsuitable Regraded Spoils

According to ARM 17.24.501(2), "...materials which are not conducive to revegetation techniques, establishment, and growth must not be left on the top nor within 8 feet of the top of regraded spoils...". Deviations from this requirement may be considered if it can be demonstrated "to the Department's satisfaction that a lesser depth will provide for reclamation consistent with the act". The 8-foot cover requirement may be complied with by placement of a combination of soil and other suitable material (overburden and/or spoil) to an 8-foot thickness above the suspect spoil. The permittee should consult with the Department prior to implementing measures to mitigate suspect spoils.

(1) Sodic and Saline Spoil Materials

Numerous mitigation measures have been documented in the research to ameliorate sodic and/or saline spoils. The effectiveness of some of these measures including incorporation of chemical and organic amendments, deep ripping, and installation of gravel capillary barriers has been somewhat inconclusive and short-lived. It appears that at this juncture, the use of suitable cover material to reconstruct the plant rooting profile is the most fail-safe method to ensure successful vegetation establishment in regraded areas where sodic and saline spoils are encountered.

(2) Acid-Forming Materials

For the most part acid-forming materials in the southeastern Montana coal fields are rare to non-existent. Exceptions may include coal processing waste (CPW) and coaly boxcut spoils. The primary source of CPW is coal cleaning operations.

This material is usually buried in the active pits either "high and dry" between the spoil groundwater table and 8 feet below the final graded surface or below the predicted post-mine water table at the base of the pit. According to the literature, both methods appear to be equally effective in reducing the likelihood of acid formation from iron pyrite oxidation. In terms of coaly spoils, any regraded areas identified during the sampling program as potentially acid-forming must be buried under at least 8 feet of suitable cover material (soil and/or spoil).

(3) Other Suspect Spoil Material

Mitigation measures for other spoil material containing suspect levels of boron, molybdenum, selenium, or other constituents must be handled on a case-by-case basis in consultation with the Department.

V. Respread Soil

A. Soil Thickness Sampling Program

Companies, in consultation with the Department, must design a respread soil thickness sampling program to determine the accuracy of soil replacement to specified thicknesses [ARM 17.24.313(5)(j)]. The Department is aware that most companies "depth stake" regraded surfaces to facilitate scrapers in achieving required soil laydown depths; however, considering scraper capability, soil replacement thicknesses can be highly variable.

Soil respread areas must be sampled at a frequency approved by the Department and thickness of first and second lift replacement must be recorded. The recorded soil replacement thicknesses along with a map showing sample locations must be incorporated into the comprehensive Annual Report (ARM 17.24.1129) for Departmental review.

B. Phase II Bond Release: Soils Aspects

In respect to Phase II bond release (ARM 17.24.1116(7)(b)), the Department will conduct an inspection to verify compliance with the following soil-related aspects:

(1) Soil replacement

In addition to evaluating the soil respread information submitted in the annual reports (see V.A. above), the Department will spot check the proposed bond release area to substantiate the average thickness of 1st (topsoil) and 2nd (subsoil) lift soil laydown. If the average soil laydown thickness of each reclaimed field is within +/-6 inches of the required soil replacement thickness, the permittee has successfully met this criterion.

(2) Erosion and Stability Aspects

All active erosion features that are impairing post-mining land use or contributing to off-site sedimentation must be stabilized prior to Phase II bond release. Stabilization measures have been previously addressed in II.H. above. During the bond release inspection, inspectors will inventory erosion features to determine whether appropriate measures have been taken to reduce soil loss and impairment of vegetation. In addition, reclamation will be checked for surface anomalies such as areas of differential settling, nick points in reconstructed drainages, and depressions.

(3) Blending with Adjacent Undisturbed and Reclaimed Ground

Edges of the proposed bond release area will be walked during the bond release inspection to ascertain whether grading activities and soil laydown were performed to allow for a smooth transition between reclaimed fields and adjacent undisturbed areas. The reclamation must be blended smoothly with adjoining areas to prevent future erosion and instability problems.

C. Soil Fertility Evaluation and Fertilization Program

As necessary, companies should design and recommend a respread soil fertility evaluation/fertilization program based upon sampling, field experience, and/or the literature, which will insure adequate soil nutrients for the proposed plant species to be reestablished. Proposals for fertilizer amendments will be subject to Departmental approval.

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Appendix A

Unsuitability Criteria for Soil or Soil Substitutes

Parameter	Suspect Level[1]	
pH		<5.5
		>8.5
Conductivity (mmhos/cm)	Lift 1	> 4.0
	Lift 2	> 4.0-8.0[2]
Saturation percentage	> 90%	
	< 25%	
Sodium Adsorption Ratio	Lift 1	> 10.0
	Lift 2	> 15.0
Boron		> 5.0 ppm
Molybdenum		> 1.0 ppm[3]
Selenium		> 0.1 ppm
Textural Class	c, sic, si, s, sc	
Rock Fragments	Lift 1	> 20%[4 5]
	Lift 2	> 35%[4 5]

[1]The suspect levels are to be used as a guide in evaluating the suitability of a soil material for reclamation. An evaluation should take into account the 'total system', including post-mining land use, topography, plant communities, wildlife habitat needs, etc. Interactive parameters may either nullify or verify the significance of a potential problem.

[2]The actual maximum acceptable salt level will depend on the plant species proposed in the revegetation plan and the potential for upward salt movement.

[3]The actual maximum acceptable molybdenum level will depend upon the plant species proposed in the revegetation plan and their potential for molybdenum accumulation.

[4]These values may vary depending upon the plant species proposed for revegetation and wildlife habitat reestablishment in specific locations (e.g., a soil with a very high rock fragment content throughout its profile may be completely salvaged if used for certain shrub or tree plantings).

[5]These values are based upon the >2mm fraction found in soils; this fraction can be determined by summing field % volume estimates of the 20-75, 75-250 and >250mm fractions and the laboratory % weight (converted to volume) of the 2-20mm fraction.

Other Parameters	Evaluated on a case-by-case basis

Appendix B

Unsuitability Criteria for Overburden and Regraded Spoils

Parameter	Suspect Level[1]
pH	< 5.5 > 8.5
Conductivity (mmhos/cm)	> 4.0-8.0[2]
Saturation Percentage	< 25% > 90%
SAR	> 20
Boron	> 5 ppm
Molybdenum	> 1.0 ppm[3]
Nitrate-Nitrogen	>130 ppm
Selenium	> 0.1 ppm
Textural Class	c, sic, si, s, sc
Acid-base potential	< -5 tons $CaCO^3$ equiv./1000 tons material
Other Parameters	Evaluated on a case-by-case basis

[1]See footnote 1 in Appendix A

[2]See footnote 2 in Appendix A

[3]See footnote 3 in Appendix A

Appendix C

Rules Specific to the Soil Science Discipline
Administrative Rules of Montana (ARM)

ARM Rule	Subject
Permit Application Requirements	
17.24.304 (7)	Description of overburden
17.24.304 (11)	Baseline Soil Survey Requirements
17.24.306 (all)	Prime Farmland Investigation
17.24.308 (2)(b)	Construction/Maintenance/Removal of Overburden & Soil Storage Areas
17.24.308 (3)(a)	Disposal of Acid/Toxic Forming Materials
17.24.313 (4)	Soil Handling Plan
17.24.313 (5)(j)	Soil/Spoil Sampling/Analyses Monitoring Plan
17.24.324 (all)	Prime Farmlands: Special Application Requirements
17.24.325 (2)(a)	Alluvial Valley Floor (AVF) Determination - Soils Information Requirements
17.24.325 (3)(d)(ii)	AVF Investigation - Soil Data Collection and Analyses
17.24.325 (3)(e)(ii)(c)	AVF Investigation - Information on Soil Moisture Holding Capabilities
Performance Standards	
17.24.501 (2)	Burial of Suspect Overburden and Parting Materials
17.24.501 (3)	Backfilling Requirements for Acid/Toxic Forming Materials
17.24.505 (2)	Burial and Treatment of Undesirable Waste Materials
17.24.510 (all)	Disposal of Offsite - Generated Waste and Fly Ash
17.24.638 (all)	Sediment Control Measures
17.24.641 (all)	Handling of Acid/Toxic-Forming Spoils
17.24.701 (all)	Soil Salvage Requirements
17.24.702 (all)	Soil Redistribution/Stockpiling Requirements
17.24.703 (all)	Soil Substitution Plans
17.24.718 (all)	Use of Soil Amendments
17.24.721 (all)	Eradication of Erosion Features
17.24.811 (all)	Prime Farmland: Soil Handling
17.24.825 (1)	Alternate Revegetation: Soils Criteria
17.24.1116 (7)(b)	Bond Release Criteria: Reclamation Phase II