

SOILS INFORMATION

FOR THE
PROPOSED BACA GEOTHERMAL PROJECT

PROVIDED BY THE U.S. FOREST SERVICE, SANTA FE
and
EARTH ENVIRONMENTAL CONSULTANTS, ALBUQUERQUE

This volume includes

SECTION 1

U. S. Forest Service Soils Information

SECTION 2

Soil Survey of Bandelier National Monument

SOILS INFORMATION

PREPARED BY

U. S. FOREST SERVICE

SANTA FE

Public Service Company of New Mexico

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Map unit 8 as of 1/25

Mapping Unit: 8 -- Entic Haploborolls, Cumulic Haploborolls - complex,
0-15% slopes

PRELIMINARY
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Acres: 2107

Landform: Nearly level to gently sloping flood plains and stream terraces.

Parent Material: Recent alluvium from various volcanic rocks.

Slope: 0 to 15 percent; average 5 percent.

Elevation: 7,100 feet to 8,000 feet.

Temperature: Mean annual 32°F to 47°F; mean summer 47°F.

Precipitation: 20 to 30 inches per year.

Potential Natural Vegetation: Douglas fir-ponderosa pine forest or
ponderosa pine forest.

Existing Vegetation: grass.

Modal Profiles

Entic Haploboroll

Typifying Pedon:

0 to 4 inches -- very dark grayish brown (10 ^{YR}/₁, 3/2) loam, very dark
brown (10 ^{YR}/₂, 2/2) moist; soft, very friable, nonsticky,
non plastic; about 10 percent coarse fragments; slightly
alkaline (pH 7.4). (3 to 5 inches thick)

4 to 11 inches -- dark grayish brown (10 ^{vc}yr. 4/2) gravelly sandy loam, very dark grayish brown (10 ^{vc}yr. 3/2) moist; soft, very friable, non-sticky, non plastic; approximately 30 percent coarse fragments; slightly alkaline (pH 7.6). (5 to 10 inches thick)

11 to 14 inches --grayish brown (10 ^{vc}yr. 5/2) very gravelly sandy loam, dark brown (10 ^{vc}yr. 3/3) moist; soft, very friable, non-sticky, non plastic; approximately 40 percent coarse fragments; slightly alkaline (pH 7.8). (3 to 5 inches thick)

14 to 32 inches --light brownish gray (10 ^{vc}yr. 6/2) extremely gravelly sand, dark grayish brown (10 ^{vc}yr. 4/2) moist; loose, nonsticky, non plastic; approximately 75 percent coarse fragments; slightly alkaline (pH 7.8). (15 to 60 inches thick)

Range in Characteristics: The mallic epipedon has hue of 10 ^{vc}yr. or 7.5 ^{vc}yr., value of 3 through 5 dry, 2 or 3 moist and chroma of 2 or 3. It is loam or sandy loam and has 5 to 25 percent coarse fragments. Reaction is neutral to slightly alkaline.

The substratum has hue of 10 yr. or 7.5 yr., value dry of 5 or 6, 3 or 4 moist and chroma of 2 or 3. It is sand or loamy sand and has 5 to 80 percent coarse fragments. Reaction is slightly alkaline to moderately alkaline and it is calcareous.

Cumulic Haploboroll

Typifying Pedon:

0 to 8 inches -- brown (10 ^{vc}yr. 4/3) light clay loam, very dark grayish brown (10 ^{vc}yr. 3/2) moist; slightly hard, friable, slightly sticky, slightly plastic; approximately 5 percent gravel; slightly alkaline (pH 7.4). (2 to 8 inches thick)

Mapping Unit 679: Cryoborolls, 16 to 40 percent slopes

PRELIMINARY
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Acres: 235

Landform: Strongly sloping to steep mountain sideslopes

Parent Material: Rhyolite

Slope: 16 to 40 percent

Elevation: 7,800 to 8,800 feet

Temperature: Mean annual air is 34° F to 38° F.

Precipitation: 27 to 36 inches per year

Potential Natural Vegetation: Douglas fir-Engelmann spruce

Modal Profile

Cryoboroll

Typifying Pedon:

0 to 3 inches--dark yellowish brown (10 yr 3/4) loam, very dark gray
(mollic) (10 yr 3/1) moist; soft, friable, nonsticky, nonplastic;
approx. 5% coarse fragments; neutral (pH 7.2)

3 + inches--loam; subangular blocky structure; soft, very friable,
(mollic-cambic) nonsticky, nonplastic; approx. 20% coarse fragments;
neutral (pH 7.2).

Range in Characteristics: Sufficient data is not available to make a meaningful range. The mean annual soil temperature is 36° F to 40° F and the mean summer soil temperature is 42° F to 47° F. The soil moisture regime is udic.

Inclusions: None identified

Management Implications: This soil has high inherent fertility, although plant production is usually limited by the short growing season.

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8 to 20 inches -- very dark grayish brown (10 ^{VC} yr. 3/2) clay loam, black (10 ^{YR} yr. 2/1) moist; slightly hard, friable, slightly sticky, slightly plastic; approximately 5 percent coarse fragments; slightly alkaline (pH 7.4). (0 to 14 inches thick)

20 to 27 inches --dark grayish brown (10 yr. 4/2), heavy clay loam, very dark grayish brown (10 yr. 3/2 moist; hard, friable, sticky, plastic; approximately 5 percent coarse fragments; slightly alkaline (pH 7.4). (7 to 14 inches thick)

27 to 34 inches --dark gray (10 yr. 4/1) very gravelly sandy loam, very dark grayish brown (10 yr. 3/2) moist; soft, friable, nonsticky, non plastic; approximately 50 percent coarse fragments; slightly alkaline (pH 7.6). (7 to 43 inches thick)

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Range in Characteristics: The mollic epipedon has hue of 10 yr., value dry of 3 or 4, 2 or 3 moist and chroma of 1 through 3. It is loam or clay loam and has 5 to 20 percent coarse fragments. Reaction is slightly alkaline.

The cambic horizon has hue of 10 ^{YR} yr., value dry of 3 or 4, 2 or 3 moist and chroma of 1 through 3. It is loam or clay loam and has 5 to 20 percent coarse fragments. Reaction is slightly alkaline to moderately alkaline. Some pedons are calcareous in the cambic horizon.

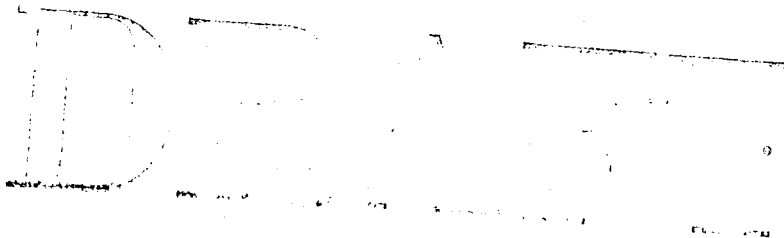
The substratum has hue of 10 ^{YR} yr., value dry of 3 through 5, 3 or 4 moist and chroma of 1 through 4. It is sandy loam, or sandy clay and has 5 to 60 percent coarse fragments. Reaction is slightly alkaline to moderately alkaline and ^{it} is calcareous.

Andogleptic

Inclusions: 15 percent ~~Type~~ Haplaquolls, 15 percent Aquic Udifluvents.

These inclusions occur in the lower positions on the landscape.

Management Implications: Erosion hazard is high in this unit due to its position on the landscape and its subsequent susceptibility to overland flow. The wet areas, which constitute approximately 30% of this unit are quite fragile and should be avoided. A perched water table occurs in these areas at depths of 1 1/2 to 3 feet.



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Mapping Unit 102: Rock outcrop - Boralf complex 41 to 120 percent slopes

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Acres: 272

Landform: Steep to extremely steep canyon and scarp land

Parent Material: Sandstone and shale

Slope: 41 to 120 percent;

Elevation: 7,500 to 8,500 feet

Temperature: Mean annual is 40° F to 45° F.

Precipitation: 18 to 25 inches per year

Potential Natural Vegetation: Ponderosa Pine

Mapping Unit Composition: This unit is a complex of 50 percent Rock outcrop and 50 percent Boralfs. No inclusions have been identified

Range in Characteristics: Not enough data is available for determination of meaningful ranges. These soils have an argillic horizon. Mean annual soil temperature is 42° F to 47° F, and mean summer soil temperature is 52° F to 56° F. The soil moisture regime is ustic.

Management Implications: Steep slopes and rock outcrop preclude most management practices.

Mapping Unit 118: Rock outcrop - Eutrochrepts complex, 41 to 120 percent slopes

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Acres: 5914

Landform: Steep to extremely steep complex mountain and mesa sideslopes.

Parent Material: Residual materials weathered from tuff, andesite and rhyolite

Slope: 41 to 120 percent

Elevation: 5,400 to 8,400 feet

Temperature: Mean annual air is 40° F to 45° F.

Precipitation: 18 to 25 inches per year

Potential Natural Vegetation: Ponderosa Pine

Modal Profile

Eutrochrept

Typical Pedon:

0 to 8 inches--Brown (10 yr 5/3) gravelly sandy loam (10 yr 3/3) moist;
soft, very friable, nonsticky, nonplastic; approx. 15%
coarse fragments; neutral (pH 7.0)

8 + inches-- Cobble sandy loam; granular structure (clay increase);
soft, very friable, slightly sticky, nonplastic; approx.
50% coarse fragments; neutral (7.0)

Range in Characteristics: Sufficient data is not available to make a
meaningful range.

The mean annual soil temperature is 42° F to 47° F. The soil moisture
regime is ustic.

Inclusions: None identified

Management Implications: This unit is an intricate complex of 60 percent
Rock outcrop and 40 percent Entrochrept soils. Steep slopes and rock
outcrop preclude most management activities.

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Mapping Unit 119: Rock outcrop-Glossoboralf-Udorthent complex, 41 to 120 percent slopes.

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Acres: 4837

Landform: Steep to extremely steep complex mountain side slopes and canyon walls.

Parent Material: Tuff

Slope: 41 to 120 percent

Elevation: 7,850-9,350 feet

Temperature: Mean annual air 38° F to 42° F.

Precipitation: 22 to 34 inches per year

Potential Natural Vegetation: Douglas fir-Ponderosa Pine

Modal Profile

Glossoboralfs:

0 to 3 inches--Brown (7.5 yr 4/2) sandy loam (7.5 yr 3/2) moist; soft, (ochric) friable, non-sticky, non-plastic; approx 10% coarse fragments; neutral (pH 7.2)

3 + inches-- Gravelly sandy clay loam, subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; approx. 25% coarse fragments; neutral to slightly alkaline

(pH 8.2)

Range in Characteristics: Sufficient data is not available to make a meaningful range. These soils have low base saturation. The mean annual soil temperature is 40° F to 44° F, and the mean summer soil temperature is 48° to 52° F. The soil moisture regime is udic.

Udorthents:

0 to 5 inches--Light gray (10 yr 7/2) stony sandy loam (10 yr 4/4)
(ochric) moist; soft, friable, non-sticky, non-plastic; approx.
40% coarse fragments; moderately alkaline (pH 8.2)

Range in Characteristics: Sufficient data is not available to determine a meaningful range.

The mean annual soil temperature is 40° F to 44° F, and the mean summer soil temperature is 48° F to 52° F. The soil moisture regime is udic.

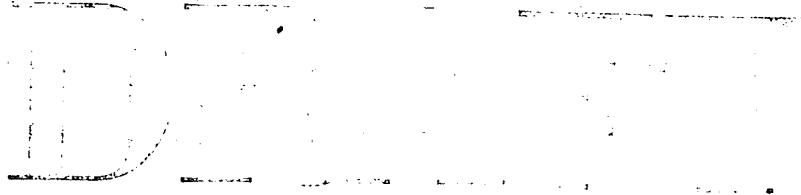
Inclusions: 15% M.U. 118, 5% Dystrandeps

Management Implications: This unit is a complex of 40 percent Rock outcrop, 30 percent Glossoboralfs, and 30 percent Udorthents. Steep slopes and rock outcrop limit most management activities.

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Mapping Unit 124: Rock outcrop-Pelado complex, 41 to 120 percent slopes

PRELIMINARY
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Acres: 1483

Landform: Steep to extremely steep canyon and mountainous terrain.

Parent Material: Dacite, latite, andesite, rhyolite, and tuff

Slope: 41 to 120 percent

Elevation: 8,000 - 9,000 feet

Temperature: Mean annual air is 38° F to 42° F.

Precipitation: 22 to 34 inches per year

Potential Natural Vegetation: Douglas fir - Ponderosa Pine

Existing Vegetation: Douglas-fir, ponderosa pine, white fir (scattered), gambel oak, mountain lover boxleaf, New Mexico locust, mountain mahogany, mountain brome, mountain muhly, Junegrass and timber oat grass.

Modal Profile

Pelado Soils: See mapping unit 673 for representative profile, location, and range in characteristics.

Inclusions: 15% Typic Udorthents

Management Implications: This unit has 50 percent Rock outcrop and 50 percent Pelado soils. The Pelado soils have moderate erosion hazard. Steep slopes and complex occurrence of rock outcrop preclude most management practices.

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Mapping Unit: 125 - Rock outcrop - ~~CRYOBOROLL~~ ^{Griegos complex} ~~complex~~, 41-120% slopes.

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Acres: 523

Landform: Steep to extremely steep canyon and scarp land.

Rock Type: Rhyolite, andisite and some tuff.

Slope: 41 to 120 percent: average 60 percent.

Elevations: 8,000 to 8,500 feet.

Temperature: Average annual temperature is 34°F. to 38°F.

Precipitation: 27 to 34 inches per year.

Potential Natural Vegetation: Douglas fir - Engelman spruce forest.

Modal Profile

~~CRYOBOROLL~~

~~0 to 10 inches -- very dark grayish brown (10 yr. 3/2) cobbly loam,
very dark brown (10 yr. 2/2) moist: soft, friable,
nonsticky, nonplastic; approximately 20 percent
coarse fragments; neutral (pH 7.2)~~

Rock Outcrop

No representative profile

Griegos

See mapping unit 667 for representative profile

14

10 to 27 inches -- light yellowish brown (10 ~~yr.~~^{yr.} 6/4) very gravelly sandy clay loam, yellowish brown (10 ~~yr.~~^{yr.} 5/4) moist; slightly hard, friable, slightly sticky, nonplastic; weak subangular blocky structure; few thin patchy clay films on ped faces; approximately 80 percent coarse fragments; slightly alkaline (pH 7.4).

Range in Characteristics: Adequate data is not available to provide a meaningful range except; Mean annual soil temperature is 36°F. to 40°F. and mean summer soil temperature is 42°F. to 47°F. Soil moisture regime^e (udic) is not limiting during the growing season. The base saturation in the argillic horizon is ~~greater~~^{less} than 50 percent (by NH_4OAc).

Inclusions: none encountered.

Management Implications: Erosion hazard is extreme on the soil components of this unit. Steep slopes and complex occurrence of rock outcrop preclude most management practices.

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Mapping Unit: 128 - ^AEUTROBORILFS - Rock outcrop complex, 41-120% slopes.

PRELIMINARY
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Acres: 12,682

Landform: Steep to extremely steep canyon and scarp land.

Rock Type: Dominantly tuff.

Slope: 41 to 120 percent; average 60 percent.

Elevation: 6,500 to 8,500 feet.

Temperature: Mean annual temperature is 43°F. to 48°F.

Precipitation: 18 to 23 inches per year.

Potential Natural Vegetation: Ponderosa pine - alligator juniper forest.

Modal Profile

~~EUTROBORILFS~~
~~EUTROBORILFS~~

- 0 to 10 inches -- light brownish gray (10 ^{VE} ~~VE~~. 6/2) gravelly sandy clay loam, (10 ^{VE} ~~VE~~. 4/2) moist; slightly hard, friable, slightly sticky, nonplastic; approximately 50 percent coarse fragments; slightly alkaline (pH 7.4).
- 10 to 15 inches -- light gray (10 ^{VE} ~~VE~~. 7/2) very gravelly sandy loam, (10 ^{VE} ~~VE~~. 5/2) moist; soft, very friable, nonsticky, nonplastic; approximately 80 percent coarse fragments; slightly alkaline (pH 7.4).

15 to 43 inches -- light yellowish brown (10 ~~yr~~^{yr}. 6/4) sandy clay, (10 ~~yr~~^{yr}. 4/4) moist; very hard, very firm, sticky, slightly plastic; common thin clay films in pores^{res} and on ped^e faces; approximately 10 percent coarse fragments; slightly alkaline (pH 7.6).

Range in Characteristics: Adequate data is not available to provide a meaningful range except: Mean annual soil temperature is ~~less than 47°F.~~ ^{between 32°F and 47°F.}

Average annual precipitation is 18 to 23 inches with peak periods in winter and mid-summer.

Inclusions: none encountered.

Management Implications: Erosion hazard is extreme on the soil components of this unit. Steep slopes and complex occurrence of rock outcrop preclude most management practices.

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Mapping Unit: 604 - ^{ANDIC} ~~UMBRIC~~ DYSTROCHREPT, ^{nectal} ~~coarse-loamy, mixed~~, frigid,
0-15% slopes.

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Acres: 4085

Landform: Nearly level to strongly sloping mesa tops.

Rock Type: Tuff.

Slope: 0 to 15 percent; average 10 percent.

Elevation: 8,200 to 8,700 feet.

Temperature: Mean annual temperature is 38°F. to 42°F.

Precipitation: 22 to 34 inches per year.

Potential Natural Vegetation: Douglas fir - ponderosa pine forest.

Existing Vegetation: Douglas fir, white fir, ponderosa pine, aspen, scattered Engleman spruce, limber pine, Gambel's oak, New Mexico locust, common juniper and numerous forbes and grasses.

Modal Profile

^{ANDIC} ~~UMBRIC~~ DYSTROCHREPT, ^{nectal} ~~coarse-loamy mixed~~, frigid.

1 inch to 0 -- partially decomposed organic matter.

0 to 2 inches -- dark grayish brown (10 YR 4/2) fine sandy loam,
(10 YR 3/2) moist; soft, very friable, nonsticky
PRELIMINARY and nonplastic; neutral (pH 6.8). (1 1/2 to 3
DRAFT inches thick)

2 to 8 inches -- pale brown (10 YR 6/3) fine sandy loam, (10 YR 4/3)
moist; soft, very friable, nonsticky and nonplastic;
neutral (pH 6.8). (4 to 6 inches thick)

8 to 23 inches -- pale brown (10 YR 6/3) sandy loam, (10 YR 3/3) moist;
slightly hard, friable, nonsticky and nonplastic;
approximately 5 percent coarse fragments; neutral
(pH 7.0). (12 to 16 inches thick)

23 to 27 inches -- light gray (10 YR 7/2) sandy clay loam, (10 YR 5/4)
moist; slightly hard, friable, slightly sticky,
slightly plastic; neutral (pH 7.0). (2 to 20 inches
thick)

Range in Characteristics: The achric epipedon has hue of 10 YR or
7.5 YR, value dry of 4 through 7, 3 through 6 moist and chroma of 1
through 3. It is fine sandy loam or loam and has 0 to 10 percent coarse
fragments. Reaction is neutral to mildly alkaline.

The cambic horizon ranges in thickness from 13 to 52 inches. Texture
ranges from sandy loam to sandy clay loam with 0 to 20 percent coarse
fragments. Reaction is neutral to mildly alkaline.

The control section (10 to 30 inches) has less than 18 percent clay and
greater than 15 percent fine sand with 0 to 20 percent coarse fragments.

Mean annual soil temperature is 40°F. to 44°F. Average annual precipitation
ranges from 22 to 34 inches per year and the moisture regime is udic.

Inclusions: 10 percent TYPIC ARGIBOROLLS; 15 percent EUTRIC GLOSSOBORALF.

Management Implications: Erosion hazard is low in this mapping unit.
The most limiting factor in this unit is nutrient availability. These soils will respond well to added fertilizers.

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Mapping Unit: 614 - Sanjue - TYPIC EUTROBORALFS complex, 0-15% slopes.

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Acres: 4788

Landform: Nearly level to strongly sloping mesa tops.

Rock Type: Pumice and tuff.

Slope: 0 to 15 percent; average 8 percent.

Elevation: 7,200 to 8,500 feet.

Temperature: Mean annual temperature is 40°F to 45°F.

Precipitation: 18 to 25 inches per year.

Potential Natural Vegetation: Ponderosa pine forest.

Existing Vegetation: Ponderosa pine, New Mexico locust, Gamble's oak, western yarrow, American ^{VE} witch, snakeweed, pine dropseed, arizona fescue bottlebrush squirreltail, little bluestem and junegrass.

Modal Profile

Sanjue very gravelly sandy loam.

See mapping 631 for representative profile.

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~~TYPIC~~ EUTROBORALF

- 0 to 8 inches -- pale brown (10 YR 6/3) loam, (10 YR 4/4) moist; slightly hard, friable, slightly sticky, slightly plastic; approximately 10 percent coarse fragments; mildly alkaline (pH 7.4). (4 to 10 inches thick)
- 8 to 43 inches -- light yellowish brown (10 YR 6/4) clay loam, (10 YR 5/6) moist; hard, firm, sticky and slightly plastic; common thin clay films on ped faces; mildly alkaline; (pH 7.8). (20 to 40 inches thick).
- 43 to 48 inches -- light yellowish brown (10 YR 6/4) gravelly sandy clay loam, (10 YR 5/8) moist; slightly hard, friable, slightly plastic; approximately 15 percent coarse fragments; moderately alkaline (pH 8.2). (0 to 10 inches thick).
- 48 inches plus -- Pumice.

Range in Characteristics: The achric epipedon has hue of 10 YR or 7.5 YR, value dry of 5 through 7, 4 or 5 moist and chroma of 2 through 4. Texture ranges from sandy loam to clay loam with 0 to 40 percent coarse fragments. Reaction is neutral to mildly alkaline.

The argillic horizon is 20 to 40 inches thick. Texture ranges from clay loam to clay with 0 to 60 percent coarse fragments. Reaction is neutral to moderately alkaline.

Mean annual soil temperature is 42°F. to 47°F. Average annual precipitation is 18 to 25 inches with peak periods in winter and mid-summer. Variability is too great for further classification.

Inclusions: 5 percent UDIC USTOCHREPTS.

Management Implications: These ^Ssanjue soils (60 percent of unit) have pumice at shallow depths. These soils, consequently, are highly susceptible to windthrow. In addition, the sanjue soils are low in inherent fertility and moisture supplying capacity. They will not show much response to added fertilizers. The ^{ANDEPTIC}~~UDIC~~ EUTROBORALFS (40 percent of unit) have more favorable characteristics. ~~They are deeper and have more favorable characteristics:~~ They are deeper and have more nutrient and moisture supplying capacity. They will show a moderate response to added fertilizer.

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Mapping Unit 620: Entic Dystrandept, ashy-skeletal, frigid-Peralta complex, 0 to 15 percent slopes

PRELIMINARY
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Acres: 2896

Landform: Gently to moderately sloping mesa tops

Parent Material: Pumice and Tuff

Slope: 0 to 15 percent

Elevation: 7,400 - 9,000 feet

Temperature: Mean annual air is 38° F to 42° F

Precipitation: 22 to 34 inches per year

Potential Natural Vegetation: Douglas fir-Ponderosa Pine

Existing Vegetation: Douglas-fir, ponderosa pine, white fir, aspen, limber pine, wildrose, New Mexico locust, common juniper, snowberry, kinnickinnick, mountain brome, Junegrass, Mountain muhly and Kentucky bluegrass.

Modal Profiles

Entic Dystrandept, ashy-skeletal, frigid

Typifying pedon:

2 to 0 inch--Needles, twigs, etc., in various stages of decomposition

0 to 3 inches--Gray brown (10 yr 5/2) loam, very dark gray brown (10 yr 3/2) moist; soft, friable, non-sticky, non-plastic; approx. 20% coarse fragments; slightly acid (pH 6.4). (2 to 9 inches thick)

3 to 13 inches--Light gray (10 yr 7/2) stony clay loam, brown (10 yr 5/3) (cambic) moist; subangular blocky structure; soft, friable, slightly sticky, slightly plastic; approx. 70% coarse fragments; slightly acid (pH 6.4) (1 to 11 inches thick)

13 to 23 inches--Light gray (10 yr 7/2) Very stony sandy loam, light yellowish brown (10 yr 6/4) moist; massive; soft, friable, non-sticky, non-plastic; approx. 90% coarse fragments; neutral (pH 6.6)

23 + inches--Bedrock

Range in Characteristics: The ochric epipedon has hue of 10 yr, value of 5 through 7 dry, 3 or 4 moist, and chroma of 1 through 4. The texture is sandy loam or loam with 10 to 40 percent coarse fragments. Reaction is slightly acid to neutral (pH 6.4-6.6).

The cambic horizon is 1 to 11 inches thick. Texture is clay loam with 25 to 90 percent coarse fragments. Reaction is slightly acid to neutral (pH 6.4-6.8).

The control section (10 inches to bedrock) has more than 35 percent coarse fragments and the fine-earth fraction has 60 percent or more (by weight) of volcanic ash, cinders and pumice. Depth to Bedrock ranges from 23 to 28 inches. These soils have a thin, dark epipedon or an ochric epipedon. Base saturation is less than 50 percent.

The mean annual soil temperature is 40° F to 44° F, with a mean summer soil temperature of 48° F to 52° F. The soil moisture regime is udic.

Peralta Soils

Taxonomic Class: Ashy-skeletal, frigid Typic Uitrandept See Unit 621 for profile, location and range

Inclusions: 15% Typic Udorthent, 5% Eutric Glossoboralfs

Management Implications: This unit is a complex of 60 percent Entic Dystrandept, ashy-skel., frigid and 40 percent Peralta soils. The Entic Dystrandepths have serious limitations due to the occurrence of bedrock at less than 3 feet, and a high content of cobbles and stones in the profile. The Peralta soils have raw pumice in the lower part of the profile but the potential of the soil is very good.

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Mapping Unit 621: Peralta-Anesa complex, 16-40% slopes.

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Acres: 1669

Landform: Strongly sloping to steep mesa tops and sideslopes.

Rock Type: Pumice and tuff.

Slope: 16 to 40 percent

Elevation: 7,400 to 9,000 feet.

Temperature: Mean annual temperature is 38° F to 42° F.

Precipitation: 22 to 34 inches per year.

Potential Natural Vegetation: Douglas fir - ponderosa pine forest.

Existing Vegetation: Douglas fir, white fir, ponderosa pine, aspen, limber pine, New Mexico locust, Gambel's oak, numerous forbs and grasses.

Modal Profile

Taxonomic Class: Typic Vitrandept, ashy-skeletal, frigid.

Peralta gravelly loam.

A--0 to 3 inches; Dark gray (10 yr 4/1) gravelly loam; very dark gray (10 yr 3/1) moist; moderate, very fine and fine granular structure; soft, very friable, nonsticky and nonplastic; few very fine and fine roots; many very fine and fine pores; approximately 15 percent coarse fragments; neutral

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(pH 6.8); abrupt smooth boundary. (2 to 10 inches thick)

A2--3 to 12 inches: Light gray (10 yr 7/2) gravelly loam, dark yellowish brown (10 yr 4/4) moist; moderate fine and medium granular structure; soft, very friable, nonsticky and nonplastic; common very fine and fine, and few medium and coarse roots; many very fine and fine pores; approximately 15 percent coarse fragments; neutral (pH 7.0); clear smooth boundary. (6 to 24 inches thick)

B2--12 to 24 inches; Very pale brown (10 yr 7/3) gravelly sandy clay loam, brown (10 yr 5/3) moist; moderate fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; common very fine and fine pores; approximately 25 percent coarse fragments; neutral (pH 7.0). (0 to 25 inches thick)

B3--24 to 39 inches; Very pale brown (10 yr 7/4) very gravelly sandy loam, yellowish brown (10 yr 5/6) moist; weak, fine and medium subangular blocky structure; soft, friable, nonsticky and nonplastic; few fine roots; common very fine and fine pores; approximately 60 percent coarse fragments; neutral (pH 7.0). (0 to 15 inches thick)

C1--39 to 60 inches; pumice.

Type Location: Sandoval County, New Mexico; NW1/4 SE1/4 Section 8, T.18N., R.5#.

Range in Characteristics: The solum is 16 to 44 inches thick. The soil is strongly acid to neutral (pH 5.4 to 7.2). Base saturation is less than 50 percent. 15 bar moisture is less than 20 percent in the

control section. Mean annual soil temperature is 40° F to 44° F.

Pyroclastic materials constitute 60 percent or more of the control section.

The A1 horizon has hue of 10 yr, value dry of 5 through 7, 3 through 5 moist and chroma of 1 through 4. It is loam or sandy loam with 5 to 45 percent gravel, cobbles and stones.

The A2 horizon has hue of 10 yr or 7.5 yr, value dry of 7 or 8, 4 through 6 moist and chroma of 1 through 4. It is loam or sandy loam with 5 to 50 percent gravel cobbles and stones.

The B2 horizon has hue of 10 yr or 7.5 yr, value dry of 6 through 8, 5 through 7 moist and chroma of 1 through 4. Texture ranges from sandy loam to clay loam with 25 to 75 percent gravel cobbles and stones.

Taxonomic Class: Andeptic Udorthent, ashy-skeletal, frigid. Anesa loam, forested.

PRELIMINARY
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01--2.5 to 1 inch; undecomposed organic matter consisting principally of needles, twigs and bark

02--1 inch to 0; partially decomposed organic matter

A1--0 to 3 inches; light brown gray (10 yr 6/2) loam, very dark gray brown (10 yr 3/2) moist; moderate fine and medium granular structure; soft, friable, nonsticky, nonplastic; common very fine, fine and few coarse roots; many very fine and fine pores; approx. 10% coarse fragments; slightly acid (pH 6.4); abrupt smooth boundary. (3 to 4 inches thick)

A2--3 to 10 inches; very pale brown (10 yr 7/3) gravelly very fine sandy loam, brown (10 yr 5/3) moist; moderate fine and medium granular structure; soft, friable, nonsticky, nonplastic; common very fine and fine, few medium and coarse roots; many very fine and fine pores; approx. 15% coarse fragments; slightly acid (pH 6.4); clear smooth boundary. (7 to 10 inches thick)

C1--10 to 25 inches; pale brown (10 yr 6/3) very gravelly loamy sand, brown (10 yr 4/3) moist; massive; loose, very friable, nonsticky, nonplastic; approx. 90% coarse fragments; neutral (pH 6.6); clear smooth boundary. (15 to 30 inches thick)

C2--25 to 60 inches; raw pumice

Type Location: Sandoval county, New Mexico; NW1/4, NW1/4; Section 16, T.18N., R.5E.

Range in Characteristics: The solum is 10 to 25 inches thick. The soil reaction is slightly acid to moderately alkaline (pH 6.4 to 8.2). Pyroclastic materials constitute 60 percent or more of the fine earth fraction. Mean annual soil temperature is 40° F to 44° F. Soil moisture regime is udic. The A1 horizon has hue of 10 yr, value dry of 4 through 6, 3 or 4 moist and chroma of 1 through 3. It is sandy loam or loamy sand and has 10 to 65 percent gravel.

The A2 horizon has hue of 10 yr, value dry of 6 through 8, 4 or 5 moist and value of 3 through 8. It is sandy loam or loamy sand and has 15 to 85 percent gravel.

Inclusions: Non identified

PRELIMINARY
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Management Implications: This mapping unit is an intricate mixture of Peralta and Anesa soils. Peralta soils constitute about 60 percent of the mapping unit. The two soils are quite similar, the primary difference being that Anesa soils lack the weakly developed subsoils present in the Peralta soils. Also, Anesa soils usually have the pumice layer closer to the surface than do the Peralta soils. Peralta soils will show moderate response to added fertilizer while Anesa soils will show only a low response. Windthrow hazard is high on Anesa soils. Anesa soils have low inherent fertility and are low in plant available water.

Mapping Unit 622: Peralta-Anesa complex, 41-80% slopes.

PRELIMINARY
DRAFT

Acres: 389

Landform: Steep to extremely steep mesa and mountain sideslopes.

Rock Type: Pumice and tuff.

Slope: 41 to 80 percent.

Elevation: 7,400 to 9,000 feet.

Temperature: Mean annual temperature is 38° F to 42° F.

Precipitation: 22 to 34 inches per year.

Potential Natural Vegetation: Douglas fir - ponderosa pine forest.

Existing Vegetation: See unit 621

Modal Profile

See mapping unit 621 for representative profiles of both Peralta and Anesa soils.

Inclusions: 10 percent Sanjue soils on south aspects.

Management Implications: This is a steeper sloping phase of mapping unit 621. Management implications mentioned in unit 621 apply here.

In addition, the average slopes of 50 percent in mapping unit 622 severely restrict most management practices.

Mapping Unit 623: Peralta-Anesa-Rock outcrop complex, 41 to 120 percent slopes

PRELIMINARY
DRAFT

Acres: 1344

Landform: Steep to extremely steep mesa and canyon walls

Parent Material: Tuff and pumice

Slope: 41 to 120 percent

Elevation: 7,400-9,000 feet

Temperature: Mean annual air is 38° F to 42° F.

Precipitation: 22 to 34 inches per year

Potential Natural Vegetation: Douglas fir-Ponderosa Pine

Existing Vegetation: Douglas-fir, ponderosa pine, white fir, aspen, Kinnickinnick, wax currant, common juniper, New Mexico locust, wild rose, mountain brome, mountain muhly, Junegrass, and bottlebrush squirreltail.

Modal Profiles'

See mapping unit 621 for specific information on Peralta and Anesa soils.

Inclusions: 10% Eutric Glossoboralfs

Management Implications: This unit is a complex of 50 percent Peralta soils, 30 percent Anesa soils, and 20 percent Rock outcrop. It is a

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steeper sloping phase of mapping unit 621. Management implications mentioned in unit 621 apply here. In addition, the steep slopes and rock outcrop would restrict most management practices.

PRELIMINARY
DRAFT

Mapping Unit 630: Andeptic Eutroboralf, Sanjue complex, 0 to 15 percent slopes

PRELIMINARY
DRAFT

Acres: 2416

Landform: Gently to moderately sloping mesa tops

Parent Material: Tuff

Slope: 0 to 15 percent

Elevation: 7,200-8,500 feet

Temperature: Mean annual air is 40° F to 45° F.

Precipitation: 18 to 25 inches per year

Potential Natural Vegetation: Ponderosa Pine

Existing Vegetation: Ponderosa pine, gambel oak, New Mexico locust, wild rose, snakeweed snowberry, mountain brome, mountain muhly, Junegrass, little bluestem, pine dropseed, Arizona fescue and bottlebrush squirreltail.

Modal Profiles

Andeptic Eutroboralf, medial

Typifying pedon:

1 to 0 inch--needles, twigs, etc., in various stages of decomposition
0 to 13 inches--Light brown gray (10 yr 6/2) loam, dark gray brown (10

(ochric) yr 4/2) moist; soft, very friable non-sticky, slightly plastic; approx. 15% coarse fragments; neutral (pH 6.8) (5 to 14 inches thick)

13 to 39 inches--Pale brown (10 yr 6/3) gravelly clay loam, brown (10 yr 5/3) moist; subangular blocky structure; hard, firm, sticky, plastic; moderately thick clay films on ped faces; approx. 30% coarse fragments; neutral (pH 6.8) (12 to 31 inches thick)

PRELIMINARY
DRAFT

39 to 40+inches--Very pale brown (10 yr 7/4) very gravelly loamy sand, brownish yellow (10 yr 6/6) moist; massive; loose, very friable, non-sticky, non-plastic; approx. 80% coarse fragments; neutral (pH 7.2)

Range in Characteristics: The ochric epipedon has hue of 10 yr, value of 5 through 7 dry, 3 through 5 moist, and chroma of 2 through 4. The texture is sandy loam or loam with 0 to 25 percent coarse fragments.

Reaction is slightly acid to neutral (pH 6.4-7.2)

The argillic horizon is 12 to 31 inches thick. The texture is clay loam or clay with 0 to 50 percent coarse fragment content. Reaction is neutral to slightly alkaline (pH 6.6-7.4)

The control section (upper 20 inches of argillic) has an average of less than 35 percent coarse fragment content. The texture is clay or clay loam, Less than 60 percent (by weight) is volcanic ash, cinders and pumice. All subhorizons of the argillic horizon have 60 percent or more base saturation. The mean annual soil temperature is 42° F to 47° F, with mean summer soil temperature of 52° F to 56° F. The soil moisture regime is ustic.

Sanjue soils See unit 631 for information on profile, location and range.

Inclusions: 5% Andic Ustochrept, 5% Typic Eutroboralf over rhyolite

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Management Implications: This unit is a complex of 50 percent Andeptic Eutroboralfs, medial and 50 percent Sanjue soils. Sanjue soils have high windthrow hazard. They are also low in inherent fertility and moisture supplying capacity. The Andeptic Eutroboralf component has more favorable characteristics.

PRELIMINARY
DRAFT

Mapping Unit 633: Sanjue - Lithic Ustorthent, medial-skeletal, (nonacid)
frigid - Rock Outcrop complex, 41-120% slopes.

PRELIMINARY
DRAFT

Acres: 1365

Landform: Steep to extremely steep mountain and canyon sideslopes.

Rock Type: Tuff and pumice.

Slope: 41 to 120 percent.

Elevation: 7,000 to 8,000 feet.

Temperature: Mean annual temperature is 40° F to 45° F.

Precipitation: 18 to 25 inches per year.

Potential Natural Vegetation: Ponderosa pine forest.

Existing Vegetation: Ponderosa pine forest.

Modal Profile

Sanjue soils. See mapping unit 631 for representative profile, and range
in characteristics.

Lithic Ustorthent, medial-skeletal, (nonacid), frigid

Typifying pedon:

0 to 4 inches--Gray (10 yr 6/1) stony coarse sandy loam, very dark gray

Brown (10 yr 3/2) moist; soft, very friable, nonsticky,

nonplastic; approx. 45% coarse fragments; neutral (pH 6.8)
(2 to 7 inches thick)

4 to 6 inches--Light gray (10 yr 7/2) stony sandy loam, light gray (10 yr
7/2) moist; soft, very friable, nonsticky, nonplastic;
PRELIMINARY
DRAFT approx. 40% coarse fragments; moderately acid (pH 6.0)
(5 to 8 inches thick)

6 inches plus--Tuff Bedrock

Range in Characteristics: The solum has hue of 10 yr, value dry of 5 through 8, 2 through 6 moist, and chroma of 1 through 4. The control section has 35 to 60 percent vitric materials in the fine earth fraction and 35 to 60 percent coarse fragments. Texture ranges from sandy loam to loam. Bedrock occurs at 20 inches or less. Mean annual soil temperature is 42° F to 47° F, and the mean summer soil temperature is 52° F to 56° F. The soil moisture regime is ustic.

Inclusions: 5% Mollic Eutroboralf

Management Implications: This mapping unit is an intricate mixture of 40 percent Sanjue soils, 40 percent Lithic Ustorthents, medial-skeletal, (nonacid) frigid and 20 percent tuff rock outcrop. These soils have high windthrow hazard. They have low moisture and nutrient supplying capacities. The steep slopes and the complex occurrence of rock outcrop preclude most management practices in this unit.

Mapping Unit 634: Sanjue-Eutroboralfs-Rock outcrop complex, 0 to 40 percent slopes

PRELIMINARY
DRAFT

Acres: 1216

Landform: Gently sloping to moderately steep mesa tops and sideslopes

Parent Material: Tuff with small areas of andesite and rhyolite

Slope: 0 to 40 percent

Elevation: 6,800 to 8,000 feet

Temperature: Mean annual air is 40° F to 45° F.

Precipitation: 18 to 25 inches per year

Potential Natural Vegetation: Ponderosa Pine

Existing Vegetation: Ponderosa pine, scattered juniper and pinyon pine, fringed sage, snakeweed, blue grama, ring muhly and bottlebrush squirreltail.

Modal Profile

Sanjue Soils See mapping unit 631 for representative profile and range in characteristics.

Eutroboralf

Typifying Pedon:

0 to 13 inches--Light brown gray (10 yr 6/2) very gravelly loam (10 yr 4/2)

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(ochric) moist; soft, very friable, nonsticky, slightly plastic;
approx. 15% coarse fragments; neutral (pH 6.8) (12 to 13
inches thick)

13 + inches--Gravelly clay loam; subangular blocky structure; hard, firm,
sticky, plastic; mod. thick clay films; approx. 35% coarse
fragments; neutral (pH 6.8)

Range in Characteristics: The ochric epipedon has hue of 10 yr, value
of 6 dry, 3 or 4 moist, and chroma of 2 or 3. Texture is loam or sandy
loam with 5 to 10 percent coarse fragments. Reaction is neutral (pH 6.6-
7.0). The argillic horizon has textures of sandy clay loam or clay loam.
Coarse fragments range from 5 to 45 percent. Reaction is neutral to
slightly alkaline (pH 6.8-7.6)

The mean annual soil temperature is 42° F to 47° F. The soil moisture
regime is ustic.

Inclusions: None identified

Management Implications: This unit is an intricate complex of 40 percent
Sanjue soils, 40 percent Eutroboralfs, and 20 percent Rock outcrop. See
unit 630 for more information.

PRELIMINARY
DRAFT

Mapping Unit: 641 - Cajete loams, 0-15% slopes.

PRELIMINARY
DRAFT

Acres: 1195

Landform: Nearly level to strongly sloping mountain slopes and sideslopes.

Rock Type: Pumice.

Slope: 0 to 15 percent; average 10 percent.

Elevation: 7,900 to 8,300 feet.

Temperature: Mean annual temperature is 40°F. to 45°F.

Precipitation: 18 to 25 inches per year.

Potential Natural Vegetation: Ponderosa pine forest.

Existing Vegetation: Ponderosa pine forest.

Modal Profile

Cajete loam.

Taxonomic Class: MOLLIC VITRANDEPT, ashy-skeletal, frigid.

01 -- 2 to 1 inch; needles, leaves, twigs.

02 -- 1 to 0 inch; partially decomposed organic matter.

PRELIMINARY
DRAFT

A1 -- 0 to 5 inches; dark grayish brown (10 YR 4/2) loam, very dark grayish brown (10 YR 3/2) moist; weak fine and medium granular structure; soft, very friable, nonsticky and nonplastic; many very fine, fine and medium roots; many very fine and fine pores; mildly alkaline (pH 7.3); abrupt wavy boundary. (2 to 11 inches thick)

B2 -- 5 to 14 inches; brown (10 YR 5/3) loam, dark brown (10 YR 3/3) moist; moderate medium subangular blocky structure; soft, friable, slightly sticky and slightly plastic; many very fine through coarse roots; many very fine and fine pores; approximately 10 percent pumice gravels; mildly alkaline (pH 7.4); clear wavy boundary. (6 to 23 inches thick)

B3 -- 14 to 26 inches; light yellowish brown (10 YR 6/4) very gravelly sandy loam, light yellowish brown (10 YR 6/4) moist; weak fine subangular blocky structure; soft, very friable, nonsticky and nonplastic; many very fine through coarse roots; many very fine and fine pores; approximately 80 percent pumice gravels; mildly alkaline (pH 7.5); ^{abrupt} smooth boundary. (0 to 13 inches thick)

C1 -- 26 to 40 inches plus; light gray (10 YR 7/2) pumice gravels. (several feet thick)

Type Location: Sandoval County, New Mexico; SW $\frac{1}{4}$ SE $\frac{1}{4}$ Section 11, T.18N., R.3E.

PRELIMINARY
SOIL

Range in Characteristics: Thickness of the solum ranges from 20 to 33 inches. The soil is neutral to mildly alkaline (pH 6.6 to 7.5). Weighted average of 15 bar water is less than 20 percent. The upper portion (4 to 12 inches) of the control section contains 60 to 70 percent vitric volcanic materials including 5 to 30 percent pumice gravels. The lower portion (22 to 36 inches) contains 60 to 95 percent pumice gravels. Mean annual soil temperature is 42°F. to 47°F. Average annual precipitation is 18 to 25 inches with peak periods in winter and mid-summer.

The A horizon has hue of 10 YR, value dry of 3 through 5, 2 or 3 moist and chroma of 1 through 3. It is loam or sandy loam with 5 to 20 percent pumice gravel.

The B horizon has hue of 10 YR, value dry of 5 or 6, 3 through 6 moist and chroma of 1 through 4. Texture ranges from sandy loam to sandy clay loam with 10 to 50 percent pumice gravels.

Inclusions: 10 percent LITHIC VITRANDEPTS, ashy, frigid.

Management Implications: Erosion hazard is low in this unit. Wind-throw hazard is moderate due to the large amounts of pumice gravel in the substratum. Moisture and nutrient supplying characteristics are favorable and this unit should exhibit a good response to improved management.

Mapping Unit: 642 - Cajete loams, 16-40% slopes.

PRELIMINARY
DRAFT

Acres: 22-5

Landform: Moderately steep to steep mountain and mesa sideslopes.

Rock Type: Pumice.

Slope: 16 to 40 percent: average 20 percent.

Elevation: 8,000 to 8,500 feet.

Temperature: Mean annual temperature is 40°F. to 45°F.

Precipitation: 18 to 25 inches per year.

Potential Natural Vegetation: Ponderosa pine forest.

Existing Vegetation: Ponderosa pine forest.

Modal Profile

Cajete loam.

See mapping unit 641 for representative soil profile.

Inclusions: 10 percent LITHIC VITRANDYPTS, ashy, frigid.

Management Implications: This is a steeper sloping phase of mapping unit 641. Management implications mentioned in unit 641 apply here.

In addition the average slopes of 20 percent in this unit increase erosion and restrict some management practices.

Mapping Unit: 646 - Cajete - TYPIC EUTROBORALFS complex, 0-15% slopes.

PRELIMINARY
DRAFT

Acres: 397

Landform: Nearly level to strongly sloping benches.

Rock Type: Tuff.

Slope: 0 to 15 percent; average 10 percent.

Elevation: 7,700 to 8,000 feet.

Temperature: Mean annual temperature is 40°F. to 45°F.

Precipitation: 18 to 25 inches per year.

Potential Natural Vegetation: Ponderosa pine forest.

Modal Profile

Cajete loam.

See mapping unit 641 for representative profile.

~~Typic~~ Eutroboralf

See mapping unit 614 for representative profile.

Inclusions: None encountered.

Management Implications: This is a complex of Cajete soils and
Typic Eutroboralfs. The two components occur in roughly equal percentages.
Cajete soils are discussed in mapping unit 641. Typic Eutroboralfs are
discussed in mapping unit 614.

PRELIMINARY
DRAFT

647- Andeptic Ustorthents, medial (non-acid) frigid, C-40%
Mapping Unit: 647 - ~~Typic~~ USTORTHENTS, 0-40% slopes. slopes

PRELIMINARY
DRAFT

Acres: 1003

Landform: Nearly level to steep mesas and mountain slopes.

Rock Type: Tuff.

Slope: 0 to 41 percent; average 25%.

Elevation: 7,700 to 8,000 feet.

Temperature: Mean annual temperature is 40°F. to 45°F.

Precipitation: 18 to 25 inches per year.

Potential Natural Vegetation: Ponderosa pine forest.

Modal Profile

~~ANDRETTIC~~
~~TYPIC~~ USTORTHENT

0 to 15 inches -- (10 YR 5/2) fine sandy clay loam, (10 YR 4/2) moist;
soft, very friable, slightly sticky and slightly
plastic; approximately 15 percent gravels; moderately
acid (pH 6.0). (4 to 15 inches thick)

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15 to 28 inches -- (10 YR 6/3) sandy clay loam, (10 YR 4/2) moist;
slightly hard, friable, slightly sticky and slightly
plastic; approximately 10 percent gravel; neutral
(pH 6.8). (7 to 13 inches thick)

28 to 60 inches + -- (10 YR 5/3) sandy clay loam, (10 YR 4/3) moist;
massive; slightly hard, friable, slightly sticky and
slightly plastic; neutral (pH 6.8). (several feet
thick)

PRELIMINARY
DRAFT

Range in Characteristics: The achric epipedon has hue of 10 YR, value dry of 5 through 7, 2 through 5 moist and chroma of 2 through 4. Texture ranges from sandy loam with less than 10 percent clay to sandy clay loam with less than 30 percent clay. Percent gravel, cobble and stone ranges from 0 to 20 percent. Reaction is moderately acid to neutral.

The substratum is massive. Texture ranges from loamy sand to sandy clay loam with 0 to 80 percent gravel cobbles and stones. Reaction is neutral to mildly alkaline.

Mean annual soil temperature is 42°F. to 47°F. Average annual precipitation is 18 to 25 inches with peak periods in winter and mid-summer. Depth to hard tuff bedrock ranges from 40 inches to greater than 5 feet.

Inclusions: None encountered.

Management Implications: Erosion hazard is moderate in this mapping unit. Soil characteristics are favorable for most engineering operations.

Inherent fertility
~~Soil moisture supplying capacity~~ is the main limiting factor for tree growth and ^{may} ~~will~~ limit the success of reforestation efforts.

Mapping Unit 667: Griegos soils, 16 to 40 percent slopes

PRELIMINARY
DRAFT

Acres: 107

Landform: Strongly sloping to moderately steep canyon and mountain slopes

Parent Material: Dacite, andesite and rhyolite

Slope: 16 to 40 percent;

Elevation: 8,500-10,000 feet

Temperature: Mean annual air is 34° F to 38° F.

Precipitation: 27 to 36 inches per year.

Potential Natural Vegetation: Douglas fir-Engelmann spruce

Existing Vegetation: Douglas fir, Engelmann spruce, scattered amounts of Aspen, white fir, and blue spruce, Rocky mountain maple, whortleberry, raspberry, mountain brome, and kentucky bluegrass.

Modal Profile

Taxonomic Class: Loamy-skeletal, mixed Dystric Cryochrept

Typical Pedon: Griegos soils, forested

02--2 inches to 0; organic matter in various stages of decomposition

A1--0 to 12 inches; brown (10 yr 5/3) cobbly loam, dark brown (10 yr 4/3)

moist; weak fine granular structure; soft, friable, nonsticky, nonplastic,

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PRELIMINARY
DRAFT

many very fine to coarse roots; many very fine and fine interstitial pores; approx. 25% coarse fragment; neutral (pH 7.2); clear smooth boundary. (2 to 12 inches thick)

A2--12 to 20 inches; light gray (10 yr 7/2) cobbly sandy loam, dark brown (10 yr 4/3) moist; weak medium subangular blocky structure; soft, friable, nonsticky, nonplastic; common very fine through coarse roots; common very fine and fine tubular pores; approx. 35% coarse fragments; neutral (pH 7.0); clear smooth boundary. (0 to 10 inches thick)

B2--20 to 35 inches; light yellowish brown (10 yr 6/4) cobbly sandy clay loam, yellowish brown (10 yr 5/4) moist; weak medium subangular blocky structure; soft, friable, slightly sticky, nonplastic; few very fine through coarse roots; common very fine and fine tubular pores; approx. 45% coarse fragments; neutral (pH 7.0); clear wavy boundary. (15 to 30 inches thick)

B3--35 to 50 inches; very pale brown (10 yr 7/4) very cobbly sandy loam, yellowish brown (10 yr 5/6) moist; weak medium granular structure; soft, friable, nonsticky, nonplastic; few very fine through coarse roots; common very fine and fine interstitial pores; approx. 85% coarse fragments; neutral (pH 7.0); clear wavy boundary. (0 to 15 inches thick)

C1--50 to 60 inches; light yellowish brown (10 yr 6/4) very cobbly sandy loam, light yellowish brown (10 yr 6/4) moist; massive; soft, friable, nonsticky, nonplastic; approx. 85% coarse fragments; neutral (pH 7.2)

Type Location: Sandoval County, New Mexico; SE1/4, NW1/4, Section 10, T. 18N., R.4E.

Range in Characteristics: The A1 horizon has hue of 10 yr, value of 4 through 6 dry, 3 through 5 moist, and chroma of 1 through 3. The texture is loam or sandy loam with 20 to 60 percent coarse fragments. The A2 horizon has hue of 10 yr, value of 7 or 8 dry, 4 or 5 moist, and chroma

of 1 through 4. The texture is sandy loam or sandy clay loam with 45 to 75 percent coarse fragments. The solum is 12 to 60 inches thick. The soil reaction is moderately acid to neutral. The control section has greater than 35 percent coarse fragments and less than 35 percent clay content.

Mean annual soil temperature is 36° F to 40° F and the mean summer soil temperature is 42° F to 47° F. The soil moisture regime is udic.

Inclusions: 10% Andeptic Cryorthents

Management Implications: Erosion hazard is moderate. This soil should respond to added fertilizer. This unit is a very small area on the District.

PRELIMINARY
DRAFT

Mapping Unit 668: Griegos soils, 41 to 80 percent slopes

PRELIMINARY
DRAFT

Acres: 1451

Landform: Steep to extremely steep canyon and mountain slopes

Parent Material: Andesite, rhyolite and dacite

Slope: 41 to 80 percent; average 55 percent

Elevation: 8,500 - 10,000 feet

Temperature: Mean annual air is 34° F to 38° F.

Precipitation: 27 to 36 inches per year

Potential Natural Vegetation: Douglas fir-Engelmann spruce

Existing Vegetation: Douglas-fir, Engelmann spruce, with scattered Aspen and white fir, New Mexico locust, wild raspberry, mountain brome.

Modal Profile

Griegos Soils See mapping unit 667 for profile and range in characteristics

Inclusions: 10% Rock outcrop, 5% Typic Cryoboralf, 5% Entic Cryandept

Management Implications: This unit is a steeper sloping phase of mapping unit 667. Management implications for unit 667 are applicable here, with the additional restrictions that 55% average slopes will have on most management practices. The eroision hazard is also high.

Mapping Unit 670: Pelado-Anesa complex, 0 to 15 percent slopes

PRELIMINARY
DRAFT

Acres: 155

Landform: Gently to moderately sloping mountain slopes

Parent Material: Andesite, rhyolite, tuff and pumice

Slope: 0 to 15 percent

Elevation: 8,600-9,500 feet

Temperature: Mean annual air is 38° F to 42° F

Precipitation: 22 to 34 inches per year

Potential Natural Vegetation: Douglas fir-Ponderosa Pine

Existing Vegetation: Douglas fir, ponderosa pine, white fir, aspen, wax currant, New Mexican locust, wild raspberry, Junegrass, mountain muhly, Arizona fescue, Thurber fescue, nodding brome, smooth brome (seeded), orchard grass (seeded).

Modal Profile

Pelado Soils: See mapping unit 673

Anesa Soils: See mapping unit 621

Inclusions: None identified

Management Implications: This unit is a complex of 70 percent Pelado soils and 30 percent Anesa soils. Anesa soils lack the weakly developed subsoil present in the Pelado soils. The Anesa soils usually have a pumice layer close to the surface, which makes the windthrow hazard high on these soils. Pelado soils should respond to management practices while Anesa soils have severe limitations.

PRELIMINARY
DRAFT

Mapping Unit 671: Pelado-Anesa complex, 16 to 40 percent slopes

PRELIMINARY
DRAFT

Acres: 1568

Landform: Strongly sloping to moderately steep canyon and mountain slopes.

Parent Material: Andesite, rhyolite, Tuff and pumice

Slope: 16 to 40 percent

Elevation: 8,600-9,500 feet

Temperature: Mean annual air is 38° F to 42° F.

Precipitation: 22 to 34 inches per year

Potential Natural Vegetation: Douglas fir-Ponderosa Pine

Existing Vegetation: See unit 670

Modal Profile

Pelado soils: See mapping unit 673

Anesa soils: See mapping unit 621

Inclusions: 10% Entic Dystrandeps

Management Implications: This is a steeper sloping phase of mapping unit 670, with Pelado soils constituting about 60 percent of this unit. Management implications mentioned in unit 670 will apply to this unit, however the steeperslopes will limit same management practices.

Mapping Unit 672: Pelado-Anesa complex, 41 to 80 percent slopes

PRELIMINARY
DRAFT

Acres: 1232

Landform: Steep to extremely steep mountain slopes and canyon walls

Parent Material: Andesite, rhyolite and pumice

Slope: 41 to 80 percent

Elevation: 8,600-9,500 feet

Temperature: Mean annual air is 38° F to 42° F.

Precipitation: 22 to 34 inches per year

Potential Natural Vegetation: Douglas fir-Ponderosa Pine

Existing Vegetation: See unit 670

Modal Profile

Pelado Soils: See unit 673

Anesa soils: See unit 621

Inclusions: 10% Entic Dystrandeps, medial-skeletal, frigid

Management Implications: This is a steep sloping phase of mapping unit 670. Pelado soils constitute about 60 percent of the mapping unit.

The erosion hazard on both soils is moderate. Management implications mentioned for unit 670 are applicable here, however the steep slopes will restrict most management practices.

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Mapping Unit 673: Pelado-Anesa-Rock outcrop complex, 41 to 120 percent slopes

PRELIMINARY
DRAFT

Acres: 8287

Landform: Steep to extremely steep mountain slopes and canyon walls

Parent Material: Andesite, rhyolite, pumice and tuff

Slope: 41 to 120 percent

Elevation: 8,600-9,500 feet

Temperature: Mean annual air 38° F to 42° F.

Precipitation: 22 to 34 inches per year

Potential Natural Vegetation: Douglas fir-Ponderosa Pine

Existing Vegetation: See unit 670

Modal Profile

Taxonomic Class: Loamy-skeletal, mixed, frigid Typic Dystrochrept

Typical Pedon: Pelado soil, forested

01--2 to 1 inch; needles, leaves and twigs

02--1 to 0 inch; partially decomposed organic matter

All--0 to 5 inches; light brownish gray (10 yr 6/2) loam, very dark grayish brown (10 yr 3/2) moist; moderate fine and medium granular

structure; soft, friable, nonsticky, nonplastic; common very fine and fine, few medium and coarse roots; many very fine and fine interstitial pores; approx. 10T coarse fragments; neutral (pH 6.6); clear smooth boundary (1 to 5 inches thick).

PRELIMINARY
DRAFT

A12--5 to 14 inches; light brownish gray (10 yr 6/2) gravelly loam, dark grayish brown (10 yr 4/2) moist, moderate fine and medium granular structure; soft, friable, nonsticky, nonplastic; common very fine and fine, few medium roots; many very fine and fine pores; approx. 15% coarse fragments; slightly acid (pH 6.4); clear smooth boundary (0 to 10 inches thick)

B21--14 to 32 inches; light gray (10 yr 7/2) gravelly sandy clay loam, pale brown (10 yr 6/3) moist; moderate fine and medium subangular blocky structure; soft, friable, nonsticky, nonplastic; common very fine, fine and medium roots; many very fine and fine pores; approx. 20% coarse fragments; slightly acid (pH 6.2); clear smooth boundary. (10 to 20 inches thick)

B22--32 to 48 inches; pale brown (10 yr 6/3) stony sandy clay loam, brown (10 yr 5/3) moist; weak very fine and fine subangular blocky structure; soft, friable, slightly sticky, slightly plastic; common very fine, fine and medium, few coarse roots; many very fine and fine pores; approx. 70% coarse fragments; neutral (pH 6.6); gradual wavy boundary. (0 to 20 inches thick)

C1--48 to 60 inches; very pale brown (10 yr 8/4) stony loamy sand, light yellowish brown (10 yr 6/4) moist; single grain structure; loose, loose, nonsticky, nonplastic; approx 70 percent coarse fragments; neutral (pH 6.6)

Type Location: Sandoval County, New Mexico; SW1/4, NE1/4, Section 2, T.18N., R.4E.

Range in Characteristics: The A11 horizon has hue of 10 yr, value of 4 through 6 dry, 2 through 4 moist, and chroma of 1 or 2. Texture is loam and has 5 to 30 percent coarse fragments.

The A12 horizon has hue of 10 yr, value of 4 through 6 dry, 3 or 4 moist, and chroma of 1 or 2. The texture is loam with 15 to 30 percent coarse fragments.

The B2 horizons have hue of 10 yr, value of 5 through 7 dry, 3 through 5 moist, and chroma of 2 or 3. The texture is clay loam or sandy clay loam with 40 to 65 percent coarse fragments.

The C horizon is typically loamy sand and the coarse fragment content is 55 to 90 percent.

The control section (10 to 40 inches) has more than 35 percent coarse fragment content and clay content averages less than 35 percent. The solum is 32 to 60 inches thick. The reaction ranges from slightly acid to slightly alkaline (pH 6.2-7.4). Base saturation is less than 60 percent in all subhorizons.

The mean annual soil temperature is 40° F to 44° F and the mean summer soil temperature is 48° F to 52° F. The soil moisture regime is udic.

Anesa Soils. See mapping unit 621.

Inclusions: 10% Typic Paleboralfs

Management Implications: This mapping unit is a complex mixture of 50 percent Pelado soils, 25 percent Anesa soils, and 25 percent Rock outcrop. The erosion hazard on the soil components is moderate. Steep slopes and complex occurrence of rock outcrop preclude most management practices.

PRELIMINARY
DRAFT

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Mapping Unit 677: Typic Eutroboralf, loamy-skeletal, mixed-Cabra-
Rock outcrop complex, 41 to 120 percent slopes

PRELIMINARY
DRAFT

Acres: 8085

Landform: Steep to extremely steep mountain slopes and canyon walls

Parent Material: Andesite and rhyolite

Slope: 41 to 120 percent

Elevation: 7,500-8,500 feet

Temperature: Mean annual air is 40° F to 45° F.

Precipitation: 18 to 25 inches per year

Potential natural vegetation: Ponderosa Pine

Existing Vegetation: Ponderosa pine, gambel oak, New Mexican locust,
junegrass, mountain muhly, bottlebrush squirreltail, and little blue-
stem.

Modal Profile

Typic Eutroboralf, loamy-skeletal, mixed

Typifying pedon:

1 to 0 inch--needles, twigs etc. in various stages of decomposition

0 to 9 inches--Light brown gray (10 yr 6/2) stony loam, very dark

(ochric) gray brown (10 yr 3/2) moist; soft, friable, nonsticky,
Nonplastic; approx 65% coarse fragments; neutral (pH 6.6)
(3 to 11 inches thick)

9 to 47 inches--Light brown (7.5 yr 6/4) cobbly clay loam, dark brown
(argillic) (7.5 yr 4/4) moist; subangular blocky structure; slightly
hard, firm, slightly sticky, slightly plastic; moderately
thick clay films; approx. 60% coarse fragments; neutral
(pH 6.6-7.0) (18 to 38 inches thick)

47 inches plus--bedrock

Range in Characteristics: The ochric epipedon has hue of 10 yr, value
of 6 through 8 dry, 3 through 5 moist, and chroma of 1 through 4. The
texture ranges from sandy loam to clay loam with 30 to 70 percent coarse
fragments. The reaction is slightly acid to neutral (pH 6.6-7.0). The
argillic horizon ranges in thickness from 18 to 38 inches. Texture is
sandy loam to clay loam with 25 to 80 percent coarse fragments. Reaction
is neutral to slightly alkaline (pH 6.6-7.0).

The control section has over 35 percent coarse fragment content, and
the clay content averages less than 35 percent.

The mean annual soil temperature is 42° F to 47° F. The soil moisture
regime is ustic.

Cabra Soils

PRELIMINARY
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Taxonomic Class: Clayex-skeletal, mixed Typic Eutroboralf

Typical Pedon:

O2--2 to 0 inches; organic matter in various stages of decomposition
A1--0 to 5 inches; light brown gray (10 yr 6/2) very stony loam, dark
gray brown (10 yr 4/2) moist; moderate medium granular structure; soft,
friable, slightly sticky, nonplastic; many very fine and fine, few

medium and coarse roots; many very fine and fine interstitial pores; approx. 80% coarse fragments; neutral (pH 6.6); gradual wavy boundary. (3 to 6 inches thick)

B21+--5 to 12 inches; light brown (7.5 yr 6/4) very stony loam, brown (7.5 yr 5/4) moist; strong fine angular blocky structure; slightly hard, firm, sticky, plastic; common very fine to coarse roots; common very fine and fine interstitial pores; common thin clay films; approx. 65% coarse fragments; neutral (pH 6.8); gradual wavy boundary. (4 to 7 inches thick)

PRELIMINARY
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B22+--12 to 25 inches; light brown (7.5 yr 6/4) stony clay loam, brown (7.5 yr 5/4) moist; strong medium angular blocky structure; slightly hard, firm, sticky, plastic; common very fine through coarse roots; common very fine and fine interstitial pores; many moderately thick clay films; approx. 65% coarse fragments; neutral (pH 6.8); clear wavy boundary. (6 to 15 inches thick)

B23+--25 to 38 inches; light brown (7.5 yr 6/4) stony clay, brown (7.5 yr 5/4) moist; strong coarse angular blocky; hard, firm, sticky, plastic; few very fine and fine, common medium and few coarse roots; common very fine and fine interstitial pores; many moderately thick clay films; approx. 75% coarse fragments; neutral (pH 7.2); clear wavy boundary.

B24+--38 to 50 inches; reddish yellow (7.5 yr 7/6) stony clay loam, reddish yellow (7.5 yr 6/6) moist; strong medium angular blocky; hard, firm, sticky, plastic; few very fine to coarse roots; many very fine and fine pores; many moderately thick clay films; approx. 80% coarse fragments; slightly alkaline (pH 8.4); gradual wavy boundary.

R--50 inches plus; Andesite bedrock

Range in Characteristics: The surface soil has hue of 10 yr, value of

32

6 dry, 3 or 4 moist, and chroma of 2 or 3. The texture is stony loam or gravelly sandy loam with 50 to 80 percent coarse fragments. The reaction is slightly acid to slightly alkaline (pH 6.4-7.4). The orgillic horizon (B21+-B24+) ranges in thickness from 18 to 45 inches. The texture is clay or clay loam. The coarse fragment content ranges from 45 to 95 percent. The reaction is neutral to slightly alkaline (pH 6.6-7.6). The control section has more than 35 percent coarse fragment content and over 35 percent average clay content. The mean annual soil temperature is 42° F to 47° F. The soil moisture regime is ustic.

Inclusions: 10% Mapping unit 675.

PRELIMINARY
DRAFT

Management Implications: This mapping unit is an intricate complex of Typic Eutroboralfs, loamy-skeletal (50%), Cabra soils (25%) and Rock outcrop (25%). The erosion hazard is high on the Cabra soils. Steep slopes and complex occurrence of rock outcrop preclude most management practices.

SOIL SURVEY
OF THE
BANDELIER NATIONAL MONUMENT

PREPARED FOR
OFFICE OF NATURAL SCIENCE
SOUTHWEST REGION
NATIONAL PARK SERVICE

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BY
EARTH ENVIRONMENTAL CONSULTANTS, INC.
ALBUQUERQUE, NEW MEXICO

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SOIL SURVEY
FOR
BANDELIER NATIONAL MONUMENT

INTRODUCTION

The Bandelier National Monument was surveyed to determine soil characteristics and conditions. That part of the Monument which occurs in Santa Fe County was mapped by the USDA Soil Conservation Service during the period of 1960 to 1968, and is published in the "Soil Survey of Santa Fe Area, New Mexico," 1975. This area comprises approximately 7 square miles. The southern two-thirds of the Monument was surveyed by Earth Environmental Consultants, Inc., (EECI) in the summer of 1974. This area comprises about 25 square miles. The remainder of the Monument was surveyed by EECI in April and May of 1978. This includes the area north of Frijoles Canyon to State Highway 4 in Los Alamos County, the recently acquired lands on the Baca Location in Sandoval County, and the Upper Frijoles Canyon in Los Alamos County. These areas comprise about 25 square miles. The entire Monument comprises about 57 square miles and, except for the discrete area in Santa Fe County, is in one contiguous unit comprising parts of Sandoval and Los Alamos Counties, New Mexico.

Soil names and classifications used in this report for areas in Sandoval and Los Alamos Counties are tentative as correlation is not yet complete. The soil names and classifications used for the area in Santa Fe County were approved in 1971 and represent established soil series of the National Cooperative Soil Survey. Several "unnamed" soils in the EECI, 1974 report are tentatively named in this report to correspond to the tentative soil names being used by the USDA-SCS and FS in Los Alamos and Sandoval Counties. The soils are classified according to "Soil Taxonomy," USDA-SCS, Agricultural Handbook No. 436, 1975.

This system does not classify "land types" such as rock outcrop; consequently land types are not classified in the descriptions of map units beyond the map unit names, which indicate the land type.

The Soil Map at the back of this report is a composite of previous mapping done by SCS and EECI, and new mapping done by EECI. The soil descriptions and classifications are presented in the most recent terminology.

It is not the intent of this report to replace on-site investigations and engineering tests for specific structures. In addition, this report is not designed to provide detailed data for limited areas, but rather portrays general conditions on an overall basis. It should be kept in mind that some variations in soil characteristics will occur within individual delineations.

LOCATION AND TOPOGRAPHY

The Bandelier National Monument is located in northcentral New Mexico, approximately 50 miles north of Albuquerque, and 22 miles west of Santa Fe. Within the Monument, elevations range from about 5,300 feet along the Rio Grande, to 10,199 feet at the northwest boundary (Cerro Grande Peak).

The topography within the Monument boundary is variable and is composed primarily of narrow floodplains and terraces, steep rocky escarpments, and gently to moderately sloping mesa tops. Some mountainous terrain occurs in the northwest part of the Monument. The most dominant feature of the topography consists of the north-south and northwest-southeast trending mesas that are separated by very deep and steep-sided canyons. Many of these canyons are 700 to 800 feet deep.

CLIMATE

The climate at Bandelier National Monument is semiarid to subhumid with an average annual precipitation around 15 inches at the lower elevations and up to about 30 inches at the highest elevation. The mean annual air temperature is near 50°F. at the higher elevations in the northwest part of the Monument. In general, the precipitation increases with elevation whereas the air temperature decreases.

GEOLOGY

Bandelier National Monument is situated on the eastern flank of the Jemez Mountains. These mountains are essentially volcanic in origin and geology at the Monument is intimately associated with the volcanic nature of the region.

Briefly, rocks exposed in the survey area consists primarily of limited areas of Tertiary and perhaps Pleistocene sediments and extensive areas of rhyolite tuff with some basalt. Recent alluvium occurs along the Rio Grande and streams in the area.

In the northwest part of the Monument on the Baca Location, the area consists primarily of thick massive flows and domes of tertiary sediments. These consist primarily of coarsely porphyritic dacite, rhyodacite, and quartz latite.

The oldest rocks exposed in the survey area are red sandstones and shales of the Galisteo formation (probably Eocene and Oligocene) and sandstones and gravels of the Santa Fe formation (probably Miocene or later). These rocks are of limited extent and are exposed along the southeast flank of the San Miguel Mountains in the southwest part of the survey area.

Basalt flows underlie most of the lower mesas and are exposed primarily along deep arroyo cuts near the Rio Grande. Overlying the basalt in most places is the Bandelier rhyolite tuff. This tuff is generally thin near the Rio Grande, but thickens to 100 feet and more westward. Bandelier rhyolite tuff is the primary parent material for soils on the lower mesas and crops out in most canyons and arroyos as well as on the mesa tops.

Unconsolidated deposits of pumice occur as patches covering the rhyolite tuff. These deposits are usually a few inches to several feet in thickness.

SOILS

The soils of Bandelier National Monument were studied and mapped by EECI during the summer of 1974, and the spring of 1978. The various kinds of soils were examined, described, and notes were taken as to the soil characteristics. Soils having similar characteristics (consequently similar behavior) were grouped together into mapping units. Because of the soils occurrence (position and extent in the landscape) and the scale of maps used, it was impractical to separate each and every individual kind of soil and the land type on the map. As the scale of mapping allowed, individual kinds of soil were separated into mapping units on the soil map. In some instances it was necessary to combine different kinds of soil or rock outcrop into a single unit called a complex. Individual soils and their relationships are described in the map unit descriptions.

Twenty-two mapping units were delineated on the Soil Map. Of these 22 map units, 7 are rock outcrop types. Rock outcrop is defined as land area having so much bare rock that any soil characteristics are relegated to minor significance. Rock outcrop is a dominant feature on

the study area and occurs on tops of mesas and along canyon walls. The soils on the study area occur as thin mantles on mesa tops, shallow to deep soils in topographically depressed areas, moderately deep and deep soils in pumice deposits, and shallow to deep soils in the alluvial and colluvial canyon bottoms.

It is of interest to note that the rock outcrop will support essentially no vegetative biomass on the steep canyon walls, and up to 350 pound per acre per year where slopes are less than 15 percent. The shallow and moderately deep soils and the droughty pumice soils will support a vegetative biomass of 500 to 1,800 pounds per acre per year. The deep alluvial soils will support a vegetative biomass of 4,000 pounds or more per acre per year.

MAPPING UNIT DESCRIPTIONS

Map Unit 1 - Rhyolite Tuff Rock outcrop-Hackroy complex, 3 to 15 percent slopes.

Map Unit 1 is extensive and occurs on mesa tops. The parent material for this unit is primarily rhyolite tuff which crops out along tops and edges of the mesas and in drainageways. Rock outcrops are a major feature in this map unit although shallow soils occur on the broader, flatter areas and in pockets, depressions, as well as cracks and crevices in the rock. The Rock outcrop makes up about 60 percent, and Hackroy soils make up about 25 percent of this map unit. About 15 percent of the unit is made up of Nyjack and Frijoles soils. Hackroy soil typically has a surface layer composed of about 3 inches of gravelly sand loam that has weak, fine, granular structure and a Unified Engineering Classification of SM. This layer is usually underlain by about 3 inches of gravelly sandy clay loam that contains some visible calcium carbonate and has a weak, medium, subangular blocky structure and a Unified Engineering Classification of SC or CL. This layer is usually underlain by rhyolite tuff.

Where soils exist in this map unit, accelerated soil erosion is a common feature. Because of the abundance of rock outcrop and shallow soil, this map unit has rather severe limitations for most uses. The gentle to moderate slopes of this map unit make it amenable to foot traffic by people and animals. However, most animal trails are deeply worn.

The Hackroy soil in this map unit is tentatively classified as being in the fine-loamy, mixed, mesic family of Lithic Aridic Haplustalfs.

Where vegetation exists on this map unit, blue grama is the dominant grass, with lesser amounts of black grama and galleta. Juniper is the dominant woody species with lesser amounts of pinon and occasional ponderosa pine in the drainageways.

Where this map unit joins the National Forest on the western boundary of the Monument, it is included in the Forest Service Mapping Unit 635 (uncorrelated map units from the field descriptive legend of Santa Fe National Forest Soil Survey as of May, 1978, Jimmy Gass, Party Leader) Yelo-Comada complex, 0 to 15 percent slopes.

Map Unit 2 - Hackroy-Nyjack complex, 3 to 15 percent slopes.

Map Unit 2 is of moderate extent and occurs on mesa tops and on sideslopes of ridges. The map unit occurs most frequently on east-and southeast-facing slopes. The map unit consists of about 45 percent Hackroy soils and about 45 percent Nyjack soils and contains about 10 percent inclusions of rock outcrop and other dissimilar soils. The Hackroy soil typically has a surface layer of about 4 inches of gravelly sandy loam that has weak, fine, granular structure and a Unified Engineering Classification of SM. This layer is usually underlain by about 6 inches of sandy clay loam that has moderate, medium, subangular blocky structure and a Unified Engineering Classification of SC or SM. This layer is usually underlain by about 6 inches of gravelly sandy loam that is single-grained or has

weak, medium, subangular blocky structure and a Unified Engineering Classification of SM. This layer usually has some accumulation of lime in the upper part. Rhyolite tuff bedrock is normally encountered at depths of 12 to 20 inches. The small gravels throughout the soil profile consist mainly of rhyolite tuff and pumice. The Nyjack soil typically has a loam surface layer about 4 inches thick that has moderate, fine, granular structure and a Unified Classification of ML. This layer is usually underlain by about 10 inches of clay loam that has moderate, medium, angular blocky structure and a Unified Engineering Classification of CL. This layer is usually underlain by about 12 inches of gravelly sandy clay loam that is massive and has a Unified Engineering Classification of SC or SM. Rhyolite tuff bedrock is usually encountered at depths of 20 to 40 inches.

The Hackroy and Nyjack soils in this map unit are tentatively classified as being in the fine-loamy, mixed, mesic family of Lithic Haplustalfs, and Aridic Haplustalfs, respectively.

Little bluestem is the dominant grass on this map unit with lesser amounts of blue grama, Arizona fescue and Junegrass. Ponderosa pine is the dominant woody species with lesser amounts of pinon, juniper and apache plume.

Soil erosion on this map unit is variable. Soil removal varies from slight sheet erosion to severe accelerated erosion where V-shaped gullies occur. Soils in this map unit have few limitations for most engineering uses except for those in which the shallow to moderate depth to bedrock is detrimental. The gentle to moderate slopes of this map unit make it amenable to foot traffic by people and animals.

On adjacent National Forest lands this map unit is included in Forest Service Mapping Unit 635 Yelo-Comada complex, 0 to 15 percent slopes. Soils in this map unit are very similar to the Yelo soil series except they are shallower to bedrock.

Map Unit 3 - Frijoles gravelly sandy loam, 3 to 15 percent slopes.

Map Unit 3 is of moderate extent and occurs primarily on the mesas and colluvial slopes in the canyons where pumice is the parent material. The pumice deposits occur mainly on northeast, east, and southeast-facing slopes. Typically, this soil contains a thin argillic horizon and some accumulation of lime below the argillic horizon. A typical profile has about 4 inches of gravelly or very gravelly sandy loam as a surface layer over a very gravelly sandy clay loam argillic horizon about 6 inches thick, having weak, medium, subangular blocky structure. The argillic horizon usually has a Unified Engineering Classification of SM or GM. Normally, below the argillic horizon is raw pumice gravel with an accumulation of lime in the upper part. The pumice varies in depth from about 20 inches to greater than 5 feet. It is underlain by a variety of materials. In places, the pumice was deposited on rhyolite tuff, whereas in other places it overlies shallow and moderately deep soils which, in turn, are underlain by rhyolite tuff. In the canyons, the pumice overlies cobbly and stony, colluvial materials which may exhibit some soil formation.

Accelerated soil erosion is a common feature of this map unit, as V-shaped gullies frequently occur. The thin soils in these pumice deposits have few limitations for most engineering uses, except those that require slow permeabilities.

The Frijoles soil in this map unit is tentatively classified as being in the cindery, mesic family of Aridic Haplustalfs.

Grass is sparse on this map unit, but includes blue grama, little bluestem, sideoats grama and Arizona fescue. Apache plume is the dominant woody species with some juniper and pinon. At the higher elevations, ponderosa pine is predominant.

On adjacent National Forest lands, this map unit is included in the Forest Service Mapping Unit 635 Yelo-Comado complex, 0 to 15 percent slopes and

in Mapping Unit 638, pumice soil, tuff soil-rock outcrop complex, 41 to 120 percent slopes.

Map Unit 4 - Rhyolite Tuff Rock outcrop, 0 to 15 percent slopes.

Map Unit 4 is extensive and represents large areas on mesa tops where pre-existing soils have been eroded away, leaving bare exposed rhyolite tuff bedrock. Shallow, loamy soil material exists only in pockets, cracks, and crevices.

Because of the exposed bedrock, this map unit has severe limitations for most engineering uses. Because of the gentle to moderate slopes, this map unit is amenable to foot traffic by people and animals.

Vegetation is sparse but some juniper and pinon occur on the mesas and some ponderosa pine occurs in drainageways. Blue grama often occurs where patches of soil exist. This map unit is included in Forest Service Mapping Units 635, 638, and 117 on adjacent National Forest lands.

Map Unit 5 - Very steep Rhyolite Tuff Rock outcrop, 45 to 120 percent slopes.

Map Unit 5 is moderately extensive and occurs as very steep canyon walls and cliffs. It contains little or no vegetation and is generally inaccessible to humans and most animals. This unit has very severe restrictions for engineering uses and for most wildlife. This map unit is included in Forest Service Mapping Units 116 and 117 on adjacent National Forest lands.

Map Unit 6 - Typic Ustorthents, 15 to 75 percent slopes.

This map unit occurs as stony, cobbly colluvial soil materials at the foot of steep canyon walls. It occurs below the steep rock outcrop on the canyon walls and above the gently sloping alluvial soils in the canyon bottoms.

The colluvial soils vary greatly in depth. They are shallow on the upper slopes where they join the canyon walls and are several feet thick where they coalesce with the alluvial soils on the lower slopes. A typical profile consists of a deep, very stony, cobbly sandy loam or loam. There is some accumulation of organic matter in the surface layer and organic matter decreases with depth. In a few localities, there is a weak accumulation of lime in the lower part of the profile. The principal feature of a typical profile is the large amount of stone and cobble.

Steep slopes and stoniness make this map unit limiting for most engineering uses and make foot traffic difficult for people and many animals.

The typical soil in this map unit is tentatively classified as being in the loamy-skeletal, calcareous, mesic family of Typic Ustorthents.

The vegetation on this unit consists mainly of blue grama, sideoats grama, little bluestem, galleta grass and pinon, juniper, true mountainmahogany, curlleaf mountainmahogany, and occasional ponderosa pine.

This map unit is included in Forest Service Mapping Units 116 and 117 where it occurs on adjacent National Forest lands.

Map Unit 7 - Aquic Haplustolls, 1 to 3 percent slopes.

Map Unit 7 is of moderate extent and occurs only in the bottoms of canyons along the major drainageways. The soils are mainly deep, with varying amounts of sand, gravel, cobble, and stones. Included in the map unit are areas of cobbly, stony stream wash and areas that are subject to seasonal flooding. The Aquic Haplustolls typically have a surface layer of about 12 inches of gravelly sandy loam, containing some cobble and occasional stones.

This layer is often high in organic matter and frequently has a layer of organic litter on the surface. This layer usually has strong, fine, granular structure and a Unified Engineering Classification of SM. Underlying this layer is several feet of very gravelly, cobbly sandy loam or loamy sand. This layer is usually stratified with stream washed cobble and stones.

Except near the streams or where flood hazards exist, this map unit has few use limitations. Deep soils, additional runoff water from surrounding areas, and gentle slopes all combine to give this unit the largest biomass potential of any soil on the Monument.

The typical soil in this map unit is tentatively classified as being in the coarse-loamy, mixed, mesic family of Aquic Haplustolls.

Because of the additional moisture and shallow depth to ground water in some areas, this unit has the most diversified vegetation on the Monument. Some of the most common species of vegetation include ponderosa pine, narrow leaf cottonwood, several species of juniper, pinon pine, wild cherry, wild grape, wild rose, currants, wild strawberry, Virginia creeper, mountain brome, mountain muhly, sideoats grama, blue grama, little bluestem, and a variety of annual weeds and flowers.

Where these alluvial soils occur on adjacent National Forest lands, they are included in Forest Service Mapping Units 113, 116, and 117.

Map Unit 8 - Basalt Rock outcrop-Prieta complex, 3 to 15 percent slopes.

Map Unit 8 is not extensive and occurs only in the southeastern part of the Monument near the Rio Grande. It occurs on high basalt mesas above the river. This map unit is very similar to Map Unit 1, except basalt is

the underlying material rather than the rhyolite tuff as in Map Unit 1. Other characteristics of this map unit are similar to those described in Map Unit 1. The user is referred to that description for further details of this unit.

This unit is included in the Forest Service Mapping Unit 113 where it occurs on adjacent National Forest lands.

Map Unit 9 - Sandstone Rock outcrop, 15 to 75 percent slopes.

Map Unit 9 is not extensive and occurs in the southwestern part of the Monument near Red Rock Canyon. It occurs as steep hills of stratified sandstone and shale of the Galesteo geological formation. The beds of sandstone range in color from nearly white, to buff, to red, with red being the dominant color. There are thin patches of rocky, stony shallow soils that occur in depressions, cracks and crevices in the bedrock. These shallow soils are cobbly sandy loam for the most part, but are deeper and more clayey in areas where red shale crops out.

Erosion is severe and, because of the rock outcrops and steep slopes, this unit has severe limitations for most uses.

Blue grama is the dominant grass on this map unit with lesser amounts of little bluestem, sideoats grama, and galleta. Juniper dominates the woody species with lesser amounts of pinon, mountainmahogany, oak brush, and occasional ponderosa pine between ridges and in drainageways. This map unit is not known to occur on adjacent National Forest lands.

Map Unit 10 - Nyjack loam, 0 to 15 percent slopes.

Map Unit 10 is of moderate extent and occurs mainly in the north and northwestern part of the Monument in Los Alamos County. The map unit occurs on

mesa tops where slopes are gentle to moderate. The soils are moderately deep to deep over tuff bedrock and usually contain some pumice gravel in the lower part of the soil profile immediately overlying the bedrock. The Nyjack soil typically has a loam surface layer with weak, fine, granular structure about 8 inches thick. This layer has a Unified Engineering Classification of ML. Below this is a layer about 18 inches thick that is a clay loam with moderate, medium, subangular blocky structure and a Unified Engineering Classification of CL. Below this is a layer about 8 inches thick that is a gravelly sandy loam or sandy clay loam. It is massive and has a Unified Engineering Classification of SM. The gravel in this layer is mainly pea-size pumice. Below this layer is tuff bedrock. Technically, Nyjack soils have tuff bedrock within depths of 20 to 40 inches; however, deeper soils were included in mapping. These deeper soils have profiles very similar to the Nyjack soil described above except they have more pumice in their substrata and are deeper than 40 inches to tuff bedrock.

This map unit has few use limitations. It is amenable to foot traffic; however, where surface vegetation and litter are destroyed, trails are dusty and in the steeper areas are subject to water erosion.

The typical soils in this map unit (both moderately deep and deep) are classified as being in the fine-loamy, mixed, mesic family of Aridic Haplustalfs.

The principal vegetation on this map unit is ponderosa pine with occasional oak, pinon, and juniper. Grass is very sparse except in occasional open areas. The principal grass species are poa spp., Junegrass, and mountain muhly. Wild strawberry and columbine are common forbs.

Where these soils occur on adjacent National Forest lands they are included in Forest Service Mapping Units 705 and 645.

Map Unit 11 - Unnamed Eutric Glossoboralfs, fine, mixed, 0 to 15 percent slopes.

Map Unit 11 is of moderate extent and occurs on the mesas between the Baca Location and Escobas Mesa in the northwest part of the Monument. It occurs on moderately sloping mesa tops. The soils are moderately deep to deep over tuff bedrock. The Unnamed Eutric Glossoboralfs typically has a loam surface layer with moderate, coarse, platy to weak, medium, subangular blocky structure. This layer has a Unified Engineering Classification of ML. Below is a layer about 40 inches thick that is a clay or clay loam with moderate to strong, medium, angular or subangular blocky structure having a Unified Engineering Classification of CL. Below this layer is tuff bedrock that may be partly weathered in the upper part.

Included in this mapping unit are soils that are very similar to the one described above, except they are moderately deep to tuff bedrock (20 to 40 inches), or have very gravelly, cobbly subsoils. Some occasional small areas of rock outcrop are also included. The combined total of these inclusions comprise up to 30 percent of the map unit.

This map unit has few use limitations except those that might be imposed by the moderate slopes. It is amenable to foot traffic; however, where surface vegetation and litter are destroyed, trails are dusty, and in the steeper areas are subject to water erosion.

The typical soils in this map unit (both moderately deep and deep) are classified as being in the fine, mixed, family of Eutric Glossoboralfs.

The principal vegetation on this map unit is ponderosa pine with lesser amounts of Douglas-fir and aspen. Grass is very sparse except in occasional open areas. The principal grass species are poa spp., Junegrass, mountain muhly, and mountain brome. Wild strawberry, peavine, and columbine are common forbs.

Where these soils occur on adjacent National Forest lands, they are included in the Forest Service Map Unit 705.

Map Unit 12 - Eutric Glossoboralfs complex, 5 to 10 percent slopes.

Map Unit 12 is not extensive and occurs on mesas and sideslopes of domes in the Baca Location. The soils are mainly deep to dacite bedrock. The two principal soils in this map unit are very similar and differ primarily by the amount of gravel and cobble they contain in their subsoils. Fine, mixed, Eutric Glossoboralfs make up about 45 percent of the map unit. Typically it has a loam surface layer about 6 inches thick with moderate, medium, granular structure and a Unified Engineering Classification of ML. Below this is a layer about 6 inches thick that is a clay loam with moderate, fine, granular structure. It has a Unified Engineering Classification of ML-CL. Below this is a layer about 50 inches thick that is a heavy clay loam or clay with less than 35 percent gravel and cobble. It has strong, fine to medium, angular or subangular blocky structure and a Unified Classification of CL. Clayey-skeletal Eutric Glossoboralfs make up about 40 percent of the map unit. Typically it is very similar to the soil described above except it has about 55 percent gravel and cobble in the lower layer and has a Unified Engineering Classification of GC. Other soils that are shallower to bedrock and rock outcrop make up about 15 percent of the map unit. All soils in this map unit typically have an organic layer of surface litter a few centimeters to a few inches thick.

This map unit is similar to Map Unit 11 except it contains more soils with a higher content of gravel and cobble and the soils are typically greater than 60 inches to bedrock.

This map unit has few use limitations. It is amenable to foot traffic; however, where surface vegetation and litter are destroyed, trails are dusty, and in the steeper areas, are subject to water erosion.

The typical soils in this map unit are classified as being in the fine, mixed and clayey-skeletal, mixed family of Eutric Glossoboralfs.

The principal vegetation on this map unit is Douglas-fir with lesser amounts of ponderosa pine, white fir, and aspen. Bluegrass, Junegrass, mountain muhly and mountain brome are the principal grass species. Wild strawberry, peavine, and columbine are common forbs.

Where these soils occur on adjacent National Forest lands, they are included in the Forest Service Map Unit 704.

Map Unit 13 - Eutric Glossoboralfs rock outcrop complex, 20 to 45 percent slopes.

Map Unit 13 is moderately extensive on the Baca Location and occurs on steep sideslopes of domes and in canyons. The principal soil in this map unit is deep and contains very gravelly and cobbly clayey subsoils. Clayey-skeletal, mixed, Eutric Glossoboralfs make up about 50 percent of the map unit. Typically it has a loam surface layer about 10 inches thick with moderate, fine, granular structure and a Unified Engineering Classification of ML. Below this is a silty clay loam or light clay loam layer about 10 inches thick, with strong, medium, subangular blocky structure and a Unified Engineering Classification of ML-CL. This layer is underlain by about 30 inches of clay or heavy clay loam that has about 55 percent gravel, cobble, and occasional stone. It has a strong, medium, subangular blocky structure and a Unified Engineering Classification of GC. This layer is usually underlain by dacite bedrock.

Rock outcrop makes up about 30 percent of the map unit. Inclusions of shallow and moderately deep soils make up about 10 percent of the map unit.

Because of steepness of slope and rock outcrop, this unit has rather severe use limitations. It is amenable to foot traffic; however, where vegetation and surface litter are destroyed, it is subject to a severe water erosion hazard.

The principal soil in this map unit is classified as being a member of the clayey-skeletal mixed family of Eutric Glossoboralfs.

The principal vegetation is Douglas-fir with lesser amounts of ponderosa pine, aspen, and white fir. Bluegrass, Junegrass, mountain muhly, and mountain brome are the principal grass species. Wild strawberry, peavine and columbine are common forbs.

Where these soils occur on adjacent National Forest lands, they are included in the Forest Service Mapping Unit 703.

Map Unit 14 - Cumulic Haploborolls-Eutric Glossoboralfs complex, 0 to 15 percent slopes.

This map unit is not extensive and occupies gently undulating to moderately sloping mesa tops. It occurs on Sawyer Mesa and along St. Peters Dome Road in the Baca Location. The Cumulic Haploborolls make up about 50 percent of the map unit and occupies nearly level areas with concave slopes. Typically this soil has a loam or silt loam surface layer about 20 inches thick that has moderate, fine, granular structure and a Unified Engineering Classification of ML. Below this layer is about 40 inches of light silty clay loam or light clay loam with weak, medium, subangular blocky structure and a Unified Engineering Classification of ML-CL. This soil is usually underlain by dacite bedrock at depths of 5 to 10 feet. Occasional cobbles and stones are common throughout the soil profile and tend to be more concentrated in the lower subsoil. The Eutric Glossoboralf makes up about 35 percent of the map unit and occupies gentle to moderate, convex slopes. Typically this soil has a loam or silt loam surface layer about 10 inches thick that has moderate, fine, granular structure and a Unified Engineering Classification of ML. Below this horizon is about 20 inches of clay loam that has strong, medium, subangular blocky structure and a Unified Engineering Classification of ML-CL or CL. Below this layer is dacite bedrock. Other shallow and moderately deep soils and occasional rock outcrop make up about 15 percent of the map unit.

Except in minor areas of occasional rock outcrop, this map unit has few use limitations. It is amenable to foot traffic; however, where surface vegetation and litter are destroyed, trails are dusty and the steeper areas are subject to water erosion.

The typical soils in this map unit are classified as being in the fine-loamy, mixed family of Cumulic Haploborolls and fine-loamy, mixed family of Eutric Glossoboralfs. These soils are deep and moderately deep respectively.

The principal vegetation on this map unit is Douglas-fir, with lesser amounts of white fir, aspen, and ponderosa pine. Bluegrass, Junegrass, and mountain muhly are the principal grasses. Wild strawberry, peavine, columbine, and dandelion are common forbs.

Where these soils occur on adjacent National Forest lands, they are included in Forest Service Map Unit 620.

Map Unit 15 - Argic Cryoborolls-Rock outcrop complex, 5 to 45 percent slopes.

This map unit is not extensive and occupies moderately sloping mountain tops and ridges and steep mountain sides. It occurs on Cerro Grande Mountain in the northern part of the Baca Location. The Argic Cryoboroll is the principal soil in the map unit. It is extremely stony and is moderately deep. It makes up about 60 percent of the map unit. In a typical profile, this soil has a surface layer of extremely stony loam or silt loam about 12 inches thick. This layer has moderate, fine, granular structure and a Unified Engineering Classification of GM. Below this layer is about 20 inches of extremely stony light clay loam. It has weak, medium, subangular blocky structure or is massive and has a Unified Engineering Classification of GM or GC. Below this layer is dacite bedrock. The stones (and cobble) in this soil occupy 55 to 90 percent of the surface and profile. Rock outcrop and loose dacite rubble make up about 30 percent of the map unit. About 10 percent of the map unit

is made up of very shallow soils and small areas that are less stony. Most of this map unit has slopes of 20 to 45 percent; however, small moderately sloping areas occur along ridgetops.

Excessive stoniness and rock outcrop, along with steep slopes, cause this map unit to have severe use limitations. It is amenable to foot traffic only along the ridge tops.

The typical soil in this map unit is classified as being in the loamy-skeletal, mixed, family of Argic Cryoborolls.

The principal vegetation is grass with bluegrass, mountain muhly, mountain brome and Arizona fescue being the principal species. Some stunted Douglas-fir trees and some oak brush and aspen also occur in the map unit.

This soil is not known to occur on adjacent National Forest lands.

Map Unit 16 - Griegos soils, 40 to 80 percent slopes.

This map unit occurs on very steep north and east facing slopes on high mountains. The deep, Griegos cobbly loam is the principal soil in this map unit and makes up about 70 percent of the area. In a typical profile, this soil has a cobbly loam or sandy loam surface layer about 20 inches thick, with weak, fine, granular or weak, medium, subangular blocky structure. The Unified Engineering Classification of this layer is SM or ML. Below this layer is about 40 inches of very cobbly sandy clay loam or sandy loam that has weak, medium, subangular blocky structure or is massive. It has a Unified Engineering Classification of GM. Bedrock is usually encountered at depths of 5 to 10 feet. Shallow and moderately deep soils, along with rock outcrop, make up about 30 percent of this map unit.

Because of the very steep slope, this map unit has severe limitations for most uses. Trails are highly erodible.

The Griegos soil in this map unit is classified by as being in the loamy-skeletal, mixed family of Dystric Cryochrepts.

The vegetation is principally a thick Douglas-fir-Englemann-spruce forest. Because of the heavy shade and surface litter, very few grass species or forbs occur.

Where this soil occurs on adjacent National Forest land, it is included in Forest Service Map Unit 668.

The following map units are those mapped by the USDA Soil Conservation Service in Santa Fe County. These descriptions are abstracted from the published soil survey "Santa Fe Area, New Mexico." The map unit designations are letters rather than numbers. Earth Environmental Consultants, Inc., assumes no responsibility for the design of these map units or the soils map. The user may wish to refer to the published report for more detailed descriptions and interpretations for the soils mapped in Santa Fe County. These are included for the sole purpose of presenting to the user a single survey and map of the soils for the entire Monument in a single document.

Map Unit BD - Basalt Rock Land, 50 to 90 percent slopes

Map Unit BD is of slight extent and occurs as very steep rock outcrop. The mapped areas are about 50 percent basalt rock outcrop and basalt boulders. Because of the slope and extensive areas of exposed rock, cliffs, and ledges, this map unit has severe limitations for engineering uses. Because of the very steep slopes, this map unit is not amenable to foot traffic by people and animals.

Vegetation is sparse, but with grasses often occurring where patches of soil exist.

Map Unit BH - Bluewing gravelly sandy loam, 0 to 5 percent slopes.

Map Unit BH is of slight extent and occurs on terraces formed in recent alluvium of mixed origin. The Bluewing soil typically has a surface layer that is about 4 inches thick of sandy loam that has weak, fine, granular structure and a Unified Engineering Classification of SM. This layer is usually underlain by about 16 inches of sandy loam that is massive and has a Unified Engineering Classification of SM. This layer is usually underlain by about 40 inches of very gravelly fine sand that is single-grained and has a Unified Engineering Classification of GP-GM or GM. The soil material is mildly alkaline to moderately alkaline. It is noncalcareous to a depth of 2 to 6 inches, and calcareous below this depth.

Soil erosion hazard in this map unit is severe. Soils in this map unit have moderate to severe limitations for most engineering uses. The gentle slopes of this map unit make it amenable to foot traffic for people and animals.

The Bluewing soil in this map unit is classified as being in the sandy-skeletal, mixed, mesic family of Typic Torriorthents.

The native vegetation that exists in this map unit is dominately midgrasses of blue grama, galleta, black grama, and bluestem.

Map Unit GL - Guaje gravelly sandy loam, 10 to 30 percent slopes.

Map Unit GL is of moderate extent and occurs on foot slopes and hills. The parent material for this unit is primarily pumice and other volcanic debris. Other soils included make up 20 percent or less of the map unit and these include areas of Los Alamos and Silver soils, and scattered areas of stony,

steep land. The Guaje soil typically has a surface layer composed of about 9 inches of gravelly sandy loam that has weak, fine, granular structure and a Unified Engineering Classification of GM or GW-GM. This layer is usually underlain by about 5 inches of very gravelly sandy loam that is massive and has a Unified Engineering Classification of GM or GW-GM. This layer is usually underlain by 44 inches of weakly cemented white pumice. This layer is noncalcareous to a depth of about 9 inches and calcareous below this depth.

Soil erosion on this map unit is variable. Soil removal varies from moderate sheet erosion to severe accelerated erosion where v-shaped gullies occur. Soils in this map unit have severe limitations for most engineering uses. The moderate to steep slopes of this map unit make it poorly suited for foot traffic by people and animals, due to erosion hazard.

The Guaje soil in this map unit is classified as being in the medial-skeletal, mesic, shallow family of Ustollic Calciorthisds.

The native vegetation that exists is dominantly blue grama and lesser amounts of black grama and galleta of the grass species. Juniper and pinon are the dominant woody species.

Map Unit LS - Los Alamos-Silver sandy loams, 0 to 10 percent slopes.

Map Unit LS is of slight extent and occurs on uplands and alluvial fans. This complex consists of about 55 percent Los Alamos sandy loam and 35 percent Silver sandy loam. About 10 percent of the unit is made up of Guaje and soils formed in alluvium. Silver sandy loam is found on alluvial fans and is formed from material weathered from basalt and wind-laid deposits of volcanic debris. Los Alamos sandy loam is found on uplands and is formed from material weathered from pumice and other volcanic debris. The Los Alamos soil typically has a surface layer composed of about 5 inches of sandy loam that has weak, thin, platy structure in the upper one inch and weak, fine, granular below this and a Unified Engineering Classification of SM.

This layer is underlain by 20 inches of clay loam and loam that has moderate and strong, fine and medium, subangular blocky structure to weak, fine, subangular blocky structure and a Unified Engineering Classification of CL or ML. This layer is usually underlain by 15 inches of gravelly sandy loam that is massive and has a Unified Engineering Classification of SM. This layer is usually underlain by 20 inches or more of weakly cemented pumice and ash. The Unified Engineering Classification for this layer is GW-GM or GM. The soil material in this layer is noncalcareous to a depth of 11 to 17 inches and is mildly to strongly alkaline. The Silver soil typically has a sandy loam surface layer about 3 inches thick that has moderate, thick, platy structure and a Unified Engineering Classification of SM. This layer is usually underlain by 11 inches of clay that has moderate, medium, prismatic structure and strong, medium, subangular blocky structure and a Unified Engineering Classification of CL. This layer is usually underlain by 16 inches of silty clay loam that has moderate, medium, subangular blocky to a weak, medium, subangular blocky structure and a Unified Engineering Classification of CL. This layer is usually underlain by 25 inches of very fine sandy loam that is massive and has a Unified Engineering Classification of ML. This layer is strongly calcareous and moderately alkaline.

Accelerated soil erosion is a common feature in this map unit; yet the erosion hazard is moderate. Soils in this map unit have moderate to severe limitations for most engineering uses. The gentle to slightly moderate slopes of this map unit makes it amenable to foot traffic for people and animals.

The Los Alamos soil in this map unit is classified as being in the fine-loamy, mixed, mesic family of Ustollic Haplargids. The Silver soil is classified as being in the mesic family of Ustollic Haplargids.

The native vegetation that exists in this map unit is blue grama, galleta, black grama and bluestem grass species. Woody species are generally juniper and pinon, and occasional ponderosa pine.

Map Unit PD - Penistaja fine sandy loam, 0 to 5 percent slopes.

Map Unit PD is of moderate extent and occurs along alluvial fans formed in mixed water-laid and wind-laid material. The Penistaja soil typically has a surface layer that is about 3 inches thick and consists of fine sandy loam that has weak, fine, granular structure and a Unified Engineering Classification of SM. This layer is usually underlain by about 27 inches of sandy clay loam that has weak, coarse, prismatic structure to a weak or moderate, medium, subangular blocky structure and a Unified Engineering Classification of SM or SC. This layer is underlain by about 30 inches or more of very fine sandy loam that is massive and has a Unified Engineering Classification of ML. This layer is moderately alkaline, and noncalcareous to a depth of 10 to 16 inches and calcareous below this depth.

Soil erosion in this map unit is moderate. These soils have few limitations for engineering uses. The level to gentle slopes of this map unit make it amenable to foot traffic by people and animals.

The Penistaja soil in this map unit is classified as being in the fine-loamy, mixed, mesic family of Ustollic Haplargids.

Vegetation that exists in this map unit is mostly midgrasses, dominantly blue grama, black grama, galleta, and bluestem with some shrubs, dominantly apache plume.

Map Unit TU - Tuff Rock Land

Map Unit TU is extensive and occurs as steep walls, cliffs, and mesa tops.

The map unit consists of exposed areas of welded tuff and pumice and, in places, extremely stony talus slopes. The tuff and pumice are along very steep canyon walls. Included with this land type in mapping were areas of Guaje and small acreage of unclassified soils that are moderately deep.

This map unit contains little or no vegetation and is generally inaccessible to humans and most animals. This unit has very severe limitations for engineering uses and for most wildlife.

FORMATION OF THE SOILS

This section discusses the major factors of soil formation as they relate to the soils of Bandelier National Monument.

Factors of Soil Formation

Soil is formed from and in parent materials that have been deposited or accumulated by geologic agencies. It is produced by physical and chemical weathering and other soil-forming factors acting on the parent materials. The characteristics of a soil at any given point are determined by the kind of parent materials; the climate under which the soil materials accumulated and has existed since accumulation; the biological activity in and on the soil; the topography; and the length of time these soil-forming factors have acted on the soil materials.

Climate and biological activity are active factors in soil formation. They act on the parent material to slowly change it into a natural formation having genetically related horizons. The effects of climate and vegetation are conditioned by topography. The kind and nature of parent material effects the kind of profile that is formed. Finally, time is needed to change the parent material into a soil profile. The time needed to form horizons is variable, but generally long periods of time are needed for the formation of distinct horizons.

The interaction of all the soil-forming factors determines the characteristics of the soil profile. The interaction of the factors is complex, and it is difficult to isolate the effects of any one factor. In some areas the effects of four factors may be nearly constant so the effects of the fifth factor can be evaluated. Even in these cases, however, measurements of the effects cannot be exact.

Parent Material Factor

The soils in Bandelier formed primarily in four kinds of parent materials. These are acid igneous rocks, alluvial and colluvial sediments, basic igneous rock, and sedimentary rocks.

The acid igneous parent materials include rhyolite, rhyolite tuff, rhyodacite, dacite, and pumice. The areas of Bandelier in which this type of parent material is dominant are in Map Units 1, 2, 3, 4, 5, and 12, as shown on the soil map at the back of this survey. This kind of parent material is the most common on the Monument and occurs as long broad mesas with steep canyon walls. The alluvial and colluvial sediments are materials that have been deposited in canyons between the mesas and along the Rio Grande. These materials, especially those directly adjacent to stream courses, have been transported mainly from hills and mountains upstream and vary in mineralogy as a reflection of the source area. The materials have been mixed and sorted in transport and have a wide range of minerals and particle sizes. The areas in Bandelier in which alluvial sediments are dominant are in Map Unit 7. Colluvial materials are usually located at the base of steep slopes and their character reflects the nature of upslope material and are dominant in Map Unit 6.

Basic igneous parent materials make up a small percent of the Monument and occur along the Rio Grande. Basalt is the major kind of rock included in this type of parent material. Areas of soils formed in basic igneous parent materials are in Map Unit 8.

Sedimentary parent materials consist mainly of sandstone rocks. The major areas where these materials occur are in the area of Red Canyon in the southwestern part of the Monument. They are in Map Unit 9.

Climate Factor

The climate of Bandelier is continental. It is characterized by wide annual and daily temperature ranges and distinct seasons. Spring and fall are warm and dry. Summer is hot, and a moderate amount of rain falls as a result of thunderstorms. Winter is mild to cold and precipitation falls as light showers and snow. Because of high temperature and low humidity, evaporation rates are high. The soils usually are not leached of the basic elements, because of the small to moderate amount of rainfall. As a result, most of the soils in Bandelier have a high base saturation. Even though the soils have not been leached of basic elements, some soils show evidence of calcium carbonate movement through the profile. Where this has occurred, the soils are free of lime in their upper part, but have accumulations of lime in the lower part of the soil profile. These soils also show evidence of clay having been translocated from the A horizon to the B2t horizon in some cases.

Wetting and drying, freezing and thawing, and the depth to which the soils are wetted influence the formation of the soil horizons. The effects of these actions are modified by other soil-forming factors. The presence and depth of lime accumulation in some of the soils indicate the average depth to which water moves. The wetter soils at the higher elevations generally lack a zone of lime accumulation or the accumulation occurs at deeper depths than in the dryer soils on the lower mesas. The coarse-textured soils and the alluvial soils, where they receive additional water because of runoff from surrounding areas, usually do not have a zone of lime accumulation.

Biological Activity Factor

Plant and animal life, both on and in the soil, is an active factor in soil formation. As plants die and decay, they add organic matter to the soil. This darkens the upper part of the soil profile. The soils at higher elevations have a darker surface layer than the soils at lower elevations in Bandelier because the soils at higher elevations receive more precipitation and support a larger biomass, and organic materials decompose at a faster rate. The soils in swales and canyons, which receive runoff water from surrounding areas, are darkened to a greater depth than the surrounding soils. They support more plant life because they receive more moisture.

Many kinds of micro-organisms are needed to transform organic remains into humus from which plants can obtain nutrients. Earthworms and small burrowing animals such as badgers, gophers and ground squirrels, influence soil formation by mixing the organic and mineral parts of the soil. This action deepens the zone in which organic matter accumulates. Because soil life thrives in a moist, warm environment, it is most active in Bandelier during the summer rainy season.

Topography Factor

The topography of Bandelier is characterized primarily by moderately to strongly sloping areas on the tops of large mesas and intervening very deep canyons with steep canyon walls.

Soils on gentle slopes commonly have a more distinct profile than the soils on steeper slopes. This is because the steeper areas generally erode before distinct horizons can form. Also, the amount of moisture that enters the soil decreases as the slope increases. Where slopes are greater than three percent, generally more than half the rainfall runs off. Several factors other than slope influence the amount of runoff. Some of these are amount of bedrock exposure, soil texture, intensity of rainfall and vegetative cover.

In Bandelier there is an exception to these general rules in that the gently sloping soils on flood plains do not have distinct horizons because they formed in recently deposited alluvial sediments and have not had time to develop.

Time Factor

A considerable length of time is required for the formation of soils. After the parent materials have been deposited or have accumulated in place through weathering, the surface soil is darkened by the accumulation of organic matter. Calcium carbonate (lime) and soluble salts are leached downward from the surface soil. The movement of clay downward proceeds more slowly. When clay is leached from the A horizon, it accumulates and develops a B horizon. The rate of this process depends on several factors, including how rapidly the parent materials are weathered, the soil temperature, the amount of moisture moving through the profile and percentage of clay.

The nature of the parent material greatly influences the rate of soil formation. Quartz, for example, weathers so slowly that soils high in quartz may not have distinct horizons, regardless of time. Soils in Bandelier that formed in igneous materials, mostly rhyolite and basalt, form at moderate rates. In Bandelier, under present conditions, rainfall is low to moderate and long periods of time are required to leach lime from the upper horizons. Some of the alluvial soils in the canyons have faint horizons because the materials in which they are forming have been deposited so recently that the horizon-forming processes have had little time to work.

The age of the soil is not the same as the geological age of the parent material. The soils are always younger than the geological parent materials. Long periods of time are required before the geological material is stable with respect to slope and erosion. It must be relatively stable before the soils can form. In Bandelier, the oldest soils are on the mesas. These soils generally have the most distinct horizons.

TRENDS IN SOIL FORMATION ON BANDELIER NATIONAL MONUMENT

It was noted that most of the mapping units on the lower mesas were actively eroding. This is especially true with respect to the upland soils on the mesa tops. The rather strong profile development in these upland soils indicates that they were formed under more stable conditions than presently exist. Consequently, it is evident that the soils are in a process of degradation. Since the soil-forming factors of parent material and topography are essentially the same today as they were when the strong profiles were developed, and since adequate time was available for the profile development, then the reasons for the degradation process must lie in the factors of climate and/or biological activity.

A gradual decrease in effective precipitation could account for a decrease in vegetation biomass, which would allow for less vegetative soil protection, and consequently, erosion would increase. However, this process would be gradual and erosion would occur over a long period of time. There is evidence that indicates relatively recent active erosion. For example, fairly extensive areas, where blue grama is the dominant grass, were noted where the clumps of grass were on erosional pedestals approximately two inches higher than the unvegetated soil. This would indicate that about two inches of soil had eroded in the life time of the grass plants. If the grass covered approximately 25 percent of the ground surface and the average age of the grass plants is seven years, then the rate of erosion is approximately 1.5 inches of soil erosion in seven years or about .21 inches per year on these sites. This is equivalent to about 35.7 tons of soil removal per acre per year, a rate far too high to be accounted for by a gradual decrease in precipitation alone.

The vegetative study done in conjunction with the soil survey of the southern part of the Monument (1974) indicates that historical use of

the Monument for livestock grazing and grazing by trespass livestock and feral burros has had, and is having, an effect on the kinds and amounts of vegetation. Obvious erosion is caused by foot traffic of animals where trails are deeply worn (even into the bedrock). Runoff water collects from surrounding areas and erodes the trails into gullies. Besides this more obvious erosion, the use of grass by burros or livestock upsets the delicate balance between a drying climate, soil and plants, resulting in accelerated sheet erosion, which is difficult or impossible to reverse in several life times of man.

Map Unit 4 illustrates severe erosion. It is a rock land that probably had at least a shallow soil which has been removed by erosion. Areas in this map unit will not recover to form soil for at least several hundred years, even under ideal conditions. Consequently, this area will not presently support the biomass that once existed.

It was concluded that the process of soil degradation on the lower mesas was caused partly by a drying climate and that the degradation of soils was being greatly accelerated by past livestock and burro use.

Soils on the upper mesas such as in the Baca Location and the Unnamed mesa above (west of) Escobas Mesa are stable in relation to geologic and accelerated erosion. These areas, due to their occurrence at higher elevations, receive more moisture and support a greater biomass which has and is creating a stable soil condition. The thick dark colored epipedons (surfaces) as well as illuvial and eluvial horizons (A2 & B2t horizons) present in the soils are indicative of long term stability. A stable soil condition does not imply that some natural geologic erosion does not occur. It means simply that the soil forming process is equal to or greater than soil loss by erosion. Should the surface vegetation and litter be destroyed in these areas, accelerated soil erosion will occur; however, due to the amount of moisture at these higher elevations, revegetation can usually be quickly

accomplished to stop accelerated erosion. This was the case in the 1977 fire which destroyed vegetation and litter on fairly large acreages on the higher mesas. Native grass species were seeded soon after the fire with good success and most of the accelerated soil erosion has been stopped in less than two growing seasons.

Based on observations while mapping (April and May 1978), about 75 percent of the burned areas now have stable soils with some improvement in soil stability on the remaining 25 percent. With normal rainfall, the soil stability should continue to increase.

PHYSICAL AND CHEMICAL PROPERTIES OF SOILS FOR TYPICAL PROFILES*

Map Symbol	Depth From Surface (in.)	Textural Classification			Range in Permeability (in/hr)	Available Water Holding Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential	Hydrologic Group	Erodibility of Exposed Soil	
		USDA	Unified	AASHO						By Water	By Wind
1 (Rock Land Part) (Shallow Soil)	0 - 3	Rock	-	-	-	-	-	-	D	-	-
	3 - 9	Gravelly, sandy loam	SM	A-2	1 - 2.5	.07 - .10	7.0 - 7.8	Low	C	Severe	Slight
	9 - 12	Clay	CL	A-6	.20 - .63	.17	7.5 - 8.0	Moderate			
	12+	Gravelly, sandy clay loam	SC or CL	A-4 or A-6	1 - 2.5	.10	8.0 - 8.6	Low			
1 (Hackroy Part)	0 - 4	Rock	-	-	-	-	-	-			
	4 - 10	Gravelly, sandy loam	SM	A-2	1.0 - 2.5	.07 - .10	6.8 - 7.5	Low	C	Severe	Slight
	10 - 16	Sandy clay loam	SC or SM	A-2 or A-4	1.0 - 2.5	.15	7.0 - 8.0	Low			
	16+	Gravelly, sandy loam	SM	A-2	2.0 - 3.5	.07 - .10	8.0 - 8.6	Low			
2 (Nyjack Part)	0 - 4	Tuff rock	-	-	-	-	-	-	D	-	-
	4 - 14	Loam	ML	A-4	1.0 - 2.5	.17	6.8 - 7.5	Low	C	Moderate	Slight
	14 - 26	Clay loam	CL	A-6	.20 - .63	.17	7.0 - 8.0	Moderate			
3	0 - 4	Sandy clay loam	SC or SM	A-2 or A-4	.63 - 1.0	.17	8.0 - 8.6	Moderate			
	4 - 10	Gravel	GP	A-1	>10	.05	6.8 - 7.5	Very low	B	Moderate	Slight
	10 - 60	Very gravelly, sandy clay loam	GM	A-1	2.0 - 5.0	.05 - .10	7.0 - 8.2	Low			
4	0 - 60	Gravel	GP	A-1	>10	.05	8.2 - 8.6	Very Low			
	-	Rock	-	-	-	-	-	-	D	-	-
5	-	Rock	-	-	-	-	-	-	D	-	-
	0 - 60	Very stony cobbly sandy loam	GM	A-1	2 - 10	.05 - .10	6.8 - 8.2	Low	C	Moderate	Slight
6	0 - 12	Gravelly, sandy loam	SM	A-2	2 - 3	.05 - .07	6.8 - 7.8	Low	B	Slight	Slight
	12 - 60	Very gravelly sandy loam	GP	A-1	2 - 10	.05 - .07		Low			
7	0 - 6	Very gravelly loam	GM	A-1		.05 - .10	6.8 - 8.2	Low			
	6+	Rock	-	-	-	-	-	-	D	Severe	Slight
8	0 - 8	Loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	B	Moderate	Slight
	8 - 26	Clay loam	CL	A-6	.20 - .63	.17	7.0 - 8.2	Moderate			
	26 - 34	Gravelly sandy loam	SM	A-2	1.0 - 2.5	.10	8.0 - 8.6	Low			
	34+	Tuff rock	-	-	-	-	-	-			
9	0 - 10	Loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	B	Moderate	Slight
	10 - 50	Clay or clay loam	CL or CH	A-6 or A-7	.20 - .63	.17	7.0 - 8.2	High			
	50+	Tuffrock	-	-	-	-	-	-			
10	0 - 6	Loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	B	Moderate	Slight
	6 - 12	Clay loam	ML or CL	A-4 or A-6	.63 - 1.0	.17	6.8 - 7.5	Moderate			
	12 - 62	Gravelly clay loam or gravelly clay	CL	A-6	.20 - .63	.14	8.0 - 8.6	Moderate			
11	0 - 6	Loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	B	Moderate	Slight
	6 - 12	Gravelly clay loam	CL	A-6	.20 - .63	.14	6.8 - 7.5	Moderate			
	12 - 62	Very gravelly and cobbly clay loam	GC	A-2-6	.20 - .63	.10	7.5 - 8.6	Moderate			
12 (E.G. fine, mixed part)	0 - 6	Loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	B	Moderate	Slight
	6 - 12	Clay loam	ML or CL	A-4 or A-6	.63 - 1.0	.17	6.8 - 7.5	Moderate			
	12 - 62	Gravelly clay loam or gravelly clay	CL	A-6	.20 - .63	.14	8.0 - 8.6	Moderate			
(E.G. clayey skeletal, mixed part)	0 - 6	Loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	B	Moderate	Slight
	6 - 12	Gravelly clay loam	CL	A-6	.20 - .63	.14	6.8 - 7.5	Moderate			
	12 - 62	Very gravelly and cobbly clay loam	GC	A-2-6	.20 - .63	.10	7.5 - 8.6	Moderate			

PHYSICAL AND CHEMICAL PROPERTIES OF SOILS FOR TYPICAL PROFILES* (Cont'd)

Map Symbol	Depth From Surface (in.)	Textural Classification			Range in Permeability (in/hr)	Available Water Holding Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential	Hydrologic Group	Erodibility of Exposed By Water	
		USDA	Unified	AASHTO							
13 (E.G. clayey-skeletal, mixed part)	0 - 10	Loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	C	Severe S	
	10 - 20	Silty clay loam or clay loam	ML-CL	A-4 or A-6	.63 - 1.0	.18	6.8 - 7.5	Moderate			
	20 - 50	Very gravelly cobbly clay or heavy clay loam	GC	A-2-6	.20 - .63	.10	7.5 - 8.6	Moderate			
	50+	Dacite rock	-	-	-	-	-	-			
(Rock outcrop part)	-	-	-	-	-	-	-	-	D	-	
14 (Cumulic Haploboroll part)	0 - 20	loam or silt loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	B	Slight S	
	20 - 60	Light silty clay loam or light clay loam	ML-CL	A-4 or A-6	.63 - 1.5	.18	6.8 - 8.2	Low			
	(Eurric Glossoboralf part)	0 - 10	Loam or silt loam	ML	A-4	1.0 - 2.5	.18	6.8 - 7.5	Low	B	Moderate S
	10 - 30	Clay loam	ML-CL or CL	A-4 or A-6	.63 - 1.5	.18	7.5 - 8.2	Moderate			
30+	Dacite rock	-	-	-	-	-	-				
15 (Argic Cryoboroll Part)	0 - 12	Extremely stony loam	GM	A-2-4	1.0 - 2.5	.10	6.8 - 7.5	Low	C	Moderate S	
	12 - 30	Extremely stony clay loam	GM or GC	A-2-4 or A-2-6	.63 - 1.0	.10	6.8 - 7.5	Low to Moderate			
	30+	Dacite Rock	-	-	-	-	-	-			
(Rock Outcrop part)	-	-	-	-	-	-	-	-	D	-	
16	0 - 20	Cobbly loam or sandy loam	SM or ML	A-2 or A-4	1.0 - 2.5	.14	6.5 - 7.5	Low	C	Severe S	
	20 - 60	Very cobbly sandy clay loam	GM	A-2-4	1.0 - 2.5	.07	6.5 - 8.2	Low			
BD		Rock Outcrop	-	-	-	-	-	-	D	-	
BH	0 - 20	Sandy loam	SM	A-2	2.5 - 6.0	.14	6.5 - 8.2	Low	B	Moderate S	
	20 - 60	Very gravelly fine sand	GP	A-1	6.0 - 12.0	.04	8.2 - 8.6	Low			
GL	0 - 9	Gravelly sandy loam	GM	A-2	2.5 - 6.0	.10	6.5 - 8.2	Low	C	Severe S	
	9 - 14	Very gravelly sandy loam	GM	A-2	2.5 - 6.0	.10	8.2 - 8.6	Low			
	14 - 60+	Pumice	-	-	-	-	-	-			
LS (Los Alamos part)	0 - 5	Sandy loam	SM	A-2	2.5 - 6.0	.14	6.5 - 7.5	Low	B	Severe S	
	5 - 25	Clay loam	ML or CL	A-2 or A-6	.20 - 1.0	.18	7.5 - 8.6	Moderate			
	25 - 40	Gravelly sandy loam	SM	A-2	2.5 - 6.0	.10	8.2 - 8.6	Low			
	40+	Pumice	-	-	-	-	-	-			
(Silver part)	0 - 3	Sandy loam	SM	A-2	1.0 - 2.5	.14	6.5 - 7.5	Low	C	Severe S	
	3 - 14	Clay	CL	A-6	.20 - .63	.18	8.0 - 8.6	High			
	14 - 20	Silty clay loam	CL	A-6	.20 - .63	.18	8.2 - 8.6	Moderate			
	20 - 55	Very fine sandy loam	SM	A-2	1.0 - 2.5	.14	8.2 - 8.6	Low			
PD	0 - 3	Fine sandy loam	SM	A-2	1.0 - 2.5	.14	6.5 - 8.2	Low	B	Moderate S	
	3 - 30	Sandy clay loam	SM or SC	A-2 or A-2-6	1.0 - 2.5	.18	8.2 - 8.6	Moderate			
	30 - 60	Very fine sandy loam	ML	A-4	1.0 - 2.5	.14	8.2 - 8.6	Low			
TU		Tuff Rock Land	-	-	-	-	-	-	D	-	

*Data shown are extrapolated from actual tests performed on representative samples of soil horizons or are estimated. Because of slight horizontal and vertical soil variations within soil mapping units, these data should be considered as general. For specific structures, on-site tests should be performed.

Hydrologic Group: A - High intake rate, low runoff
 B - moderately high intake rate, moderately low runoff
 C - moderately low intake rate, moderately high runoff
 D - low intake rate, high runoff