

APPENDIX A-1

2003 SOIL SURVEY REPORT  
LIFE OF MINE COAL RESOURCE AREAS  
BLACK MESA MINING COMPLEX

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**BLACK MESA MINING COMPLEX**

**Submitted to:**

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## LIST OF ATTACHMENTS

### Attachment

- 1 Approval Letter from Office of Surface Mining (OSM) Regarding Proposed Soils Scope-of-Work (SOW); and OSM Soil Suitability Table “Topsoil and Topsoil Substitute Suitability Criteria for the Southwestern United States”
- 2 Black Mesa Lease Area - Map Unit Descriptions (Intermountain Soils, Inc. 1985)
- 3 NRCS Official Soil Series Descriptions
- 4 Black Mesa Mine: J9 Coal Resource Area Soil Laboratory Data

## LIST OF MAPS

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- 85305C N9 Soil Type & Topsoil Salvage Map (Drawing File Name N09-SOIL.DWG)
- 85305C N10 Soil Type & Topsoil Salvage Map (Drawing File Name N10-SOIL.DWG)
- 85305C N12-N99S Soil Type & Topsoil Salvage Map (Drawing File Name N12-N99S-SOIL.DWG)
- 85305C N99N Soil Type & Topsoil Salvage Map (Drawing File Name N99N-SOIL.DWG)
- 85305C J2-J15 Soil Type & Topsoil Salvage Map (Drawing File Name J2J15-SOIL.DWG)
- 85305C J4 Soil Type & Topsoil Salvage Map (Drawing File Name J04-SOIL.DWG)
- 85305C J6-J14 Soil Type & Topsoil Salvage Map (Drawing File Name J6J14-SOIL.DWG)
- 85305C J8 Soil Type & Topsoil Salvage Map (Drawing File Name J8-SOIL.DWG)
- 85305C J9-J10 Soil Type & Topsoil Salvage Map (Drawing File Name J9-SOIL.DWG)
- 85305C J28 Soil Type & Topsoil Salvage Map (Drawing File Name J28-SOIL.DWG)
- 85305C J23 Corridors Soil Type & Topsoil Salvage Map (Drawing File Name J23-SOIL.DWG)



## 2.0 METHODS

### 2.1 Order 2 Soil Survey

A detailed soil survey was conducted during the summer of 2003 on approximately 15,803 acres associated with all of the various coal resource areas listed above except J9 (550 acres) and the J23 Coal Transportation Corridors (2620 acres). The J9 Coal Resource Area and the J23 Coal Transportation Corridors were mapped in the summer of 2000. These surveys have been added to the 2003 Life of Mine Coal Resource Areas Soil Survey for a grand total of approximately 18,973 acres.

The soil survey used the existing Peabody Black Mesa Lease Area soils map unit legend (Intermountain Soils, Inc. 1985), except many of the previous slope classes were combined into broader slope range map units. For instance, previous map unit 1A (Dulce very channery fine sandy loam, 1 to 4 percent slopes) was combined with map unit 1B (Dulce very channery fine sandy loam, 4 to 8 percent slopes) to create map unit 1AB (Dulce very channery fine sandy loam, 1 to 8 percent slopes).

Based on previous discussion with OSM personnel, no soils were to be sampled for laboratory characterization unless new soils were identified and mapped that were not on the previous soils legend. Attached to this report is a copy of a letter from Mr. Jerry D. Gavette (OSM Leader, Black Mesa/Kayenta Mine Team) to Mr. Brian Dunfee (PWCC Environmental Engineering Manager) concurring with a previously submitted proposed soils scope-of-work letter from Mr. Dunfee to Mr. Gavette which remains on file at both PWCC and OSM.

Soils description, classification, and mapping was conducted in accordance with the procedures and standards of the National Cooperative Soil Survey (Soil Survey Staff 1993 and 1999; and Schoeneberger et. al. 2002). The mapping was delineated on Peabody 1"=400' rectified orthophotoquad maps with topographic contour overlay. The photography date was September 3, 1997. The Coal Resource Areas study area boundaries are outlined on the maps as well.

The soil resources of the study area were investigated by Jim Nyenhuis and Tim Overdier, both Certified Professional Soil Scientists, during the summer of 2003. Jim Nyenhuis completed the J9 Coal Resource Area and J23 Coal Transportation Corridors surveys during the summer of 2000. Based on previous discussion, the various Coal Resource Areas were mapped to the Order 2 level of intensity.

The entire areas were traversed by vehicle and on foot. Soil map unit boundaries were initially delineated by exposing soil profiles using a sharpshooter and bucket auger as well as observing topographic, geomorphic, vegetation, and geologic conditions. The primary tool for soil observation was the use of a backhoe. A total number of 555 holes were dug across the study area, approximately 90 percent of which were dug by backhoe. The backhoe was able to dig to 12 feet or deeper in the very deep alluvial soils under sagebrush vegetation, and to and into the weathered bedrock contact in the very shallow and shallow residual soils dominantly under Pinyon-Juniper woodland vegetation.

The current study also benefited from experience gained in 1996 during which approximately 175 backhoe pits were dug throughout the Black Mesa and Kayenta Mines and adjacent areas. Soil profiles from these pits were described, photographed, and sampled for selective laboratory characterization.

The J9 Coal Resource Area and J23 Coal Transportation Corridors soil survey were previously completed in the summer of 2000. Thirty soil profiles were fully described in the J9 soil survey area, most from deep backhoe pits. Numerous soil profiles were tested with a sharpshooter and bucket auger in the J23 Coal Transportation Corridors survey area but no descriptions were recorded. No new soils were encountered on the J9 and J23 corridors study areas, and therefore no soils were sampled for baseline laboratory characterization although four samples were collected for deep salvage suitability evaluation.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Soil Survey Maps

The detailed soil survey maps for the various Coal Resource Areas and J23 Coal Transportation Corridors are presented on Drawing 85305C (11 sheets total). Each base map is a rectified orthophotoquad with topographic contour overlay. The map scale is 1"=400'. The soils map unit legend, all field sample sites, and recommended soil salvage depths are provided on the maps as well. The maps were digitized by PWCC from the original soil field maps which are kept in the PWCC archive.

### 3.2 Soil Map Unit Legend

The map unit legend contained in the previous Black Mesa Lease Area soil survey (Intermountain Soils, Inc. 1985) was used for the 2003 soil survey except certain slope classes were combined. No new soils were identified, and no new map units were necessary for the current survey. The revised map unit legend is provided as **Table 1, 2003 Soil Survey Map Unit Legend**.

Based on recent taxonomic reclassification of three soils by the USDA Natural Resources Conservation Service (NRCS), the site-specific Peabody soils that were previously named Cahona, Pulpit, and Sharps had been recorrelated as part of the J9 Coal Resource Area and J23 Coal Transportation Corridors soil surveys conducted in 2000, and those changes were also used in the current 2003 soil survey.

The soil that was 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 names or soil name modifiers, they were not sampled for baseline laboratory characterization.

### 3.3 Soil Map Unit Descriptions

Map unit descriptions are contained in the previous Black Mesa Lease Area soil survey, and can be used for the 2003 soil survey. **Attachment 2** is a copy of the map unit descriptions taken from the previous survey (Intermountain Soils, Inc. 1985). The soil name "Blanding" should be substituted for "Cahona" in the map unit name for Map Units 10, 10A, 10B, 10C, 11, 11A, 11B, 11C, G11C, X11, X11A, X11B, and X11C. Similarly, the soil name "Pulpit ustic-aridic" should be substituted for "Pulpit" in the map unit name for Map Unit 5. And finally, the soil name "Sharps ustic-aridic" should be substituted for "Sharps" in the map unit name for Map Units 6, 6A, 6B, and 6C.

## 3.4 Soil Series

### 3.4.1 Soil Series Names

**Table 2** lists the soil series currently identified and mapped on the Black Mesa Lease Area. The table also shows the soil correlation changes over time on the lease area, beginning with the 1979 Espey Huston & Associates soil survey (Espey, Huston, & Associates, Inc. 1980), and continuing with the 1984 Mariah Associates soil survey, the 1985 Intermountain Soils soil survey, and ending with the 2000 and 2003 Nyenhuis soil surveys of the additional areas of the Black Mesa Lease Area.

This soil list could change in the future if there are additional NRCS taxonomic and/or soil correlation changes for these soils, or if new soils are identified on newly mapped areas.

**Table 5** lists all 555 soil holes that were dug and described during soil survey field activities. These holes were distributed across the 11 Coal Resource Areas as follows: N9, 2345 acres, 82 holes; N10, 1794 acres, 62 holes; N12/N99S, 2773 acres, 70 holes; N99N, 1645 acres, 52 holes; J2/J15, 1664 acres, 61 holes; J4, 524 acres, 17 holes; J6/J14, 2343 acres, 49 holes; J8, 717 acres, 28 holes; J9, 550 acres, 30 holes; J10, 592 acres, 44 holes; and J28, 1406 acres, 60 holes.

Table 5 is subdivided into the 11 Coal Resource Areas. Areas N12 and N99S are combined into one area, as well as areas J2 and J15, and areas J6 and J14. Each area contains a numeric listing of all soil holes dug, as well as for each hole the soil name, soil map unit symbol, depth to rock, and any pertinent comments including whether the hole received a brief soil profile description.

### 3.4.2 Soil Series Taxonomic Classification

**Table 3** provides the current taxonomic classification for the soils of the Black Mesa Lease Area. This information was obtained in September 2003 from the official NRCS web site.

### 3.4.3 Soil Series Descriptions

Because no new soils were identified and mapped on the 2003 Soil Survey area, the collection of soil samples and additional detailed profile descriptions were not necessary. Numerous detailed soil profile descriptions for each of the soils on the Black Mesa Lease Area are contained in the previous soil survey report (Intermountain Soils, Inc. 1985).

In addition, there were approximately 175 detailed profile descriptions completed from deep backhoe pits in 1996 (one half of which were on nondisturbed native areas), and an additional 30 detailed soil profile descriptions were completed during the summer of 2000 for the Black Mesa J9 Coal Resource Area.

A copy of the current NRCS official soil series descriptions for each of the soils mapped on the 2003 soil survey area is attached to this report (Attachment 3). All of these soils are active, established soil series. Please refer to the NRCS descriptions for additional

information as needed. The series descriptions included the following soils: Begay, Blanding (formerly Cahona), Bond, Cahona, Dulce, Las Lucas, Oelop, Pulpit, San Mateo, Sharps, Travessilla, and Zyme.

### 3.5 Soil Moisture Regime and Soil Reclassification

One of the issues in the previous soil survey was the determination of the proper "soil moisture regime". The original soil survey considered the lease area to be dominantly "typic-aridic" (Espey, Huston & Associates, 1980). However, the NRCS considered the area to be a slightly wetter "aridic-ustic". In order to resolve this difference, a letter was written in early 1985 to NRCS seeking information concerning the inter-relationships among soil moisture regime, mean annual precipitation, vegetation, and soil characteristics particularly in northeast Arizona (letter to Mr. R. Kover, SCS West National Technical Center, Portland Oregon, April 22, 1985).

No reply was received by late 1985, and the soil moisture regime for the lease area was subsequently changed by Intermountain Soils to "ustic-aridic" (see discussion on pages 6, 7, and 8 of the Soil Resources of the Black Mesa Lease Area, Intermountain Soils, Inc., 1985). The "ustic-aridic" soil moisture regime is midway between the drier "typic-aridic" and the wetter "aridic-ustic".

Because the soil moisture regime was considered to be "ustic-aridic", all of the soil names used in the 1985 soil survey were correlated to this moisture regime. This included the Cahona, Sharps, and Pulpit soil series. All three soils were classified as "Fine-silty, mixed, mesic Ustollic Haplargids". Cahona is a very deep soil, and Sharps and Pulpit are moderately deep.

In 1992 the NRCS held a "Four Corners Moisture and Temperature Meeting" in order to adopt consistent criteria for use in moisture and temperature classifications in the four state region (NRCS, 1992). Although no site-specific information was presented for the Black Mesa area, two sites in northeast Arizona were discussed. Navajo Mountain (6020 feet elevation, 9.34 inches mean annual precipitation, 49.6 degrees mean annual temperature) was considered "ustic-aridic". Teec Nos Pos (5290 feet elevation, 7.99 inches precipitation) was considered "typic-aridic".

Based on these two Arizona sites, and other sites in the Four Corners Area, the Black Mesa lease area would be consistent with an "ustic-aridic" moisture regime placement. Site-specific data also supports this conclusion. Sixteen years of precipitation data has been collected by Peabody at three sites on the Black Mesa Lease Area (sites 1, 8, and 12). The average annual precipitation between 1983 and 1998 was 8.7 inches with a general range of 8 to 10 inches. The high and low values during this time period were 3 inches (1989) and 11.6 inches (1997) (Esco Associates, 1998).

As a result of these data, the conclusion reached by Intermountain Soils in 1985 for the Black Mesa Lease area appears correct, and the area should be considered "ustic-aridic".

As part of the overall changes adopted at the Four Corners meeting, NRCS reclassified Cahona, Sharps, and Pulpit soils from an "ustic-aridic" to a slightly wetter "aridic-ustic" moisture regime. Cahona is now classified as a "Fine-silty, mixed, superactive mesic Calcic Haplustalf". Sharps and Pulpit are classified as "Fine-silty, mixed, superactive, mesic Aridic Haplustalfs".

Because the Black Mesa Lease Area is in an "ustic-aridic", not "aridic-ustic", moisture regime, the Cahona, Sharps, and Pulpit soil names are no longer appropriate. The Blanding soil series is similar in morphology to Cahona but is "ustic-aridic" and therefore Blanding is suitable for use on the Black Mesa Lease Area (Sasser, 2000).

Neither the Sharps nor Pulpit soils currently have an "ustic-aridic" soil counterpart. Therefore, these soil names have been retained for the current survey, but an "ustic-aridic" has been added to the name for use in the lease area. In the future there may be new names for an "ustic-aridic" Sharps and Pulpit, but there are none at the present time.

### 3.6 Soil Laboratory Results

The previous Black Mesa Lease Area soil survey did identify a few high salinity and/or sodicity values at depth in some of the alluvial soils adjacent to drainages. In 2000 when the J9 soil survey was conducted, it was proposed that some of the deep alluvial material be sampled in the field from deep backhoe pits, and analyzed in the laboratory to determine whether values might exceed suitability levels for electrical conductivity ( $EC > 12$ ) and adsorbed sodium ( $SAR > 12$  to 15 depending on soil texture).

Four soil samples were collected in the J9 Coal Resource Area. One sample was collected from the 80 to 108 inch depth interval of Blanding (formerly Cahona) fine sandy loam at soil hole #J9-26. Three soil samples were collected from Begay very fine to fine sandy loam: from the 76 to 108 depth interval of soil hole #J9-18, and from the 80 to 89 depth interval of soil hole #J9-24.

**Attachment 4** is the Inter-Mountain Laboratories (Farmington, New Mexico) soils data for the four samples. The following parameters were included in the laboratory analysis: pH, EC, SAR, texture (sand, silt, and clay), and Acid Base Potential ABP (total sulfur %, total sulfur t/kt, neutralization potential t/kt). Discussion of the soil analysis results is included in the following section.

### 3.7 Topsoil Suitability and Salvage Depth Recommendation

A topsoil suitability evaluation and salvage depth recommendation was completed for all soils in the previous Black Mesa Lease Area soil survey (Intermountain Soils, Inc. 1985). Because no new soils were found during the current survey, the previous evaluations were considered the starting point for use in the 2003 soil survey. However, the soils and map units were reevaluated based on site-specific data.

The major change from the previous survey is the recommendation of soil salvage of shallow residual soils under Pinyon-Juniper vegetation. Previously, all #1 map units (1, 1A, 1B, 1C, and 1D), #3 map units (3A, 3BC, 3C, 3D, 3E, 3DE, and 3F), #4 map units (4B, 4C, 4D, and 4E), #7 map units (7B, 7C, 7D, and 7E), and #16 map units (16C, 16E, and 16F) were not recommended for soil salvage based on high content of surficial rock fragments, clay content of the Zyme soil, erosion status, and shallow nature of the soils (Intermountain Soils, Inc., 1985). The previous report does state these soils (Dulce, Zyme, Travessilla, and Ustic Torriorthents) do not have any chemical properties limiting soil suitability.

The concept of soil suitability has evolved since 1985. The presence of gravel (2mm to 3") and cobble (3" to 10") size rock coarse fragments, including sandstone channers and shale chips, is not considered limiting or unsuitable for coarse fragment content as high as 35 to 45 percent. The State of Utah Division of Oil, Gas, and Mining (UDOGM) has even removed coarse fragment content as a criterion in their current soil suitability table (UDOGM, 2002).

The presence of 15 to even 50 percent sandstone channers and shale chips predominantly on the surface of residual soils such as Dulce, Zyme, and Travessilla should not be considered unsuitable for salvage, especially when the overall volume of available soil is limiting. This range of coarse fragment content can be beneficial for erosion resistance and should not create droughty conditions in the reclaimed soil profile. Additionally, coarse fragment content often decreases in the underlying soil horizons above the weathered bedrock contact.

Soil erosion itself is not limiting for salvage. It makes the actual salvage operation more difficult but does not make the remaining soil material unsuitable. Shallow soils (less than 20 inches to bedrock) are not by definition unsuitable. There is just less soil material to salvage. Soil depth as low as 6 inches can be salvaged. However, soil salvage may not be feasible in the steeper portions of certain map units that approach 40 to 50 percent slopes due to equipment limitations and operator safety concerns.

In addition, the upper part (up to 1 foot in thickness) of the weathered sandstone or shale bedrock (the "paralithic" Cr horizon) in residual soils is also suitable for salvage, if needed. This weathered upper bedrock material was consistently observed in backhoe pits to have many roots and no signs of salinity and/or sodicity. The soil backhoe easily and consistently dug through this upper bedrock material. Furthermore, the current contract salvage operators at Black Mesa have coined a term for this material, "toprock", and consider it to be suitable soil or soil substitute material available for salvage if and when needed.

Based on extensive backhoe pit observations, it is recommended that approximately 0.5 foot of suitable soil material be salvaged from residual soils (Dulce, Zyme, Travessilla) under Pinyon-Juniper vegetation, especially when soil resources are limited and these soils are needed for successful reclamation. Actual average depth of residual soil to the weathered sandstone or shale bedrock contact is slightly deeper, but has been rounded to the nearest 0.5 foot. Map units 3F (Ustic Torriorthents-Rock Outcrop, 50 to 80% slopes) and 7E (Zyme-Travessilla-Rock Outcrop complex, 30 to 50% slopes) continue to have no

recommended salvage due to steep slopes and rock outcrop.

**Table 4** is a list of recommended salvage depths for soils in the 2003 Black Mesa Lease Area (Coal Resource Areas N9, N10, N12-N99S, N99N, J2-J15, J4, J6-J14, J8, J9, J10, J28, and J23 Coal Transportation Corridors). The list includes an overall recommended salvage depth for each map unit as well as differentiated "Topsoil" and "Subsoil" salvage depths as an additional option for some map units. Based on Peabody practice, salvage depths are listed to the nearest 0.5 feet.

The following is a discussion of recommended salvage depths for each map unit. **Table 5** lists the 555 soil observations and soil characteristics from which the following data evaluation and salvage recommendations were generated.

**Map Unit 1AB (Dulce very channery fine sandy loam, 1 to 8 percent slopes)** is composed of the shallow, residual Dulce soil and generally occupies sloping uplands under Pinyon-Juniper vegetation. Dulce was observed in 50 backhoe pits in Map Unit 1AB and averaged 9 inches to the weathered bedrock contact. Dulce very channery loam ranged in depth from 5 to 18 inches. Soil inclusions (Zyme, Bond, Pulpit, Sharps, and Travessilla) were observed in another 16 backhoe pits within Map Unit 1AB, and averaged 19 inches to bedrock with a soil depth range of 6 to 32 inches. Soil inclusions comprised about 24 percent of Map Unit 1A. The recommended soil salvage depth for Map Unit 1A is 0.5 feet, with the concept that all soil to weathered bedrock contact is suitable and could be salvaged where deeper than 0.5 feet.

**Map Unit 1CD (Dulce very channery loam, 8 to 30 percent slopes)** is similar to Map Unit 1AB except for slope. Dulce was observed in 5 backhoe pits in Map Unit 1CD and averaged 12 inches to the weathered bedrock contact, with a depth range of 9 to 20 inches. Blanding very fine sandy loam was observed to 54 inches in one additional backhoe pit. Because only 5 Dulce backhoe pits were dug in Map Unit 1CD, the average 12 inch soil depth was reduced to a conservative recommended salvage depth of 0.5 feet in order to be consistent with Dulce in Map Unit 1AB.

**Map Unit 2B (Bond very fine sandy loam)** is composed of the shallow Bond soil and generally occupies gently sloping upland areas under a sagebrush and mixed grasses vegetation. Delineations of Map Unit 2B are also mapped in gently sloping open Pinyon-Juniper woodland. A total of 37 backhoe pits were dug in Bond very fine sandy loam, and these averaged 14 inches to the weathered bedrock contact, with a depth range of 8 to 20 inches. Soil inclusions were observed in another 13 backhoe pits (comprising 26% of the total observation in Map Unit 2B) and these averaged 22 inches in depth with a range of 6 to 72 inches.

Bond has an overall recommended salvage depth of 1 foot, the rounded average depth to sandstone or shale bedrock. All soil parameters are suitable. The upper 0.5 feet (the surface "A" horizon and the underlying "Bt" argillic horizon) have higher organic matter content than below and could be salvaged as an upper or "topsoil" lift. The underlying 0.5 feet to the bedrock contact could be salvaged as a lower or "subsoil" lift. The previous survey also recommended a salvage depth of 1.0 feet.

**Map Units 3AB, 3CD, and 3DE (Zyme-Dulce complex)** are composed of shallow residual soils under Pinyon-Juniper vegetation. Map Unit 3AB had 15 backhoe pit observations and 1 soil inclusion and averaged 9 inches to the weathered bedrock contact with a soil depth range of 3 to 18 inches. The total recommended salvage depth is rounded to 0.5 feet.

Zyme and Dulce soils were observed in 45 backhoe pits in Map Unit 3CD and averaged 8 inches to the weathered bedrock contact with a soil depth range of 3 to 17 inches. Three additional backhoe pits had soil inclusions which averaged 17 inches to bedrock. The overall total recommended salvage depth of Map Unit 3CD is rounded to 0.5 feet.

Zyme and Dulce soils were observed in 14 backhoe pits in Map Unit 3DE and averaged 8 inches to the weathered bedrock contact with a depth range of 3 to 18 inches. Two additional backhoe pits had soil inclusions that averaged 14 inches to bedrock. The overall total recommended salvage depth of Map Unit 3DE is rounded to 0.5 feet. Topsoil salvage may not be feasible in the steeper portions of this map unit that approach 40 to 50 percent slopes due to equipment limitations and operator safety concerns.

**Map Unit 3F (Ustic Torriorthents – Rock Outcrop Complex)** Soils in Map Unit 3F are not recommended for salvage due to the high percentage of Rock Outcrop and very steep slopes. This map unit often has bedrock ledges and cliffs.

**Map Units 4AB and 4CD (Zyme very channery loam)** are composed of Zyme clay loam on shale influenced sideslopes and ridges scattered throughout the study area. Although Zyme was observed many times in backhoe pits in other map units, it was not inventoried in Map Units 4AB and 4CD. It is assumed that Zyme has similar characteristics in all map units in which it is a component, and therefore the overall total recommended salvage depth for Map Units 4AB and 4CD is 0.5 feet.

**Map Unit 5 (Pulpit, ustic-aridic, very fine sandy loam)** is composed of the moderately deep Pulpit soil over hard sandstone bedrock. Pulpit is located on gently sloping uplands. Vegetation is a mix of sagebrush, mixed grasses, and scattered Pinyon-Juniper. Pulpit was observed in 27 backhoe pits and averaged 28 inches to sandstone bedrock with a depth range of 20 to 39 inches. Soil inclusions were observed in an additional 17 backhoe pits (comprising about 38% of the map unit) and averaged 45 inches to bedrock. The weighted average soil depth for Map Unit 5 is 35 inches. The total recommended salvage depth for Map Unit 5 is rounded to 3 feet. The previous survey recommended a salvage depth of 2.5 feet. The upper 1.0 feet (the surface "A" horizon and the underlying "Bt" argillic horizon) could be salvaged as an upper or "topsoil" lift. The underlying 2 feet to the bedrock contact could be salvaged as a lower or "subsoil" lift.

**Map Units 6AB and 6C (Sharps, ustic-aridic, very fine sandy loam)** are composed of the moderately deep Sharps soil and are located on gently sloping to sloping uplands dominantly under a sagebrush and mixed grasses vegetation. Sharps was observed in Map Unit 6AB in 36 backhoe pits and averaged 29 inches to the shale contact, with a depth range of 20 to 39 inches. Soil inclusions were observed in an additional 12 pits (comprising about 25% of the map unit) and averaged 41 inches to bedrock. The weighted average soil

depth of Map Unit 6AB is 32 inches. The total recommended salvage of Map Unit 6AB is rounded to 2.5 feet. The upper 1.0 feet (the surface "A" horizon and the underlying "Bt" argillic horizon) could be salvaged as an upper or "topsoil" lift. The underlying 1.5 feet to the bedrock contact could be salvaged as a lower or "subsoil" lift. The previous survey also recommended a salvage depth of 2.5 feet.

Sharps very fine sandy loam in Map Unit 6C was observed in 6 backhoe pits and averaged 33.5 inches to the shale bedrock. No inclusions were observed. The total recommended salvage depth is rounded to 2.5 feet. The previous survey also recommended a salvage depth of 2.5 feet.

**Map Units 7B (Travessilla-Zyme-Dulce complex); and 7CD and 7E (Zyme - Travessilla - Rock Outcrop complex)** are composed of shallow soils over sandstone and shale bedrock. They are located on weathered upland ridges with scattered rock outcrop and have dominantly Pinyon-Juniper vegetation. Soils in Map Unit 7B were observed in 13 backhoe pits and averaged 10 inches to bedrock with a depth range of 4 to 20 inches. No inclusions were noted. Soils in Map Unit 7CD were observed in 8 backhoe pits and averaged 7 inches to bedrock with a depth range of 3 to 15 inches. The total recommended salvage depth of Map Units 7B and 7CD is rounded to 0.5 feet. Map Unit 7E is not recommended for salvage due to high amounts of Rock Outcrop and very steep slopes.

**Map Units 10AB and 10C (Blanding very fine sandy loam, bedrock substratum); 11AB and 11C (Blanding very fine sandy loam); G11B (Blanding very fine sandy loam, gravelly substratum); and X11AB and X11C (Blanding - Blanding, bedrock substratum)** are composed of very deep local alluvial and reworked aeolian soils on alluvial fans, flats, sideslopes, and toeslopes scattered across the study area. Blanding generally has a sagebrush and mixed grasses vegetation. Blanding was observed in a high number of backhoe pits, and the average depth to bedrock in Map Units 10AB and 10C is more than 6.5 feet with a depth range of 4.5 to 9 feet or more. The depth to very gravelly sandy loam, loamy sand, or sand and gravel texture is about 5 feet.

Blanding has low salinity (EC) and low sodicity (SAR) values. Although all soil parameters are technically suitable, the coarse texture below an average of 5 feet can lead to a droughty and erosion prone condition if this "sandy" material constitutes the surface layer after reclamation activities have been completed. The overall recommended salvage depth for Blanding in Map Units 10AB and 10C is 5 feet, the average depth until "sandy" material is encountered. The recommended salvage depth for a "topsoil" lift is 1 foot. The recommended salvage depth for an underlying "subsoil" lift is 4 feet.

The average depth for Blanding in Map Units X11AB, X11C, and G11B is 7.5 feet, and 10 feet for Map Units 11AB and 11C. All of this material is suitable and constitutes the total recommended salvage depths for these map units. The upper foot of soil is recommended for a "topsoil" lift and the remaining material for the "subsoil" lift.

**Map Units 12AB and 12C (Begay loam)** are composed of the very deep alluvial Begay soil located on nearly level to strongly sloping terraces of drainages scattered throughout the study area. Total soil depth was an average of at least 9.7 feet. All soil parameters of

Begay are suitable, although very gravelly loamy sand and sandy loam material can be encountered at depth in some areas. This material, when encountered, is droughty and has high erosion hazard. Overall recommended salvage depth is rounded to 9.5 feet. The upper 1.5 feet, including the surface "A" horizon and the underlying "Bw" cambic horizon, could be salvaged as a "topsoil" lift. The underlying 8 feet, or the depth to the dominantly very gravelly loamy sand contact, could be salvaged as a "subsoil" lift.

**Map Unit 13A (San Mateo loam)** is composed of fine-loamy material on nearly level to very gently sloping stream terraces, drainageway bottomlands, and floodplains. The overall recommended salvage depth is 14.5 feet. The upper 1.5 feet (including the surface "A" horizon and the underlying upper part of the "C" horizon) can be salvaged as a "topsoil" lift. The underlying 13 feet can be salvaged as a "subsoil" lift. Individual delineations of San Mateo may have high electrical conductivity (EC) and/or high sodicity (Sodium Adsorption Ratio - SAR) at depths between 8 to 18 feet which could limit subsoil salvage to more shallow depths in these areas.

**Map Unit 14AB (Oelop very fine sandy loam)** is composed of the deep Oelop soil on gently sloping valley sideslopes and bottoms. The overall salvage depth is 9.5 feet. The upper 1.5 feet (including the surface "A" horizon and the underlying "Bt" argillic horizon) can be salvaged as a "topsoil" lift. The underlying 8 feet can be salvaged as a "subsoil" lift.

**Map Unit 15A (Las Lucas sandy clay loam)** is composed of the very deep Las Lucas soil located on terraces and drainage bottomlands throughout the study area. The overall recommended salvage depth is 11.5 feet. The upper 1.5 feet can be salvaged as a "topsoil" lift, and the underlying 10 feet as a "subsoil" lift. The previous survey recommended a maximum salvage depth of 11.6 feet.

**Map Units 16C, 16CE, and 16F (Soil A- Soil B extremely channery very fine sandy loams)** are composed of soils on crests, summits, and sideslopes of some hills scattered across the study area. These soils formed in porcellanite (scoria) and contain a very high volume of rock fragments. These soils were previously considered unsuitable for salvage due to their very high rock fragment content. However, these soils have been selectively salvaged at Black Mesa with positive results. Fifteen soil backhoe pits were dug in Map Unit 16C and fifteen in Map Unit 16CE. Soil depth averaged 6 inches for Map Unit 16C, with a depth range of 4 to 18 inches. Soil depth for Map Unit 16CE averaged 10 inches, with a depth range of 2 to 27 inches. The total recommended salvage depth for these map units is rounded to 0.5 feet. Topsoil salvage may not be feasible in the steeper portions of Map Unit 16CE that approach 40 to 50 percent slopes due to equipment limitations and operator safety concerns. Map Unit 16F is not recommended for salvage due to very steep slopes, from 50 to 70 percent or greater.

**Map Unit DL (Disturbed Land)** is composed of various delineations of previously disturbed areas. There is no soil for salvage within these disturbed areas.

**Map Unit P (Pond)** contains various constructed ponds distributed across the study area. There is no soil for salvage within these delineations although the pond and embankment "soil materials" will be tested for suitability when the ponds are reclaimed.

**Map Unit RL (Reclaimed Land, no topsoil)** is composed of various small delineations of previously reclaimed areas. For various reasons, these areas are not presently topsoiled and therefore have no soil available for salvage. Although no topsoil is presently available for salvage, the current 6 inch surface layer may be suitable for salvage and use as a topsoil substitute material if these areas are projected to be redisturbed.

**Map Unit RLT (Reclaimed Land, topsoiled)** is composed of various delineations of previously reclaimed areas that were topsoiled during reclamation activities. One large area of Map Unit RLT exists on the west side of Coal Resource Area N10. This reapplied topsoil was not sampled for laboratory analysis, but it is assumed that 6 inches of suitable topsoil can be salvaged from these areas if they are projected to be redisturbed.

**Map Unit TS (Topsoil Stockpile)** is composed of some areas where stockpiled topsoil is located. This material will be used during overall reclamation activities, but it was not studied as part of the current soil survey.

**Map Unit RD (Reconstructed Drainage)** is composed of a few areas where drainage channels have been reconstructed across reclaimed areas, most notably Coal Resource Area N10. Soil material is not available for salvage from these areas if they are projected to be redisturbed.

**Map Unit RW (Riverwash)** is composed of the very coarse-textured channel bed of various drainages in the study area. These channel beds will not be disturbed, and have no topsoil for salvage.

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**TABLE 1****2003 Soil Survey Map Unit Legend**

1AB	Dulce very channery fine sandy loam, 1 to 8 percent slopes
1CD	Dulce very channery fine sandy loam, 8 to 30 percent slopes
2B	Bond very fine sandy loam, 1 to 8 percent slopes
3AB	Zyme - Dulce complex, 1 to 8 percent slopes
3CD	Zyme - Dulce complex, 8 to 30 percent slopes
3DE	Zyme - Dulce complex, 30 to 50 percent slopes
3F	Ustic Torriorthents - Rock Outcrop complex, 50 to 80 percent slopes
4AB	Zyme very channery loam, 1 to 8 percent slopes
4CD	Zyme very channery loam, 8 to 30 percent slopes
5	Pulpit very fine sandy loam, ustic-aridic, 2 to 8 percent slopes
6AB	Sharps very fine sandy loam, ustic-aridic, 1 to 8 percent slopes
6C	Sharps very fine sandy loam, ustic-aridic, 8 to 15 percent slopes
7B	Travessilla - Zyme - Dulce complex, 2 to 6 percent slopes
7CD	Zyme-Travessilla-Rock Outcrop complex, 6 to 30 percent slopes
7E	Zyme-Travessilla-Rock Outcrop complex, 30 to 50 percent slopes
10AB	Blanding very fine sandy loam, bedrock substratum, 1 to 8 percent slopes
10C	Blanding very fine sandy loam, bedrock substratum, 8 to 15 percent slopes
X11AB	Blanding - Blanding, bedrock substratum, very fine sandy loams 1 to 8 percent slopes
X11C	Blanding - Blanding, bedrock substratum, very fine sandy loams, 8 to 15 percent slopes
11AB	Blanding very fine sandy loam, 1 to 8 percent slopes
11C	Blanding very fine sandy loam, 8 to 15 percent slopes
G11B	Blanding very fine sandy loam, gravelly substratum, 2 to 8 percent slopes
12AB	Begay loam, 1 to 8 percent slopes
12C	Begay loam, 8 to 15 percent slopes
13A	San Mateo loam, 0 to 3 percent slopes
14AB	Oelop very fine sandy loam, 1 to 8 percent slopes
15A	Las Lucas sandy clay loam, 2 to 6 percent slopes
16C	Soil A - Soil B, extremely channery very fine sandy loams, 4 to 15 percent slopes
16CE	Soil A - Soil B, extremely channery very fine sandy loams, 15 to 50 percent slopes
16F	Soil A - Soil B, extremely channery very fine sandy loams, 50 to 70 percent slopes
DL	Disturbed Land
P	Pond
RL	Reclaimed Land, no topsoil
RLT	Reclaimed Land, topsoiled
TS	Topsoil Stockpile
RD	Reconstructed Drainage
RW	Riverwash

**TABLE 2****Current Correlation of Soil Series  
on the Black Mesa Lease Area**

1980 Espey Huston & Associates	1984 Mariah Associates	1985 Intermountain Soils	2000 & 2003 Nyenhuis
Fruitland	Begay	Begay	Begay
Not mapped	Not mapped	Bond	Bond
Clovis	Cahona	Cahona	Blanding
Not mapped	Not mapped	Chilton	Not mapped
Moenkopi	Dulce	Dulce	Dulce
Ives	Mikim	Las Lucas	Las Lucas
Not Mapped	Not mapped	Oelop	Oelop
Not Mapped	Pulpit	Pulpit	Pulpit, ustic-aridic
Youngston	San Mateo	San Mateo	San Mateo
Not mapped	Sharps	Sharps	Sharps, ustic-aridic
Moenkopi	Not mapped	Travessilla	Travessilla
Claysprings	Not mapped	Zyme	Zyme
Not mapped	Not mapped	Soil A	Soil A
Not mapped	Not mapped	Soil B	Soil B

**TABLE 3****Taxonomic Classification of Soil Series of the Black Mesa Lease Area**

<b>Series</b>	<b>Family</b>
Begay	Coarse-loamy, mixed, superactive, mesic Ustic Haplocambid
Blanding	Fine-silty, mixed, superactive, mesic Ustic Haplargid
Bond	Loamy, mixed, superactive, mesic Lithic Ustic Haplargid
Chilton	Loamy-skeletal, mixed, calcareous, mesic Ustic Torriorthent
Dulce	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

**TABLE 4**

**2003 Life of Mine Coal Resource Areas Soil Survey  
Recommended Soil Salvage Depths**

<b>Symbol</b>	<b>Map Unit Name</b>	<b>Total Recommended Salvage Depth<sup>1</sup> (feet)</b>	<b>Topsoil/Subsoil Salvage Thickness<sup>1</sup> (feet)</b>
1AB	Dulce very channery fine sandy loam, 1 to 8 percent slopes	0.5	0.5/0.0
1CD	Dulce very channery fine sandy loam, 8 to 30 percent slopes	0.5	0.5/0.0
2B	Bond very fine sandy loam, 1 to 8 percent slopes	1.0	1.0/0.0
3AB	Zyme - Dulce complex, 1 to 8 percent slopes	0.5	0.5/0.0
3CD	Zyme - Dulce complex, 8 to 30 percent slopes	0.5	0.5/0.0
3DE	Zyme - Dulce complex, 30 to 50 percent slopes	0.5 <sup>2</sup>	0.5/0.0
3F	Ustic Torriorthents - Rock Outcrop complex, 50 to 80 percent slopes	0.0	-
4AB	Zyme very channery loam, 1 to 8 percent slopes	0.5	0.5/0.0
4CD	Zyme very channery loam, 8 to 30 percent slopes	0.5	0.5/0.0
5	Pulpit, ustic-aridic, very fine sandy loam, 2 to 8 percent slopes	3.0	1.0/2.0
6AB	Sharps, ustic-aridic, very fine sandy loam, 1 to 8 percent slopes	2.5	1.0/1.5
6C	Sharps, ustic-aridic, very fine sandy loam, 8 to 15 percent slopes	2.5	1.0/1.5
7B	Travessilla - Zyme - Dulce complex, 2 to 6 percent slopes	0.5	0.5/0.0
7CD	Zyme-Travessilla-Rock Outcrop complex, 6 to 30 percent slopes	0.5	0.5/0.0
7E	Zyme-Travessilla-Rock Outcrop complex, 30 to 50 percent slopes	0.0	-
10AB	Blanding very fine sandy loam, bedrock substratum, 1 to 8 percent slopes	5.0	1.0/4.0
10C	Blanding very fine sandy loam, bedrock substratum, 8 to 15 percent slopes	5.0	1.0/4.0
X11AB	Blanding - Blanding, bedrock substratum, very fine sandy loams 1 to 8 percent slopes	7.5	1.0/6.5

Symbol	Map Unit Name	Total Recommended Salvage Depth <sup>1</sup> (feet)	Topsoil/Subsoil Salvage Thickness <sup>1</sup> (feet)
X11C	Blanding - Blanding, bedrock substratum, very fine sandy loams, 8 to 15 percent slopes	7.5	1.0/6.5
11AB	Blanding very fine sandy loam, 1 to 8 percent slopes	10.0	1.0/9.0
11C	Blanding very fine sandy loam, 8 to 15 percent slopes	10.0	1.0/9.0
G11B	Blanding very fine sandy loam, gravelly substratum, 2 to 8 percent slopes	7.5	1.0/6.5
12AB	Begay loam, 1 to 8 percent slopes	9.5	1.5/8.0
12C	Begay loam, 8 to 15 percent slopes	9.5	1.5/8.0
13A	San Mateo loam, 0 to 3 percent slopes	14.5	1.5/13.0
14AB	Oelop very fine sandy loam, 1 to 8 percent slopes	9.5	1.5/8.0
15A	Las Lucas sandy clay loam, 2 to 6 percent slopes	11.5	1.5/10.0
16C	Soil A - Soil B, extremely channery very fine sandy loams, 4 to 15 percent slopes	0.5	0.5/0.0
16CE	Soil A - Soil B, extremely channery very fine sandy loams, 15 to 50 percent slopes	0.5 <sup>2</sup>	0.5/0.0
16F	Soil A - Soil B, extremely channery very fine sandy loams, 50 to 70 percent slopes	0.0	-
DL	Disturbed land	0.0	-
P	Pond	0.0	-
RL	Reclaimed Land, no topsoil	0.0	-
RLT	Reclaimed Land, topsoiled	0.5	0.5/0.0
TS	Topsoil Stockpile	0.0	-
RD	Reconstructed Drainage	0.0	-
RW	Riverwash	0.0	-

- Salvage depths are estimated to the nearest 0.5 feet based on data presented in Table 5, List of Dug Holes and Soil Characteristics. Salvage depth information for each map unit is also presented on the Soil Maps for each Coal Resource Area.
- Topsoil salvage may not be feasible in the steeper portions of this map unit that approach 40 to 50 percent slopes due to equipment limitations and operator safety concerns.

TABLE 5

## N9 COAL RESOURCE AREA, 2345 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
1	Begay sandy loam	12AB	6'+	Profile description, valley fill
2	Begay sandy loam	12AB	7'+	Drainage cut
3	Begay sandy loam	12AB	10'+	Profile description, valley fill, major rooting depth 30"
4	San Mateo loam	13A	15'	Drainage cut
5	Begay fine sandy loam	12AB	12'+	Profile description, major rooting depth 34"
6	Blanding fine sandy loam	11C	50" to SS	
7	Begay fine sandy loam	12AB	17'+	Drainage cut, coarse-loamy alluvium
8	Begay fine sandy loam	12AB	17'+	Drainage cut, coarse-loamy alluvium
9	Begay sandy loam	12AB	12'+	Middle of drainage
10	Begay sandy loam	12AB	12'+	Middle of drainage
11	Dulce channery sandy loam	3CD	10" to scoria	
12	Begay sandy loam	12AB	12'+	Middle of drainage
13	Zyme clay loam	3DE	18" to carb SH	
14	Begay fine sandy loam	12AB	6'+ to SS	
15	Zyme clay loam	3DE	14" to weathered SH	
16	Begay sandy loam	12AB	15'+	Drainage cut
17	Begay sandy loam	12AB	15'+	Drainage cut
18	Begay fine sandy loam	12AB	15'+	Drainage cut
19	Begay fine sandy loam	12AB	15'+	Drainage cut
20	Begay sandy loam	12AB	15'+	Drainage cut
21	Begay sandy loam	12AB	15'+	Drainage cut
22	Begay sandy loam	12AB	15'+	Drainage cut
23	Begay fine sandy loam	12AB	15'+	Drainage cut
24	Dulce channery loam	1AB	18" to weath platy siltstone	Profile description, ridge crest flat (x), photos
25	Pulpit fine sandy loam	1AB (inclusion)	32" to SH	Profile description, photos
26	Dulce loam	1AB	9" to fract. SS	
27	Dulce channery loam	1AB	6" to fract. SS	
28	Dulce channery loam	1AB	5" to fract. SS	
29	Dulce channery loam	1AB	13" to weath. SH over fract. SS	
30	Pulpit fine sandy loam	5	26" to fract. SS	Profile description
31	Blanding sandy loam	5 (inclusion)	5'+	Profile description, photos
32	Dulce channery loam	3CD	12" to weath. SH	Shale Cr 12 to 24" with roots
33	Soil A-B gravelly loam	16CE	8" to fract. SS	Sideslope of scoria hill
34	Blanding loam	X11C	42" to weath. SH	Major rooting depth 17", photo
35	Pulpit fine sandy loam	5	30" to weath. soft SS	Profile description, photo
36	Dulce channery loam	3CD	12" to weath. sandy SH	
37	Pulpit very fine sandy loam	X11C (inclusion)	24" to scoria SH	

TABLE 5

## N9 COAL RESOURCE AREA, 2345 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
38	Dulce fine sandy loam	5 (inclusion)	17" to hard, shaly SS	
39	Pulpit very fine sandy loam	5	27" to weath. hard SH	
40	Pulpit sandy loam/loam	5	30" to fract. SS	
41	Oelop very fine sandy loam	5 (inclusion)	7.7'+	Profile description
42	Dulce channery loam	3CD	4" to fract. SS	
43	Pulpit very fine sandy loam	5	38" to weath. SS	Contains old buried 7.5YR Bt
44	Sharps very fine sandy loam	5 (inclusion)	28" to weath. fract. SS	Profile description
45	Oelop very fine sandy loam	14AB	6'+	Drainage cut
46	Oelop very fine sandy loam	14AB	6'+	Drainage cut
47	Oelop very fine sandy loam	14AB	6'+	Drainage cut
48	Dulce channery loam	3CD	5" to fract. SS	
49	Dulce channery loam	3CD	5" to fract. scoria	
50	Dulce channery loam	3CD	5" to scoria SS	
51	Dulce channery loam	3CD	5" to scoria SS	
52	Blanding sandy loam/loam	X11AB	6.8'+	Major rooting depth 18"
53	Oelop very fine sandy loam	14AB	6'+	
54	Pulpit fine sandy loam	2B (inclusion)	39" to SS	Profile description, photos
55	Dulce channery loam	1AB	6" to fract. Siltstone	Photos
56	Blanding fine sandy loam	11AB	7'+	Profile descripton
57	Oelop very fine sandy loam	14AB	10'+	Drainage cut
58	Oelop very fine sandy loam	14AB	10'+	Drainage cut
59	Dulce channery loam	1AB	5" to scoria SS	
60	Dulce channery loam	1AB	6" to weath. scoria SH	Major rooting depth goes to 14" in weath. SH, photos
61	Dulce channery loam	1AB	6" to weath. SH	Major rooting depth goes to 14" in weath. SH, photos
62	Dulce channery loam	1AB	14" to weath. SH	
63	Blanding fine sandy loam	5 (inclusion)	4.5'+	Major rooting depth 16"
64	Dulce channery loam	3CD	8" to fract. Siltstone	
65	Blanding fine sandy loam	11AB	7'+	Major rooting depth 26"
66	Dulce channery loam	2B (inclusion)	18" to weath. SH	
67	Bond fine sandy loam	2B	14" to fract. Hard SS	
68	Dulce channery loam	1AB	6" to fract. SS	
69	Bond fine sandy loam	2B	9" to hard SS	
70	Blanding very fine sandy loam	X11C	40'+	
71	Pulpit very fine sandy loam	5	35" to weath. SS	Photos

**TABLE 5**

**N9 COAL RESOURCE AREA, 2345 Acres**

<b>Hole#</b>	<b>Soil Name - surface texture</b>	<b>Map Unit</b>	<b>Depth to rock</b>	<b>Comments / profile description</b>
72	Dulce channery loam	3CD	6" to fract. SS	
73	Blanding very fine sandy loam	5 (inclusion)	53" to weath. SH	
74	Soil A-B very channeryloam	16CE	16" to weath. scoria	Weath. scoria SS & SH from 16 to 40"
75	Begay sandy loam	12AB	6'+	Drainage cut
76	Dulce channery loam	1AB	6" to fract. SS	
77	Dulce channery loam	3CD	10" to weath. sandy SH	Photos
78	Pulpit very fine sandy loam	2B (inclusion)	28" to hard SS	Photos
79	Pulpit very fine sandy loam	2B (inclusion)	29" to hard SS	
80	Bond very fine sandy loam	2B	18" to fract. SS	Photos
81	San Mateo loam	13A	8'+	
82	San Mateo loam	13A	8'+	

TABLE 5

## N10 COAL RESOURCE AREA, 1794 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
1	Dulce channery sandy loam	3CD	5" to fract. SS	
2	Travessilla very channery sandy loam	3CD (inclusion)	4" to hard SS	
3	Dulce channery sandy loam	3CD	7" to fract. SS	
4	Zyme clay loam	3CD	6" to weath. SH	
5	Blanding fine sandy loam	10AB	55" to SS	
6	Zyme clay loam	3CD	4" to weath. SH	
7	Zyme clay loam	3CD	6" to weath. SH	
8	Dulce channery loam	1AB	6" to fract. SS	
9	Sharps very fine sandy loam	5 (inclusion)	30" to SS	
10	Las Lucas sandy clay loam	15A	15'+	Drainage cut
11	Las Lucas sandy clay loam	15A	15'+	Drainage cut
12	Las Lucas sandy clay loam	15A	15'+	Drainage cut
13	Las Lucas sandy clay loam	15A	15'+	Drainage cut
14	Las Lucas sandy clay loam	15A	15'+	Drainage cut
15	Dulce channery loam	3CD	4" to fract. SS	
16	Dulce channery loam	3CD	6" to fract. SS	
17	Zyme clay loam	3CD	3" to weath. SH	
18	Dulce channery loam	3AB	3" to fract. SS	
19	Blanding fine sandy loam	10AB	6'+	Profile description
20	Begay sandy loam	12AB	7'+	Profile description
21	Blanding fine sandy loam	10C	6.7'+	Profile description
22	Dulce channery loam	3CD	9" to weath. SH	
23	Pulpit very fine sandy loam	5	30" to hard SS	
24	Blanding fine sandy loam	10C	57" to SS	
25	Blanding fine sandy loam	10C	44" to SS	
26	Bond very fine sandy loam	2B	13" to weath. SS	
27	Blanding very fine sandy loam	10AB	7'+	
28	Dulce channery loam	2B (inclusion)	9" to fract. SS	Thin, weak scoria on soil surface
29	Bond very fine sandy loam	2B	10" to fract. SS	
30	Bond very fine sandy loam	2B	9" to fract. SS	
31	Bond very fine sandy loam	2B	9" to fract. SS	
32	Bond very fine sandy loam	2B	16" to sandy SH	
33	Blanding very fine sandy loam	3DE (inclusion)	5' to SS	Major rooting depth 30"
34	Pulpit very fine sandy loam	3DE (inclusion)	22" to sandy SH	
35	Dulce channery loam	3DE	12" to fract. SS	
36	Blanding fine sandy loam	5 (inclusion)	53" to SS	
37	Dulce channery loam	5 (inclusion)	16" to fract. SS	

TABLE 5

## N10 COAL RESOURCE AREA, 1794 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
38	Dulce channey loam	1CD	20" to SS	Scoria colluvium
39	Dulce channery loam	1CD	9" to SS	Scoria colluvium
40	Dulce channery loam	1CD	16" to SS	Scoria colluvium
41	Dulce channery loam	1CD	10" to fract. SS	
42	Pulpit very fine sandy loam	5	28" to SS	
43	Pulpit very fine sandy loam	5	24" to soft SS	
44	Pulpit very fine sandy loam	5	23" to soft SS	
45	Dulce channery loam	5 (inclusion)	16" to soft SH	
46	Las Lucas sandy clay loam	15A	15'	Drainage cut
47	Las Lucas sandy clay loam	15A	15'	Drainage cut
48	Pulpit very fine sandy loam	5	26" to SS	
49	Blanding fine sandy loam	5 (inclusion)	7' to SS	
50	Zyme very channery loam	3DE	4" to weath. SH	
51	Zyme very channery loam	3DE	3" to weath. SH	
52	Bond very fine sandy loam	2B	13" to fract. SS	
53	Bond very fine sandy loam	2B	12" to fract. SS	
54	Pulpit very fine sandy loam	2B (inclusion)	22" to fract. SS	
55	Dulce channery loam	2B (inclusion)	9" to fract. SS	
56	Bond very fine sandy loam	2B	16" to fract. SS	
57	Bond very fine sandy loam	2B	16" to fract. SS	
58	Bond very fine sandy loam	2B	12" to fract. SS	
59	Bond very fine sandy loam	2B	12" to fract. SS	
60	Pulpit very fine sandy loam	2B (inclusion)	24" to fract. SS	
61	Sandstone Rock Outcrop	3F	0"	
62	Sandstone Rock Outcrop	3F	0"	

TABLE 5

## N12/N99S COAL RESOURCE AREA, 2773 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
1	Blanding fine sandy loam	X11AB	11'+	Buried Btk at 6 to 7.5'
2	Blanding fine sandy loam	X11AB	6.5' to SS	
3	Dulce channery loam	1AB	6" to weath. shaly SS	
4	Oelop very fine sandy loam	14AB	14' to SS	Drainage cut, sage terrace
5	Blanding fine sandy loam	X11AB	9' to SS	
6	Blanding fine sandy loam	X11AB	64" to SS	Hard Bk at 30"
7	Dulce channery loam	16CE (inclusion)	5" to fract. SS	
8	Dulce channery sandy loam	1AB	5" to fract. SS	
9	Dulce channery sandy loam	16CE (inclusion)	16" to fract. SS	
10	Soil A-B very channery loam	16CE	4" to fract. scoria	
11	Blanding very fine sandy loam	11AB	12'+	Gravelly lense at 8 to 9'
12	Oelop very fine sandy loam	14AB	14'	Drainage cut
13	Dulce channery loam	1AB	5" to fract. SS	Slight scoria influence
14	Dulce channery loam	1AB	5" to fract. SS	
15	Dulce channery sandy loam	1AB	6" to fract. SS	Photos
16	Blanding very fine sandy loam	14AB (inclusion)	63'+ to SS	Profile description, photos
17	Oelop very fine sandy loam	14AB	8.3'+	Lower fan-valley sideslope, very channery loam lense at 4 to 5'
18	Oelop very fine sandy loam	14AB	12'+	Drainage cut
19	Oelop very fine sandy loam	14AB	8'+	Local alluvium from trib. drainage
20	Oelop channery sandy loam	14AB	8'+	Drainage cut
21	Oelop channery sandy loam	14AB	9'+	Drainage cut
22	Blanding very fine sandy loam	X11AB	4'+	
23	Blanding very fine sandy loam	X11AB	5'+	
24	Blanding very fine sandy loam	X11AB	5'+	Drainage cut
25	Blanding channery sandy loam	X11AB	54" to whitish gray SH	
26	Blanding fine sandy loam	X11AB	9'+	
27	Dulce channery loam	1AB	12" to fract. SS	
28	Oelop channery fine sandy loam	14AB	4'+	Drainage cut
29	Dulce channery loam	1AB	12" to fract. SS	
30	Pulpit very fine sandy loam	5	32" to hard, fract. SS	
31	Pulpit very fine sandy loam	5	30" to hard, fract. SS	Photos
32	Dulce very cobbly loam	1AB	4 to 8" to fract. SS (6")	
33	Dulce loam	1AB	12" to fract. SS	
34	Dulce loam	G11B (inclusion)	9" to fract. SS	
35	Soil A-B very channery loam	16C	5"	Scoria hilltop
36	Soil A-B very channery loam	16C	6"	Scoria hilltop
37	Soil A-B very channery loam	16C	6"	Scoria sideslope, roots in upper part of scoria, photos

TABLE 5

## N12/N99S COAL RESOURCE AREA, 2773 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
38	Blanding very fine sandy loam	X11C	9.5' to SS	Small saddle between 2 knob ridges, photos
39	Blanding fine sandy loam	X11C	4' to SS	
40	Bond channery loam	2B	8" to SS	Photos
41	Bond loam	2B	16" to weath. SS & SH	Weath. bedrock with roots from 16 to 25", photos
42	Bond loam	2B	15" to weath. SS & SH	Weath. bedrock with roots, photos
43	Bond loam	2B	12" to scoria	
44	Dulce channery loam	3CD	13" to SH	
45	Zyme channery silty clay loam	3CD	12" to fract. SS	Photos
46	Soil A-B flaggy sandy loam	16C	6" to fract. Scoria SS	
47	Soil A-B cobbly sandy loam	16C	6" to fract., hard scoria	
48	Soil A-B cobbly loam	16C	4" to scoria	
49	Begay fine sandy loam	12AB	12'+	Slopewash alluvium, photo
50	Dulce fine sandy loam	1AB	5" to fract., hard SS	
51	Blanding fine sandy loam	G11B	54"+	Profile description, photo
52	Begay fine sandy loam	G11B (inclusion)	8'+	Drainage cut
53	Zyme clay loam	3DE	12" to weath. SH	
54	Dulce channery loam	16CE (inclusion)	8" to weath. scoria	
55	Dulce fine sandy loam	3AB	5" to fract., hard SS	
56	Dulce fine sandy loam	3AB	5" to fract., hard SS	
57	Zyme clay loam	3AB	5" to weath. SH	
58	Zyme clay loam	3CD	17" to weath. platy SH	
59	Zyme channery clay loam	3CD	5" to weath., platy SH	Roots go into SH to 12"
60	Bond fine sandy loam	2B	17" to weath. sandy SH	
61	Dulce gravelly fine sandy loam	2B (inclusion)	14" to weath. SH	Weath. SH with roots 14 to 24"
62	Bond fine sandy loam	2B	12" to fract. SS	
63	Dulce fine sandy loam	2B (inclusion)	7" to hard, fract. SS	
64	Dulce fine sandy loam	2B (inclusion)	6" to hard, fract. SS	
65	Bond fine sandy loam	2B	13" to hard, fract. SS	Photos
66	Zyme clay loam	3AB	9" to weath. SH over SS	
67	Reclaimed Land	RL	-	Old sed. pond basin – taken out, reclaimed

TABLE 5

N12/N99S COAL RESOURCE AREA, 2773 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
68	Las Lucas sandy clay loam	15A	4'+	
69	Soil A-B very channery loam	16CE	3" to scoria	
70	Dulce channery loam	1AB	12" to fract. SS	Photos

TABLE 5

## N99N COAL RESOURCE AREA, 1645 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments /profile description
1	Pulpit fine sandy loam	5	39"	Profile description
2	Dulce channery loam	1AB	9" to fract. SS	
3	Dulce channery loam	5 (inclusion)	17" to fract. SS	
4	Dulce channery loam	1AB	14" to fract. shaly SS	
5	Pulpit very fine sandy loam	5	29" to hard, fract. SS	
6	Pulpit very fine sandy loam	5	23" to hard, fract. SS	
7	Blanding fine sandy loam	5 (inclusion)	7' to hard, fract. SS	
8	Zyme clay loam	3CD	4" to sandy SH	
9	Zyme clay loam	3CD	3" to sandy SH	
10	Las Lucas sandy clay loam	15A	6.3'	Drainage cut
11	Sharps very fine sandy loam	6AB	23" to SH & soft SS	
12	Sharps very fine sandy loam	6AB	24" to soft SH	
13	Zyme clay loam	3CD	13" to soft, sandy SH	
14	Sharps channery sandy loam	6AB	23"	Residual material from scoria
15	Scoria Rock Outcrop	16CE	2" to baked SS	
16	Dulce channery fine sandy loam	16CE (inclusion)	6" to baked SS	
17	Zyme clay loam	3CD	3" to SH	
18	Pulpit very fine sandy loam	1AB (inclusion)	27" to hard SS	
19	Dulce channery loam	3CD	14" to SS	
20	Soil A-B very channery sandy loam	16CE	27" to weath. baked bedrx	
21	Dulce channery sandy loam	6AB (inclusion)	14" to weath. SH	14 to 40" very weath. SH with roots
22	Sharps very fine sandy loam	6AB	32" to weath. SH	
23	Dulce channery loam	3CD	11" to fract. SS	
24	Las Lucas sandy clay loam	15A	7'+	Drainage cut
25	Sharps very fine sandy loam	6AB	23" to weath. SH	
26	Las Lucas sandy clay loam	15A	15'	Drainage cut
27	Las Lucas sandy clay loam	15A	20'	Drainage cut
28	Zyme clay loam	3CD	7" to weath. SH	Roots in SH to 24"
29	Soil A-B extremely channery sandy loam	16CE	11" to baked SH	
30	Sharps very fine sandy loam	3CD (inclusion)	24"	11 to 24" very weath. SH, photos
31	Blanding very fine sandy loam	2B (inclusion)	6' to weath. carb.SH	Major rooting depth to 38", photo
32	Bond channery fine sandy loam	2B	19" to weath. SH	Weath. SH 19 to 50", photo

TABLE 5

N99N COAL RESOURCE AREA, 1645 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments /profile description
33	Bond channery fine sandy loam	2B	19" to weath. SH	
34	Bond channery fine sandy loam	2B	14" to fract. scoria SS	
35	Soil A-B channery sandy loam	16CE	12" to mixed scoria	
36	Dulce channery loam	3DE	6" to fract. SS	
37	Zyme clay loam to clay	3DE	12" to weath. SH	
38	Sharps loam	3CD (inclusion)	24" to weath. SH	Major rooting depth 12"
39	Zyme clay loam	3CD	6" to weath. SH	
40	Dulce channery loam	3CD	11" to weath. SS	
41	Zyme clay loam	3CD	9" to weath. SH	
42	Zyme clay loam	3CD	6" to weath. SH	
43	Zyme clay loam	3CD	5" to weath. SH	
44	Dulce channery loam	1AB	10" to weath. SH	
45	Dulce channery sandy loam	1AB	8" to weath. SS	
46	Sandstone Rock Outcrop	7E	0"	
47	Travessilla channery sandy loam	7E	9" to SS	
48	Dulce channery sandy loam	3CD	4" to fract. SS	
49	Dulce channery loam	3AB	10" to fract. SS	
50	Dulce channery loam	3AB	12" to fract. SS	
51	Dulce channery loam	1AB	12" to weath. SH	
52	Pulpit very fine sandy loam	1AB (inclusion)	24" to fract. SS	

TABLE 5

## J2/J15 COAL RESOURCE AREA, 1664 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments /profile description
J2-1	Sharps channery very fine sandy loam	1AB (inclusion)	30"	Profile description, platy SH Cr 30 to 60"
J2-2	Zyme channery silty clay loam	1AB	7" to platy SH	Profile description
J2-3	Dulce very channery loam	1AB	9" to fract. SS	Profile description
J2-4	Dulce taxajunct very gravelly loam	1AB	10" to variable scoria	Profile description, variable scoria 10"+ with SS, SH, clinker (red with white ashy material)
J2-5	Dulce taxajunct channery loam	2B (inclusion)	10" to scoria with duric & petrocalcic features	Profile description, scoria substratum, open swale
J2-6	Bond taxajunct loam	2B	18" to fract. SS, hard SS @ 26"	Profile description, scoria substratum
J2-7	Bond very fine sandy loam	1AB (inclusion)	12"	Profile description
J2-8	Bond flaggy very fine sandy loam	2B	16" to fract. rock	Profile description
J2-9	Soil A	1AB (inclusion)	10"	
J2-10	Blanding channery loam	10AB	55" to SH Cr	Profile description, valley swale
J2-11	Dulce channery fine sandy loam	3DE	5"	Rock outcrop present, slopes go to 45%
J2-12	Bond very fine sandy loam	2B	9"	Profile description, Crk 9 to 21", hard SS @ 21", backslope
J2-13	Dulce very channery loam	1AB	12"	Profile description, Crk 12 to 29", hard scoria @ 29", backslope
J2-14	Chilton like very channery fine sandy loam	14AB	55"	Profile description, scoria @ 55"
J2-15	Oelop fine sandy loam	14AB	7.5'+	Profile description; open valley sideslope; ext. gravelly fine sandy loam 53 to 90"
J2-16	Oelop fine sandy loam	14AB	8'+	Profile description; ext. gravelly discontinuous strata 45 to 70", valley lower sideslope
J2-17	Oelop very fine sandy loam	14AB	8.3'+	Scoria R @ 8.3'
J2-18	Oelop very gravelly-channery very fine sandy loam	14AB	6.8' to gravel	Profile description; gravel 6.8 to 8.6', then hard scoria, lower valley
J2-19	Oelop very fine sandy loam	14AB	9'+	Profile description; gravelly lense @ 3 to 5', valley sideslope
J2-20	San Mateo very fine sandy loam	13A	8' to SH	Profile description, terrace, common salt filaments & seams 85 to 96" (7 to 8')
J2-21	Travessilla very channery loam	1AB (inclusion)	7" to SS	
J2-22	Travessilla very cobbly fine sandy loam	1AB (inclusion)	6"	
J2-23	Blanding very fine sandy loam	10AB	5.7'	Profile description, white SS @ 5.7'
J2-24	Oelop loam	14AB	7.5'	Very gravelly loamy fine sand 55 to 70"
J2-25	Zyme clay loam	3CD	6"	Depth ranges from 6 to 30", gullied
J2-26	Dulce loam	1AB	12"	

TABLE 5

## J2/J15 COAL RESOURCE AREA, 1664 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments /profile description
J2-27	Dulce very channery loam	1AB	9" to white SS	Profile description, shoulder, drainage exceeds 8% to the south
J2-28	Sharps very fine sandy loam	6AB	25"	SH with clinker @ 25", hard @ 58"
J2-29	Dulce like loam	1AB	9"	White SS @ 9"
J2-30	Blanding loam	10AB	50"	Cr 50 to 74", then hard rock
J2-31	Begay very fine sandy loam	12AB	12'	
J2-32	Pulpit very fine sandy loam	5	32"	SS/scoria @ 32"
J15-1	Soil A very channery loam	16C	4" to carbonates	Profile description, backslope-nose, very to ext gravelly loam to sandy loam @ 4 to 30", scoria @ 30", PJ veqt.
J15-2	Soil A very channery loam	16C	5" to carbonates	Profile description, convex summit, very channery loam to sandy loam 5 to 28", ext channery loamy sand 28 to 64", then hard scoria
J15-3	Oelop very fine sandy loam	14AB	62"	Profile description, valley sideslope, olive SH 62 to 88", then SS
J15-4	Dulce loam	1AB	8"	Cr SH/coal
J15-5	Bond like very fine sandy loam	2B	21"	Profile description, open summit, sandy clay loam Crk 21 to 32", then hard SS
J15-6	Travessilla fine sandy loam	7B	4" to buff SS	Profile description, convex summit
J15-7	Sharps like very fine sandy loam	6AB	25"	Profile description, summit, Crk 25 to 45", then buff SS
J15-8	Sharps like very fine sandy loam	6AB	18" to soft SH	
J15-9	Sharps very fine sandy loam	6AB	28" to gray SH	Profile description, open swale
J15-10	Soil A very cobbly loam	16C	7" to fract. scoria	Profile description, backslope, sage with scattered PJ
J15-11	Soil A very cobbly loam	16C	6" to fract. Scoria	Profile description, backslope, sage
J15-12	Soil B extremely channery loam	16CE	7" to fract. Scoria	Profile description, backslope, PJ
J15-13	Soil A very channery loam	16C	8" to fract. Scoria	Profile description, backslope, PJ & sage
J15-14	Blanding loam	11AB	7.8' to soft SH	Profile description, sage
J15-15	Travessilla very fine sandy loam	7B	9"	
J15-16	Sharps very fine sandy loam	6AB	36" to soft SS & SH	
J15-17	Soil A extremely cobbly loam	16C	18" to scoria	
J15-18	Blanding loam	10AB	45" to Cr SS & SH	
J15-19	Travessilla very fine sandy loam	1CD	8" to white SS	
J15-20	Oelop/Blanding very fine sandy loam	10AB	60" to gray platy SH	Profile description
J15-21	Blanding very fine sandy loam	X11AB	8'+	Profile description, valley sideslope, sage, hard SS at 8.3'
J15-22	Pulpit very fine sandy loam	5	34" to hard SS	Profile description, open swale, sage
J15-23	Pulpit very fine sandy loam	1AB (inclusion)	21"	Profile description, ridge, PJ, Crk 21 to 39", then hard SS

**TABLE 5**

**J2/J15 COAL RESOURCE AREA, 1664 Acres**

<b>Hole#</b>	<b>Soil Name - surface texture</b>	<b>Map Unit</b>	<b>Depth to rock</b>	<b>Comments /profile description</b>
J15-24	Pulpit like very fine sandy loam	1AB (inclusion)	39"	Profile description, upland, PJ, Crk very fine sandy loam 39 to 50", then hard SS
J15-25	Travessilla very channery fine sandy loam	7B	8"	Patches of scoria & Dulce
J15-26	Blanding very fine sandy loam	11C	8.3'+	Profile description, valley dissected & gullied, loam & very fine sandy loam textures, slightly coarser sands with depth
J15-27	Begay gravelly very fine sandy loam	12AB	6'+	Alluvial fan, stratified very fine sandy loam, fine sandy loam, and loam
J15-28	Sharps very channery fine sandy loam	6C	39" to SH & SS	Gullied
J15-29	Soil A	16C	5"	

TABLE 5

J4 COAL RESOURCE AREA, 524 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
1	Blanding very fine sandy loam	5 (inclusion)	51"	Profile description; Crk 51 to 70", then white SS @ 70"
2	Soil B very channery loam	1AB (inclusion)	7"	Profile description
3	Sharps very fine sandy loam	6AB	25 to 36" (30")	
4	Sharps very fine sandy loam	6AB	35"	35 to 45" weath. SH
5	Blanding loam, very fine sandy clay loam	6AB (inclusion)	58"	Buried argillic; white SS @ 58"
6	Bond very fine sandy loam	2B	17"	SH and SS Cr in same pit
7	Begay fine sandy loam	12C	8'+	Dissected
8	Sharps very fine sandy loam	6AB	39"	Gray SH Cr 39 to 45", then hard SS
9	Blanding very fine sandy loam	X11AB	8.1'	Profile description, 97 to 120" soft SS, then hard, white SS
10	Blanding very fine sandy loam	11AB	11'	0 to 7' very fine sandy loam & sandy clay loam; 7 to 11' loamy fine sand
11	Sharps very fine sandy loam	6AB	38"	SH Cr 38 to 66", then hard scoria
12	Pulpit very fine sandy loam	5	20"	20 to 28" Cr, then hard, white SS
13	Pulpit very fine sandy loam	5	18"	Surface disturbed
14	Dulce like very channery loam	1AB	8"	Profile description
15	Zyme channery clay loam	3DE	6"	Gray, calcareous SH Cr
16	Dulce channery very fine sandy loam	3CD	8"	Gray SH Cr; also inclusion of Sharps
17	Dulce very channery loam	1AB	8"	Buff SS & olive gray SH Cr

TABLE 5

## J6/J14 COAL RESOURCE AREA, 2343 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
J6-1	Begay loamy fine sand	X11AB (inclusion)	10.5' to SS	Profile description, backslope, wind reworked
J6-2	Unnamed inclusion	X11AB (inclusion)	7.8'	Profile description, slickspot – barren, blowout surface
J6-3	Sharps very fine sandy loam	6AB	32" to gray SH	Profile description, convex ridge, depth to SH varies in pit from 32 to 42"
J6-4	Travessilla very fine sandy loam	7B	5" to hard SS	Upland dissection up to 15% slopes
J6-5	Pulpit very fine sandy loam	5	26" to SS	Profile description, bench, shadscale vegetation
J6-6	Blanding very fine sandy loam	10AB	6.3' to gray shale	Profile description, bench, shadscale vegetation
J6-7	Begay very fine sandy loam	X11C (inclusion)	10.5'+	Profile description, bench, 6% slope but sides range up to 12%, annual vegetation
J6-8	Blanding very fine sandy loam	X11AB	49" to Cr SH	
J6-9	Sharps very fine sandy loam	6AB	24" to Cr mudstone	8" to strong carbonates
J6-10	Soil A	16CE	14"	Profile description, backslope
J6-11	Blanding very fine sandy loam	10AB	60" (5') to Cr SH, rock @ 66"	Profile description, bench, shadscale vegetation
J6-12	Pulpit very fine sandy loam	6AB (inclusion)	27", to Cr, rock @ 36"	Profile description, bench, shadscale vegetation, >18% clay Bt
J6-13	Sharps like very fine sandy loam	6AB	26"	Profile description, bench, shadscale vegetation, platy SH & SS digs easy to 60"
J6-14	Blanding very fine sandy loam	X11C	9.5'+	
J6-15	Blanding very fine sandy loam	X11C	10'+	0 to 50" very fine sandy loam, 50 to 125" loamy fine sand (lee side of hilltops)
J6-16	Sharps loamy very fine sand	6AB	28" to Cr SH	
J6-17	Blanding very fine sandy loam	10AB	60", variable depth	60" to gravelly sandy loam/loamy sand, 86" to Cr SH, 3% slope
J6-18	Blanding very fine sandy loam	10AB	70"	Weath. scoria
J6-19	Blanding very fine sandy loam	X11C	12'+	72-140" loamy very fine sand, loamy fine sand, 8% slope
J6-20	Blanding very fine sandy loam	X11AB	9' to SS	0 to 5' very fine sandy loam, 5 to 9' gravelly very fine sandy loam
J6-21	Travessilla fine sandy loam	7B	10"	
J6-22	Dulce channery loam	1AB	14"	Sharps inclusions on bench
J6-23	Pulpit very fine sandy loam	6AB (inclusion)	38"	Inclusions of Rock Outcrop and Dulce
J6-24	Zyme channery clay loam	3AB	6"	Slopes range to 15%
J6-25	Blanding very fine sandy loam	10C	52"	8% slope, eroded
J6-26	Dulce very channery fine sandy loam	3DE	6"	Inclusions of Sharps, Pulpit, and Zyme
J6-27	San Mateo loam	13A	12'+	Greasewood vegetation
J6-28	Zyme	3DE	<6"	15-20% RO,
J6-29	Sharps very fine sandy loam	6AB	30"	Eroded, patches of Zyme & Blandin

**TABLE 5**

**J6/J14 COAL RESOURCE AREA, 2343 Acres**

<b>Hole#</b>	<b>Soil Name - surface texture</b>	<b>Map Unit</b>	<b>Depth to rock</b>	<b>Comments / profile description</b>
J6-30	Sharps very fine sandy loam	6C	30"	Inclusions of Blanding eroded
J14-1	Blanding very fine sandy loam	6AB (inclusion)	44" to gray SH with scoria fragments	Profile description, Cr SH 44 to 60"
J14-2	Sharps very fine sandy loam	6AB	37" to Cr SH	Profile description, upland
J14-3	Pulpit very fine sandy loam	6AB (inclusion)	36" to white SS	5% slope
J14-4	Blanding very fine sandy loam	10AB	45" to hard, white SS	2% slope
J14-5	Blanding very fine sandy loam	6AB (inclusion)	55" to olive, cal SH	Profile description, 4% slope
J14-6	Bond very fine sandy loam	2B	13" to hard SS/scoria	3% slope
J14-7	Blanding very fine sandy loam	11AB	9' to SS	4% slope
J14-8	Blanding very fine sandy loam	X11AB	88"+	6% slope, loamy fine sand 64 to 88"
J14-9	Pulpit very fine sandy loam	6C (inclusion)	30"	SS & SH observed in gully, moderately deep
J14-10	Blanding very fine sandy loam	5 (inclusion)	66" to white SS	6% slope
J14-11	Soil A very channery loam	16C	6" to white SS	Profile description, shoulder, 4% slope
J14-12	Dulce loam	1AB	20"	Sharps inclusions
J14-13	Blanding very fine sandy loam	10AB	60" to interbedded SS & SH	
J14-14	Dulce very fine sandy loam	1AB	12"	Inclusions of Zyme and Sharps
J14-15	Sharps very fine sandy loam	6C	30"+	Incised Sharps and Blanding
J14-16	Dulce channery loam	3AB	8" to SS	Sharps inclusions
J14-17	Pulpit very fine sandy loam	5	24" to hard SS	
J14-18	Soil A	16C	4" to hard SS	Both hard SS & scoria present
J14-19	Scoria-SS	16C	0"	

TABLE 5

## J8 COAL RESOURCE AREA, 717 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
1	Begay fine sandy loam	12AB	7.5'+	Valley fill
2	Sharps taxajunct very channery fine sandy loam	6AB	36" to SH	2Bck @ 13 to 36" clay
3	Sharps very fine sandy loam	6AB	26" to SH	Eroded surface, Bk 8 to 26"
4	Sharps very fine sandy loam	6AB	33" to soft SS	Bk 18 to 33"
5	Dulce very channery fine sandy loam	6AB (inclusion)	15" to SH	SH is soft, gray & calcareous
6	Blanding very fine sandy loam	10AB	56" to SH	Btk at 12", es at 22"
7	Blanding very fine sandy loam	10AB	58" to SS	Dissected land
8	Dulce very channery loam	1AB	5" to fract. SS	7% slope, 10% Rock Outcrop
9	Blanding very fine sandy loam	X11AB	13' to soft SH	Loamy fine sand @ 42 to 85"
10	Sharps taxajunct very fine sandy loam	6AB	23"	23 to 34" calcic, 34"+ dark SH/coal
11	Sharps very fine sandy loam	6AB	23"	Soft SH to 76"
12	Blanding very fine sandy loam	X11AB	60" to SH	Profile description, 2% slope
13	Zyme clay loam	3AB	18"	Also Dulce 6" to Cr, also Sharps eroded
14	Blanding very fine sandy loam	X11AB	52" to SS	
15	Sharps very fine sandy loam	10AB (inclusion)	22" to SS & SH	
16	Blanding very fine sandy loam	10AB	51" to fract. white SS	
17	Blanding very fine sandy loam	10AB	40"	Coal/SH at 40 to 60" in gully
18	Sharps taxajunct very fine sandy loam	6AB	25"	Weak argillic, coal @ 25"
19	Blanding very fine sandy loam	10AB	72" to SH	
20	Sharps very fine sandy loam	6AB	33" to SH	Well developed argillic
21	Blanding very fine sandy loam	6AB (inclusion)	58" to SS & SH	
22	Sharps very fine sandy loam	6AB	38" to SS & SH	
23	Sharps very fine sandy loam	6C	36"	Dissected (gullied), inclusions of Blanding
24	Blanding very fine sandy loam	X11AB	48" to SH	
25	Blanding very fine sandy loam	X11AB	72"+	
26	Blanding taxajunct fine sandy loam	X11AB	74" to SH	2' of fine sandy loam eolian on top
27	Unnamed loamy fine sand	10C (inclusion)	72"+	Psamment, old substratum, CO3 24-40" weakly cemented
28	Sharps very channery fine sandy loam	6AB	36"	Eroded, Zyme in gullies

TABLE 5

## J9 COAL RESOURCE AREA, 550 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
1	Zyme sandy clay loam	7CD	8" to somewhat weath. SH	Complete profile description
2	Travessilla gravelly fine sandy loam	7CD	7" to hard SS	Complete profile description
3	Bond fine sandy loam	2B	12" to hard SS	Complete profile description
4	Reclaimed Land	RL	6" weath. OB	Complete profile description
5	Bond sandy loam	2B	13" to SH	Complete profile description
6	Bond channery fine sandy loam	2B	12" to hard SS	Complete profile description
7	Travessilla sandy loam	7CD	9" to hard SS	Complete profile description
8	Zyme very channery clay loam	7CD	3" to weath. SH	Complete profile description
9	Sharps, ustic-aridic, fine sandy loam	6AB	33" to soft SS	Complete profile description
10	Dulce channery fine sandy loam	3AB	9" to soft SS	Complete profile description
11	Bond fine sandy loam	2B	20" to weath. SH	Complete profile description
12	Bond fine sandy loam	2B	20" to hard SS	Complete profile description
13	Blanding, bedrock substratum, fine sandy loam	11AB (inclusion)	65" to somewhat soft SH	Complete profile description
14	Blanding fine sandy loam	10AB (inclusion)	72" to hard SS	Complete profile description
15	Blanding fine sandy loam	11AB	80"+	Complete profile description
16	Blanding fine sandy loam	11AB	96"+	Complete profile description
17	Sharps, ustic-aridic, fine sandy loam	6AB	26" to weath. SH	Complete profile description
18	Begay very fine sandy loam	12AB	108"+	Complete profile description
19	Blanding fine sandy loam	11AB	87"	Complete profile description
20	Blanding loamy sand	11AB	65"+	Complete profile description
21	Begay fine sandy loam	12AB	89"+	Complete profile description
22	Blanding fine sandy loam	11AB	80"+	Complete profile description
23	Blanding sandy loam	11AB	80"+	Complete profile description
24	Begay fine sandy loam	12AB	88"+	Complete profile description
25	Blanding fine sandy loam	10AB (inclusion)	106"+	Complete profile description
26	Blanding fine sandy loam	11AB	108"+	Complete profile description
27	Travessilla gravelly sandy loam	7CD	6" to hard SS	Complete profile description
28	Bond fine sandy loam	2B	16" to hard SS	Complete profile description
29	Zyme clay loam	7B	4" to weath. SH	Complete profile description
30	Blanding fine sandy loam	11AB	72"	Complete profile description

TABLE 5

## J10 COAL RESOURCE AREA, 592 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile descriptio
1	Begay very fine sandy loam	12AB	5'+	Fan position, 4% slope, gravel @ 60"
2	Zyme channery silty clay loam	3AB	10"	
3	Travessilla very channery loam	7CD	6"	Rock Outcrop ledges approx. 25%, Zyme inclusions
4	Dulce very channery loam	1AB	8"	Scoria influence, 6% slope
5	Blanding very fine sandy loam	X11AB	4.5'	C03 at 14", fine sandy loam at 40"
6	Zyme clay loam	3CD	12"	
7	Blanding very fine sandy loam	X11AB	6'+	C03 at 12", loamy fine sand at 40"
8	Dulce channery fine sandy loam	3CD	12"	Dulce-Zyme-Travessilla-Rock Outcrop present
9	Dulce very channery loam	1AB	6"	PJ vegetation
10	Pulpit very fine sandy loam	1AB (inclusion)	22"	
11	Pulpit very fine sandy loam	1AB (inclusion)	24"	
12	Pulpit very fine sandy loam	5	30"	Calcic at 12"
13	Zyme very channery clay loam	7B	10"	Shoulder position, 6% slope, SS ledges present
14	Zyme very channery loam	3CD	16"	Profile description, 8% slope, PJ vegetation, SS-SH & scoria influence
15	Travessilla very channery fine sandy loam	7CD	15"	Profile description
16	Pulpit very fine sandy loam	5	34"	Eroded
17	Dulce very channery very fine sandy loam	3CD	8"	Zyme-Dulce-Travessilla present
18	Dulce very channery loam	3AB	16" to fract. White & red SS	
19	Dulce very channery loam	1AB	10"	Bedrock is mix of SS, SH, and scoria
20	Dulce very channery loam	1AB	6"	PJ vegetation
21	Pulpit very fine sandy loam	5	21" to fract. SS	15% Rock Outcrop & Dulce soils
22	Oelop very fine sandy loam	14AB	6'+	Valley fill, loam 0 to 36", fine sandy loam 36 to 72"
23	Sharps very fine sandy loam	6C	36"	
24	Blanding fine sandy loam	X11AB	5'+	Btk @ 24"
25	Blanding very fine sandy loam	X11AB	8'+	
26	Blanding very fine sandy loam	X11C	6' to SS	Dissected, eroded, variable depths
27	Blanding very fine sandy loam	X11C	5.5' to SH	Blackslope, eroded, Zyme & Begay in bottoms
28	Blanding very fine sandy loam	10C	50"	Summit noseslope
29	Blanding fine sandy loam	1CD (inclusion)	54"	Blackslope, eroded
30	Blanding very fine sandy loam	X11AB	8'+	Old eolian loamy fine sand @ 5 to 8'
31	Pulpit	5	24"	BCK @ 14", Rock @ 24"
32	Sharps very fine sandy loam	6AB	24" to gray SH	10% inclusions of Dulce & Zyme
33	Sharps very fine sandy loam	6AB	30" to soft SH	0 to 18" very fine sandy loam, 18 to 30" clay
34	Blanding very fine sandy loam	X11AB	5' to gray SH	Profile description, summit, 3% slope
35	Sharps very fine sandy loam	6AB	20" to Cr SH	Silty clay loam C horizon at 12"
36	Dulce very channery fine sandy loam	1AB	6"	Scoria, SS & SH bedrock with Sharps remnants

TABLE 5

J10 COAL RESOURCE AREA, 592 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
37	Blanding very fine sandy loam	X11AB	48" to scoria	Profile description, convex summit
38	Blanding very fine sandy loam	X11AB	7' to SH	Profile description, backslope, soft SH from 7 to 9'
39	Blanding very fine sandy loam	10AB	53" to hard SS	6% slope
40	Pulpit very fine sandy loam	5	24" to hard SS	6% slope
41	Blanding very fine sandy loam	10AB	48" to SH	SS at 70"
42	Blanding very fine sandy loam	5 (inclusion)	43"	
43	Sharps very fine sandy loam	1AB (inclusion)	16"	Eroded, remnant inclusion in 1AB
44	Travessilla flaggy fine sandy loam	7B	10"	Zyme very channery loam also present

TABLE 5

## J28 COAL RESOURCE AREA, 1406 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
1	Blanding very fine sandy loam	X11AB	7.5' to SH	Mollic surface, loam & very fine sandy loam to SH, Bk1 @ 20"
2	San Mateo very fine sandy loam	13A	18'	Profile description, terrace, very few gravels-uniform texture throughout profile, generally loam
3	Blanding very fine sandy loam	X11C	76" to hard SS	PJ vegetation, 8% slope
4	Blanding very fine sandy loam	X11AB	87"	Profile description, valley side, borderline mollic
5	San Mateo very fine sandy loam	13A	15'	SS rises to 7' east of knoll
6	Blanding channery very fine sandy loam	X11C	86"	Profile description, knoll, very gravelly fine sandy loam 75 to 86", PJ vegetation, 6% slope, dissected
7	San Mateo very fine sandy loam	13A	15'+	12 to 15' are very gravelly
8	Oelop very fine sandy loam	14AB	21'+	Loam Bt
9	San Mateo channery loam	14AB (inclusion)	17'	6 to 17' alternating loamy & gravelly
10	Oelop channery very fine sandy loam	14AB	17'+	7 to 17' alternating gravelly & loamy
11	Unnamed gravelly very fine sandy loam	X11C	6'	50 to 72" gravelly very fine sandy loam
12	Oelop very channery very fine sandy loam	14AB	10.5' to SS & SH	Eroded valley fill
13	Oelop channery very fine sandy loam	14AB	12'+	6% slope, very fine sandy loam, loam, and clay loam textures
14	San Mateo loam	13A	12'+	2% slope, loamy, greasewood
15	Blanding channery very fine sandy loam	X11AB	6'	Profile description, mollic surface layer
16	San Mateo loam	13A	18'+	6 to 12' gravelly mix with loams & very fine sandy loam above & below, saline filaments visible at depth
17	Travessilla channery fine sandy loam	7B	20" to hard, white SS	Bench, 3% slope
18	Unnamed fine sandy loam	X11C	8.6'+	Profile description, valley side, 9% slope, old alluvium with relic mottles 16" to 103" (8.6'), SS flagstones at 8.6'
19	San Mateo loam	13A	20'+	Loam textures with scattered 3-5" gravelly strata
20	Blanding very fine sandy loam	10AB	5' to SS	Mollic upper 12", 4% slope
21	San Mateo loam	13A	10' to SS	SS exposed at depth along drainageway
22	Unnamed channery loam	6AB (inclusion)	46" to rock	Profile description, 0 to 26" old channery alluvium, 26 to 46" shaly C horizon, mollic surface 0 to 8"
23	Blanding very fine sandy loam	14AB (inclusion)	10'+	0 to 16" A, Bt; 16 to 42" Bk, 42-57" loamy fine sand
24	San Mateo loam	13A	12'+	Profile description, terrace, 2% slope, all horizons stratified, variable textures, irregular OM%
25	Oelop fine sandy loam	14AB	12'+	Profile description, valley side, 7% slope

TABLE 5

## J28 COAL RESOURCE AREA, 1406 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
26	Oelop fine sandy loam	14AB	10'+	Fine sandy loam/sandy clay loam A,Bt; substratum to 10' sandy clay loam, very fine sandy loam, silty clay loam, and loam
27	Travessilla like very channery fine sandy loam	7B	19" to buff-white SS	Profile description, has an argillic, loses argillic near Rock Outcrop's
28	Dulce-Travessilla very channery fine sandy loam	7B	10" to SS	Channers easily crushable
29	Unnamed gravelly fine sandy loam	X11C (inclusion)	6'+	Profile description, 5% slope, gravelly alluvium, Chilton like
30	Blanding very fine sandy loam	X11AB	9.5'+	7% slope, textures include very fine sandy loam and loam
31	Blanding channery very fine sandy loam	14AB (inclusion)	55" to SH	Eroded
32	Sharps channery very fine sandy loam	6AB	30" to SH	
33	Oelop channery very fine sandy loam	14AB	10' to SH	Eroded, variable textures
34	Zyme very channery clay loam	7E	6"	35% slope with SS fragments
35	Dulce very channery loam	3CD	6" to fract. SS	
36	Dulce channery loam	1AB	10" to soft, fract. SS	
37	Blanding channery very fine sandy loam	X11C	8.5'	Dissected, gravelly alluvium @ 8.5'
38	Sharps channery very fine sandy loam	6AB	21" to SH	Eroded & shaly
39	Dulce very channery loam	1AB	5" to fract. SS	
40	Zyme very channery clay loam	3AB	8" to SH	Dulce over fract. SS also present
41	Zyme channery clay loam	3DE	6" to fract. SS	40% slopes, smoother slopes
42	Dulce channery loam	3AB	8"	Zyme-Travessilla-Dulce 4 to 12" to rock
43	Blanding very fine sandy loam	X11C	9'+	Dissected valley remnant
44	Oelop channery very fine sandy loam	3AB (inclusion)	11'+	Dissected inclusion in 3AB
45	Bond channery very fine sandy loam	5 (inclusion)	12" to SS	
46	Oelop channery loam	14AB	11' to soft SS	Eroded, range overgrazed
47	Zyme channery clay loam	3CD	8"	
48	Blanding very fine sandy loam	X11C	6'+	Dissected, PJ vegetation
49	Oelop very channery very fine sandy loam	14AB	10.5'+	Eroded, 5-10% gravels throughout
50	Zyme channery clay loam	7B	7"	Dulce-Zyme-Travessilla, higher OM%, more clay than typical
51	Oelop very channery very fine sandy loam	14AB	7'+	
52	Oelop channery very fine sandy loam	6AB (inclusion)	5'+	Higher OM%, remnant in 6AB
53	Dulce channery loam	7B	6"	Higher OM% & some argillic inclusion
54	Dulce very channery fine sandy loam	3DE	9"	Unit is 3 to 16" to rock
55	Zyme very channery loam	7B	6" to rock	
56	Soil A extremely channery to extremely cobbly loam	16CE	3"	45% slope

TABLE 5

J28 COAL RESOURCE AREA, 1406 Acres

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile descriptio
57	Bond very fine sandy loam	1AB (inclusion)	12" to hard SS	3% slope
58	Travessilla channery very fine sandy loam	1AB (inclusion)	18" to SS	
59	Pulpit very fine sandy loam	6AB (inclusion)	40" to SS	
60	Sharps very fine sandy loam	6AB	36" to SH	

**ATTACHMENT 1**

**Approval Letter from Office of Surface Mining (OSM) Regarding Proposed  
Soils Scope-of-Work (SOW); and OSM Soil Suitability Table  
“Topsoil and Topsoil Substitute Suitability Criteria for the Southwestern  
United States”**



IN REPLY REFER TO:

# United States Department of the Interior

OFFICE OF SURFACE MINING  
Reclamation and Enforcement  
1999 Broadway, Suite 3320  
Denver, Colorado 80202-5733

*c: Wendt  
Schlenker  
Pflanzenstiel  
Cohen  
Lohn*

AZ0001

June 25, 2003

Mr. Brian Dunfee  
Environmental Engineering Manager  
Peabody Western Coal Company  
P.O. Box 650  
Navajo Route 41  
Kayenta, Arizona 86033

**RE: Baseline Wildlife, Soils and Overburden Studies-Black Mesa Complex**

Dear Mr. Dunfee:

The Office of Surface Mining (OSM) is in receipt of Peabody Western Coal Company's (PWCC) letters dated June 3, 2003 and June 19, 2003. The letters described PWCC's proposals for gathering baseline data regarding wildlife, soils and overburden in un-mined coal resource areas. This data will be used for future mine planning and permitting activities.

We have discussed PWCC's approach to gathering this data during phone conversations and you have received, via email, OSM's Guidance for soil and overburden sampling. PWCC's previous sampling (122 deep cores) and the continuing regraded spoil sampling program, in the existing mining areas, has resulted in excess of 6,000 samples and analyses. The current proposal for soil and overburden sampling is less intense than is recommended in the OSM Guidance. However, based on the above information, OSM is confident that the proposed sampling schemes will provide the needed information as to soil and overburden quality. In addition, PWCC has committed to doing additional overburden sampling if the results of the initial sampling indicates there are unexpected changes in overburden quality from mined areas or areas currently being mined.

PWCC has continued to monitor, on an annual basis, several threatened and endangered (T&E) wildlife species and species of special interest and has conducted wildlife studies on an ongoing basis within the leasehold. Therefore, focusing on T&E species and species of special interest and their critical habitat should be satisfactory baseline for future mine planning and permitting activities.

Therefore, based upon PWCC's description of proposed baseline studies for wildlife, soils and overburden OSM concurs with the proposals referenced in the above cited letters.

By copy of this letter, OSM/WRCC requests PWCC, other OSM offices, and other agencies to file the attached material appropriately.

If you have questions or concerns please contact me at 303-844-1400 x1496.

Sincerely;

A handwritten signature in black ink that reads "Jerry D. Gavette". The signature is written in a cursive style with a long horizontal flourish extending to the right.

Jerry D. Gavette, Leader  
Black Mesa/Kayenta Mine Team

cc/with enc: AFO  
BIA-Navajo Regional Office  
BIA-Western Regional Office  
BLM-Phoenix  
Forest Lake Chapter House  
Hopi Office of Realty Services  
Hopi Office of Mining &  
Mineral Resources  
Navajo Minerals Department

**TOPSOIL AND TOPSOIL SUBSTITUTE SUITABILITY CRITERIA\***  
**FOR THE SOUTHWESTERN UNITED STATES**

<b>Parameter - - - - - Material Quality - - - - -</b>			
	<b>Good</b>	<b>Marginal</b>	<b>Unsuitable</b>
PH	6.0-8.4	5.5-6.0 8.4-8.8	< 5.5 > 8.8
EC mmhos/cm (1)	< 4.0	4.0-12.0	> 12.0
SAR (2)			
sl and coarser	< 12.0	12.0-18.0	> 18.0
1 and cl	< 10.0	10.0-16.0	> 16.0
40% clay	< 8.0	8.0-14.0	> 14.0
Texture (3)	ls, sl, 1, sil, with 35% c	s, lcs, cl, sicl with 45% c	>45% c
Saturation %	25-80	25-80	<25 or >80
CaCo3 %	0-15	15-30	30
Coarse Fragments (4)			
< 3 inch %	15	15-35	35
> 3 inch %	3	3-10	10
Erosion Factor (5)	< .37	< .37	
Acid-base potential	+5 T CaCO3 equiv./1000T	+0 T CaCo3 equiv./1000T	-5 T CaCO3 equiv./1000T
Boron	5 ppm	5 ppm	>5 ppm
Selenium (Total)		≤ 0.8 ppm	> 0.8 ppm
Selenium (Extractable)		≤ 0.15 ppm	> 0.15 ppm

\*These suitability criteria may be modified on a case by case basis if sufficient data are submitted to support the modifications and the

submitted data technically represent the site specific nature of the modification.

1. When EC is less than 2.0, then SAR's can not be >18.
2. SAR values can be modified if adequate data is submitted to support proposed modifications.
3. ls=loamy sand; lcs=loamy coarse sand; sl=sandy loam; l=loam; sil=silt loam; scl=sandy clay loam; s=sand; cl=clay loam; sicl=silty clay loam; cl=clay.
4. For topsoil substitutes/supplements, percentage can be increased if it is shown that the higher percentage will increase slope stability and/or vegetation establishment. Suitabilities will be determined on a site specific basis.

**ATTACHMENT 2**

**Black Mesa Lease Area  
Map Unit Descriptions  
(Intermountain Soils, Inc. 1985)**

## Order 1 and 2 Map Unit Descriptions

- 1A Dulce very channery fine sandy loam, 1 to 4 percent slopes.
- 1, 1B Dulce very channery fine sandy loam, 4 to 8 percent slopes.
- 1C Dulce very channery fine sandy loam, 8 to 15 percent slopes.
- 1D Dulce very channery fine sandy loam, 15 to 30 percent slopes.

The less steep phases of these map units are found on ridge crests and shoulders whereas the steeper phases are found on shoulders and sideslopes. The soils in these map units are reddish brown and have a surface layer high in rock fragments. Depth to soft or fractured sandstone bedrock is 2 to 10 inches with bedrock generally occurring at less than 6 inches. Contrasting soils which may occur in these map units include Zyme soils found on sideslopes and Bond soils found on ridge crests, soils with bedrock deeper than 20 inches found in concave areas and rock outcrop occurring as narrow escarpments. Similar soils which may occur in these map units include soils with over 35 percent rock fragments, soils that are non-calcareous throughout, and Travessilla soils.

Dulce soils are marginally suitable for topsoil and are limited by the amount of rock fragments on the soil surface. The shallow depth to bedrock of these soils may restrict the amount of soil which can be salvaged. The included Bond soils have a good suitability for topsoil and should be salvaged where practicable.

- 2B Bond very fine sandy loam, 1 to 8 percent slopes.

This map unit occurs on ridge crests and shoulders throughout the lease area. The Bond soils are reddish throughout and have a surface layer high in very fine sand. Depth to hard sandstone bedrock is between 12 and 20 inches. Contrasting soils which may occur in these map units include Dulce soils on shoulders and Sharps soils near the delineated boundaries of this map unit. Soils similar to Bond which may occur in these map units include soils with less than 18 percent clay, soils with less very fine sand, and soils underlain by soft bedrock.

Bond soils are suitable for topsoil and have an average stripping depth of 12 inches. The high very fine and fine sand content make these soils susceptible to wind and water erosion.

- 3A Zyme-Dulce complex, 2 to 8 percent slopes.
- 3BC Zyme-Dulce complex, 2 to 15 percent slopes.
- 3C Zyme-Dulce complex, 6 to 15 percent slopes.
- 3D Zyme-Dulce complex, 15 to 30 percent slopes.
- 3DE Zyme-Dulce complex, 15 to 50 percent slopes.
- 3E Zyme-Dulce complex, 30 to 50 percent slopes.

The less steep phases of these map units are found on ridge crests and shoulders whereas the steeper phases are found on ridge sideslopes. Generally, Zyme soils are found on the steeper portions of the map units. Zyme soils are variable in color, depending on the color of the underlying shale bedrock. They are clayey throughout and have numerous surficial rock fragments. Dulce soils are reddish brown and also have a surface layer high in rock fragments. Both these soils in these map units are extremely eroded. Depth to soft or fractured bedrock is 2 to 10 inches with bedrock generally occurring at less than 6 inches. Contrasting soils which may occur in these map units include soils deeper than 20 inches, Bond soils, and Soils A and B. Bond soils and Soils A and B are found on ridge crests and sideslopes, and the soils deeper than 20 inches are found in concave areas. Rock outcrop occurs as narrow escarpments. Similar soils which may occur in these map units include those with over 35 percent rock fragments, soils that are non-calcareous throughout, and Travessilla soils.



The soils in these map units are marginally suitable for topsoil and are limited by clayey texture of the Zyme soils and high surficial rock fragment content of both soils. The shallow depth to bedrock of these soils may restrict the amount of soil which can be salvaged. The included Bond soils have a good suitability for topsoil and should be salvaged where practicable.

**3F Ustic Torriorthents-rock outcrop complex, 50 to 80 percent slopes.**

This map unit occurs on very steep sideslopes of ridges. Because of the slope steepness and the interbedded nature of the bedrock, soils are quite variable and mapped only to the subgroup level. Rock outcrop consists of areas of exposed sandstone or shale bedrock. The soils in this map unit are not considered salvageable because of the steep slopes and high amounts of rock outcrop.

**4A Zyme very channery loam, 1 to 4 percent slopes.**

**4B Zyme very channery loam, 4 to 8 percent slopes.**

**4C Zyme very channery loam, 8 to 15 percent slopes.**

**4D Zyme very channery loam, 15 to 30 percent slopes.**

The less steep phases of these map units are generally found on toeslopes or upper sideslopes, and the steeper phases are found on sideslopes. Zyme soils are variable in color, depending on color of the underlying shale bedrock. They are clayey throughout and have a surface high in rock fragments. Depth to shale bedrock is 2 to 10 inches with bedrock generally occurring at less than 6 inches. Contrasting soils which may occur in these map units include Dulce and Bond soils found on crests and sideslopes, and soils deeper than 20 inches occurring in concave areas. Rock outcrop, where present, occurs as narrow escarpments. Similar soils which may occur in these map units include soils that are non-calcareous throughout and soils with less clay.

The soils in these map units are marginally suitable for topsoil and are limited by clayey texture and high surficial rock fragment content. The shallow depth to bedrock of these soils may restrict the amount of soil which can be salvaged. The included Bond soils have a good suitability for topsoil and should be salvaged where practicable.

**5 Pulpit very fine sandy loam, 2 to 8 percent slopes.**

This map unit occurs on valley sideslopes, and crests and sideslopes of ridges. The soils in this map unit are reddish brown and have a surface layer high in very fine sand. Depth to hard sandstone bedrock is 20 to 40 inches. Contrasting soils which may occur in these map units include Cahona soils on sideslopes and Bond soils on crests. Soils similar to Pulpit which may occur in this map unit include soils with less than 18 percent clay and/or a sand fraction with more than 15 percent fine or coarser sand. The J/7 mining areas has more of these similar soils than the other mining areas. Sharps is also a similar soil.

Pulpit soils are suitable for topsoil and have an average stripping depth of 28 inches. The high very fine and fine sand content make these soils susceptible to wind and water erosion.

**6 Sharps very fine sandy loam, 2 to 8 percent slopes.**

**6A Sharps very fine sandy loam, 1 to 4 percent slopes.**

**6B Sharps very fine sandy loam, 4 to 8 percent slopes.**

**6C Sharps very fine sandy loam, 8 to 15 percent slopes.**

The less steep phases of these map units are found on ridge crests and shoulders, and the steep phases are found on shoulders and sideslopes. The soils in these map units are reddish brown and have a surface layer high in very fine sand. Depth to soft or fractured bedrock is 20 to 40 inches. Contrasting soils which may occur in these map units include Cahona soils on sideslopes and Bond soils on crests. Similar soils which may occur in



this map unit include soils with less than 18 percent clay and/or a sand fraction with more than 15 percent fine or coarser sand. The J/7 mining areas has more of these similar soils than the other mining areas. Another similar soil is Pulpit.

Sharps soils are suitable for topsoil and have an average stripping depth of 28 inches. The high very fine and fine sand content make these soils susceptible to wind and water erosion.

**7B Travessilla-Zyme-Dulce complex, 2 to 6 percent.**

This map unit is found primarily in the J/7 mining area on ridge crests and sideslopes. Zyme and Dulce soils are generally found on the sideslopes and the Travessilla soils on the crests. Zyme soils are variable in color, depending on the color of the underlying shale bedrock. They are clayey throughout. Travessilla and Dulce soils are reddish brown and are coarse-textured. All of these soils in this map unit are very eroded. Depth to bedrock is 2 to 10 inches with bedrock generally occurring at less than 6 inches. Contrasting soils which may occur in this map unit include soils deeper than 20 inches in concave areas and Bond soils on ridge crests. Rock outcrop also is included.

The soils in these map units are marginally suitable for topsoil and are limited by clayey texture of the Zyme soils and high surficial rock fragment content of each of the soils. The shallow depth to bedrock of these soils may restrict the amount of soil which can be salvaged. The included Bond soils have a good suitability for topsoil and should be salvaged where practicable.

**7C Zyme-Travessilla-Rock outcrop complex, 6 to 15 percent slopes.**

**7D Zyme-Travessilla-Rock outcrop complex, 15 to 30 percent slopes.**

**7E Zyme-Travessilla-Rock outcrop complex, 30 to 50 percent slopes.**

These map units are also found primarily in the J/7 mining area. They are found on sideslopes and include significant amounts of rock outcrop. Zyme soils are found on the steeper portion of the map unit. Zyme soils are variable in color, depending on the color of the underlying shale bedrock. They are clayey throughout. Travessilla soils are reddish brown and are coarse-textured. Both these soils in these map units are very eroded. Depth to bedrock is 2 to 10 inches with bedrock generally occurring at less than 6 inches. Rock outcrop occurs as narrow escarpments. Contrasting soils which may occur in these map units include soils deeper than 20 inches found in concave areas and Bond soils found randomly throughout. Similar soils which may occur in these map units are Dulce soils.

The soils in these map units are marginally suitable for topsoil and are limited by the clayey texture of the Zyme soils and the high surficial rock fragment content of both soils. The shallow depth to bedrock of these soils and the amount of rock outcrop occurring in these map units may restrict the amount of soil which can be salvaged. The included Bond soils have a good suitability for topsoil and should be salvaged where practicable.

**10 Cahona very fine sandy loam, bedrock substratum, 2 to 8 percent slopes.**

**10A Cahona very fine sandy loam, bedrock substratum, 1 to 4 percent slopes.**

**10B Cahona very fine sandy loam, bedrock substratum, 4 to 8 percent slopes.**

**10C Cahona very fine sandy loam, bedrock substratum, 8 to 15 percent slopes.**

These soils are found on valley sideslopes. The soils in these map units are reddish brown and have a surface layer high in very fine sand. Depth to bedrock is 40 to 72 inches. Contrasting soils which may occur in these map units include Cahona soils which are deeper than 72 inches on sideslopes, and Sharps soils on crests. Similar soils which may occur in these map units include soils with less than 18 percent clay and/or a sand fraction with more than 15 percent fine or coarser sand. The J/7 mining areas has more of these similar soils than the other mining areas.



Cahona soils are suitable for topsoil and have an average stripping depth of 58 inches. The high very fine and fine sand content make these soils susceptible to wind and water erosion.

- 11 Cahona very fine sandy loam, 1 to 6 percent slopes.
- 11A Cahona very fine sandy loam, 1 to 4 percent slopes.
- 11B Cahona very fine sandy loam, 4 to 8 percent slopes.
- 11C Cahona very fine sandy loam, 8 to 15 percent slopes.

These soils are found on valley sideslopes. They are reddish brown and have a surface layer high in very fine sand. Depth to soft or fractured bedrock is 72 to more than 180 inches. Contrasting soils which may occur in these map units include Cahona, bedrock substratum, soils on upper sideslopes and Sharps soils on crests. Soils similar to Cahona which may occur in these map units include soils with less than 18 percent clay and/or a sand fraction with more than 15 percent fine or coarser sand. The J/7 mining areas has more of these similar soils than the other mining areas. Oelop soils are also similar.

Cahona soils are suitable for topsoil and have a weighted average stripping depth of 10.0 feet. The high very fine and fine sand content make these soils susceptible to wind and water erosion.

- G11C Cahona very fine sandy loam, gravelly substratum, 8 to 15 percent slopes.

This soils occurs on valley sideslopes and alluvial fans in the area of the proposed Wild Ram Dam. It is very similar to the Cahona soil in map unit 11, but is underlain by material high in rock fragments at a depth of 24 to 40 inches. Depth to soft or fractured bedrock is 40 to more than 72 inches. Contrasting soils which may occur in this map unit include Sharps on the upper slopes and Chilton soils on the steeper sideslopes. Similar soils which may occur in these map units include those with less than 18 percent clay and/or a sand fraction with more than 15 percent fine or coarser sand.

These soils are suitable for topsoil and have an average stripping depth of 2.5 feet. The high very fine and fine sand content make these soils susceptible to wind and water erosion.

- X11 Cahona-Cahona, bedrock substratum, very fine sandy loams, 2 to 10 percent slopes.
- X11A Cahona-Cahona, bedrock substratum, very fine sandy loams, 1 to 4 percent slopes.
- X11B Cahona-Cahona, bedrock substratum, very fine sandy loams, 4 to 8 percent slopes.
- X11C Cahona-Cahona, bedrock substratum, very fine sandy loams, 8 to 15 percent slopes.

These soils are found on valley sideslopes. The soils in these map units are reddish brown and have a surface layer high in very fine sand. Depth to soft or fractured bedrock is 40 to more than 72 inches. Contrasting soils which may occur in these map units include Sharps soils on crests. Similar soils which may occur in these map units include those with less than 18 percent clay and/or a sand fraction with more than 15 percent fine or coarser sand. The J/7 mining areas has more of these similar soils than the other mining areas. Oelop soils are also similar.

These soils are suitable for topsoil and have an average stripping depth of 7.6 feet. The high very fine and fine sand content make these soils susceptible to wind and water erosion.



- 12 Begay loam, 2 to 10 percent slopes.
- 12A Begay loam, 1 to 4 percent slopes.
- 12B Begay loam, 4 to 8 percent slopes.
- 12C Begay loam, 8 to 15 percent slopes.

These map units are found on valley-filling sideslopes. These soils are reddish to reddish brown and are coarse-textured. Contrasting inclusions which may occur in these map units are soils with bedrock between 40 and 72 inches, primarily in the J/7 area. Similar soils which may occur in these map units include soils with over 18 percent clay and soils lacking a structural B horizon.

Begay soils are suitable for topsoil and have an average stripping depth of 9.8 feet. The high very fine and fine sand content make these soils susceptible to wind and water erosion.

- 13, 13A San Mateo loam, 0 to 3 percent slopes.

This map unit is found on stream terraces and remnant floodplains. The soils in this unit are very deep and are brownish in color. There are no contrasting soils included in the mapping. Soils similar to San Mateo which may occur in this map unit are the Las Lucas and Oelop soils and soils with a sand fraction of less than 15 percent fine or coarser sand.

San Mateo soils are suitable for topsoil and have an average stripping depth of 14.7 feet. These soils are affected by salinity and/or sodicity at varying depths. Most of these soils which are saline or sodic are in or near Reed Valley. Depth to high salt or sodium levels ranged from 8 to more than 18 feet.

- 14A Oelop very fine sandy loam, 1 to 4 percent slopes.
- 14B Oelop very fine sandy loam, 4 to 8 percent slopes.

These map units are found on valley sideslopes and bottoms. These soils are brown and are high in very fine and fine sand. These map units tend to occupy relatively small areas but they occur commonly throughout the Black Mesa lease area. No inclusions of contrasting soils were observed within these map units. Soils similar to Oelop found in the study area are the Las Lucas and Cahona soils and soils with a sand fraction of less than 15 percent fine or coarser sand.

Oelop soils are suitable for topsoil and have an average stripping depth of 9.8 feet. These soils are affected by salinity and/or sodicity at varying depths. Most of these soils which are saline or sodic are in or near Reed Valley. Depth to unsuitably high levels ranged from 20 to more than 120 inches. The high very fine and fine sand content make these soils susceptible to wind and water erosion.

- 15, 15A Las Lucas sandy clay loam, 2 to 6 percent slopes.

This map unit is found on lower valley sideslopes. The soils in this unit are very deep and are brownish in color. No inclusions of contrasting soils were observed within this map unit. Similar soils which may occur in this map unit include the Cahona, San Mateo and Oelop soils. Other similar soils included are those with a sand fraction with more than 15 percent fine or coarser sand and those lacking a structural B horizon.

Las Lucas soils are suitable for topsoil and have an average stripping depth of 11.6 feet. These soils are affected by salinity and/or sodicity at varying depths. Most of these soils which are saline or sodic are in or near Reed Valley. Depth to unsuitably high levels ranged from 31 to more than 120 inches. The high very fine and fine sand content make these soils susceptible to wind and water erosion.



- 16C Soil A-Soil B extremely channery very fine sandy loams, 4 to 15 percent slopes.
- 16E Soil A-Soil B extremely channery very fine sandy loams, 15 to 50 percent slopes.
- 16F Soil A-Soil B extremely channery very fine sandy loams, 50 to 70 percent slopes.

These map units are found on the crests of hills throughout the lease. The soils in these map units formed in porcellanite, and as a result, contain a very high volume of rock fragments. Other surface textures found in this map unit are very channery, very cobbly or extremely cobbly very fine to fine sandy loams. Since these soils are unsuitable for topsoil because of high rock fragment content, they were not sampled or described.

- 17C--Chilton very gravelly fine sandy loam, 6 to 15 percent slopes.

This map unit occurs only at the proposed Wild Ram Dam site and is very limited in areal extent. It occurs on the sideslopes of the alluvial fans in this area. The soil in this map unit were not sampled or described. Based on field observations, this soil has a gravelly fine sandy loam surface layer and a very gravelly sandy loam substratum layers. Because of high rock fragment content in all but the surface layers, these soils are suitable for topsoil down to six inches.

- RW Riverwash.

The riverwash map unit was mapped along the channel of some of the drainages in the permit area. Most of the areas are very narrow. These soils are affected by salinity and/or sodicity and are not suitable for topsoil.

- DL Disturbed land.

This map unit consists of land disturbed by activities associated with mining. It is similar to map unit 34 in the Order 3 survey.

- RL Reclaimed land.

This map unit is composed of areas that have been disturbed by mining and subsequently reclaimed. It is similar to map unit 35 in the Order 3 survey.

- TS Topsoil Stockpile.

This map unit consists of stockpiled soil material to be used in reclamation.

## **ATTACHMENT 3**

### **NRCS Official Soil Series Descriptions**

**Begay  
Blanding  
Bond  
Cahona  
Dulce  
Las Lucas  
Oelop  
Pulpit  
San Mateo  
Sharps  
Travessilla  
Zyme**

LOCATION BEGAY

UT+AZ CO

Established Series  
Rev. RLM/GWL/RLB  
10/2002

## BEGAY SERIES

The Begay series consists of very deep, well drained, moderately rapidly permeable soils that formed in eolian deposits and alluvium, derived mainly from sandstone. Begay soils are on structural benches, broad mesas, fan remnants and have slopes of 0 to 30 percent. The average annual precipitation is about 12 inches, and the mean annual temperature is about 48 degrees F.

**TAXONOMIC CLASS:** Coarse-loamy, mixed, superactive, mesic Ustic Haplocambids

**TYPICAL PEDON:** Begay loamy fine sand, rangeland. (Colors are for air-dry soil unless otherwise noted.)

**A**--0 to 3 inches; yellowish red (5YR 5/6) loamy fine sand, yellowish red (5YR 4/6) moist; single grained; loose; very slightly effervescent, carbonates are disseminated; moderately alkaline (pH 7.9); clear smooth boundary. (2 to 5 inches thick)

**Bw**--3 to 16 inches; yellowish red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; soft, friable; common fine roots; few fine pores; slightly alkaline (pH 7.8); clear wavy boundary. (11 to 17 inches thick)

**Bk1**--16 to 28 inches; yellowish red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; slightly hard, firm; few fine roots; common fine pores; very slightly effervescent, carbonates are disseminated; moderately alkaline (pH 7.9); gradual wavy boundary. (10 to 14 inches thick)

**Bk2**--28 to 42 inches; yellowish red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; slightly hard, firm; strongly effervescent, moderately alkaline (pH 8.0); gradual wavy boundary. (12 to 16 inches thick)

**C**--42 to 60 inches; yellowish red (5YR 5/8) very fine sandy loam, yellowish red (5YR 5/8 or 4/6) moist; massive; soft, very friable; few fine pores; very slightly effervescent, carbonates are disseminated; moderately alkaline (pH 8.1).

**TYPE LOCATION:** San Juan County, Utah; 7 miles east and 5 miles north of Navajo Mountain School; SW 1/4, SE 1/4 sec. 31, T. 42 S., R. 17 E.

### RANGE IN CHARACTERISTICS:

Soil moisture: In 7 out of 10 years the soils are dry in all parts of the moisture control section for 50 to 75 percent of the time (cumulative) that the soil temperature at depth of 20 inches is above 41

degrees F. The soils are moist in some part of the moisture control section for 30 to 40 days during the summer and are dry in some part of the moisture control section for 60 to 90 consecutive days during winter and early spring and are moist in some parts between July and October.

Mean annual soil temperature ranges from - 47 to 57 degrees F

Mean summer soil temperature at a depth of 20 inches ranges from - 61 to 65 degrees F.

Combined thickness of A and B horizons is - 35 to 50 inches.

Depth to secondary carbonates accumulation ranges from - 7 to 22 inches.

Particle-size control section ranges from - 15 to 40 percent fine sand or coarser

Rock fragments: 0 to 15 percent

#### A horizon

Hue: 2.5YR to 10YR

Value: 4 to 6 dry, 3 to 5 moist

Chroma: 3 to 6 dry or moist

Reaction: slightly alkaline or moderately alkaline

Calcium carbonate equivalent: ranges from 0 to 3 percent.

#### Bw horizon

Hue: 2.5YR to 7.5YR

Value: 4 to 6 dry, 3 to 5 moist

Chroma: 4 to 8 dry or moist

Texture: ranges from very fine sandy loam, loamy very fine sand, fine sandy loam, sandy loam

Reaction: slightly alkaline to strongly alkaline

Calcium carbonate equivalent: ranges from 0 to 3 percent.

#### Bk and C horizons

Hue: 2.5YR to 7.5YR

Value: 5 to 8 dry, and 4 to 8 moist

Chroma: 4 to 6 dry or moist

Textures: ranges from very fine sandy loam, fine sandy loam, or sandy loam, and thin strata of gravelly fine sandy loam, or loamy fine sand, below a depth of 40 inches

Reaction: ranges from slightly alkaline to strongly alkaline.

Calcium carbonates equivalent: ranges from 0 to 5 percent.

**COMPETING SERIES:** These are the Delvalle (NM), Ignacio (NM), Kitsili (NM), Koshare (NM), Ojito (NM), Parida (NM), Remmit (CO), Sandspring (T AZ), and Turnback (WY) series.

Delvalle soils have a lithologic discontinuity at 27 to 60 inches and contain 55 to 70 percent sand; Fine sand or coarser content: more than 50 percent.

Ignacio and Turnback soils have bedrock at depths of 20 to 40 inches.

Parida soils have more than 15 percent rock fragments in the particle-size control section.

Remmit and Sandspring soils have hue yellower than 7.5YR.

Koshare soils contain 10 to 25 percent mica content in the coarse silt to fine sand fraction.

Kitsili soils are effervescence throughout the entire profile and contain less than .6 percent organic matter.

Ojito soils are moderately deep to bedrock.

**GEOGRAPHIC SETTING:** Begay soils occur on fan remnants, structural benches, broad and mesa tops at elevations of 4,700 to 7,400 feet. Slopes are 0 to 30 percent. These soils formed in deep eolian deposits and alluvium from sedimentary rocks. The climate is semiarid and the average annual precipitation ranges from 8 to 14 inches. The mean annual temperature is 44 to 55 degrees F. The mean summer temperature is 59 to 63 degrees F. and the freeze-free period ranges from 110 to 175 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are Anasazi, Aneth and Sogzie soils. Anasazi soils have calcic horizon and lithic contact at 20 to 40 inches. Aneth soils do not have cambic horizons but have a sandy particle size control section. Sogzie soils have calcic horizons.

**DRAINAGE AND PERMEABILITY:** Well drained; very slow to medium runoff; moderately rapid permeability.

**USE AND VEGETATION:** Used only as rangeland. Potential vegetation is needleandthread, big sagebrush, blue grama, Indian ricegrass.

**DISTRIBUTION AND EXTENT:** Southeastern Utah and northwestern Colorado. Begay soils are moderately extensive. MLRA 34, 35 and 48A.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** San Juan County, Utah, 1976.

**REMARKS:**

These soils have been correlated to semidesert range sites in Utah.

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - from 0 to 3 inches (A horizon).

Cambic horizon - from 3 to 16 inches (Bw horizon).

The Bk horizon is assumed to have too little carbonate to be a calcic horizon.

In December 1994 the classification was changed from Ustollic Camborthids to Ustic Haplocambids.

Classified according to Soil Taxonomy Second Edition, 1999.

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National Cooperative Soil Survey  
U.S.A.

LOCATION BLANDING

UT+NM

Established Series

Rev. TBH/AJE/MJD

7/97

## BLANDING SERIES

The Blanding series consists of very deep, well drained soils that formed in eolian deposits derived mainly from sandstone. Blanding soils occur on gently sloping and rolling uplands, and have slopes of 2 to 10 percent. The average annual precipitation is about 12 inches, and the mean annual air temperature is about 50 degrees F.

**TAXONOMIC CLASS:** Fine-silty, mixed, superactive, mesic Ustic Haplargids

**TYPICAL PEDON:** Blanding very fine sandy loam, rangeland. (Colors are for air dry soil unless otherwise stated.)

**A--**0 to 4 inches; reddish brown (5YR 5/4) very fine sandy loam, reddish brown (5YR 4/4) moist; weak thin and medium platy structure; slightly hard, friable, nonsticky and nonplastic; many fine roots; moderately alkaline (pH 8.1); abrupt wavy boundary. (3 to 8 inches thick)

**Bt--**4 to 16 inches; yellowish red (5YR 5/6) sandy clay loam, yellowish red (5YR 3/6) moist; weak coarse prismatic structure that parts to very weak medium subangular blocky, slightly hard, friable, slightly sticky and slightly plastic; many fine pores; slightly alkaline (pH 7.7); clear wavy boundary. (9 to 25 inches thick)

**Btk1--**16 to 50 inches; reddish yellow (5YR 4/6) very fine sandy loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; extremely hard, firm, slightly sticky and slightly plastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline (pH 8.1); clear smooth boundary. (15 to 35 inches thick)

**Btk2--**50 to 60 inches; reddish yellow (5YR 6/6) sandy clay loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; very hard, firm, slightly plastic; moderately calcareous; moderately alkaline (pH 8.2). (8 to 15 inches thick)

**TYPE LOCATION:** San Juan County, Utah; about 6.5 miles south of Blanding; 200 feet south of trail and 0.4 miles west of Utah Highway 47; NW1/4 NE1/4 sec. 33, T.37S., R.22E.

**RANGE IN CHARACTERISTICS:** The depth to carbonate accumulation ranges from 9 to 30 inches. Organic matter in the upper 15 inches ranges from .4 to .9 percent. The mean annual soil temperature at depth of 20 inches ranges from 52 degrees to 55 degrees F., and the average summer soil temperature ranges from 68 degrees to 73 degrees F. In more than 7 out of 10 years, the moisture control section is dry in some parts 25 to 45 consecutive days during the summer and is dry in all parts 50 to 75 percent of the time when the soil temperature is above 41 degrees F.

The A horizon has value of 3 or 4 moist, 5 or 6 dry, and chroma of 4 through 6. It is dominantly very fine sandy loam but ranges to fine sandy loam. The A horizon is neutral to moderately alkaline. In some pedons thin BA horizons are present above the argillic horizon.

The Bt horizon has value of 3 through 5 moist, 5 or 6 dry, and chroma of 4 through 6. It is dominantly sandy clay loam, but includes very fine sandy loam or loam. This horizon has 18 to 27 percent clay and less than 15 percent coarser than very fine sand. It is neutral to moderately alkaline.

The Btk or Bk horizons have value of 4 or 5 moist, 5 or 6 dry, and chroma of 4 through 6. It ranges from very fine sandy loam to sandy clay loam. This horizon has 3 to 12 percent calcium carbonate. It is slightly or moderately alkaline.

Buried horizons occur in places at depths below 40 inches.

**COMPETING SERIES:** This is the Snapill (T) series. Snapill soils have a calcic horizon.

**GEOGRAPHIC SETTING:** Blanding soils are on uplands and plateaus, at elevations of 5,000 to 6,500 feet in a semiarid climate. Slopes are 2 to 10 percent. These soils formed in eolian deposits derived mainly from sandstone. Average annual precipitation is 8 to 13 inches. The mean annual temperature is 50 degrees to 54 degrees F. The mean summer temperature is 70 degrees to 73 degrees F. The frost-free period is 130 to 150 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** This is the the Northdale series. Northdale soils have mollic epipedons.

**DRAINAGE AND PERMEABILITY:** Well drained; slow runoff; moderate permeability.

**USE AND VEGETATION:** Used mainly for rangeland. Some areas are used for irrigated or nonirrigated cropland. Vegetation is dominantly blue grama, galleta, Wyoming big sagebrush, Indian ricegrass, and snakeweed.

**DISTRIBUTION AND EXTENT:** Southeastern Utah, western Colorado, northeastern Arizona, northwestern New Mexico. These soils are of moderate extent.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** San Juan County, Utah, 1952.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from 0 to 4 inches (A horizon).

Argillic horizon - the zone from 4 to 16 inches (Bt horizon)

Ustalfic feature - dry in all parts of the moisture control half to three-fourths of the time, and soil moisture regime is aridic bordering on ustic.

National Cooperative Soil Survey  
U.S.A.

LOCATION BOND

NM+AZ CO UT

**Established Series**

Rev. TLP/CDL/LWH/SAZ/WWJ

04/2002

## BOND SERIES

The Bond series consists of very shallow and shallow, well drained, moderately permeable soils that formed in alluvium, slope alluvium, and eolian deposits derived from sandstone on cuestas, mesas, hills and ridges. Slopes range from 0 to 50 percent. The mean annual precipitation is about 11 inches and mean annual temperature is about 51 degrees F.

**TAXONOMIC CLASS:** Loamy, mixed, superactive, mesic Lithic Ustic Haplargids

**TYPICAL PEDON:** Bond sandy loam - on dipslopes; northeast aspect of cuesta with 4 percent slopes - rangeland. (Colors are for dry soil unless otherwise noted.)

**A--**0 to 3 inches; brown (7.5YR 5/4) sandy loam, brown (7.5YR 4/4) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; few medium, fine and very fine roots; few very fine irregular pores; neutral; clear smooth boundary. (2 to 4 inches thick)

**BA--**3 to 7 inches; brown (7.5YR 5/4) sandy loam, brown (7.5YR 4/4) moist; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; few very fine and fine roots; common very fine irregular pores; neutral; abrupt smooth boundary. (0 to 4 inches thick)

**Bt--**7 to 13 inches; reddish brown (5YR 4/4) sandy clay loam, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; hard, friable, sticky and slightly plastic; common moderately thick clay films on faces of peds and lining pores; common very fine and few fine roots; common very fine and fine tubular pores; neutral; abrupt smooth boundary. (5 to 12 inches thick)

**C--**13 to 16 inches; light brown (7.5YR 6/4) sandy clay loam; brown (7.5YR 5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few very fine roots; common very fine irregular pores; strongly effervescent; moderately alkaline; abrupt smooth boundary. (0 to 4 inches thick)

**2R--**16 inches; sandstone.

**TYPE LOCATION:** Cibola County, New Mexico; about 7 miles north of Milan; Bluewater Quadrangle; 300 feet south and 2,600 feet east of the northwest corner, sec. 8, T. 12 N., R. 10 W.

**RANGE IN CHARACTERISTICS:**

**Soil Moisture:** Usually dry, dry in all parts of the soil moisture control section in late spring and early summer, but moist intermittently in some part of the soil moisture control section from July to October.

Soil Temperature: 51 to 55 degrees F.

Depth to lithic contact: 6 to 20 inches

Rock fragments in the profile: 0 to 35 inches

Clay content in the particle-size control section: 18 to 35 percent

**A horizon**

Hue: 5YR, 7.5YR or 10YR

Value: 4 to 6 dry, 3 through 5 moist

Chroma: 2 to 4

Texture: loamy fine sand, sandy loam or fine sandy loam

**BA horizon (where present)**

Hue: 5YR or 7.5YR

Value: 4 to 6 dry, 4 or 5 moist

Chroma: 3 or 4

Texture: sandy loam, sandy clay loam or fine sandy loam

**Bt horizon**

Hue: 5YR or 7.5YR

Value: 4 or 6 dry, 3 to 6 moist

Chroma: 3 to 6

Texture: sandy clay loam, loam, sandy loam or clay loam

**C horizon**

Hue: 5YR or 7.5YR

Value: 5 to 8 dry, 5 or 6 moist

Chroma: 4 through 6 dry and moist

Fine earth fraction: sandy clay loam, loam, sandy loam or clay loam

Some pedons have Btk horizons

**COMPETING SERIES:** These are the Barboncito, Bondman, Frontier, and Kech series. The Barboncito soils have cooler mean annual temperatures and receive more effective winter moisture. Bondman soils have soil temperatures ranging from 47 to 50 degrees F, and receive more winter moisture. Frontier and Kech soils have horizons with segregated secondary carbonates. In addition, Frontier soils have hue yellower than 7.5YR in the argillic horizon and are in LRR-G and are moist in May and June.

**GEOGRAPHIC SETTING:** Bond soils are on cuestas, mesas, hills, and ridges with slopes ranging from 0 to 50 percent. They formed in alluvium, slope alluvium, and eolian deposits from sandstone. Elevations are 5,600 to 7,200 feet. Typically, the average annual precipitation is 10 to 13 inches, but ranges to 15 inches in some areas; mean annual temperature is 49 to 54 degrees F. The frost-free period is 110 to 160 days. In Colorado, the temperature ranges as low as 43 degrees F. In Arizona elevations are as low as 4,500 feet, temperatures as high 55 degrees and frost free as long as 165 days

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Aparejo, Hagerman, Penistaja and Skyvillage soils. Aparejo and Penistaja soils are deep. Hagerman soils have lithic contact between 20 and 40 inches. Skyvillage soils do not have argillic horizons.

**DRAINAGE AND PERMEABILITY:** Well drained; medium runoff; moderately permeable.

**USE AND VEGETATION:** The major use of this soil is for livestock grazing. The present vegetation is blue grama, sideoats grama, New Mexico feathergrass, Indian ricegrass, scattered oneseed juniper, and winterfat.

**DISTRIBUTION AND EXTENT:** West-central New Mexico, Northern Arizona, southwestern Colorado and southern Utah. MLRA 36, LRR-D. The series is of moderate extent.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** Zuni Mountain Area, New Mexico; McKinley County, New Mexico; 1964.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric Horizon - The zone from 0 to 3 inches (A horizon).

Argillic Horizon - The zone from about 7 to 13 inches (Bt horizon).

Lithic contact - the boundary with sandstone at 16 inches

The type location of the Bond series was moved from McKinley to Cibola County in 1984 to better reflect the present concepts of the Bond series.

Classified according to Soil Taxonomy Second Edition, 1999.

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National Cooperative Soil Survey  
U.S.A.

LOCATION CAHONA

CO+UT

Established Series  
Rev. DKR/JWH/WWJ  
06/2000

## CAHONA SERIES

The Cahona series consists of very deep, well drained soils that formed in eolian material derived from sandstone. Cahona soils are on hills and mesas. Slopes range from 1 to 12 percent. Mean annual precipitation is about 14 inches and the mean annual temperature is about 48 degrees F.

**TAXONOMIC CLASS:** Fine-silty, mixed, superactive, mesic Calcic Haplustalfs

**TYPICAL PEDON:** Cahona loam, on a south facing, 4 percent slope in rangeland at an elevation of 6,800 feet. (Colors are for dry soil unless otherwise noted.)

**A1**--0 to 1 inch; reddish brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) moist; single grain; loose, loose, nonsticky and nonplastic; slightly effervescent; slightly alkaline (pH 7.5); clear smooth boundary. (1 to 8 inches thick)

**A2**--1 to 5 inches; reddish brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) moist; moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots throughout; common very fine discontinuous tubular pores; noneffervescent; slightly alkaline (pH 7.4); clear smooth boundary. (0 to 6 inches thick)

**Bt**--5 to 15 inches; yellowish red (5YR 4/6) clay loam, reddish brown (5YR 4/4) moist; moderate medium prismatic structure parting to moderate medium angular blocky; hard, friable, slightly sticky and moderately plastic; common fine roots throughout; common fine discontinuous tubular pores; slightly effervescent; slightly alkaline (pH 7.8); gradual smooth boundary. (4 to 16 inches thick).

**Btk**--15 to 25 inches; yellowish red (5YR 5/6) clay loam, reddish brown (5YR 4/4) moist; weak medium prismatic structure parting to moderate medium angular blocky; hard, friable, moderately sticky and moderately plastic; common fine and medium roots throughout; common fine discontinuous tubular pores; common fine irregular soft masses of carbonate; violently effervescent; moderately alkaline (pH 8.0); clear wavy boundary. (3 to 15 inches thick).

**Bk1**--25 to 38 inches; pinkish white (5YR 8/2) loam, light reddish brown (5YR 6/3) moist; weak coarse prismatic structure parting to moderate medium subangular blocky; hard, firm, slightly sticky and moderately plastic; common medium roots throughout; 43 percent calcium carbonate equivalent; violently effervescent; strongly alkaline (pH 8.6); clear wavy boundary. (6 to 20 inches thick).

**Bk2**--38 to 60 inches; pinkish gray (5YR 7/2) loam, light reddish brown (5YR 6/3) moist; massive; hard, firm, slightly sticky and slightly plastic; common medium roots throughout; violently effervescent; moderately alkaline (pH 8.4)

**TYPE LOCATION:** Dolores County, Colorado; about 5 miles northwest of Dove Creek; located about 500 feet south and 1500 feet east of the northwest corner of sec. 9, T. 41 N., R. 19 W.; Dove Creek USGS quad; lat. 37 degrees 47 minutes 12 seconds N. and long. 108 degrees 56 minutes 24 seconds W., NAD

**RANGE IN CHARACTERISTICS:**

Soil moisture regime: ustic bordering on aridic

Soil temperature regime: mesic

Mean annual soil temperature: 48 to 52 degrees F

Mean annual summer soil temperature: 63 to 67 degrees F

Particle-size control section: 18 to 35 percent clay

Depth to calcic horizon: 20 to 40 inches

Depth to secondary calcium carbonate: 5 to 30 inches

Depth to the base of the argillic horizon: 20 to 30 inches

**A horizon:**

Hue: 5YR or 7.5YR

Value: 4 to 7 (3 to 6 moist)

Chroma: 2 to 6

Texture: fine sandy loam or loam

Rock fragments: 0 to 5 percent

Calcium carbonate equivalent: 0 to 1 percent

Reaction: neutral or slightly alkaline

**Bt and Btk horizon:**

Value: 4 to 7 dry (3 to 5 moist)

Chroma: 3 to 6

Texture: loam or clay loam

Calcium carbonate equivalent: 0 to 10 percent

Rock fragments: 0 to 5 percent

Reaction: slightly to strongly alkaline

**Bk horizon:**

Hue: 5YR to 7.5YR

Calcium carbonate equivalent: 15 to 50 percent

Reaction: slightly to strongly alkaline

**COMPETING SERIES:** This is the Plughat and Villegreen series. Plughat soils are deep. Villegreen soils are moderately deep.

**GEOGRAPHIC SETTING:**

Parent material: eolian material derived from sandstone

Landform: hills and mesas

Slopes: 1 to 12 percent

Elevation: 6,200 to 7,400 feet

Mean annual temperature: 46 to 50 degrees F

Mean annual precipitation: 13 to 16 inches

Precipitation is fairly evenly distributed throughout the year with July and August being slightly wetter and June being slightly dryer.

Frost-free period: 100 to 120 days

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Wetherill, Pulpit, and Sharps series. All these soils are on the same landscape positions as Cahona. Wetherill soils have a calcic horizon below 40 inches. Pulpit and Sharps soils have bedrock above 40 inches.

**DRAINAGE AND PERMEABILITY:** well drained, medium to very high runoff, moderately slow or slow permeability

**USE AND VEGETATION:** These soils are used for dryland and irrigated cropland, and for grazing. The native vegetation is scattered pinyon and juniper, big sagebrush, Indian ricegrass, muttongrass, and western wheatgrass.

**DISTRIBUTION AND EXTENT:** Southwest Colorado and southeast Utah. LRR D, MLRA 36. This series is of moderate extent.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** Canyonlands Area, Utah - parts of Grand and San Juan counties Utah. August 1983.

**REMARKS:** This OSED reclassified the Cahona series into the 13 to 16 inch precipitation zone in southwest Colorado and Utah. Change results from the Four Corners Climate Conference of 10/92. Type location was moved to better reflect the central concept of the Cahona series.

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon: The zone from 0 to 5 inches. (A1, A2 horizons)

Argillic horizon: The zone from 5 to 25 inches. (Bt, Btk horizons)

Calcic horizon: The zone from 25 to 60 inches. (Bk1, Bk2)

Particle size control section: The zone from 5 to 25 inches. (Bt, Btk)

Particle size control section: The zone from 5 to 25 inches. (Bt, Btk)

Soil Taxonomy Second Edition, 1999

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National Cooperative Soil Survey  
U.S.A.

LOCATION DULCE

CO

Tentative Series  
Rev. GB/JPP  
02/2003

## DULCE SERIES

The Dulce series consists of shallow, or very shallow, well drained soil that formed in residuum from sandstone. Dulce soils are on foothill slopes and ridges. Slopes range from 6 to 60 percent. Mean annual precipitation is about 14 inches, and mean annual temperature is about 49 degrees F.

**TAXONOMIC CLASS:** Loamy, mixed, superactive, calcareous, mesic, shallow Ustic Torriorthents

**TYPICAL PEDON:** Dulce sandy loam - native range with pinyon-juniper (Colors are for dry soils unless otherwise noted).

**A--**0 to 4 inches; brown (10YR 5/3) sandy loam, brown (10YR 4/3) moist; weak medium granular structure; soft, very friable; nonsticky and nonplastic; 2 percent stones; moderately alkaline (pH 8.0); clear smooth boundary. (2 to 6 inches thick)

**AC--**4 to 9 inches; grayish brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moist; very weak medium subangular blocky structure parting to weak fine granular; soft, very friable; nonstick nonplastic; 2 percent stones; slightly effervescent; moderately alkaline. (3 to 10 inches thick)

**Ck--**9 to 13 inches; very pale brown (10YR 7/3) sandy loam, pale brown (10YR 6/3) moist; massive; soft, very friable, nonsticky and nonplastic; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary. (2 to 5 inches thick)

**Cr--**13 to 17 inches; soft sandstone and interbedded sandy shale that can be dug with an auger and a spade.

**TYPE LOCATION:** La Plata County, Colorado; 700 feet south and 300 feet west of the northeast corner of Sec. 4, T. 32 N., R. 10 W. U.S.G.S. Long Mountain quad.; Lat. 37 degrees, 03 minutes, 05 seconds N., and Long. 107 degrees, 55 minutes, 49 seconds W.

**RANGE IN CHARACTERISTICS:** Mean annual soil temperature ranges from 47 to 52 degrees F. Depth to the paralithic contact is 8 to 20 inches. Bedrock is soft sandstone or sandy shale. Coarse fragments range from 0 to 20 percent and are typically sandstone chips ranging from pebble to stone size. Typically, these soils contain free carbonates throughout, but some pedons may be leached as much as 5 inches. Clay content of the particle-size control section ranges from 5 to 18 percent, sand from 50 to 80 percent, and silt from 5 to 45 percent. The moisture control section is dry for 15 consecutive days from May 15 to July 15 when the soil temperature at 20 inches is greater than 41 degrees F., (5 degrees C.). It is not dry in all parts of the moisture control section for at least 45 consecutive days following the summer solstice to October 20, and for at least 90 cumulative days during that period.

The A horizon has hue of 10YR or 2.5Y, value of 5 or 6, 4 or 5 moist, and chroma or 2 or 3. It is slightly alkaline or moderately alkaline.

The AC horizon has hue of 10YR or 2.5Y, value of 5 to 6, 4 or 5 moist, and chroma of 2 or 3. Reaction is slightly alkaline or moderately alkaline.

The C horizon has hue of 10YR or 2.5Y, value of 6 or 7 dry, or 6 moist, and chroma of 2 through 4. It is slightly alkaline or moderately alkaline.

**COMPETING SERIES:** These are the Canyon (NE), Epping (NE), Eslendo (NM), Fairburn (SD), Gerst (UT), Kinusta (AZ), Klondike (AZ), Picante, (CO), Redarrow (WY), Sandoval (NM), Shingle (WY), Spearfish (SD), Taluca (WY), and Tassel (NE) series. The Canyon, Eslendo, Fairburn, Gerst, Picante, Sandoval, Shingle, and Spearfish soils have more than 18 percent clay in the particle-size control section. Epping and Tassel soils are dry less than 15 consecutive days throughout the soil moisture control section between May 15 and July 15, and are in a climatic setting that receives over half of the precipitation between April and August. Kinusta soils have particle-size control sections that are very fine sandy loam or silt loam. Klondike and Redarrow soils have hue of 5YR or redder. Taluca soils are dry in all parts of the moisture control section for at least 60 consecutive days from July 15 to October 25, and for at least 90 cumulative days during this period.

**GEOGRAPHIC SETTING:** Dulce soils are on foothill slopes and ridges. Slope ranges from 6 to 60 percent. The soils formed in residuum from sandstone. Elevation ranges from 5,000 to 7,500 feet. Average annual precipitation ranges from 13 to 16 inches and about half comes as snow. The precipitation is distributed fairly evenly throughout the year with May and June being the driest months. Mean annual temperature ranges from 45 to 50 degrees F., and mean summer temperature ranges from 60 to 66 degrees F. P.E. Index is about 42 at the type location and ranges from 35 to 50 for the series.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Lazear, Mikim, Travessilla, and Zyme soils. Lazear and Travessilla soils are shallow, loamy soils over hard sandstone. Mikim soils are deep, loamy soils on gently sloping to sloping alluvial fans, toe slopes, and foothill valleys. Zyme soils are shallow, fine-textured soils over shale.

**DRAINAGE AND PERMEABILITY:** Well drained; slow to medium runoff; moderately rapid permeability to bedrock.

**USE AND VEGETATION:** Dulce soils are used primarily for rangeland and wildlife habitat. Native vegetation consists of western wheatgrass, Indian ricegrass, junegrass, sand dropseed, needleandthread grass, blue grama, Red three-awn, big sagebrush, pinyon pine, and Rocky Mountain juniper.

**DISTRIBUTION AND EXTENT:** Dulce soils occur in southwestern Colorado and possibly adjacent parts of Utah. The series is of moderate extent.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES PROPOSED:** La Plata County Area, Colorado, 1982.

**REMARKS:** Diagnostic features include an ochric epipedon from 0 to 4 inches. Particle-size control section with 5 to 18 percent clay. A paralithic contact at 13 inches, and a mesic temperature regime. Last updated by the state 3/95.

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National Cooperative Soil Survey  
U.S.A.

LOCATION LAS LUCAS

NM

Established Series

Rev. ARA/WWJ

10/2002

## LAS LUCAS SERIES

The Las Lucas series consists of deep, well drained, slowly permeable soils that formed from gray and olive shales on alluvial fans and valley fill side slopes. Mean annual precipitation is about 15 inches, and mean annual temperature is about 50 degrees F.

**TAXONOMIC CLASS:** Fine-silty, mixed, active, mesic Ustic Haplocambids

**TYPICAL PEDON:** Las Lucas clay loam

**A**--0 to 8 inches; pale brown (10YR 6/3) clay loam, brown (10YR 4/3) moist; weak medium platy structure in the upper 1 or 2 inches, moderate fine granular structure in the lower part; slightly hard, friable; abundant roots; weakly calcareous in upper 4 inches becoming strongly calcareous in lower part; clear boundary. 5 to 10 inches thick.

**Bw**--8 to 15 inches; brown (10YR 5/3) heavy clay loam, brown (10YR 4/3) moist; moderate medium and coarse subangular blocky structure; hard, friable; roots are common; very strongly calcareous; clear irregular boundary. 5 to 9 inches thick.

**Bk**--15 to 22 inches; yellowish brown (10YR 5/4) clay loam, dark yellowish brown (10YR 4/4) moist; weak angular and subangular blocky structure; very hard, firm; very strongly calcareous; this is a weak ca horizon with a few small calcium carbonate concretions; gradual boundary. 5 to 10 inches thick.

**Ck**--22 to 40 inches; pale olive (5Y 6/3) light clay loam, light olive brown (2.5Y 5/3) moist; massive; hard, friable; strongly calcareous; this is a weak ca horizon with a few small calcium carbonate concretions and thin seams; gradual boundary. 8 to 14 inches thick.

**R**--40 to 50 inches +; Gray and olive shales, laminated and with common salt crystals between the laminations.

**TYPE LOCATION:** Sandoval County, New Mexico, 20 feet NE of SW corner of section 16, T19N, R2W.

### RANGE IN CHARACTERISTICS:

A horizon

Hue: 10YR and 2.5Y

Chroma: 2 and 3

Value: 5 and 6 dry and 3 and 4 moist (Surface horizons having values as dark as 5 dry and 3 moist)

should not exceed 4 inches in thickness)  
Texture: loam or clay loam  
Calcium carbonate: noncalcareous to weakly calcareous

B horizon  
Hue: 10YR to 5Y  
Chroma: 3 through 4  
Value: 5 to 7 dry and 3 to 5 moist  
Texture: clay loam  
Clay content: 27 to 35 percent  
Silt content: 20 to 60 percent  
Sand content: 10 to 45 percent  
Depth to shale bedrock: greater than 40 inches

**COMPETING SERIES:** There are no competing series.

**GEOGRAPHIC SETTING:** Nearly level to sloping alluvial fans and valley filling slopes.

**GEOGRAPHICALLY ASSOCIATED SOILS:**

**DRAINAGE AND PERMEABILITY:** Well drained; slow permeability; runoff is rapid.

**USE AND VEGETATION:** Western wheatgrass, alkali sacaton, blue grama and galleta. Rangeland.

**DISTRIBUTION AND EXTENT:** Central and north central New Mexico.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** The Upper Puerco Recon. Survey, SCS, 1937.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric Epipedon - The zone from the surface to a depth of 8 inches. (A horizon)

Cambic horizon - The zone from 8 to 15 inches. (Bw horizon)

Classified according to Soil Taxonomy Second Edition, 1999.

Series name after a small village in Bernalillo County, New Mexico. Soil at type location differs from typical profile for series description by having a light clay texture at 8 to 15 inches and having slightly coarser structure throughout the horizon.

OSD scanned by SSQA. Last revised by state on 1/24/64.

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National Cooperative Soil Survey  
U.S.A.

LOCATION OELOP

NM

Established Series  
Rev. JER/RJA/LWH  
11/2000

## OELOP SERIES

The Oelop series consists of very deep, well drained soils that formed in alluvium and eolian material derived from sandstone and shale. Oelop soils are on stream terraces, mesas, plateaus and alluvial fans. Slopes are 0 to 10 percent. The mean annual precipitation is about 11 inches, and the mean annual temperature is about 51 degrees F.

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, mesic Ustic Haplargids

**TYPICAL PEDON:** Oelop loam--rangeland. (Colors are for dry soil unless otherwise stated.)

**A**--0 to 3 inches; dark yellowish brown (10YR 4/4) loam, dark yellowish brown (10YR 3/4) moist; weak fine granular structure; soft, very friable, slightly sticky and slightly plastic; few fine and medium roots; few fine irregular pores; slightly alkaline; abrupt smooth boundary. (3 to 6 inches thick)

**Bt1**--3 to 8 inches; dark yellowish brown (10YR 4/4) clay loam, dark yellowish brown (10YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and medium roots; few fine tubular pores; common moderately thick clay films on faces of peds and in pores; slightly alkaline; clear smooth boundary. (4 to 9 inches thick)

**Bt2**--8 to 16 inches; dark yellowish brown (10YR 4/4) clay loam, dark yellowish brown (10YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; few very fine and medium and common fine roots; few fine tubular pores; common moderately thick clay films on faces of peds and in pores; slightly alkaline; clear smooth boundary. (3 to 15 inches thick)

**Bk1**--16 to 34 inches; dark yellowish brown (10YR 4/4) clay loam, dark yellowish brown (10YR 3/4) moist; massive; slightly hard, friable, sticky and plastic; few very fine and fine roots; few fine irregular pores; slightly effervescent with disseminated calcium carbonate; moderately alkaline; clear smooth boundary. (3 to 26 inches thick)

**Bk2**--34 to 44 inches; dark yellowish brown (10YR 4/4) loam, dark yellowish brown (10YR 3/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few very fine and irregular pores; strongly effervescent; calcium carbonate occurs as few fine irregular filaments; moderately alkaline; clear smooth boundary. (3 to 30 inches thick)

**Bk3**--44 to 64 inches; dark yellowish brown (10YR 4/4) loam, dark yellowish brown (10YR 3/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few very fine irregular pores; strongly effervescent; calcium carbonate occurs as few fine irregular filaments; moderately alkaline.

**TYPE LOCATION:** Cibola County; about 4.5 miles southwest of south Garcia; 2,480 feet east and 100 feet north of the southwest corner of Sec. 33, T. 8 N., R. 3 W. 107 degrees, 10 minutes, 00 seconds west longitude; 34 degrees, 52 minutes, 28 seconds north latitude.

**RANGE IN CHARACTERISTICS:**

Soil moisture - The soil moisture control section is typically dry in all parts during April, May and June and are moist in some part periodically July through October. It is dry in all parts 50 to 75 percent of the time that the soil temperature is above 41 degrees F.

Soil temperature - 50 to 55 degrees F.

Depth to the base of the argillic horizon - 15 to 30 inches.

Particle-size control section - Texture: loam, clay loam or silty clay loam. Clay content: 18 to 35 percent Sand content: 15 to 40 percent with less than 15 finer than fine sand. Rock fragments: less than 5 percent dominantly pebbles.

A horizon - Hue: 5YR through 10YR. Value: 4 through 6 dry, 3 through 5 moist. Chroma: 3 or 4. Texture: loam, silt loam, fine sandy loam, or sandy loam.

Bt horizon - Hue: 5YR through 10YR. Value: 4 through 6 dry, 3 through 5 moist. Chroma: 3 or 4. Lower subhorizons have fine seams of carbonate in some pedons.

Bk horizon - Hue: 5YR through 10YR. Value: 4 through 7 dry, 4 through 6 moist. Chroma: 3 through 6. Texture: sandy loam, loam, sandy clay loam, clay loam or silty clay loam. Calcium carbonate equivalent: less than 15 percent.

**COMPETING SERIES:** These are the Balon(AZ), Barx(UT), Bowbac(WY), Buckle(NM), Cambria(WY), Cerrillos(NM), Clovis(NM), Cushman(WY), Decolney(T)(AZ), Fattig(MT), Fernando(NM), Flaco(NM), Forkwood(WY), Fort Collins(CO), Gaddes(AZ), Gapbutte(T)(AZ), Hagerman(NM), Harbord(CO), Hiland(WY), Los Alamos(NM), Maysdorf(WY), Millett(AZ), Olney(NM), Palacid(NM), Penistaja(NM), Pokeman(WY), Potts(WY), Progreso(CO), Pugsley(WY), Rauzi(T)(WY), Scholle(NM), Spangler(WY), Spenlo(UT), Stoneham(CO), Sundance(CO), Tapia(NM), Threetop(WY), Toluca(MT), Tuweep(AZ), and Yenlo(CO) series. Balon, Decolney, Gaddes and Rauzi soils are noncalcareous throughout. Barx, Cerrillos, Clovis, Fernando, Hiland, Los Alamos, Millett, Scholle, Sundance, Tapia, Toluca and Tuweep soils have calcic horizons. Bowbac, Cushman, Fattig, Flaco, Gaddes, Gapbutte, Hagerman, Pokeman, Progreso, Pugsley and Spangler soils have bedrock at depths between 20 and 40 inches. Buckle, Maysdorf and Palacid soils are deeper than 40 inches to the base of the argillic horizon. Cambria and Stoneham soils are 10 to 15 inches to the base of the Bt horizon. Forkwood, Fort Collins, Harbord, Olney, Potts and Threetop soils are moist in some part, periodically, during April, May and June. Penistaja and Yenlo soils have more than 40 percent sand. Spenlo soils are deeper than 30 inches to the base of the argillic horizon and are noncalcareous to depths of 30 inches.

**GEOGRAPHIC SETTING:** Oelop soils are on stream terraces, mesas, plateaus and alluvial fans, with slopes of 0 to 10 percent. Elevations range from 5,900 to 7,500 feet. The mean annual precipitation ranges from 10 to 12 inches. The mean annual temperature is about 48 to 53 degrees F.,

and the frost-free period is about 120 to 160 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Shingle, Skyvillage and competing Penistaja soils. The Shingle and Skyvillage soils are both shallow to bedrock.

**DRAINAGE AND PERMEABILITY:** Well drained; medium runoff, moderately slow permeability.

**USE AND VEGETATION:** These soils are used mainly for grazing. Present vegetation is sage, blue grama, galleta and Indian ricegrass.

**DISTRIBUTION AND EXTENT:** Northwestern New Mexico. Series is moderately extensive.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** Cibola County, New Mexico, 1985.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from the surface to a depth of about 3 inches. (A horizon)

Argillic horizon - The zone from about 3 to 16 inches. (Bt1, Bt2 horizons)

Ustollic feature - organic carbon content and soil moisture regime meets the requirements for "Ustollic".

In October 2000, taxonomic classification was converted to the closest match found in Soil Taxonomy, Second Edition 1999. No update was made to horizon nomenclature, competing series section, etc. Other placements may be more appropriate after a complete update.

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National Cooperative Soil Survey  
U.S.A.

LOCATION PULPIT

CO

Established Series  
Rev. DKR/JWH/WWJ  
06/2000

## PULPIT SERIES

The Pulpit series consists of moderately deep, well drained soils that formed in eolian material derived from sandstone. Pulpit soils are on hills and mesas. Slopes range from 2 to 12 percent. Mean annual precipitation is about 14 inches and the mean annual temperature is about 48 degrees F.

**TAXONOMIC CLASS:** Fine-silty, mixed, superactive, mesic Aridic Haplustalfs

**TYPICAL PEDON:** Pulpit loam, on a southeast facing slope, in nonirrigated cropland at an elevation of 6,680 feet. (Colors are for dry soil unless otherwise noted.)

**Ap**--0 to 7 inches; reddish brown (5YR 5/4) loam, dark reddish brown (5YR 3/4) moist; moderate medium granular structure; soft, very friable; neutral (pH 7.2); clear smooth boundary. (3 to 8 inches thick)

**Bt1**--7 to 10 inches; reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure parting to moderate fine granular; slightly hard, very friable, slightly sticky and slightly plastic; few faint clay films on faces of peds and in root channels; few fine pores; slightly alkaline (pH 7.4); clear smooth boundary. (0 to 4 inches thick)

**Bt2**--10 to 20 inches; reddish brown (5YR 5/4) clay loam, reddish brown (5YR 4/4) moist; weak medium prismatic structure parting to moderate medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common faint clay films on faces of peds and in root channels; few tubular pores; slightly alkaline (pH 7.6); clear wavy boundary. (7 to 30 inches thick)

**Btk**--20 to 25 inches; reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few faint clay films on faces of peds and in root channels; common medium calcium carbonate threads and soft masses; strongly effervescent; moderately alkaline (pH 8.2); gradual wavy boundary. (3 to 8 inches thick)

**Bk1**--25 to 30 inches; reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; massive; hard, firm, slightly sticky and slightly plastic; common medium calcium carbonate threads and soft masses; strongly effervescent; moderately alkaline (pH 8.2); clear wavy boundary. (0 to 29 inches thick)

**Bk2**--30 to 36 inches; pink (7.5YR 8/4) fine sandy loam, pink (7.5YR 7/4) moist; massive; slightly hard, friable; common medium calcium carbonate threads and soft masses; violently effervescent; moderately alkaline (pH 8.2); abrupt wavy boundary. (0 to 10 inches thick)

**2R**--36 inches; hard calcareous sandstone.

**TYPE LOCATION:** Dolores County, Colorado.; about 6 miles northwest of Dove Creek; located in the northeast quarter of sec. 24, T. 41 N., R. 20 W.; Northdale USGS quad; lat. 37 degrees 48 minutes 21 seconds N. and long. 109 degrees 01 minutes 41 seconds E., NAD

**RANGE IN CHARACTERISTICS:**

Soil moisture regime: ustic bordering on aridic

Soil temperature regime: mesic

Mean annual soil temperature: 49 to 53 degrees F

Mean summer soil temperature: 66 to 70 degrees F

Particle-size control section: 18 to 35 percent clay

Depth to lithic contact: 20 to 40 inches

Depth to secondary calcium carbonate: 6 to 20 inches

**A horizon:**

Hue: 2.5YR to 7.5YR

Value: 5 to 7 and (3 to 6 moist)

Chroma: 2 to 4

Texture: loam, fine sandy loam, silt loam, or sandy loam

Rock fragments: 0 to 10 percent gravel

Calcium carbonate equivalent: 0 to 1 percent

Reaction: neutral or slightly alkaline

**Bt horizon:**

Hue: 5YR to 10R

Value: 5 to 7 and 3 to 6 (moist)

Chroma: 3 to 6

Texture: clay loam, silty clay loam, loam, silt loam, or sandy clay loam

Rock fragments: 0 to 10 percent gravel

Calcium carbonate equivalent: 0 to 5 percent

Reaction: neutral to moderately alkaline

**Bk horizon:**

Hue: 5YR to 7.5YR

Value: 5 to 8 (4 to 7 moist)

Chroma: 2 to 4

Texture: loam, fine sandy loam, or clay loam

Rock fragments: 0 to 10 percent gravel

Calcium carbonate equivalent: 5 to 10 percent

Reaction: slightly or moderately alkaline

**COMPETING SERIES:** These are the Buick, Keiser, Klinedraw, Oshoto, Roubideau, Sharps,

Verde, Wetherill, and Wiley soils. Potential competitors that do not yet have CEA class assigned are the Amal, Chita, Elpedro, and Moncha series. Amal, Buick, Chita, Elpedro, Keiser, Moncha, Oshoto, Wetherill, and Wiley soils are very deep. Klinedraw and Sharps soils are moderately deep over soft sandstone or shale. Roubideau soils lack carbonates in the lower part of the solum. Verde soils have a fragipan-like horizon.

**GEOGRAPHIC SETTING:**

Parent material: eolian material derived from calcareous sandstone

Landform: hills and mesas

Slopes: 2 to 12 percent

Elevation: 6,200 to 7,800 feet

Mean annual air temperature: 46 to 50 degrees F

Mean annual precipitation: 13 to 16 inches

Precipitation is fairly evenly distributed throughout the year with July and August being slightly wetter and June being slightly dryer.

Frost-free period: 100 to 120 days

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Cahona, Gladel, Wetherill, and Sharps series. All soils are found on the same landforms. Gladel soils are shallow over hard bedrock.

**DRAINAGE AND PERMEABILITY:** well drained, low to high runoff, moderately slow permeability

**USE AND VEGETATION:** These soils are used for grazing and for dry or irrigated cropland. Native vegetation is predominantly sagebrush, pinyon, juniper, western wheatgrass, and Indian ricegrass.

**DISTRIBUTION AND EXTENT:** Southwest Colorado. LRR D, MLRA 36. This series is of moderate extent.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** La Plata County Area, La Plata County, Colorado. 1982.

**REMARKS:** Reclassified due to moisture regime change resulting from Four Corners Climate Conference 10/92.

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon: The zone from 0 to 7 inches. (Ap)

Argillic horizon: The zone from 10 to 20 inches. (Bt)

Lithic contact: The zone at 36 inches. (R)

Particle size control section: The zone from 10 to 25 inches. (Bt, Btk)

Soil Taxonomy Second Edition, 1999

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National Cooperative Soil Survey  
U.S.A.

LOCATION SAN MATEO NM

**Established Series**

Rev. TLP/RJA/LWH/SAZ/WWJ

04/2002

## SAN MATEO SERIES

The San Mateo series consists of very deep, well drained, moderately slowly permeable soils that formed in alluvium, fan alluvium and stream alluvium from mixed sources on alluvial fans on valley sides and flood plains on valley floors. Slopes are 0 to 5 percent. Average annual temperature is about 52 degrees F. Average annual precipitation is about 11 inches.

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, calcareous, mesic Ustic Torrifuvents

**TYPICAL PEDON:** San Mateo loam -- rangeland. (Colors are for dry soil unless otherwise noted.)

**A**--0 to 2 inches; light yellowish brown (2.5Y 6/4) loam, olive brown (2.5Y 4/4) moist; moderate fine granular structure; soft, friable, nonsticky and nonplastic; common fine and very fine roots; strongly effervescent; slightly alkaline; abrupt smooth boundary. (1 to 12 inches thick)

**C1**--2 to 12 inches; light olive brown (2.5Y 5/4) loam, olive brown (2.5Y 4/4) moist; massive; slightly hard, friable, nonsticky and nonplastic; common fine and very fine roots; 5 percent pebbles; strongly effervescent; slightly alkaline; clear smooth boundary.

**C2**--12 to 29 inches; light olive brown (2.5Y 5/6) sandy clay loam, olive brown (2.5Y 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common very fine and few fine roots; common very fine irregular pores; 5 percent pebbles; strongly effervescent; slightly alkaline; gradual smooth boundary.

**C3**--29 to 70 inches; light olive brown (2.5Y 5/6) sandy clay loam, olive brown (2.5Y 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few very fine roots; few very fine irregular pores; 5 percent pebbles; strongly effervescent; slightly alkaline. (Combined thickness of the C horizon is greater than 40 inches.)

**TYPE LOCATION:** Cibola County, New Mexico, Moquino Quadrangle; about 1 mile northwest of Moquino, New Mexico, at 35 degrees, 11 minutes and 10 seconds north latitude, and 107 degrees, 18 minutes and 21 seconds west longitude .

**RANGE IN CHARACTERISTICS:**

**Soil Moisture:** Intermittently moist in some part of the soil moisture control section December through March and July through October. The soil is driest during May and June. Ustic aridic moisture regime.

**Soil Temperature:** 51 to 57 degrees.

Reaction: slightly to strongly alkaline.

Carbonates: Calcareous throughout.

Salinity: EC of 1 to 8 mmhos/cm

Control section: weighted average - 18 to 35 percent clay and more than 15 percent fine sand or coarser.

#### A horizon

Hue: 10YR or 2.5Y Value: 5 or 6 dry, 3 through 5 moist

Chroma: 2 to 4 dry and moist

When the surface mantle has colors and organic carbon content of a mollic epipedon, it lacks the thickness requirements.

Chroma: 2 through 6

Texture: sandy loam, fine sandy loam, loam, sandy clay loam, silt loam, silty clay loam, and clay loam

#### C horizon

Hue - 10YR or 2.5Y

Value: 5 or 6 dry; 3 through 5, moist

Chroma: 2 through 6

Texture: Stratified sandy loam, fine sandy loam, loam, sandy clay loam, silt loam, silty clay loam, and clay loam.

Sodicity: SAR of 5 to 30

**COMPETING SERIES:** Current competitor is the Hamburn, Haverdad, Haversid, and Manikan, series. Potential competitors that do not yet have the CEA class assigned are the Barnum, Panitchen and Suwanee series. Manikan and Suwanee soils are redder than 10YR. Hamburn and Panitchen soils have gypsum accumulations. The Barnum, Haversid, and Haverdad soils are more moist in May and June.

**GEOGRAPHIC SETTING:** The San Mateo soils formed in alluvium, fan alluvium and stream alluvium from mixed sources on flood plains on valley floors, and alluvial fans on valley sides. Slopes are 0 to 5 percent. Elevations range from 5,200 to 7,800 feet. The mean annual temperature is 49 to 54 degrees F. The average annual precipitation is 9 to 13 inches. Peak precipitation occurs in July, August, September and October. The frost-free period is 120 to 180 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Sparank soils. Sparank soils have more than 35 percent clay in the control section.

**DRAINAGE AND PERMEABILITY:** Well drained, low to medium runoff, and moderately slowly permeability.

**USE AND VEGETATION:** This series is used for rangeland. The present vegetation is alkalai sacaton, western wheatgrass, blue gram, fourwing saltbush, and galleta.

**DISTRIBUTION AND EXTENT:** Northwestern New Mexico, Arizona and Utah. MLRA 36, LRR-

D. This series is of large extent.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** Cibola County, New Mexico, 1956.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon: the zone from 0 to 2 inches. ( A horizon)

Fluventic feature - An irregular decrease in organic carbon due to stratification.

Classified according to Soil Taxonomy Second Edition, 1999.

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National Cooperative Soil Survey  
U.S.A.

LOCATION SHARPS

CO+NM

Established Series

Rev. DKR/JWH/WWJ

06/2000

## SHARPS SERIES

The Sharps series consists of moderately deep, well drained soils that formed in eolian material derived from sandstone overlaying shale. Sharps soils are on mesas, ridges, and hills. Slopes range from 2 to 12 percent. Mean annual precipitation is about 14 inches and the mean annual temperature is about 48 degrees F.

**TAXONOMIC CLASS:** Fine-silty, mixed, superactive, mesic Aridic Haplustalfs

**TYPICAL PEDON:** Sharps loam, in a cultivated field. (Colors are for dry soil unless otherwise noted.)

**Ap**--0 to 6 inches; light reddish brown (5YR 6/4) loam, reddish brown (5YR 4/4) moist; moderate medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; neutral; clear smooth boundary. (4 to 8 inches thick)

**BA**--6 to 9 inches; light reddish brown (5YR 6/4) loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure parting to moderate medium granular; slightly hard, very friable, slightly sticky and slightly plastic; few faint clay films in root channels; slightly alkaline; clear smooth boundary. (0 to 6 inches thick)

**Bt**--9 to 19 inches; reddish brown (5YR 5/4) clay loam, reddish brown (5YR 4/4) moist; moderate medium prismatic structure parting to moderate medium subangular blocky; hard, friable, slightly sticky and slightly plastic; common faint clay films on faces of peds and in root channels; slightly alkaline; clear wavy boundary. (4 to 32 inches thick)

**Bk1**--19 to 25 inches; light reddish brown (5YR 6/4) loam, reddish brown (5YR 5/4) moist; weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few faint clay films on faces of peds and in root channels; common calcium carbonate threads and soft masses; strongly effervescent; moderately alkaline; gradual wavy boundary. (4 to 8 inches thick)

**Bk2**--25 to 30 inches; pink (5YR 8/4) loam, pink (5YR 7/4) moist; massive; hard, friable, slightly sticky and slightly plastic; many soft masses of calcium carbonate; strongly effervescent; moderately alkaline; gradual wavy boundary. (0 to 28 inches thick)

**2Cr**--30 inches; shale and soft sandstone.

**TYPE LOCATION:** Dolores County, Colorado; about 6 miles northwest of Dove Creek; located in the northwest quarter of sec. 18, T. 41 N., R. 19 W.; Northdale USGS quad; lat. 39 degrees 49 minutes 19 seconds N. and long. 109 degrees 00 minutes 46 seconds E., NAD27

**RANGE IN CHARACTERISTICS:**

Soil moisture regime: ustic bordering on aridic

Soil temperature regime: mesic

Mean annual soil temperature: 49 to 52 degrees F

Mean summer soil temperature: 58 to 64 degrees F

Rock fragments: 0 to 15 percent gravel

Particle-size control section: 18 to 35 percent clay  
with 15 to 70 percent sand, most being very fine sand

Depth to paralithic contact: 20 to 40 inches to soft shale or sandstone

Depth to secondary calcium carbonate: 10 to 36 inches

**A horizon:**

Hue: 5YR to 10YR

Value: 5 to 7 and 3 to 6 moist

Chroma: 2 to 6

Texture: loam, silt loam, or fine sandy loam

Rock fragments: 0 to 20 percent gravel

Calcium carbonate equivalent: 0 to 1 percent

Reaction: neutral or slightly alkaline

**Bt horizon:**

Hue: 5YR or 7.5YR

Value: 5 to 7 (3 to 6 moist)

Chroma: 3 to 6

Texture: loam, silty clay loam, or clay loam

Rock fragments: 0 to 15 percent gravel

Calcium carbonate equivalent: 5 to 10 percent

Reaction: Neutral to moderately alkaline

**Bk horizon:**

Hue: 5YR to 10YR

Value: 4 to 8 (4 to 7 moist)

Chroma: 4 to 8 (moist)

Texture: loam, silty clay loam, or clay loam

Rock fragments: 0 to 15 percent gravel

Calcium carbonate equivalent: 10 to 15 percent

Reaction: moderately alkaline or strongly alkaline

**COMPETING SERIES:** These are the Buick, Keiser, Klinedraw, Oshoto, Pulpit, Roubideau, Verde, Wetherill, and Wiley series. Potential competitors that do not yet have CEA class assigned are the

Amal, Chita, Elpedro, and Moncha soils. Amal, Buick, Chita, Elpedro, Keiser, Moncha, Oshoto, Wetherill, and Wiley soils are very deep. Klinedraw soils have hue of 10YR or 2.5Y. Pulpit, Roubideau, and Verde soils are moderately deep over hard sandstone. In addition, Roubideau soils lack carbonates in the lower part of the solum, and Verde soils have a fragipan-like horizon.

**GEOGRAPHIC SETTING:**

Parent material: eolian material derived from sandstone and shale.

Landform: mesas, ridges, and hills

Slopes: 2 to 12 percent

Elevation: 6,200 to 7,400 feet

Mean annual temperature: 46 to 50 degrees F

Mean annual precipitation: 13 to 16 inches

Precipitation is fairly evenly distributed throughout the year with July and August being slightly wetter and June being slightly dryer.

Frost-free period: 100 to 120 days

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Cahona, Pulpit, and Wetherill series. All these soils are on the same landscape position as Sharps. Cahona soils have a calcic horizon. Wetherill soils are very deep.

**DRAINAGE AND PERMEABILITY:** well drained, low to high runoff, moderate and moderately slow permeability

**USE AND VEGETATION:** Sharps soils are used for grazing or as irrigated or dry cropland. Native vegetation is mainly sagebrush, cactus, pinyon, juniper, western wheatgrass, and Indian ricegrass.

**DISTRIBUTION AND EXTENT:** Southwest Colorado and New Mexico. LRR D, MLRA 35, 36 and 39. This series is of moderate extent.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona.

**SERIES ESTABLISHED:** Lincoln County, NM. 1981.

**REMARKS:** Classification changed due to the change in moisture regime due to the Four Corners Climate Conference of 10/92. Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon: The zone from 0 to 6 inches. (Ap)

Argillic horizon: The zone from 9 to 19 inches. (Bt)

Particle size control section: The zone from 9 to 19 inches. (Bt)

Soil Taxonomy Second Edition, 1999

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National Cooperative Soil Survey  
U.S.A.

LOCATION TRAVESSILLA

NM+AZ CO KS MT OK SD UT WY

**Established Series**

Rev. VGL-AJC-RJA-ACT

05/2002

# TRAVESSILLA SERIES

The Travessilla series consists of very shallow and shallow, well drained soils that formed in calcareous eolian sediments and material weathered from sandstone. These soils are on hills, cuerdas, scarps, and mesas with slopes ranging from 0 to 75 percent. Mean annual precipitation is about 11 inches. The mean annual temperature is above 53 degrees F.

**TAXONOMIC CLASS:** Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthents

**TYPICAL PEDON:** Travessilla stony sandy loam - rangeland. (Colors are for dry soil unless otherwise noted.)

**A--**0 to 4 inches; light brownish gray (10YR 6/2) stony sandy loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine and medium roots; common fine pores; 15 percent stones; slightly effervescent; slightly alkaline; clear smooth boundary. (2 to 6 inches thick)

**C--**4 to 8 inches; pale brown (10YR 6/3) channery loam, brown (10YR 4/3) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; common fine and medium roots; common fine pores; 20 percent channers; slightly effervescent; moderately alkaline; abrupt smooth boundary. (2 to 14 inches thick)

**R--**8 inches; hard sandstone with some fractures.

**TYPE LOCATION:** Union County, New Mexico; approximately 1,560 feet north and 4,200 feet west of the southeast corner, sec. 24, T. 31 N., R. 36 E.

**RANGE IN CHARACTERISTICS:**

**Soil Moisture** - Typically, moist intermittently from April 30 through October in some part of the soil moisture control section and dry in all parts periodically from November 1 to April 30.

**Soil Temperature** - 50 to 58 degrees F.

**Depth to lithic contact:** typically 4 to 10 inches but ranges to 20 inches.

**Particle-size Control Section:**

**Clay Content:** 5 to 18 percent.

**Silt Content:** 5 to 50 percent.

**Sand Content:** 40 to 90 percent with more than 25 percent fine sand or coarser.

**Rock fragment content:** 0 to 10 percent stones, 0 to 10 percent cobbles and 0 to 25 percent pebbles

but weighted average is less than 35 percent.

A and C horizons - (an AC horizon is present in some pedons)

Hue: 7.5YR to 2.5Y

Value: 5 to 7 dry, 3 to 5 moist

Chroma: 2 to 4

Texture of the Fine Earth Fraction: sandy loam, fine sandy loam, loam or very fine sandy loam.

Rock fragment content: 0 to 35 percent

Reaction: slightly alkaline or moderately alkaline.

**COMPETING SERIES:** These are the Hideout (UT), Kenzo (T UT), Lazear (CO), Redspear (WY), Rizno (UT), Rizozo (NM), Simel (UT), Skyvillage (NM), Tesihim (AZ), Travson (WY), and Zukan (UT) series.

Hideout soils: have a mean annual temperature of 47 to 50 degrees F.

Kenzo soils: have hue of 7.5YR or redder.

Lazear soils: have more than 18 percent clay.

Redspear, Rizno and Rizozo soils: have hue of 5YR or redder.

Simel soils: average 27 to 35 percent clay.

Skyvillage soils: are dry in all parts of the soil moisture control section periodically from May 1 to June 30.

Tesihim soils: are derived from soft volcanic tuff.

Travson soils: are dry in the soil moisture control section July through September.

Zuchan soils: have accumulated carbonates in the form of a Bk horizon.

#### **GEOGRAPHIC SETTING:**

Parent material: calcareous eolian sediments and residuum weathered from sandstone and shale.

Outcrops of sandstone with a minor amount of shale are common on steep slopes.

Landform: hills, cuestras, scarps, and mesas

Slopes: 0 to 75 percent.

Elevation: 4,700 to 8,000 feet.

Mean annual precipitation: 10 to 16 inches, but has ranged higher.

Mean annual temperature: 50 to 57 degrees F.

Frost-free period is typically 115 to 170 days. Utah has a frost-free period as low as 70 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Bernal, Carnero, Hagerman, Quay and Pajarito soils.

Bernal and Hagerman soils: have an argillic horizon.

Carnero soils: have bedrock at depths of 20 to 40 inches.

Quay and Pajarito soils: do not have bedrock within a depth of 40 inches.

Quay soils have more than 18 percent clay in the particle size control section and have a prominent zone of lime accumulation

**DRAINAGE AND PERMEABILITY:** Well drained; runoff is high on slopes less than 1 percent and very high on slopes greater than 1 percent; moderate or moderately rapid permeability.

**USE AND VEGETATION:** Rangeland. Juniper, pinyon, squawbush, oakbrush, blue grama, sideoats grama and snakeweed are the principal plants.

**DISTRIBUTION AND EXTENT:** Northern New Mexico, Arizona, Colorado, Montana, western

Oklahoma, Utah and Wyoming. LRR E, G; MLRA'S 49, 67, 69, 70, 77. The series is extensive.

**MLRA OFFICE RESPONSIBLE:** Temple, Texas

**SERIES ESTABLISHED:** Eastern New Mexico Reconnaissance, Harding County, New Mexico, 1937.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric Epipedon - 0 to 4 inches. (A horizon).

Lithic Contact - 8 inches. (R horizon).

Particle-size Control Section - The zone from the surface of the soil to about 8 inches: (A, C horizons).

Additional data: None

Taxonomic Version: Second Edition, 1999

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National Cooperative Soil Survey  
U.S.A.

LOCATION ZYME

CO+UT+AZ

**Established Series**

Rev. JPP/JWH/DKR/SAZ/WWJ

09/2001

## ZYME SERIES

The Zyme series consists of shallow or very shallow, well drained soils that formed in residuum derived from shale. Zyme soils are on ridges, knobs, and hills. Slopes range from 3 to 80 percent. The mean annual precipitation is about 13 inches and the mean annual temperature is about 46 degrees F.

**TAXONOMIC CLASS:** Clayey, smectitic, calcareous, mesic, shallow Ustic Torriorthents

**TYPICAL PEDON:** Zyme clay loam, on a southeast facing, simple, 30 percent slope in pinyon and juniper woodland at an elevation of 6760 feet. (Colors are for dry soil unless otherwise noted.) When described on 7/12/79 the soil was dry from 0 to 10 inches.

**A1--**0 to 1 inch; grayish brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) moist; medium fine granular structure; loose, friable, sticky and plastic; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary. (0 to 2 inches thick)

**A2--**1 to 4 inches; grayish brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) moist; massive; very hard, firm, sticky and plastic; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary. (2 to 5 inches thick)

**C--**4 to 10 inches; grayish brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) moist; massive; hard, firm, sticky and plastic; 10 percent shale chips; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary. (4 to 14 inches thick)

**Cr--**10 to 14 inches; gray platy calcareous shale.

**TYPE LOCATION:** La Plata County, Colorado; west of the cemetery on the west side of Durango; located about 2,700 feet west and 300 feet north of the southeast corner of Sec. 19, T. 35 N., R. 9 W.; Durango West USGS quad; lat. 37 degrees 16 minutes 40 seconds N. and long. 107 degrees 53 minutes 34 seconds W., NAD 27

### RANGE IN CHARACTERISTICS:

**Soil moisture regime:** Ustic-aridic. The soil moisture control section is dry for 15 consecutive days from May 15 to July 15 when the soil temperature at 20 inches is greater than 41 degrees F. It is not dry in all parts of the moisture control section for at least 45 consecutive days following the summer solstice to October 20 and for at least 90 cumulative days during that period.

**Soil temperature regime:** mesic

Mean annual soil temperature: 47 to 55 degrees F

Mean annual summer soil temperature: 59 to 68 degrees F

Particle-size control section: 35 to 45 percent clay, 20 to 60 percent silt, 5 to 45 percent sand, 0 to 15 percent rock fragments

Depth to paralithic contact: 6 to 20 inches to shale

Depth to secondary calcium carbonate: 0 to 3 inches

A horizon:

Hue: 5Y to 10YR

Value: 4 or 6 dry, 3 to 5 moist

Chroma: 2 to 6

Texture: clay loam or silty clay loam

Rock fragments: 0 to 60 percent, mostly gravel and channers

Calcium carbonate equivalent: 0 to 5 percent

Reaction: slightly or moderately alkaline

C horizon:

Hue: 5Y to 10YR

Value: 4 to 7 dry, 3 or 5 moist

Chroma: 2 to 4

Texture: clay, clay loam, silty clay, or silty clay loam

Rock fragments: 0 to 15 percent

Calcium carbonate equivalent: 1 to 10 percent

Reaction: slightly or moderately alkaline

Cr horizon: shale bedrock

Some pedons have accumulations of gypsum

**COMPETING SERIES:** These are the Cannonville, Danko, Midway, Orella, and Samday, series. Cannonville soils are dry in all parts of the moisture control section 65 to 75 percent of the time when the temperature at 20 inches is greater than 41 degrees F. Danko soils have hue redder than 10YR and more than 15 percent exchangeable sodium. Epsie soils contain 50 to 60 percent clay in the C horizon. Midway soils are dry less than 15 consecutive days in all parts of the moisture control section between May 15 to July 15. Orella soils are strongly alkaline and sodic. Samday soils have consistent gypsum accumulations in the C horizon.

#### **GEOGRAPHIC SETTING:**

Parent material: residuum derived from shale

Landform: ridges, knobs, and hills

Slopes: 3 to 80 percent

Elevation: 5,000 to 8,100 feet

Mean annual air temperature: 45 to 53 degrees F

Mean annual precipitation: 10 to 16 inches

Wettest months: except for May and June, monthly precipitation is about the same. About half the precipitation falls between April and September.

Driest months: May and June receive the least precipitation.

Frost-free period: 90 to 135 days

PE Index: 30 to 50 for the series

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are Arboles, Bayfield, Bodot, and Sili soils.

Arboles and Sili soils are very deep and have cambic horizons.

Bayfield soils are very deep.

Bodot soils are moderately deep to bedrock.

**DRAINAGE AND PERMEABILITY:** Well drained, high or very high runoff, slow permeability

**USE AND VEGETATION:** These soils are used for livestock grazing, wildlife habitat, and homesite development. Native vegetation is pinyon pine, Utah juniper, big sagebrush, Indian ricegrass, western wheatgrass, mountainmahogany, Gambel oak, serviceberry, and bitterbrush.

**DISTRIBUTION AND EXTENT:** Western Colorado and similar areas in Arizona and Utah. LRR D, MLRA 39, 35, 34B. This series is of large extent.

**MLRA OFFICE RESPONSIBLE:** Phoenix, Arizona

**SERIES ESTABLISHED:** La Plata County Area, Colorado, 1982.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon: The zone from 0 to 4 inches. (A1 and A2 horizons)

Paralithic feature: Shale bedrock at 10 inches.

Particle size control section: The zone from 0 to 10 inches. (A1, A2, C)

Classified according to Soil Taxonomy Second Edition, 1999.

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National Cooperative Soil Survey

U.S.A.

**ATTACHMENT 4**

**Black Mesa Mine: J9 Coal Resource Area  
Soil Laboratory Data**



August 24, 2000

Mr. Gary Wendt  
Peabody Western Coal Co.  
PO Box 650  
Navajo Route 41  
Kayenta, Arizona 86033

Dear Mr. Wendt:

Enclosed are the results of the analyses performed on the soil samples received by IML on August 4, 2000. The samples were from Black Mesa Mine and correspond to IML lab numbers 0300S03226 - 29. The 1999 PWCC QC Split Analytical Suite was requested for each sample.

If you have any questions or comments, please feel free to contact me at 1-800-828-1409.

Sincerely,

Eric J Jaquez  
Soil Lab Supervisor  
IML-Farmington

enclosure: analytical report



Inter-Mountain Laboratories, Inc.

2506 West Main Street

Farmington, New Mexico 87401

Tel. (505) 326-4737

Peabody Western Coal Company

Kayenta, AZ

IML Project #0300S03226

Client Project ID: Black Mesa Mine

Date Received: 08/04/00

J-19

Report Date: 08/24/00

Lab Id	Sample Id	Depths Inch	pH	EC	Ca	Mg	Na	SAR	Sand	Silt	Clay	Texture
			s.u.	mmhos/cm	meq/L	meq/L	meq/L		%	%	%	
0300S03226	J9-18 <i>Bejay</i>	76 - 108	7.3	3.06	13	8.7	13	4.0	81	8	11	SL
0300S03227	J9-21 <i>Bejay</i>	80 - 89	7.3	3.14	8.2	7.5	14	4.9	80	8	12	SL
0300S03228	J9-24 <i>Bejay</i>	54 - 88	7.3	3.27	11	9.3	12	3.8	82	8	10	LS
0300S03229	J9-26 <i>Blantyre</i>	80 - 108	7.1	8.34	42	23	32	5.6	69	11	20	SCL



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**Peabody Western Coal Company**

Kayenta, AZ

IML Project #0300S03226

Client Project ID: Black Mesa Mine

Date Received: 08/04/00

J-19

Report Date: 08/24/00

Lab Id	Sample Id	Depths Inch	Total Sulfur	Acid Base	Neutral.	ABP
			%	Total Sulfur t/Kt	Potential t/Kt	Total Sulfur t/Kt
0300S03226	J9-18	76 - 108	0.03	0.9	34.6	33.6
0300S03227	J9-21	80 - 89	0.01	0.3	32.1	31.8
0300S03228	J9-24	54 - 88	0.01	0.3	21.8	21.5
0300S03229	J9-26	80 - 108	0.05	1.6	28.1	26.6



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2506 West Main Street

Peabody Western Coal Company

Kayenta, AZ

J-19

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Client Project ID: Black Mesa Mine

Date Received: 08/04/00

IML Project #0300S03226

Report Date: 08/24/00

Lab Id	Sample Id	Depths Inch	Selenium Total mg/Kg	Selenium Soluble mg/Kg
1300S03226	J9-18	76 - 108	0.39	<0.02
1300S03227	J9-21	80 - 89	0.37	<0.02
1300S03228	J9-24	54 - 88	0.27	<0.02
1300S03229	J9-26	80 - 108	0.34	<0.02



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Peabody Western Coal Company

Kayenta, AZ

IML Project #0300S03226

Client Project ID: Black Mesa Mine

J-19

Report Date: 08/24/00

Date Received: 08/04/00

Lab Id	Sample Id	Depths Inch	pH s.u.	EC mmhos/cm	Ca meq/L	Mg meq/L	Na meq/L	SAR	Sand %	Silt %	Clay %	Texture
0300S03229	J9-26	80 - 108	7.1	8.34	42	23	32	5.6	69	11	20	SCL
0300S03229D	J9-26	80 - 108	7.1	8.41	42	23	32	5.6	69	11	20	SCL



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Peabody Western Coal Company

Client Project ID: Black Mesa Mine

Kayenta, AZ

IML Project #0300S032

Date Received: 08/04/00

J-19

Report Date: 08/24/00

Lab Id	Sample Id	Depths Inch	Total Sulfur		Neutral		ABP	
			%	TKT	Potential	Total Sulfur	TKT	TKT
0300S03229	J9-26	80 - 108	0.05	1.6	28.1	26.6		
0300S03229D	J9-26	80 - 108	0.05	1.6	27.4	25.8		



**Inter-Mountain Laboratories, Inc.**

Farmington, New Mexico 87401

Tel. (505) 326-4737

**Peabody Western Coal Company**

Kayenta, AZ

J-19

IML Project #0300S03226

Report Date: 08/24/00

2506 West Main Street

Client Project ID: Black Mesa Mine

Date Received: 08/04/00

Page 6 of 6

Lab Id	Sample Id	Depths Inch	Selenium	
			Total mg/Kg	Soluble mg/Kg
0300S03229	J9-26	80 - 108	0.34	<0.02
0300S03229D	J9-26	80 - 108	0.33	<0.02