CHAPTER 8

SOILS RESOURCES AND OVERBURDEN

LIST OF TABLES (CONT.)

ATTACHMENTS

CHAPTER 8

SOILS RESOURCES AND OVERBURDEN

Introduction

This chapter provides a description of the soils resources on the Black Mesa leasehold including: (1) an overview of the studies that have been conducted; (2) soil identification; (3) maps delineating the different soils; (4) maps delineating topsoil material salvage depths and acreages; (5) soil and map unit descriptions; (6) present and potential productivity of the soils; and (7) evaluation of the soils suitability for use as topsoil materials. This chapter also provides a description of the overburden strata in each mining area and characterizes the quality of these strata with regard to their potential liability to, or resource for, successful revegetation. The quantity of available topsoil material and near-surface overburden for suitable soil supplements is presented in Chapter 22. The potential effects of overburden quality on surface and ground water resources are addressed in Chapter 18.

Soils Studies

In 1979, Peabody retained Espey, Huston and Associates, Inc. (EH&A) of Austin, Texas, to study the soil resources on and surrounding the Black Mesa leasehold. The study was necessary because no pre-existing soil survey information of the kind and intensity necessary for mine planning purposes was available for the region which includes the leasehold. The only previous study of which Peabody was aware was a soil and range inventory of the 1882 Executive Order Area conducted by the Bureau of Indian Affairs (BIA 1964).

The objectives of the EH&A study were to develop the soils information (maps, soil descriptions and chemical and physical data) necessary to assess the potential for reclamation following coal mining, and characterize the present soils environment within a buffer zone surrounding the mine permit area. Soil scientists from EH&A surveyed the project area at three levels of intensity. An Order 1 survey was made on approximately 1,127 acres of area to be disturbed by mining. An Order 3 survey was conducted on the remaining parts of the leasehold. An Order 4 survey was conducted on a buffer area comprising about 78,000 acres surrounding the leasehold. The project resulted in a report

prepared for Peabody (EH&A, 1980) that accompanied a permit application package submitted to the Office of Surface Mining (OSM) in 1981 in support of Permit AZ-0001.

In 1983, Peabody began preparation of a Mine Plan Modification to mine in a previously unpermitted portion of the leasehold. Peabody contracted with Mariah Associates to conduct an Order 2 survey and mapping of those soils in the disturbance area that had potential for use in reclamation. This included the alluvial soils along wash terraces, the valley soils occupying side slopes, and the deeper inclusions of eolian material in the pinyon-juniper woodland. Approximately 4,400 acres were surveyed with the primary objective of characterizing the quality and quantity of topsoil material in the area. The information derived from the project was inserted in the Mine Plan Modification package that was approved upon issuance of Mining Permit AZ-0002A.

In conjunction with the Order 2 soil survey performed by Mariah, Peabody conducted a geobotanical study in the project area. The study was designed to evaluate the potential for selenium toxicity, because selenium accumulating plant species occurred in the baseline vegetation studies.

In 1985, Peabody contracted with Intermountain Soils, Inc. (IMS) to survey all remaining areas to be disturbed on the Black Mesa leasehold during the life-of-mine (as projected thru 2011) and conduct geobotanical studies. The soils in the projected disturbance areas, including a 1,000-foot buffer were surveyed and mapped by IMS. The soils under the pinyon-juniper woodland were mapped at the Order 2 level while the remaining deeper soils were mapped at the Order 1 level. In addition, IMS was contracted to review, consolidate, and standardize the 1979, 1983, and 1985 soil survey data, and prepare a comprehensive summary report on the soil resources of the leasehold. The Scope of Work for this project was reviewed with appropriate personnel from the OSM prior to beginning the fieldwork.

In 2003, Peabody Western Coal Company (PWCC) contracted James Nyenhuis, Certified Professional Soil Scientist, to conduct a soil survey in the J-28, N-9, N-10, N-12, and N-99 coal resource areas (N-11 extension area). The N-12, N-99, and N-11 reserve areas are all one contiguous coal reserve. The report for this Order 2 survey, covering about 9,963 acres, can be found in Appendix A-1.

In summary, the status of the soils resources studies on the Black Mesa leasehold is as follows (Figure 1). Order 4 survey information is available for approximately 78,000

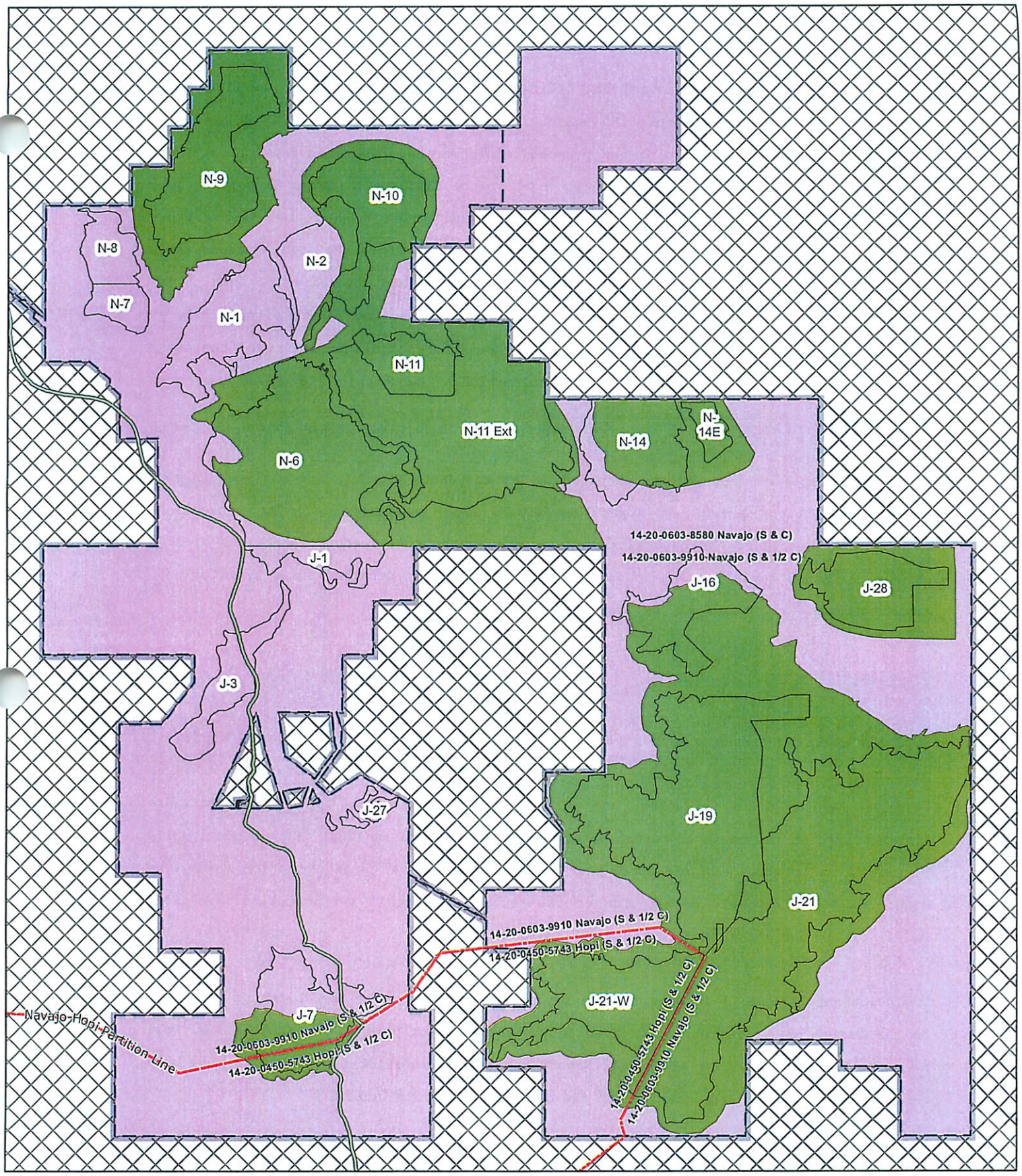

FIGURE 1 - Soil Survey Areas
Peabody Western Coal Co.

1 inch = 8,875.114608 feet

Order 1 and 2 Survey Area
Order 3 Area
Order 4 Area
Kayenta Complex Permit
PWCC Lease Line
Navjo/Hopi Partition Line

Kayenta Complex
PO Box 650
Kayenta, Arizona 86033

PEABODY WESTERN

Produced by PWCC GIS, eb
Date: Thursday, April 26, 2012

Path: T:\Projects\Permit\Mineplan 85210\Maps\Special Projects\Figure 1 Mineplan LOM.mxd

acres surrounding Peabody's leasehold. Order 3 survey information is available for approximately 57,237 acres within the leasehold and between Tracts 1 and 2 of the Joint Mineral Use Area leases excluding the proposed mining areas. These surveys characterize the present soils environment surrounding areas to be disturbed. Order 1 and 2 survey information is available for the proposed mining areas plus a 1,000-foot buffer. These surveys characterize the present soils environment in the disturbance areas, assess their chemical and physical quality for use as topsoil material, and determine the quantity of topsoil material available for reclamation purposes. The varying levels of intensity of the surveys in mining areas were required based upon the spatial complexity of the soils relative to their potential for use in reclamation. Geobotanical studies have been completed in all disturbance areas to assess the potential for selenium toxicity.

The comprehensive summary reports prepared by IMS and James Nyenhuis are included in this permit application package as Appendices A and A-1, respectively. The appropriate material in the report has been extracted to prepare the soil resources sections of this chapter. The survey and sampling methods, analytical data, detailed soils descriptions, and interpretation records may be found in Appendices A and A-1.

Soil Identification

Fourteen soils, representing four major soil groups have been identified and mapped in proposed disturbance areas (Table 1). These soils represent the components of less resolved mapping units throughout and surrounding the leasehold. The soil groups are distinguished on the basis of parent materials. These groups include: (1) residual soils derived from interbedded sandstones and shales of the Mesa Verde Formation (refer to Chapter 4 for a complete description of the regional geology); (2) porcellanite-derived soils; (3) eolian soils; and (4) alluvial soils.

The Dulce soil (Table 1) is considered a series taxadjunct because the colors of the soils on the leasehold outlie the range given in the formal description. Two other soils, Soil A and Soil B, could not be classified beyond the family level because no series have been established by the SCS for them. Both are derived from porcellanite.

Based on recent taxonomic reclassification of three soils by the USDA Natural Resources Conservation Service (NRCS) in the late 1990s, the site-specific Peabody soils that were previously named Cahona, Pulpit, and Sharps have been recorrelated. The soil that was

TABLE 1

Taxonomic Classification of the Soil Series Identified

On the Black Mesa Leasehold

Series	Family
Begay	Coarse-loamy, mixed, superactive, mesic Ustic Haplocambid
Bond	Loamy, mixed, superactive, mesic Lithic Ustollic Haplargid
Cahona (Blanding)	Fine-silty, mixed, superactive, mesic Ustic Haplargid
Chilton	Loamy-skeletal, mixed, calcareous, mesic Ustic Torriorthent
Dulce[1]	Loamy, mixed, superactive, calcareous, mesic, shallow Ustic Torriorthent
Las Lucas	Fine-silty, mixed, active, mesic Ustic Haplocambid
Oelop	Fine-loamy, mixed, superactive, mesic Ustic Haplargid
Pulpit, ustic-aridic	Fine-silty, mixed, superactive, mesic Aridic Haplustalf
San Mateo	Fine-loamy, mixed, superactive, calcareous, mesic Ustic Torrifluvent
Sharps, ustic-aridic	Fine-silty, mixed, superactive, mesic Aridic Haplustalf
Travessilla	Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthent
Zyme	Clayey, smectitic, calcareous, mesic, shallow Ustic Torriorthent
Soil A	Loamy-skeletal over fragmental, mixed, calcareous, mesic Ustic Torriorthent
Soil B	Loamy-skeletal over fragmental, mixed, mesic Ustic Haplocalcid

[1]This soil is a taxadjunct to the series

named Cahona is renamed Blanding. An "ustic-aridic" soil moisture regime modifier has been added to the Pulpit and Sharps soil names (Pulpit, ustic-aridic; and Sharps, ustic-aridic). Because these soils are not new soils, but rather recorrelated to different soil name modifiers, they were not sampled for baseline laboratory characterization following taxonomic reclassification.

Soil Maps

Four sets of soils maps are contained in Chapter 25. Drawing 85300, Sheets 1 through 9, provides the map units and boundaries of the Order 3 and 4 soil surveys. Mapping was conducted at a scale of 1" = 2000' on black and white aerial photography with orthophotoquad topographic line overlay. Drawing 85305A, Sheets 1 through 15, provides the map units and boundaries of the Order 1 and 2 soil surveys conducted in 1979, 1983, and 1985. Drawing 85305B, Sheets 1 through 15 provides topsoil salvage depth delineations for the 1979, 1983, and 1985 surveys. The base map for Drawing 85305A and 85305B is a 1" = 400' scale black and white aerial photograph. The 2003 soil survey and topsoil salvage information is presented on Drawing 85305C (5 sheets total). Each base map is a rectified orthophotoquad with topographic contour overlay at a scale of 1" = 400'.

Soil Series and Map Unit Descriptions

Fifty-four map units were described in the 1979, 1983, and 1985 Order 1 and Order 2 surveys (Table 2; Drawing 85305A, Sheets 1 through 15). Twenty-nine map units were described in the 2003 Order 2 survey (Table 2; Drawing 85305C, 5 sheets total). Seventeen map units were identified in the Order 3 survey and four map units were identified in the Order 4 survey (Table 2; Drawing 85300, Sheets 1 through 9). Map unit descriptions may be found in Appendices A and A-1. Each description provides basic information about the soils in the map unit, such as position on the landscape, type(s) of soil dominating the unit, and contrasting and similar soils that may occur within any delineation. Those descriptions, as originally prepared by EH&A, Mariah Associates, or IMS have been modified by James Nyenhuis only to achieve agreement with the most recent taxonomic classification.

Soil series descriptions for the 14 soils identified in the Order 1 and 2 surveys may be found in Appendices A and A-1. The relevant physical and chemical data and SCS Form 5 Soil Interpretation Records are presented as well.

extent and distribution of soils that exhibit the potential for contributing to toxic concentrations of selenium in forage. The studies were justified on the basis of the existence of selenium accumulator plant species on the disturbance areas. A comprehensive report of the studies may be found in Appendix A.

The geobotanical studies demonstrated that selenium-accumulating plant populations are locally common in certain subhabitats in the study areas. The populations are usually distributed throughout the study areas, are generally predictable in their areas of occurrence, and are important components of the vegetation in the areas where they occur. The selenium accumulators occurred on the shallow soils associated with wooded ridges and disturbed areas, and were absent from the broad sagebrush valleys and wash terraces where the deeper soils occur.

Based upon the results of selenium analysis in plants and soils at a representative cross section of sites where accumulator plants were found, the soils in which they were found growing are not seleniferous. This conclusion was reached for several reasons. The primary selenium accumulator species did not contain unusually high concentrations of the element and known secondary accumulator plants sampled at the sites did not contain concentrations that are toxic. Secondary accumulators are known to accumulate toxic levels of selenium if present on seleniferous soils. Second, the plant available concentrations in the soils at the sites were low. One soil stratum at one site (Location 29-1) and two strata at another site (Location 22-5 and 22-6) out of 27 sites had plant-available selenium concentrations greater than 0.1. One additional stratum at another site (84-14A) exceeded the suspect concentration. This stratum was an unconsolidated gray shale encountered at a depth of 44 inches. Plant-available selenium concentrations exceeding 0.1 ppm are generally regarded as suspect for soils that have potential for use in reclamation. They are not considered unsuitable. Third, no selenium poisoning of livestock has been reported in or surrounding the leasehold.

Topsoil Material Suitability Evaluation (2003 Soil Survey)

Topsoil suitability and salvage depth recommendations for the 2003 soil survey areas are based on site-specific soils and map unit data. The information is presented in Appendix A-1 and shown on Drawing 85305C (5 sheets total).

Overburden Sampling Program - Background

Peabody began an overburden-sampling program at the Black Mesa and Kayenta Mines in August of 1977. The objectives of the program have evolved based upon the need for compliance with the Surface Mining Control and Reclamation Act and pertinent regulations pursuant to the Act. Since initiation of the program, 133 deep overburden cores, 49 shallow cores, and 20 highwall cores have been drilled to characterize the geochemistry and physical properties of the overburden on the Black Mesa leasehold. Seventy-eight of the deep cores and all of the shallow and highwall cores are pertinent to this permit application (Table 4). The remaining cores are located in areas that have been mined out or in areas that are not projected to be disturbed in the life-of-mine plans.

The procedures used to drill, handle, and describe the overburden cores are presented in Chapter 4. The deep cores were sampled at logical geologic intervals not to exceed ten feet in length or to a major change in lithology. Strata less than two feet in thickness, except nonmineable coals, were combined with the next logical unit where possible. Sampling intervals began at ground surface and included the stratum immediately below the lowest mineable coal seam. The highwall cores were sampled at two-foot intervals to a depth of ten feet. The shallow cores were sampled at two-foot intervals to a depth of thirty feet or to contact with a coal seam greater than 0.5 feet in thickness. From 1977 through 1979, staff geologists from Peabody's Corporate Office in St. Louis, Missouri performed all drilling supervision and completed the geologic core descriptions. Fifty-seven cores were drilled during this time period. From 1980 to the present, geologists or soil scientists from Peabody's Black Mesa and Kayenta Mines performed all drilling supervision and completed the geologic descriptions.

Overburden core locations from 1977 through 1985 were determined using a grid system that is fit to the contour of the outermost coal cropline in a given mining area. Within the confines of terrain, irregular coal croplines, and variable numbers and thicknesses of the coal seams, the deep holes were spaced approximately 2,000 feet apart. Thus, deep overburden core coverage in the mining areas is approximately one per 90 acres with the exception of the contiguous J-19, J-21, and J-21 West mining areas (Table 4).

The J-19, J-21, and J-21 West mining areas were some of the last areas to be drilled. The drilling intensity was reduced because the stratigraphy and geochemical variability, as indicated by the holes in other areas, was so great that no benefit would be derived from

TABLE 4

Summary of Overburden Sampling Intensity by Mining Area

Mining Area	Area (Acres)	Deep Cores (No.)	Coverage (Acres/Core)	Shallow and Highwall Cores (No.)
J-7	333.4	4	83.4	-
J-16	481.9	6	80.3	-
J-19 thru J-21 West	5,022.0	18	279.0	64
J-28	769.5	7	109.9	-
N-6	2,011.0	18	111.7	-
N-9	1,279.3	4	319.8	-
N-10	846.6	4	211.6	5
N-11	494.2	4	123.6	-
N-11 Extension	2,647.8	7	378.3	-
N-14	579.8	6	96.6	-

drilling at 90-acre centers. Also, Peabody's plan for handling selected overburdens does not require complete lateral and vertical determination of unsuitable overburdens. Rather, the plan is designed to identify zones of near-surface overburden that can be used as topsoil material supplements should toxic or potentially toxic forming spoils that require burial be identified following grading. Sixty-four additional shallow and highwall cores were drilled in the J-19, J-21, and J-21 West areas, and five additional shallow cores were drilled in the N-10 mining area to supplement the deep overburden core data. Peabody's plan for insuring that unsuitable overburden will not affect plant growth in the postmining landscape is presented in Chapter 22. Thirteen deep core holes were drilled in the J-21 West, N-9, N-10, N-12, and N-99 coal resource areas in 2003. The N-12, N-99, and N-11 reserve areas (N-11 extension area) are all one contiguous coal reserve. The OSM-approved drill hole density was two core holes per section (Gavette-OSM June 25, 2003 letter to Dunfee-PWCC). This density was justified because coal seams in the new areas are identical to those currently being recovered so overburdens are expected to be similar to those previously encountered and characterized. The locations of the overburden core holes are shown on Drawings 85613 and 85613A.

Overburden Analytical Assessment Procedures

Descriptions and references for the analytical procedures used on the overburden samples are presented in Attachment 2. The analytical methods, including field, laboratory, and quality control procedures for the 2003 sampling episode are those described in Chapter 22, Table 12. Different parameter suites have been analyzed on different sets of cores depending upon: (1) whether or not they were shallow, highwall, or deep cores; or (2) when they were drilled relative to the status of negotiations with the regulatory authority regarding the necessary parameters needed for characterization. The different suites used are presented in Table 5. A summary of suites used on the cores in each mining area, and in several cases on individual cores, is presented in Table 6. The majority of the cores drilled prior to 1984 were originally analyzed using Suite 1 only. These cores were reanalyzed in 1985 for additional parameters. The results of the analyses and associated lithologic descriptions are presented in Appendix B.

An assessment of the deep core data was performed to estimate the characteristics of the regraded spoil and to identify those parameters that must be considered in planning mined soil reconstruction. The assessment was performed at two levels of intensity. First, the data were inspected to determine the parameters that could realistically contribute to potentially unsuitable spoils and minesoils. A detailed assessment of the parameters so

TABLE 5

Parameter Suites Used on the Overburden Cores[1]

Suite 1	Suite 2	Suite 3	Suite 4	Suite 5	Suite 6[2]	Suite 7
pH	B	Cl	S (pyritic)	pH	pH	pH
E.C.	As	F		Saturation %	E.C.	E.C.
Saturation %	Se (Sol.)	CO_3		E.C.	Na	Na
Na	Mo	HCO_3		Na	Ca	Ca
Ca	Hg	SO_4		Ca	Mg	Mg
Mg	Co			Mg	SAR	SAR
SAR	Cu			SAR	ESP	S (total)
ESP	Fe			ESP	S (total)	S (pyritic)
P	Mn			S (total)	S (pyritic)	CaCO3 equiv.
K	Zn			$CaCO_3$	$CaCO_3$	Particle Size
N				Particle Size	Particle Size	B
S (total)				B	Se (total)	Se (sol.)
$CaCO_3$ equiv.				Se (sol.)		Se (total)
Particle Size						
Moisture %						
Org. Mat.						

[1] Suites 1 through 4 pertain to the 1977-1985 deep cores, Suite 5 was run on the highwall cores, Suite 6 was run on the shallow cores, and Suite 7 was used for the 2003 deep cores.

[2] Total Selenium analysis was run on selected cores.

TABLE 6

Summary of the Parameters Analyzed on the

Overburden Cores by Mining Area

Mining Area	Core Type	Parameter Suites (Table 5) and Exceptions
J-7	deep	- Suites 1 and 2 on all
J-16	deep	- Suites 1 and 2 on all
		- Suite 4 on Core 26462C only
J-19, J-21, & J-28	deep	- Suite 1 except N,P,K, % Moist., and Org. Mat. on all
		- Suite 2 except B, Se, Hg, Zn
		- Suites 1, 2 and 3 on Cores 24292C and 24589C only
	shallow	- Suite 6 on all
	highwall	- Suite 5 on all
N-6	deep	- Suite 1 on all
N-10	deep	- Suite 1 on all
	shallow	- Suite 6 on all
N-11	deep	- Suites 1, 2, 3, 4 except N,P,K, % Moist., Org. Mat., B, and Se on all
N-14	deep	- Suite 1 on Core 20268C only
		- Suite 1 and 2 on Core 20257C only
		- Suites 1, 2 and 3 except B and Se on Core 20346C only
		- Suites 1, 2, 3 and 4 except B and Se on Core 20259C only
		- Suites 1, 2 3 and 4 except N,P,K, % Moist., Org. Mat., B and Se on Cores 26269C and 26271C only
N-9, N-11 Extension & J-21 West	deep	- Suite 7

identified was then made. The diagnostic criteria and suitability limits, except for selenium, were taken from the Criteria for Evaluation of Overburden and Regraded Spoils in Attachment 3 (Office of Surface Mining Draft Guideline, unpublished). The Wyoming DEQ guideline was used for selenium (Volume II, Appendix A, Page 24). The 2003 deep core data was assessed using criteria presented in Chapter 22, Table 11.

The percentage of the total core volume manifested by an unsuitable parameter was calculated as part of the detailed assessment. The parameters and suitability limits used for the 1977 to 1985 core data were: (1) pH less than 5.5 and pH greater than 8.8; (2) electrical conductivity (E.C.) greater than 12.0 mmho/cm; (3) sodium absorption ratio (SAR) greater than 18 or 22, depending upon texture; (4) acid-base accounts ($CaCO_3$ equivalence based on total sulfur) less than zero; and (5) clay content greater than 50 percent or both clay and silt content greater than 40 percent. The functional portion of each core, minus mineable coal and topsoil, down to the lowest mineable seam was used to perform the calculations. For interpretive purposes, parameters with unsuitable levels representing more than five percent of the total core volume were considered possible contributors to unsuitable or suspect spoils. Levels representing more than 15 percent of the total core volume were considered probable contributors to unsuitable or suspect spoils. In addition, weighted mean SAR's and negative and positive acid-base accounts were calculated based upon the thickness of each stratum in a particular core.

The shallow and highwall cores were assessed using the Criteria for Evaluation of Topsoil and Topsoil Substitutes in Attachment 3 (Office of Surface Mining Draft Guideline, unpublished) except for selenium. The Wyoming DEQ guideline for plant-available selenium contained in Volume II, Appendix A, Page 24 was used for samples analyzed for soluble selenium (highwall cores). The New Mexico guideline for total selenium (greater than 0.5 ppm), that is identical to OSMRE's criteria for Evaluation of Overburden and Regraded Spoils was utilized to interpret the results of analyses for total selenium on selected shallow cores. The New Mexico soil and soil substitute suitability rating guidelines are presented in Attachment 3.

Overburden Assessment (1977-1985 Core Data)

A cursory inspection of the cores indicates that unsuitable strata, with regard to one or more parameters, exist in most cores (Appendix B). However, the geochemistry and stratigraphic sequence of the overburden exhibits such extreme variability that the

lateral and vertical extent of unsuitable or suspect strata cannot be correlated within or between mining areas. The primary chemical attributes that could contribute to unsuitable spoils and minesoils are elevated SAR's (potential for sodic zones), negative acid-base accounts (potential for acid-forming zones), acid pH values, and suspect selenium concentrations (potential for selenium enriched zones) in the N-10 mining area. These strata are typically located at moderate to considerable depth or are associated with the coal seams. The near surface overburden is generally of much better quality.

Inspection of the cores for which trace element analysis is available does not indicate consistent levels of any suspect trace elements, with the possible exception of selenium, which could potentially contribute to phytotoxicity or animal toxicity. However, this statement must be qualified to the extent that toxicity levels are questionable or do not exist for most of the trace elements and suspect concentrations may or may not have any adverse effects depending on a variety of other factors.

One core in the J-1/N-6 mining area (Core No. 23165C) had strata that exhibited an unsuitable boron concentration that was greater than five percent of the total core volume. The percentage was 6.2 percent. The boron concentration was 5.7 ppm. None of the remaining cores in the J-1/N-6 mining area or in any other mining area exhibited percentages exceeding five percent. The Kayenta Complex overburden will not contribute phytotoxic concentrations of boron to graded spoils.

The detailed assessment of the remaining parameters of concern in the Kayenta Complex overburden are summarized in Table 7. Electrical conductivity and clay content are included for demonstration purposes and to aid in the interpretation of the other parameters. The clay content of the Kayenta Complex overburden will not contribute to undesirably heavy minesoils. Electrical conductivities are well within the suitable limits in the majority of cores.

Soluble selenium concentrations in strata from several of the deep cores on which the analysis was performed exceeded the suspect level of 0.1 ppm that is recommended by the Wyoming DEQ (Table 7). Analysis for plant available forms of selenium are not normally recommended for deep overburden because of the reducing environment. However, it was judged to be the appropriate method for the cores on which it was run because the samples have been stored in the laboratory for extended periods of time. Oxidation has undoubtedly occurred. All cores applicable to the J-7 mining area had strata that

TABLE 7

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

Overburden	pH		E.C. (mmho/cm)	Se (ppm)		SAR	$CaCO_3$ equiv.				Clay Content
Core No.	% >8.8	% <5.5	% >12.0	$\bar{x}_w$	% >0.1	% unsuit.	$\bar{x}_w$	% neg.	$\bar{x}_w$ (neg.)	$\bar{x}_w$ (pos.)	% unsuit.
J-7 Mining Area:											
15418-C	1.9	0.0	0.0	.07	6.1	60.3	19.4	10.6	2.7	20.5	0.0
23154-C	26.3	9.1	0.0	0.12	25.2	47.3	14.5	0.0		Not Calculated	2.8
23156-C	0.0	0.0	25.1	0.11	21.0	80.9	23.0	16.2	0.2	30.8	6.7
23158-C	0.0	14.5	0.0	0.10	8.3	47.4	11.3	20.9	2.3	16.3	3.2
J-16 Mining Area:											
23146-C	1.5	22.1	0.0	0.05	0.0	37.3	16.5	51.2	15.3	19.0	13.0
23147-C	11.9	26.5	0.0	0.05	5.0	36.4	16.3	31.0	14.1	20.3	12.3
23148-C	0.0	9.8	0.0	0.04	7.8	65.8	25.3	46.5	16.6	23.1	12.4
23325-C	8.1	12.8	0.0	0.08	21.6	36.6	12.8	37.9	5.3	24.1	16.3
23328-C	24.4	9.2	1.8	0.09	23.1	68.0	23.5	36.7	16.1	28.0	5.8
26462-C	45.6	7.4	0.0	-		48.3	24.4	1.6	0.1	29.0	0.0

TABLE 7 (Cont.)

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

Overburden	pH		E.C. (mmho/cm)	Se (ppm)	SAR		$CaCO_3$ equiv.			Clay Content
Core No.	% >8.8	% <5.5	% >12.0	$\bar{x}_w$ % >0.1	% unsuit.	$\bar{x}_w$	% neg.	$\bar{x}_w$ (neg.)	$\bar{x}_w$ (pos.)	% unsuit.
J-19 thru J-21 West Mining Areas:										
24403-C	0.0	0.0	0.0	-	23.4	12.1	13.0	3.0	79.2	0.0
24404-C	6.4	0.0	0.0	-	52.6	20.7	5.0	0.1	70.3	0.0
24405-C	0.0	0.0	0.0	-	41.4	16.9	10.3	0.9	50.9	0.0
24406-C	43.8	0.0	0.0	-	62.1	17.7	30.1	1.5	26.7	21.1
24407-C	21.4	0.0	0.0	-	73.9	26.1	30.9	5.4	23.7	8.0
24408-C	42.5	4.3	0.0	-	34.8	11.5	13.6	1.0	30.6	23.5
24412-C	23.1	5.1	0.0	-	53.2	19.6	13.4	4.3	28.9	5.1
24413-C	19.9	8.0	0.0	-	70.0	19.9	23.0	2.7	30.4	12.4
24415-C	39.7	3.3	0.0	-	80.8	26.1	14.8	2.2	41.7	16.7
24416-C	2.9	0.0	0.0	-	38.8	16.2	15.4	3.0	30.9	4.9
24417-C	36.2	7.9	0.0	-	33.2	15.7	20.8	1.5	21.4	10.8
24418-C	26.8	0.0	0.0	-	59.1	22.2	24.7	4.0	23.4	1.3
24419-C	0.0	0.0	0.0	-	6.2	7.6	7.4	0.2	47.1	0.0
24420-C	0.0	0.0	0.0	-	46.4	21.7	38.5	8.4	14.3	0.0

TABLE 7 (Cont.)

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

Overburden	pH		E.C. (mmho/cm)	Se (ppm)		SAR			$CaCO_3$ equiv.		Clay Content
Core No.	% >8.8	% <5.5	% >12.0	$\bar{x}_w$	% >0.1	% unsuit.	$\bar{x}_w$	% neg.	$\bar{x}_w$ (neg.)	$\bar{x}_w$ (pos.)	% unsuit.
J-19 thru J-21 West Mining Areas (Cont.):											
24423-C	25.3	0.0	0.0	-		71.1	21.3	10.9	2.8	29.7	5.5
24292-C	0.0	0.0	0.0	0.04	0.0	36.9	16.7	18.1	5.7	65.1	0.0
24589-C	0.0	0.0	0.0	0.06	2.9	75.8	27.6	18.8	2.6	21.8	13.3
N-6 Mining Area:											
21104-C	0.0	9.9	0.0	0.06	10.9	35.4	13.0	10.6	2.7	36.9	5.0
23160-C	0.0	5.5	0.0	0.07	13.2	18.2	7.8	19.7	1.5	19.7	1.6
23161-C	28.3	0.0	0.0	0.03	3.5	38.2	15.6	2.6	0.3	28.9	10.9
23162-C	0.0	0.0	0.0	0.07	5.2	49.9	17.7	4.4	0.5	42.5	0.0
23163-C	0.0	7.8	0.0	0.13	34.3	47.1	13.6	7.4	0.8	44.4	25.3
23164-C	0.0	9.8	0.0	0.09	23.1	52.8	16.0	13.3	0.4	30.7	0.0
23165-C	0.0	9.5	0.0	0.10	27.7	61.5	18.6	22.9	2.0	30.0	16.0
23166-C	9.2	6.8	0.0	0.09	26.0	19.4	7.4	6.2	0.8	58.4	31.5
24093-C	19.0	2.4	0.0	0.14	34.2	61.3	20.4	7.1	1.1	42.9	7.1

TABLE 7 (Cont.)

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

Overburden	pH		E.C. (mmho/cm)	Se (ppm)		SAR			$CaCO_3$ equiv.		Clay Content
Core No.	% >8.8	% <5.5	% >12.0	$\bar{x}_w$	% >0.1	% unsuit.	$\bar{x}_w$	% neg.	$\bar{x}_w$ (neg.)	$\bar{x}_w$ (pos.)	% unsuit.
N-6 Mining Area (Cont.):											
24094-C	0.0	1.4	0.0	0.06	8.6	41.2	19.5	22.7	1.8	53.1	6.9
24095-C	33.2	0.0	0.0	0.06	7.6	81.7	29.5	8.4	1.2	45.9	18.3
24096-C	0.0	0.0	0.0	0.10	29.9	79.6	25.4	7.4	0.5	51.0	0.0
24097-C	9.2	5.0	0.0	0.11	30.1	90.6	28.3	16.0	0.3	37.9	17.2
24098-C	20.9	16.2	0.0	0.05	5.4	44.6	15.5	22.6	3.7	36.4	2.7
24099-C	23.8	4.1	0.0	0.08	15.0	47.2	19.7	15.6	1.0	19.0	14.5
24400-C	0.0	0.0	0.0	0.09	18.4	12.1	11.9	5.6	4.1	56.8	0.0
24401-C	0.0	0.0	0.0	0.07	12.7	0.0	-	17.8	1.6	15.4	8.3
24402-C	0.0	2.8	0.0	0.04	10.4	21.9	7.4	27.7	4.8	21.6	6.0
N-10 Mining Area:											
21099-C	0.0	33.6	0.0	-		5.2	4.0	54.7	15.2	12.3	4.6
21100-C	0.0	35.9	4.9	-		6.6	4.3	44.1	18.1	19.8	12.4
21101-C	0.0	37.7	3.4	-		6.8	3.5	36.6	14.4	17.2	0.0

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The percent of total core volumes that have negative $CaCO_3$ equivalence (Table 7) indicates that acid or acid-forming spoils can be anticipated in most areas. Eighty-eight percent of the cores have percentages of negative equivalence that are greater than five, and 57 percent have total percentages greater than 15. The problem of acidity will not be as bad as the percentages indicate because of the excess alkalinity in many of the cores. For example, three of the four cores applicable to the J-7 mining area have percentages greater than five, but the proportion of negative to positive acid-base accounting favors an alkaline environment.

Twenty shallow cores, designated as the highwall cores, were drilled on the J-21 mining area highwall to characterize the near surface overburden. The cores were drilled to a depth of ten feet and sampled at two-foot intervals. The laboratory results are presented in Appendix B. The core data was first assessed in terms of the suitable category for topsoil and topsoil supplements. Five percent, or one core (Core No. 11EO) was suitable throughout. Marginally suitable or unsuitable material was encountered at the second sampling interval in ten percent of the cores (Core Nos. 16EO and 20EO). Marginally suitable or unsuitable material was encountered at the third sampling interval (below four feet) in fifteen percent of the cores (Core Nos. 15EO, 17EO and 21EO). Marginally suitable material or unsuitable material was encountered at the first sampling interval (surface) in the remaining 70 percent of the cores. The parameters that failed the suitable category criteria were texture (sand or clay content) and pH (less than 5.5 or greater than or equal to 8.4).

The highwall cores were then assessed in terms of the marginally suitable category for topsoil and topsoil supplements. Unsuitable material was encountered at the first sampling interval in ten percent of the cores (Nos. 5EO and 10EO). Cores 13EO and 16EO were marginally suitable to a depth of two feet. Ten percent were marginally suitable to four feet (Core Nos. 17EO and 20EO) and another ten percent were marginally suitable to eight feet (Core Nos. 18EO and 21EO). The remaining 60 percent of the cores were marginally suitable throughout the entire 10-foot increment.

Forty-four additional shallow cores were drilled throughout the contiguous J-19 thru J-21 West mining area to further characterize the near surface overburden (Appendix B). The cores were drilled to a depth of 30 feet or to coal. Thirty-one of the cores were not suitable at the first two-foot sampling interval. The texture (sand or clay content) and pH (acidic or alkaline) were the dominant parameters that were out of range. The depth of

suitable material in the remaining cores ranged between 2 and 14 feet with a mean suitable depth of 5.1 feet. Six of the cores were marginally unsuitable at the first sampling interval. Negative calcium carbonate equivalence, pH less than 5.5 and texture (clay content greater than 50 percent) were the parameters that went out of range. The depth of marginally suitable material in the remaining cores ranged between 2 and 30 feet with a mean depth of 13.4 feet.

Five shallow cores were drilled in the N-10 mining area to aid in the characterization of the near surface overburden (Appendix B). The cores were drilled to a depth of 30 feet or to coal. Three cores were not suitable at the first sampling interval due to pH (Core No. 26530C), sand content (Core No. 26531C), and selenium (Core No. 26533C). The depth of suitable material in the remaining two cores ranged between two and four feet with a mean suitable depth of three feet. The depth of marginally suitable material in the five cores ranged between 0 and 8 feet with a mean depth of 2.8 feet.

The data collected for the highwall and shallow cores, coupled with assessment of the quality of near-surface overburden in the deep cores, indicates that a considerable volume of topsoil supplements is available in each mining area. This material is an excellent source of supplemental material if demand so requires. The assessment of the deep overburden cores, which identified toxic or potentially toxic strata, indicates that the supplemental material may be needed to bury unsuitable zones of graded spoil.

Overburden Assessment (2003 Core Data)

The purpose of the 2003 overburden study was to augment the existing characterization of the geology in the permit area and proposed future life-of-mine permit areas in sufficient detail to identify acid- and toxic-forming materials and topsoil supplements/substitutes. Green Analytical Laboratories, Inc. (GAL) in Durango, Colorado and Energy Laboratories, Inc. (EL) in Helena, Montana performed the overburden analyses. GAL and EL also completed duplicate analyses on about 10 percent of the samples collected. The analytical data for the 13 core holes is contained in Appendix B along with the lithologic descriptions and the data is summarized in Table 8.

The 2003 overburden quality is very similar to the overburdens previously encountered and characterized from mined areas or areas currently being mined and to regraded spoil quality. A cursory inspection of the cores indicates that unsuitable strata, with regard

Table 8
Evaluation of Overburden Suitability in the Mining Areas[1,2]
(2003 Core Data)

Overburden	pH		E.C. (mmho/cm)	Tot Se (ppm)		Sol Se (ppm)		Boron (ppm)		SAR		Acid Base Potential			Clay
Core No.	% > 8.8	% < 5.5	% > 12	avg	% > 2.5	avg	% > 0.26	avg	% > 10	avg	% unsuit.	% neg.	avg (neg.)	avg (pos.)	% unsuit.
J21 West Mining Area:															
30365EO	0	1.1	0	0	0	0	0	0	0	28.6	63.0	13.0	-17.4	49.9	0
N09 Mining Area:															
30355EO	19.4	0	0	4.4	1.3	0	0	0	0	37.9	75.9	29.6	-32.6	63.6	1.2
30356EO	0	1.5	0	2.7	2.2	0	0	0	0	32.6	37.7	54.6	-24.9	28.6	6.8
30357EO	1.0	0.6	0	2.7	0.5	0	0	0	0	45.6	27.6	34.3	-35.0	53.3	0
30358EO	10.2	0	0	0	0	0.3	0.9	0	0	38.4	55.0	32.1	-33.5	97.2	0
N10 Mining Area:															
30354EO	0	6.0	0	0	0	0	0	0	0	32.0	39.8	12.3	-31.2	36.5	2.1
N12 Mining Area:															
30370EO	8.2	0	0	0	0	0	0	0	0	42.3	58.5	17.2	-31.6	28.3	0.8
N99 Mining Area:															
30351EO	1.1	5.2	0	10.4	1.6	0	0	0	0	37.9	45.7	11.1	-27.6	31.0	9.9
30352EO	11.2	4.4	0	0	0	0	0	0	0	35.9	50.2	32.0	-20.7	30.8	3.1
30353EO	0	0	0	0	0	0	0	0	0	32.1	24.1	18.9	-23.4	29.6	1.6
30368EO	3.2	0	0	0	0	0	0	0	0	31.4	42.9	28.1	-30.0	37.9	0
30369EO	22.3	2.9	0	2.6	1.4	0.4	0.8	0	0	33.2	54.0	32.5	-37.3	30.4	3.9
30381EO	0	3.3	0	0	0	0	0	0	0	33.3	31.9	26.6	-27.7	51.9	0

[1]The percent of core with an unsuitable parameter = $\frac{\Sigma(\text{depth intervals with unsuitable parameter values})}{\text{total core interval (adjusted)*}} \times 100$

[2]Weighted average (avg) = $\frac{\Sigma(\text{depth intervals with unsuitable parameter values x parameter value})}{\text{total core interval (adjusted)*}}$

*Adjusted total core depth (minus mineable coal depths)

to one or more parameters, exist in all cores (Appendix B). The primary chemical attributes that will likely contribute to unsuitable spoils and minesoils are elevated SARs, negative acid-base accounts, and alkaline pH values. These strata are typically located at moderate to considerable depth or are associated with the coal seams. The near surface overburden is generally of much better quality (Chapter 22, Tables 1 and 2).

All cores exhibited suitable boron and salinity levels (Table 8). Unsuitable total selenium, soluble selenium, clay, and acid pH values almost always comprised less than five percent of the total core volume. The three exceptions included the acid pH and clay percentage at Site 30351EO where the percentage of unsuitable material was 5.2 and 9.9 percent, respectively, the clay percentage at Site 30356EO where the percentage of unsuitable material was 6.8 percent, and the pH at Site 30354EO where the percentage of unsuitable material was 6.0 percent. Based on the above data, boron, selenium, salinity, acid pH, and clay will typically not contribute to unsuitable or suspect spoils. This is in concert with the existing spoil sampling program from the areas currently being mined and reclaimed.

Unsuitable levels representing more than 15 percent of the total core volume will likely contribute to unsuitable or suspect spoils. The percent of total unsuitable core volume and weighted mean SAR's (Table 8) indicate the potential exists for sodic zones to occur at or near the surface of regraded spoils. One hundred percent of the cores have unsuitable SAR values comprising more than 15 percent of the total core volume. Soil and overburden materials with unsuitable SAR values often have associated unsuitable alkaline pH values. Forty percent of the cores have unsuitable alkaline pH values that are greater than five, and 20 percent have total percentages greater than 15. The percent of total core volumes that have negative and positive CaCO3 equivalence (Table 8) is quite balanced suggesting neutral-forming spoils can be anticipated in most areas. One hundred percent of the cores have percentages of negative equivalence that are greater than five and 90 percent have total percentages greater than 15. However, the problem of acidity will not be as severe as the percentages indicate because of the excess alkalinity in most of the cores.

SAR and negative acid-base potential values are the two parameters most often detected as being unsuitable in final graded spoil at existing mining and reclamation areas. Historically, these parameters have been detected at unsuitable levels in about 10 to 15 percent of the total samples collected and analyzed. However, suitable mitigative

overburden materials are available in sufficient quantities in all existing and proposed mining areas to reclaim these sites wherever unsuitable spoil is detected in regraded spoil based on the volumes of suitable near-surface overburden material that has been identified (Chapter 22, Tables 1 and 2).

Quality Control and Duplicate Samples (2003 Core Data). Quality control is an important part of the overburden-sampling program. GAL and EL completed duplicate analyses on about 10 percent of the total samples. These analyses were completed to determine the comparability between the two laboratories since both were used for core analyses. Duplicate overburden sample data for GAL and EL are presented in Table 9. Duplicate data between GAL and EL for all parameters is statistically valid, comparable, and correlated with a high degree of significance. Although boron values between labs varied considerably, a good correlation still existed and no values were determined to be unsuitable. The difference in boron values between labs is likely attributable to slightly variable laboratory techniques.

Table 9. Duplicate Core Sample Results for Black Mesa and Kayenta Mines
Analyzed by Green Analytical Lab (GAL) in Durango, Colorado and Energy Lab (EL) in Helena, Montana (1)
2003

SITE NO.	DEPTH (FEET)	DATE	pH-GAL	pH-EL	EC-GAL (mmhos/cm)	EC-EL (mmhos/cm)	SAR-GAL	SAR-EL	Clay-GAL %	Clay-EL %	ABP-GAL (2)	ABP-EL (2)	ABPP-GAL (2)	ABPP-EL (2)	Set-GAL (ppm)	Set-EL (ppm)	Ses-GAL (ppm)	Ses-EL (ppm)	Bhws-GAL (ppm)	Bhws-EL (ppm)
(1) Abbreviations include EC-electrical conductivity; SAR-sodium adsorption ratio; ABP-acid base potential; ABPP-acid base potential pyritic; Set-total selenium; Ses-hot water soluble selenium; and Bhws-hot water soluble boron.																				
(2) Units are tons calcium carbonate equivalent per 1000 tons of material.																				
30351EO	040.0-053.0	07/10/03	7.4	7.7	0.4	1.9	1.3	1.3	12	18	4.3	10.2	--	--	0.1	0.1	0.01	0.01	0.81	0.29
30351EO	117.6-127.5	07/10/03	6.2	6.2	3.7	4.2	3.4	3.4	21	29	-40.8	-33.8	-25.0	-22.1	0.7	0.6	0.06	0.01	3.06	1.00
30351EO	181.6-184.7	07/10/03	8.6	8.7	1.8	1.7	53.7	33.5	36	36	61.2	45.4	--	--	0.3	0.2	0.02	0.01	4.19	0.85
30351EO	236.5-243.0	07/10/03	8.6	8.4	1.6	1.7	50.1	46.5	42	40	6.7	11.1	--	--	0.8	0.8	0.08	0.05	3.63	0.51
30352EO	010.0-014.0	07/12/03	8.0	8.1	1.1	1.4	3.6	3.6	6	5	5.4	7.4	--	--	0.1	0.1	0.01	0.01	0.25	0.33
30352EO	080.3-086.5	07/12/03	8.3	8.2	2.2	2.2	24.8	29.3	18	14	41.4	50.2	--	--	0.1	0.2	0.07	0.01	1.36	0.87
30352EO	133.1-142.2	07/12/03	7.7	7.9	4.5	5.1	43.3	49.9	31	25	-56.0	-52.3	-51.8	-41.3	0.6	0.6	0.07	0.01	4.45	1.40
30352EO	216.0-220.0	07/12/03	8.7	8.8	1.2	1.3	29.4	31.8	34	25	8.5	13.8	--	--	0.1	0.2	0.08	0.05	2.03	0.46
30353EO	076.4-085.9	07/14/03	8.3	8.2	1.0	1.4	18.1	16.8	31	29	40.5	55.6	--	--	0.4	0.5	0.04	0.01	2.17	0.70
30353EO	148.0-155.6	07/14/03	8.0	7.6	1.6	1.5	6.6	3.5	11	10	43.1	48.3	--	--	0.1	0.1	0.01	0.01	0.25	0.36
30353EO	210.0-216.4	07/14/03	7.6	7.3	1.1	0.9	0.8	0.8	19	18	8.6	30.1	--	--	0.2	0.1	0.03	0.01	0.82	0.40
30353EO	280.0-290.0	07/14/03	8.2	8.5	1.3	1.3	35.3	36.9	36	34	28.2	33.6	--	--	0.3	0.5	0.10	0.01	1.46	0.42
30354EO	047.7-050.0	07/15/03	6.9	7.0	4.5	4.1	15.9	14.2	35	27	-35.7	-28.0	-27.2	-19.7	0.9	1.0	0.08	0.05	0.25	1.20
30354EO	098.8-105.7	07/15/03	7.1	7.0	4.5	4.4	24.3	27.4	22	19	-14.7	7.4	-9.1	--	0.5	0.6	0.06	0.01	0.25	0.88
30354EO	181.0-189.6	07/15/03	7.7	7.9	3.1	3.2	28.8	35.7	34	29	-10.5	10.8	1.3	--	0.4	0.4	0.04	0.01	0.25	1.10
30354EO	265.9-269.3	07/15/03	8.6	8.7	1.2	1.0	38.8	25.3	44	37	6.0	12.1	--	--	0.6	0.7	0.08	0.06	1.70	0.55
30355EO	051.4-056.3	07/21/03	8.3	8.5	2.2	2.1	38.0	32.7	12	12	51.6	90.3	--	--	0.3	0.3	0.05	0.03	0.75	0.25
30355EO	094.5-98.0	07/21/03	8.5	8.7	3.4	3.4	60.6	40.5	18	19	27.7	62.2	--	--	0.3	0.3	0.09	0.05	0.78	0.15
30355EO	172.7-180.0	07/21/03	9.7	9.3	0.9	1.6	32.5	27.6	32	29	3.7	6.1	--	--	0.6	0.1	0.14	0.13	1.11	0.21
30356EO	020.8-030.0	07/22/03	7.0	7.2	1.9	2.5	1.9	1.8	28	24	13.3	26.3	--	--	0.6	0.5	0.08	0.06	1.57	0.45
30356EO	082.8-091.8	07/22/03	8.3	8.4	1.2	1.0	16.8	19.2	26	26	18.4	35.3	--	--	0.3	0.2	0.03	0.03	1.52	0.46
30356EO	139.3-150.0	07/22/03	7.1	7.3	1.8	2.3	1.4	1.4	30	26	-32.5	-12.9	-26.2	-5.1	0.7	0.6	0.06	0.03	1.65	0.57
30356EO	214.1-218.0	07/22/03	7.5	7.7	3.1	3.1	39.4	31.8	15	12	7.3	26.4	--	--	0.6	0.3	0.11	0.06	0.79	0.35
30357EO	058.2-063.3	07/23/03	7.1	7.1	2.6	3.4	0.6	0.6	21	19	11.8	23.7	--	--	0.8	0.5	0.08	0.06	0.98	0.27
30357EO	149.0-155.1	07/23/03	7.4	7.1	3.1	5.1	10.6	6.6	16	14	7.6	19.6	--	--	0.5	0.3	0.06	0.05	2.25	0.68
30357EO	188.7-192.9	07/23/03	7.6	6.7	6.2	10.9	58.1	49.9	28	23	-60.7	-58.3	-64.9	-40.2	1.4	1.0	0.09	0.08	1.33	0.38
30358EO	006.3-016.3	07/24/03	8.2	8.2	0.4	0.4	1.2	1.2	10	6	149.0	153.0	--	--	0.2	0.1	0.01	0.02	0.25	0.14
30358EO	087.1-090.8	07/24/03	7.8	7.6	2.5	3.0	36.8	37.4	25	22	-23.2	-7.1	-11.2	1.8	1.0	0.8	0.12	0.07	2.40	0.46
30358EO	132.2-136.0	07/24/03	8.2	8.2	2.1	2.7	32.3	42.5	16	13	18.6	27.5	--	--	0.3	0.2	0.05	0.02	0.51	0.22
30358EO	183.7-188.8	07/24/03	9.4	9.0	1.3	2.0	40.3	51.8	38	24	1.4	21.3	--	--	0.7	0.4	0.20	0.13	1.53	0.3
30365EO	032.7-041.3	07/30/03	8.3	8.2	1.6	1.3	21.3	19.2	20	11	138.0	141.0	--	--	0.1	0.4	0.05	0.01	0.67	0.18
30365EO	123.8-127.0	07/30/03	8.4	8.3	1.0	1.3	28.0	33.1	51	36	-1.6	-0.2	4.7	5.1	1.0	0.9	0.16	0.07	0.74	0.16
30365EO	179.6-188.7	07/30/03	8.3	8.3	1.4	1.5	33.7	34.5	25	17	26.2	27.3	--	--	0.2	0.4	0.10	0.07	0.61	0.22
30368EO	024.0-034.0	08/06/03	7.1	7.3	2.1	2.6	0.5	0.5	8	5	7.7	10.6	--	--	0.1	0.1	0.02	0.01	0.25	0.15
30368EO	087.6-093.0	08/06/03	7.9	7.9	3.9	4.9	47.4	48.1	19	19	-32.3	-23.2	-19.5	-9.5	1.3	1.3	0.13	0.10	1.25	0.25
30368EO	147.5-154.0	08/06/03	8.7	8.7	1.2	1.8	31.3	33.8	44	41	15.8	33.1	--	--	0.8	0.9	0.15	0.16	1.10	0.17
30368EO	215.9-220.0	08/06/03	8.6	8.5	0.9	1.4	13.1	18.6	34	28	2.7	9.1	--	--	0.6	0.5	0.12	0.10	2.10	0.26
30369EO	075.6-084.0	08/08/03	6.9	6.3	3.6	4.3	15.0	12.2	25	22	-37.5	-32.0	-26.4	-18.8	0.9	0.9	0.08	0.06	1.40	0.33
30369EO	124.0-133.6	08/08/03	7.9	7.6	2.6	3.0	31.6	26.8	15	10	26.7	34.0	--	--	0.2	0.2	0.04	0.01	0.90	0.32
30369EO	191.6-201.6	08/08/03	8.8	8.7	2.0	2.0	28.8	34.1	14	10	6.4	10.3	--	--	0.1	0.1	0.04	0.01	0.25	0.20
30370EO	040.0-044.9	08/09/03	6.4	6.3	2.6	2.6	0.6	0.6	30	24	-21.6	-8.0	-0.5	2.0	0.6	0.8	0.04	0.02	1.38	0.47
30370EO	090.0-100.0	08/09/03	8.3	8.3	1.9	2.6	48.2	58.2	48	30	-13.0	7.4	-6.1	--	0.6	0.8	0.08	0.02	1.58	0.35
30370EO	145.5-151.4	08/09/03	9.0	8.7	0.8	1.6	24.7	50.5	34	28	8.2	29.0	--	--	0.3	0.7	0.07	0.06	1.95	0.33
30370EO	239.8-246.0	08/09/03	8.7	8.7	0.8	1.0	18.5	14.3	46	35	15.1	23.6	--	--	0.3	0.5	0.10	0.05	2.32	0.40
30381EO	047.7-054.0	08/10/03	8.2	8.0	1.2	1.3	2.2	2.0	11	6	80.4	83.7	--	--	0.1	0.1	0.01	0.02	0.50	0.16
30381EO	092.5-095.5	08/10/03	6.6	6.6	2.0	1.7	8.8	8.3	16	13	-32.7	-38.0	-28.4	-14.3	2.0	1.8	0.07	0.02	6.17	1.27
30381EO	151.1-154.5	08/10/03	7.8	7.8	3.4	3.1	49.5	44.8	19	16	-61.7	-59.7	-46.2	-35.5	2.4	1.6	0.11	0.06	6.23	0.36

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Radioactive Materials

Radioactivity is a part of the energy released by certain naturally occurring unstable elements as their nuclei decay to a more stable state. There are only a few such unstable elements occurring in significant concentrations in coal bearing rock strata. The most common of these elements is potassium 40, with minor occurrences of uranium 238, uranium 235, and thorium 232. Gamma radiation of various levels and intensities are generated during some of these decay processes. The level of natural gamma radiation depends on the chemical composition of the rock. In a coal bearing rock sequence, an increase in natural gamma rays usually reflects an increase of potassium 40, concentrated in clay minerals.

Since 1982 Peabody has incorporated the use of calibrated down-hole digital geophysical logging equipment capable of detecting concentrations of radioactive mineralization in the coal and overburden material. To date, approximately 6,000 drill holes, located throughout Peabody's lease, have been geophysically logged to help delineate coal quantity and quality as well as providing lithologic data on the Wepo formation, the coal bearing formation currently being mined by Peabody.

The geophysical logging suite consists of high-resolution density, natural gamma, resistivity, and caliper logs. The gamma ray log, calibrated in counts per second (cps) is a measurement of the naturally occurring gamma radiation in the rock strata and borehole. Within the Wepo formation on Peabody's lease, the natural gamma log fluctuates from a low of 1 cps in coals and clean sandstones to highs of 80-120 cps in shales and mudstones. These observations are exhibited on typical geophysical logs presented in Attachment 4 to this chapter. The locations of the drill holes whose logs are presented may be found on a map of the leasehold also contained in Attachment 4. To place this range in perspective, a lower grade uranium mineralization would require natural gamma log readings in the 5,000 cps range. Geologic interpretation of all calibrated geophysical logs has provided no evidence of any potential uranium mineralization in the coals or overburden of the Wepo formation within Peabody's lease.

The continued use of advanced geophysical techniques will provide for future evaluation of potentially hazardous radiation occurring in the coal or overburden material. In the highly unlikely event of detecting such mineralization, the appropriate regulatory agencies will be notified.

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