

**2003 SOIL SURVEY REPORT**  
**J-28, N-9, N-10, AND N-11 EXTENSION (N-12 & N-99)**  
**COAL RESOURCE AREAS**  
**KAYENTA COMPLEX**

**Submitted to:**

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## 1.0 INTRODUCTION

The identification and proper management of topsoil resources in the various Coal Resource Areas of the Peabody Western Coal Company (PWCC) Kayenta Complex is essential for: (1) the successful reclamation of any areas that might be disturbed during project activities and (2) the achievement of the post-mining land use. The information presented in this report is designed to aid in the formulation of a practical and successful reclamation plan.

A detailed Order 2 soil survey of the J-28, N-9, N-10, and N-11 Extension (N-12 and N-99) Coal Resource Areas was completed as required by the Office of Surface Mining (OSM). Approximately 9,963 acres were included in the 2003 Kayenta Complex Soil Survey as follows:

- Coal Resource Area J-28                      1406 acres
- Coal Resource Area N-9                      2345 acres
- Coal Resource Area N-10                    1794 acres
- Coal Resource Area N-12/N99S            2773 acres
- Coal Resource Area N-99N                1645 acres

The federal Office of Surface Mining (OSM) was contacted prior to the start of soils field work to ensure all requirements were met with this study. Only small portions of N-10, N-12, and N-99N were included in the previous PWCC Order 1 and Order 2 Kayenta Complex soil survey (Intermountain Soils, Inc. 1985). All of the areas had been previously mapped to the less detailed Order 3 and Order 4 level of intensity (Intermountain Soils, Inc. 1985).

## 2.0 METHODS

### 2.1 Order 2 Soil Survey

A detailed soil survey was conducted during the summer of 2003 on 9,963 acres comprising the J-28, N-9, N-10 and N-11 Extension (N-12 and N-99) coal resource areas.

The soil survey used the existing Kayenta Complex 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.

Jim Nyenhuis and Tim Overdier, both Certified Professional Soil Scientists, investigated the soil resources of the study area during the summer of 2003. Based on previous discussion, the J-28, N-9, N-10, and N-11 Extension (N-12 and N-99) 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 326 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.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Soil Survey Maps

The detailed soil survey maps for the J-28, N-9, N-10, and N-11 Extension (N-12 and N-99) Coal Resource Areas are presented on Drawing 85305C (5 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, 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 Kayenta Complex. 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 2003 Nyenhuis soil survey.

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 326 soil holes that were dug and described during soil survey field activities. These holes were distributed across the five Coal Resource Areas as follows: J28, 1406 acres, 60 holes; N9, 2345 acres, 82 holes; N10, 1794 acres, 62 holes; N12/N99S (N-11 Extension south portion), 2773 acres, 70 holes; and N99N (N-11 Extension north portion), 1645 acres, 52 holes.

Table 5 is subdivided into the five Coal Resource Areas. Areas N-12 and N-99S are combined into one area. 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 Kayenta Complex. 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 Kayenta Complex 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).

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 dominately "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 Kayenta Complex 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 Kayenta Complex (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 Kayenta Complex 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 Kayenta Complex 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 Kayenta Complex (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

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. Extensive laboratory results for each of the soils on the Kayenta Complex are contained in the previous Soil Survey report (Intermountain Soils, Inc. 1985).

### 3.7 Topsoil Suitability and Salvage Depth Recommendation

A topsoil suitability evaluation and salvage depth recommendation was completed for all soils in the previous Kayenta Complex 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 Kayenta Complex 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 Kayenta Complex Soil Survey Area of Coal Resource Areas J-28, N-9, N-10, N-12-N99S, and N-99N). 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 326 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 Unit 4CD (Zyme very channery loam)** is 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 Unit 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 Unit 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 Unit 6AB (Sharps, ustic-aridic, very fine sandy loam)** is 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.

**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 (Begay loam)** is 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
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
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
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 Kayenta Complex**

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 Kayenta Complex**

<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 Torrifuvent
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**

**J-28, N-9, N-10, and N-11 (N-12 & N-99) 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	-
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
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
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

**TABLE 4**

**J-28, N-9, N-10, and N-11 (N-12 & N-99) Coal Resource Areas Soil Survey  
Recommended Soil Salvage Depths**

Symbol	Map Unit Name	Total Recommended Salvage Depth <sup>1</sup> (feet)	Topsoil/Subsoil Salvage Thickness <sup>1</sup> (feet)
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	-
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
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
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

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**

<b>Hole#</b>	<b>Soil Name - surface texture</b>	<b>Map Unit</b>	<b>Depth to rock</b>	<b>Comments / profile description</b>
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	

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

Hole#	Soil Name - surface texture	Map Unit	Depth to rock	Comments / profile description
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 (N-11 EXTENSION SOUTH PORTION) 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 (N-11 EXTENSION SOUTH PORTION) 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 (N-11 EXTENSION SOUTH PORTION) COAL RESOURCE AREA, 2773 Acres**

<b>Hole#</b>	<b>Soil Name - surface texture</b>	<b>Map Unit</b>	<b>Depth to rock</b>	<b>Comments / profile description</b>
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 (N-11 EXTENSION NORTH PORTION) 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 (N-11 EXTENSION NORTH PORTION) 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	