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SOIL INVENTORY

FOR THE
PROPOSED BACA GEOTHERMAL PROJECT

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TABLE OF CONTENTS

MAPS

SOILS OF THE BACA TRANSMISSION LINE

INTRODUCTION

The soil survey of the transmission line goes from the geothermal wells on the west side of the Baca to Los Alamos, NM. Much of the information in this report was provided by the soil conservation service of the USDA and from a soil survey report of Los Alamos County. The consultants express gratitude to Mr. Leroy Hacker of the USDA-SCS for his help.

The survey objective was to prepare soils information (maps and descriptions) that could be used in accessing the impact of putting in an electric transmission line. The soil survey maps of the Baca are provided at an order 3 level. The soil survey of the Los Alamos portion of the transmission line is at an order 2 level and is attached as an appendix. The order 3 maps of the Baca are attached and are at a scale of 1:31,680. The soils of an order 3 map are identified by transecting, traversing and some observations. Boundaries are plotted by observation and interpretation of remotely sensed data and verified with some observations. The kinds of map units are mainly associations. The map unit components are mainly phases of soil series and phases of soil families. USDA-SCS Agriculture Handbook 436 should be used for definition of the soil families (Soil Taxonomy).

A survey of this type is intended as a tool for planning purposes and is not site specific. In many instances, on site investigations will be required for intensive use. The estimates given for the kinds of soils, amounts of inclusions, and extent of each mapping unit may vary by 20 or more percent. The limitations of an order 3 map should be considered before intense or detailed planning is initiated.

HOW THIS SURVEY WAS MADE

The consultants made this soil survey to learn what kind of soil is located in the survey area, where they are located, and how they can be used in the construction of a transmission line. The survey was started with the knowledge that many of the soils have been identified, but some have not. The consultants observed steepness, length and shape of slopes; the kind of native plants; the kind of rocks; and many facts about soils. Many holes were dug to expose soil profiles. Many of the map unit names and supportive information was provided by the Soil Conservation Service.

The observed soil profiles were classified and named according to the procedures of the National Cooperative Soil Survey. The soil series, soil family and their phases are the categories of soil classification most used in this survey.

Soils that have profiles almost alike make up a soil series. Except for different textures of the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement and other important characteristics. Where soil series have not been named through the National Cooperative Soil Survey, the soil family was used. This is the next category in soil classification.

Soils of one series or family can differ in the texture of the surface layer, in slope or some other characteristic that affect use. On the basis of such differences, a soil series or family is divided into phases.

After a guide for classifying and naming the soils had been established, the consultants drew the boundaries of the individual soils on aerial photographs. The areas shown on the soil map are called mapping units. Most mapping units are made up of soils of different series or families. The most common mapping unit shown on the soil map of this survey area is a soil association.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but that are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils can differ greatly one from another.

DESCRIPTION OF THE SOILS

A total of 16 mapping units were described in the Baca part of the soil survey. The Los Alamos portion of the soil survey is provided as appendix 2 to this report. Many sites were investigated by digging to determine the number of soil series and families which make up the map units. The following section is a discussion of the map units for the Baca. The description of the central concept of the series and families used to describe map units is provided in appendix 1.

CA Cryoboralf-Cryochrept Association, 15-35% slopes

This map unit is on mountain sideslopes. Slope is 15 to 35 percent. The native vegetation is mainly Douglas fir, blue spruce, aspen, mountain brome, with introduced timothy and wheat grass.

This unit is 25 percent coarse-loamy, mixed Psammentic Cryoboralfs and 25 percent coarse-loamy, mixed Alfic Cryochrepts.

Included in this unit are small areas of loamy-skeletal, mixed Alfic Cryochrepts, loamy-skeletal, mixed Psammentic Cryoboralfs and loamy-skeletal, mixed Alfic Cryochrepts. Included areas make up about 50 percent of the total acreage.

The coarse-loamy, mixed Psammentic Cryoboralfs are deep, well drained soils. They formed in rhyolytic colluvium on mountain sideslopes. A typical profile has a grayish brown cobbly loam to sandy loam about 30 inches thick. The subsurface is brown to dark brown cobbly sandy loam to more than 70 inches.

The coarse-loamy, mixed Alfic Cryochrepts are deep, well drained soils. They formed in rhyolytic colluvium and tuff on mountain sideslopes. A typical profile has a brown sandy loam about 10 inches thick. The subsurface is brown sandy loam to more than 60 inches.

CC Cryoboralf Association, 15-35% slopes

This map unit is on mountain sideslopes. Slope is 15 to 35 percent. The native vegetation is mainly Douglas fir, white pine, limber pine, aspen, Kentucky bluegrass and mountain brome.

This unit is 50 percent loamy-skeletal, mixed Psammentic Cryoboralfs and 30 percent coarse-loamy, mixed Psammentic Cryoboralfs.

Included in this unit are small areas of coarse-laomy, mixed Alfic Cryochrepts, loamy-skeletal, mixed Alfic Cryochrepts, and loamy-skeletal, mixed Cryic Paleborolls. Included areas make up about 20 percent of the total acreage.

The coarse-loamy and loamy-skeletal, mixed Psammentic Cryoboralfs are deep, well drained soils. They formed in rhyolytic colluvium on mountain sideslopes. The coarse-loamy soils have less than 35% coarse fragments while the loamy-skeletal soils have more than 35% coarse fragments. A typical profile has grayish brown loam to cobbly loam to 30 inches. The subsurface has brown to dark brown sandy laom to cobbly sandy loam to more than 70 inches.

CT Cryoboralfs-Rubble land Association, >35% slopes

This map unit is on mountain sideslopes. Slope is >35 percent. The native vegetation is mainly Douglas fir, Engleman spruce, corkbark fir, wildoats, Timothy grass, wild strawberry and Arizona fescue.

This unit is 40 percent loamy-skeletal, mixed Typic Cryoboralfs, 20 percent fine-loamy, mixed Typic Cryoboralfs, 20 percent fine-loamy, mixed Psammentic Cryoboralfs, and 20 percent Rubbleland.

The loamy-skeletal, mixed Typic Cryoboralfs are deep, well drained soils. They formed in tuff on mountain sideslopes. A typical profile has dark grayish brown sandy loam to 15 inches. The subsurface has brown extremely gravelly, gravelly and cobbly sandy loam to 87 inches.

The fine-loamy, mixed Typic Cryoboralfs are deep, well drained soils. They formed in pumice and tuff on mountain sideslopes. A typical profile has very dark grayish brown gravelly sandy loam to 8 inches. The subsurface has yellowish red and reddish brown gravelly sandy loam and sandy clay loam.

The fine-loamy, mixed Psammentic Cryoboralfs are deep, well drained soils. They formed in pumice and tuff on mountain sideslopes. A typical profile has brown and dark grayish brown loam to 22 inches. The subsurface has brown gravelly sandy clay loam and clay loam to 118 inches.

Rubble land is a miscellaneous land type made up of loose rhyolyte colluvium with little or no soil filling the voids between rocks. The loose, unstable rocks range in size from a few inches to a few feet in diameter. These materials usually lack vegetation.

GA Glossoboralfs-Argiboroll Association, 15-35% slopes

This map unit is on mountain sideslopes. Slope is 15 to 35 percent. The native vegetation is mainly Douglas fir, blue spruce, aspen, white fir, limber pine and ponderosa pine.

This unit is 40 percent fine-loamy, mixed Eutric Glossoboralfs, 25 percent fine-loamy, mixed Psammentic Glossoboralfs and 25 percent fine-loamy, mixed Typic Argiborolls.

Included in this unit are small areas of loamy-skeletal, mixed Eutric Glossoboralfs. Included areas make up about 10 percent of the total acreage.

The fine-loamy, mixed Eutric Glossoboralfs are deep, well drained soils. They formed in rhyolytic and tuff colluvium on mountain sideslopes. A typical profile has dark brown to brown loam and sandy loam to 24 inches. The subsurface has brown gravelly sandy clay loam to 80 inches.

The fine-loamy, mixed Psammentic Glossoboralfs are deep, well drained soils. They formed in tuff on mountain sideslopes. A typical profile has dark brown to brown sandy loam to 23 inches. The subsurface has ¼-½ inch bands of brown sandy clay loam in a matrix of brown loamy sand to sandy loam to 60 inches.

The fine-loamy, mixed, Typic Argiborolls are deep, well drained soils. They formed in rhyolytic colluvium on mountain sideslopes. A typical profile has very dark brown gravelly loam to 9 inches. The subsurface has brown gravelly sandy clay loam to 60 inches.

GE Glossoboralf Association, 15-35% slopes

This map unit is on mountain side slopes. Slope is 15 to 35 percent. The native vegetation is mainly Douglas fir, blue spruce, aspen, white fir, and limber pine.

This unit is 50 percent loamy-skeletal, mixed Eutric Glossoboralfs, 25 percent fine-loamy, mixed Eutric Glossoboralfs and 20 percent fine-loamy, mixed Psammentic Glossoboralfs.

Included in this unit are small areas of loamy-skeletal, mixed Psammentic Glossoboralfs. Included areas make up about 5 percent of the total acreage.

The loamy-skeletal, mixed Eutric Glossoboralfs are deep, well drained soils. They formed in tuff on mountain sideslopes. A typical profile has very dark grayish brown to pinkish gray sandy loam to 18 inches. The subsurface has light brown to reddish brown sandy loam and gravelly sandy clay loam to 94 inches.

The fine-loamy, mixed Eutric Glossoboralfs are deep, well drained soils. They formed in rhyolytic and tuff colluvium on mountain sideslopes. A typical profile has dark brown to brown loam and sandy loam to 24 inches. The subsurface has brown gravelly sandy clay loam to 80 inches.

The fine-loamy, mixed Psammentic Glossoboralfs are deep, well drained soils. They formed in tuff on mountain sideslopes. A typical profile has dark brown to brown sandy loam to 23 inches. The subsurface has ¼-½ inch bands of brown sandy clay loam in a matrix of brown loamy sand to sandy loam to 60 inches.

GG Glossoboralf Association, 0-15% slopes

This map unit is on mountain sideslopes and footslopes. Slope is 0 to 15 percent. The native vegetation is mainly Douglas fir, blue spruce, aspen, white fir, and limber pine.

This unit is 40 percent fine-loamy, mixed Eutric Glossoboralfs, 25 percent loamy-skeletal, mixed Eutric Glossoboralfs and 25 percent fine-loamy, mixed Psammentic Glossoboralfs.

Included in this unit are small areas of loamy-skeletal, mixed Psammentic Glossoboralfs. Included areas make up about 10 percent of the total acreage.

The fine-loamy, mixed Eutric Glossoboralfs are deep, well drained soils. They formed in rhyolytic and tuff colluvium on mountain sideslopes. A typical profile has dark brown to brown loam and sandy loam to 24 inches. The subsurface has brown gravelly sandy clay loam to 80 inches.

The loamy-skeletal, mixed Eutric Glossoboralfs are deep, well drained soils. They formed in tuff on mountain sideslopes. A typical profile has very dark grayish brown to pinkish gray sandy loam to 18 inches. The subsurface has light brown to reddish brown sandy loam and gravelly sandy clay loam to 94 inches.

The fine-loamy, mixed Psammentic Glossoboralfs are deep, well drained soils. They formed in tuff on mountain sideslopes. A typical profile has dark brown to brown sandy loam to 23 inches. The subsurface has ¼-½ inch bands of brown sandy clay loam in a matrix of brown loamy sand to sandy loam to 60 inches.

GH Glossoboralfs-Rubble land Association, >35% slopes.

This map unit is on mountain sideslopes. Slope is >35 percent. The native vegetation is mainly Douglas fir, blue spruce, aspen, white fir and limber pine.

This unit is 40 percent loamy-skeletal, mixed Eutric Glossoboralfs, 25 percent Rubble land and 20 percent fine-loamy, mixed Eutric Glossoboralfs.

Included in this unit are small areas of loamy-skeletal, mixed Psammentic Glossoboralfs. Included areas make up about 15 percent of the total acreage.

The loamy-skeletal, mixed Eutric Glossoboralfs are deep, well drained soils. They formed in tuff on mountain sideslopes. A typical profile has very dark grayish brown to pinkish gray sandy loam to 18 inches. The subsurface has light brown to reddish brown sandy loam and gravelly sandy clay loam to 94 inches.

Rubble land is a miscellaneous land type made up of loose rhyolyte colluvium with little or no soil filling the voids between rocks. The loose, unstable rocks range in size from a few inches to a few feet in diameter. These materials usually lack vegetation.

The fine-loamy, mixed Eutric Glossoboralfs are deep, well drained soils. They formed in rhyolytic and tuff colluvium on mountain sideslopes. A typical profile has dark brown to brown loam and sandy loam to 24 inches. The subsurface has brown gravelly sandy clay loam to 80 inches.

GL Glossoboralf-Rubble land Association, >35% slope

This map unit is on mountain sideslopes. Slope is >35 percent. The native begetation is mainly Ponderosa pine, blue spruce, aspen, limber pine and Douglas fir.

This unit is 55 percent loamy-skeletal, mixed Psammentic Glossoboralfs and 30 percent Rubble land.

Included in this unit are small areas of loamy-skeletal, mixed, frigid Typic Udorthents, fine-loamy, mixed Typic Paleborolls and loamy-skeletal, mixed Typic Dystrochrepts. Included areas make up about 15 percent of the total acreage.

The loamy-skeletal, mixed Psammentic Glossoboralfs are deep, well drained soils. They formed in Tuff and rhyolytic colluvium on mountain sideslopes. A typical profile has a brown to grayish brown gravelly to cobbly loam to sandy loam to 20 inches. The subsurface has brown sandy clay loam lamellae ½ to 1 inch wide to a depth of greater than 60 inches in a matrix of pale brown gravelly and cobbly sandy loam.

Rubble land is a miscellaneous land type made up of loose rhyolyte colluvium with little or no soil filling the voids between rocks. The loose, unstable rocks range in size from a few inches to a few feet in diameter. These materials usually lack vegetation.

GP Glossoboralf-Dystrochrept-Paleboroll Association, 15-35%

This map unit is on mountain sideslopes. Slope is 15 to 35% percent. The native vegetation is mainly Douglas fir, ponderosa pine, white fir, limber pine, aspen and Arizona fescue.

This unit is 30 percent loamy-skeletal, mixed Psammentic Glossoboralfs, 20 percent coarse-loamy, mixed Psammentic Glossoboralfs, 20 percent loamy-skeletal, mixed Typic Dystrochrepts, and 20 percent fine-loamy, mixed Typic Paleborolls.

Included in this unit are small areas of coarse-loamy, mixed Typic Dystrochrepts. Included areas make up about 10 percent of the total acreage.

The loamy-skeletal and coarse-loamy, mixed Psammentic Glossoboralfs are deep, well drained soils. They formed in tuff and rhyolytic colluvium. The loamy-skeletals have more than 35% coarse fragments and the coarse-loamy soils have less than 35% coarse-fragments. A typical profile has a brown to grayish brown sandy laom and loam to cobbly and gravelly loam and sandy loam to 20 inches. The subsurface has brown sandy clay loam and clay loam lamellae ½ to 1 inch wide to a depth of greater than 60 inches in a matrix of pale brown gravelly and cobbly sandy loam.

The loamy-skeletal, mixed Typic Dystrochrepts are deep, well drained soils. They are formed in tuff and rhyolytic colluvium on mountain sideslopes. A typical profile has a grayish brown gravelly loam to sandy loam to 10 inches. The subsurface has brown gravelly loam to sandy loam to a depth of greater than 60 inches.

The fine-laomy, mixed Typic Paleborolls are deep, well drained soils. They formed in rhyolytic colluvium on mountain sideslopes. A typical profile has a dark brown loam to 25 inches. The subsurface is brown to dark brown clay loam to a depth of more than 60 inches.

CS Cryoboralf-Cryochrept Association, 35%+ slope

This map unit is on mountain sideslopes. Slope is >35 percent. The native vegetation is mainly Douglas fir, aspen, blue spruce white fir and limber pine.

This unit is 60 percent loamy-skeletal, mixed Psammentic Cryoboralfs and 20 percent coarse-laomy, mixed Alfic Cryochrepts.

Included in this unit are small areas of coarse-loamy, mixed Psammentic Cryoboralfs and rubble land. Included areas make up about 20 percent of the total acreage.

The loamy-skeletal, mixed Psammentic Cryoboralfs are deep, well drained soils. They formed in rhyolytic colluvium on mountain sideslopes. A typical profile has a grayish brown cobbly loam to sandy loam about 30 inches thick. The subsurface is brown to dark brown cobbly sandy loam to more than 70 inches.

The coarse-loamy, mixed Alfic Cryochrepts are deep, well drained soils. They formed in rhyolytic colluvium and tuff on mountain sideslopes. A typical profile has a brown sandy loam about 10 inches thick. The subsurface is brown sandy loam to more than 60 inches.

HS Hesperus-Seco Association, 3-15% slope

This map unit is on mountain sideslopes and footslopes. Slope is 3 to 15 percent. The native vegetation is mainly Arizona fescue, pine dropseed, wildoats, Thurber fescue, blue spruce and ponderosa pine.

This unit is 50 percent Seco silt loam and 50 percent Hesperus silt loam.

Hesperus silt loam, a fine-loamy, mixed Typic Argiboroll, is a deep, well drained soil. It formed in lacustrine on old terraces. A typical profile has dark grayish brown silt loam to 15 inches. The subsurface is pale brown to brown sandy clay loam to 53 inches. The substratum is brown sandy clay loam to loamy sand to a depth of 87 inches.

Seco silt loam, a loamy-skeletal, mixed Typic Paleboroll, is a deep, well drained soil. It formed in rhyolytic colluvium on toe slope positions. A typical profile has very dark brown silt loam to 15 inches. The subsurface has brown to dark brown gravelly and cobbly sandy clay loam and clay loam to 60 inches.

LI La Jara-Irim Association, 0-5% slope

This map unit is on floodplains of small streams. Slope is 0 to 5 percent. The native vegetation is mainly sedges, Junegrass, iris, and Arizona fescue.

This unit is 50 percent La Jara silt loam and 40 percent Irim silt loam.

Included in this unit are small areas of Tranquilar, Hesperus silt loam and Pavo silt loam. Inlcuded areas make up about 10 percent of the total acreage.

The La Jara series is a deep, somewhat poorly drained soil. It formed in alluvium on floodplains of streams. A typical profile has very dark brown silt loam to 11 inches. The subsurface has dark gray clay and clay loam to 21 inches. The substratum has dark grayish brown sandy clay loam and gravelly sandy loam to 60 inches.

The Irim series is a deep poorly drained soil. It formed in alluvium in depressed areas of small stream floodplains. A typical profile has black loam to 11 inches. The subsurface has dark grayish brown very gravelly loam to 60 inches.

PC Paleboroll-Cryoboralf Association, 3-15% slope

This map unit is on mountain sideslopes and footslopes. Slope is 0 to 15 percent. The native vegetation is mainly Douglas fir, aspen, blue spruce, Arizona fescue, spike muhly, pine dropseed, and wildoats.

This unit is 60 percent fine-loamy, mixed Cryic Paleborolls, 20 percent loamy-skeletal, mixed Psammentic Cryoboralfs and 20 percent coarse-loamy, mixed Psammentic Cryoboralfs.

The fine-laomy, mixed Cryic Paleborolls are deep, well drained soils. They formed in rhyolytic colluvium on mountain sideslopes. A typical profile has a dark brown loam to 25 inches. The subsurface is brown to dark brown clay loam to a depth of more than 60 inches.

The coarse-loamy and loamy-skeletal, mixed Psammentic Cryoboralfs are deep, well drained soils. They formed in rhyolytic colluvium and tuff on mountain sideslopes. The coarse-loamy soils have less than 35 % coarse fragments while the loamy-skeletal soils have more than 35% coarse fragments. A typical profile has grayish brown loam to cobbly loam to 30 inches. The subsurface has brown to dark brown sandy loam to cobbly sandy loam to more than 70 inches.

PE Pavo-Cryoboralf Association, 5-40% slope

This map unit is on mountain sideslopes and footslopes. Slope is 3 to 15 percent. The native vegetation is mainly Arizona fescue, spike muhly, pine dropseed, wild oats, blue spruce and Douglas fir.

This unit is 60 percent Pavo loam and 40 percent coarse-laomy, mixed Psammentic Cryoboralfs.

Pavo loam, a fine-loamy, mixed Cryic Paleborall is a deep, well drained soil. Pavo formed in Tuff on mountain sideslopes. A typical profile has dark grayish brown loam or sandy loam to 20 inches. The subsurface has brown sandy loam and sandy clay loam to 60 inches.

The coarse-loamy, mixed Psammentic Cryoboralfs are deep, well drained soils. They formed in rhyolytic colluvium and tuff on mountain sideslopes. A typical profile has grayish brwon loam to cobbly and gravelly loam to 30 inches. The subsurface has brown to dark brown sandy loam to cobbly and gravelly sandy loam to more than 70 inches.

RC Rubble land-Cryoboralfs Association, >35% slope

Slope is >35 percent. The native vegetation is mainly Engleman spruce, blue spruce, aspen, Douglas firm, Arizona fescue, wildoats, wild strawberry and sedges.

This unit is 40 percent Rubble land, 25 percent loamy-skeletal, mixed Typic Cryoboralfs and 20 percent loamy-skeletal, mixed Psammentic Cryoboralfs.

Included in this unit are small areas of fine-loamy, mixed Typic Cryoboralfs. Included areas make up about 15 percent of the total acreage.

Rubble land is a miscellaneous land type made up of loose rhyolyte colluvium with little or no soil filling the voids between rocks. The loose, unstable rocks range in size from a few inches to a few feet in diameter. These mateirals usually lack vegetation.

The loamy-skeletal, mixed Typic Cryoboralfs are deep, well drained soils. They formed in tuff on mountain sideslopes. A typical profile has dark grayish brown sandy loam to 15 inches. The subsurface has brown extremely gravelly, gravelly and cobbly sandy loam to 87 inches.

The loamy-skeletal, mixed Psammentic Cryoboralfs are deep, well drained soils. They formed in rhyolytic colluvium on mountain sideslopes. A typical profile has grayish brown loam to cobbly loam to 30 inches. The subsurface has brown to dark brown sandy loam to cobbly sandy loam to more than 70 inches.

TJ Tranquilar-Jarmillo complex, 3-10% slope

This map unit is on old alluvial and lacustrine terrace positions. Slope is 3 to 10 percent. The native vegetation is mainly Arizona fescue, pine dropseed, sedges, wheatgrass, and Junegrass.

This unit is 50 percent Jarmillo silt loam and 50 percent Tranquilar silt loam.

Tranquilar silt loam, a fine, mixed, frigid Typic Argialboll, is a deep, moderately well drained soil. It formed in lacustrine on benches in the valleys. A typical profile has very drak grayish brown silt loam to silty clay loam to 13 inches. The subsurface has dark brown to brown clay and silty clay loam to 75 inches.

Jarmillo silt loam, a fine-loamy, mixed Pachic Haploboroll, is a deep, well drained soil. It formed in lacustrine on an old terrace position. A typical profile has very dark grayish brown silt loam to loam to 20 inches. The subsurface has brown and yellowish brown sandy clay loam and silty clay loam to a depth of 50 inches. The substratum is yellowish brown sandy loam and grayish brown silty clay loam to a depth of 76 inches.

This complex is given a general rating of moderate-severe because of the drainage and low stability. If the areas can not be avoided structures may have to be made self suporting.

INTERPRETATIONS

Land use decisions are very involved and incorporate many aspects to derive the best "land use". One aspect is land suitability or specifically soil suitability for a particular use. Too often the soil properties are not considered and projects proceed ignorant to the limitation of the land. Such projects fail and the cost to correct the limitation after the fact, may be several fold as compared to the cost of recognizing the problem in the planning stage.

The interpretations in this section are based on soil properties that reflect the soils suitability for an electrical transmission line. A great number of properties could be considered, however those that are considered important and potentially the most limiting were evaluated.

Procedure. The procedure used in this study basically involved using available soil maps, interpretating the properties relative to the transmission line and making recommendations. The soils information in Sandoval County was obtained in part from personal visits to the study area and in part from soils maps prepared by the Soil Conservation Service. We are deeply grateful for the cooperation received from Mr. LeRoy W. Hacker of the SCS, USDA.

Soils information for Los Alamos County was obtained from the "Soil Survey of Los lamos County, New Mexico" (USDE, Nyhan, et al 1978). The following characteristics were considered and the soils were given a slight, moderate or severe rating as they might limit the transmission line.

1. Erosion. Erosion is the loss of soil from an area and generally has a fairly permanent effect. This aspect is considered relative to the construction phase and to the long term phase where the line may be revisited for inspection and maintainence. The present erosion status was considered as opposed to the potential erosion hazard.

In general erosion is minor in the study area and a few isolated areas could be considered severe. In nearly all cases the erosion has been caused by misuse, the most common of which results from roads or trails that have been established in drainage-ways (see photo 1). Great care should be taken to avoid traffic along fall-lines and other activities that cause water to collect and concentrate into unnatural drainage-ways.

Erosion categores

slight - little or no observable soil movement, rills shallow (< ½") and few (>10' apart), gullies uncommon or nearly completely vegetated and no obvious pedestalling of plants or surface gravels.

moderate - slight terracing and movement of debris, rills moderate (½ - 3" deep) and common (5 - 10 feet apart), gullies common and 50-90% of the gully slopes vegetated and some pedestalling of vegetation and gravels.

severe - subsoil exposed, rills deep (3" - 6" deep) and many (< 5' apart), gullies numerous and vegetation on 50% or less of the gully slopes, pedestalling very obvious and many roots exposed.

Mitigation

Erosion is best controlled by not causing erosion. This is not always possible or erosion may be a problem and have to be corrected before the project begins. In the study area water spreading techniques will be of great value; water bars along roads and revegetation techniques will also reduce or correct erosion. Some of the worst consequences of erosion are that erosion will become so severe as to limit access, cause a structure to fail and negatively affect grazing and timber potential. Interpretation for soil erosion is presented as map number 3 .

2. Soil Depth. Depth of soil is considered the depth to which hard bedrock is encountered. The power live structures are placed in the soil and bedrock limits the placement of structures. In general the soils of the area are deep and placement of the structures is not a problem except in certain areas of Los Alamos County.

Soil Depth Categories

slight - soils having depths to bedrock greater than 60 inches. These soils may be gravelly (3" dia., 20-50%), very gravelly (3" dia., 50-90% and cobbly (3-10; dia., 20-50%).

moderate - soils having depths to bedrock from 40-60". These soils may be very cobbly (3"-10" dia., 50-90%) or stony (>10" dia., 20-50%) and very stony (>10" dia., 50-90%).

severe - soils having depths to bedrock less than 40". These are shallow soil areas, Rubble land and Rock outcrop.

Mitigation

Little can be done to correct soil depth, other than avoid the areas. In some instances with special equipment holes can be dug in the bedrock or supported metal structures can be used. Interpretation for soil depth is presented as map number 4 .

3. Soil Stability. The stability of a soil is a measure of how well a structure will remain in place and upright. Soils are noted for slumping on steep slopes, slipping as mud-flows, and movement from wetting and drying. This last process in known as shrink-swell and can be predicted by knowing the amount and kind of clays. Stability was determined largely by the shrink-swell capacity of the soils but also consideration to slumping and other forms of gravelly related movement. In general the most severe areas are the Rubble land. The soils of the study area are very

stable and low shrink-swell with only a few exceptions.

Stability categories

slight - soils with sandy textures (sand, loamy sand, and sandy loam) and a COLE = <.03 (expansion-contraction less than 3%).

moderate - soils with loamy and clayey textures and mixed minerals (silty clay, silty clay loam, clay loam, sandy clay loam, clay and sandy clay) and a COLE = .03 - .06.

severe - soils with clayey textures with montmorillinite clays (clay, clay loam, silty clay, silty clay loam) and a COLE = >.06. Rubble-land is also included.

Mitigation

In most instances unstable land is best avoided. Fortunately the soils of the study area are very stable with the exception of the bottom meadow soils and the Rubble-land areas. One solution in moderate shrink-swell soils is to back-fill with gravelly material to reduce the forces of the expansion and contraction. In most cases there is no cheap way to stabilize a soil. Interpretation for soil stability is presented as map number 5 .

4. Drainage. Soil drainage is a characteristic of how well water drains away from the soil. In poorly drained soils water may remain at or near the surface for many months of the year. The main considerations are the access to the sites and the effect of water-logging the structures. With only a few exceptions nearly all of the soils in the study area are well drained.

Drainage categories

slight - well drained, somewhat excessive and excessively drained soils-water logging is not a problem.

moderate - moderately well drained soils. Water logging may occur for short period of time.

severe - somewhat poorly, poorly and very poorly drained soils. Water logging frequently occurs and may persist over half the time.

<u>Mitigation</u>

Drainage can be corrected by placing drain tiles in the soil if the water can be removed. Because the areas are limtied it would be best to avoid the poorly drained areas. Interpretation for soil drainage is presented as map number 6 .

5. <u>Corrosivity</u>. Soil corrosivity is a characteristic of the effect soil has on wood, steel, concrete and other materials. Corrosivity is in part a result of pH, water holding capacity and aeriation. The factors affecting corrosivity of wood structures is little known and most data are available for steel and concrete. The soils of the study area vary greatly for the corrosivity of concrete and this characteristic has been used as an indicator of the possible problems.

<u>Corrosivity categories</u> - "<u>concrete</u>"

slight - soils having medium-coarse textures and pH's greater than 6.5, soils having medium-fine textures and pH's greater than 6.0.

moderate - soils having medium-coarse textures and pH's from 5.5-6.5, soils having medium-fine textures and pH's from 5.0-6.0.

severe - soils having medium-coarse textures and pH's less than 5.5, soils having medium-fine textures and pH's less than 5.0.

<u>Mitigation</u>

Soil pH is very difficult to change and thus the corrosivity properties are difficult to change. It is recommended that the structures be treated properly to resist the corrosivity of the soils or attempt to avoid the acid soils when possible. Interpretation of soil corrosivity is presented as map number 7 .

6. Runoff. Runoff is a determination of the flow of water over the surface. Runoff is affected by slope, infiltration, vegetative cover and the type and intensity of precipitation. Generally as runoff increases erosion hazard is more severe and the possibility of hazards resulting from over-land flow increases. The soils of the study area are very permeable and runoff is estimated to be a slight hazard for most soils.

Runoff categories

slight - slopes less than 15% and water flow patterns appear to direct water in a spreading pattern or flow pattern are not obvious. Some steeper slopes are included if the flow patterns are not obvious and surface textures are coarse-loamy. Erosion hazard is usually slight.

moderate - slopes from 15-35% and some evidence of flow patterns. Erosion hazard is moderate and these soils can become a problem if misused but generally are easily managed.

severe - slopes greater than 35% and obvious flow pattern. Erosion may be severe and these soils usually require some protection because they naturally have very rapid runoff.

Mitigation

In areas sensitive to runoff construction and vehicle traffic should be careful not to start head-cuts and cause water to collect. Water bars can be used along roads and revegetation on disturbed areas. The very steep areas should be avoided when possible. Interpretation for runoff is presented as map number 8.

7. Topsoil. An interpretation of topsoil sources is given to reflect the limitations of revegetation in disturbed construction areas. In many areas topsoil soil sources may not be necessary or they may be borrowed from good sources. Topsoil is vaguely defined but generally is the top-dress material used to support vegetation in revegetation projects.

Topsoil categories

good - loamy textures (sandy loam, silt loam and loam) that are at least 16" deep; few coarse fragments (<3%) and on gentle slopes (<8%). Another consideration is the subsoil properties that will remain after the topsoil is removed.

fair - clayey textures (clay loam, sandy clay loam, silty clay loam, sandy clay) that are 8-16" deep on 8-15% slopes and have 3-15% gravels. There may be some problem of revegetation of the subsoil.

poor - sandy or clayey textures (sand, loamy sand, clay, silty clay) and depths less than 8 inches with more than 15% gravels and steep slopes.

Mitigation

The main concern is having material available to revegetate the construction sites, roads or other forms of disturbance. If the disturbance is minimal, then the need for topsoil will be a minimum. This aspect is not as some others and the need for topsoil will depend on the construction activities. Interpretation for topsoil is presented as map number 9 .

The interpretations of the soil mapping units are tabulated in Table 1 for Sandoval County and Table 2 for Los Alamos County.

Sandoval County - the interpretations in Table 1 are based on personal observation of the soils and material supplied by the Soil Conservation Service. Descriptions of the soils and mapping units are included in this report. The general ratings are explained for each mapping unit.

Los Alamos County - the interpretations in Table 2 are based on soils information found in the "Soil Survey of Los Alamos County (USDE, Nyhan, et al, 1978). This report is included in the Appendix of this report. The general ratings for each mapping unit are given in Table 2. Mitigation procedures are similar for those given for the Sandoval County mapping units.

TABLE 1. Interpretation of the Soil Mapping Units of Sandoval County, New Mexico

Map Unit		Erosion	Depth	Stability Shrink Swell	Drainage	Top-soil	Runoff	Corro	General Sensitivity
LaJara-Irim Assoc. 0-5% slope	LI	moderate	slight	moderate	severe	fair	slight	slight	severe
Tranguilar-Jarmillo Complex 3-10% slope	TJ	slight	slight	severe	moderate	fair	slight	slight	mod-severe
Hesperus-Seco Assoc. 3-15% slope	HS	slight	slight	moderate	slight	fair	slight	slight	slight-moderate
Pavo-Eutraboralf Assoc. 3-15% slope	PE	moderate	slight	moderate	slight	fair	slight	slight	slight-moderate
Glossoboralf-Dystrochrept Paleboroll assoc. 15-35% slope	GP	moderate	slight	slight	slight	poor	moderate	slight	slight-moderate
Glossoboralf-Rubble Assoc. >35% slope	GL	moderate	moderate	moderate	slight	poor	moderate	slight	slight-moderate
Paleboroll-Cryoboralf Assoc. 3-15% slope	PC	slight	slight	moderate	slight	fair	slight	severe	moderate
Cryoboralfs Assoc. 15-35% slope	CC	slight	slight	slight	slight	poor	slight	severe	moderate
Cryoboralf-Cryochrept Assoc. 15-35% slope	CA	slight	slight	slight	slight	poor	slight	severe	moderate
Cryoboralf-Cryochrept Assoc. >35% slope	CS	moderate	slight	slight	slight	poor	moderate	severe	moderate
Glossoboralfs Assoc. 0-15% slope	GG	slight	slight	moderate	slight	fair	slight	slight	slight
Glossoboralfs Assoc. 15-35% slope	GE	slight	slight	moderate	slight	fair	moderate	slight	slight-moderate
Glossoboralf-Rubble Assoc. >35% slope	GH	slight	moderate	severe	slight	poor	moderate	slight	moderate-severe
Cryoboralfs-Rubble Assoc. >35% slope	CT	slight	slight	moderate	slight	poor	moderate	moderate	moderate
Rubble land-Cryoboralf Assoc. >35% slope	RC	slight	severe	severe	slight	poor	moderate	moderate	severe
Glossoralfs-Argiboroll Assoc. 15-35% slope	GA	slight	slight	slight	slight	poor	moderate	moderate	slight-moderate

TABLE 2. Interpretations of the Soil Mapping Units of Los Alamos County, New Mexico

Map Unit		Erosion	Depth	Stability Shrink Swell	Drainage	Top-soil	Runoff	Corro	General
Abrigo laom	AB	moderate	slight	moderate	slight	good	slgiht	slight	slight-moderate
Arriba-Copal complex	AC	moderate	moderate	moderate	slight	fair	slight	slihgt	moderate
Armstead loam	AR	moderate	slight	severe	slight	poor	slight	slight	moderate-severe
Cuervo gravelly loam 0-15% slope	CL	moderate	moderate	slight	slight	poor	slight	slight	moderate
Carjo loam	CR	moderate	severe	moderate	slight	poor	slight	slight	severe
Cuervo gravelly loam 16-40% slope	CS	moderate	moderate	slight	slight	poor	moderate	slight	moderate
Frijoles very fine sandy loam	FR	moderate	slight	slight	slight	poor	slight	slight	slight-moderate
Griegos Cobbly loam 16-40% slope	GR	moderate	slight	slight	slight	poor	moderate	slight	moderate
Griegos Cobbly loam 41-80% slopes	GS	severe	slight	slight	slight	poor	moderate	slight	moderate-severe
Griegos-Rock outcrop complex	GT	severe	severe	slight	slight	poor	moderate	slight	severe
Hackroy sandy loam	HA	moderate	severe	slight	slight	poor	slight	slight	severe
Hackroy-Rock outcrop complex	HR	severe	severe	slight	slight	poor	moderate	slight	severe
Kwage-Pelado-Rock outcrop complex	KW	moderate	slight	slight	slight	fair	moderate	slight	slight-moderate
Myjack loam	MJ	slgiht	moderate	moderate	slight	fair	slgiht	slight	moderate
Pueblo Stony loam	PB	moderate	slight	slight	slight	poor	slight	slight	slight-moderate
Pogna fine sandy loam	PG	moderate	severe	slight	slight	poor	slight	slight	severe
Pelado cobbly loam	PL	moderate	slight	slight	slight	poor	slight	slight	slight-moderate
Quemazon-Arriba Rock outcrop complex	QU	moderate	moderate	slight	slight	poor	slight	slight	moderate
Rock outcrop-Pines-tentrock complex	RE	moderate	severe	slight	slight	poor	moderate	slight	severe
Rock outcrop frigid	RF	moderate	severe	slight	slight	poor	moderate	slight	severe
Rock outcrop mesic	RM	moderate	severe	slight	slight	poor	moderate	slight	severe
Rock outcrop-colle-painted cave complex	RO	moderate	severe	slight	slight	poor	moderate	slight	severe
Rock outcrop, steep	RS	severe	severe	slight	slight	poor	moderate	slight	severe
Rabbit-Tsankawi Rock outcrop complex	RT	moderate	severe	slight	slight	poor	slight	slight	severe
Santa Klara-Armstead complex	SC	moderate	moderate	severe	slight	poor	slight	slight	moderate-severe
Seaby loam	SL	moderate	severe	slight	slight	poor	slight	slight	severe
Talus slopes, cryic	TA	slight	severe	severe	slight	poor	slight	slight	severe
Typic Eutro boralf clayey-skeletal	TC	moderate	slight	moderate	slight	poor	slight	moderate	slight-moderate
Turkey-Cabra Rock outcrop complex	TL	moderate	severe	moderate	slight	poor	slight	slight	severe
Typic Eutroboralf fine-loamy	TL	moderate	slight	moderate	slight	fair	slight	slight	slight-moderate
Tocal very fine sandy loam	TO	moderate	severe	moderate	slight	poor	slight	slight	severe
Typic Ustorthents-Rock outcrop complex	TR	moderate	moderate	slight	slight	poor	slight	slight	moderate
Typic Eutroboralf, fine	TS	moderate	slight	severe	slight	poor	slight	slight	moderate-severe
Totavi gravelly loamy sand	TV	slight	slight	slight	slight	poor	slight	slight	slight-moderate

GENERAL INTERPRETATIONS FOR EACH MAPPING UNIT.

CA Cryoboralf-Cryochrept Association, 15-35% slope

This soil association has moderate limitations relative to the use associated with the proposed transmission line, (Table 1). Corrosivity is severe and the structures will require protection, and the soils are poor sources of topsoil. Other interpretations have slight limitations.

CC Cryoboralfs Association, 15-35% slope

This soil association has moderate limitations relative to the use associated with the proposed transmission line (Table 1). The limitations are the same described for mapping unit (CA).

CT Cryoboralf-Rubble land Associations, > 35% slope

This soil association has moderate limitations relative to the use associated with the proposed transmission line (Table 1). Corrosivity may be a problem (moderate rating), shrink-swell and runoff are rated moderate. Soils are poor sources of topsoil and other interpretations are rated slight. The Rubble land in this association should be avoided.

GA Glossoboralfs-Argiboroll Association, 15-35% slopes

This soil association has slight-moderate limitations relative to the use associated with the proposed transmission line (Table 1). Corrosivity and runoff are rated as having moderate limitations and the soils are poor sources of topsoils. The other interpretations are rated slight.

GE Glossoboralfs Association, 15-35% slopes

This association has slight-moderate limitations relative to the use associated with the proposed transmission line (Table 1). Runoff and shrink-swell are rated as having moderate limitations - both would require some mitigation. The other interpretations are rated slight.

GG Glossoboralfs Association, 0-15% slopes

This association has slight limitations relative to the use associated with the proposed transmission line (Table 1). This association is rated as the most suitable unit in the study area.

GH Glossoboralfs-Rubble land Association >35% slopes

This soil association has moderate-severe limitations relative to the use associated with the proposed transmission line (Table 1). Stability is rated severe because of the rubble land and the clayey soils; these areas should be avoided. Runoff and soil depth are rated as having moderate limitations and topsoil sources are poor. The other interpretations are rated slight.

GL Glossoboralf-Rubble land association >35% slopes

This soil association has slight-moderate limitations relative to the use associated with the proposed transmission line (Table 1). Stability is rated moderate, however the Rubble land should be avoided. Erosion, and runoff will require some mitigation. In other respects the Glossoboralfs are suitable areas and are rated with slight limitations.

GP Glossoboralf-Dystrochrept-Paleboroll Association, 15-35%

This soil association has slight-moderate limitations relative to the use associated with the proposed transmission line (Table 1). Erosion and runoff are rated having moderate limitations and mitigation will be required. Topsoil sources are poor. The other interpretations are rated slight.

CS Cryoboralf-Cryochrept Association, >35% slope

This association has moderate limitations relative to the use associated with the proposed transmission line (Table 1). This association is rated the same as units (CA & CC). Erosion will require mitigation in these units.

HS Hesperus-Seco Association, 3-15% slope

This association has slight-moderate limitations relative to the use associated with the proposed transmission line (Table 1). Stability is rated moderate, otherwise, the interpretations are rated slight.

LI La Jara-Irim Association, 0-5% slope

This association has severe limitations relative to the use associated with the proposed transmission line (Table 1). Drainage is rated severe and these soils should be avoided. Mitigation would not be economically feasible.

PC Paleboroll-Cryoboralf Association, 3-15% slopes

This association has moderate limitations relative to the use associated with the proposed transmission line (Table 1). Corrosivity is rated severe in the cryoboralf soils and should be avoided or the structures protected. Stability is rated moderate and the other interpretations are rated slight.

PE Pavo-Eutraboralf Association, 3-15% slopes

This association has slight-moderate limitations relative to the use associated with the proposed transmission line (Table 1). Erosion and stability are rated moderate and will require mitigation. The other interpretations are rated slight.

RC Rubble land-Cryoboralfs Association, >35% slope

This association has severe limitations relative to the use associated with the proposed transmission line (Table 1). Stability and depth are rated severe for the Rubble land and these areas should be avoided. The Cryoboralfs have moderate limitations with respect to corrosivity, and runoff.

TJ Tranquilar-Jarmillo complex, 3-10% slopes

This complex has moderate-severe limitations relative to the use associated with the proposed transmission line (Table 1). Drainage is rated moderate and could be mitigated but the stability is rated severe and should either be avoided or mitigated correctly. The other interpretations are rated slight.

Figure 1 The Baca portion of the study area. The grassland soils are rated having moderate to severe limitations for the proposed transmission line because of low stability and poor drainage. The forest soils are generally rated having slight-moderate limitations.

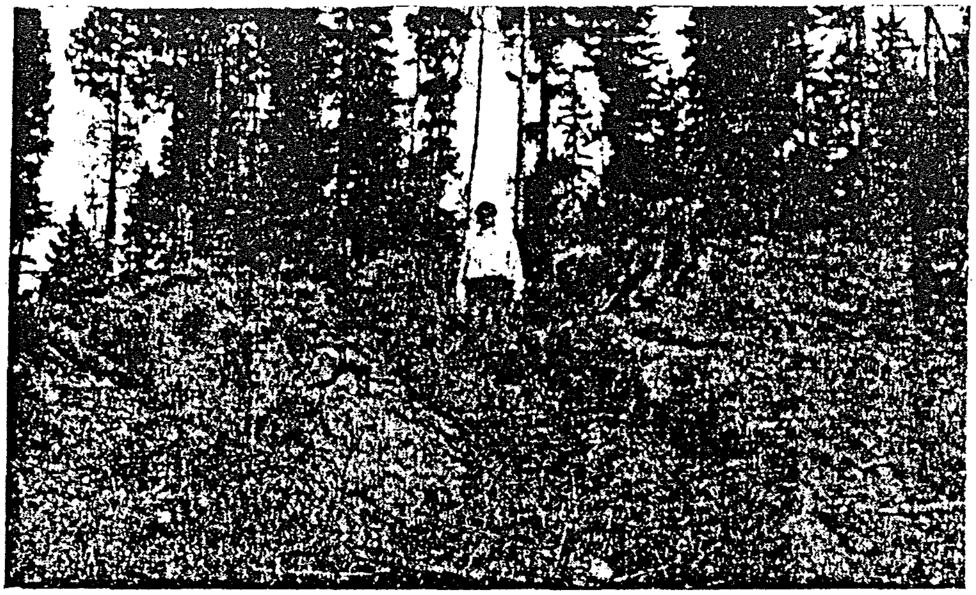

Figure 2 Soil erosion in the Baca portion of the study area. Most of the erosion observed was caused by water being concentrated along disturbance (roads) directed with the full line.

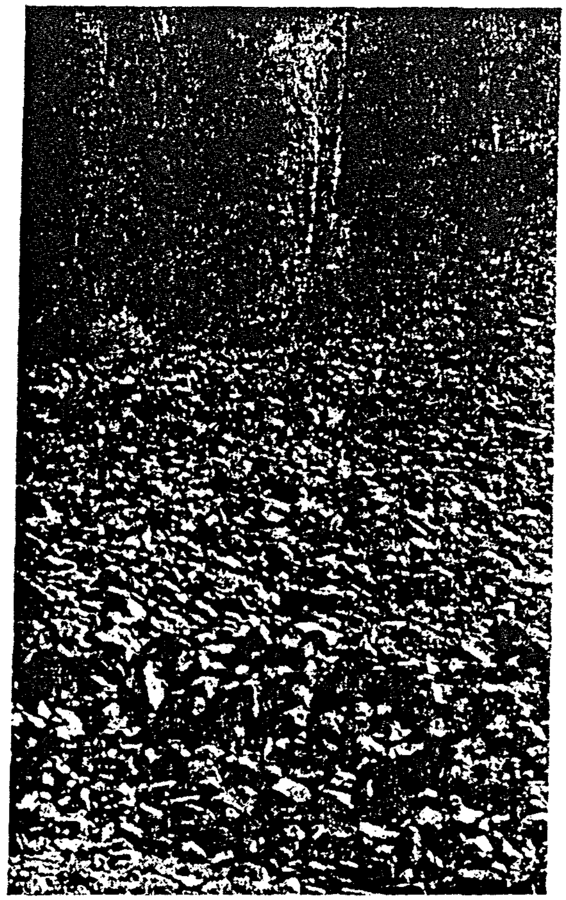

Figure 3 Rubble land located in the Baca portion of the lease. These areas are very unstable, shallow and not suited for use associated with the transmission line. These areas should be avoided.

Figure 4 Soil profile exposed by a road cut in the Baca portion of the study area. Soils are generally deep and the gravel and cobble content vary greatly. This profile is typical of the loamy-skeletal cryoboralfo and they are generally rated having slight limitations for use associated with the transmission line.

APPENDIX 1

CLASSIFICATION: fine-loamy, mixed, Typic Argiboroll
N. VEG.: ponderosa pine, Douglas fir, Arizona fescue
PARENT MATERIAL: rhyolytic colluvium
PHYSIOGRAPHY: mountain sideslope
RELIEF: linear-concave
ELEVATION: 9,680'
SLOPE: 20%
ASPECT: S
EROSION: slight
DRAINAGE: well
GR. WATER: deep
MOISTURE: moist

PROFILE DESCRIPTION

A1--0-9"; Very dark brown (10YR2/2) gravelly loam; moderate to strong coarse granular structure; friable, slightly sticky and slightly plastic; many fine and very fine roots; and few medium and coarse roots; neutral; clear wavy boundary.

A&B--9-17"; Very dark grayish brown (10YR3/2) gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; friable, slightly sticky and slightly plastic; common fine and very fine and few medium roots; neutral; clear wavy boundary.

B21t--7-33"; Brown (10YR4/3) gravelly sandy clay loam; moderate coarse subangular blocky structure; firm, slightly sticky and slightly plastic; common fine and very fien roots; common moderately thick clay films on the ped faces and in the pores; neutral; gradual wavy boundary.

B22t--33-60"; Yellowish brown (10YR5/4) gravelly sandy clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; many moderately thick clay films on ped faces and in pores; very strongly acid.

CLASSIFICATION: fine-loamy, mixed Typic Cryoboralf
N. VEG.: Douglas fir, Engleman spruce, corkbark fir, wild oats, Timothy grass and wild strawberry
PARENT MATERIAL: mixed tuff and pumice
PHYSIOGRAPHY: ridge top
RELIEF: linear
ELEVATION: 9,750'
SLOPE: 4%
ASPECT: east
EROSION: slight
DRAINAGE: well
GR. WATER: deep

PROFILE DESCRIPTION

A11--0-2"; Grayish brown (10YR5/2) sandy loam, very dark grayish brown (10YR3/2) moist; weak fine subangular blocky parting to weak fine crumb structure; soft, very friable, slgihtly sticky and slightly plastic; many very fine and few medium roots; slightly acid (pH 6.4); abrupt smooth boundary.

A2--2-8"; Light gray (10YR7/2) gravelly sandy loam, grayish brown (10YR5/2) moist; weak moderate platy parting to weak moderate subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many very fine and few medium roots; 5 percent cobble and 12 percent gravel; slightly acid (pH 6.4); clear wavy boundary.

B1--8-19"; White (10YR8/2) very gravelly sandy loam, light brownish gray (10YR6/2) moist; weak medium coarse subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and few medium to coarse roots; silt coats on ped tops; 40 percent gravel; slightly acid (pH 6.4); clear wavy boundary.

B21t--19-26"; pink (7.5YR8/4) extremely gravelly sandy, loam, brown (7.5YR5/4) moist; weak moderate subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and medium roots; few moderately thick clay films on top of coarse fragments; 60 percent gravel; slightly acid (pH 6.4); gradual wavy boundary.

IIB22t--26-32"; Light reddish brown (5YR6/3) sandy clay loam, yellowish red (5YR5/6) moist; weak coarse prismatic structure; hard, firm, sticky and plastic, few very fine and medium roots; common moderately thick clay films on ped faces; 12 percent gravel; slightly acid (pH 6.2); abrupt wavy boundary.

IIB23t--32-44"; Reddish yellow (5YR6/6) gravelly sandy loam, yellowish red (5YR4/6) moist; massive structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and medium roots; clay flows on rocks; 20 percent gravel; medium acid (pH 6.0); gradual wavy boundary.

IIC1--44-50"; Light reddish brown (5YR6/4) gravelly sandy loam, reddish brown (5YR4/4) moist; massive structure; slightly hard, friable, slightly sticky and slightly plastic; clay flows on rocks; 20 percent gravel; medium acid (pH6.0); gradual wavy boundary.

IIC2--50-59"; Light reddish brown (5YR6/4) extremely gravelly sandy loam, reddish brown (5YR4/4) moist; massive structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine roots; clay flows on rocks; 67 percent gravel; medium acid (pH5.6); gradual wavy boundary.

IIIC3--59-83"; Reddish yellow (5YR7/8) extremely cobbly sandy clay loam, yellowish red (5YR5/8) moist; massive; hard, firm, sticky and plastic; clay flows on rocks; 85 percent cobble with 10 percent stone; strongly acid (pH5.4); gradual wavy boundary.

IIIC4--83-88"; Reddish yellow (5YR7/8) extremely cobbly sandy clay loam, yellowish red (5YR5/8) moist; massive, hard, firm, sticky and plastic; 70 percent cobble; strongly acid (pH5.4); abrupt wavy boundary.

IVC1--88-106"; Reddish brown (5YR5/4) clay loam, reddish brown (5YR4/4) moist; massive; hard, firm, sticky and plastic; strongly acid (pH5.4); boundary unknown (auger hole).

IVC2--106-116"; Reddish brown (5YR5/4) clay loam, reddish brown (5YR4/4) moist; massive; hard, firm, sticky and plastic; medium acid (pH 5.6).

CLASSIFICATION: loamy-skeletal, mixed Typic Cryoboralf
N. VEG.: Engleman spruce, aspen, Douglas fir, Arizona fescue, wild strawbe-ry and sedges
PARENT MATERIAL: Tuff
PHYSIOGRAPHY: mountain sideslope
RELIEF: linear
SLOPE: 19%
ASPECT: SW
EROSION: slight
DRAINAGE: well
GR. WATER: deep

PROFILE DESCRIPTION

A1--0-2"; Grayish brown (10YR5/2) sandy loam, very dark grayish brown (10YR3/2) moist; weak medium crumb structure; soft, very friable, slightly sticky and slightly plastic; many very fine and few medium roots; slightly acid (pH6.4), clear smooth boundary.

A21--2-7"; Light brownish gray (10YR6/2) sandy loam, dark grayish brown (10YR4/2) moist; weak medium platy parting to weak fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common very fien and few medium roots; few thin silt coatings on ped faces; slightly acid (pH 6.0), clear smooth boundary.

A22--7-15:; Light gray (10YR7/2) sandy loam, brown (10YR5/3) moist; weak medium platy parting to weak fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common very fine and few medium roots; few thin clay films on ped faces; one percent cobble; medium acid (pH 5.8), clear wavy boundary.

B1--15-22"; Very pale brown (7.5YR7/4) sandy laom, brown (7.5YR5/4) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine and very fien roots; few thin clay films on ped faces; medium acid (pH5.8), clear wavy boundary.

B21t--22-29"; Light gray (10YR 7/2) sandy loam, brown (10YR5/3) moist; weak fine and medium subangular blocky structure; slightly sticky and slightly plastic; few very fine roots; common moderately thick clay films on ped faces; medium acid (pH 5.8), gradual wavy boundary.

IIB22t--29-38"; Light brown (7.5YR6/4) very gravelly coarse sandy loam, brown (7.5YR4/4) moist; weak medium and coarse subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine medium and coarse roots; common moderately thick clay films on coarse fragments; 5 percent stone, 10 percent cobble, 20 percent gravel; medium acid (pH 5.8), diffuse wavy boundary.

B23t--38-54"; Light brown (7.5YR6/4) extremely gravelly coarse sandy loam, brown (7.5YR4/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots; common moderately thick clay films on coarse fragments; 15 percent stone, 5 percent cobble, sixty percent gravel; medium acid (pH 5.8), diffuse wavy boundary.

B31--54-71"; Light brown (7.5YR6/4) extremely cobbly sandy clay loam, brown (7.5YR4/4) moist; massive; hard, firm, slightly sticky and slightly plastic; few medium roots; few moderately thick clay films on coarse fragments; 15 percent stone, 25 percent cobble, and 30 percent gravel; medium acid (pH 5.8), diffuse wavy boundary.

B32--71-87"; Pink (7.5YR7/4) extremely cobbly sandy clay loam, brwon (7.5YR5/4) moist; massive; hard, firm, slightly sticky and plastic; 15 percent stone, 25 percent cobble and 30 percent gravel; medium acid (pH 5.8), diffuse wavy boundary.

C1--87-97"; Reddish yellow (7.5YR6/6) extremely cobbly sandy clay laom, strong brown (7.5YR4/6) moist; massive; hard, firm, sticky and plastic; 20 percent stone, 30 percent cobble, 20 percent gravel; medium acid (pH 5.8).

SOIL TYPE: Psammentic Cryoboralf; coarse-loamy, mixed
CLASSIFICATION: coarse-loamy, mixed
N. VEG: Spruce, Aspen, Mt. Brome, Timothy, wheatgrass
PARENT MATERIAL: Pumice
PHYSIOGRAPHY: Mountain sideslope
RELIEF: convex
ELEVATION: 9200'
SLOPE: 24%
ASPECT: N.E.
EROSION: slight to moderate
DRAINAGE: well
GR. WATER: Deep
MOISTURE: bottom three layers
LOCATION: northeast side of Cerro Medio

PROFILE DESCRIPTION

O1--2-0";

A11--0-4"; Grayish brown (10YR5/2) gravelly sandy loam, dark grayish brown (10YR4/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many fine and very fine roots; 25% fine gravel; neutral; clear smooth boundary.

A12--4-11"; Light brownish gray (10YR6/2) gravelly sandy loam, brown (10YR5/3) moist; weak fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and very fine roots; 20% gravel; medium acid; clear smooth boundary.

A2--11-23"; Light gray (10YR7/2) gravelly loamy sand, brown (10YR5/3) moist; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common fine and very fine roots; 20% gravel; medium acid; gradual smooth boundary.

B2t--23-51"; Pale brown (10YR6/3) gravelly sandy clay loam, dark yellowish brown (10YR 4/4) moist; weak fine and medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few very fine and micro roots; 15% gravel; slightly acid.

B2t--23-51"; Very pale brown (10YR7/3) gravelly light sandy loam, light yellowish brown (10YR6/4) moist; massive; slightly hard, friable, nonsticky and nonplastic; few very fine and micro roots; 15% gravel; slightly acid.

CLASSIFICATION: fine-loamy, mixed Psammentic Cryoboralf
N. VEG.: Douglas fir, Engleman spruce, Ponderosa pine, aspen, common juniper, orchard grass, Arizona fescue, bluegrass
PARENT MATERIAL: pumice and tuff
PHYSIOGRAPHY: mountain sideslope
RELIEF: linear
SLOPE: 25%
ASPECT: ESE
EROSION: slight
DRAINAGE: well
GR. WATER: deep

PROFILE DESCRIPTION

A11--0-2"; Dark grayish brown (10YR4/2) laom, very dark brown (10YR2/2) moist; weak fine crumb structure; soft, very friable, slgihtly sticky and slightly plastic; many fine and very fine roots; neutral (pH 6.8); clear, smooth boundary.

A12--2-8"; Light brownish gray (10YR6/2) loam, brown (10YR4/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many fine roots; 1 percent gravel; slightly acid (pH 6.1), clear smooth boundary.

A21--8-15"; Pale brown (10YR 6/3) loam, brown (10YR4/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and coarse roots; 2 percent gravel; slightly acid (pH 6.3), gradual smooth boundary.

A22--15-22"; Light gray (10YR7/2) gravelly loam, dark grayish brown (10YR4/2) moist; weak fine subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine and coarse roots; 15 percent gravel; slightly acid (pH 6.2); gradual smooth boundary.

B1--22-28"; White (10YR 8/1) clay loam, grayish brown (10YR5/2) moist; moderate fine subangular structure; hard, firm, slightly sticky and plastic; common fine and coarse roots; two bands ¼-½ inch thick; two percent cobble, 10 percent gravel; slightly acid (pH 6.3); abrupt wavy boundary.

B21t--28-44"; White (10YR 8/1) gravelly sandy clay loam, grayish brown (10YR5/2) moist; weak medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine and coarse roots; bands ¼-½ inch thick; textures and colors are composite of bands and matrix; 1 percent cobble, 15 percent gravel; slightly acid (pH 6.1); gradual wavy boundary.

IIB22t--44-59"; White (10YR8/2) very gravelly sandy loam, brown (10YR5/3) moist; massive; soft, friable slightly sticky and slightly plastic; few fine and coarse roots; few moderately thick clay films on coarse fragments; 3 percent cobble, 40 percent gravel; slightly acid (pH 6.2); gradual wavy boundary.

IIB23--59-67"; Light gray (10YR7/2) extremely gravelly, sandy loam, brown (10YR5/3) moist; massive; sfot, very friable, nonsticky and non-plastic; few fine and coarse roots; thick discontinuous clay films on coarse fragments; 5 percent cobble, 65 percent gravel; slightly acid (pH 6.5); gradual wavy boundary.

IIIB24t--67-83"; Light gray (10YR7/2) sandy loam, grayish brown (10YR5/2) moist; massive; soft, very friable, slightly sticky and slightly plastic; few fine and coarse roots; heavy band in middle of horizon, thick discontinuous clay films on coarse fragments; 2 percent cobble; neutral (pH 6.6); gradual wavy boundary.

IIIB25t--83-106"; Light gray (10YR7/2) gravelly sandy loam, brown (10YR4/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common moderately thick clay films; 1 percent cobble, 15 percent gravel; slightly acid (pH 6.5); gradual wavy boundary.

IIIB3--106-118"; Very pale brown (10YR7/3) gravelly clay loam, brown (10YR4/3) moist; massive; slightly hard, friable, sticky and plastic; 1 percent cobble, 20 percent gravel; slightly acid (pH 6.4).

CLASSIFICATION: loamy-skeletal, mixed Psammentic Cryoboralf
N. VEG.: Douglas fir, white pine, limber pine, aspen, Kentucky blue grass, mountain brome
PARENT MATERIAL: rhyolytic colluvium
PHYSIOGRAPHY: mountain sideslope
RELIEF: convex
ELEVATION: 9,200'
SLOPE: 52%
ASPECT: N
EROSION: slight
DRAINAGE: well
GR. WATER: deep
MOISTURE: moist

PROFILE DESCRIPTION

A11--0-5"; Grayish brown (10YR5/2) loam, very dark grayish brown (10YR3/2) moist; moderate fine and medium crumb structure; soft, very friable, slightly sticky and slightly plastic; many fine and veyr fine roots; slightly acid; clear smooth boundary.

A12--5-11"; Light gray (10YR7/1) heavy sandy loam, grayish brown (10YR5/2) moist; weak fine and medium granular structure; soft, very friable, slightly sticky and slightly plastic; many fine and very fien roots; 25% stones, 35% cobbles and 5% gravel; medium acid; clear smooth boundary.

A2--11-31"; White (10YR8/2) sandy loam, pale brown (10YR6/3) moist; weak fine granular structure; slightly hard, friable, slightly sticky and non plastic; many coarse, medium and fine roots; 25% stones, 35% cobbles and 5% gravel; medium acid; clear smooth boundary.

B21t--31-55"; (Bands) Pink (7.5YR7/4) sandy loam, brown (7.5YR5/4) moist; sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common medium roots; 40% cobbles, 10% stones, and 5% gravel; extremely acid; gradual smooth boundary; 30% bands.

B21t--31-55"; (Matrix) Pine (7.5YR8/4) loamy sand, light brown (7.5YR6/4) moist; massive; soft, loose, non sticky and non plastic; common medium roots; 40% cobbles, 10% stones and 5% gravel; very strongly acid; gradual smooth boundary.

B22t--55-71"; (Bands) Light brown (7.5YR7/4) sandy loam, brown to dark brown (7.5YR4/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; 50% cobbles and 15% stones; extremely acid; 40% bands.

B22t--55-71"; Pinkish white (7.5YR8/2) loamy sand, pink (7.5YR7/4) moist; massive; soft, loose, non sticky and non plastic; 50% cobbles and 15% stones; medium acid.

CLASSIFICATION: fine-loamy, mixed Eutric Glossoboralf
N. VEG.: Douglas fir, blue spruce, aspen, white fir
PARENT MATERIAL: Rhyolytic colluvium and tuff
PHYSIOGRAPHY: Mountain sideslope
RELIEF: convex
ELEVATION: 9,240'
SLOPE: 25%
ASPECT: NW
EROSION: slight
DRAINAGE: well
GR. WATER: deep

PROFILE DESCRIPTION

A11--0-7"; Light brownish gray (10Y6/2) loam, dark brown (7.5YR3/2) moist; moderate coarse granular structure; friable, non sticky and slightly plastic; many fine, medium and coarse roots; clear wavy boundary.

A12--7-12"; Light brownish gray (10YR6/2) loam, dark brown (7.5YR3/2) moist; weak fine subangular blocky structure; friable, slightly sticky and slightly plastic; many fine, medium and coarse roots; clear wavy boundary.

A2--12-24"; Light gray (10YR7/2) sandy loam, brown (7.5YR5/2) moist; weak coarse subangular blocky and prismatic structure; friable, non sticky and non plastic; many fine and medium and common coarse roots; clear wavy boundary.

IIB21t--24-30"; Light brown (7.5YR6/4) gravelly sandy clay loam, brwon (7.5YR5/4) moist; weak medium to thick platy parting to moderate fine and medium subangular blocky structure; firm to very firm, slightly sticky and slightly plastic; common fine and medium roots; many moderately thick clay films on ped faces; clear wavy boundary.

IIB22t--30-40"; Light brown (7.5YR6/4) gravelly sandy clay loam, brown (7.5YR5/4) moist; moderate medium to thick platy parting to moderate fine and medium subangular blocky structure; firm, slightly sticky and slightly plastic; common fine and medium roots; many moderately thick clay films on ped faces; gradual wavy boundary.

IIB23t--40-51"; Pinkish gray (7.5YR6/2-7/2) gravelly sandy clay loam, pinkish gray (7.5YR6/2) moist; moderate medium to thick platy parting to moderate fine and medium subangular blocky structure; friable, slight sticky and slightly plastic; common fine and medium roots; many moderately thick clay films on ped faces; gradual wavy boundary.

IIIB24t--51-80"; Light brown (7.5YR6/4) gravelly sandy loam, brown (7.5YR5/4) moist; weak coarse subangular blocky structure; friable, slightly sticky and slightly plastic; common fine and medium roots; many moderately thick clay films on ped faces.

CLASSIFICATION: loamy-skeletal, mixed Eutric Glossoboralf
N. VEG.: Douglas fir, ponderosa pine, limber pine, white fir, aspen, common juniper, spike muhly, pine dropseed, bottlebrush squirreltail, and mountain brome
PARENT MATERIAL: tuff
PHYSIOGRAPHY: mountain sideslope
RELIEF: linear
SLOPE: 35%
ASPECT: SE
EROSION: slight
DRAINAGE: well
GR. WATER: deep

PROFILE DESCRIPTION

A11--0-3"; Grayish brown (10YR5/2) sandy loam, very dark grayish brown (10YR3/2) moist; weak fine crumb structure; loose, slightly sticky and slightly plastic; many very fine and few medium roots; slightly acid (pH 6.2); clear smooth boundary.

A12--3-6"; Light brownish gray (10YR6/2) sandy loam, dark grayish brown (10YR4/2) moist; weak fine crumb structure; soft, very friable, slightly sticky and slightly plastic; many coarse and common very fine roots; slightly acid (pH 6.2); clear wavy boundary.

A21--6-13"; Pinkish gray (7.5YR7/2) sandy loam, pinkish gray (7.4YR6/2) moist; weak very fine subangular blocky and weak medium angular blocky structure, parting to weak fine subangular blocky structure; soft, very friable, common very fine and coarse roots; 3 percent cobble and 3 percent gravel; slightly acid (pH 6.2); gradual wavy boundary.

A22--13-18"; Pinkish gray gravelly sandy loam, pinkish gray (7.5YR6/2) moist; weak very fine crumb structure; soft, very friable, nonsticky and nonplastic; common medium and few very fine roots; 2 percent cobble and 30 percent gravel; slightly acid (pH 6.2); clear wavy boundary.

A&B--18-25"; Pinkish gray (5YR7/2) gravelly sandy loam, reddish brown (5YR5/3) moist; weak coarse platy parting to weak fine subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common coarse and few very fine roots; 2 percent cobble and 15 percent gravel; horizon has small lumps of "B" material that are light colored on the outside (perhaps degradation); slightly acid (pH 6.2); abrupt wavy boundary.

B2--25-47"; Pink (7.5YR7/4) sandy loam, light brown (7.5YR6/4) moist with 10-15-25mm bands (sample No. S78-NM-43-10-6a); dark yellowish brown (10YR4/4) sandy clay loam, dark-yellowish brown (10YR3/4) moist; massive; hard, firm; slightly sticky and slightly plastic; common coarse and few very fine roots; 7 percent gravel; slightly acid (pH 6.2); abrupt wavy boundary.

B31--47-54"; Yellow (10YR7/6) gravelly sandy loam, yellowish brown (10YR5/8) moist; massive; hard, firm, slightly sticky and slightly plastic; few of each fine, medium and coarse roots; moderately thick clay films of coarse fragments; 30 percent gravel; medium acid (pH 6.0); gradual wavy boundary.

B32--54-74"; Light reddish brown, very gravelly sandy clay loam, reddish brown (5YR4/4) moist; massive; hard, firm, sticky and plastic; few moderately thick clay films on coarse fragments; fine roots; few fine roots; 40 percent gravel and 10 percent cobble; medium acid; gradual wavy boundary.

B33--74-94"; Light reddish brown extremely stony, sandy clay loam, reddish brown (5YR4/4) moist; massive; hard, firm, sticky and plastic; few fine roots; thick clay films on top of coarse fragments; 40 percent stones, 10 percent cobble, 40 percent gravel; medium acid (pH 6.0).

CLASSIFICATION: fine-loamy, mixed, Psammentic Glossoboralf
N. VEG.: ponderosa pine, blue spruce, aspen, limber pine, Douglas fir
PARENT MATERIAL: tuff
PHYSIOGRAPHY: Mountain sideslope
RELIEF: convex
ELEVATION: 9,560'
SLOPE: 40%
ASPECT: SE
EROSION: slight
DRAINAGE: well
GR. WATER: deep

PROFILE DESCRIPTION

A11--0-3"; very dark brown (10YR2/2) loam; moderate coarse granular structure; soft, friable, non sticky and slightly plastic; many fine and very fine roots and common coarse and medium roots; neutral; abrupt wavy boundary.

A12--3-17"; Dark grayish brown (10YR4/2) sandy loam; moderate very coarse granular and moderate coarse subangular blocky structure; soft, friable, non sticky and slightly plastic; many fine and very fine, common medium and few coarse roots; neutral; clear wavy boundary.

A2--17-23"; Brown (10YR4/3-5/3) sandy loam; weak to moderate, coarse subangular blocky structure; soft, friable, non sticky and non plastic; common medium, fine and very fine and few coarse roots; neutral; clear wavy boundary.

B21t--23-43"; (Bands) Brown (7.5YR4/4) sandy clay loam; moderate medium to coarse subangular blocky structure; slgihtly hard, firm, slightly sticky and slightly plastic; common fine and very fine and few coarse and medium roots; many moderately thick clay films on ped faces and in pores; neutral; bands range from ¼ to 1 inch thick; abrupt wavy boundary.

B21t--23-43"; (Matrix) Brown (7.5YR5/3) loamy sand to sandy loam; weak to moderate medium to coarse subangular blocky structure; sfot, friable, non sticky and non plastic; common fine and very fine roots and few coarse and medium roots; neutral; abrupt wavy boundary.

IIB22t--43-60"; Brwon (7.5YR 5/4) sandy clay loam; moderate very coarse subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine and very fine and few coarse and medium roots; many thick clay films on ped faces and in pores; neutral.

SOIL TYPE: Hesperus
CLASSIFICATION: Fine-loamy, mixed Typic Argiboroll
N. VEG: Arizona fescue, wild oats, pine drop seed
PARENT MATERIAL lacustrine
PHYSIOGRAPHY: terrace
RELIEF: convex
ELEVATION: 8500'
SLOPE: 4%
ASPECT: N
EROSION: slight
DRAINAGE: well
GR. WATER: deep
MOISTURE: moist

PROFILE DESCRIPTION

A11--0-7"; Dark grayish brown (10YR4/2) silt loam, very dark gray (10YR3/1) moist; weak fine subangular parting to weak fine crumb structure; soft, very friable, slightly sticky and plastic; many fine and very fine roots; slightly acid; gradual smooth boundary.

A12--7-15"; Grayish brown (10YR5/2) silt loam, dark grayish brown (10YR4/2) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common fine roots; slightly acid; clear wavy boundary.

B1t--15-24"; Very pale brown (10YR7/3) sandy clay loam, yellowish brown (10YR5/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few thin patchy clay films and clay bridging; few fine and medium roots; slightly acid; gradual wavy boundary.

IIB21t--24-33"; Pink (7.5YR7/4) sandy clay loam, brown (7.5YR5/4) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few thin patchy clay films and clay bridging; few fine roots; slightly acid; gradual smooth boundary.

IIB22t--33-43"; Pink (7.5YR7/4) sandy clay loam, brown (7.5YR5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few thin patchy clay bridges; neutral, gradual smooth boundary.

IIB3t--43-53"; Pink (7.5YR7/4) sandy loam, brown (7.5YR5/4) moist; massive; hard, firm, slightly sticky and slightly plastic; few clay bridges; neutral; clear smooth boundary.

IIIC1--53-63"; Light brown (7.5YR6/4) sandy clay loam, brown (7.5YR5/4) moist; massive; hard, firm, slightly sticky and slightly plastic; neutral; abrupt smooth boundary.

IVC1--63-70"; Light brown (7.5YR6/4) loamy sand; brown (7.5YR5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; neutral; gradual wavy boundary.

IVC2--70-87"; Light brown (7.5YR6/4) loamy sand, brown (7.5YR5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; neutral.

SOIL TYPE: Irim
CLASSIFICAITON: loamy-skeletal, mixed, frigid Typic haplaquoll
N. VEG.: grasses and sedges
PARENT MATERIAL: alluvium and lacustrine
PHYSIOGRAPHY: depressions
RELIEF: concave
SLOPE: 1%
DRAINAGE: poor
GR. WATER: less than 1 foot

PROFILE DESCRIPTION

01--1-0"; Undecomposed organic material, mostly grass remains and roots.

A1g--0-11"; Dark gray (10YR4/31) loam, black (10YR2/1) moist; common medium distinct yellowish brown (10YR5/6) moist mottles; soft, very friable, slightly sticky, slightly plastic; 10 percent gravel; neutral; gradual wavy boundary. (6 to 23 inches thick)

B2g--11-60"; Grayish brown (10YR5/2) very gravelly loam, dark grayish brown (10YR4/2) moist; common medium prominnet light olive brown (2.5Y5/6) and dark gray (2.5Y4/1) mottles; weak subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; mildly alkaline.

SOIL TYPE: Jarmillo silt loam
CLASSIFICATION: Pachic Haploboroll; fine-laomy, mixed
N. VEG.: Arizona fescue, Pine dropseed, sedges
PARENT MATERIAL: Lacustrine
PHYSIOGRAPHY: Terrace
RELIEF: convex
ELEVATION: 8400'
SLOPE: 4%
ASPECT: E
EROSION: none
DRAINAGE: well
GR. WATER: deep
MOISTURE: moist

PROFILE DESCRIPTION

A11--0-4"; Dark grayish brown (YR4/2) silt loam, bery dark brown (10YR2/2) moist; weak fine subangular blocky parting to weak fine crumb structure, slightly hard, friable, slightly sticky and slightly plastic; many fine, common very fine and few medium roots; slightly acid; clear smooth boundary.

A12--4-13"; Dark grayish brown (10YR4/2) loam, very dark brown (10YR2/2) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and few medium roots; slightly acid; clear smooth boundary.

A3--13-20"; Light brownish gray (10yr6/2) loam, very dark grayish brown (10YR3/2) moist; weak fine subangular blocky structure; slightly hard, friable; slightly sticky and slightly plastic; few very fine roots; neutral; gradual wavy boundary.

B21t--20-36"; Very pale brown (10YR7/3) fine sandy clay loam, brown (10YR4/3) moist; weak fine subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; few fine roots; clay bands (12) ranging from 1-5 mm; neutral; gradual wavy boundary.

IIB22t--36-41"; Light yellowish brown (10YR6/4) light fine sandy clay loam; yellowish brown (10YR5/4) moist; massive; slightly hard, firm, slightly sticky and slightly plastic; few very fine roots; clay bands (5) ranging from 2-5mm; neutral; abrupt wavy boundary.

IIB3t--41-51"; White (2.5Y8/2) silty clay loam, light yellowish brown (2.5Y6/4) moist; weak coarse prismatic structure; hard, firm, slightly sticky and plastic; common fine roots at ped faces; common thick clay flows on ped faces; neutral, abrupt wavy boundary.

IVC$_1$--51-67"; White (2.5Y8/2) light sandy loam, light yellowish brown (2.5Y6/4) moist; massive; hard, firm, slightly sticky and slightly plastic; neutral; clear wavy boundary.

VC$_2$--67-76"; Light gray (2.5Y7/2) very gravelly (47%) silty clay loam, grayish brown (2.5Y5/2) moist; massive; hard, firm, sticky and plastic; neutral; abrupt wavy boundary.

SOIL TYPE: La Jara
CLASSIFICATION: fine, mixed Typic Argialboll
N. VEG.: sedges, Junegrass, iris, Arizona fescue
PARENT MATERIAL: alluvium
PHYSIOGRAPHY: alluvial floodplain
RELIEF: concave
ELEVATION: 8,500'
SLOPE: 0-1%
EROSION: gullies
DRAINAGE: somewhat poor
GR. WATER: 42 inches
MOISTURE: moist

PROFILE DESCRIPTION

A1--0-9"; Grayish brown (10YR5/2) light silt loam, very dark brown (10YR2/2) moist; weak medium subangular blocky structure; slightly hard, friable sticky and plastic; many fine and very fine roots; slightly acid; abrupt smooth boundary.

A2--9-11"; Gray to light gray (10YR6/1) silt loam, very dark gray (10YR3/1) moist; weak thin platy structure; slightly hard, firm, slightly sticky and slightly plastic; common fine and very fine roots; neutral, abrupt smooth boundary.

B21t--11-17"; Dark gray (10YR4/1) light clay, very dark gray (10YR3/1) moist; moderate medium prismatic parting to weak medium subangular blocky structure; very hard, very firm, very sticky and very plastic; common fine roots; thick continuous clay films on ped faces and in pores; neutral; clear smooth boundary.

B3t--17-21"; Grayish brown (10YR5/2) heavy clay loam; dark gray (10YR4/1) moist; weak medium subangular blocky structure; very hard, very firm, very sticky and very plastic; few fine roots; common thin clay films on ped faces; neutral; clear smooth boundary.

IIC1--21-42"; Light brownish gray (10YR6/2) light sandy clay loam, dark grayish brown (10YR4/2) moist; massive; sticky and plastic; few fine roots; 15% gravel; neutral; gradual smooth boundary.

IIC2--42-60"; Grayish brown (2.5Y5/2) very gravelly sandy loam, dark grayish brown (2.5Y4/2) moist; massive; non sticky and non plastic; 40% gravel; neutral.

SOIL TYPE:
CLASSIFICATION: Typic Paleboralf, loamy-skeletal, mixed
N. VEG: Ponderosa Pine, Douglas Fir, White Fir, Oak, Locust
PARENT MATERIAL: Rhyolyte
PHYSIOGRAPHY: Mountain side
RELIEF: convex
ELEVATION: 9150'
SLOPE: 58%
ASPECT: S
EROSION: slight
PERMEABILITY: Moderate to rapid
DRAINAGE: well
GR. WATER: Deep
MOISTURE: moist
LOCATION: South side Ceno Seco

PROFILE DESCRIPTION

A11--0-2"; Dark gray (10YR4/1) sandy loam, very dark gray (10YR3/1) moist; moderate fine and medium crumb structure; soft, very friable, non sticky and non plastic; many fine and very fine and common medium roots; 30% stones, 7% cobbles and 3% gravel; neutral; abrupt smooth boundary.

A12--2-8"; Light brownish gray (10YR6/2) light sandy loam, dark grayish brown (10YR4/2) moist; moderate fine and medium crumb structure; soft, very friable, non sticky and non plastic, many fine and very fine and common medium roots; 20% stones, 40% cobbles and 10% gravel; neutral; clear wavy boundary.

A2--8-30"; Light gray (10YR7/2) light sandy loam, brown (10YR5/3) moist; weak fine crumb structure; soft, very friable, non sticky and non plastic; few coarse, many medium and common fine roots; 35% stones, 30% cobbles and 5% gravels; neutral; gradual wavy boundary.

B21t--30-51"; (Bands) Light brown (7.5YR6/4) heavy sandy loam, brown to dark brown (7.5YR4/4) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few medium and fine roots; 20% stones, 30% cobbles and 5% gravel; neutral; abrupt wavy boundary with matrix of horizon.

B21t--30-51"; (matrix) Pink (7.5YR7/4) sandy loam, brown (7.5YR5/4) moist; weak fine granular and crumb structure; soft, very friable, non sticky and non plastic; few medium and few fine roots; 20% stones, 30% cobbles and 5% gravel; neutral; gradual wavy boundary.

B22t--51-60"+; Light brown (7.5YR6/4) sandy clay loam, brown to dark brown (7.5YR4/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; 15% stones, 25% cobbles and 5% gravel; neutral.

SOIL TYPE: Pavo
CLASSIFICATION: fine-loamy, mixed Cryic Paleboroll
N. VEG: Arizona fescue, spike muhly, pine dropseed, wildoats
PARENT MATERIAL: Tuff (pumice)
P_YSIOGRAPHY: mountain sideslopes and footslopes
RELIEF: convex
ELEVATION: 8,700'
SLOPE: 4%
ASPECT: NNE
EROSION: slight
DRAINAGE: well
GR. WATER: deep

PROFILE DESCRIPTION

A11--0-9"; Grayish brown (10YR5/2) loam, very dark grayish brown (10YR3/2) moist; weak medium granular structure; soft, very friable, slightly sticky and slightly plastic; many fine and very fine roots; slightly acid; clear wavy boundary.

A12--9-12"; Light brownish gray (10YR8/2) sandy loam, dark grayish brown (10YR4/2) moist; weak coarse subangular blocky structure; soft, very friable. slightly sticky and slightly plastic; common very fine roots; 5% cobbles and 5% gravels; neutral; clear wavy boundary.

A2--12-21"; White (10YR8/2) sandy loam, brown (10YR5/3) moist; weak fine subangular blocky structure grading to single grain; soft, very friable, non sticky and non plastic; few fine roots; 15% gravel; neutral; clear wavy boundary.

B1--21-35"; (Bands) Yellowish brown (10YR5/4) light sandy clay loam, dark yellowish brown (7.5YR4/4) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; 5% gravel; neutral; bands range from ¼-½" in thickness; clear wavy boundary.

B1--21-35"; (Matrix) White (10YR8/2) sandy loam, brown (10YR5/3) moist; weak fine subangular blocky structure; slightly hard, friable, non sticky and slightly plastic; 5% gravel; neutral; clear wavy boundary.

B21t--35-45"; (Bands) Yellowish brown (10YR5/4) sandy clay loam, brown (10YR4.3) moist; weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; 5% gravel; neutral; 50% of the horizon is bands; clear smooth boundary.

B21t--35-45"; (Matrix) White (10YR8/2) fine sandy loam, brown (10YR5/3) moist; weak medium subangular blocky structure; soft, very friable, non sticky and non plastic; 5% gravel; neutral; clear smooth boundary.

B22t--45-50"; Brown (7.5YR5/4) very gravelly clay loam, brown (7.5YR4/4) moist; weak fine subangular blocky structure; hard, frialbe, sticky and plastic; 40% fine gravel; slightly acid; clear smooth boundary.

B23t--50-60"; Very pale brown (10YR7/2) heavy sandy loam, dark yellowish brown (10YR4/4) moist; weak coarse subangular blocky structure; hard, friable, slightly sticky and slightly plastic; 5% cobbles and 10% gravel; neutral.

SOIL TYPE: Seco
CLASSIFICATION: loamy-skeletal, mixed Typic Paleboroll
N. VEG: wild oats, Arizona fescue, Thurbers fescue
PARENT MATERIAL: Ryolite colluvium
PHYSIOGRAPHY: toe slope
RELIEF: convex
ELEVATION: 8,750'
SLOPE: 7%
ASPECT: ENE
EROSION: slight
DRAINAGE: well
GR. WATER: deep
MOISTURE: moist

PROFILE DESCRIPTION

A11--0-9"; Dark grayish brown (10YR4/2) silt loam, black (10YR2/1) moist; weak fine granular structure; soft, friable, slightly sticky and slightly plastic; many fine and very fine roots; slightly acid; clear smooth boundary.

A12--9-15"; Grayish brown (10YR5/2) silt loam, very dark brown (10YR2/2) moist; moderate coarse granular structure; soft, friable, slightly sticky and slightly plastic; many fine and very fine roots; slightly acid; clear smooth boundary.

B1t--15-26"; Very pale brown (10YR8/3) gravelly loam, brown to dark brown (10YR4/3) moist; weak medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; few fine and very fine roots; few thin clay films on ped faces; 10% cobbles and 20% gravel; slightly acid; gradual smooth boundary.

B21t--26-34"; Very pale brown (10YR7/3) very gravelly light fine sandy clay loam, brown to dark brwon (10YR4/3) moist; weak medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; few fine and very fine roots; common moderately thick clay films on ped faces; 10% cobbles and 50% grave; slightly acid; gradual smooth boundary.

B22t--34-60"; Very pale brown (10YR7/3) extremely cobbly heavy clay loam mixed with light brown (7.5YR6/4), brown to dark brown (10YR4/3) and brown to dark brown (7.5YR4/4) moist; weak medium subangular blocky structure; hard, firm sticky and plastic; thick continuous clay films on ped faces and in pores; 40% cobbles and 30% gravel; slightly acid.

SOIL TYPE: Tranquilar
CLASSIFICATION: fine, mixed, frigid Typic Argialboll
N. VEG.: Arizona fescue, wheat grass, June grass, pine dropseed
PARENT MATERIAL: lacustrine
PHYSIOGRAPHY: valley bench
RELIEF: convex
ELEVATION: 8,450'
SLOPE: 2%
ASPECT: NW
DRAINAGE: moderate well
GR. WATER: deep

PROFILE DESCRIPTION

A11--0-4"; Dark grayish brown (10YR4/2) silty clay loam, very dark grayish brown (10YR3/2) moist; weak very fine subangular blocky structure; soft, very friable, sticky and plastic; many fine and very fine roots; slightly acid; clear smooth boundary.

A12--4-8"; Dark grayish brown (10YR4/2) silty clay loam, very dark grayish brown (10YR3/2) moist; weak fine subangular blocky structure; slightly hard, friable, sticky and plastic; common very fine roots and few micro roots; slightly acid; clear smooth boundary.

A21--8-11"; Grayish brown (10YR5/2) silty clay loam, very dark grayish brown (10YR3/2) moist; weak fine subangular blocky structure; slightly hard, friable, sticky and plastic; few very fine roots; slightly acid; abrupt smooth boundary.

A22--11-13"; Light gray (10YR7/2) silt loam ped faces and light brownish gray (10YR6/2) ped interiors, dark grayish brown (10YR4/2) moist ped faces and very dark grayish brown (10YR3/2) moist ped interiors; weak thin platy parting to moderate fine subangular blocky structure; slightly hard, friable, sticky and plastic; few very fine roots; medium acid; abrupt smooth boundary.

B21--13-20"; Very dark grayish brown (10YR3/2) clay ped faces and brown (10YR5/3) ped interiors, very dark brown (10YR2/2) moist ped faces and dark brown (10YR3/3) moist ped interiors; strong medium prismatic parting to strong coarse angular blocky structure; very hard, very firm, very sticky and very plastic; few very fine and micro roots; few thin clay films on ped faces; strongly acid; gradual wavy boundary.

B22t--20-34"; Dark grayish brown (10YR4/2) clay ped faces and very pale brown (10YR7/3) ped interiors, very dark grayish brwon (10YR3/2) moist ped faces and brown (10YR4/3) moist ped interiors; strong medium prismatic parting to strong medium angular blocky structure; very hard, very firm, very sticky and very plastic; few very fine roots; continuous moderately thick clay films on ped faces; very strongly acid; gradual wavy boundary.

Tranquilar (cont'd)

B23t--34-42"; Light yellowish brown (10YR6/4) clay, dark grayish brown (10YR4/4) moist, common fine prominant yellowish red (5YR5/6) mottles, yellowish red (5YR4/6) moist; strong coarse prismatic parting to strong fine and medium angular blocky structure; very hard, very firm, very sticky and very plastic; few very fine and micro roots; moderately thick continuous clay films on ped faces; very strongly acid; gradual wavy boundary.

B24t--42-50"; Light gray (2.5Y7/2) clay, light brownish gray (2.5Y6/2) moist, common fine prominant reddish yellow (7.5YR6/6) mottles, strong brown (7.5YR5/6) moist; moderate coarse prismatic parting to moderate fine and medium angular blocky structure; very hard, very firm, very sticky and very plastic; few very fine and micro roots; continuous moderately thick clay films on ped faces; very strongly acid; gradual wavy boundary.

B25t--50-65"; Light gray (2.5Y7/2) clay loam, light brownish gray (2.5Y6/2) moist, common fine prominant reddish yellow (7.5YR6/8) mottles, yellowish red (5YR4/6) moist; moderate coarse prismatic parting to moderate fine and medium angular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; few very fine and micro roots; continuous moderately thick clay films on ped faces; very strongly acid; gradual wavy boundary.

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Soil Survey of Los Alamos County, New Mexico

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CONTENTS

SOIL SURVEY OF LOS ALAMOS COUNTY, NEW MEXICO

by

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ABSTRACT

An intensive soil survey of about 79% of the 280 000 000 m² of Los Alamos County has been made to identify the kinds of soils in the area, where they are located and how they can best be used. A soil survey map is included, with detailed soils information presented in the report. Past and present land use in the Los Alamos area is discussed and general information about soils and their formation is evaluated, including the regional soil formation factors of geologic parent materials, climate, living organisms, topography, and time.

The soils of the area are classified according to the current system of soil classification and described in detail. The relationship of soil formation to classification is discussed and the current soil classification system is explained. General and detailed descriptions are given for each of the 61 soil mapping units, and include information on soil color, texture, structure, consistence, clay films, coarse and fine fragment distributions, permeability, depth, hydrologic properties, pores, pH, and soil horizon boundaries. Soil mapping units are also described relative to their specific soil formation factors. The use and management of these soils for engineering and recreational purposes are also considered.

I. INTRODUCTION

Information on the capability of soils for their numerous present and potential uses is essential for planning the best possible use of Los Alamos County land and water resources. Soils information can be applied in managing land for conservation, wildlife habitat, urban planning and for recreational, agricultural, and military uses. For example, a detailed soils data base can be used in selecting sites for local buildings, sanitary facilities, roads, ponds, and other structures, and for locating suitable source materials for roadfill, sand, gravel, and topsoil. Soils information is also needed in the radioecological and stable element research performed at the Los Alamos Scientific Laboratory (LASL) by the Environmental Studies Group and for environmental research relevant to the Los Alamos National Environmental Research Park. The possibilities of selecting poorly-suited soils for many of the above-mentioned purposes are continually increasing and the cost of mistakes, both in money and unhappiness, could be substantial. Many of these problems can be overcome if the kinds, distribution, and usefulness of local soils are known, and these are the end products of this soil survey.

II. HOW THIS SOIL SURVEY WAS MADE AND HOW TO USE IT

The purpose of this survey was to identify the kinds of soil in Los Alamos County (Fig. 1), where they are located, and how they can be used. Soil scientists initially went into the area in 1973 knowing they would likely find many soils they had never seen and perhaps some they had previously encountered. They observed the steepness, length, and shape of slopes, the size of watersheds, the kinds of native plants and rocks, and many facts about the soils. Numerous pits and holes were dug to expose soil profiles, which were compared with profiles in nearby and more distant areas.

Each soil type was delineated on aerial photographs. Two sets of aerial photos were used for the LASL-Soil Conservation Service survey. These were provided by Koogle and Pouls Engineering, Inc. from photos taken in 1965 and consisted of a set of 23 × 23 cm photos used for initial mapping in the field (mapping scale: 1:12 672 or 5 in./mi) and four semicontrolled aerial mosaic photos used for publication (mapping scale: 1:15 840 or 4 in./mi). The field mapping for the Forest Service soil survey was done on a set of Army Map Service photos made in 1954 (mapping scale: 1:63 360 or 1 in./mi). The results of both soil surveys were combined to produce the soils map, which is at the back of this publication and has a mapping scale of 1:15 840 (5 in./mi). The soils were also classified and named according to nationwide uniform procedures originally set up by the National Cooperative Soil Survey in 1960[1] and updated in 1971[2] and 1973[3] (see Chapter V for additional information).

The soils of the Los Alamos area are shown on the detailed soil map at the back of this publication. This map consists of many sheets made from aerial photographs; each sheet is numbered to correspond with a number on the Index to Map Sheets, which precedes the soil map. Soil areas are outlined and are identified by symbols on this map. All areas marked with the same symbol are the same kind of soil but may also contain small areas of other kinds of soils included in the mapping unit. The soil symbol is usually placed inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

After determining what kind of soil exists in an area of interest, additional information on the properties, uses, and management of the soils is provided in Chapters VI and VII.

III. LAND USE IN THE LOS ALAMOS AREA

The agricultural use of soils predates recorded history and has its roots in the Agricultural Revolution, which started some 9000 years ago when man began growing his own crops rather than gathering his food. Although early nomadic wanderings of Indians may have occurred near Los Alamos in this time period (around B.C. 2500), it wasn't until the early 1300s that the Keresans and Tewa-speaking people came to the Los Alamos area from the Four Corners region.[4,5] Drought and soil depletion were partially responsible for this migration and also played a part in the Tewa's move in 1350 from local mesa tops to nearby canyon floors and along the Rio Grande. By the late 1600s, more overused farmland was abandoned and the Indians grew cotton, corn, beans, and squash near the Rio Grande and other areas having permanent water.

By the late 1880s, local land areas were used for year-round habitation, which rapidly increased with the coming of the Denver and Rio Grande Railroad. Great numbers of individual

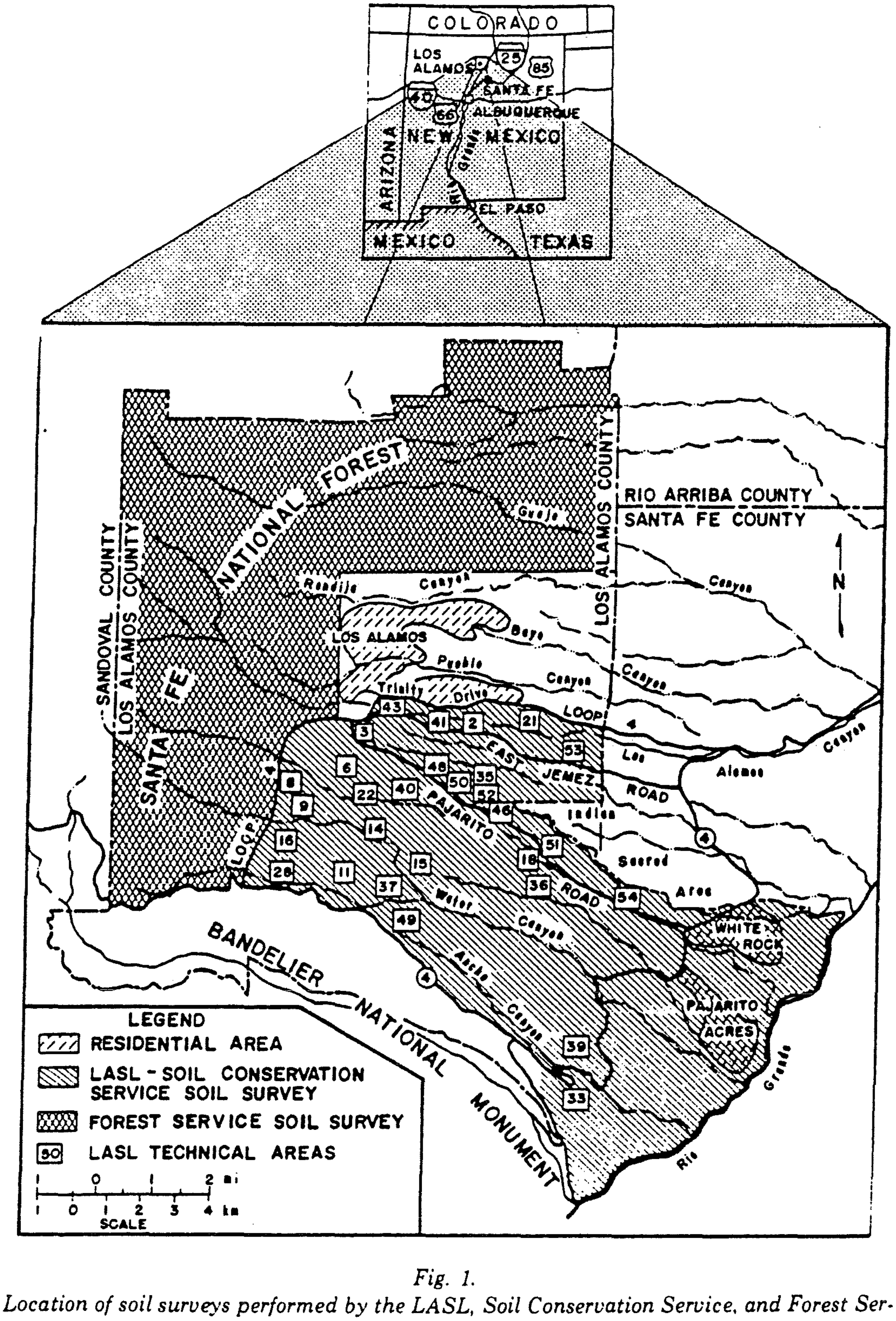

Fig. 1.
Location of soil surveys performed by the LASL, Soil Conservation Service, and Forest Service in Los Alamos County.

failures among settlers during the push westward stimulated early attempts at soil studies in order to better utilize the various kinds of soils in the west. The Los Alamos Homestead Era started in 1894 with the establishment of a small subsistence farm in Los Alamos, where beans, grain, and fruit were grown, largely under dryland conditions.[4] In 1911, H. H. Brook, a graduate of the Illinois College of Agriculture, filed for the Alamo Ranch homestead, which eventually reached a size of 600 acres and produced alfalfa, sorghum, wheat, and train loads of pinto beans.[6] By 1952, there were 35 farm tracts in the County, spread out over a total of 3600 acres. A portion of this farm land around Los Alamos Canyon is shown as it was in 1935 in Fig. 2.

As time progressed, the use of the land around Los Alamos has become more diversified. Lumbering was the foremost industry of the early 1900s, as evidenced by the lumber yard at the railroad station town of Buckman (NE of White Rock), which was kept well-supplied by H. S. Buckman's lumber mills in the Jemez Mountains and on the mesa tops. Ashley Pond II set up a dude ranch in 1914 on the Ramon Vigil Grant and then bought out Brook's interests in Los Alamos, establishing the Los Alamos Ranch. This ranch and the Baca Location in the Valle Grande were responsible for the major cattle- and sheep-raising activities in the area.[4]

In 1942, the Federal government purchased most of what is now Los Alamos County for use in developing the world's first atomic fission weapon. In 1946, the McMahon Atomic Energy Act was passed, which established a national policy of maintaining U. S. preeminence in the field of atomic energy, and the newly created Atomic Energy Commission (AEC) took control of the LASL in 1947. The AEC jurisdiction included operation of the Los Alamos community, providing government housing, schools, a commercial center, and other support facilities, as well as Laboratory facilities. The Los Alamos townsite was declared an "open city" in 1957; many security restrictions were lifted and land around White Rock, Pajarito Acres, and Barranca Mesa was developed as residential areas. The small business and service operations have currently increased, and the LASL is the major employer in Los Alamos County and in North Central New Mexico, and as such, will probably continue to have a large impact on land use in the area.

The many past and potential uses of land in Los Alamos County emphasize the importance of understanding the extent and properties of local soils and their soil forming factors. Both the factors of soil formation and the soil profile concept are discussed in the following chapter to provide a basis for understanding the soils information presented in the remainder of this report.

IV. THE SOIL AND ITS FORMATION

Soil is sometimes defined as the natural medium for plant growth, or as the loose surface material of the earth in which plants grow. Soil is more complex than these simple definitions indicate, i.e., the "loose surface material of the earth" contains many different kinds of soil, which vary in their ability to provide nutrients, air, water, and anchorage for plants. The soil, a collective term, consists of a large number of soil individuals. A soil or soil individual is a member of a continuum that mantles the surface of the earth except where interrupted by water, shifting sand, salt deposits, perpetual ice and snow, and steep, rocky, or mountainous areas. Each soil has a unique combination of characteristics, but each soil also has characteristics common to all soils.

All soils consist of solid materials and pore space. Soil solids are composed of organic matter and mineral matter. The organic portion of the soil includes plants and animals, living and in various stages of decay. The mineral matter consists of particles of various sizes such as sand, silt, and clay that have formed through the physical and chemical breakdown of rocks and minerals. The soil pores contain the gas (air) and liquid (water) phases of the soil. The three phases — solid, liquid and gas — are present in all soils. However, the amount, kind, and size of organic matter, mineral particles, and pore space for air and water are not uniform in all soils or even within a soil.

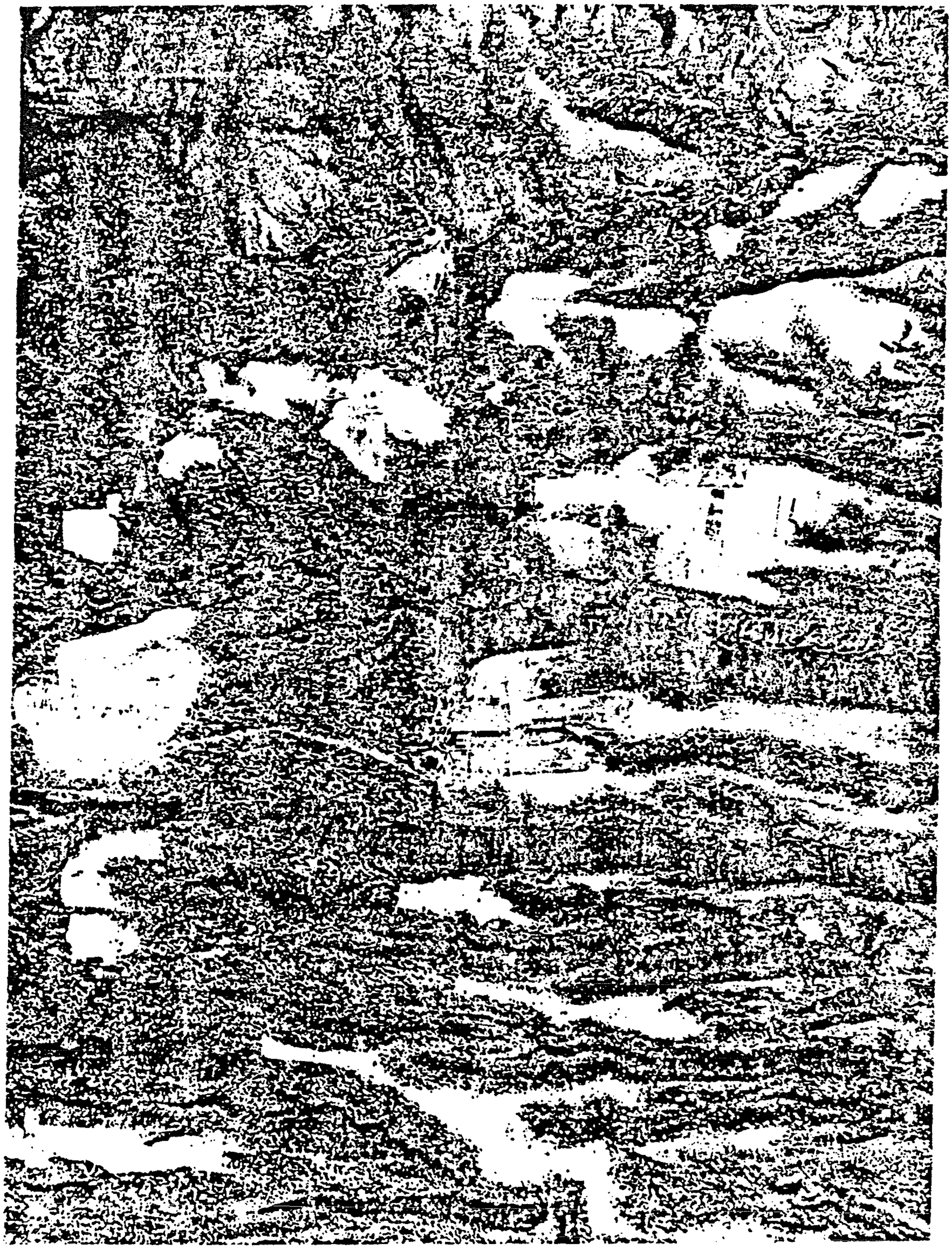

Fig. 2.

Aerial photograph of Los Alamos townsite taken in 1935 showing extensive farming activities. Ashley Pond (center of photograph) and Los Alamos Canyon (major canyon below Ashley Pond).

A. The Factors of Soil Formation

The properties that characterize a soil are due to the influence of a particular combination of the five soil formation factors of parent material, climate, living organisms, topography, or relief, and time (Fig. 3).

These factors work interdependently in producing a particular soil. Differences or similarities between soils are due to differences or similarities in the influence of the interrelated soil forming factors. Each factor modifies, and is modified by, the other soil-forming factors. For example, topography modifies the effects of rainfall — a climatic factor. The release of plant food nutrients from soil minerals, originating in the soil parent material, depends upon climate and time. Thus, the effect of living organisms, such as growing plants on soil formation, is influenced by time, climate, and soil parent materials. Variations in soil properties can be interpreted and explained only through consideration of the interrelated influences of the factors of soil formation.

1. Parent Material. The initial step in the development of a soil profile is the formation of soil parent material, which provides a soil with a mineral skeleton, consisting of unconsolidated and partly decayed rocks. Most soils are formed from the weathering of bedrock in place, but many soils in the Los Alamos area formed from material that was transported from the site of the parent rock and redeposited at a new location. Ice, water, wind, and gravity are transporting agencies, which may act independently or in combination with two or more agencies. Wind and water were the significant agents in transporting and redepositing the parent materials from which Los Alamos soils developed.

The principal parent materials of about 95% of Los Alamos soils are Bandelier Tuff (the tan-colored rock outcrops in the foreground of the photograph on the cover), volcanic rocks of the Tschicoma and Puye Formations, the basaltic rocks of Chino Mesa and the remnants of the El Cajete pumice (which is contained in portions of the previously named mapping units listed in

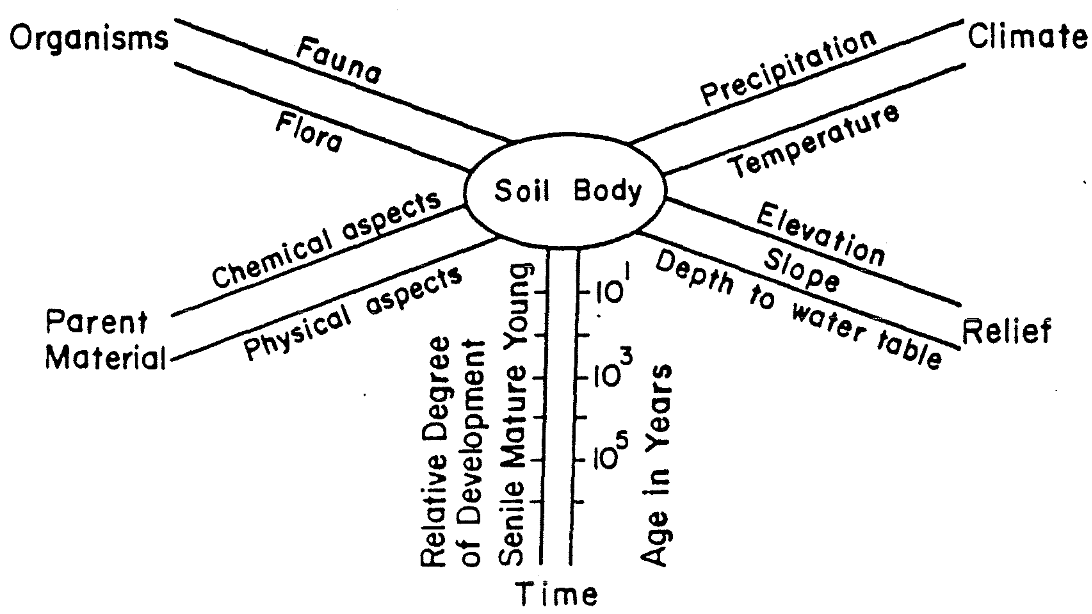

Fig. 3.
Five soil formation factors.

Table I). The remaining 5% formed from colluvium, alluvium, andesitic rocks of the Paliza Canyon Formation, Cerro Rubio Quartz Latites, and tuffs and associated sediments of Cerro Toledo Rhyolite (Table I).

Almost all of the parent materials of Los Alamos soils were formed millions of years ago during periods of volcanic activity.[7,8] The Rio Grande Depression began to form as a result of local downfaulting over 20 million years ago and was followed by accumulations of rocks of the Santa Fe Group, the Tesuque Formation, as fill in the depression (Fig. 4). The andesitic rocks of the Paliza Canyon Formation represent effusions of numerous coalesced composite volcanoes that occurred 8.5-9.1 million years ago in the southwestern portion of the county. The next sequence of volcanic activity in the county took place along faults at or near the western boundary of the Rio Grande Depression when the flow rocks of the Jemez Mountains volcanic pile, the Tschicoma Formation, were erupted from volcanic feeders. The Puye Formation was then deposited as an alluvial fan from the Tschicoma Formation during a period of erosion. The basaltic lavas of Chino Mesa subsequently erupted from volcanic centers in the Cerros del Rio area and flowed northwest into the White Rock-Pajarito Acres area (Fig. 1).

TABLE I

DISTRIBUTION OF GEOLOGIC SURFACE MATERIALS IN LOS ALAMOS COUNTY

Geologic Map Unit	Percentage of the Area of the County Occupied by Mapping Unit
Bandelier Tuff	
Tshirege Member	58.6
Otowi Member	4.83
Tschicoma Formation	22.4
Puye Formation	4.44
Basaltic Rocks of Chino Mesa	5.31
Tuffs and Associated Sediments of Cerro Toledo Rhyolite	1.86
Landslide and Fan Deposits	1.66
Cerro Rubio Quartz Latites	0.690
Andesitic Rocks of Paliza Canyon Formation	0.140
Tesuque Formation of Santa Fe Group	0.070

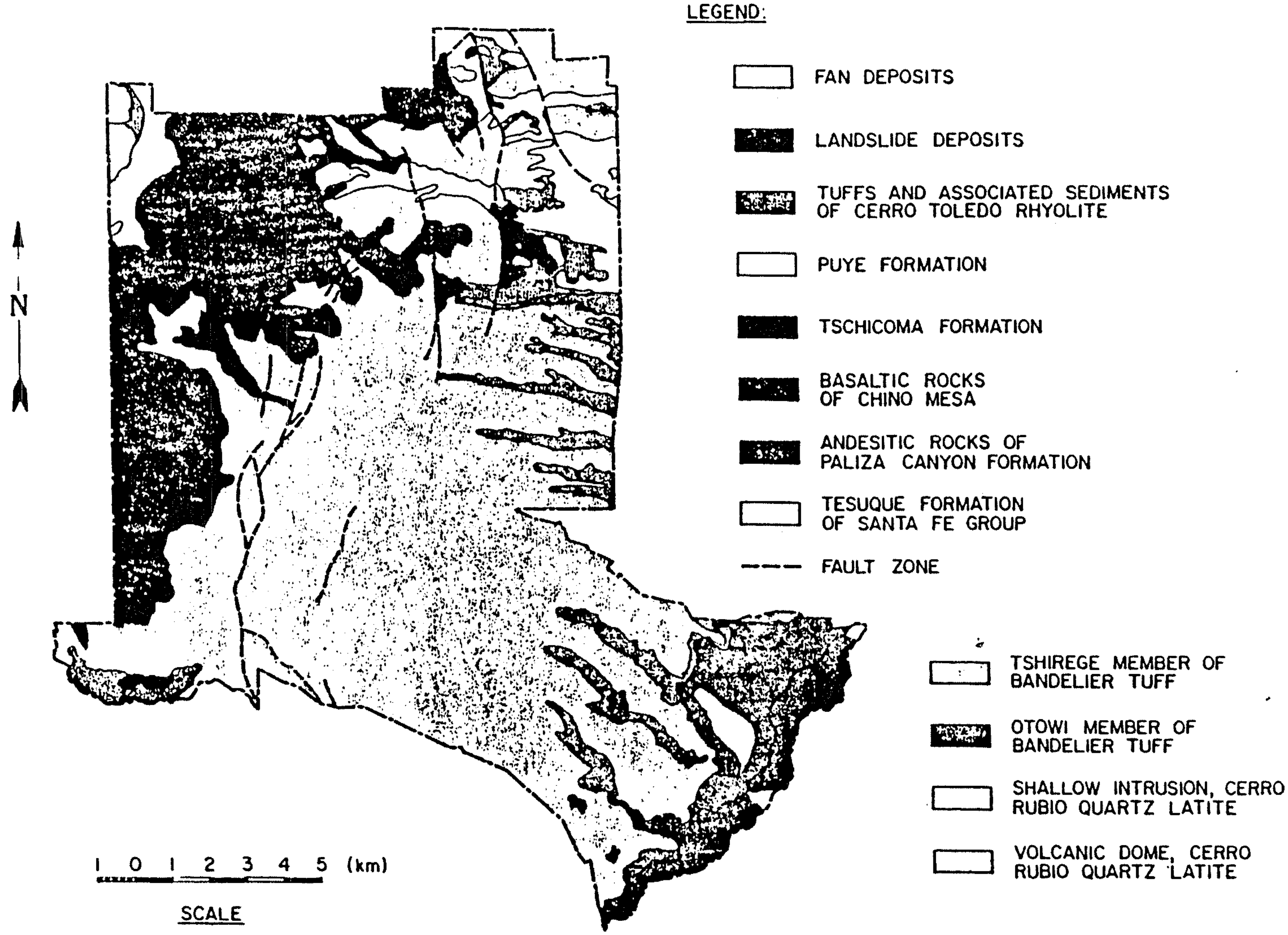

Fig. 4.
Geology of Los Alamos County.

In mid-Pleistocene time, local volcanism was climaxed by two gigantic pyroclastic outbursts that deposited nearly 418 km^3 (100 mi^3) of rhyolite ash and pumice.[7] Rhyolitic magma worked upward under the Toldeo Caldera area about 1.4 million years ago until they were exposed to the atmosphere, at which the Guaje pumice was ejected into the atmosphere. The remaining magma shot out great volumes of the Otowi Member of the Bandelier Tuff, which swept down the flanks of the volcanic pile as a granular pumice flow. Subsequent collapse of the crater occurred and a portion of the viscous, volatile-poor magma was extruded to form the Cerro Toledo Rhyolite domes, and subsequently, the Cerro Rubio Quartz Latite and Latite domes. About 0.3 million years later, rhyolitic magma worked upward under the Valles Caldera area (west of Los Alamos County) and ejected small amounts of Tsankawi pumice into the atmosphere, followed by several ash flows in rapid succession, which produced the Tshirege Member of the Bandelier Tuff. A few eruptions of minor magnitude followed the Tshirege flows and produced a small amount of ash-fall pumice deposition on top of the Bandelier Tuff. Final volcanic activity in the Los Alamos area occurred 42 000 yr ago in the form of a mantle-bedded, air-fall deposit of rhyolite pumice, the El Cajete Member of the Valles Rhyolite.[8]

Faulting and erosion of the geologic materials found in the County have continued to influence the soils of the County. The Pajarito Fault Zone, which extends in a northerly direction west of Los Alamos (Fig. 4), is the major local fault with a maximum surface displacement of 120 m. Although some of the faulting in the Los Alamos area predates the deposition of the Bandelier Tuff,[10] faulting has resulted in the displacement of soil, which was subsequently subjected to water erosion. The erosion processes that were responsible for cutting the canyons in the area occurred mainly during the latter part of the Pleistocene Epoch, but continue to date.

2. Climate. Climate both directly and indirectly influences soil development. Direct effects include the influence of temperature and precipitation upon the weathering of rocks and minerals, i.e., high temperatures encourage rapid weathering because the speed of chemical reactions increases as temperature increases. Wind, important in soil transport, is a climatic factor that influences the soil directly through its impact on erosion and leaching losses. Climate plays an indirect role in soil formation through its effect upon plant growth and adaptation. Thus, climatic variation between areas was important in determining the location of the broad soil areas of the world.

Although the climate near the Rio Grande is an arid continental climate, the rest of the County has a semiarid continental mountain climate.[11,12] The annual precipitation pattern throughout the County reflects the 1524-m elevation gradient from the southern portion of the County near the Rio Grande to the high mountains in the northwestern sections of the County. Although no climatological data exist for the Rio Grande area in Los Alamos County, specifically, the Española weather station, at an elevation of 1705 m, approximates this climate with a total annual precipitation of 24 cm (Table II).[12] Proceeding up the elevation gradient, the White Rock (1944 m) and the Los Alamos (2259 m) stations received 34 and 49 cm of mean annual precipitation (Table II), whereas the high mountain areas in the County (3139 m) probably receive about 90 cm of precipitation annually. More than two-thirds of the yearly moisture falls during the months of May through October, and rainfall activity peaks in August. Most of the winter precipitation falls as snow, with 127 cm descending during an average winter and as much as 15 cm often falling in a 24-h period.

The overall seasonal temperature variations are similar throughout the County, the hottest and coldest months occuring in July and January, respectively (Table II). Although the annual mean temperature of the three weather stations in Table II increased with decreasing elevation, the White Rock station exhibited the largest mean monthly temperature variation (−22 to 35°C). The growing season in Los Alamos is approximately 5 months long, lasting from May 6 (average date of last freezing temperature) to October 16 (average date of first freeze).

TABLE II

CLIMATOLOGICAL DATA FOR LOS ALAMOS, WHITE ROCK AND ESPAÑOLA

Climatological Parameter	Weather Station	Month												
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean Maximum Temperature (°C)	Los Alamos[a]	12	13	18	21	26	31	31	29	27	22	16	12	22
	White Rock[a]	14	16	20	24	29	34	35	33	30	27	20	14	24
	Española[b]	7.2	11	15	20	25	31	32	31	28	22	15	8.3	21
Mean Minimum Temperature (°C)	Los Alamos[a]	−18	−14	−12	−6.1	−1.1	5.0	10.	8.9	1.7	−5.6	−10	−15	−4.4
	White Rock[a]	−22	−15	−13	−6.1	−2.2	3.9	8.3	7.8	0.56	−6.7	−13	−20	−6.1
	Española[b]	−11	−7.2	−3.9	1.1	5.0	9.4	13.	12.	7.2	0.56	−6.1	−9.4	1.1
Mean Precipitation Totals (cm)	Los Alamos[a]	1.24	1.65	2.77	1.50	2.54	3.89	10.2	10.9	5.84	3.63	1.45	3.28	49.0
	White Rock[a]	0.64	0.61	0.61	0.81	3.05	3.81	5.82	9.35	4.39	2.59	0.99	1.70	34.3
	Española[b]	1.37	1.04	1.27	1.96	2.36	1.75	3.63	4.01	1.91	2.62	1.04	1.19	24.2

[a]Average values for the years 1965 through 1974, according to climatological records of the Atmospheric Science Section of LASL Group H-8.
[b]Average values for the years 1913 through 1960, according to Eschen.[12]

3. Living Organisms. In addition to mineral matter provided by parent material, soils also include organic matter — living organisms (plants and animals) or the remains of living organisms. Living organisms perform two chief functions in soil development. They are the source of soil organic matter and, in the case of deep-rooted plants, they help bring plant nutrients up from lower depths. The organic matter may be stored in the A horizon and will, upon decomposition, release nutrients for plant use.

Seven major overstory vegetation types were identified throughout the 1500-m elevation gradient in the County (Fig. 5).[13] These were, from east to west, the Juniper of the Upper Sonoran Life Zone, the Piñon-Juniper, Ponderosa Pine/Piñon-Juniper, and Ponderosa Pine-Fir of the Transition Life Zone, and the Fir and Fir-Aspen of the Canadian Life Zone. A non-forested, shrub-grass-forb component occurs primarily within the Upper Sonoran and Transition Life Zones. A variety of habitats is created by the east-west orientation of the mesa-canyon ecosystems: north-facing slopes support biota of the next higher Life Zone and south-facing slopes contain representatives of the next lower Life Zone (see foreground of photograph on cover); wide canyon floors contain biota of both Life Zones. The current list of understory vegetation types contains 164 plant species of 36 families, reflecting the diversity of the plant communities in the area.

Microorganisms also play important roles in soil development. They are a source of organic matter, aid in decomposing organic matter, combine free nitrogen into forms that can be used by plants, and aid in the release of nitrogen and other organic stored nutrients for use by plants.

Man, through his use of the soil, also influences soil development in ways that may either improve, maintain, or permanently decrease soil productivity.

4. Topography. Topography refers to the lay of the land, from very steep to nearly level or somewhere in between. The primary influence of topography on soil development is its effect on drainage, runoff, and erosion, and consequently is an important factor in determining the pattern and distribution of the soils of a landscape. The aspect or direction a slope faces is an important secondary influence of topography. For example, south-facing slopes normally are warmer and drier than north-facing slopes. This has an important effect on the kind and amount of vegetation that grows in an area, as discussed previously.

Much of Los Alamos County is located on the Pajarito Plateau, which occupies the eastern flank of the Jemez Mountains in north-central New Mexico. The Plateau occupies about 47% of the land area of the County from 2073-2377 m (Table III, Fig. 6), with the Jemez Mountains occupying about 32% of the land area above 2377 m (see background of photograph on cover).

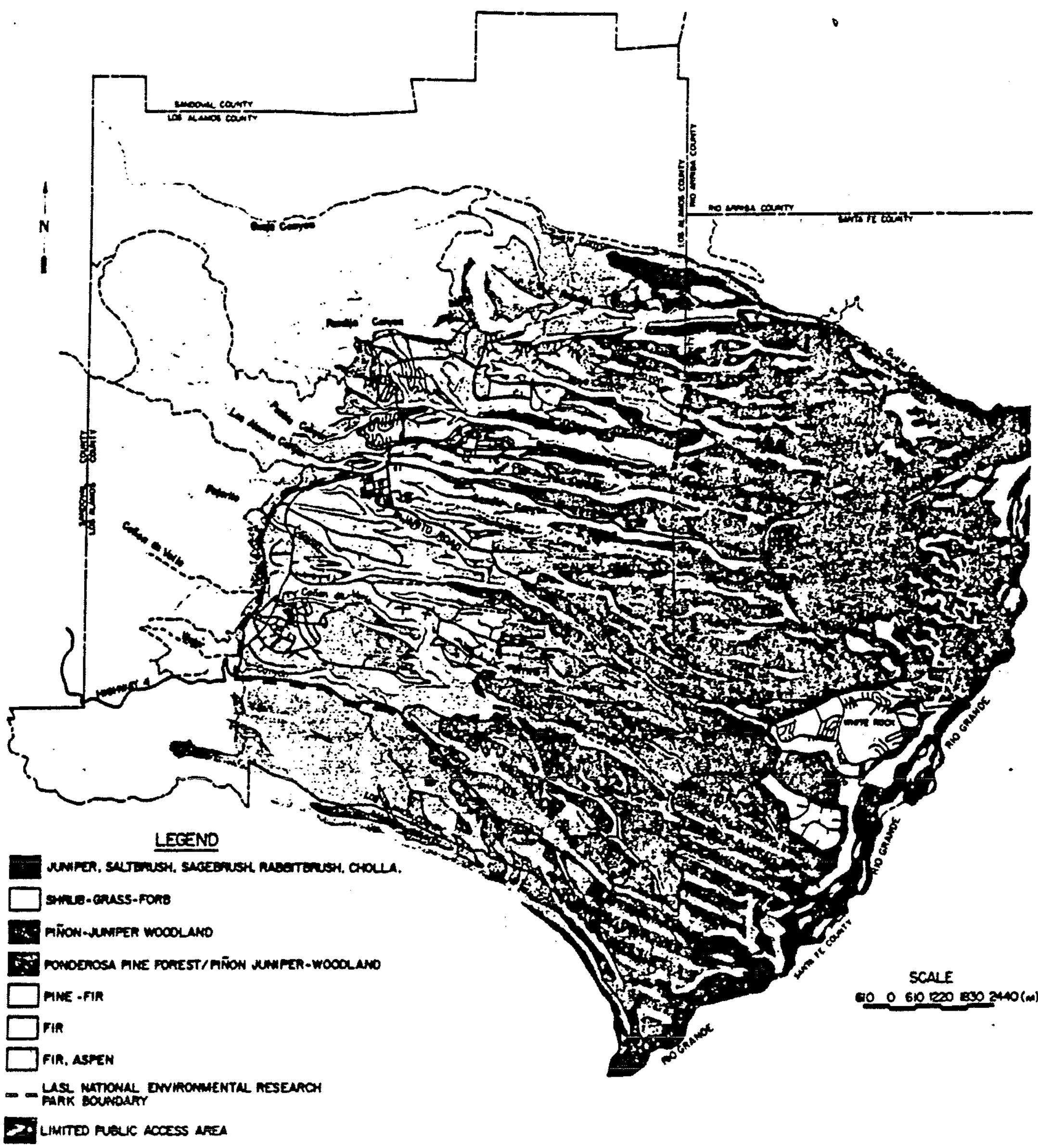

Fig. 5.
Overstory vegetation of Los Alamos environs.

TABLE III

ESTIMATED PERCENTAGES OF LOS ALAMOS COUNTY LAND AREA IN VARIOUS ELEVATION CLASSES

Elevation Class (m)	Per Cent of County Land Area
1615 - 1768	1.86
1768 - 1920	2.80
1920 - 2073	17.4
2073 - 2225	27.9
2225 - 2377	19.5
2377 - 2530	9.63
2530 - 2682	8.11
2682 - 2835	6.13
2835 - 2987	5.57
2987 - 3139	1.10

Many portions of the Plateau have been deeply eroded by runoff, resulting in a series of mesas separated by canyons, many of which are several hundred feet deep (see photograph on cover). Most of the canyons contain intermittent streams, which flow during the rainy season (Fig. 6). Frijoles Creek, located on the southern border of the County, and the Rio Grande, located along the eastern border of the County are the only permanent natural streams in the area.

Topography may be characterized by the gradient (degree or per cent of slope), length, shape, aspect, and uniformity of the slopes that make up a particular landscape. Although each of these slope characteristics is important, the topography of Los Alamos is most frequently expressed in terms of slope gradient or per cent of slope. Four slope gradient classes and the per cent of the Los Alamos land area represented by each are presented in Table IV.

Individual slope gradient classes occur in extensive areas through several portions of the County. The 20% or greater slope class, comprising about 54% of the County land area, occurs extensively in the mountainous regions of the County, in areas with steep canyon sideslopes, and along the Rio Grande. Similarly, many portions of the broad mesa tops and canyon floors have slope gradients of 0-5%. More frequently, however, two or more slope gradient classes occur within an an area the size of White Rock, for example, which has mostly 0-5% slopes, but also 5-10%, and 10-20% slope classes. Areas with a wide range in slope gradient, such as found in the northeastern section of the County, generally represent a more complex topography than areas with a narrow range of gradient. In addition, the pattern of the various topographic areas in different sections of the County is an indication of the complexity of the topography.

Topography is important in determining the pattern of occurrence of soil types within different areas of the County. This pattern is closely related to topography because of topographic influences on drainage, erosion, climate, and plant growth. Soil suitability for various uses is also closely related to topography.

5. Time. The amount of time necessary for the various processes of soil formation to take place may vary from a few days to thousands of years. In general, when other factors are favorable, as soils continue to weather over a long period of time, the subsoil texture becomes finer and the soils are more leached of soluble materials. However, soils formed from materials resistant to weathering, such as quartz sand, do not change much with time. Soils occurring on very steep topography, where runoff is high and water infiltration is low, weather more slowly than soils on less steep topography.

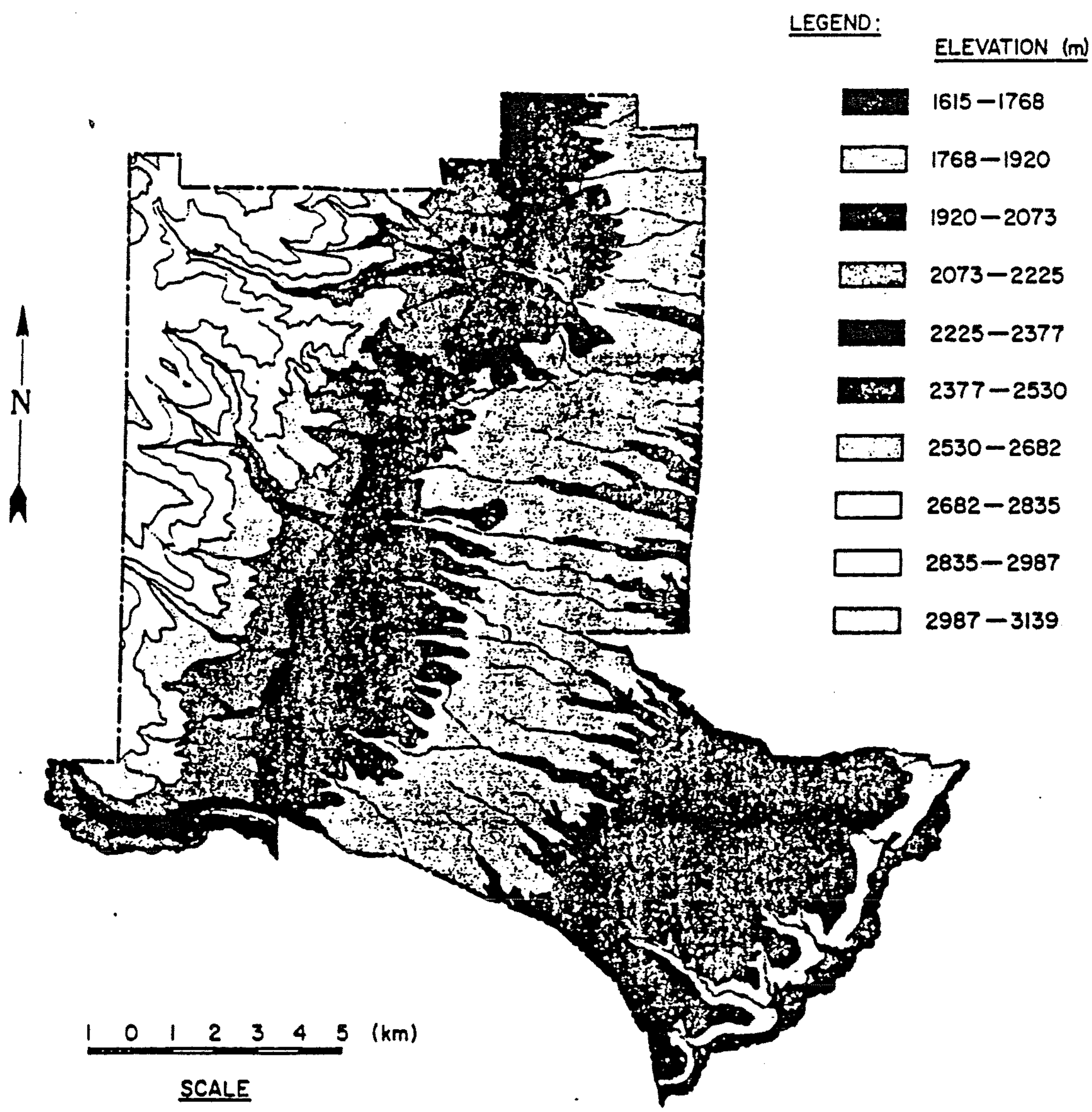

Fig. 6.
Topography and intermittent streams of Los Alamos County.

TABLE IV

ESTIMATED PERCENTAGES OF LOS ALAMOS COUNTY LAND AREA IN VARIOUS SLOPE CLASSES

Slope Class (%)	Per Cent of County Land Area
0 - 5	19.9
5 - 10	12.1
10 - 20	14.4
+20	53.6

Variations in ages of geologic deposits were discussed in the section on parent materials of Los Alamos County soils, and are summarized in Table V.* Most of the geologic historical data presented in Table V represent the results of potassium-argon dating of rocks. The potassium-argon clock makes use of the fact that ^{40}K in a mineral decays to ^{40}Ar, which is subsequently trapped in the rock and can only escape if the mineral is melted, recrystallized, or heated to several hundred degrees Celsius. Although ^{40}K is constantly decaying, a silicate melt (such as occurred during the lava flows discussed in the parent materials section) usually will not retain the ^{40}Ar that is produced. Thus, the potassium-argon clock is not set until the mineral solidifies and cools sufficiently to allow the ^{40}Ar to accumulate in the mineral lattice. This cooling process usually takes place within a few months or a few years in lava flows.

These geologic materials range in age from more than 20 million years to less than 42 000 years. Many of the older deposits were covered by later sediments laid down by wind or water. The existing landscape has been influenced by geologic erosion between cycles of volcanic activity in the area, as well as by fault activity. The canyons on the Pajarito Plateau have been eroding at rates as fast as 0.024 cm/yr and as slow as 0.0022 cm/yr, according to Purtymun and Kennedy.[14] The youngest landscapes are thus in the alluvial areas in the canyons and in wide, stable landscapes containing El Cajete pumice deposits. The oldest undisturbed landscapes occur in the southeastern portion of the county where the Paliza Canyon Formation was deposited, although the landscapes underlaid by the Tschicoma Formation occupy a larger percentage of the land area. The oldest undisturbed landscapes are not found on the Rio Grande where the Tesuque Formation is found, because these landscapes were buried for many years after the Bandelier Tuff filled the current Rio Grande Gorge adjacent to Los Alamos County.

B. The Soil Profile

A soil consists of one or more layers called horizons. A soil horizon is a layer of soil material, approximately parallel to the earth's surface, with individual characteristics resulting from the influence of living organisms, climatic factors, and the mineral matter from which the horizon has developed. The horizons of a soil occur in a sequence from the surface down to a depth of several feet, each horizon differing from those above or below it in one or more soil properties. Examples of these soil properties are thickness, color, texture (relative proportion of different sizes of mineral particles), structure (arrangement of mineral particles into clusters or peds), and consistence (the mutual attraction of soil particles, which is expressed as resistance to change in shape by crushing).

TABLE V

GEOLOGIC HISTORY OF LOS ALAMOS COUNTY

Geologic Mapping Unit	Approximate Age (Millions of Years)
Tesuque Formation of Santa Fe Group	20
Andesitic Rocks of Paliza Canyon Formation	8.5 - 9.1[a]
Tschicoma Formation and Puye Formation	3.7 - 6.7[a]
Basaltic Rocks of Chino Mesa	1.4 - 3.7
Guaje Pumice and Otowi Member of Bandelier Tuff; Cerro Toledo Rhyolite	1.4[a]
Cerro Rubio Quartz Latite and Latite Domes	1.1 - 1.4
Tsankawi Pumice and Tshirege Member of Bandelier Tuff	1.1[a]
El Cajete Pumice of Valles Rhyolite	0.042[a]

[a]Potassium-argon date.

The sequence of horizons from the surface downward, as seen in an exposed road cut or pit, collectively make up what is called a soil profile. Each soil has a unique profile that varies in kind and number of horizons. Some of these horizons merge gradually over a vertical distance of several inches and cannot be observed without close examination by the layman; however, in other soils, the boundaries between horizons are sharp and easily seen.

Most Los Alamos soils have three major horizons. These are designated with the letters A, B, and C from the surface downward. Some soils, such as certain very steep soils, do not have B horizons, or, if erosion has been severe, the entire A horizon and occasionally the B horizon may be missing. The A and B horizons are often designated as the solum or "true soil," which has developed through the interaction of the five soil forming factors. In scientific studies of soil profiles, the major horizons may be further subdivided and are designated A1, A2, A3, B1, B2, and B3, and so on. In addition, other notations are also used in detailed descriptions of soil profiles. Figure 7 is a hypothetical profile showing most of the commonly used notations.

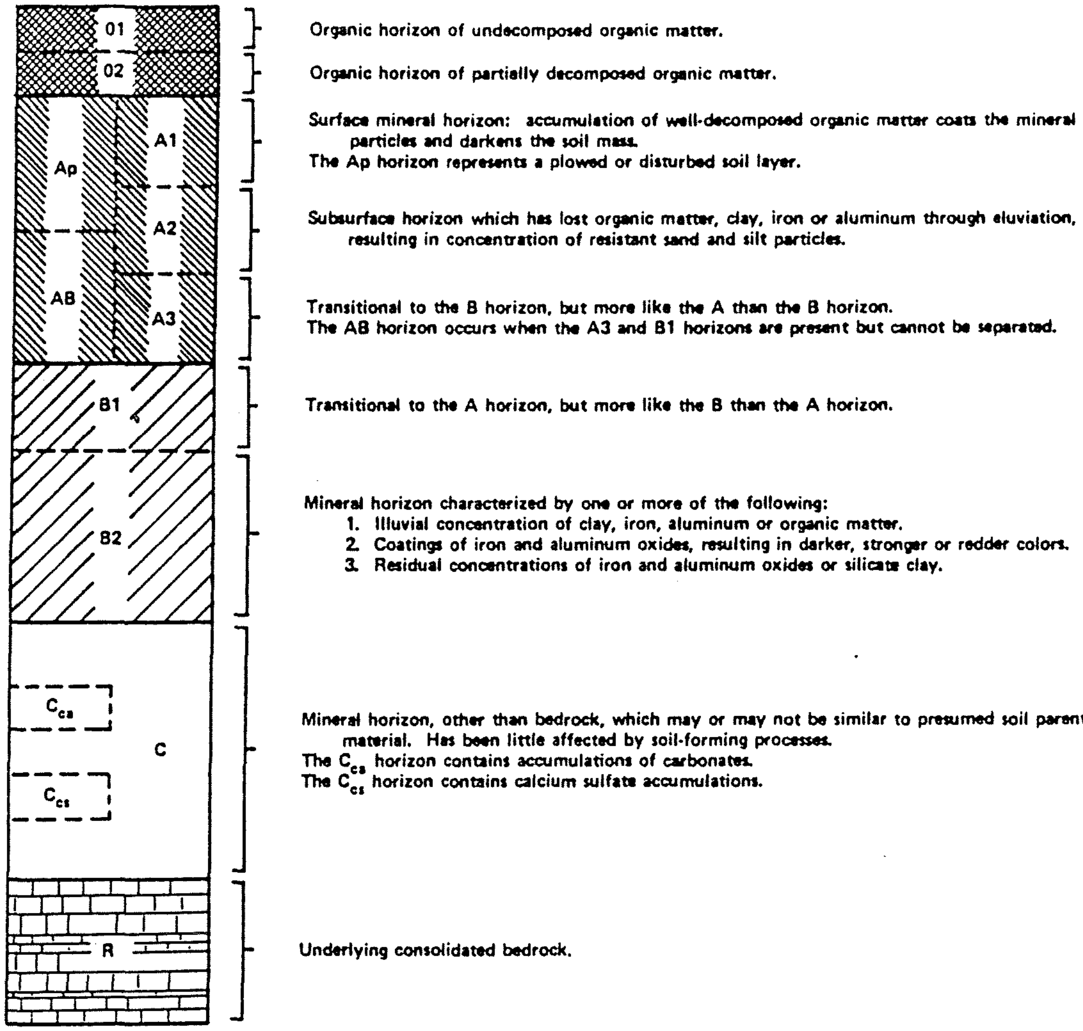

Fig. 7.
Hypothetical soil profile showing principal horizons.

1. The A Horizon. The A horizon of Los Alamos soils ranges from 5 to 76 cm in thickness, but A horizons 13 to 30 cm in thickness are more common. The A horizon is commonly referred to as the surface soil and is the part of the soil that is most active biologically. Plant roots, bacteria, fungi, insects, and small animals are most commonly found in the A horizon. The extensive root systems of the native prairie grasses and trees were important sources of organic matter for many Los Alamos soils. Well-decomposed organic matter, coating the mineral particles, is responsible for the color of the A horizon.

The A horizon receives precipitation before the lower lying B and C horizons. As water moves through the A horizon, soluble substances are carried to lower layers or even completely removed from the profile. This removal or leaching of bases such as calcium is an important cause of soil acidity. Limestone (calcium carbonate) can be applied to replace the calcium that was leached away and to maintain a soil reaction favorable for plant growth. Clay particles may form in the surface soil either through the decomposition of larger mineral particles or by synthesis or recombination of ions. The minute clay particles (10 000 clay particles = 1 linear inch) may be carried out of the A horizon in suspension. Iron, magnesium, potassium and other elements, as well as calcium carbonate (lime), may also be removed from the A horizon in solution and suspension, a process called eluviation. Thus, the A horizon is often called the horizon of maximum eluviation.

2. The B Horizon. The B horizon may occur immediately below the surface soil, or it may occur below an A2 horizon or subsurface layer. The B horizon is commonly called the subsoil. The B horizon of most local soils is usually found 13 to 30 cm below the surface and has a common thickness of 14-53 cm, although the range in thickness is 0 to 150 cm or more.

The B horizon is lower in biological activity than the A horizon and thus is lower in organic matter. It is usually harder when dry and stickier when wet, than the A horizon, because of the low amounts of organic matter and the accumulation of clay as a result of leaching from the A horizon.

The mineral particles in the B horizon may be arranged in block-like or prism-like peds. The soil color of the B horizon is due less to organic matter coatings and more to the presence of iron compounds. The materials removed from the A horizons in solution and suspension may accumulate in the B horizon, making the B horizon the horizon of illuviation. The B horizon is important to agriculture because of its influence on water movement and root development. Characteristics of the B horizon determine the suitability for management practices such as tile drain systems and terraces for erosion control or water management.

3. The C Horizon. The C horizon occurs beneath the B horizon, or the A horizon in AC profiles; or it may be missing altogether, as in some shallow soils. Biological activity — plant and animal life — is low in the C and other horizons that occur below the subsoil. The C horizon may consist of material from which the A and B horizons developed, or may be of a different geologic material, as in soil profiles that have two or more geological materials stacked upon each other. The presence of two different geologic materials in the same profile is called a geologic discontinuity. It is indicated in horizon notations with a Roman numeral II.

The C horizon of local soils usually includes the top 19 to 59 cm below the solum (A and B horizons), although the C horizon usually does not have a distinct lower boundary. Materials in the C horizon are less affected by weathering processes than the A and B horizons, and contain less organic matter and clay than the A and B horizons.

4. The O and R Horizons. The O horizon is an organic-matter rich (20% or more) layer that occurs above the surface mineral layer. They consist of fresh and partly decomposed organic matter, such as leaf litter and other forest residue. These layers occur most commonly in undisturbed timber areas and are seldom found in grassland soils. Disturbances such as clearing, plowing, or pasturing, alter or destroy these layers.

Underlying, consolidated bedrock such as tuff, pumice, basalt, dacites, or latites is designated as the R horizon. The symbol "R" is used if the overlying soil is presumed to have formed from similar parent rock. If the R horizon is unlike the overlying materials, the R is preceded by a Roman numeral, as in "IIR."

V. SOIL CLASSIFICATION.

Soil classification is a branch of soil science concerned with arranging the many kinds of soil into groups or classes. This is done to provide knowledge of soil properties and their relationships relevant to a certain purpose or objective. The objectives of soil classification include (1) organizing knowledge of soils, (2) helping to remember soil relationships, (3) bringing out soil relationships, and (4) providing units for predictions about soil behavior. The central objective is to predict and better understand the behavior of soils. The amount of variation within groups and classes determines the kind and precision of the predictions that can be made. Knowledge of soil formation provides a basis for a system of classification that allows predictions at various levels of accuracy.

A. Relationship of Soil Formation to Soil Classification

Individual soils exist for each significant combination of parent material, climate, living organisms, topography, and time. Often a slight variation in one soil-forming factor results in the formation of a different soil individual; thus, there are many kinds of soils in most areas like the Los Alamos environs. The character of the surface soil, the subsoil, and the substratum, i.e., the soil profile, is considered in determining if a new kind of soil occurs. The physical and chemical properties of soil profiles provide the basis for arranging the soil individuals into groups that have similar characteristics. The range in properties of the individuals included in a group or class determine the kind and precision of the predictions that can be made about the behavior of its members, i.e., the narrower the range in properties, the greater is the precision of behavioral prediction. Broad groupings, then, have limited prediction value, but are useful in helping one remember broad soil relationships or broad influences of the soil-forming factors. Examples of narrowly-defined groups and classes are soil series, soil type, and soil phase. Orders are examples of the most broadly defined groups or classes.

B. Soil Series, Soil Type, and Soil Phase

After soils are identified and classified in the field, maps are prepared that show the pattern of occurrence and distribution of groups of soil individuals. Aerial photographs commonly serve as the basis for preparation of such maps, as explained in Chapter II. The groups or classes of soil individuals shown on detailed soil maps (such as those included in this report) are the soil series, soil type, and soil phase.

A soil series is a group of soil individuals that have horizons similar in characteristics (except surface texture) and arrangement in the soil profile, and that have developed from a particular type of parent material. Thus, the soil series includes soil individuals with a narrow range in profile characteristics other than surface texture, slope, depth to bedrock, degree of erosion, stoniness, and topographic position, unless these features greatly modify the kind and arrangement of the soil horizons. A soil series may be named for a geographical place or feature, such as a town or river that is located near the area where the series was first defined. For example, the Frijoles series is named after Frijoles Canyon, which is located in the southern portion of Los Alamos County.

A soil type is a subdivision of the soil series based on the texture of the surface soil according to the textual classes shown in Fig. 8. It includes a group of soil individuals with the same range in characteristics as in the soil series, but restricted to a narrow range of surface texture, i.e., the Potrillo series includes soils with both loam and gravelly sandy loam surface textures. Soil types are named by combining the series name with the surface texture class name, i.e., Potrillo (series name) plus loam (soil textural class) equals Potrillo loam, a soil type. Most soil series of Los Alamos County have only one soil type.

A soil phase is a subdivision of a soil type or other classification unit. The soil phase has variations in characteristics that are not important to the genetic classification of the soil in its natural landscape; however, they are important to the use and management of the soil. Soil features, which may vary over a rather wide range in the soil series or soil type are defined over a narrow range for the soil phase, such as per cent slope and degree of accelerated erosion. Occasionally, topographic position, soil depth, and thickness of surface horizon are shown as

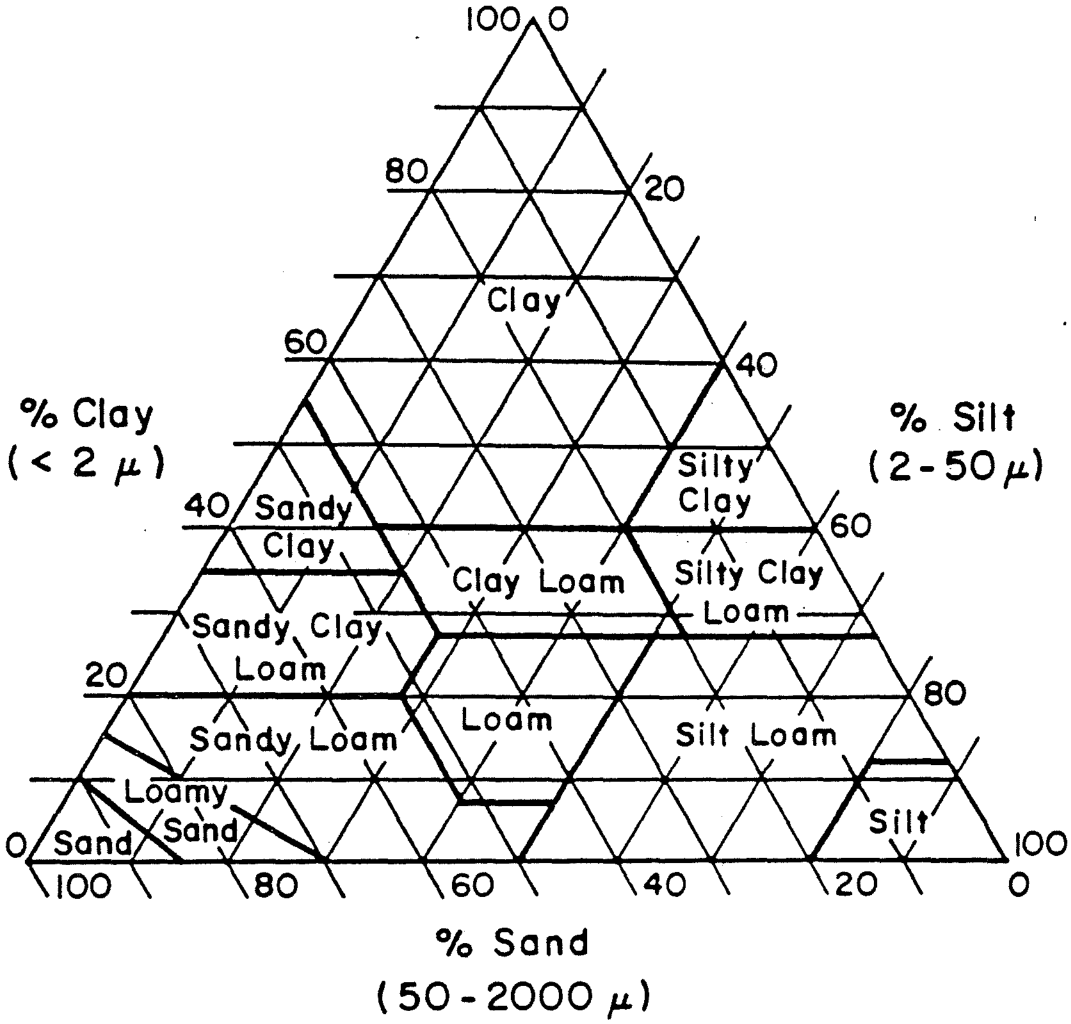

Fig. 8.
The soil texture triangle.

phases. Griegos cobbly loam, 16-40% slope and Griegos cobbly loam, 41-120% slope are examples of slope phases of the soil type Griegos cobbly loam.

Two additional classification terms are sometimes used in county soil survey reports. These are the soil complex and miscellaneous land types. The soil complex is not a unit in the classification system. It is a complex of two or more soil types, which can be identified but are so intermingled that it is often not practical to separate the individual soil types at the scale of mapping and intensity used in the survey. Miscellaneous land types are used in soil classification and mapping for areas with little or no natural soil, for areas that are dominated by other physical features, and for other areas where it is not feasible to classify the soils. Land containing rock outcrop, such as some of the areas adjacent to the mesas and the Rio Grande, are examples of miscellaneous land types.

C. Soil Order, Soil Subgroup, and Soil Family

The current system of soil classification[3] has six categories. Beginning with the broadest category, these are: order, suborder, great group, subgroup, family, and series. The criteria used as the basis for this classification are soil properties that are observable and measurable. These soil properties are chosen, however, so that soils of similar origin are grouped together. Some of the categories of the current system are briefly defined in the following paragraphs, with the exception of the previously-discussed soil series class.

Of the 10 recognized soil orders, only 5 exist in the Los Alamos area: Alfisols, Aridisols, Entisols, Inceptisols, and Mollisols (Table VI). About 80% of the County soils can be grouped into the Alfisol, Entisol, and Inceptisol soil orders. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. However, the Entisols are an exception in that they occur in many different kinds of climates. Each order is named with a word of three or four syllables ending in "sol," i.e., -Ent-i-sol.

Each great group is divided into subgroups, one of which represents the central (typic) segment of the great group. The others are called intergrades and contain soils having properties primarily of the great group, but also one or more properties of soils in another great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Udorthent (a typical Udorthent).

Each subgroup is divided into families, primarily on the basis of properties important to plant growth or behavior of soils for engineering uses. Significant properties are texture, mineralogy, reaction, temperature, thickness of horizons, and consistence. An example is the fine-loamy (texture), mixed (mineralogy), mesic (temperature regime) family of Udic Haplustalfs.

VI. DESCRIPTIONS OF THE SOILS

This chapter describes the soil series and mapping units used in the soil survey of Los Alamos County. Detailed information is given on soil formation factors involved in the genesis of the soil for each soil series or mapping unit (Fig. 3). The relationship of slope, vegetation, soil parent materials, and selected soil profile characteristics is shown in a series of illustrations for groups of soils occurring together in the field. Many of the soils are so intermingled in the field that it is not practical to separate the individual soil types at a particular scale of mapping; thus, the inclusions in each mapping unit and their extent are also described for each mapping unit.

Because an important part of the description of each soil series is the soil profile, each series contains two profile descriptions. The first is brief and in terms familiar to the layman. The second is much more detailed and is included for those who need to make thorough and precise studies of soils. Several terms used in both types of descriptions have quantitative descriptions, which are defined in the Glossary.

The less detailed soil descriptions include information on classes of soil depth, slope, permeability, available water holding capacity, runoff and erosion hazards for each soil mapping unit in the survey. Soil depth and slope classes are important considerations in making maximum use of the soils, as is soil permeability, the rate at which water can penetrate or pass through a soil mass or horizon. Many of the soil mapping units are also rated relative to their potential capability for holding water that is usable by plants, the soil available water capacity. This is estimated from the texture and depth of the solum and may be modified according to the effective rooting depth of the soil profile. Potential runoff and erosion hazard classifications of the soils are also included to indicate potential rates of soil loss by water erosion for each soil in the survey.

The detailed description of each soil profile follows the brief layman's description of each soil series. Information is given in the detailed profile descriptions related to dry and moist soil color,

TABLE VI

SOIL SERIES CLASSIFIED ACCORDING TO THE CURRENT SYSTEM OF CLASSIFICATION

Series	Family	Subgroup	Order
Abrigo	Clayey-skeletal, mixed	Pachic Paleboroll	Mollisol
Anesa	Ashy-skeletal, frigid	Typic Udorthent	Entisol
Armstead	Fine, mixed	Eutric Glossoboralf	Alfisol
Arriba	Fine, mixed	Typic Eutroboralf	Alfisol
Atomic	Fine-loamy, mixed, mesic	Udic Haplustalf	Alfisol
Barrancas	Fine, mixed	Typic Eutroboralf	Alfisol
Bayo	Ashy-skeletal, mesic	Typic Ustorthent	Entisol
Boletas	Clayey-skeletal, mixed, mesic	Udic Haplustalf	Alfisol
Cabra	Clayey-skeletal, mixed	Typic Eutroboralf	Alfisol
Carjo	Clayey, mixed	Mollic Eutroboralf	Alfisol
Colle	Fine-loamy, mixed	Eutric Glossoboralf	Alfisol
Comada	Fine, mixed, mesic	Typic Haplustalf	Alfisol
Cone	Medial-skeletal, mesic	Typic Vitrandept	Inceptisol
Copar	Ashy-skeletal, frigid	Typic Ustorthent	Entisol
Cuervo	Medial-skeletal	Entic Cryandept	Inceptisol
Dacite	Sand, mixed	Cumulic Haploboroll	Mollisol
Emod	Ashy-skeletal, mesic	Typic Ustorthent	Entisol
Frijoles	Loamy-skeletal, mixed, mesic	Aridic Haplustalf	Alfisol
Griegos	Loamy-skeletal, mixed	Dystric Cryochrept	Inceptisol
Hackroy	Clayey, mixed, mesic	Lithic Aridic Haplustalf	Alfisol
Jemell	Fine-loamy, mixed	Typic Eutroboralf	Alfisol
Korral	Fine, mixed, mesic	Lithic Haplustalf	Alfisol
Kwage	Sandy-skeletal, mixed, frigid	Typic Udorthent	Entisol
Latas	Ashy, frigid	Typic Ustipsamment	Entisol
Nyjack	Fine-loamy, mixed, mesic	Lithic Aridic Haplustalf	Alfisol
Painted Cave	Ashy-skeletal, frigid	Andeptic Udorthent	Entisol
Pelado	Loamy-skeletal, mixed, frigid	Typic Dystrochrept	Inceptisol
Penistaja	Fine-loamy, mixed, mesic	Ustollic Haplargid	Aridisol
Pines	Loamy-skeletal, mixed, frigid	Dystric Eutorchrept	Inceptisol
Pogna	Loamy, mixed, frigid	Lithic Ustorthent	Entisol
Potrillo	Fine-loamy, mixed, mesic	Aridic Ustochrept	Inceptisol
Prieta	Clayey, mixed, mesic	Lithic Ustollic Haplargid	Aridisol
Pueblo	Loamy-skeletal, mixed	Pachic Argiboroll	Mollisol
Puye	Medial, mixed, frigid	Mollic Vitrandept	Inceptisol
Quemazon	Loamy-skeletal, nonacid, frigid	Lithic Ustorthent	Entisol
Rabbit	Medial-skeletal, frigid	Entic Dystrandept	Inceptisol
Rendija	Clayey-skeletal, mixed, mesic	Typic Haplustalf	Alfisol
Sanjue	Ashy-skeletal, frigid	Typic Ustorthent	Entisol
Santa Klara	Clayey-skeletal, mixed	Eutric Glossoboralf	Alfisol
Seaby	Loamy-skeletal, mixed	Typic Eutroboralf	Alfisol
Servilleta	Fine, mixed, mesic	Ustollic Haplargid	Aridisol
Shell	Medial-skeletal, frigid	Typic Vitrandept	Inceptisol
Stonelion	Loamy-skeletal, mesic	Lithic Ustorthent	Entisol
Tentrock	Medial-skeletal, frigid	Entic Eutrandept	Inceptisol
Tocal	Clayey, mixed	Lithic Eutroboralf	Alfisol
Totavi	Medial, mixed, mesic	Ustic Torriorthent	Entisol
Tsankawi	Loamy-skeletal, nonacid, frigid	Lithic Ustorthent	Entisol
Turkey	Loamy-skeletal, mixed, frigid	Udic Ustochrept	Inceptisol
Unnamed Soil A	Ashy-skeletal, mesic	Entic Eutrandept	Inceptisol
Unnamed Soil B	Fine, mixed, mesic	Udic Haplustalf	Alfisol
Unnamed Soil C	Clayey-skeletal, mixed	Typic Eutroboralf	Alfisol
Unnamed Soil D	Fine, mixed	Typic Eutroboralf	Alfisol
Unnamed Soil E	Fine-loamy, mixed	Typic Eutroboralf	Alfisol
Unnamed Soil F	Sandy-skeletal, mixed, mesic	Typic Ustorthent	Entisol
Unnamed Soil G	Ashy, mesic	Typic Ustipsamment	Entisol
Unnamed Soil H	Loamy-skeletal, mixed, mesic	Ustochreptic Camborthid	Aridisol

texture, structure, moist and wet consistence, presence of clay films, gravel, cobble, stone, plant roots, and pores, soil reaction (pH), and soil horizon boundaries, consecutively. Explanations of these soil characteristics are contained in the Glossary.

Soil colors are good indicators of many physical-chemical soil characteristics, and are useful in the study of the genesis of soils and in arriving at conclusions concerning their best use and management. The Munsell color system is commonly used to describe soil colors, which vary with the water content of the soil. In recording a moist or dry soil color by Munsell notation, the symbol for hue (relation to red, yellow, green, blue or purple) is written first and is followed by a symbol written in fraction form. The numerator of the fraction indicates the value (lightness) of the color and the denominator indicates its chroma (strength or departure from neutral color). For example, a soil sample that is 5.0 Red in hue, 5 in value, and 8 in chroma, is described as 5.0R 5/8.

Information is also presented as to the distribution of fine and coarse particles in each soil horizon of a soil type. The texture of the soil is given in the description and indicates the amounts of sand, silt, and clay in the sample, as shown in Fig. 8. In addition, many of the soil profiles in Los Alamos County contain large amounts of pumice and larger rocks, making an estimate of the amounts of gravel, cobbble, and stone in the soil necessary. This is generally done by visually estimating the per cent (by volume) of these coarse fragments in each soil horizon.

Several soil morphological characteristics were also recorded for each soil profile. The soil structure of each soil horizon examined is described in terms of its grade, size, and form. Soil consistence, a measure of the property of a soil to adhere, cohere, or resist deformation, was measured for moist and wet soils. Clay films were described by recording their frequency of occurrence, thickness, and location in the soil mass. The shape and abundance of various-sized soil pores and plant roots were measured, as well as the soil pH or reaction of each soil sample. The lower boundary of each soil horizon is described as to its distinctness and topography. Soil pH and presence of carbonates were also described for each soil type.

The proportionate extent of the 61 soil mapping units used in the LASL-Soil Conservation Service and Forest Service portions of the soil survey (Fig. 1) are given in Table VII. With the exceptions of the previously characterized Penistaja and Prieta series, all of the soil series names currently have proposed series status, because they have not undergone the national review of established series. About 20% of the land surveyed (about 220 000 000 m^2) contained rock outcrop mapping units, and 38% of the land surveyed contained soil complexes with rock outcrop members. The soil complexes containing rock outcrop and the pelado and Kwage soil were the most extensive soils in the Forest Service portions of the survey, accounting for over 14% of the land surveyed (Table VII). The LASL-Soil Conservation Service survey contained almost 10% of the steep rock outcrop mapping unit and over 3% of the Hackroy-Rock Outcrop Complex.

The soil mapping units of each portion of the survey are described in detail in the following two sections. The relationship of slope, vegetation, soil parent materials, and selected soil profile characteristics is shown for all the soils included in each section at the end of each of these two sections (Figs. 9-13 and 14-25).

A. Soils Described in the LASL-Soil Conservation Service Soil Survey

1. **Carjo Series.** The Carjo series consists of moderately deep, well-drained soils that formed in material weathered from tuff. These soils are found on nearly level to moderately sloping mesa tops (Figs. 9 and 10) near the Jemez Mountains. Included with this soil in mapping are areas of Pogna, Tocal, and fine Typic Eutroboralf soils, all of which make up about 10% of this mapping unit. Native vegetation is mainly blue and black grama, and ponderosa pine.

TABLE VII

SIZES AND FORMS OF SOIL STRUCTURE

Soil Mapping Unit	Per Cent of Land Area Surveyed
Abrigo series	0.49
Armstead series	0.41
Arriba-Copar complex	1.43
Atomic-Korral complex	0.25
Barrancas-Sanjue-Jemell complex	0.02
Boletas-Rock outcrop complex	0.34
Borrow Pit	0.15
Cabra series, 0-15% slopes	0.29
Cabra series, 16-40% slopes	0.97
Carjo series	2.60
Cinders	0.03
Comada-Bayo complex	0.16
Cuervo series, 0-15% slopes	0.36
Cuervo series, 16-40% slopes	0.17
Dacite series	0.15
Emod series	1.24
Frijoles series	1.03
Griegos series, 16-40% slopes	1.01
Griegos series, 41-80% slopes	2.07
Griegos-Rock outcrop complex	1.23
Hackroy series	2.25
Hackroy-Rock outcrop complex	3.25
Kwage-Pelado-Rock outcrop complex	6.89
Latas series	1.27
Nyjack series	1.69
Pelado series	3.39
Penistaja series	1.98
Pogna series	1.28
Potrillo series	1.23
Prieta series	1.03
Pueblo series	1.14
Puye series	0.45
Quemazon-Arriba-Rock outcrop complex	3.97
Rabbit-Tsankawi-Rock outcrop complex	2.11
Rendija-Bayo complex	0.34
Rock outcrop, basalt	0.07
Rock outcrop-Bayo complex	0.44

Soil Mapping Unit	Per Cent of Land Area Surveyed
Rock outcrop-Colle-Painted Cave complex	1.74
Rock outcrop-Cone-Stonelion complex	0.47
Rock outcrop, frigid	2.62
Rock oucrop, mesic	3.29
Rock outcrop, Pelado-Kwage complex	7.51
Rock outcrop-Pines-Tentrock complex	2.35
Rock outcrop, steep	9.98
Rock outcrop, very steep	3.84
Sanjue-Arriba complex	2.94
Santa Klara-Armstead complex	1.23
Seaby series	1.00
Servilleta series	0.38
Shell-Ànesa complex	0.07
Shell-Anesa-Rock outcrop complex	1.10
Talus slopes, cyric (no soil present)	0.10
Tocal series	2.54
Totavi series	2.89
Turkey-Cabra-Rock outcrop complex	6.00
Unnamed soils:	
Eutrandepts-Ustipsamments-Haplustalfs complex	0.61
Typic Eutroboralfs, clayey-skeletal, mixed	0.46
Typic Eutroboralfs, fine, mixed	0.66
Typic Eutroboralfs, fine-loamy, mixed	0.25
Typic Ustorthents-Rock outcrop complex	0.54
Ustochreptic Camborthids-Rock outcrop complex	0.25

The surface layer of Carjo soils is a grayish brown loam, or very fine sandy loam, about 10 cm thick. The subsoil is a brown and reddish brown clay loam and clay about 40 cm thick. The substratum is a light brown, very fine sandy loam about 10 cm thick. Depth to tuff and the effective rooting depth range from 51 to 102 cm, and the available water holding capacity is medium. Runoff in this slowly permeable soil is medium, and the water erosion hazard is moderate.

A typical profile description of Carjo loam (1 to 8% slope) is given as follows:

A1 0-10 cm, grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft and very friable moist; many fine roots; many very fine interstitial pores; neutral; clear smooth boundary.

B1 10-30 cm, brown (7.5YR 4/4) clay loam, dark brown (7.5YR 3/3) moist; weak fine subangular blocky structure; slightly hard and very friable moist; sticky and plastic wet; many fine roots; many very fine interstitial pores; neutral; clear smooth boundary.

B2t 30-51 cm, reddish brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; moderate fine angular blocky structure; hard and firm moist, sticky and plastic wet; many fine and medium roots; common fine tubular pores; thin discontinuous clay films on peds; neutral; clear smooth boundary.

C 51-64 cm, light brown (7.5YR 6/4) very fine sandy loam, brown (7.5YR 4/4) moist; massive; few fine roots; common fine tubular pores; mildly alkaline; abrupt smooth boundary.

R 64+ cm, tuff.

2. **Frijoles Series.** The Frijoles series consists of deep, well-drained soils that formed in thick pumice beds on nearly level to moderately sloping mesa tops (Fig. 10). Included with this soil in mapping are Seaby, Nyjack, and fine Typic Eutroboralf soils; these inclusions make up about 10% of the mapping unit. Native vegetation is mainly piñon pine, one-seed juniper, and blue grama.

Typically, the surface layer is a brown, very fine sandy loam, or loam, about 5 cm thick. The subsoil is reddish brown and brown, very gravelly clay loam and very gravelly sandy clay loam about 40 cm thick and contains about 35 to 70% pumice. The substratum consists of gravel-sized white pumice to 152 cm or more and may be banded with clay films. Permeability is moderately slow in the upper 45 cm and very rapid below. The available water capacity is very low, and the effective rooting depth is about 45 cm. Runoff is slow to medium, and the erosion hazard is moderate.

A typical profile of Frijoles very fine sandy loam (1 to 8% slope) is described as follows:

A1 0-5 cm, brown (10YR 5/3) very fine sandy loam, dark brown (10YR 4/3) moist; weak fine granular structure; soft and very friable moist; many fine roots; many fine vesicular pores; neutral; abrupt smooth boundary.

B2t 5-30 cm, reddish brown (5YR 4/4) very gravelly clay loam, dark reddish brown (5YR 3/4) moist; weak fine subangular blocky structure; slightly hard and friable moist, sticky and plastic wet; many fine roots; many fine vesicular pores; thin discontinuous clay films on peds; 55% fine gravel-sized pumice; neutral; clear smooth boundary.

B3 30-46 cm, brown (7.5YYR 4/4) very gravelly sandy clay loam, dark brown (7.5YR 3/4) moist; weak fine granular structure; soft and very friable moist, sticky and plastic wet; many fine roots; many fine vesicular pores; 55% fine gravel-sized pumice; moderately alkaline; clear smooth boundary.

C 46-152+ cm, white (N 8/0) gravel, white (N 8/0) moist; single grain; loose, dry and moist; few fine roots; many fine vesicular pores; 85% fine gravel-sized pumice; slightly calcareous; strongly alkaline.

3. **Hackroy Series.** The Hackroy series consists of very shallow to shallow, well-drained soils that formed in material weathered from tuff on mesa tops (Fig. 11). Individual areas of Hackroy soils are 5 to 80 acres in size and include small areas (<2 acres) of rock outcrop, and Nyjack and fine-loamy Typic Eutroboralf soils; the inclusions may compose 25% of this mapping

unit. A Hackroy-Rock outcrop complex was also mapped in the survey and consists of small areas of Hackroy soils and 70% rock outcrop that are so intermingled that they could not be separated at the scale selected for mapping. This second unit consists of nearly level to moderately sloping shallow soils over tuff bedrock and tuff rock outcrop; mapped areas are mostly elongated and oriented with the mesa tops and are 1/4 to 3 acres in size. The shallow, well-drained Hackroy soils make up about 20% of this complex and the Nyjack soils and very shallow undeveloped soils make up about 10% of the Hackroy-Rock outcrop mapping unit. The native vegetation is mainly piñon pine, one-seed juniper, scattered ponderosa pine, and blue grama.

The surface layer of the Hackroy soils is a brown sandy loam, or loam, about 10 cm thick. The subsoil is a reddish brown clay, gravelly clay, or clay loam, about 20 cm thick. The depth to tuff bedrock and the effective rooting depth are 20 to 50 cm. Both the Hackroy and the Hackroy-Rock outcrop mapping units exhibit slow permeability and low available water capacities. The Hackroy mapping unit has medium runoff and only moderate water erosion hazard, whereas the Hackroy-Rock outcrop unit has a moderate to severe water erosion hazard and medium to high runoff.

A typical profile of Hackroy sandy loam (1 to 5% slope) is described as follows:

A1 0-8 cm, brown (10YR 5/3) sandy loam, brown (10YR 4/3) moist; weak fine subangular blocky structure; hard and friable moist; many fine roots; common fine tubular pores; mildly alkaline; abrupt smooth boundary.

B2t 8-25 cm, dark reddish brown (5YR 3/4) clay, dark reddish brown (5YR 3/4) moist; moderate fine prismatic structure; hard and firm moist, sticky and plastic wet; many fine roots; few very fine tubular pores; 3% gravel; continuous clay films on peds; mildly alkaline; abrupt smooth boundary.

B3 25-30 cm, yellowish red (5YR 5/6) gravelly clay, yellowish red (5YR 5/6) moist; moderate fine subangular blocky structure; slightly hard and firm moist, sticky and plastic wet; many fine roots; 25% gravel; slightly calcareous; neutral.

R 30+ cm, tuff bedrock.

4. **Nyjack Series.** The Nyjack series consists of moderately deep, well-drained soils that formed in material weathered from tuff on nearly level to gently sloping mesa tops (Fig. 12). Individual areas of these soils are 5 to 75 acres in size and include about 20% rock outcrop, and Hackroy and fine-loamy Typic Eutroboralf soils in the mapping unit. The native vegetation is mainly piñon pine, one-seed juniper and blue grama.

Typically, the surface layer is a brown loam, very fine sandy loam, or sandy loam about 5 cm thick, and the subsoil is a brown clay loam about 50 cm thick. The substratum is a gravelly sandy loam about 40 cm thick, which may contain as much as 30% pumice. Depth to tuff bedrock and the effective rooting depth range from 50 to 102 cm. Available water capacity is medium. Runoff is slow in this moderately permeable soil, and the water erosion hazard is slight.

A representative profile of Nyjack loam (1 to 5% slope) is given as follows:

A1 0-8 cm, brown (10YR 5/3) loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; soft and very friable moist; many fine roots; many vesicular pores; slightly acid; abrupt smooth boundary.

B1 8-33 cm, brown (7.5YR 5/4) light clay loam, brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; slightly hard and very friable moist, slightly sticky and slightly plastic wet; many medium roots; many vesicular pores; neutral; clear smooth boundary.

B2t 33-61 cm, brown (7.5YR 4/4) clay loam (est. 34% clay), dark brown (7.5YR 3/4) moist; moderate medium angular blocky structure; hard and friable moist; sticky and plastic wet; few fine roots; many fine tubular pores; thin discontinuous clay films on peds; neutral; abrupt smooth boundary.

C 61-99 cm, light brown (7.5YR 6/4) gravelly sandy loam, brown (7.5YR 4/4) moist; massive; few fine roots; 25% coarse fragment (pumice); mildly alkaline; abrupt smooth boundary.

R 99+ cm, tuff bedrock.

5. **Penistaja Series.** The Penistaja series consists of deep, well-drained soils that formed in material weathered from alluvial and eolian deposits on basalt (Fig. 13). This soil is found on nearly level to gently sloping topography in the White Rock and Pajarito Acres area. Native vegetation is mainly blue grama, piñon pine, and one-seed juniper. Small areas (<3 acres) of Prieta, Servelleta, and Nyjack soils are included in the Penistaja mapping unit and make up less than 10% of the area of the unit.

The surface layer of the Penistaja series is a brown sandy loam about 8 cm thick. The subsoil is a brown to light brown clay loam and heavy fine sandy loam about 95 cm thick. The substratum is a light brown sandy loam about 50 cm thick and contains carbonates ranging from disseminated to soft masses and threads. Permeability is moderate. The available water capacity is high, and the effective rooting depth is 150 cm or more. Runoff is slow, and the water erosion hazard is low.

A typical pedon of Penistaja sandy loam (1 to 5% slope) is described as follows:

A1 0-8 cm, brown (7.5YR 5/4) sandy loam, brown (7.5YR 4/2) moist; weak fine granular parting to weak fine subangular blocky structure; soft and very friable moist; common medium roots; moderately alkaline; clear smooth boundary.

B21t 8-30 cm, brown (7.5YR 4/4) light clay loam, brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard and very friable moist, slightly sticky and slightly plastic wet; common fine roots; thin discontinuous clay films on peds; mildly alkaline; clear smooth boundary.

B22t 30-76 cm, light brown (7.5YR 4/4) light clay loam, brown (7.5YR 5/4) moist; moderate medium subangular blocky structure; hard and friable moist, slightly sticky and slightly plastic wet; few fine roots; thin continuous clay films on peds; slightly calcareous; moderately alkaline; clear smooth boundary.

B3 76-102 cm, light brown (7.5YR 6/4) heavy fine sandy loam, brown (7.5YR 5/4) moist; weak coarse subangular blocky structure; hard and friable moist; slightly calcareous; moderately alkaline; clear smooth boundary.

C 102-152+ cm, light brown (7.5YR 6/4) sandy loam, brown (7.5YR 5/4) moist; massive; slightly calcareous; moderately alkaline.

6. **Pogna Series.** The Pogna series consists of shallow well-drained soils that formed in material weathered from tuff on gently to strongly sloping mesa tops (Fig. 9). Included with this soil in mapping are rock outcrop and Carjo, fine Typic Eutroboralf, and Tocal soils; the inclusions make up about 10% of this mapping unit. Native vegetation is mainly ponderosa pine, mountain mahogany, and Kentucky bluegrass.

Typically, the soil is a light brownish gray fine sandy loam, or sandy loam, over tuff bedrock at 25 to 50 cm. The available water capacity of this moderately rapid permeable soil is low, and the effective rooting depth is 25 to 50 cm. Runoff is medium, and there is a moderate water erosion hazard.

The representative profile of the Pogna fine sandy loam (3 to 12% slope) is described as follows:

A1 0-13 cm, light brownish gray (10YR 6/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard and very friable moist; many medium roots; many interstitial pores; neutral; clear smooth boundary.

C 13-30 cm, light brownish gray (10YR 6/2) fine sandy loam, grayish brown (10YR 5/2) moist; weak fine granular structure; slightly hard and very friable moist; many medium and coarse roots; many interstitial pores; slightly acid.

R 30+ cm, tuff bedrock.

7. **Potrillo Series.** The Potrillo series consists of deep, well-drained soils that formed in alluvial and colluvial sediments derived from tuff and pumice. Potrillo soils are found on level to gently sloping canyon floors (Fig. 11) and on inextensive, flat benches along the Rio Grande Gorge (Fig. 13). Native vegetation is blue grama, piñon pine, one-seed juniper, and annual grasses and forbs. About 10% of this mapping unit in the canyon floors consists of Puye and Totavi soils and some soils that have a more developed subsoil than the Potrillo soils. When the Potrillo soils are found along the Rio Grande Gorge, small areas of Totavi soils and soil profiles containing silt or cobble throughout the profile are included in the Potrillo mapping unit.

When the Potrillo series is found in canyon floors the surface layer is typically a brown loam about 10 cm thick. The subsoil is a brown loam, or a sandy loam, about 30 cm thick. The substratum is light brown sandy loam with 15% gravel-sized pumice fragments and is neutral to mildly alkaline. The available water capacity of this moderately permeable soil is high, and the effective rooting depth is 150 cm or more. Runoff is very slow, and the erosion hazard is low.

When the Potrillo series is found along the Rio Grande, the surface layer is a brown gravelly sandy loam about 15 cm thick. The subsoil is a brown gravelly sandy loam about 25 cm thick. The substratum is a light brown gravelly sandy loam to 150 cm or more, and the entire profile has 10 to 20% gravel-sized pumice. Permeability is moderate, and the available water capacity is medium to high with an effective rooting depth of 150 cm or more. Runoff is slow, and the erosion hazard is low.

A typical pedon of Potrillo loam (0 to 5% slope) is described as follows:

A1 0-10 cm, brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; soft and very friable moist; common fine roots; neutral; clear smooth boundary.

B2 10-20 cm, brown (7.5YR 5/4) loam, dark brown (7.5YR 3/4) moist; weak medium subangular blocky structure; slightly hard and very friable moist; slightly sticky and slightly plastic wet; common very fine roots; neutral; clear smooth boundary.

B3 20-41 cm, brown (7.5YR 5/4) sandy loam, dark brown (7.5YR 3/4) moist; weak fine subangular blocky structure; slightly hard; very friable moist, slightly sticky and slightly plastic wet; few very fine roots; 5% gravel-sized pumice; mildly alkaline; clear smooth boundary.

C 41-152+ cm, light brown (7.5YR 6/4) sandy loam, brown (7.5YR 4/4) moist; massive; 15% gravel-sized pumice; mildly alkaline.

8. **Prieta Series.** The Prieta series consists of shallow, well-drained soils that formed in wind-deposited sediments and some material weathered from basalt on gently to moderately sloping mesa tops (Fig. 13). Native vegetation is mainly piñon pine, one-seed juniper, blue grama, and big sagebrush. Individual areas of Prieta soils are 5 to 80 acres in size, and about 15% of this mapping unit consists of inclusions of rock outcrop and Servilleta soils.

The surface layer of the Prieta soils is a light brown silt loam, or loam, about 10 cm thick. The subsoil is a brown and light brown clay loam, or clay, about 25 cm thick. The substratum is a pink gravelly silt loam, about 10 cm thick, and depth to basalt ranges from 25 to 50 cm. The available water capacity is low, and the effective rooting depth is 25 to 50 cm. Runoff is medium in this slowly permeable soil, and water erosion is moderate.

A typical profile of Prieta silt loam (3 to 8% slope) is described as follows:

A1 0-13 cm, light brown (7.5YR 6/4) silt loam, brown (7.5YR 4/4) moist; weak fine granular structure; soft and very friable moist; many fine and medium roots; many interstitial pores; mildly alkaline; clear smooth boundary.

B2t 13-28 cm, brown (7.5YR 5/2) clay loam, dark brown (7.5YR 4/2) moist; moderate medium subangular blocky structure; slightly hard and friable moist, sticky and plastic wet; many fine and medium roots; many fine interstitial pores; thick continuous clay films on peds; mildly alkaline; clear smooth boundary.

B3ca 28-38 cm, light brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) moist; hard and friable moist, sticky and plastic wet; many fine roots; many interstitial and tubular pores; 5% gravel; slightly calcareous; moderately alkaline; clear smooth boundary.

Cca 38-48 cm, pink (7.5YR 7/4) gravelly silt loam, brown (7.5YR 5/4) moist; structureless; hard and very friable moist, slightly sticky and slightly plastic wet; many fine and medium roots; 25% gravel and cobblestone; many interstitial and tubular pores; strongly calcareous; thick caliche coats on gravel and cobblestone, moderately alkaline.

R 48+ cm, basalt.

9. Puye Series. The Puye series consists of deep, well-drained soils that formed in alluvium in level to gently sloping canyon bottoms near the mountains (Fig. 12). Individual areas of Puye soils are 2 to 40 acres in size and occur as long slender bodies. Included with this soil in mapping are areas of this soil with up to 10% slope on the side of the canyons, and a few intermingled areas of Totavi soils adjacent to the north canyon walls; the inclusions make up about 10% of this mapping unit. Native vegetation is Kentucky bluegrass, western wheatgrass, mountain muhly, ponderosa pine, oak species, and annual grasses and forbs.

Typically, the surface soil is a dark grayish brown sandy loam, fine sandy loam, or loam, to 150 cm or more. Permeability is moderately rapid, the available water capacity is high, and the effective rooting depth is 150 cm or more. Runoff is very slow, and the erosion hazard is low.

A typical profile of Puye sandy loam (0 to 5% slope) is described as follows:

A1 0-15 cm, dark grayish brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft and very friable moist; many fine and very fine roots; neutral; clear smooth boundary.

C 15-152+ cm, dark grayish brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; massive; soft and very friable moist; common fine and very fine roots; neutral.

10. Rock Outcrop, Basalt. This land type has a slope of 15 to 50% and consists of about 95% basalt rock outcrop (Fig. 13). The inclusions in this mapping unit are very shallow undeveloped soils on basalt bedrock. The unit is generally found south of White Rock where the native vegetation is piñon pine and one-seed juniper.

11. Rock Outcrop, Frigid (5-30% Slope). This land type is found on gently sloping to steep mesa tops and edges (Fig. 9) and consists of about 65% tuff rock outcrop. The inclusions in the mapping unit are about 5% very shallow undeveloped soils on bedrock, 5% Tocal soils and 25% narrow escarpments. Native vegetation is mainly Kentucky bluegrass, ponderosa pine, spruce, fir, and oak.

12. Rock Outcrop, Mesic (5-30% slope). This land type is found on moderately sloping to steep mesa tops and edges and consists of about 65% tuff rock outcrop (Fig. 11). The inclusions in this mapping unit are about 5% very shallow, undeveloped soils on tuff bedrock, 5% Hackroy soils, and 25% narrow escarpments. Native vegetation is blue grama, piñon pine, and one-seed juniper.

13. Rock Outcrop, Steep. This land type has slopes greater than 30% on steep to very steep mesa breaks and canyon walls (Figs. 10, 11, 12) and consists of about 90% rock outcrop. The rocks are mainly tuff except at the lower end of some of the canyons where there is basalt.

The inclusions in this mapping unit are very shallow undeveloped soils on tuff, mesic rock outcrop (5-30% slope), and frigid rock outcrop (5-30% slope). The south-facing canyon walls are steep and have little or no soil material or vegetation, but the north-facing walls have areas of very shallow dark-colored soils. Vegetation is ponderosa pine, spruce, and fir.

14. Rock Outcrop, Very Steep. This land type has slopes generally greater than 50% and is on the canyon wall of the Rio Grande Gorge (Fig. 13). It consists of about 90% rock outcrop. The rocks are mainly basalt, although there is some tuff near the mesa tops, and there are exposures of rocks of the Tesuque Formation near the river. There are also large areas of basalt rubble consisting of boulders as large as 5 to 7 m in diameter, deposited by landslide and exfoliation activity. Vegetation is very sparse and is dominantly piñon pine, one-seed juniper, and blue grama.

15. Seaby Series. The Seaby series consists of shallow to moderately deep, well-drained soils that formed in material weathered from tuff on gently to moderately sloping mesa tops (Fig. 9). in mapping are Nyjack, Frijoles, fine Typic Eutroboralf, and Carjo soils; these inclusions make up about 10% of this mapping unit. Native vegetation is ponderosa pine, Kentucky bluegrass, and annual grasses and forbs.

The surface layer of the Seaby soils is a brown loam, or sandy loam, about 10 cm thick. The subsoil is a brown to strong brown gravelly (35-70% pumice) clay loam about 20 cm thick, but this horizon is not present in some of these profiles. The substratum is a white gravelly pumice about 35 cm thick, which may have bands of fine soil material in it originating from the B horizon. The depth to tuff bedrock and the effective rooting depth range from 25 to 66 cm. Permeability is moderate in the upper soil layers and very rapid below. Available water capacity is low, and the runoff and erosion hazards are moderate.

A typical profile of Seaby loam (3 to 12% slope) is described as follows:

A1 0-13 cm, brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard and very friable moist, slightly sticky wet; many fine and medium roots; many fine vesicular pores; neutral; clear smooth boundary.

B21t 13-25 cm, brown (7.5YR 5/4) gravelly clay loam, dark brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; slightly hard and friable moist, sticky and plastic wet; many fine and medium roots; many fine vesicular pores; some pockets of A2 material in the upper part of this horizon; 40% fine gravel-sized pumice; thin discontinuous clay films on peds and some bridging between gravels; neutral; clear smooth boundary.

B22t 25-30 cm, strong brown (7.5YR 5/6) very gravelly clay loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; slightly hard; very friable moist, sticky and plastic wet; 55% fine gravel-sized pumice; many fine vesicular pores; thin clay bridges between gravels and films on peds; neutral; clear smooth boundary.

C 30-66 cm, white (N 8/0) and strong brown (7.5YR 5/6) gravel-sized pumice, white (N 8/0) and yellowish red (5YR 5/6) moist (the darker colored areas above represent banding, not mixing); single grain; loose; few fine and coarse roots; neutral; abrupt smooth boundary.

R 66+ cm, tuff bedrock.

16. Servilleta Series. The Servilleta series consists of moderately deep, well-drained soils formed in material weathered from basalt and eolian materials on nearly level to gently sloping mesas and lava flows (Fig. 13). Individual areas of Servilleta soils are 5 to 80 acres in size and may contain about 15% Prieta soils and rock outcrop. Native vegetation is blue grama, western wheatgrass, big sagebrush, little rabbitbush, piñon pine, and one-seed juniper.

Typically, the surface layer is a brown loam or silt loam about 13 cm thick. The subsoil is a brown to light brown clay loam about 55 cm thick, and the substratum is a pinkish white loam about 20 cm thick. Depth to basalt ranges from 50 to 100 cm. Permeability and runoff are slow, and water erosion is moderate. Availabile water capacity is moderate, and the effective rooting depth is 50 to 100 cm.

The representative profile description of the Servilleta loam (1 to 5% slope) follows:

A1 0-13 cm, brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) moist; weak fine granular structure; hard and friable moist, slightly sticky wet; many fine and very fine roots; common fine vertical pores; moderately alkaline; clear smooth boundary.

B21t 13-33 cm, brown (7.5YR 4/4) clay loam, dark brown (7.5YR 4/3) moist; weak medium prismatic parting to moderate medium subangular blocky structure; very hard and firm moist, sticky and plastic wet; many fine and very fine roots; common fine vertical pores; slightly calcareous; thin continuous clay films on peds; moderately alkaline; clear smooth boundary.

B22t 33-53 cm, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 4/4) moist; weak medium prismatic parting to moderate fine and medium subangular blocky structure; very hard and firm moist; sticky and plastic wet; common very fine roots; common fine vertical pores; slightly calcareous; thick continuous clay films on peds; moderately alkaline; clear smooth boundary.

B3ca 53-69 cm, light brown (7.5YR 6/4) clay loam, brown (7.5YR 4/4) moist; weak medium subangular structure; very hard and friable moist; slightly sticky and slightly plastic wet; common fine roots; common fine vertical pores; slightly calcareous; thin discontinuous clay films on peds; moderately alkaline; abrupt wavy boundary.

Cca 69-89 cm, pinkish white (7.5YR 8/2) loam, pink (7.5YR 7/4) moist; massive; few very fine roots; slightly calcareous; moderately alkaline; abrupt wavy boundary.

R 89+ cm. caliche-coated basalt.

17. **Tocal Series.** The Tocal series consists of very shallow to shallow, well-drained soils that formed in material weathered from tuff on gently to moderately sloping mesa tops (Fig. 9). Individual areas of Tocal soils are 5 to 80 acres in size and include small amounts of Pogna, Carjo, and fine Typic Eutroboralf soils in about 15% of this mapping unit. Native vegetation is mainly ponderosa pine, mountain mahogany, and Kentucky bluegrass.

The surface layer of Tocal soils is a grayish brown very fine sandy loam, sandy loam, or loam, about 10 cm thick. The subsoil is a reddish brown clay loam, or clay, about 15 cm thick. The substratum is a light brown silt loam about 5 cm thick and the depth to tuff and the effective rooting depth range from 20 to 50 cm. The permeability is moderately slow and the available water capacity is low. Runoff is medium and the water erosion hazard is moderate.

A representative profile description of Tocal very fine sandy loam (3 to 8% slope) is as follows:

A1 0-13 cm, grayish brown (10YR 5/2) very fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft; very friable moist; many fine roots; many interstitial pores; neutral; abrupt smooth boundary.

B21t 13-20 cm, reddish brown (5YR 5/3) clay loam, reddish brown (5YR 4/3) moist; moderate very fine subangular blocky structure; hard and friable moist, sticky and plastic wet; many fine roots; few very fine interstitial pores; thin continuous clay films on peds; neutral; abrupt smooth boundary.

B22t 20-28 cm, dark reddish brown (5YR 5/3) clay, reddish brown (5YR 4/3) moist; moderate coarse prismatic structure parting to moderate medium subangular blocky structure; hard and friable moist, sticky and plastic wet; many medium roots; few very fine tubular pores; thick continuous dark brown (5YR 3/3) clay films on peds; neutral; clear smooth boundary.

C 28-36 cm, light brown (7.5YR 6/4) silt loam, dark brown (7.5YR 4/4) moist; massive; hard and friable moist, sticky and plastic wet; many medium roots; few very fine tubular pores containing a few reddish brown (5YR 4/4) clay films; neutral.

R 36+ cm, tuff bedrock.

18. Totavi Series. The Totavi series consists of deep, well-drained soils that formed in alluvium in canyon bottoms (Fig. 11) in the central and eastern portion of the soil survey area. Individual areas are 2 to 60 acres in size and occur as long slender bodies. Native vegetation is blue grama, piñon pine, one-seed juniper, and annual grasses and forbs.

The surface soil is a brown gravelly loamy sand, or sandy loam, to 150 cm or more, with 15-20% gravel. Permeability is very rapid, runoff is very slow, and the erosion hazard rating is low. The available water capacity is low, but the effective rooting depth is 150 cm or more.

A typical pedon of Totavi gravelly loamy sand (0 to 5% slope) is described as follows:

AC 0-152 cm, brown (10YR 5/3) gravelly loamy sand, brown (7.5YR 4/4) moist; single grain; loose dry and moist; few fine roots; 15% fine gravel; neutral.

19. Unnamed Soils. The series name has not been used for these mapping units because of the limited acreage involved.

a. Typic Eutroboralfs, clayey-skeletal. The clayey-skeletal Typic Eutroboralfs consist of deep, well-drained soils that formed in gravelly fan material originating close to the mountains. These soils occur on nearly level to moderately sloping mesas at the base of the mountains (Fig. 10) and the mapping units include 10% Tocal and Carjo soils. Native vegetation is mainly ponderosa pine, mountain mahogany, mountain muhly, and Gambel oak.

Typically, the surface layer of these Typic Eutroboralfs is a light gray silt loam, or loam, about 15 cm thick. The subsoil is a reddish brown and brown very gravelly or cobbly clay, or clay loam, to 120 cm or more. The coarse fragment content of the A and B horizons varies from 5 to 15% and 50 to 80%, respectively.

Permeability is slow, and available water capacity is low. The effective rooting depth is 120 cm or more. Runoff is slow to medium, and the erosion hazard is moderate.

A representative profile description of Typic Eutroboralfs, clayey-skeletal (1 to 8% slope) is as follows:

A2 0-15 cm, light gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) moist; weak fine granular structure; slightly hard and very friable moist; common fine roots; very fine vesicular pores; 10% gravel; neutral; abrupt smooth boundary.

AB 15-30 cm, pinkish gray (7.5YR 7/2) and reddish brown (5YR 5/4) very gravelly loam, brown (7.5YR 5/2) and reddish brown (5YR 4/4) moist; weak fine subangular blocky structure; hard and very friable moist, slightly sticky and slightly plastic wet; common very fine roots; 55% medium and coarse gravel; common fine black (5YR 2/1) iron and manganese concretions; medium acid; clear smooth boundary.

B21t 30-46 cm, reddish brown (5YR 5/4) very gravelly clay, reddish brown (5YR 4/4) moist; weak fine subangular blocky structure; hard and friable moist, sticky and plastic wet; few fine roots; 75% gravel and cobble; common fine black (5YR 2/1) iron and manganese concretions; thin clay films in pores and on pebbles; medium acid; clear smooth boundary.

B22t 46-122+ cm, brown (7.5YR 5/4) very gravelly clay, brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; hard and friable moist, sticky and plastic wet; few fine roots; 75% gravel and cobble; thin clay films in pores on pebbles; medium acid.

b. Typic Eutroboralfs, fine. The fine Typic Eutroboralfs consist of moderately deep, well-drained soils that formed in colluvium and material weathered from tuff. This soil type occurs on gently to strongly sloping mesa tops (Fig. 9) downhill from fault zones near the mountains. About 10% of this mapping unit consists of small areas of Seaby, Carjo, and Tocal soils. Native vegetation is mainly ponderosa pine and little bluestem.

Typically, the surface layer of the fine Typic Eutroboralfs is a grayish brown to very pale brown very fine sandy loam, or sandy loam, about 20 cm thick. The subsoil is a light reddish brown to yellowish red clay and sandy clay about 75 cm thick. The depth to tuff and the effective rooting depth range from 50 to 100 cm. The available water capacity is medium in this slowly permeable soil. Runoff is medium, and the water erosion hazard is moderate.

A typical pedon of Typic Eutroboralfs, fine (3 to 12% slope) may be described as follows:

A21 0-8 cm, grayish brown (10YR 5/2) very fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard and very friable moist; many fine and medium roots; few fine black iron and manganese concretions; neutral; clear smooth boundary.

A22 8-18 cm, very pale brown (10YR 7/3) very fine sandy loam, brown (10YR 5/3) moist; weak thin platy structure; slightly hard and friable moist; many fine roots; 5 to 10% of the mass is coarse sand-sized glass fragments; slightly acid; abrupt smooth boundary.

B21t 18-33 cm, reddish brown (5YR 4/4) clay, reddish brown (5YR 4/4) moist; moderate medium to coarse subangular blocky structure; hard and firm moist, sticky and plastic wet; many very fine and medium roots; thin discontinuous clay films on peds; soil mass has 10 to 15% coarse sand-sized glass fragments; neutral; clear smooth boundary.

B22t 33-51 cm, yellowish red (5YR 4/6) clay, reddish brown (5YR 4/4) moist; strong medium blocky structure; hard and firm moist, very sticky and very plastic wet; many fine and medium roots; thick continuous clay films on peds; 20% of the mass is coarse sand-sized glass fragments; many black manganese concretions; neutral; clear smooth boundary.

B23t 51-94 cm, light reddish brown (5YR 6/4) sandy clay, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; hard and firm moist, sticky and plastic wet; few fine and medium roots; thin continuous clay films on peds; 30% of the mass is coarse sand-sized glass framents; many fine and medium black manganese concretions; neutral.

R 94+ cm, tuff; there are clay flows, roots and oxide stains in the upper few centimeters of the tuff.

c. Typic Eutroboralfs, fine-loamy. The fine-loamy Typic Eutroboralfs consist of deep, well-drained soils that formed in material weathered from tuff on nearly level to gently sloping mesa tops (Fig. 12). Individual areas of these soils are 10 to 100 acres in size and contain about 15% Nyjack, Hackroy, and Frijoles soils in the mapping unit.

These soils contain a soil profile that has undergone weathering and was subsequently buried by a water-deposited soil layer, which was probably deposited after major faulting activity. The native vegetation is mainly blue grama, piñon pine, and one-seed juniper.

The surface layer of these Typic Eutroboralfs is a very dark grayish brown loam, sandy loam, or very fine sandy loam, about 5 cm thick. The subsoil is a brown silt loam over a clay loam about 55 cm thick. The substratum is a brown gravelly clay loam over reddish clay,which may or may not contain pumice. Permeability is moderately slow. The available water capacity is high, and the effective rooting depth is 150 cm or more. Runoff is slow in this moderately slowly permeable soil, and the water erosion hazard is moderate.

A typical profile of Typic Eutroboralfs, fine-loamy (1 to 5% slope) is described as follows:

A1 0-8 cm, very dark grayish brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak fine granular structure; soft and very friable moist; many fine roots; slightly acid; abrupt smooth boundary.

B1 8-36 cm, brown (10YR 5/3) silt loam, dark brown (7.5YR 3/3) moist, pinkish gray (7.5YR 6/2) crushed dry; weak medium subangular blocky structure; slightly hard and very friable moist; many fine roots; many vesicular pores; slightly acid; clear smooth boundary.

B2t 36-64 cm, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; hard and friable moist, sticky and plastic wet; few fine roots; many veiscular pores; thin discontinuous clay films on peds; slightly acid; clear smooth boundary.

C 64-91 cm, light brown (7.5YR 6/4) gravelly clay loam, brown (7.5YR 4/4) moist; weak fine granular structure; hard and friable moist, sticky and plastic wet; few fine roots; fine gravel-sized pumice make up 45% of this horizon; neutral; clear smooth boundary.

IIB1b 91-168 cm, reddish brown, (5YR 5/4) clay loam, reddish brown (5YR 4/4) moist; massive structure; hard and friable moist, sticky and plastic wet; many tubular pores; mildly alkaline; abrupt smooth boundary.

IIB2b 168-229 cm, reddish brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; strong medium angular blocky structure; hard and friable moist, very sticky and very plastic wet; neutral; abrupt smooth boundary.

IIB3b 229-254 cm, yellowish red (5YR 5/6) clay, yellowish red (5YR 4/6) moist; strong medium angular blocky structure; hard and friable moist, very sticky and very plastic wet; slightly calcareous; neutral.

R 254+ cm, tuff bedrock.

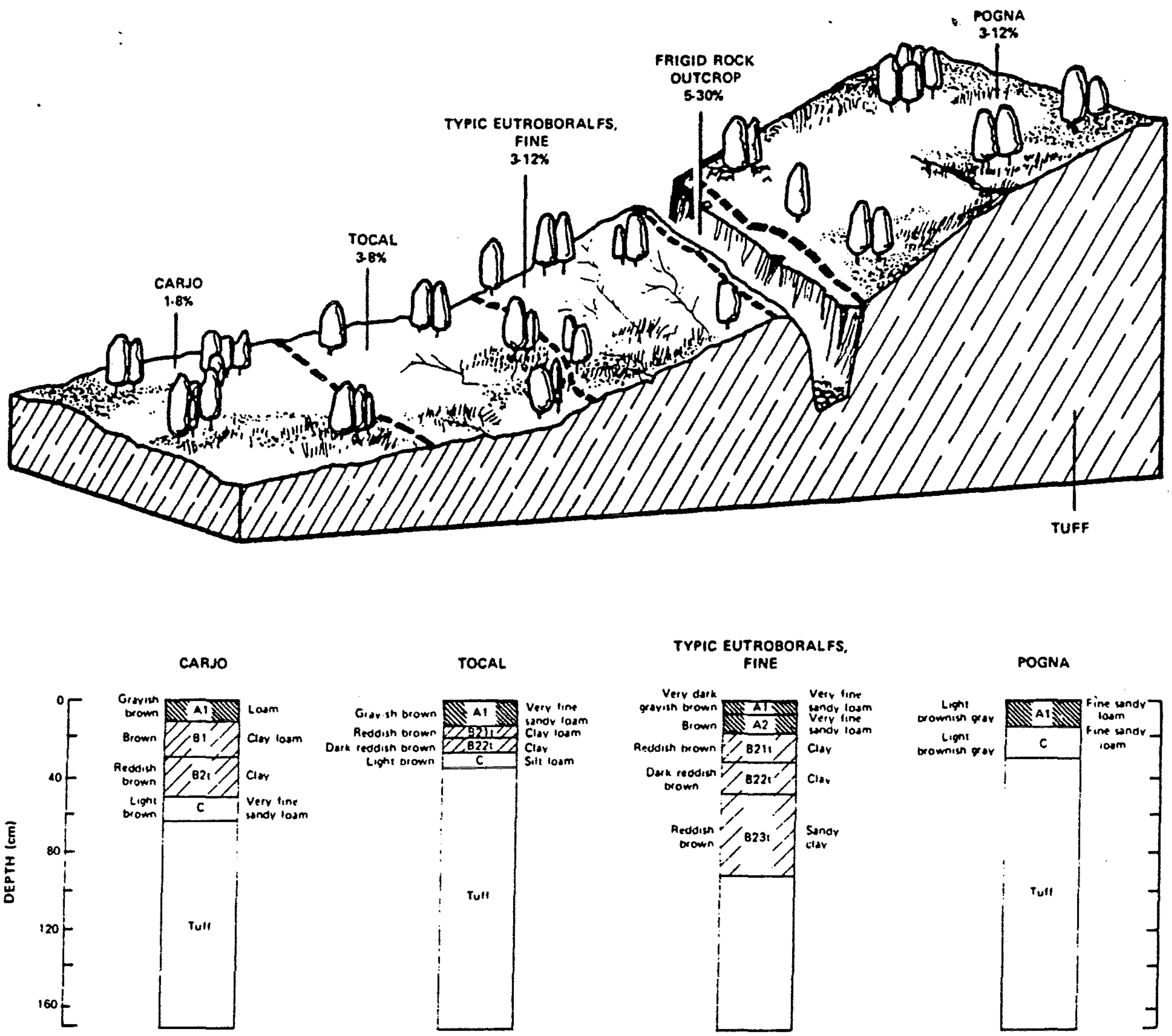

Fig. 9.
Relationship of slope, vegetation, and parent material to Carjo, Tocal, Typic Eutroboralfs, fine, and Pogna soils.

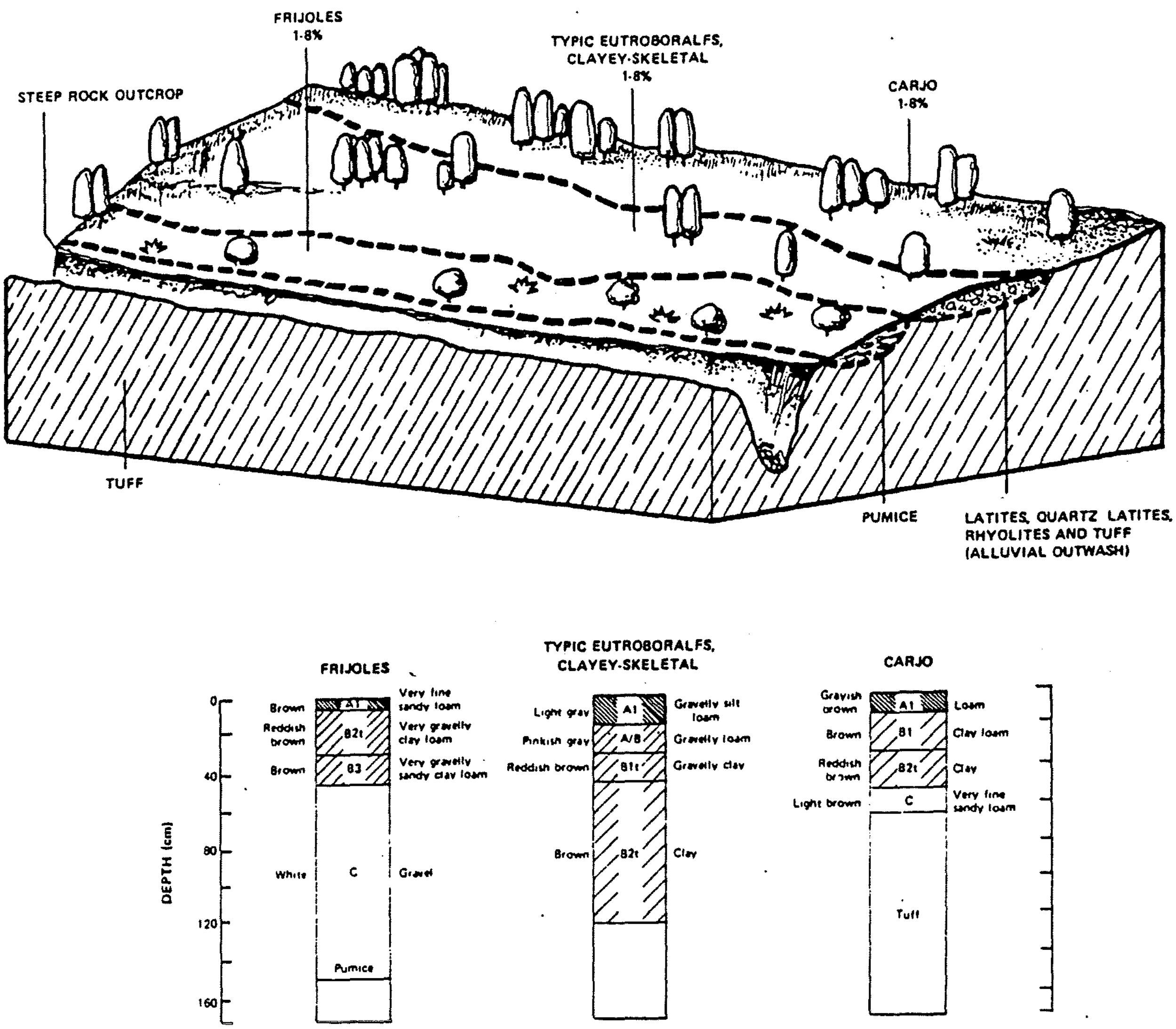

Fig. 10.

Relationship of slope, vegetation, and parent material to Frijoles, Typic Eutroboralfs, clayey-skeletal, and Carjo soils.

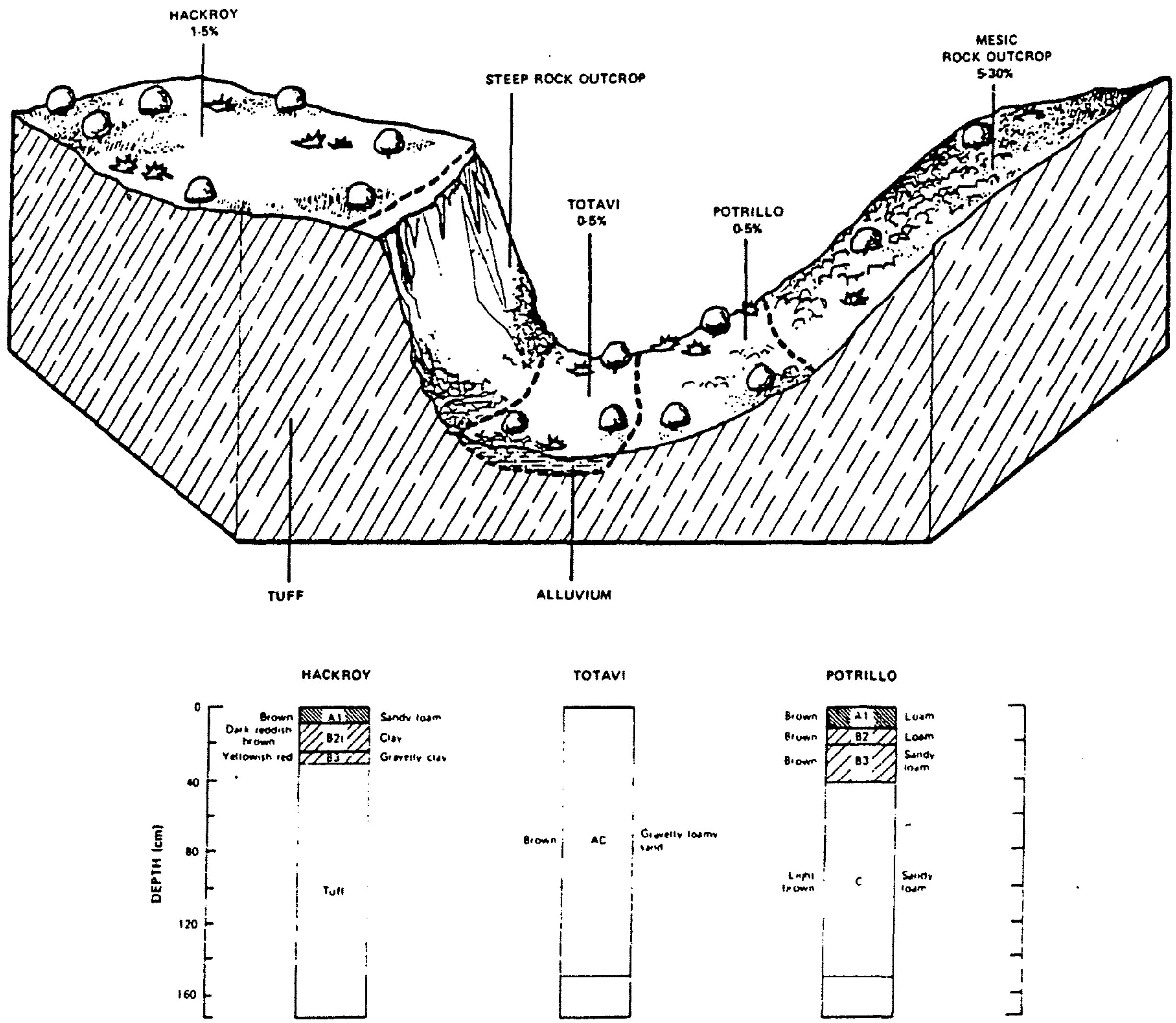

Fig. 11.
Relationship of slope, vegetation, and parent material to Hackroy, Totavi, and Potrillo soils.

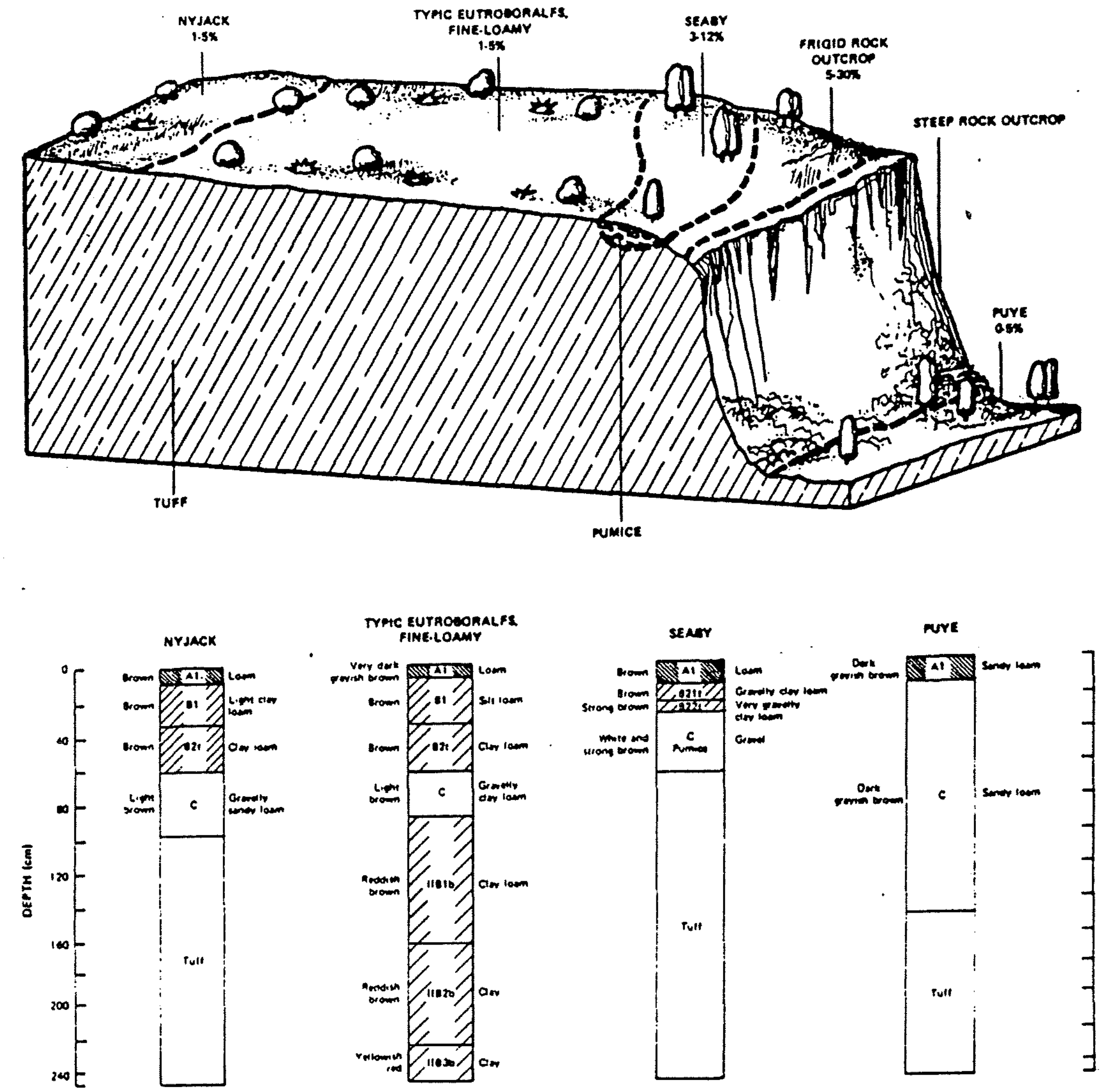

Fig. 12.

Relationship of slope, vegetation, and parent material to Nyjack, Typic Eutroboralfs, fine-loamy, Seaby, and Puye soils.

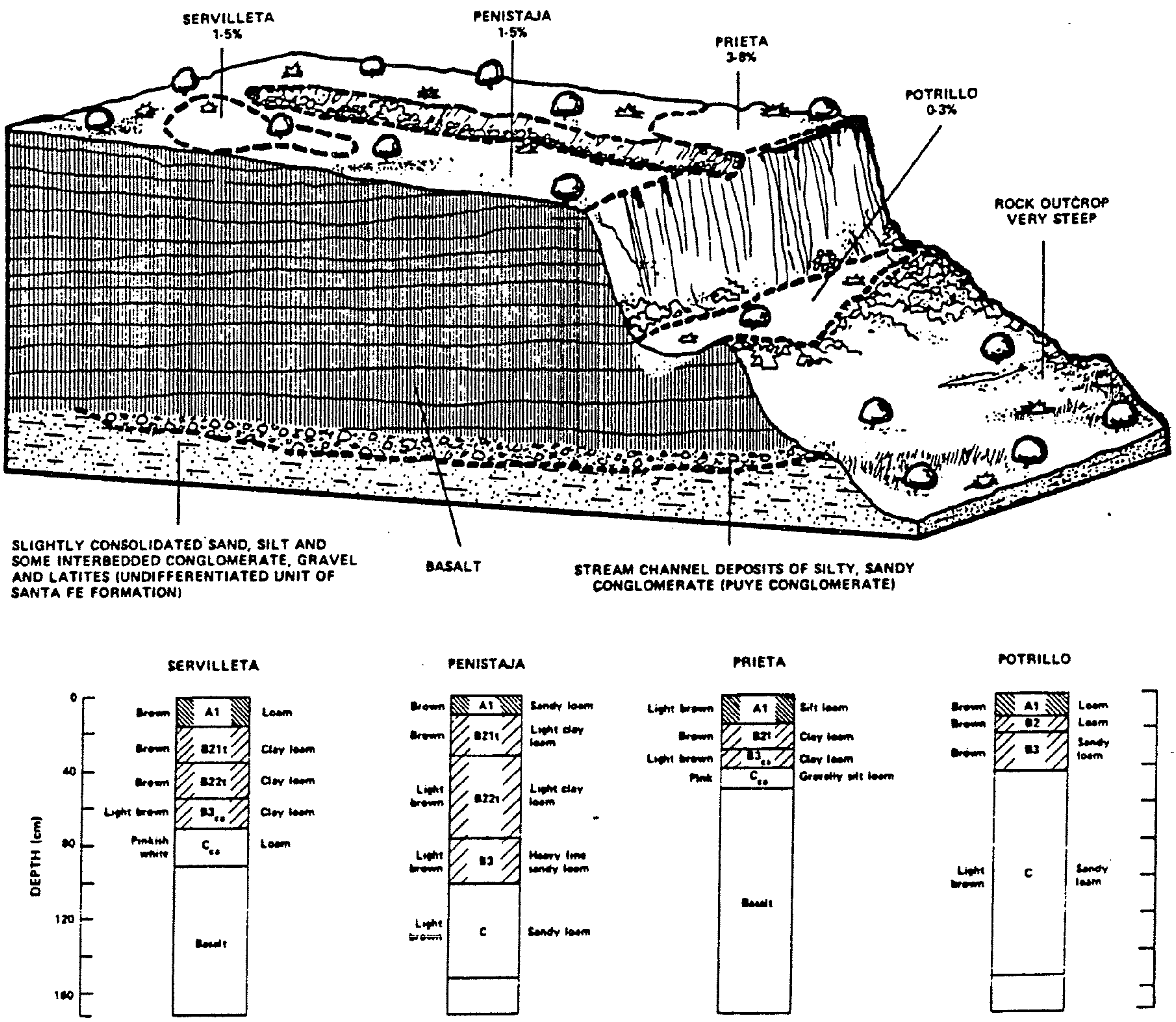

Fig. 13.
Relationship of slope, vegetation, and parent material to Servilleta, Penistaja, Prieta, and Potrillo soils.

B. Soils Described in the Forest Service Soil Survey

1. **Abrigo Series.** The Abrigo series consists of deep, well-drained soils that formed in material weathered from tuff. These soils are found on level to moderately sloping canyon bottoms (Fig. 14). Native vegetation is mainly a Douglas fir-ponderosa pine forest.

The surface layer of Abrigo soils is typically a dark grayish brown, brown, or pale brown loam about 76 cm thick. The subsoil is a light yellowish brown, very pale brown, or brownish yellow clay loam. The depth to tuff is generally greater than 153 cm, and the effective rooting depth is about 116 cm. This soil type has moderate to moderately slow permeability, high available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile description of Abrigo loam (0-15% slope) is as follows:

01,02 3-0 cm.

A11 0-14 cm, dark grayish brown (10YR 4/2) loam; very dark gray (10YR 3/1) moist; very fine and fine granular, moderate structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel; abundant very fine to fine roots; abundant very fine to fine interstitial pores; slightly acid; clear smooth boundary.

A12 14-55 cm, brown (10YR 5/3) loam, very dark gray (10YR 3/1) moist; weak fine and medium blocky structure; moderate medium granular moist; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel, 10% cobble; abundant very fine to fine roots and plentiful medium roots; abundant very fine and fine interstitial pores; slightly acid; clear smooth boundary.

A13 55-76 cm, pale brown (10YR 6/3) loam, very dark grayish brown (10YR 3/2) moist; moderate very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel; abundant very fine and fine roots, plentiful medium roots; abundant very fine and fine interstitial pores; slightly acid; clear smooth boundary.

B21t 76-92 cm, light yellowish brown (10YR 6/4) heavy clay loam, dark yellowish brown (10YR 4/4) moist; plentiful fine and medium subangular blocky structure; hard and friable moist, very sticky and plastic wet; many moderately thick clay films on ped faces; 25% gravel, 20% cobble; plentiful very fine roots, few medium roots; plentiful very fine interstitial pores, few very fine terminal pores; neutral; clear wavy boundary.

B22t 92-116 cm, very pale brown (10YR 7/3) heavy clay loam, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky structure; hard and friable moist, very sticky and plastic wet; many moderately thick clay films on ped faces; 25% gravel, 20% cobble; few very fine and medium roots; plentiful very fine interstitial pores, few very fine terminal pores; neutral; clear irregular boundary.

B3t 116-141 cm, brownish yellow (10YR 6/6) clay loam, dark yellowish brown (10YR 4/4) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, sticky and slightly plastic wet; common thin clay films on ped faces; 25% gravel, 20% cobble; very very fine interstitial pores; neutral; clear wavy boundary.

C1t 141-153+ cm, very pale brown (10YR 7/3) heavy clay loam, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and slightly plastic wet; common thin clay films on ped faces; 25% gravel, 25% cobble; plentiful very fine interstitial pores; neutral.

2. **Amstead Series.** The Amstead series consists of deep, well-drained soils that formed in materials weathered from dacites, latites, andesites, and rhyolites of the Tschicoma Formation. These soils are found on level to moderately sloping mountain sideslopes (Fig. 15). Native vegetation is mainly a Douglas fir-ponderosa pine forest.

The surface layer of Armstead soils is typically a light brownish gray loam about 6 cm thick. The subsoil is a grayish brown, very pale brown, or pink clay loam or clay, about 146 cm thick. The effective rooting depth is about 50 cm, and the soil has a moderate available water capacity. This soil type has slow to moderate permeability, moderate erodibility, and a low erosion hazard rating.

A typical profile description of Armstead loam (0-15% slope) is as follows:

01,02 2-0 cm.

A1 0-6 cm. light brownish gray (10YR 6/2) loam, dark brown (10YR 3/3) moist; weak fine and medium platy structure; nonsticky and friable moist, nonsticky and nonplastic wet; abundant very fine to fine roots, plentiful medium roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

B1 6-27 cm. grayish brown (10YR 5/2) light clay loam, dark brown (10YR 3/3) moist; weak fine and medium subangular blocky structure, moderate very fine and fine granular structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 5% gravel; plentiful very fine, fine, and medium roots, few coarse roots; plentiful very fine and fine interstitial pores; neutral; clear smooth boundary.

B21t 27-52 cm. very pale brown (10YR 8/4) heavy clay loam, yellowish brown (10YR 5/4) moist; strong fine and medium subangular blocky structure; hard and firm moist, sticky and plastic wet; few thin clay films on ped faces; 5% gravel; few very fine, fine, and medium roots; plentiful very fine and fine terminal pores; neutral; abrupt smooth boundary.

B22t 52-87 cm. pink (7.5YR 7/4) clay, pink (7.5YR 5/4) moist; strong medium and coarse angular blocky structure; very hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 10% gravel; plentiful fine and medium terminal pores; neutral; clear wavy boundary.

B23t 87-120 cm. pink (7.5YR 7/4) clay, pink (7.5YR 5/4) moist; strong fine to medium angular blocky structure; very hard and firm moist, sticky and plastic wet; many thick clay films on ped faces; 10% gravel, 5% cobble and 5% stone; few very fine and fine terminal pores; neutral; clear wavy boundary.

B24t 120-152+ cm. pink (7.5YR 7/4) clay, pink (7.5YR 5/4) moist; strong fine and medium angular blocky structure; very hard and firm moist, sticky and plastic wet; many thick clay films on ped faces; 20% gravel, 5% cobble, 15% stone; plentiful very fine and fine terminal pores; neutral.

3. Arriba-Copar Complex. The soils in this complex are deep (Arriba series) to moderately deep (Copar series) well-drained soils that formed on level to moderately sloping mesa tops (Fig. 16) with tuff as the parent material. The native vegetation of this complex is a ponderosa pine forest.

The surface layer of the Arriba soils is a grayish brown or light gray loam about 40 cm thick with a reddish yellow clay or clay loam subsoil about 90 cm thick. Depth to tuff and the effective rooting depth are about 130 cm. The Arriba soils in this complex have slow to moderate permeability, high available water capacities, a moderate erodibility index, and a low erosion hazard rating.

A typical profile of the Arriba loam (9% slope) in this complex is as follows:

01,02 3-0 cm.

A11 0-8 cm. grayish brown (10YR 5/2) loam, very dark gray (10YR 3/1) moist; moderate fine and medium platy structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 5% gravel; abundant medium, coarse, very fine, and fine roots; abundant very fine and fine interstitial pores; neutral; abrupt smooth boundary.

A12 8-24 cm. light gray (10YR 7/2) loam, brown (10YR 4/3) moist; moderate fine and medium subangular blocky structure; nonsticky and friable moist, sticky and slightly plastic wet; 5% gravel; abundant medium and coarse roots, plentiful very fine and fine roots; plentiful very fine and fine terminal and interstitial pores; neutral; clear smooth boundary.

A2 24-39 cm. light gray (10YR 7/2) loam, brown (10YR 4/3) moist; weak fine and medium platy structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 10% gravel, 5% cobble; plentiful medium, very fine, and fine roots, few coarse roots; plentiful very fine and fine terminal pores, plentiful fine and medium interstitial pores; neutral; abrupt wavy boundary.

B2t 39-81 cm. reddish yellow (7.5YR 6/8) clay, strong brown (7.5YR 5/6) moist; strong medium angular blocky structure; extremely hard and very firm moist, sticky and very plastic wet; continuous moderately thick clay films on ped faces; 5% gravel, 10% cobble, 5% stone; few medium and coarse roots, plentiful very fine and fine roots; few very fine terminal pores, plentiful very fine and fine interstitial pores; neutral; clear wavy boundary.

B3t 81-126 cm, reddish yellow (5YR 6/6) clay loam, yellowish red (5YR 5/6) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, sticky and plastic wet; common moderately thick clay films on ped faces; 10% gravel, 30% cobble, 20% stone; few medium, very fine, and fine roots; plentiful very fine, and fine interstitial pores; mildly alkaline; clear wavy boundary.

R 126+ cm, fractured tuff bedrock.

The surface layer of the Copar soils is generally a light brownish gray or light gray sandy loam about 30 cm thick, with an underlying very pale brown loamy sand substratum about 35 cm thick. Depth to tuff bedrock and the effective rooting depth are typically about 70 cm. The Copar soils in this complex have moderate to very rapid permeability, very low available water capacities, moderate erodibility, and a low erosion hazard rating.

A typical profile of the Copar sandy loam (7% slope) in this complex is described as follows:

01,02 3-0 cm.

A11 0-19 cm, light brownish gray (10YR 6/2) sandy loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium platy structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 5% gravel, 5% cobble; plentiful medium and coarse roots, abundant very fine and fine roots; plentiful fine and medium terminal pores, plentiful very fine and fine interstitial pores; neutral; clear wavy boundary.

A12 19-32 cm, light gray (10YR 7/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 40% gravel, 10% cobble; abundant medium, very fine, and fine roots, plentiful coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

C1 32-54 cm, very pale brown (10YR 7/4) loamy sand, dark yellowish brown (10YR 4/4) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 60% gravel, 20% cobble; plentiful medium and coarse roots, abundant very fine and fine roots, abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

C2 54-67 cm, very pale brown (10YR 7/4) loamy sand, dark yellowish brown (10YR 4/4) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 70% gravel, 20% cobble; plentiful medium, coarse, very fine, and fine roots; abundant very fine and fine interstitial pores; mildly alkaline; clear wavy boundary.

R 67+ cm, tuff bedrock.

4. **Atomic-Korral Complex.** The soils in this complex consist of moderately deep soils that formed in materials weathered from tuff on level to moderately sloping mesa tops (Fig. 17). Native vegetation is typically piñon-juniper woodland.

The surface layer of Atomic soils is typically a very pale brown or white loam, or sandy loam, about 40 cm thick. The subsoil is a 15-cm thick very pale brown light clay loam. The depth to bedrock and the effective rooting depth are about 60 cm. This soil has moderately slow to moderately rapid permeability, very low available water capacity, moderately high erodibility, and a low erosion hazard rating.

A typical profile of Atomic loam (5% slope) is described as follows:

A11 0-6 cm, very pale brown (10YR 7/4) loam, brown (10YR 4/3) moist; weak medium platy structure; nonsticky and very friable moist, nonsticky and slightly plastic wet; 5% gravel; abundant very fine and fine roots; abundant very fine interstitial pores; mildly alkaline; clear smooth boundary.

A12 6-29 cm, very pale brown (10YR 7/3) sandy loam, pale brown (10YR 6/3) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel; plentiful medium and coarse roots, abundant very fine and fine roots; plentiful very fine and fine interstitial pores; neutral; clear smooth boundary.

A3 29-41 cm, white (10YR 8/2) sandy loam, pale brown (10YR 6/3) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and slightly plastic wet; 5% gravel; few coarse roots, plentiful medium roots and abundant very fine and fine roots; plentiful very fine and fine terminal pores; neutral; clear wavy boundary.

B2t 41-58 cm, very pale brown (10YR 7/3) light clay loam, brown (10YR 4/3) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and slightly plastic wet; many thin clay films on ped faces; 5% gravel, 5% cobble; plentiful medium, coarse, very fine and fine roots; plentiful very fine and fine terminal pores; neutral; clear wavy boundary.

R 58+ cm, tuff bedrock.

The surface layer of Korral soils is generally a light brownish gray fine sandy loam, or sandy loam, about 15 cm thick. The subsoil is a reddish yellow clay loam, or loam, about 30 cm thick. The effective rooting depth and the depth to tuff are about 50 cm. The Korral soil associated with this complex has moderately slow to moderately rapid permeability, very low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Korral fine sandy loam (5% slope) is as follows:

A1 0-12 cm, light brownish gray (10YR 6/2) fine sandy loam, dark yellowish brown (10YR 4/4) moist; moderate fine and medium granular structure; nonsticky and friable moist, nonsticky and slightly plastic wet; 5% gravel; abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; abrupt smooth boundary.

A2 12-17 cm, light brownish gray (10YR 6/2) sandy loam, brown (10YR 4/3) moist; weak fine and medium subangular blocky structure; nonsticky and very friable moist, nonsticky and slightly plastic wet; 5% gravel; abundant very fine and fine roots, plentiful medium and coarse roots; plentiful very fine and fine interstital pores; neutral; abrupt wavy boundary.

B2t 17-36 cm, reddish yellow (7.5YR 6/6) heavy clay loam, brown (7.5YR 4/4) moist; strong fine to medium subangular blocky structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 5% gravel, 5% cobble, 5% stone; few very fine and fine roots; plentiful very fine and fine interstitial pores; neutral; clear wavy boundary.

B3 36-47 cm, reddish yellow (7.5YR 7/6) heavy loam, strong brown (7.5YR 5/6) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 20% gravel, 30% cobble, 30% stone; few very fine and fine roots; plentiful very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

R 47+ cm, tuff bedrock.

5. **Barrancas-Sanjue-Jemell Complex.** The soils in this complex consist of moderately deep (Barrancas and Jemell soils) to deep (Sanjue soils), well-drained soils that formed in materials weathered from either pumice (Barrancas and Sanjue soils) or tuff (Jemell soils). This soil complex is found on level to moderately sloping mesa tops (Fig. 18) where the native vegetation is typically a ponderosa pine forest.

The surface layer of Barrancas soils is generally a light brownish gray or light gray loam about 30 cm thick. The subsoil is about 70 cm thick and consists of a pale brown or light yellowish brown clay loam underlaid by a very pale brown loamy sand substratum. The depth to unweathered pumice and the effective rooting depth are about 100 cm. This soil series has moderate permeability, low available water capacity, moderately high erodibility, and a low erosion hazard rating.

A typical profile of Barrancas loam (3% slope) is described as follows:

01 3-0 cm.

A1 0-5 cm, light brownish gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; moderate very fine and fine granular structure; nonsticky and very friable moist, nonsticky and slightly plastic wet; 10% gravel; abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; gradual smooth boundary.

A2 5-33 cm, light gray (10YR 7/2) loam, brown (10YR 4/3) moist; moderate fine and medium granular structure; nonsticky and very friable moist, nonsticky and slightly plastic wet; 25% gravel; plentiful very fine, fine and medium roots; abundant very fine and fine interstitial pores; neutral; gradual smooth boundary.

B2t 33-74 cm. pale brown (10YR 6/3) heavy clay loam, brown (10YR 5/3) moist; moderate fine and medium subangular blocky structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 30% gravel; few very fine and medium roots; plentiful very fine and fine terminal pores; neutral; gradual smooth boundary.

B3t 74-99 cm. light yellowish brown (10YR 6/4) heavy clay loam, dark yellowish brown (10YR 4/4) moist; weak fine and medium subangular blocky structure; hard and firm moist, sticky and plastic wet; common moderately thick clay films on ped faces; 50% gravel; few very fine roots; plentiful fine terminal pores; neutral; gradual smooth boundary.

C1 99-152+ cm. very pale brown (10YR 7/4) loamy sand (unweathered pumice), brownish yellow (10YR 6/6) moist; massive structure; loose and moist, nonsticky and nonplastic wet; 80% gravel; abundant very fine and fine interstitial pores; neutral.

The surface layer of Sanjue soils is typically a gray or grayish brown very gravelly loam about 25 cm thick underlaid by a pumice-rich substratum, which is about 130 cm thick. Depth to unweathered pumice and the effective rooting depth are about 50 cm. The Sanjue soils in this complex have moderate to very rapid permeability, very low available water capacities, moderate erodibility, and low erosion hazard ratings.

A typical profile of Sanjue very gravelly loam (18% slope) is described as follows:

01,02 3-0 cm.

A11 0-8 cm. gray (10YR 5/1) very gravelly loam, very dark gray (10YR 3/1) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel; abundant fine and very fine roots, few medium roots; abundant very fine and fine interstitial pores; neutral; abrupt smooth boundary.

A12 8-25 cm. grayish brown (10YR 5/2) very gravelly loam, dark grayish brown (10YR 4/2) moist; weak fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel, 5% cobble; plentiful very fine, fine, and medium roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

C1 25-51 cm. single grain structure; loose and very friable moist, nonsticky and nonplastic wet; 80% gravel, 5% cobble; few very fine, fine, medium and coarse roots; abundant fine and medium interstitial pores; gradual smooth boundary.

C2 51-152+ cm. single grain structure; loose and very friable moist, nonsticky and nonplastic wet; 90% gravel, 5% cobble.

The Jemell soil's surface layer is usually a light brownish gray or light gray fine sandy loam about 15 cm thick. The subsoil is about 25 cm thick and consists of a reddish brown clay loam underlaid by a reddish brown substratum about 50 cm thick. The depth to tuff and the effective rooting depth are about 140 cm. The Jemell soils have moderately rapid to moderately slow permeability, moderate available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Jemell fine sandy loam (9% slope) is described as follows:

01 3-0 cm.

A1 0-5 cm. light brownish gray (10YR 6/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium platy structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel; abundant very fine roots; abundant medium interstitial pores; neutral; clear smooth boundary.

A2 5-13 cm. light gray (10YR 7/2) fine sandy loam, brown (10YR 5/3) moist; weak fine subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel; plentiful very fine and fine roots; abundant medium interstitial pores, very fine interstitial and terminal pores; neutral; abrupt irregular boundary.

B2t 13-36 cm. reddish brown (5YR 4/3) clay loam, dark reddish brown (5YR 3/3) moist; moderate fine and medium prismatic and subangular blocky structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces and in interstitial pores; 5% gravel; abundant fine and medium roots, few coarse roots; abundant very fine interstitial pores; neutral; abrupt irregular boundary.

C1t 36-86 cm, reddish brown (5YR 5/3) light clay loam, reddish brown (5YR 4/4) moist; massive structure; hard and firm moist, sticky and plastic wet; many thin clay films in interstitial pores; few fine and medium roots; plentiful very fine interstitial pores; neutral.

R 86-137+ cm, white (7.5YR 8/0) tuff bedrock, brown (7.5YR 5/2) moist; seams of clay extending into the tuff fractures.

6. Boletas-Rock Outcrop Complex. The Boletas series in this complex consists of deep well-drained soils found on very steep to extremely steep mountain sideslopes (Figs. 18 and 19). The rocks of the Rock Outcrop portion of this complex consist of rhyolites of the Tschicoma Formation, which also make up the parent materials of the Boletas soils. The native vegetation of this complex is a piñon-juniper woodland.

The surface layer of Boletas soils is a pale brown or very pale brown loam about 20 cm thick. The subsoil consists of a light brown or reddish yellow, clay or clay loam, about 76 cm thick, underlaid by a reddish yellow clay loam substratum about 30 cm thick. The depth to bedrock and the effective rooting depth are about 120 cm. The Boletas soils have slow to moderate permeability, high available water capacity, moderate erodibility, and a moderate erosion hazard rating.

A typical profile of Boletas stony loam (43% slope) is described as follows:

A11 0-5 cm, pale brown (10YR 6/3) stony loam, dark brown (10YR 3/3) moist; moderate very fine granular structure; nonsticky and friable moist, nonsticky and slightly plastic wet; 15% gravel, 20% cobble, 10% stone; plentiful very fine and fine roots; abundant very fine and fine interstitial pores; strongly alkaline; abrupt smooth boundary.

A12 5-8 cm, very pale brown (10YR 7/3) loam, yellowish brown (10YR 5/4) moist; moderate fine and medium granular structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 15% gravel, 30% cobble; plentiful very fine and fine roots, few medium roots; abundant very fine and fine interstitial pores; strongly alkaline; clear smooth boundary.

B21t 18-33 cm, light brown (7.5YR 6/4) clay, reddish yellow (7.5YR 6/6) moist; strong fine and medium angular blocky structure; hard and firm moist, sticky and plastic wet; many thin clay films on ped faces; 20% gravel, 10% cobble; few very fine, fine, medium, and coarse roots; plentiful very fine and fine terminal pores; strongly alkaline; clear smooth boundary.

B22t 33-58 cm, light brown (7.5YR 6/4) clay, reddish yellow (7.5YR 6/6) moist; moderate fine and medium angular blocky structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 20% gravel, 10% cobble, 5% stone; few very fine and fine roots; few fine terminal pores; moderately alkaline; clear smooth boundary.

B3t 58-94 cm, reddish yellow (5YR 6/6) heavy clay loam, reddish yellow (5YR 6/8) moist; weak fine and medium subangular blocky structure; hard and firm moist, sticky and slightly plastic wet; many moderately thick clay films on ped faces; 20% gravel, 30% cobble, 10% stone; few very fine and fine roots; few fine terminal pores; moderately alkaline; gradual smooth boundary.

C1 94-122 cm, reddish yellow (5YR 6/6) clay loam, reddish yellow (5YR 6/8) moist; massive structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films in interstitial pores; 10% gravel, 30% cobble, 40% stone; few very fine roots; few very fine interstitial pores; moderately alkaline.

R 122+ cm, rhyolite bedrock.

7. Cabra Series. The Cabra soils are classified into two mapping units on the basis of slope: Cabra stony loam, 0-15% slope (level to moderately sloping land) and Cabra stony loam, 16-40% slope (moderately steep to very steep land). Both mapping units are deep soils formed in materials weathered from dacites and latites of the Tschicoma Formation and found on mountain sideslopes with ponderosa pine vegetation (Figs. 15 and 19).

The surface layer of the Cabra series found on 0-15% slopes is typically a gray clay loam about 5 cm thick. The subsoil of this mapping unit is usually about 60 cm thick and consists of a light yellowish brown, reddish yellow, or pink clay loam, clay, or sandy loam. The substratum consists of a reddish yellow loamy sand about 55 cm thick. This soil has slow to moderately slow permeability, low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Cabra stony clay loam (0-15% slope) is described as follows:

01,02 2-0 cm.

A1 0-6 cm, gray (10YR 6/1) stony light clay loam, very dark gray (10YR 3/1) moist; weak medium platy structure; nonsticky and very friable moist, sticky and slightly plastic wet; 10% gravel, 10% cobble, 15% stone; abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; abrupt wavy boundary.

B1 6-23 cm, light yellowish brown (10YR 6/4) stony light clay loam, dark yellowish brown (10YR 4/4) moist; moderate fine and medium subangular blocky structure; nonsticky and friable moist, very sticky and slightly plastic wet; 10% gravel, 10% cobble, 15% stone; abundant very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine terminal pores; neutral; clear wavy boundary.

B2t 23-39 cm, reddish yellow (7.5YR 7/6) stony clay, brown (7.5YR 5/4) moist; strong medium angular blocky structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 10% gravel, 20% cobble, 20% stone; plentiful very fine and fine roots, abundant medium and coarse roots; plentiful very fine and fine interstitial pores; mildly alkaline; clear wavy boundary.

B3t 39-67 cm, pink (7.5YR 7/4) stony sandy loam, strong brown (7.5YR 5/6) moist; weak fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and nonplastic wet; common thin clay films on ped faces; 25% gravel, 25% cobble, 20% stone; plentiful very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores; mildly alkaline; clear wavy boundary.

C1t 67-93 cm, reddish yellow (7.5YR 8/6) stony loamy sand, reddish yellow (7.5YR 6/6) moist; massive structure; slightly hard and friable moist, nonsticky and nonplastic wet; few thin clay films on ped faces; 20% gravel, 25% cobble, 30% stone; few very fine and fine roots, plentiful medium and coarse roots; plentiful very fine and fine interstitial pores; moderately alkaline; clear irregular boundary.

C2 93-123 cm, reddish yellow (7.5YR 7/6) stony loamy sand, strong brown (7.5YR 5/8) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 20% gravel, 30% cobble, 40% stone; plentiful very fine and fine interstitial pores; strongly alkaline; clear irregular boundary.

R 123+ cm, dacite bedrock.

The Cabra series with 16-40% slopes generally has a brown, pinkish gray, or light brownish gray sandy loam surface soil about 35 cm thick. The subsoil of this mapping unit is a light brown, pinkish gray, brown, or strong brown clay loam or clay. Depth to dacite and latite bedrock and the effective rooting depth are greater than 150 cm. This soil has moderate to slow permeability and high available water capacity.

A typical profile of Cabra stony loam (16-40% slope) is described as follows:

01,02 4-0 cm.

A1 0-13 cm, brown (7.5YR 5/2) stony fine sandy loam, brown (7.5YR 4/2) moist; weak fine and medium platy structure; moderate fine granular structure; sticky and friable moist, nonsticky and nonplastic wet; 10% gravel, 10% cobble, 5% stone; abundant very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; neutral; abrupt wavy boundary.

A21 13-23 cm, pinkish gray (10YR 6/2) stony very fine sandy loam, gray brown (10YR 5/2) moist; weak fine and medium subangular blocky structure; slightly hard and firm moist, slightly sticky and nonplastic wet; 10% gravel, 10% cobble, 5% stone; abundant very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores, plentiful fine and medium terminal pores; neutral; clear wavy boundary.

A22 23-34 cm, light brownish gray (10YR 6/2) stony very fine sandy loam, pale brown (10YR 6/3) moist; weak fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and nonplastic wet; 10% gravel, 10% cobble, 5% stone; plentiful very fine and fine roots, abundant medium and coarse roots; moderate very fine and fine interstitial pores, moderate fine and medium terminal pores; neutral; clear wavy boundary.

B1t 34-50 cm, light brown (7.5YR 6/4) heavy clay loam, brown (7.5YR 5/4) moist; moderate fine subangular blocky structure; slightly hard and friable moist, sticky and slightly plastic wet; common thin clay films on ped faces; 15% gravel, 15% cobble, 5% stone; plentiful very fine and fine roots, abundant medium and coarse roots; plentiful very fine and fine interstitial pores, plentiful fine and medium terminal pores; neutral; clear wavy boundary.

B21t 50-64 cm, pinkish gray (7.5YR 6/2) heavy clay loam, brown (7.5YR 5/4) moist; moderate fine and medium subangular blocky structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 10% gravel, 20% cobble, 5% stone; plentiful very fine, fine, and coarse roots, abundant medium roots; plentiful very fine and fine interstitial pores; neutral; clear wavy boundary.

B22t 64-104 cm, brown (7.5YR 5/4) heavy clay loam, brown (7.5YR 4/4) moist; moderate fine and medium subangular blocky structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 20% gravel, 15% cobble, 10% stone; plentiful very fine, fine, and medium roots, few coarse roots; few very fine and fine interstitial pores; neutral; abrupt wavy boundary.

B23t 104-150+ cm, strong brown (7.5YR 5/6) clay, brown (7.5YR 4/4) moist; moderate very fine and fine angular blocky structure; hard and firm moist, sticky and plastic wet; continuous moderately thick clay films on ped faces; 10% gravel, 20% cobble, 5% stone; few very fine, fine, medium and coarse roots; few very fine and fine interstitial pores; neutral.

8. Comada-Bayo Complex. The soils in this complex are deep well-drained soils that formed on level to moderately sloping mesa tops (Fig. 17) with either tuff (Comada series) or pumice (Bayo series) as parent materials. The dominant native vegetation of this soil complex is a piñon-juniper woodland.

The surface layer of the Comada soils is typically a light brown very fine sandy loam about 10 cm thick. The subsoil is generally a brown or light brown silty clay, clay, clay loam, or sandy clay loam about 80 cm thick, underlaid by a very pale brown sandy loam substratum about 35 cm thick. The depth to tuff bedrock and the effective rooting depth are about 120 cm. The Comada soils in this complex have slow to moderate permeability and moderate available water capacity.

A typical profile of Comada very fine sandy loam (4% slope) is described as follows:

A1 0-8 cm, light brown (7.5YR 6/4) gravelly very fine sandy loam, brown (7.5YR 5/4) moist; moderate fine and medium platy structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel; few medium roots, plentiful very fine and fine roots; abundant very fine and fine interstitial pores; mildly alkaline; abrupt smooth boundary.

B1 8-15 cm, brown (7.5YR 5/4) silty clay loam, brown (7.5YR 4/4) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, sticky and plastic wet; 10% gravel; few coarse roots, plentiful very fine and fine roots; plentiful very fine and fine interstitial pores; neutral; abrupt smooth boundary.

B21t 15-41 cm, brown (7.5YR 5/4) clay, brown (7.5YR 4/4) moist; strong fine and medium prismatic structure; hard and firm moist; sticky and plastic wet; common moderately thick clay films on ped faces; plentiful medium and coarse roots, few very fine and fine roots; plentiful fine and medium interstitial pores; moderately alkaline; abrupt smooth boundary.

B22 41-56 cm, light brown (7.5YR 6/4) heavy clay loam, brown (7.5YR 5/4) moist; strong medium angular blocky structure; hard and firm moist, sticky and plastic wet; 10% gravel; few very fine and fine roots; plentiful very fine and fine interstitial pores; strongly alkaline; clear wavy boundary.

B3 56-86 cm, light brown (7.5YR 6/4) gravelly sandy clay loam, brown (7.5YR 4/4) moist; moderate fine and medium angular blocky structure; hard and firm moist, slightly sticky and slightly plastic wet; 15% gravel; few very fine and fine roots; plentiful very fine and fine terminal pores; strongly alkaline; clear wavy boundary.

C1 86-122 cm, very pale brown (10YR 7/3) gravelly sandy loam, yellowish brown (10YR 5/4) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 20% gravel; few very fine, fine, and medium roots; abundant very fine and fine terminal pores; strongly alkaline; clear wavy boundary.

R 122+ cm, tuff bedrock.

The surface layer of the Bayo soils is typically a pale brown or light gray very gravelly loam, or sandy loam, about 30 cm thick. The substratum is greater than 120 cm thick and consists of a very pale brown or white, very gravelly loamy sand or sand with a high pumice content. The Bayo soils in this complex have moderate to very rapid permeability and a very low available water capacity, with an effective rooting depth of greater than 150 cm.

A typical profile of the Bayo very gravelly loam (15% slope) is described as follows:

A11 0-15 cm, pale brown (10YR 6/3) very gravelly loam, dark grayish brown (10YR 4/2) moist; moderate very fine and fine granular structure; sticky and friable moist, nonsticky and nonplastic wet; 60% gravel; few medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A12 15-30 cm, light gray (10YR 7/2) very gravelly sandy loam, brown (10YR 4/3) moist; moderate very fine and fine granular structure; sticky and friable moist, nonsticky and nonplastic wet; 70% gravel; few coarse roots, abundant medium, very fine, and fine roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

C1 30-48 cm, very pale brown (10YR 7/3) very gravelly loamy sand, yellow (10YR 7/6) moist; massive structure; sticky and friable moist, nonsticky and nonplastic wet; 80% gravel; few coarse roots, plentiful medium roots, abundant very fine and fine roots; abundant fine and medium interstitial pores; neutral; gradual irregular boundary.

C2 48-152+ cm, white (10YR 8/1) very gravelly sand (pumice); massive structure; 95% gravel; few very fine and fine roots, plentiful medium and coarse roots; abundant fine, medium, and coarse interstitial pores.

9. Cuervo Series. The Cuervo soils are classified into two mapping units on the basis of slope, as with the Cabra soils: Cuervo gravelly loam, 0-15% slope (level to moderately sloping land) and Cuervo gravelly loam, 16-40% slope (moderately steep to very steep land). Moderately deep soils forming on mountain sideslopes in tuff make up both mapping units, which are found in a Douglas fir-Engelmann spruce forest (Fig. 14).

The Cuervo soil series found on 0-15% slopes typically has a gray or light gray gravelly loam or sandy loam topsoil about 40 cm thick. The subsoil is about 30 cm thick and consists of a very pale brown sandy loam, with a depth to tuff bedrock and an effective rooting depth of about 70 cm. This soil has moderate to moderately rapid permeability, very low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Cuervo gravelly loam (12% slope) is described as follows:

01,02 7-0 cm.

A1. 0-10 cm, gray (10YR 6/1) gravelly loam, very dark grayish brown (10YR 3/2) moist; weak medium and coarse platy structure; nonsticky and friable moist, slightly sticky and nonplastic wet; 25% gravel; abundant very fine, fine, medium and coarse roots; abundant very fine and fine interstitial pores; slightly acid; clear smooth boundary.

A2 10-39 cm, light gray (10YR 7/2) coarse sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; nonsticky and friable moist, slightly sticky and nonplastic wet; 35% gravel, 5% cobble; abundant very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

B2 39-71 cm, very pale brown (10YR 7/4) coarse sandy loam, brown (10YR 4/3) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, slightly sticky and nonplastic wet; 30% gravel, 15% cobble, 15% stone; plentiful very fine, fine, and medium roots; plentiful very fine and fine interstitial pores; slightly acid; clear wavy boundary.

R 71+ cm, densely welded tuff bedrock.

The Cuervo soils on 16-40% slopes generally have a grayish brown loam topsoil about 5 cm thick. The subsoil consists of a light brownish gray or pale brown clay loam, loam, or silt loam about 95 cm thick. The depth to densely welded tuff and the effective rooting depth are about 100 cm. This soil has moderate to moderately slow permeability, moderate available water capacity, moderate erodibility, and a moderate erosion hazard rating.

A typical profile of Cuervo gravelly loam (18% slope) is described as follows:

01,02 7-0 cm, abrupt smooth boundary.

A1 0-6 cm, grayish brown (10YR 5/2) gravelly loam, very dark gray (10YR 3/1) moist: moderate fine and medium granular structure; sticky and friable moist, nonsticky and nonplastic wet: 20% gravel; abundant very fine, fine, medium, and coarse roots; abundant very fine and fine medium and interstitial pores: neutral; clear wavy boundary.

B21 6-28 cm, light brownish gray (10YR 6/2) gravelly light clay loam, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky structure; nonsticky and friable moist, slightly sticky and nonplastic wet; 20% gravel, 20% cobble, 15% stone; abundant very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores; neutral; clear wavy boundary.

B22 20-70 cm, pale brown (10YR 6/3) gravelly loam, dark yellowish brown (10YR 4/4) moist; moderate fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 30% gravel, 20% cobble, 20% stone; plentiful very fine, fine, medium, and coarse roots; moderate very fine and fine interstitial pores; neutral; clear wavy boundary.

B23 70-99 cm, pale brown (10YR 6/3) gravelly silt loam, dark yellowish brown (10YR 4/4) moist; weak medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 30% gravel, 20% cobble, 20% stone; few very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores, plentiful fine terminal pores; neutral; clear wavy boundary.

R 99+ cm, densely welded tuff bedrock.

10. Dacite Series. The Dacite soils are deep, well-drained soils found on level to moderately sloping canyon bottoms (Fig. 20). These soils have formed in alluvial parent materials in a ponderosa pine forest.

The surface layer of Dacite soils is frequently a gray very gravelly sandy loam about 25 cm thick with a very dark gray, very dark grayish brown, or dark brown gravelly loamy sand substratum greater than 130 cm thick. This soil has a moderately rapid to very rapid permeability, and a low available water capacity.

A typical profile of a Dacite very gravelly sandy loam (0-15% slope) is described as follows:

A1 0-24 cm, gray (10YR 5/1) very gravelly light sandy loam, very dark gray (10YR 3/1) moist; weak fine and medium subangular blocky and granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 40% gravel; abundant very fine and fine roots, plentiful medium roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

C1 24-64 cm, gray (10YR 5/1) very gravelly loamy sand, very dark gray (10YR 3/1) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 45% gravel, 5% cobble; plentiful very fine, fine, and medium roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

C2 64-82 cm, gray (10YR 6/1) gravelly loamy sand, very dark grayish brown (10YR 3/2) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel; few very fine, fine, and medium roots; abundant very fine and fine interstitial pores; mildly alkaline; abrupt wavy boundary.

C3 82-127 cm, gray (10YR 6/1) gravelly loamy sand, very dark grayish brown (10YR 3/2) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 25% gravel; few very fine and fine roots; abundant very fine and fine interstitial pores; mildly alkaline; gradual wavy boundary.

C4 127-152+ cm, light brownish gray (10YR 6/2) gravelly loamy sand, dark brown (10YR 3/3) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 30% gravel; few very fine and fine roots; abundant very fine and fine interstital pores; mildly alkaline.

11. Emod Series. The Emod series consists of deep, well-drained soils that formed in materials weathered dominantly from dacites, which were water-laid over pumice and ash deposits. These soils are found on moderately steep to very steep upland areas (Fig. 21) where the native vegetation is piñon-juniper woodland.

The surface layers of Emod soils are generally a light brownish gray or light gray stony sandy loam, or loamy sand, about 30 cm thick. The substratum is greater than 125 cm thick and is composed of white pumice deposits. The Emod series has moderately rapid to very rapid permeability, very low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Emod stony sandy loam (16-40% slope) is described as follows:

A11 0-16 cm, light brownish gray (10YR 6/2) stony sandy loam, light brownish gray (10YR 4/3) moist; weak fine and medium granular structure; nonsticky and very friable moist, nonsticky and slightly plastic wet; 30% gravel, 20% cobble, 10% stone; abundant very fine and fine roots, few medium and coarse roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A12 16-28 cm, light gray (10YR 7/2) loamy sand, light yellowish brown (10YR 6/4) moist; weak fine granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 80% gravel; abundant very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine interstitial pores; mildly alkaline; abrupt smooth boundary.

C1 28-51 cm, white (10YR 8/1) sand, white (10YR 8/1) moist; massive structure; hard and firm moist, nonsticky and nonplastic wet; 95% gravel; abundant fine and medium interstitial pores; gradual smooth boundary.

C2 51-153+ cm, white (10YR 8/1) sand, white (10YR 8/1) moist; massive structure; hard and firm moist, nonsticky and nonplastic wet; 95%+ gravel; abundant fine and medium interstitial pores.

12. Griegos Series. The Griegos soils are classified into two mapping units on the basis of slope, just like the Cabra and Cuervo soils: Griegos cobbly loam, 16-40% slope (moderately steep to very steep topography) and Griegos cobbly loam, 41-80% slope (very steep to extremely steep land). Both mapping units consist of deep, well drained soils forming in dacites, latites, and andesites of the Tschicoma Formation on mountain slopes vegetated with Engelmann spruce and Douglas fir (Fig. 15).

The surface layers of Griegos soils found on the 16-40% slopes are typically a dark brown, brown or light gray cobbly loam, fine sandy loam, or sandy clay loam about 50 cm thick. The subsoil is a very pale brown or light yellowish brown cobbly sandy loam or sandy clay loam about 75 cm thick underlaid by a light yellowish brown very cobbly sandy loam about 20 cm thick. The depth to bedrock and the effectve rooting depth are about 150 cm. This soil has moderate to moderately rapid permeability, moderate available water capacity, moderate erodibility and a moderate erosion hazard rating.

A typical profile of Griegos cobbly loam (16-40% slope) is described as follows:

01,02 4-0 cm, abrupt smooth boundary.

A11 0-7 cm, dark brown (10YR 4/3) cobbly loam, very dark grayish brown (10YR 3/2) moist; weak medium and fine granular structure; sticky and friable moist, nonsticky and nonplastic wet; 10% gravel, 10% cobble; abundant very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

A12 7-31 cm, brown (10YR 5/3) heavy fine sandy loam, brown (10YR 4/3) moist; moderate medium subangular blocky structure; sticky and friable moist, nonsticky and nonplastic wet; 10% gravel, 15% cobble, 5% stone; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A2 31-51 cm, light gray (10YR 7/2) cobbly light sandy clay loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; sticky and friable moist, slightly sticky and nonplastic wet; 15% gravel, 15% cobble, 5% stone; plentiful very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores; neutral; clear smooth boundary.

B21 51-64 cm, very pale brown (10YR 7/3) cobbly fine sandy loam, brown (10YR 5/3) moist; weak medium subangular blocky structure; sticky and friable moist, nonsticky and nonplastic wet; 10% gravel, 20% cobble, 5% stone; few very fine and fine roots; plentiful medium and coarse roots; plentiful very fine and fine interstitial pores; neutral; clear smooth boundary.

B22 64-88 cm, light yellowish brown (10YR 6/4) cobbly heavy sandy clay loam, yellowish brown (10YR 5/4) moist; weak medium subangular blocky structure; sticky and friable moist, very sticky and nonplastic wet; 20% gravel, 40% cobble, 5% stone; few very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores, few medium terminal pores; neutral; clear wavy boundary.

B23 88-128 cm, very pale brown (10YR 7/4) very cobbly heavy sandy loam, yellowish brown (10YR 5/6) moist; weak medium and fine granular structure; sticky and friable moist, slightly sticky and nonplastic wet; 20% gravel, 60% cobble, 5% stone; few very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores; neutral; clear wavy boundary.

C1 128-150+ cm, light yellowish brown (10YR 6/4) very cobbly heavy sandy loam, brownish yellow (10YR 6/6) moist; massive structure; sticky and friable moist, nonsticky and nonplastic wet; 20% gravel, 60% cobble, 5% stone; few very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores; neutral; clear wavy boundary.

The surface layers of the Griego cobbly loam found on 41-80% slopes are generally a gray cobbly loam or sandy loam about 40 cm thick. The subsoil is also about 40 cm thick and consists of a gray sandy loam underlaid by a gray loamy sand substratum about 75 cm thick. The depth to bedrock and the effective rooting depth are greater than 150 cm. This mapping unit has a similar permeability, available water capacity, and erodibility as previously discussed for the Griegos soils found on 16-40% slopes, but has a high erosion hazard rating due to the steeper topography on which this soil occurs.

A typical profile of Griegos cobbly loam (41-80% slope) is described as follows:

01,02 3-0 cm.

A1 0-13 cm, gray (10YR 6/1) cobbly loam, gray (10YR 5/1) moist; moderate fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 40% gravel, 10% cobble, 5% stone; plentiful medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A2 13-41 cm, gray (10YR 6/1) sandy loam, dark gray (10YR 4/1) moist; weak fine granular or massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel, 10% cobble, 5% stone; plentiful medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine terminal pores; neutral; clear smooth boundary.

B2 41-79 cm, gray (10YR 6/1) sandy loam, dark gray (10YR 4/1) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel, 15% cobble, 10% stone; plentiful medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine terminal pores; mildly alkaline; clear wavy boundary.

C1 79-152 cm, gray (10YR 6/1) loamy sand, gray (10YR 5/1) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 65% gravel, 15% cobble, 5% stone; few medium and coarse roots, plentiful very fine and fine roots; mildly alkaline.

13. Kwage-Pelado-Rock Outcrop Complex. The soils in this complex are deep well-drained soils that formed on very steep to extremely steep mountain slopes with dacites of the Tschicoma Formation as parent materials (Fig. 22). The native vegetation of this soil complex is dominantly a Douglas fir-ponderosa pine forest.

The surface layers of the Kwage soils in this complex are generally a light gray, white, or light yellowish brown sandy loam or loamy sand about 70 cm thick. The substratum is a brownish yellow or very pale brown loamy sand about 80 cm thick. The depth to dacite bedrock and the effective rooting depth are greater than 150 cm. The Kwage soils in this complex have moderately rapid to very rapid permeability, low available water capacity, moderate erodibility, and a moderate erosion hazard rating.

A typical profile of Kwage stony sandy loam (68% slope) is described as follows:

01,02 3-0 cm.

A1 0-5 cm, light gray (10YR 7/2) heavy sandy loam, dark grayish brown (10YR 4/2) moist; weak fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 40% gravel, 10% cobble, 10% stone; abundant very fine and fine roots, plentiful medium roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A21 5-14 cm, white (10YR 8/2) sandy loam, brown (10YR 5/3) moist; weak medium and coarse granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 40% gravel, 15% cobble, 15% stone; abundant very fine, fine, medium, and coarse roots; abundant fine and medium interstitial pores; neutral; clear wavy boundary.

A22 14-30 cm, light gray (10YR 7/2) sandy loam, brown (10YR 5/3) moist; weak medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel, 15% cobble, 10% stone; abundant very fine, fine, medium, and coarse roots; abundant fine and medium interstitial pores; neutral; clear wavy boundary.

A3 30-72 cm, light yellowish brown (10YR 6/4) loamy sand, dark brown (10YR 3/3) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel, 15% cobble, 5% stone; abundant very fine, fine, medium, and coarse roots; abundant fine and medium interstitial pores; mildly alkaline; clear wavy boundary.

C1t 72-115 cm, brownish yellow (10YR 6/6) loamy sand, dark yellowish brown (10YR 4/4) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 60% gravel, 20% cobble, 15% stone; abundant very fine, fine, and medium roots, plentiful coarse roots; abundant medium and coarse interstitial pores; neutral; clear wavy boundary.

C2t 115-153 cm, very pale brown (10YR 7/3) loamy sand, dark yellowish brown (10YR 4/4) moist; weak very fine and fine subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 60% gravel, 20% cobble, 15% stone; plentiful very fine, fine, and medium roots; abundant very fine and fine interstitial pores; mildly alkaline.

The surface layers of Pelado soils are a dark grayish brown or light brownish gray loam about 65 cm thick. The subsoil is a very pale brown or light yellowish brown sandy loam or loamy sand, about 60 cm thick underlaid by a light yellowish brown sandy loam substratum greater than 30 cm thick. The depth to dacite bedrock is greater than 150 cm, and the effective rooting depth is about 120 cm. The Pelado soils in this complex have moderate to moderately rapid permeability, high available water capacity, moderate erodibility, and a moderate erosion hazard rating.

A typical profile of Pelado loam (64% slope) is described as follows:

01,02 4-0 cm.

A1 0-15 cm, dark grayish brown (10YR 4/2) loam, very dark gray (10YR 3/1) moist; weak fine and medium subangular blocky structure, moderate fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 10% gravel, 5% cobble; abundant very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine interstitial pores; clear smooth boundary.

A21 15-40 cm, light brownish gray (10YR 6/2) loam, brown (10YR 4/3) moist; moderate fine and medium subangular blocky structure, weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 25% gravel, 10% cobble; abundant very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine interstitial pores; clear smooth boundary.

A22 40-64 cm, light brownish gray (10YR 6/2) loam, brown (10YR 4/3) moist; weak very fine and fine subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 40% gravel, 50% cobble; plentiful very fine, fine, and medium roots, few coarse roots; abundant very fine and fine interstitial pores; clear wavy boundary.

B21 64-105 cm, very pale brown (10YR 7/4) coarse sandy loam, light yellowish brown (10YR 6/4) moist; moderate fine and medium subangular blocky structure; moderate fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and slightly plastic wet; 30% gravel, 10% cobble; few very fine, fine, and medium roots; moderate very fine and fine interstitial pores; clear wavy boundary.

B22t 105-122 cm, light yellowish brown (10YR 6/4) loamy sand, yellowish brown (10YR 5/4) moist; massive structure: nonsticky and very friable moist, nonsticky and nonplastic wet; few thin clay films on ped faces; 90% gravel, 5% cobble; abundant very fine and fine roots, few medium roots; abundant medium and coarse interstitial pores; clear wavy boundary.

C1t 122-152 cm, light yellowish brown (10YR 6/4) sandy loam, yellowish brown (10YR 5/4) moist; weak fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and slightly plastic wet; few thin clay films on ped faces; 25% gravel, 10% cobble; abundant very fine and fine interstitial pores.

14. **Latas Series.** The Latas soils are deep, well-drained soils that formed in materials weathered from tuff. These soils are found on level to moderately sloping mountain sideslopes where ponderosa pine is the dominant overstory vegetation (Fig. 16).

The surface layers of Latas soils are typically a pale brown gravelly sandy loam or gravelly loamy sand about 60 cm thick. The substratum is greater than 110 cm thick and consists of a pale brown gravelly loamy sand. The Latas soils have moderately rapid to very rapid permeability, a low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Latas gravelly sandy loam (8% slope) is described as follows:

01,02 3-0 cm.

A11 0-9 cm, pale brown (10YR 6/3) gravelly sandy loam, brown (10YR 4/3) moist; moderate fine and medium granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 25% gravel; abundant very fine and fine roots; abundant very fine and fine interstitial pores; moderately alkaline; clear smooth boundary.

A12 9-58 cm, very pale brown (10YR 7/3) gravelly loamy sand, dark yellowish brown (10YR 4/4) moist; weak fine and medium granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 25% gravel; abundant very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; moderately alkaline; gradual smooth boundary.

C1 58-91 cm, pale brown (10YR 6/3) gravelly loamy sand, dark yellowish brown (10YR 4/4) moist; massive structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 25% gravel; abundant very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine interstitial pores; moderately alkaline; gradual smooth boundary.

C2 91-168+ cm, very pale brown (10YR 7/3) gravelly loamy sand, dark yellowish brown (10YR 4/4) moist; massive structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 25% gravel; plentiful very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; moderately alkaline.

15. **Pelado Series.** The Pelado series consists of deep, well-drained soils that formed in materials weathered from dacites of the Tschicoma Formation (Fig. 22). This mapping unit differs from the Pelado soils found in the Kwage-Pelado-Rock Outcrop complex in that these soils are found only on less steep mountain slopes. The native vegetation is dominantly a Douglas fir-ponderosa pine forest.

The surface layers of Pelado soils found on 41-80% slopes are generally a grayish brown, light brownish gray, or light gray loam, or clay loam, about 55 cm thick. The subsoil is about 15 cm thick and consists of a light gray clay loam underlaid by a light gray loam substratum greater than 85 cm thick. This soil has moderate to moderately slow permeability, high available water capacity, moderate erodibility, and a moderate erosion hazard rating.

A typical profile of Pelado very stony loam (60% slope) is described as follows:

01,02 3-0 cm.

A11 0-9 cm, grayish brown (10YR 5/2) very stony loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium granular structure; nonsticky and friable moist, slightly sticky and plastic wet; 20% gravel, 25% cobble, 25% stone; plentiful medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

A12 9-26 cm, light brownish gray (10YR 6/2) very stony loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium granular structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 25% gravel, 25% cobble, 20% stone; plentiful medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

A2 26-55 cm, light gray (10YR 7/2) very stony light clay loam, dark brown (10YR 3/3) moist; weak fine and medium granular structure; nonsticky and friable moist, sticky and slightly plastic wet; 30% gravel, 30% cobble, 25% stone; abundant medium, very fine, and fine roots, plentiful coarse roots; plentiful fine terminal pores; abundant very fine and fine interstitial pores; mildly alkaline; gradual irregular boundary.

B2t 55-69 cm, light gray (10YR 7/2) very stony light clay loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; nonsticky and friable moist, sticky and slightly plastic wet, few thin clay films on coarse fragments; 25% gravel, 35% cobble, 35% stone; plentiful very fine, fine, medium, and coarse roots; plentiful very fine and fine terminal pores, plentiful fine and medium interstitial pores; mildly alkaline; gradual irregular boundary.

C1 69-152+ cm, light gray (10YR 7/2) very stony loam, dark brown (10YR 3/3) moist; massive structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 25% gravel, 35% cobble, 35% stone; plentiful very fine, fine, medium, and coarse roots; plentiful fine and medium interstitial pores; neutral.

16. **Pueblo Series.** The Pueblo series consists of deep well-drained soils that formed in materials derived from welded tuffs. These soils are found on moderately steep to very steep mountain sideslopes where the native vegetation is a Douglas fir-ponderosa pine forest (Fig. 14).

The surface layers of Pueblo soils are typically a dark grayish brown or very dark grayish brown cobbly loam about 40 cm thick. The subsoil is a light gray cobbly sandy clay loam about 50 cm thick underlaid by a 60-cm thick pale brown cobbly sandy loam substratum. Pueblo soils have moderate permeability, available water capacity, erodibility, and erosion hazard ratings.

A typical profile of Pueblo cobbly loam (39% slope) is described as follows:

A11 0-19 cm, dark grayish brown (10YR 4/2) cobbly loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 15% gravel, 10% cobble, 5% stone; abundant very fine and fine roots, plentiful medium roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

A12 19-41 cm, very dark grayish brown (10YR 3/2) cobbly loam, very dark gray (10YR 3/1) moist; moderate medium and coarse granular structure; nonsticky and friable moist, nonsticky and slightly plastic wet; 15% gravel, 25% cobble, 5% stone; abundant very fine, fine, and medium roots, plentiful coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

B2t 41-93 cm, light gray (10YR 7/2) cobbly sandy clay loam, brown (10YR 4/3) moist; moderate fine and medium subangular blocky structure; nonsticky and friable moist, sticky and slightly plastic wet; many moderately thick clay films on coarse fragments; 20% gravel, 15% cobble, 5% stone; abundant very fine and fine roots, plentiful medium roots; plentiful fine and medium interstitial pores; neutral; gradual wavy boundary.

C1 93-153+ cm, pale brown (10YR 6/3) cobbly heavy sandy loam, brown (10YR 4/3) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and slightly plastic wet; 25% gravel, 20% cobble, 10% stone; few very fine and fine roots; plentiful very fine and fine interstitial pores; neutral.

17. **Quemazon-Arriba-Rock Outcrop Complex.** The soils in this complex range from shallow (Quemazon series) to deep (Arriba series) well-drained soils that formed in materials weathered from tuff. This soil complex is found on level to very steep mesa tops vegetated with a ponderosa pine forest (Fig. 23).

The surface layers of the Quemazon soils in this complex are a grayish brown very stony sandy loam about 10 cm thick underlaid by a white very stony sandy loam substratum about 25 cm thick. The depth to tuff bedrock and the effective rooting depth are about 35 cm. Quemazon soils have moderately rapid permeability, very low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Quemazon very stony loam (6% slope) is described as follows:

01,02 3-0 cm.

A1 0-10 cm, grayish brown (10YR 5/2) very stony sandy loam, very dark gray (10YR 3/1) moist; weak fine and medium platy structure; nonsticky and friable moist, nonsticky and nonplastic wet: 10% gravel, 20% cobble, 30% stone; plentiful very fine and fine roots, abundant medium and coarse roots; abundant very fine and fine interstitial pores; neutral; clear irregular boundary.

C1 10-35 cm, white (10YR 8/1) very stony sandy loam, light gray (10YR 7/2) moist; massive structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 15% gravel, 35% cobble, 40% stone; plentiful very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; neutral; clear irregular boundary.

R 35+ cm, tuff bedrock.

The surface layers of Arriba soils are typically a light gray loam or very fine sandy loam about 30 cm thick. The subsoil is about 125 cm thick and consists of a very pale brown very fine sandy loam, silty clay loam, or clay loam. The depth to tuff bedrock and the effective rooting depth are about 155 cm. This soil has moderate to moderately slow permeability, high available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Arriba loam (8% slope) is described as follows:

01,02 3-0 cm.

A11 0-11 cm, light gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; weak fine platy structure; nonsticky and friable moist, slightly sticky and nonplastic wet: abundant very fine and fine roots, plentiful medium roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A12 11-28 cm, light gray (10YR 7/1) very fine sandy loam, brown (10YR 5/3) moist; weak medium subangular blocky structure; nonsticky and friable moist, nonsticky and slightly plastic wet; abundant very fine and fine roots, plentiful medium and coarse roots; plentiful very fine and fine interstitial pores; neutral; clear smooth boundary.

B1 28-58 cm, very pale brown (10YR 8/3) very fine sandy loam, light yellowish brown (10YR 6/4) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and slightly plastic wet; plentiful very fine, fine, medium, and coarse roots; plentiful very fine and fine terminal pores; neutral; clear wavy boundary.

B21t 58-92 cm, very pale brown (10YR 7/4) silty clay loam, brown (10YR 4/3) moist; moderate medium angular blocky structure; hard and friable moist, sticky and plastic wet; common thin clay films in pores and few thin clay films on ped faces; plentiful very fine, fine, medium, and coarse roots; abundant very fine and fine terminal pores, plentiful very fine and fine interstitial pores; neutral; diffuse boundary.

B22 92-153 cm, very pale brown (10YR 7/4) heavy clay loam, yellowish brown (10YR 5/4) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and plastic wet; plentiful very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial and terminal pores; mildly alkaline.

R 153+ cm, tuff bedrock.

18. **Rabbit-Tsankawi-Rock Outcrop Complex.** The soils of this complex range from moderately deep (Rabbit series) to very shallow (Tsankawi series), well-drained soils that weathered from tuff parent materials. This soil complex is found on level to very steep mesa tops where the dominant overstory vegetation is a Douglas fir-ponderosa pine forest (Fig. 23).

The surface layers of Rabbit soils are typically a light brownish gray or gray stony sandy loam about 70 cm thick. The subsoil is 1-2 cm thick and consists of a dark yellowish brown stony clay loam. The depth to tuff bedrock and the effective rooting depth are about 70 cm. Rabbbit soils have moderately rapid permeability, very low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Rabbit stony sandy loam (13% slope) is described as follows:

01,02 3-0 cm.

A1 0-6 cm, light brownish gray (10YR 6/2) stony sandy loam, very dark gray (10YR 3/1) moist; moderate fine and medium granular structure; nonsticky and friable moist, nonsticky and slightly plastic wet, 20% gravel, 10% cobble, 10% stone; abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; abrupt smooth boundary.

A21 6-15 cm, gray (10YR 6/1) stony sandy loam, dark grayish brown (10YR 4/2) moist; weak fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 25% gravel, 10% cobble, 10% stone; abundant very fine, fine and coarse roots, plentiful medium roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A22 15-69 cm, light brownish gray (10YR 6/2) stony sandy loam, dark grayish brown (10YR 4/2) moist; weak fine medium subangular blocky structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 20% gravel, 20% cobble, 25% stone; abundant very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; neutral; abrupt wavy boundary.

B2t 69-70 cm, dark yellowish brown (10YR 4/4) stony clay loam, strong brown (7.5YR 4/4) moist; moderate fine and medium subangular blocky structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 20% gravel, 20% cobble, 50% stone; plentiful very fine and fine roots; plentiful very fine and fine interstitial pores; medium acid; abrupt wavy boundary.

R 70+ cm, tuff bedrock.

The surface layers of Tsankawi soils are generally a light brownish gray stony sandy loam about 5 cm thick. The substratum is a white stony sandy loam about 20 cm thick. The depth to bedrock and the effective rooting depth are about 25 cm. This soil has a moderately rapid permeability, very low available water capacity, moderate erodibility, and a moderate erosion hazard rating.

A1 0-6 cm, light brownish gray (10YR 6/2) stony sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium platy structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 20% gravel; 15% cobble, 10% stone; plentiful very fine and fine roots; abundant very fine and fine interstitial pores; slightly acid; clear wavy boundary.

C1 6-25 cm, white (10YR 8/1) stony sandy loam, light gray (10YR 7/2) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 20% gravel, 25% cobble, 20% stone; plentiful very fine and fine roots, abundant medium and coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

R 25+ cm, tuff bedrock.

19. Rendija-Bayo Complex. This soil complex contains deep, well-drained soils that weathered from materials derived from tuff (Rendija series) or pumice (Bayo series). These soils are found on moderately steep to very steep mountain sideslopes vegetated with a juniper-piñon woodland (Fig. 24).

The Rendija soils have a light gray gravelly sandy loam surface layer about 5 cm thick. The subsoil is a dark grayish brown or light yellowish brown clay, or clay loam, about 30 cm thick underlaid by a light gray loam or sandy loam substratum greater than 100 cm thick. The depth to bedrock and the effective rooting depth are greater than 153 cm. The Rendija soils in this complex have very slow to moderate permeability, high available water capacity, moderate to high erodibility, and a moderate erosion hazard rating.

A typical profile of Rendija gravelly sandy loam (16-40% slope) is described as follows:

A1 0-5 cm, light gray (10YR 7/2) sandy loam; weak fine granular structure; 50% gravel, 10% cobble, 10% stone.

B2t 5-20 cm, dark grayish brown (10YR 4/2) gravelly light clay; weak medium prismatic structure, strong fine and medium subangular blocky structure; 40% gravel, 10% cobble, 5% stone.

B3t 20-33 cm, light yellowish brown (10YR 6/4) gravelly light clay loam; moderate fine and medium subangular blocky structure; 50% gravel, 10% cobble.

C1t 33-54 cm, light gray (10YR 7/1) gravelly heavy loam; weak fine and medium subangular blocky structure; 60% gravel, 15% cobble.

C2 54-153+ cm, light gray (10YR 7/1) gravelly sandy loam; massive structure; 70% gravel, 10% cobble.

The Bayo series was previously described as part of the Comada-Bayo complex.

20. Rock Outcrop-Colle-Painted Cave Complex. This complex contains moderately deep, well-drained soils that formed in materials weathered from welded tuff (Fig. 25). These soils are found on very steep to extremely steep mountain sideslopes where the native vegetation is dominantly a Douglas fir-ponderosa pine forest.

The surface layers of Colle soils are typically a dark brown sandy loam about 10 cm thick. The subsoil is a brown, light brown, or dark brown gravelly sandy loam, or sandy clay loam, about 55 cm thick underlaid by a brown sandy loam substratum about 15 cm thick. The depth to tuff bedrock and the effective rooting depth are about 75 cm. The Colle soils in this complex have moderate to moderately rapid permeability and a moderate available water capacity.

A typical profile of Colle sandy loam (67% slope) is described as follows:

A1 0-8 cm, dark brown (7.5YR 4/2) sandy loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 10% gravel; abundant very fine, fine, and medium roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

B1 8-18 cm, brown (7.5YR 5/2) gravelly sandy loam, dark brown (7.5YR 3/2) moist; weak fine and medium granular structure; slightly hard and very friable moist, slightly sticky and nonplastic wet; 15% gravel; abundant very fine, fine, and medium roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

B21t 18-33 cm, brown (7.5YR 5/2) cobbly sandy clay loam, brown (7.5YR 4/2) moist; moderate fine and medium granular structure; nonsticky and very friable moist, slightly sticky and slightly plastic wet; 20% gravel, 10% cobble; plentiful very fine roots, abundant fine, medium, and coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

B22t 33-49 cm, light brown (7.5YR 6/4) sandy clay loam, brown (7.5YR 4/4) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and slightly plastic wet; few thin clay films on ped faces and coarse fragments; 10% gravel, 5% cobble; few very fine and fine roots, plentiful medium roots, abundant coarse roots; plentiful very fine and fine interstitial pores; mildly alkaline; clear wavy boundary.

B3t 49-63 cm, dark brown (7.5YR 4/4) cobbly sandy clay loam, brown (7.5YR 4/4) moist; moderate fine and medium subangular blocky structure; hard and friable moist, slightly sticky and slightly plastic wet; few thin clay films on ped faces and coarse fragments; 35% gravel, 20% cobble; few very fine, fine, medium, and coarse roots; plentiful very fine and fine interstitial pores; mildly alkaline; clear wavy boundary.

C1 63-75 cm, brown (7.5YR 5/4) sandy loam, brown (7.5YR 4/4) moist; massive structure; hard and very friable moist, nonsticky and nonplastic wet; few very fine and fine roots; plentiful very fine and fine interstitial pores; mildly alkaline.

R 75+ cm, tuff bedrock.

The surface layers of the Painted Cave soils are typically a light gray stony sandy loam about 15 cm thick. The substratum is a very pale brown cobbly loamy sand about 40 cm thick. The depth to tuff bedrock and the effective rooting depth are about 55 cm. The Painted Cave soils have moderately rapid to very rapid permeability and a very low available water capacity.

A typical profile of Painted Cave stony sandy loam (55% slope) is described as follows:

01,02 3-0 cm.

A1 0-13 cm, light gray (10YR 7/2) stony sandy loam, dark yellowish brown (10YR 4/4) moist; weak fine crumb structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel, 15% cobble, 10% stone; few coarse roots, plentiful medium roots, abundant fine and very fine roots; abundant very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

C1 13-55 cm, very pale brown (10YR 7/3) cobbly loamy sand, dark grayish brown (10YR 4/2) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 20% gravel, 20% cobble, 10% stone; plentiful very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

R 55+ cm, tuff bedrock.

21. Rock Outcrop-Cone-Stonelion Complex. This complex contains deep (Cone series) and shallow (Stonelion series), well-drained soils that weathered from tuff parent materials. These soils are found on very steep to extremely steep mountain sideslopes vegetated with a piñon-juniper woodland (Fig. 20).

The surface layers of the Cone soils are generally a pale brown or light yellowish brown very cobbly sandy loam, or loamy sand, about 30 cm thick. The subsoil is a very pale brown stony sandy loam about 40 cm thick and is underlaid by a pink very fine sandy loam or sandy clay loam substratum greater than 85 cm thick. The depth to bedrock and the effective rooting depth are greater than 150 cm. The Cone soils have moderate to moderately rapid permeability and moderate available water capacity.

A typical profile of Cone very cobbly sandy loam (65% slope) is described as follows:

A11 0-8 cm, pale brown (10YR 6/3) very cobbly sandy loam, dark yellowish brown (10YR 4/4) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel, 30% cobble, 10% stone; abundant very fine and fine roots; neutral; abrupt smooth boundary.

A12 8-30 cm, light yellowish brown (10YR 6/4) very cobbly loamy sand, dark yellowish brown (10YR 6/4) moist; moderate very fine and fine granular structure; loose and friable moist, nonsticky and nonplastic wet; 15% gravel, 30% cobble, 5% stone; abundant very fine and fine roots, few medium roots; abundant very fine and fine interstitial pores; mildly alkaline; clear smooth boundary.

B2 30-68 cm, very pale brown (10YR 7/4) stony sandy loam, yellowish brown (10YR 5/4) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 20% gravel, 30% cobble, 20% stone; plentiful very fine and fine roots; plentiful fine and medium terminal pores; moderately alkaline; clear smooth boundary.

C1 68-104 cm, pink (7.5YR 7/4) very stony very fine sandy loam, yellowish brown (7.5YR 5/6) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel, 20% cobble, 40% stone; few very fine and fine roots; few very fine and fine interstitial pores; moderately alkaline; gradual smooth boundary.

C2 104-152+ cm, pink (7.5YR 7/4) very stony sandy clay loam, yellowish brown (7.5YR 5/6) moist; massive structure; slightly hard and friable moist, nonsticky and slightly plastic wet; 15% gravel, 20% cobble, 40% stone; few very fine, fine, and medium roots; few very fine and fine interstitial pores; strongly alkaline.

The Stonelion topsoil is usually a very pale brown or light gray stony sandy loam about 30 cm thick. The substratum is about 10 cm thick and consists of a very pale brown stony loamy sand. The depth to tuff bedrock and the effective rooting depth are about 40 cm. The Stonelion soils have moderately rapid to very rapid permeability and a very low available water capacity.

The typical profile of Stonelion stony sandy loam (61% slope) is described as follows:

A11 0-14 cm, very pale brown (10YR 7/3) stony sandy loam, brown (10YR 4/3) moist; moderate fine and medium granular structure; nonsticky and very friable moist, nonsticky and slightly plastic wet; 10% gravel, 20% cobble, 20% stone; abundant very fine and fine roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

A12 14-29 cm, light gray (10YR 7/2) stony sandy loam, dark brown (10YR 7/2) moist; weak fine and medium granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 10% gravel, 30% cobble, 40% stone; abundant very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

C1 29-40 cm, very pale brown (10YR 8/3) stony loamy sand, yellowish brown (10YR 5/4) moist; massive structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 10% gravel, 30% cobble, 50% stone; abundant very fine and fine roots, plentiful medium roots, few coarse roots; plentiful very fine and fine interstitial pores; moderately alkaline; abrupt wavy boundary.

R 40+ cm, tuff bedrock.

22. Rock Outcrop-Pelado-Kwage Complex. This complex contains deep (Pelado series) and moderately deep (Kwage series), well-drained soils that weathered from dacites of the Tschicoma Formation (Fig. 22). This complex contains a higher proportion of rock outcrop than the Kwage-Pelado-Rock Outcrop complex discussed previously. Both complexes are found on very steep to extremely steep mountain sideslopes vegetated with a Douglas fir-ponderosa pine forest.

The surface layers of the Pelado soils in this complex are a dark grayish brown loam or gravelly loam about 35 cm thick. The subsoil is about 85 cm thick and consists of a light gray or pale brown, gravelly or stony sandy clay loam underlaid by a very pale brown loamy sand substratum about 30 cm thick. The depth to bedrock and the effective rooting depth are greater than 150 cm. The Pelado soils have moderate to very rapid permeability and a moderate available water capacity.

A typical profile of Pelado loam (50% slope) is described as follows:

01,02 3-0 cm.

A11 0-13 cm, light brownish gray (10YR 6/2) loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 10% gravel; few medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A12 13-36 cm, light brownish gray (10YR 6/2) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel; few medium roots, plentiful very fine and fine roots; abundant very fine and fine interstitial pores; slightly acid; clear smooth boundary.

B21 36-81 cm, light gray (10YR 7/2) gravelly sandy clay loam, pale brown (10YR 6/3) moist; moderate fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 65% gravel, 5% cobble; plentiful very fine, fine, and medium roots; abundant very fine and fine terminal pores; slightly acid; clear smooth boundary.

B22 81-122 cm, pale brown (10YR 6/3) stony heavy sandy clay loam, brown (10YR 5/3) moist; weak very fine and fine subangular blocky structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 20% gravel, 30% cobble, 20% stone; few coarse roots, plentiful very fine, fine, and medium roots; few very fine and fine interstitial pores, abundant very fine and fine terminal pores; neutral; gradual wavy boundary.

C1 122-152+ cm, very pale brown (10YR 8/4) stony loamy sand, light yellowish brown (10YR 6/4) moist; massive structure; loose moist, nonsticky and nonplastic wet; 40% gravel, 10% cobble, 20% stone; few medium roots, plentiful very fine and fine roots; plentiful very fine and fine interstitial pores; neutral.

The surface layers of the Kwage soils in this complex are generally a dark grayish brown, light gray, or very pale brown gravelly loam, sandy loam, or loamy sand, about 65 cm thick. The substratum is a very pale brown gravelly loamy sand about 10 cm thick. The depth to bedrock and the effective rooting depth are about 75 cm. These Kwage soils have moderate to very rapid permeability, very low available water capacities, and moderate erodibility and erosion hazard ratings.

A typical profile of Kwage gravelly loam (62% slope) is described as follows:

01,02 2-0 cm.

A1 0-12 cm, dark grayish brown (10YR 4/2) gravelly loam, very dark grayish brown (10YR 3/2) moist; weak medium and coarse subangular blocky structure, moderate very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 40% gravel, 10% cobble, 10% stone; plentiful medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A2 12-39 cm, light gray (10YR 7/2) gravelly sandy loam, brown (10YR 5/3) moist; weak moderate subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 40% gravel, 10% cobble, 5% stone; abundant very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; slightly acid; clear smooth boundary.

A3 39-63 cm, very pale brown (10YR 7/4) gravelly loamy sand, yellowish brown (10YR 5/4) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel, 15% cobble, 10% stone; abundant very fine, fine, medium, and coarse roots; abundant fine and medium interstitial pores; neutral; clear wavy boundary.

C1 63-74 cm, very pale brown (10YR 7/3) gravelly loamy sand, brown (10YR 4/3) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel, 15% cobble, 10% stone; abundant very fine, fine, medium, and coarse roots; abundant fine and medium interstitial pores; neutral; clear wavy boundary.

R 74+ cm, fractured dacite bedrock.

23. Rock Outcrop-Pines-Tentrock Complex. The soils in this complex are deep (Pines series) and moderately deep (Tentrock series), well-drained soils that weathered from materials derived from welded tuffs (Fig. 25). This complex is found on very steep to extremely steep mountain sideslopes vegetated with ponderosa pine and contains about 20% rock outcrop in the mapping unit. The Rock Outcrop-Colle-Painted Cave complex is usually found on the cooler, north-facing slopes adjacent to this complex.

The surface layers of the Pines soils are typically a dark gray or light brownish gray gravelly sandy loam about 30 cm thick. The subsoil is about 55 cm thick and consists of a light brown very gravelly or cobbly clay loam underlaid by a 30-cm thick, brown, very cobbly clay loam substratum. The depth to tuff bedrock and the effective rooting depth are greater than 120 cm. The Pines soils have moderately slow permeability and a moderate available water capacity.

A typical profile of Pines gravelly sandy loam (55% slope) is described as follows:

01,02 3-0 cm.

A11 0-18 cm, dark gray (10YR 4/1) gravelly sandy loam, black (10YR 2/1) moist; weak fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel, 10% cobble; abundant very fine roots, plentiful fine and medium roots; abundant medium and very fine interstitial pores; neutral; clear smooth boundary.

A2 18-30 cm, light brownish gray (10YR 6/2) very gravelly sandy loam, brown (7.5YR 4/2) moist; massive structure; slightly hard and friable moist, nonsticky and slightly plastic wet; 20% gravel, 20% cobble; plentiful fine and medium roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

B1 30-53 cm, light brown (7.5YR 6/4) very gravelly clay loam, dark brown (7.5YR 3/2) moist; weak fine and medium subangular blocky structure; hard and friable moist, sticky and plastic wet; 25% gravel, 20% cobble; abundant fine, medium, and coarse roots; plentiful very fine terminal pores; neutral; clear wavy boundary.

B2 53-86 cm, light brown (7.5YR 6/4) very cobbly clay loam, brown (7.5YR 4/4) moist; weak fine and medium subangular blocky structure; hard and friable moist, sticky and plastic wet; 25% gravel, 20% cobble, 5% stone; few fine roots, plentiful medium and coarse roots; plentiful very fine terminal roots; neutral; gradual wavy boundary.

C1 86-117+ cm, brown (7.5YR 5/4) very cobbly clay loam, brown (7.5YR 4/4) moist; massive structure; hard and friable moist, sticky and plastic wet; 45% gravel; 25% cobble, 10% stone; few fine medium, and coarse roots; few very fine and fine terminal pores; neutral.

The surface layers of the Tentrock soils are generally a brown or pale brown gravelly sandy loam about 20 cm thick. The subsoil is about 10 cm thick and consists of a dark yellowish brown cobbly sandy loam, which is underlaid by a very pale brown sandy loam greater than 30 cm thick. The depth to tuff bedrock is greater than 63 cm and the effective rooting depth is about 55 cm. Tentrock soils have moderately rapid permeability and a very low available water capacity.

A typical profile of Tentrock gravelly sandy loam (74% slope) is described as follows:

01,02 1-0 cm.

A11 0-5 cm, brown (10YR 5/3) gravelly sandy loam, dark brown (10YR 3/3) moist; weak fine granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 15% gravel; plentiful very fine and fine roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A12 5-20 cm, pale brown (10YR 6/3) gravelly sandy loam, brown (10YR 4/3) moist; moderate medium granular structure, weak fine granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 15% gravel; abundant very fine and fine roots; abundant fine and very fine interstitial pores; neutral; clear smooth boundary.

B2 20-32 cm, pale brown (10YR 6/3) cobbly heavy sandy loam, dark yellowish brown (10YR 4/4) moist; moderate medium granular structure, weak fine granular structure; nonsticky and very friable moist, slightly sticky and nonplastic wet; 35% gravel, 15% cobble; plentiful very fine, fine, and medium roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

C1 32-58 cm, very pale brown (10YR 7/3) very cobbly sandy loam, brown (10YR 5/3) moist; massive structure; slightly hard and friable moist, nonsticky and nonplastic wet; 30% gravel, 40% cobble; few very fine and fine roots, plentiful medium and coarse roots; plentiful very fine and fine interstitial pores; neutral; clear smooth boundary.

C2 58-63+ cm, very pale brown (10YR 7/4) sandy loam, yellowish brown (10YR 5/4) moist; massive structure; slightly hard and friable moist, nonsticky and nonplastic wet; neutral.

24. Sanjue-Arriba Complex. The soils in this complex are deep, well-drained soils that weathered in materials derived from pumice (Sanjue series) or dacites of the Puye Conglomerate (Arriba series). This complex is found on moderately steep to very steep mountain sideslopes forested with ponderosa pine (Fig. 19).

The surface layers of the Sanjue soils are typically a grayish brown or light brownish gray gravelly sandy loam or loamy sand about 20 cm thick. The substratum is a light gray or white gravelly sand greater than 130 cm thick. The depth to unweathered pumice and the effective rooting depth are greater than 150 cm. The Sanjue soils have moderately rapid to very rapid permeability, very low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of Sanjue very gravelly sandy loam (40% slope) is described as follows:

01,02 3-0 cm.

A11 0-5 cm, grayish brown (10YR 5/2) very gravelly sandy loam, very dark gray (10YR 3/1) moist; weak fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel; few very fine, fine, and medium roots; abundant very fine and fine interstitial pores; mildly alkaline; clear smooth boundary.

A12 5-21 cm, light brownish gray (10YR 6/2) very gravelly loamy sand, very dark grayish brown (10YR 3/2) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 75% gravel; abundant very fine, fine, medium and coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

C1 21-46 cm, light gray (10YR 7/2) very gravelly sand, light yellowish brown (10YR 6/4) moist; single grain structure; loose moist, nonsticky and nonplastic wet; 90% gravel; plentiful coarse roots, abundant very fine, fine, and medium roots; plentiful fine and medium interstitial pores; neutral; abrupt wavy boundary.

C2 46-153+ cm, white (10YR 8/1) very gravelly sand (unweathered pumice), white (10YR 8/1) moist; massive structure; slightly hard and friable moist, weakly cemented, nonsticky and nonplastic wet; 95% gravel; few very fine and fine roots; plentiful fine and medium interstitial pores.

The surface layers of the Arriba soils are generally a very pale brown loam about 10 cm thick. The subsoil is greater than 145 cm thick and consists of a reddish yellow or pink clay loam, silty clay loam or sandy clay loam. The effective rooting depth is about 105 cm, but the depth to dacite bedrock is greater than 155 cm. The Arriba soils have a moderate to moderately slow permeability, high available water capacity, moderately high erodibility, and a moderate erosion hazard rating.

A typical profile of Arriba loam (18% slope) is described as follows:

01,02 3-0 cm.

A1 0-7 cm, very pale brown (10YR 7/3) loam, yellowish brown (10YR 5/4) moist; weak medium platy structure; nonsticky and very friable moist, nonsticky and slightly plastic wet; 5% gravel, 5% stone; abundant very fine and fine roots, plentiful medium roots; abundant very fine and fine interstitial pores; neutral; abrupt wavy boundary.

B21t 7-50 cm, reddish yellow (7.5YR 7/6) heavy clay loam, strong brown (7.5YR 5/6) moist; moderate fine and medium platy structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on ped faces; 10% gravel, 5% cobble; plentiful very fine, fine, medium, and coarse roots; abundant very fine and fine terminal pores; neutral; gradual wavy boundary.

B22t 50-104 cm, pink (7.5YR 7/4) silty clay loam, brown (7.5YR 5/4) moist; slightly hard and friable moist, slightly sticky and slightly plastic wet; common moderately thick clay films on ped faces; 10% gravel, 5% cobble; few very fine, fine, and medium roots; plentiful very fine and fine terminal pores, plentiful fine interstitial pores; neutral; gradual wavy boundary.

B3t 104-153+ cm, reddish yellow (7.5YR 6/6) sandy clay loam, strong brown (5YR 5/6) moist; weak fine platy structure; slightly hard and friable moist, slightly sticky and slightly plastic wet; common thin clay films on ped faces; 10% gravel, 10% cobble, 5% stone; plentiful very fine and fine interstitial pores, plentiful fine terminal pores; mildly alkaline.

25. Santa Klara-Armstead Complex. The soils in this complex are moderately deep (Santa Klara series) to deep (Armstead series) well-drained soils that weathered from dacites and latites of the Tschicoma Formation (Fig. 15). This complex is found on moderately steep to very steep mountain sideslopes vegetated with a Douglas fir-ponderosa pine forest.

The surface layers of the Santa Klara soils are a dark gray, grayish brown, or light gray very stony loam, gravelly loam, or gravelly silty clay loam about 50 cm thick. The subsoil is about 35 cm thick and consists of a light gray or reddish yellow gravelly clay loam or clay. The effective rooting depth is about 70 cm, and the depth to bedrock is about 80 cm. The Santa Klara soils in this complex have moderate to moderately slow permeability, and moderate available water capacity, erodibility and erosion hazard ratings.

A typical profile of Santa Klara very stony loam (33% slope) is described as follows:

01,02 2-0 cm.

A1 0-10 cm, dark gray (10YR 4/1) very stony loam, very dark gray (10YR 3/1) moist; moderate very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel, 10% cobble, 30% stone; abundant very fine, fine and medium roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

A21 10-26 cm, grayish brown (10YR 5/2) gravelly loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure, moderate fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 30% gravel, 10% cobble, 10% stone; abundant very fine, fine, medium, and coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

A22 26-48 cm, light gray (10YR 7/2) gravelly light silty clay loam, brown (10YR 4/3) moist; strong fine medium subangular blocky structure; slightly hard and friable moist, very sticky and plastic wet; few thin clay films on ped faces; 25% gravel, 20% cobble, 10% stone; plentiful very fine and fine roots, few medium and coarse roots; plentiful fine and medium terminal pores; neutral; abrupt wavy boundary.

B21t 48-70 cm, light gray (10YR 7/2) gravelly heavy clay loam, dark grayish brown (10YR 4/2) moist: strong medium and coarse subangular blocky structure; slightly hard and friable moist, sticky and plastic wet: many thin clay films on ped faces: 30% gravel, 20% cobble, 10% stone; few very fine, fine, and medium roots; few fine and medium terminal pores: mildly alkaline; gradual wavy boundary.

B22t 70-81 cm, reddish yellow (7.5YR 6/6) gravelly clay, yellowish brown (7.5YR 5/6) moist: strong fine and medium subangular blocky structure; hard and firm moist, sticky and plastic wet: many moderately thick clay films on coarse fragments, common moderately thick clay films on ped faces; 30% gravel, 20% cobble, 20% stone; few fine and medium terminal pores; mildly alkaline.

R 81+ cm, dacite bedrock.

The Armstead soils are described in the Armstead series section.

26. Shell-Anesa Complex. The soils in this complex are deep, well-drained soils that weathered in materials derived from tuff (Shell series) or pumice (Anesa series). Both soils developed on very steep to extremely steep mountain sideslopes vegetated with a Douglas fir-ponderosa pine forest (Fig. 20).

The surface layers of the Shell soils are typically a light brownish gray or very pale brown gravelly loam or cobbly sandy loam about 55 cm thick. The subsoil is about 20 cm thick and consists of a very pale brown cobbly sandy loam underlaid by a yellow or pinkish white cobbly or stony sandy loam substratum about 80 cm thick. The Shell soils have moderate to moderately rapid permeability and moderate available water capacity, erodibility, and erosion hazard ratings.

A typical profile of Shell gravelly loam (43% slope) is described as follows:

A11 0-5 cm, light brownish gray (10YR 6/2) gravelly loam, very dark grayish brown (10YR 3/2) moist: moderate very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet: 20% gravel, 10% cobble; abundant very fine and fine roots, few medium roots; abundant very fine and fine terminal pores: abrupt smooth boundary.

A12 5-18 cm, light brownish gray (10YR 6/2) gravelly loam, brown (10YR 4/3) moist; moderate very fine and fine granular structure: nonsticky and friable moist, nonsticky and nonplastic wet: 30% gravel, 10% cobble; abundant very fine and fine roots, few medium roots; few very fine and fine interstitial pores; neutral; abrupt smooth boundary.

A2 18-56 cm, very pale brown (10YR 7/3) cobbly sandy loam, brown (10YR /53) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet: 10% gravel, 15% cobble, 10% stone; plentiful very fine and fine roots, few medium and coarse roots; abundant very fine and fine terminal pores; neutral; clear smooth boundary.

B2 56-74 cm, very pale brown (10YR 7/4) cobbly sandy loam, yellowish brown (10YR 5/4) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel, 20% cobble, 15% stone; few very fine, fine, and medium roots; abundant very fine and fine interstitial pores; neutral; gradual smooth boundary.

C1 74-99 cm, yellow (10YR 7/6) cobbly sandy loam, yellowish brown (10YR 5/6) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet: 15% gravel, 40% cobble, 10% stone; few very fine, fine, and medium roots; abundant very fine and fine interstitial pores; neutral; gradual smooth boundary.

C2 99-152+ cm, pinkish white (5YR 8/2) stony sandy loam, pink (7.5YR 7/4) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel, 10% cobble, 20% stone; few very fine and fine roots; plentiful very fine and fine interstitial pores; neutral.

The surface layers of the Anesa soils are generally a pale brown or white very gravelly loamy sand about 20 cm thick. The substratum is more than 140 cm thick and consists of a white or very pale brown very gravelly sand, loam, or fine sandy loam. The effective rooting depth and the depth to bedrock are greater than 165 cm. The Anesa soils have moderate to very rapid permeability, low available water capacity, and moderate erodibility and erosion hazard ratings.

A typical profile of Shell gravelly loam (43% slope) is described as follows:

A11 0-5 cm, light brownish gray (10YR 6/2) gravelly loam, very dark grayish brown (10YR 3/2) moist; moderate very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 20% gravel, 10% cobble; abundant very fine and fine roots, few medium roots; abundant very fine and fine terminal pores; abrupt smooth boundary.

A12 5-18 cm, light brownish gray (10YR 6/2) gravelly loam, brown (10YR 4/3) moist; moderate very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 30% gravel, 10% cobble; abundant very fine and fine roots, few medium roots; few very fine and fine interstitial pores; neutral; abrupt smooth boundary.

A2 18-56 cm, very pale brown (10YR 7/3) cobbly sandy loam, brown (10YR 5/3) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 10% gravel, 15% cobble, 10% stone; plentiful very fine and fine roots, few medium and coarse roots; abundant very fine and fine terminal pores; neutral; clear smooth boundary.

B2 56-74 cm, very pale brown (10YR 7/4) cobbly sandy loam, yellowish brown (10YR 5/4) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel, 20% cobble, 15% stone; few very fine, fine, and medium roots; abundant very fine and fine interstitial pores; neutral; gradual smooth boundary.

C1 74-99 cm, yellow (10YR 7/6) cobbly sandy loam, yellowish brown (10YR 5/6) moist; weak very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 15% gravel, 40% cobble, 10% stone; few very fine, fine, and medium roots; abundant very fine and fine interstitial pores; neutral; gradual smooth boundary.

C2 99-152+ cm, pinkish white (5YR 8/2) stony sandy loam, pink (7.5YR 7/4) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 5% gravel, 10% cobble, 20% stone; few very fine and fine roots; plentiful very fine and fine interstitial pores; neutral.

The surface layers of the Anesa soils are generally a pale brown or white very gravelly loamy sand about 20 cm thick. The substratum is more than 140 cm thick and consists of a white or very pale brown very gravelly sand, loam, or fine sandy loam. The effective rooting depth and the depth to bedrock are greater than 165 cm. The Anesa soils have moderate to very rapid permeability, low available water capacity, and moderate erodibility and erosion hazard ratings.

A typical profile of Anesa very gravelly loamy sand (55% slope) is described as follows:

01,02 3-0 cm.

A11 0-16 cm, pale brown (10YR 6/3) very gravelly loamy sand, brown (10YR 4/3) moist; weak fine and medium granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 60% gravel; abundant very fine and fine roots, few medium and coarse roots; abundant very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

A12 16-22 cm, white (10YR 8/2) very gravelly loamy sand, yellowish brown (10YR 5/4) moist; weak fine and medium granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 75% gravel; abundant very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

C1 22-74 cm, white (10YR 8/2) very gravelly sand, pale brown (10YR 6/3) moist; massive structure; loose moist, nonsticky and nonplastic wet; 95% gravel; abundant very fine and fine roots, plentiful medium and coarse roots; abundant medium and coarse interstitial pores; moderately alkaline; clear wavy boundary.

C2 74-83 cm, white (10YR 8/1) very gravelly loam, light gray (10YR 7/2) moist; massive structure; hard and very firm moist, nonsticky and nonplastic wet; 50% gravel; plentiful very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

C3. 83-100 cm, very pale brown (10YR 8/3) very gravelly sand, yellowish brown (10YR 5/6) moist; massive structure; loose moist, nonsticky and nonplastic wet; 95% gravel; plentiful fine roots; abundant medium and coarse interstitial pores; moderately alkaline; abrupt smooth boundary.

C4 100-110 cm, white (10 YR 8/1) gravelly fine sandy loam, light gray (10YR 7/1) moist; massive structure; slightly hard and friable moist, nonsticky and nonplastic wet; 25% gravel; plentiful fine roots; abundant fine and medium interstitial pores; moderately alkaline; clear smooth boundary.

C5 110-121 cm, very pale brown (10YR 8/3) fine sandy loam, light yellowish brown (10YR 6/4) moist; massive structure; slightly hard and friable moist, nonsticky and slightly plastic wet; plentiful fine roots; plentiful very fine and fine interstitial pores; strongly alkaline; abrupt smooth boundary.

C6 121-163+ cm, very pale brown (10YR 8/3) gravelly sand, light gray (10YR 7/2) moist; massive structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 15% gravel; plentiful medium roots; abundant very fine and fine interstitial pores; strongly alkaline.

27. Turkey-Cabra-Rock Outcrop Complex. The soils in this complex are shallow (Turkey series) to deep (Cabra series), well-drained soils that weathered from dacites and latites of the Tschicoma Formation (Figs. 15 and 19). This complex is found on very steep to extremely steep mountain sideslopes vegetated with a ponderosa pine forest.

The surface layers of the Turkey soils are generally a dark grayish brown or light gray stony loam or clay loam about 30 cm thick. The subsoil is about 25 cm thick and consists of a white or brown stony sandy clay loam, or clay loam. The effective rooting depth is about 50 cm and the depth to dacite-latite bedrock is about 55 cm. The Turkey soils have moderate to moderately slow permeability, a very low available water capacity, moderate erodibility, and a high erosion hazard rating.

A typical profile of Turkey stony loam (58% slope) is described as follows:

01,02 5-0 cm.

A11 0-7 cm, dark grayish brown (10YR 4/2) stony loam, very dark gray (10YR 3/1) moist; moderate fine and medium granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 50% gravel, 15% cobble, 20% stone; few coarse roots, plentiful medium roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

A12 7-28 cm, light gray (10YR 7/2) stony clay loam, dark yellowish brown (10YR 4/4) moist; weak fine granular structure; nonsticky and friable moist, sticky and slightly plastic wet; 60% gravel, 15% cobble, 25% stone; plentiful very fine and fine roots, abundant medium and coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

B1 28-52 cm, white (10YR 8/2) stony sandy clay loam, brown (10YR 5/3) moist; massive structure; nonsticky and friable moist, sticky and slightly plastic wet; 50% gravel, 20% cobble, 20% stone; few very fine and fine roots, plentiful medium and coarse roots; abundant very fine and fine interstitial pores; mildly alkaline; clear irregular boundary.

B2t 52-54 cm, brown (7.5YR 5/4) very stony heavy clay loam, brown (7.5YR 4/4) moist; massive structure; hard and firm moist, sticky and plastic wet; many moderately thick clay films on coarse fragments; 40% gravel, 20% cobble, 35% stone; mildly alkaline; clear irregular boundary.

R 54+ cm, dacite and latite bedrock.

The Cabra soils in this complex are described in the Cabra series section.

28. Unnamed Soils of the Eutrandepts-Ustipsamments-Haplustalfs Complex. The unnamed soils of this complex are deep, well-drained soils that weathered from pumice (Entic Eutrandepts and Typic Ustipsamments) or dacites of the Puye Conglomerate (Udic Haplustalfs). This complex is found on level to moderately sloping land areas vegetated with a piñon-juniper woodland (Fig. 24).

The surface layer of the Entic Eutrandepts is typically a light yellowish brown gravelly sandy loam about 10 cm thick. The subsoil is about 20 cm thick and consists of a reddish yellow gravelly clay loam underlaid by a white very gravelly sand substratum about 125 cm thick. The effective rooting depth is about 30 cm and the depth to pumice parent materials is greater than 155 cm. These Entic Eutrandepts have a moderately rapid to moderately slow permeability, very low available water capacity, moderately high erodibility, and a low erosion hazard rating.

A typical profile of Entic Eutrandept, ashy-skeletal, mesic (5% slope) is described as follows:

A1 0-11 cm, light yellowish brown (10YR 6/4) gravelly sandy loam, brown (10YR 4/3) moist; weak medium platy structure, moderate medium granular structure; nonsticky and friable moist, nonsticky and slightly plastic wet; 15% gravel; abundant very fine and fine roots, few medium roots; abundant very fine and fine interstitial pores; neutral; clear smooth boundary.

B2 11-30 cm, reddish yellow (7.5YR 7/6) gravelly light clay loam, brown (7.5YR 4/4) moist; moderate fine and medium subangular blocky structure; nonsticky and friable moist, slightly sticky and slightly plastic wet; 20% gravel; plentiful very fine, fine, and medium roots, few coarse roots; abundant very fine and fine interstitial pores, plentiful fine terminal pores; mildly alkaline; clear wavy boundary.

C1 30-80 cm, white (10YR 8/2) very gravelly sand, white (10YR 8/2) moist; massive structure; hard and firm moist, nonsticky and nonplastic wet; 95% gravel; abundant fine and medium interstitial pores.

C2 80-153+ cm, white (10YR 8/2) very gravelly sand, white (10YR 8/2) moist; massive structure; hard and firm moist, nonsticky and nonplastic wet; 95% gravel; abundant fine and medium interstitial pores.

The surface layers of the Typic Ustipsamments are generally a very pale brown gravelly loamy sand about 30 cm thick. The substratum is greater than 130 cm thick and consists of a brown or white gravelly loamy sand or sand. The effective rooting depth is about 160 cm and the depth to pumice parent materials is greater than 160 cm. The Typic Ustipsamments have a very rapid permeability, very low available water capacity, moderate erodibility, and a low erosion hazard rating.

A typical profile of a Typic Ustipsamment, ashy, mesic (12% slope) is described as follows:

A1 0-27 cm, very pale brown (10YR 7/4) gravelly loamy sand, dark yellowish brown (10YR 4/4) moist; weak fine granular structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 25% gravel; plentiful medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; mildly alkaline; gradual smooth boundary.

C1 27-69 cm, very pale brown (10YR 7/3) gravelly loamy sand, brown (10YR 5/3) moist; massive structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 25% gravel; plentiful medium and coarse roots, abundant very fine and fine roots; abundant very fine and fine interstitial pores; mildly alkaline; gradual smooth boundary.

C2 69-160 cm, very pale brown (10YR 7/3) gravelly loamy sand, brown (10YR 5/3) moist; massive structure; nonsticky and very friable moist, nonsticky and nonplastic wet; 30% gravel; plentiful very fine, fine, medium and coarse roots; abundant very fine and fine interstitial pores; mildly alkaline; clear smooth boundary.

C3 160+ cm, white (10YR 8/1) gravelly sand, white (10YR 8/1) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 95% gravel; abundant very fine and fine interstitial pores.

The surface layer of the Udic Haplustalfs is generally a yellow loam about 5 cm thick. The subsoil is a light brown, light yellowish brown, yellow, or reddish yellow silty clay loam, or gravelly clay loam, about 90 cm thick. The substratum is about 55 cm thick and consists of a reddish yellow, pink, or white very gravelly sandy loam or loamy sand. The effective rooting depth is about 130 cm and the depth to dacite bedrock is greater than 155 cm. These Udic Haplustalfs have moderate to moderately slow permeability, moderate available water capacity, moderately high erodibility, and a low erosion hazard rating.

A typical profile of a Udic Haplustalf, fine, mixed, mesic (8% slope) is described as follows:

A1 0-6 cm, yellow (10YR 7/6) loam, dark brown (10YR 3/3) moist; weak fine platy structure, moderate very fine and fine granular structure; sticky and very friable moist, slightly sticky and nonplastic wet; 5% gravel; abundant very fine and fine interstitial pores; neutral; abrupt smooth boundary.

B1 6-15 cm, light brown (7.5YR 6/4) silty clay loam, brown (7.5YR 4/4) moist; moderate fine and medium subangular blocky structure; slightly hard and friable moist, sticky and plastic wet; 5% gravel; abundant very fine and fine roots, plentiful medium and coarse roots; plentiful very fine and fine interstitial pores; mildly alkaline; clear wavy boundary.

B21t 15-46 cm, light yellowish brown (10YR 6/4) silty clay loam, dark brown (10YR 3/3) moist; strong fine and medium angular blocky structure; hard and friable moist, sticky and plastic wet; many thin clay films on ped faces; 5% gravel; abundant very fine and fine roots, plentiful medium and coarse roots; plentiful very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

B22t 46-69 cm, yellow (10YR 7/6) silty clay loam, dark brown (10YR 3/3) moist; moderate medium prismatic structure; slightly hard and friable moist, sticky and plastic wet; common thin clay films on ped faces; 10% gravel; plentiful very fine, fine, and medium roots, few coarse roots; plentiful very fine and fine interstitial and terminal pores; moderately alkaline; clear wavy boundary.

B3tca 69-96 cm, reddish yellow (7.5YR 6/6) gravelly clay loam, brown (7.5YR 4/4) moist; moderate medium prismatic structure; nonsticky and friable moist, sticky and slightly plastic wet; many thin clay films on ped faces; 20% gravel, 5% cobble; plentiful very fine and fine roots; plentiful very fine and fine terminal pores; moderately alkaline; clear wavy boundary.

C1tca 96-128 cm, reddish yellow (7.5YR 6/6) very gravelly sandy loam, strong brown (7.5YR 5/6) moist; weak fine and medium subangular blocky structure; slightly hard and friable moist, slightly sticky and nonplastic wet; common thin clay films on ped faces; 50% gravel, 15% cobble, 5% stone; few very fine and fine roots; plentiful very fine and fine interstitial pores; moderately alkaline; clear irregular boundary.

C2tca 128-147 cm, pink (7.5YR 7/4) very gravelly loamy sand, brown (7.5YR 4/4) moist; massive structure; slightly hard and friable moist, nonsticky and nonplastic wet; common thin clay films in bridges between mineral grains; 50% gravel, 20% cobble, 10% stone; plentiful very fine and fine interstitital pores; moderately alkaline; clear irregular boundary.

C3ca 147-153+ cm, white (10YR 8/1) very gravelly loamy sand, white (10YR 8/1) moist; massive structure; slightly hard and friable moist, nonsticky and nonplastic wet; 50% gravel, 20% cobble, 15% stone; plentiful very fine and fine interstitial pores; strongly alkaline.

29. Unnamed Soils of the Typic Ustorthents-Rock Outcrop Complex. The Typic Ustorthents in this complex are deep, well-drained soils that weathered from dacites and latites of the Puye Conglomerate (Fig. 21). This complex is found on very steep to extremely steep mountain sideslopes vegetated with a piñon-juniper woodland.

The surface layers of the Typic Ustorthents are generally a pale brown stony or gravelly sandy loam about 5 cm thick. The substratum is about 150 cm thick and generally consists of a very pale brown or light gray gravelly loamy sand or sand. The effective rooting depth is about 50 cm and the depth to dacite-latite bedrock is greater than 155 cm. The Typic Ustorthents have moderately rapid to very rapid permeability and a very low available water capacity.

A typical profile of Typic Ustorthent, sandy-skeletal, mixed, mesic (64% slope) is described as follows:

A1 0-6 cm, pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 3/3) moist; strong very fine and fine granular structure; nonsticky and friable moist, nonsticky and nonplastic wet; 30% gravel, 20% cobble, 10% stone; abundant very fine and fine roots, plentiful medium roots, few coarse roots; abundant very fine and fine interstitial pores; neutral; clear wavy boundary.

C1 6-18 cm, very pale brown (10YR 8/4) very gravelly loamy sand, yellowish brown (10YR 5/4)) moist; massive structure; slightly hard and friable moist, nonsticky and nonplastic wet; 50% gravel; few very fine, fine, medium and coarse roots; plentiful very fine and fine interstitial pores; neutral; abrupt wavy boundary dry, clear wavy boundary moist.

C2 18-29 cm, light gray (10YR 7/1) gravelly sand, pale brown (10YR 6/3) moist; massive structure, nonsticky and friable moist, nonsticky and nonplastic wet; weakly cemented; 30% gravel, 10% cobble; few very fine, fine, and coarse roots, plentiful medium roots; plentiful fine and medium interstitial pores; neutral; abrupt wavy boundary dry, clear wavy boundary wet.

C3 29-52 cm, very pale brown (10YR 7/3) gravelly sand, yellowish brown (10YR 5/6) moist; massive structure; hard and friable moist, nonsticky and nonplastic wet; weakly cemented; 30% gravel; few very fine, fine, and medium roots, plentiful coarse roots; plentiful fine and medium interstitial pores; neutral; clear wavy boundary dry, gradual wavy boundary moist.

C4 52-82 cm, very pale brown (10YR 8/3) very gravelly sand, light yellowish brown (10YR 6/4) moist; massive structure; hard and friable moist, nonsticky and nonplastic wet; weakly cemented; 60% gravel; plentiful fine and medium interstitial pores; mildly alkaline; clear wavy boundary, moist, gradual wavey boundary dry.

C5 82-102 cm, very pale brown (10YR 7/3) very gravelly sand, light yellowish brown (10YR 6/4) moist; massive structure; hard and friable moist, nonsticky and nonplastic wet; weakly cemented; 70% gravel; abundant fine and medium interstitial pores; mildly alkaline; gradual wavy boundary.

C6t 102-122 cm, light gray (10YR 7/2) very gravelly sand, light yellowish brown (10YR 6/3) moist; massive structure; hard and friable moist, nonsticky and nonplastic wet; weakly cemented many thick clay films on coarse fragments; 50% gravel; abundant fine and medium interstitial pores; moderately alkaline; gradual wavy boundary.

C7 122-153+ cm, white (10YR 8/2) very gravelly loamy sand, light yellowish brown (10YR 6/3) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; weakly cemented; 40% gravel; abundant very fine and fine interstitial pores; moderately alkaline.

30. Unnamed Soils of the Ustochreptic Camborthids-Rock Outcrop Complex. The Ustochreptic Camborthids in this complex are deep well-drained soils that weathered from dacites and latites of the Puye Conglomerate (Fig. 21). This complex is found on very steep to extremely steep mountain sideslopes vegetated with a piñon-juniper woodland.

The surface layers of these Ustochreptic Camborthids is usually a pale brown or light brownish gray, very cobbly or gravelly, sandy loam about 35 cm thick. The subsoil is a pale brown or very pale brown gravelly sandy loam or loamy sand about 55 cm thick. The substratum is greater than 60 cm thick and consists of a very pale brown or light gray very gravelly loamy sand or sand. The depth to bedrock and the effective rooting depth are greater than 152 cm. This soil has moderately rapid to very rapid permeability and a low available water capacity.

A typical profile of an Ustochreptic Camborthid, loamy-skeletal, mixed, mesic (55% slope) is described as follows:

A11 0-11 cm, pale brown (10YR 6/3) very cobbly sandy loam, very dark grayish brown (10YR 3/2) moist; moderate very fine and fine granular structure; nonsticky and friable moist; nonsticky and nonplastic wet; 25% gravel, 25% cobble, 5% stone; plentiful medium roots, abundant very fine and fine roots; plentiful very fine and fine interstitial pores; moderately alkaline; clear smooth boundary.

A12 11-33 cm, light brownish gray (10YR 6/2) gravelly sandy loam, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 30% gravel, 25% cobble, 5% stone; abundant very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

B21 33-64 cm, pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 3/3) moist; plentiful fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 35% gravel, 20% cobble, 5% stone; few medium and coarse roots, plentiful very fine and fine roots; abundant very fine and fine interstitial pores; moderately alkaline; clear wavy boundary.

B22 64-90 cm, very pale brown (10YR 7/4) gravelly loamy sand, dark yellowish brown (10YR 4/4) moist; weak fine and medium subangular blocky structure; nonsticky and friable moist, nonsticky and nonplastic wet; 25% gravel, 20% cobble; plentiful coarse roots, few very fine, fine, and medium roots; abundant very fine and fine interstitial pores; moderately alkaline; gradual wavy boundary.

C1 90-145 cm, very pale brown (10YR 7/3) very gravelly loamy sand, dark yellowish brown (10YR 4/4) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 60% gravel, 20% cobble, 5% stone; few fine and medium roots; plentiful very fine and fine interstitial pores; moderately alkaline; gradual wavy boundary.

C2 145-152+ cm, light gray (10YR 7/2) very gravelly sand, brown (10YR 4/3) moist; massive structure; nonsticky and friable moist, nonsticky and nonplastic wet; 65% gravel, 20% cobble, 5% stone; few fine roots; plentiful very fine and fine interstitial pores; strongly alkaline.

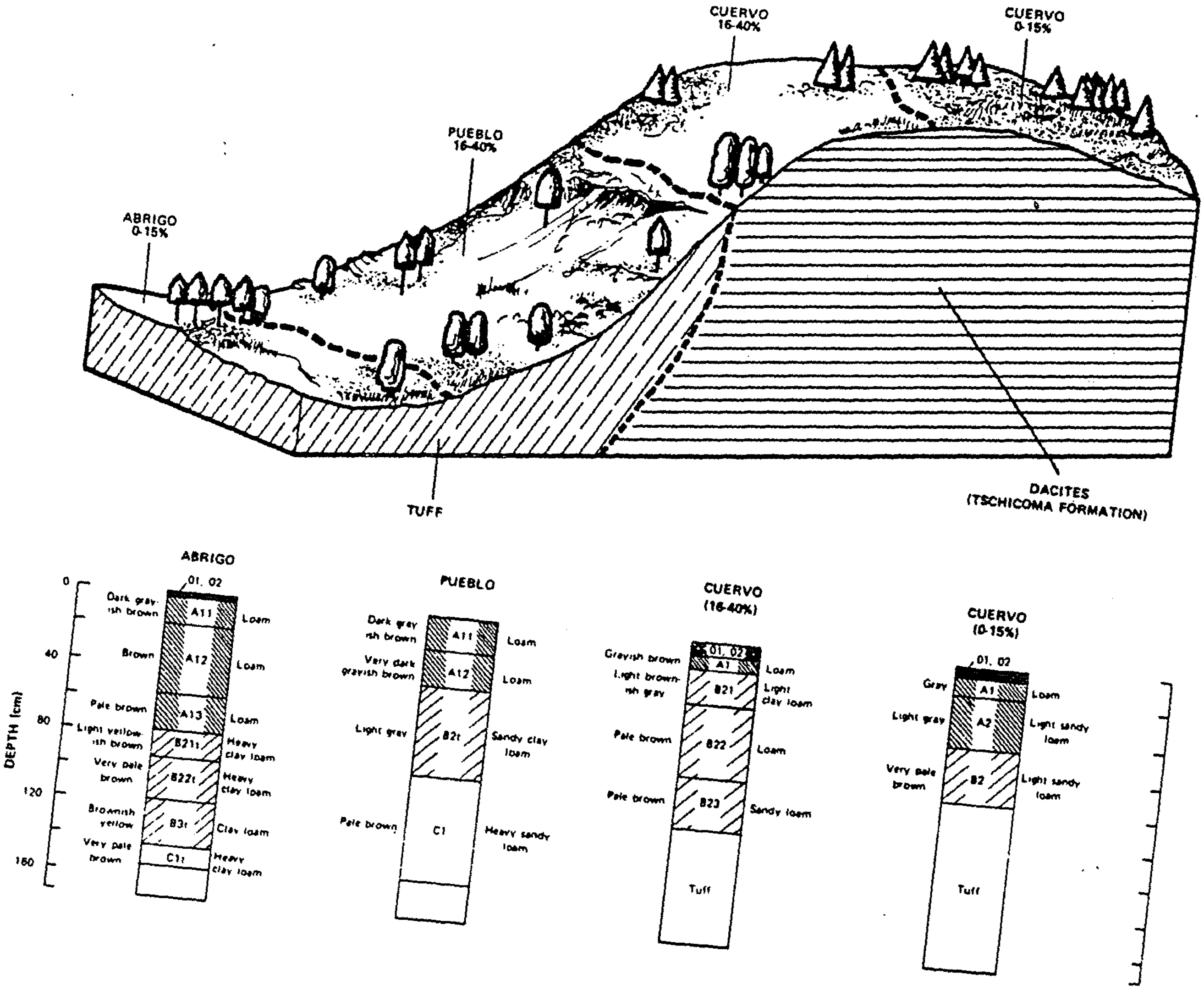

Fig. 14.

Relationships of slope, vegetation, and parent material to Abrigo, Pueblo, and Cuervo soils.

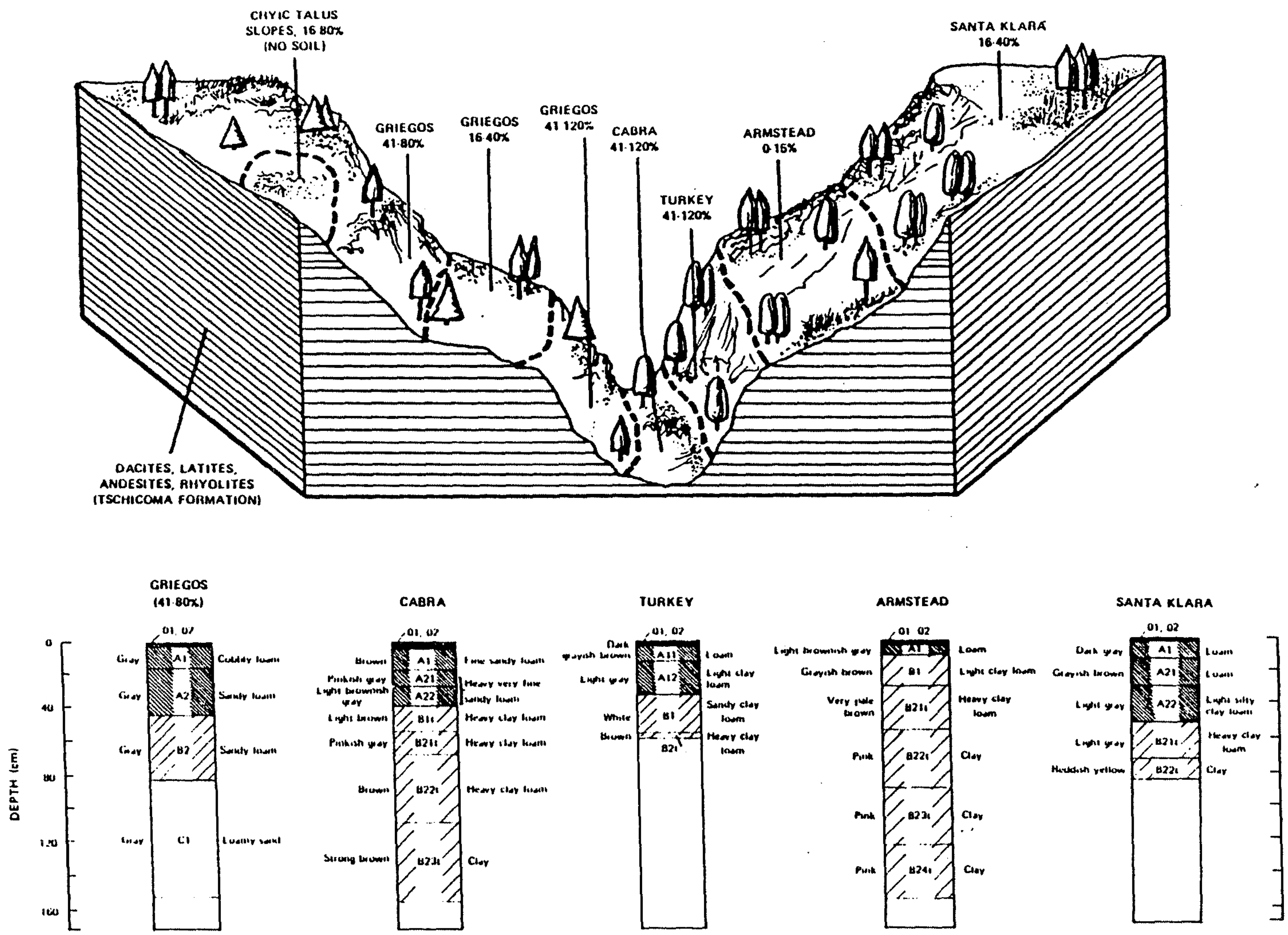

Fig. 15.
Relationship of slope, vegetation, and parent material to Griegos, Cabra, Turkey, Armstead, and Santa Klara soils.

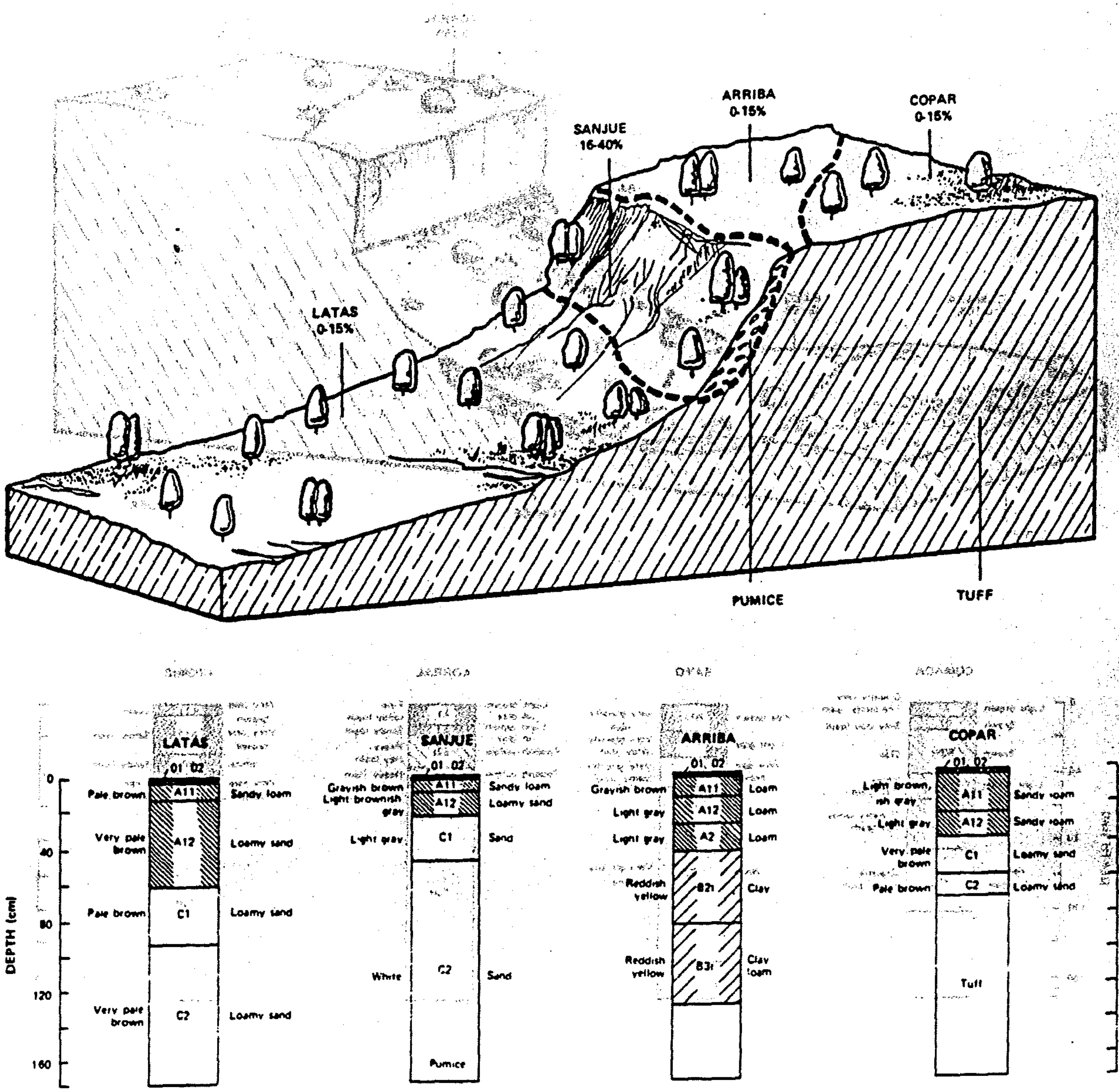

Fig. 16.

Relationship of slope, vegetation, and parent material to Latas, Sanjue, Arriba, and Copar soils.

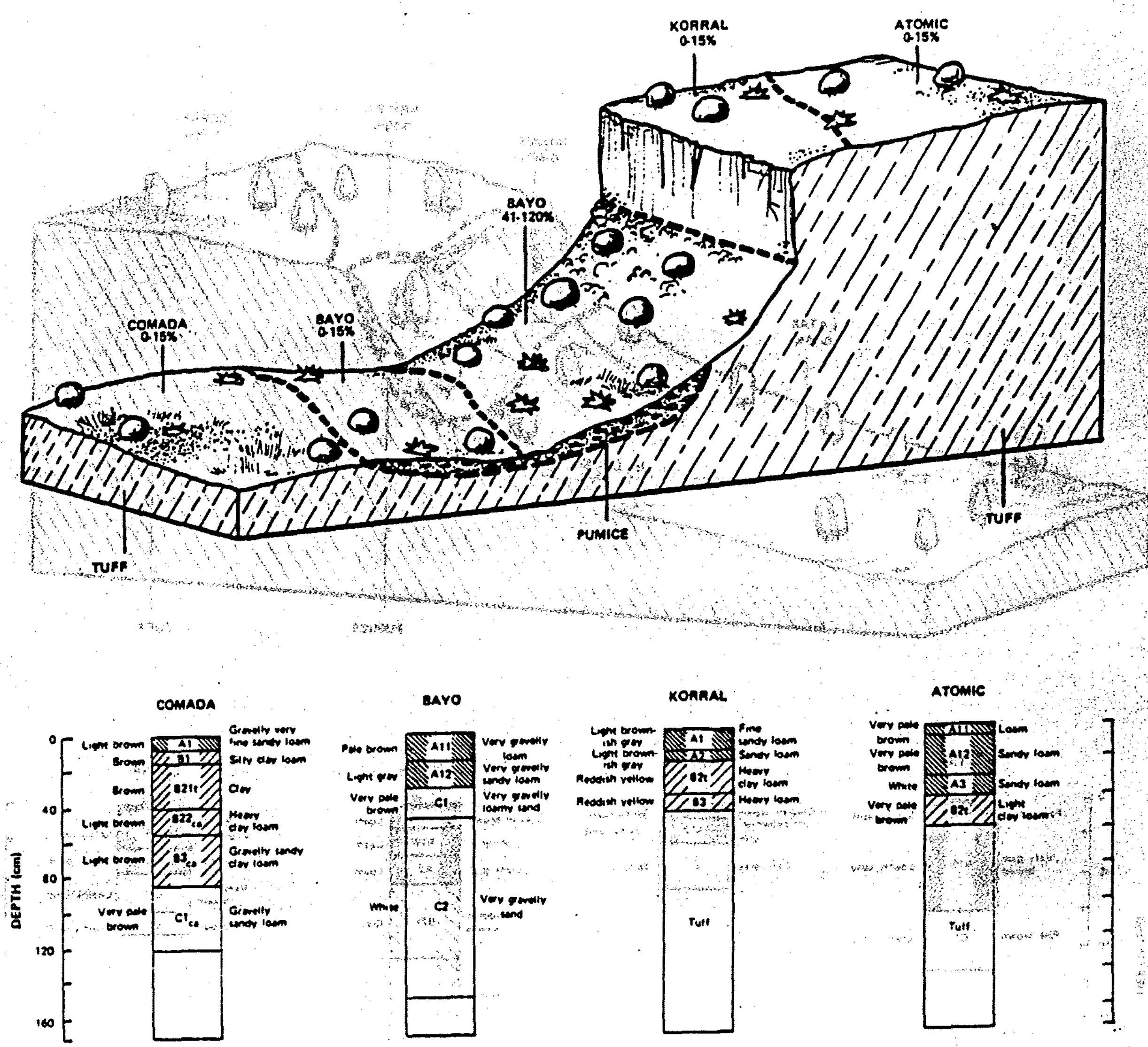

Fig. 17.
Relationship of slope, vegetation, and parent material to Comada, Bayo, Korral, and Atomic soils.

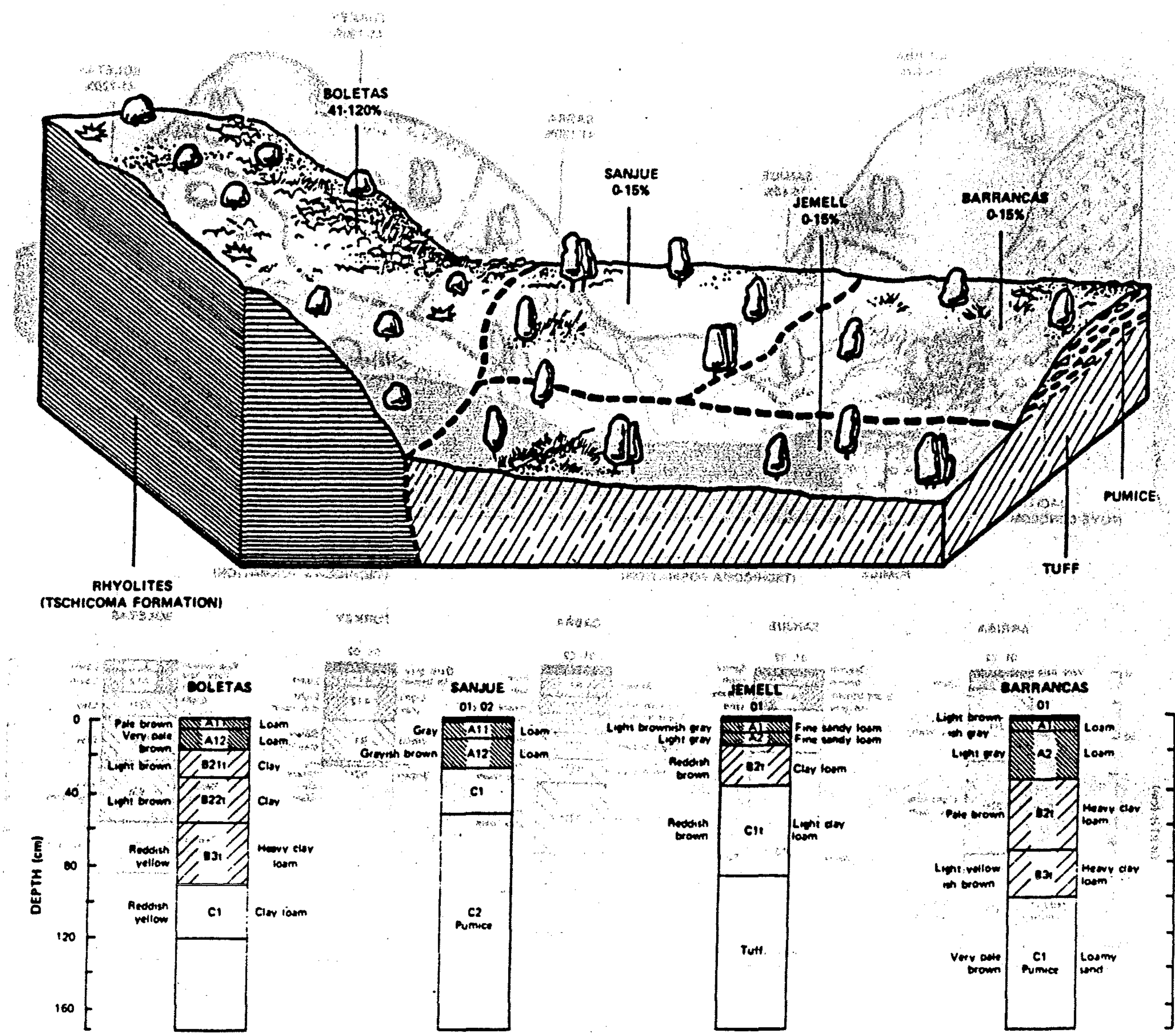

Fig. 18.
Relationship of slope, vegetation, and parent material to Boletas, Sanjue, Jemell, and Barrancas soils.

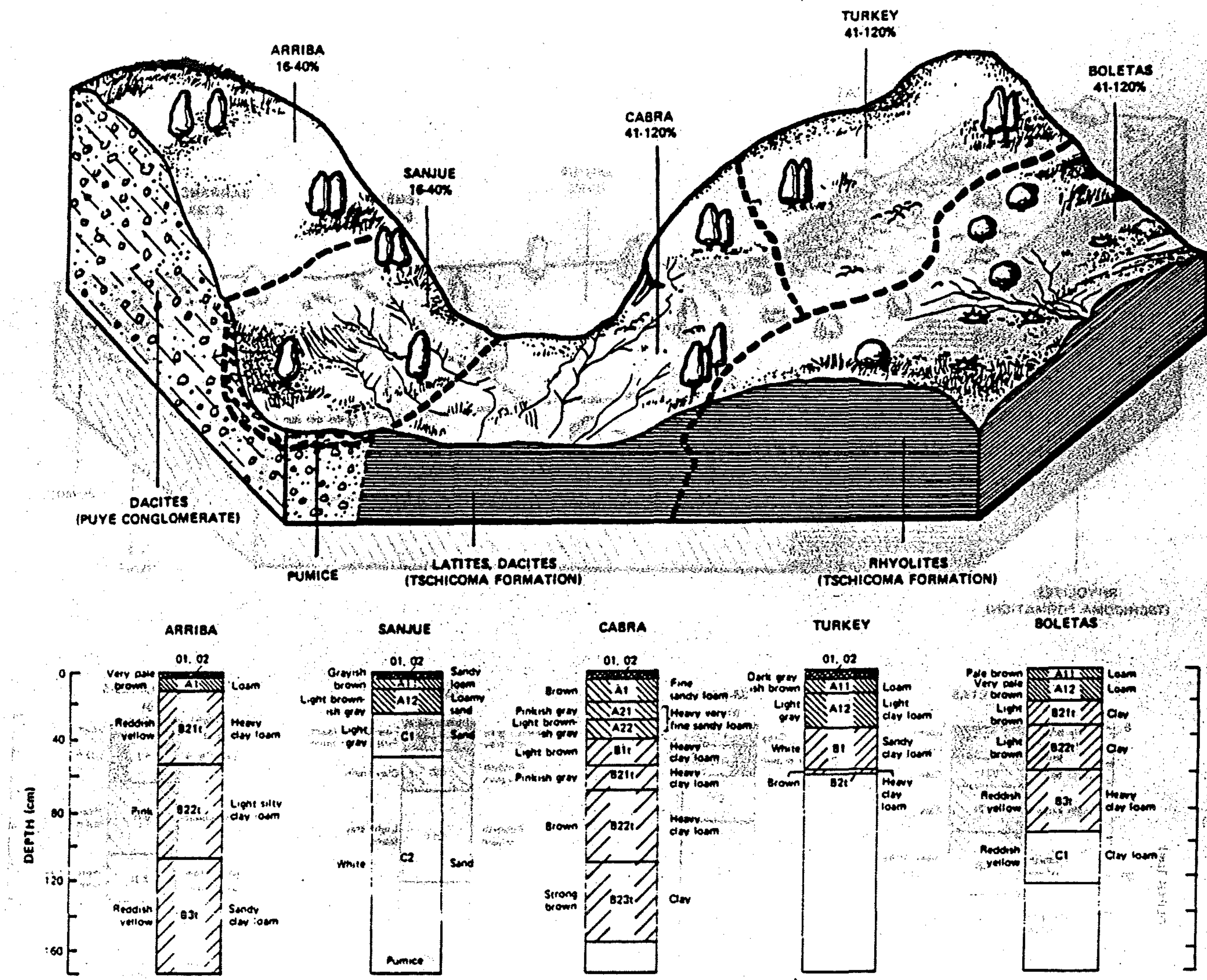

Fig. 19.

Relationship of slope, vegetation, and parent material to Arriba, Sanjue, Cabra, Turkey, and Boletas soils.

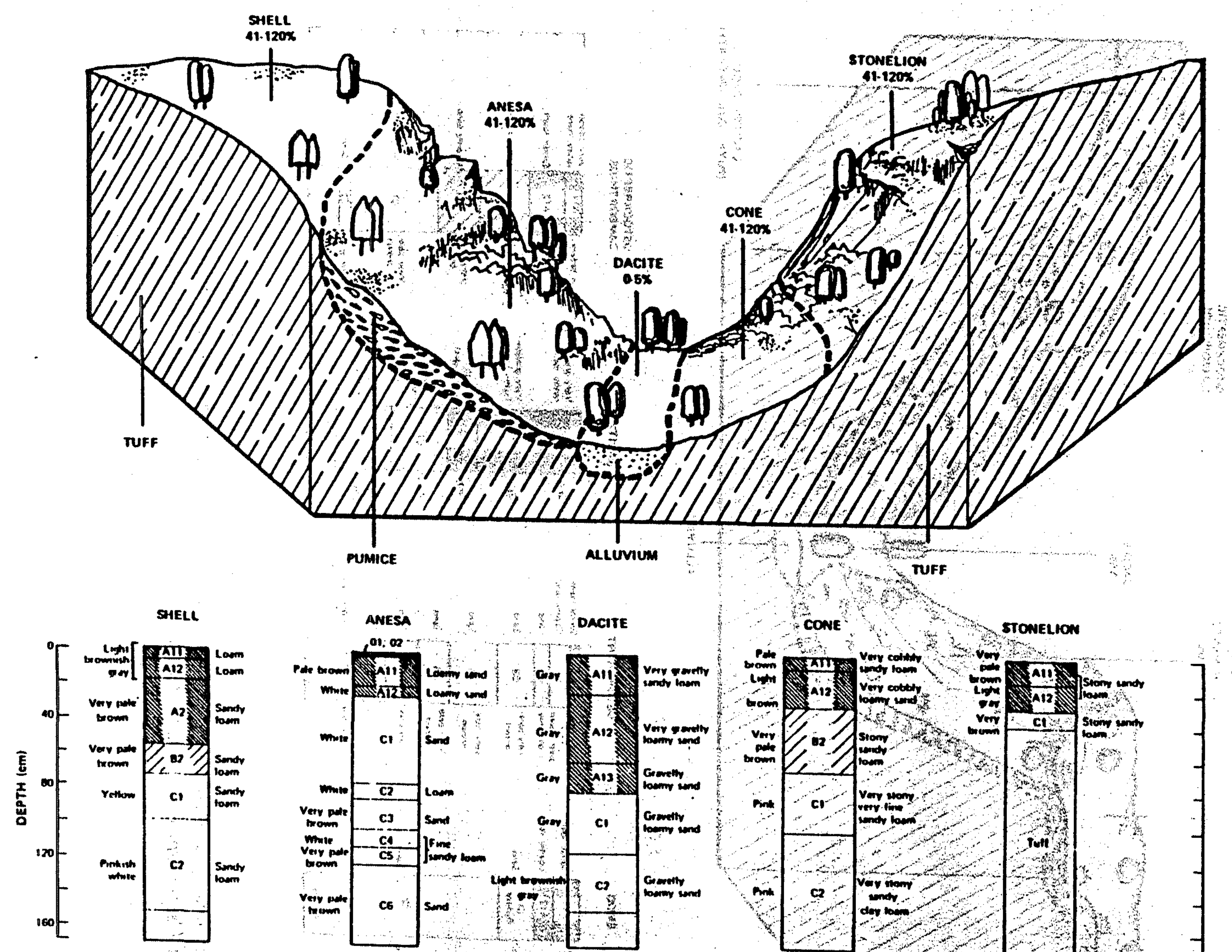

Fig. 20.

Relationship of slope, vegetation, and parent material to Shell, Anesa, Dacite, Cone, and Stonelion soils.

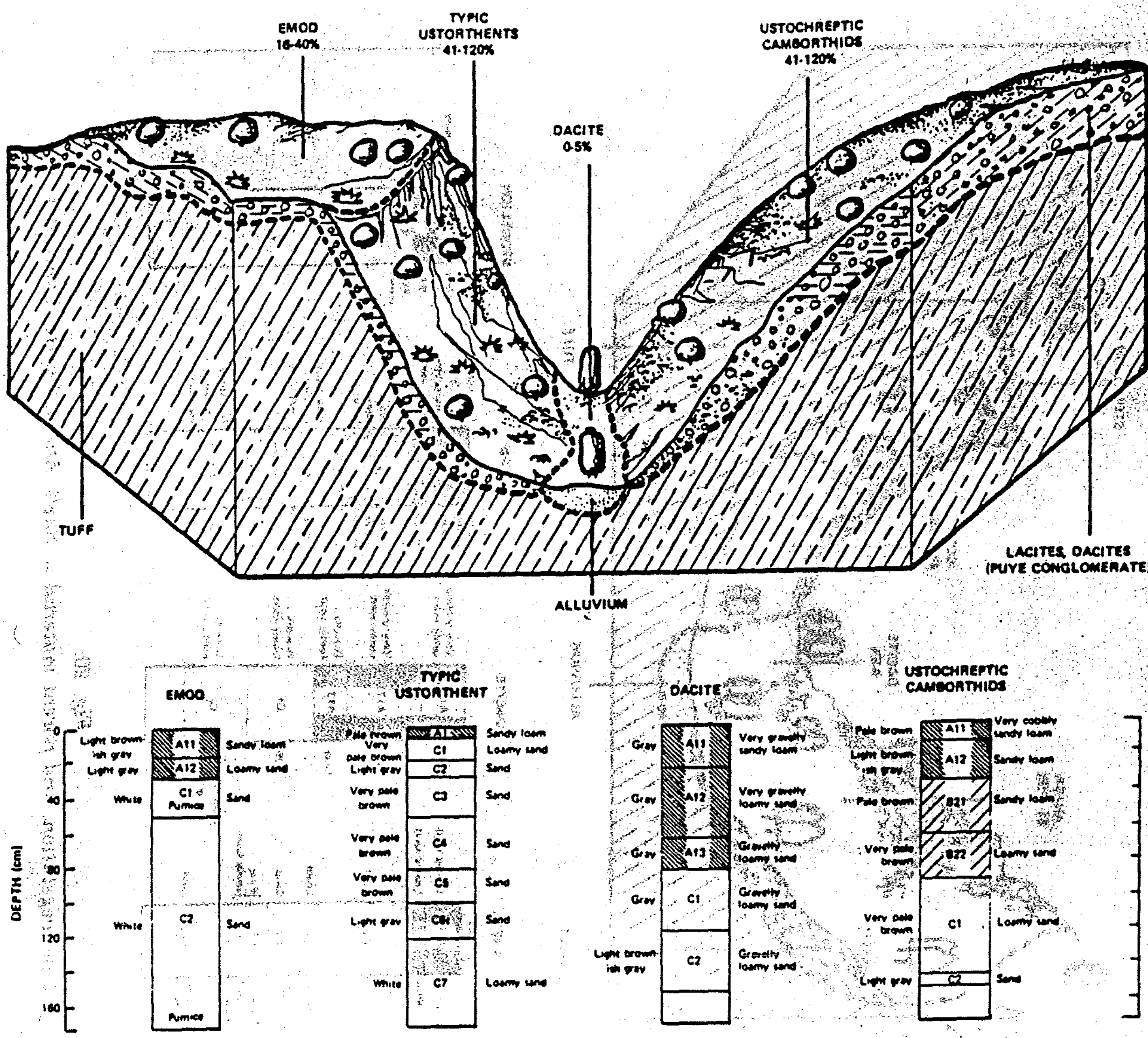

Fig. 21.
Relationship of slope, vegetation, and parent material to Emod, Typic Ustorthent, Dacite, and Ustochreptic Camborthid soils.

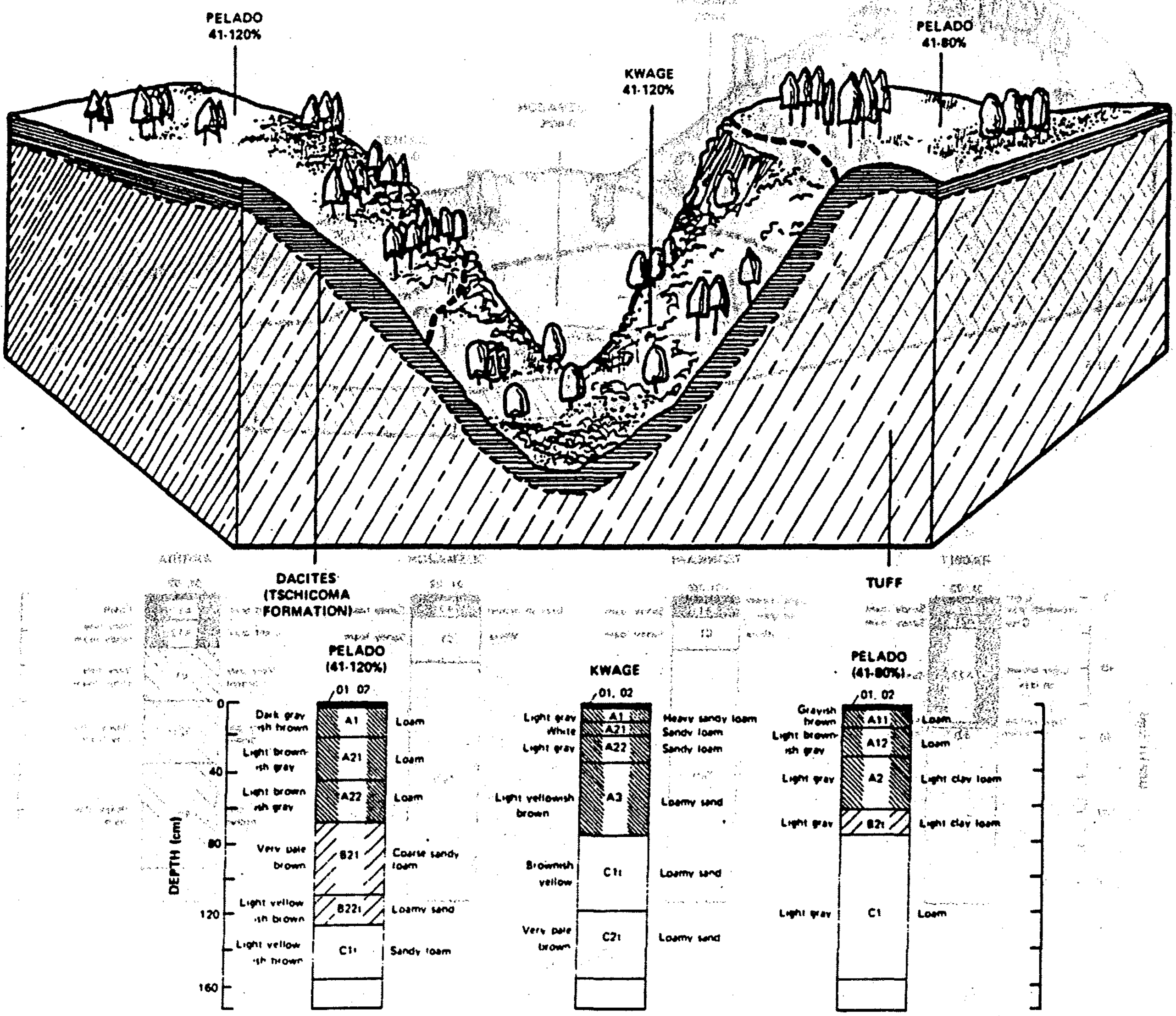

Fig. 22.
Relationship of slope, vegetation, and parent material to Pelado and Kwage soils.

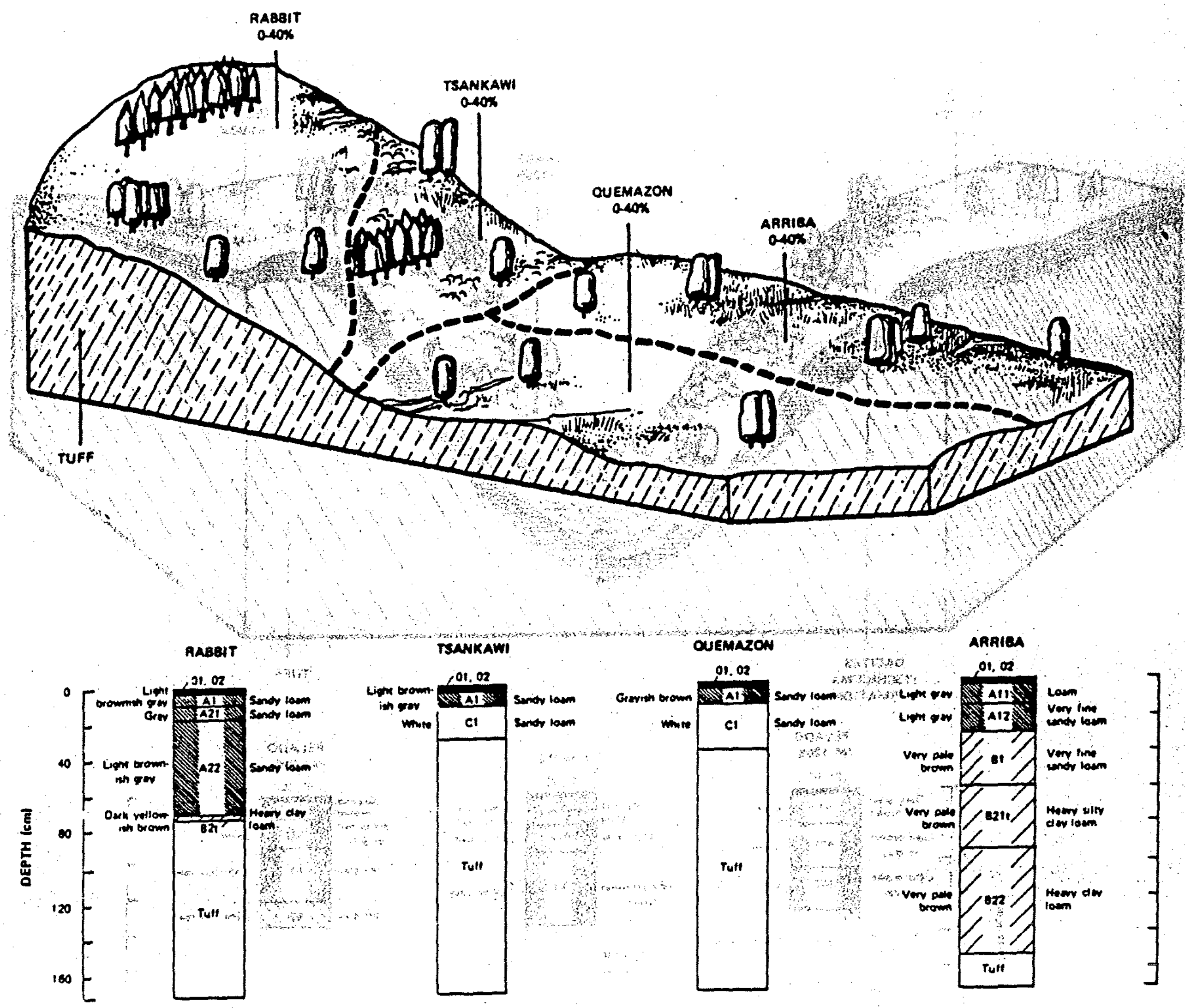

Fig. 23.

Relationship of slope, vegetation, and parent material to Rabbit, Tsankawi, Quemazon, and Arriba soils.

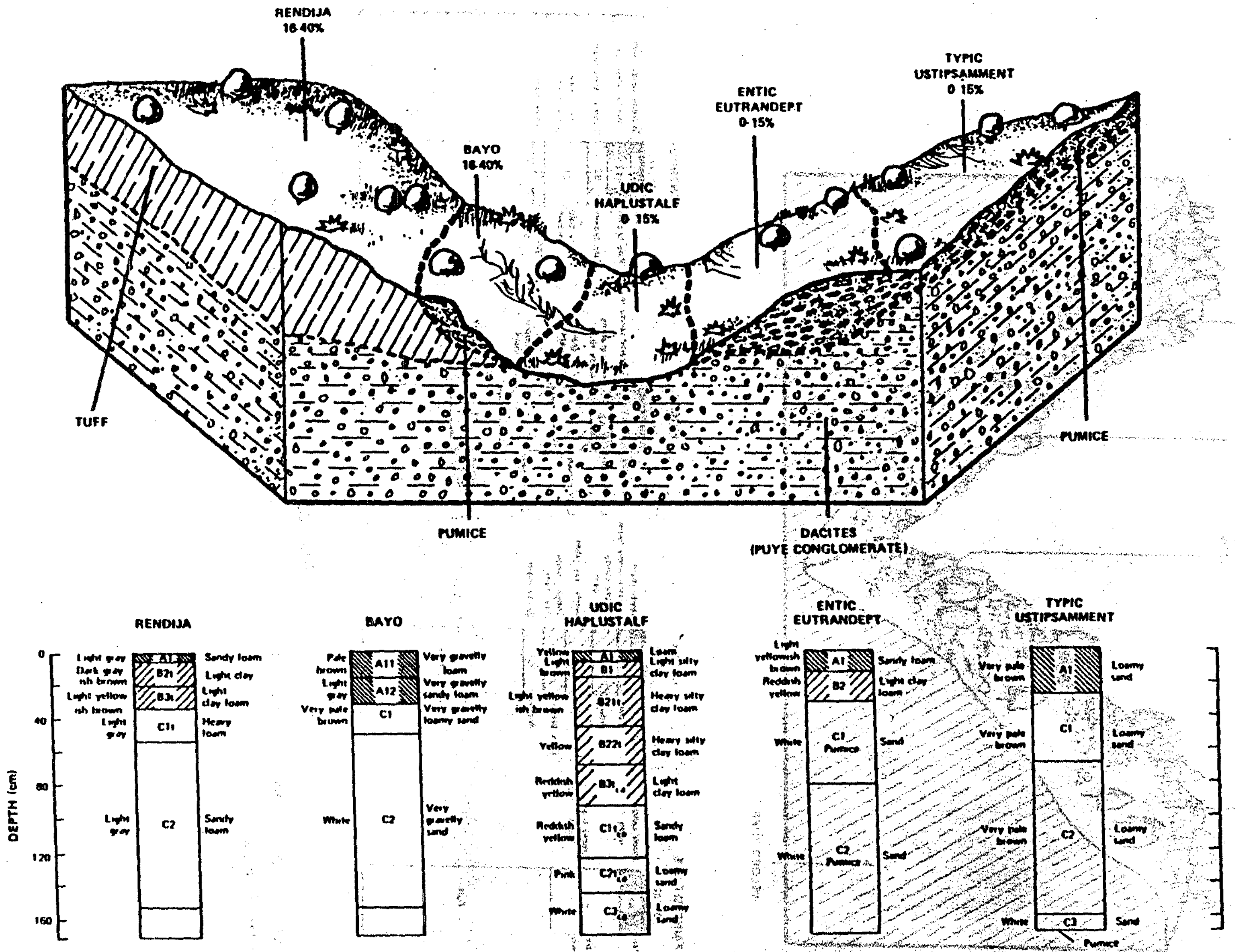

Fig. 24.

Relationship of slope, vegetation, and parent material to Rendija, Bayo, Udic Haplustalf, Entic Eutrandept, and Typic Ustipsamment soils.

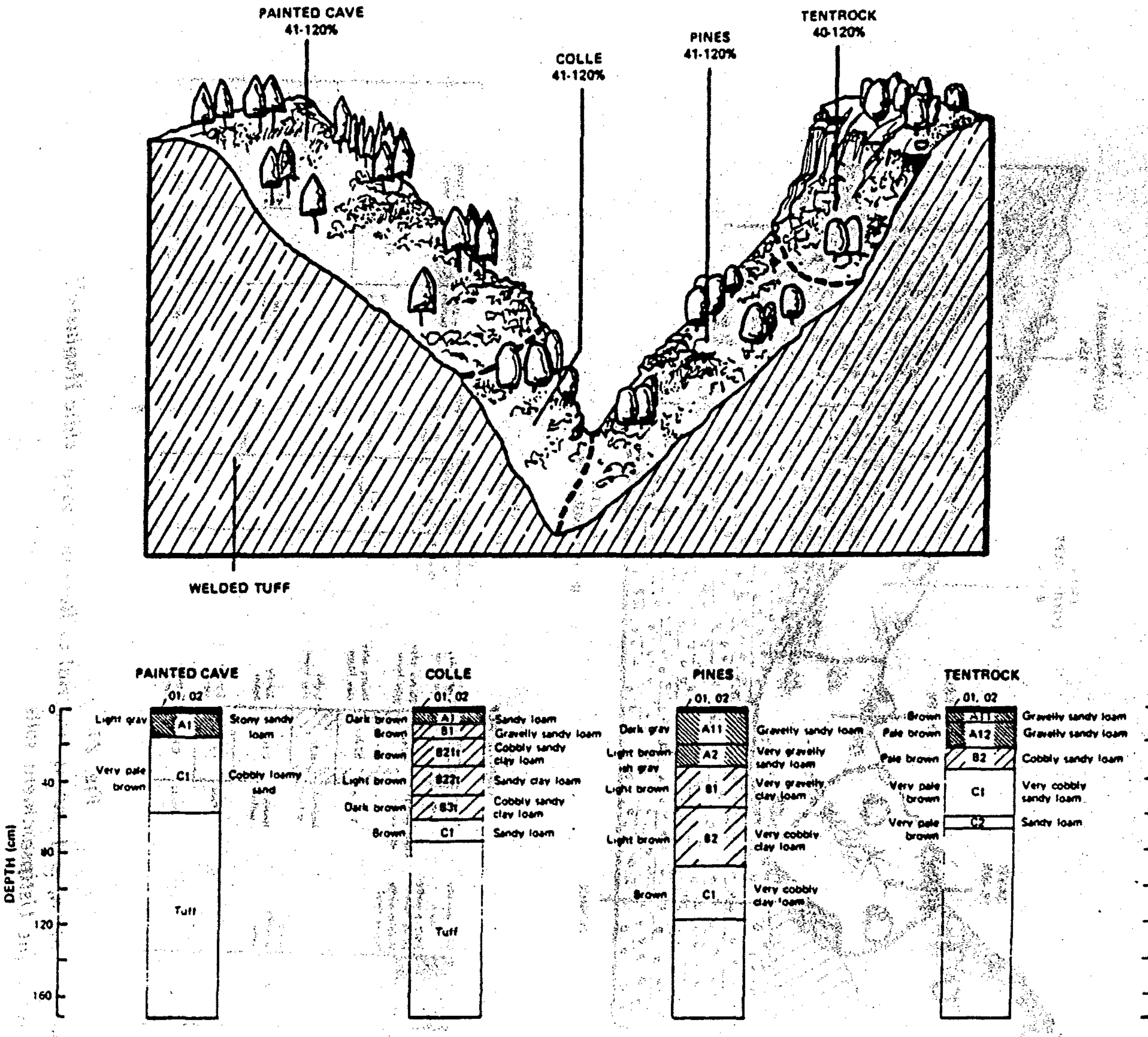

Fig. 25.

Relationship of slope, vegetation, and parent material to Painted Cave, Colle, Pines, and Tentrock soils.

VII. USE AND MANAGEMENT OF THE SOILS

The nature and distribution patterns of soils are important in determining their usefulness. This is becoming increasingly evident in Los Alamos County as the population expands and requires greater amounts of land for a wider variety of uses. Investments per unit area of land are high and increasing under such use, and mistakes are costly. These mistakes can often be avoided, and more intelligent decisions on the use of land can be made from land use interpretations of soil surveys.

This chapter provides information of special interest to planners, engineers, contractors, and others who use soil as a structural material or as a foundation for structures. This soil survey data base is also used to provide information in planning recreational areas used for camping, picnicking, playgrounds, and hiking. This information is only provided for the soils in the LASL-Soil Conservation Service portion of the survey (Fig. 1), because this area receives a higher intensity of land use than any other portion of Los Alamos County.

A. Engineering Uses of the Soils

The properties of a soil, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, buried electrical cables, foundations for small buildings, irrigation systems, ponds and small dams, and systems for the disposal of sewage and refuse. Specifically, the properties of soils highly important in engineering-related projects are permeability, strength, compaction characteristics, drainage condition, shrink-swell potential, grain size, plasticity, reaction, depth to the water table, depth to bedrock, and slope.

Information concerning these and related soils properties is given in Tables VIII and IX at the end of this section. The estimates and interpretations in these tables can be used to select areas for potential residential, recreational, and military uses; evaluate alternate routes for roads, highways, pipelines, and underground cables; locate probable sources of gravel, sand, or clay; plan drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil; correlate performance of structures already built with properties of the kind of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations; predict the trafficability of soils for cross-country movement of vehicles and construction equipment; and develop preliminary estimates pertinent to construction in a particular area.

Tables VIII and IX show, respectively, estimates of soil properties significant in engineering and interpretations for various engineering uses. The information in these tables does not eliminate the need for sampling and testing at the site of specific engineering works, especially those that involve heavy loads or that require excavations to depths greater than those shown in the tables. Also, a site that is designated as a given mapping unit can contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for engineering uses.

1. Engineering Classification System. The two systems most commonly used in classifying soils for engineering are the Unified system[15] used by engineers of the Soil Conservation Service, the Department of Defense, and others, and the system adopted by the American Association of State Highway Officials (AASHO).[16]

In the Unified system, soils are classified according to particle-size distribution, liquid limit (lowest moisture content at which the fines in the soil mass behave as a liquid), plasticity index (range in moisture content in which the fines in the soil mass behave as a plastic mass) and organic matter content.[15] The soils are grouped in 15 classes, with 8 classes of coarse-grained soils and 6 classes of fine-grained soils (Table VIII). The gravels (G) and sands (S) are each divided into 4 groups: well-graded, fairly clean material (GW, SW), poorly-graded, fairly clean material (GP, SP), coarse materials with clay fines (GC, SC), and coarse materials with silt fines (GM, SM). The fine-grained soils with low (L) and high (H) liquid limits are each divided into three groups: inorganic silty and very fine sandy soils (ML, MH), inorganic clays (CL, CH), and organic silts and clays (OL, OH). Highly organic soils, such as peat and swamp soils, are placed in one group (PT). Soils on the borderline between two classes are designated by symbols for both classes: for example, CL-ML for the Carjo series (Table VIII).

The AASHO system is used to classify soils according to those properties that affect use in highway construction and maintenance (Table VIII). In this system a soil is classified in one of seven basic groups on the basis of grain-size distribution, liquid limit, and plasticity index.[16] These groups range from A-1, which consists of soils that have the highest bearing strength and are the best soils for subgrade, to A-7, which consists of soils that have low strength when wet and are the poorest soils for subgrade. A typical group A-1 material is a well-graded mixture of stone fragments or gravel, coarse sand, volcanic cinders, fine sand, and a nonplastic or feebly plastic soil binder. Group A-3 typically contains a fine beach sand or fine desert blow sand without silty or clay fines or with a small amount of silt. Group A-2 contains a wide variety of granular materials, which are borderline between Group A-1 and A-3 materials. The typical material of Group A-4 is a nonplastic, or moderately plastic, silty soil, whereas Group A-6 contains plastic clay soils. The Group A-7 materials are typically similar to those in Group A-6, except that they have a high liquid limit and may be elastic as well as subject to a high volume change. The USDA textural classification system is used to express the relative proportions of sand, silt and clay in soil materials less than 2.0 mm in diameter (Fig. 8).

2. Engineering Properties. Table VIII also shows other estimates of soil properties that are significant in engineering. These estimates were determined for selected soils based on layers of the profile that have significantly different properties. The estimates are based on field observations, test data for these and similar soils, and experience with the same kinds of soil in other areas. Some of the terms for which data are shown are explained in the following paragraphs and in the glossary.

The coarse fraction >7.6 cm was estimated, in per cent, by weight of the soil mass. In field sampling, this part of the soil was discarded and only the size fractions <7.6 cm were estimated for the number 4, 10, 40, and 200 sieve sizes (Table VIII). This 7.6 cm size limit coincides with that used in both the AASHO and the Unified classification systems.

Soil plasticity is another property significant in engineering. It is a characteristic of a soil to take up water to form a mass that can be deformed into any desirable shape after the force applied exceeds a certain value, and to maintain this shape after the deformation pressure is removed. Plasticity is described from the point of view of the moisture range over which soil plasticity is manifested, from the liquid limit (the moisture content at which the soil will barely flow under an applied force) to the plastic limit (the moisture content at which the soil can barely be rolled out into a wire).[15] The plasticity index presented in Table VIII is calculated as the difference between the liquid and plastic limits. Large values for the liquid limit and the plasticity index given in Table VIII reflect large amounts of finer soil fractions such as clay and of exchangeable sodium in the specific soil series.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, or the extent to which the soil shrinks as it dries out and swells when it gets wet. The extent of changes is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential (Table VIII) indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Corrosion, as used in Table VIII, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion on uncoated steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosivity in concrete is influenced mainly by the content of sodium or magnesium sulfate, and also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. The risk of corrosion is low if there is a low probability of soil-induced corrosion damage. A high rating indicates a high probability of damage and indicates that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

The erosion factors K and T are given for each soil series in Table VIII. The soil erodibility factor K is a unitless constant used in the universal soil loss equation and is a function of the texture, structure, permeability, and organic matter content of a soil series. For example, increased amounts of silt and very fine sand cause many soils to be more erodible. The K values for soils range from 0.02 to 0.69 with larger K values reflecting more erosive soils. The soil loss tolerance value, T, is strictly a function of soil depth and is expressed in units of tons of allowable soil loss/acre/year. The values of T range from 1 to 5, with larger T values generally being assigned to deeper soils.

A measure of the potential rate of soil loss by wind erosion is given in Table VIII in the form of wind erodibility group ratings. These ratings can be roughly estimated by the texture of the surface 2.5 cm of soil. Wind erodibility groups 3, 5, 6, and 8 correspond to 67-113, 33-79, 29-63, and 0 tons of soil potentially eroded by wind erosion/acre/year, respectively. Once the wind erodibility group has been estimated, site-specific information on the other factors of the wind erosion equation can be collected to estimate the potential amount of wind erosion for a given field under local climatic conditions.

Hydrologic soil groups (Table VIII) are used in watershed planning to estimate runoff from rainfall. Soil properties are considered that influence the minimum rate of infiltration obtained for a bare soil after prolonged wetting. Depth to the seasonal high water table, intake rate, permeability after prolonged wetting, and depth to very slowly permeable layers are considered in hydrologic soil groupings, but the influence of ground cover is treated independently. The four hydrologic groups considered by the Soil Conservation Service are A (low runoff potential), B (moderately low runoff potential), C (moderately high runoff potential), and D (high runoff potential). Soils belonging to Group A have rapid water infiltration and transmission rates; Group D soils generally have slow infiltration rates, high shrink-swell potentials, and very slow water transmission rates.

3. Engineering Interpretations. The interpretations in Table IX are based on the engineering properties of soils shown in Table VIII, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Los Alamos. The ratings summarize the limitation or suitability of the soils for all listed purposes.

Soil limitations are given ratings of slight, moderate, or severe. Slight means that soil properties generally are favorable for the rated use; in other words, that limitations are minor and easily overcome. Moderate means that some soil properties are unfavorable, but can be overcome or modified by special planning and design. Severe indicates soil properties so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance is required. Soil suitability is rated as good, fair, or poor.

Septic tank absorption fields (Table IX) are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. For this application, the soil material from a depth of 46 to 152 cm must be evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding.

Slope affects difficulty of layout and construction and also the risks of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons (Table IX) are shallow ponds constructed to hold sewage, within a depth of 60 to 150 cm, long enough for bacteria to decompose the solids. A lagoon has a nearly level floor, and sides, or embankments, of compacted soil material. The interpretations given in Table IX assume lagoons in which the embankment is compacted to medium density and the pond is protected from flooding. Properties that affect the pond floor are permeability, organic-matter content, and slope. If the floor needs leveling, depth to bedrock is important. Properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified soil classification and the number of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Sanitary landfill (Table IX) is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils for sanitary landfill have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate.

Shallow excavations require digging or trenching to a depth of less than 150 cm and are used for pipelines, sewer lines, telephone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, a gentle slope, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Foundations for low buildings without basements, as rated in Table IX, are for buildings no more than three stories high that are supported by foundation footings placed in undisturbed soil. The rating is based on the capacity of the soil to support load and resist settlement under load and on the ease of excavation. Soil properties that affect the capacity to support a load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Local roads and streets, as rated in Table IX, have an all-weather surface expected to carry traffic all year. They have a subgrade of soil material; a base of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the material, and workability and quantity of cut and fill material available. The AASHO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect the ease of excavation and the amount of cut and fill needed to reach an even grade.

Road fill is soil material used in constructing subgrade for roads. The suitability ratings reflect the predicted performance of soil after it has been replaced in a subgrade that has been properly compacted and provided with adequate drainage. The ease of excavating the material at borrow areas is also considered.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in Table IX provide guidance on where to look for probable sources. A soil rated as a good or fair source of sand or gravel generally has a layer at least 90 cm thick, the top of which is within 180 cm of the surface. The ratings do not take into account factors that affect mining of the materials. Also, they do not indicate the quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as in preparing a seedbed; natural fertility of the material, or the response of plants if fertilizer is applied; and the absence of substances toxic to plants. Texture of the soil material and the content of stone fragments are characteristics that affect suitability. Also considered in the ratings is damage that results at the area from which topsoil is taken.

Pond reservoir areas hold water in a pit or behind embankments. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and the depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that resists seepage and piping and has favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic material, for example, are unfavorable factors.

Drainage is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and need for drainage, or the depth to the water table or bedrock.

B. Recreational Uses of the Soils

The demand for outdoor recreation is growing rapidly in the Los Alamos area and more and more local land is being used more intensively by the public for recreation. Knowledge of the soils of an area — a farm, ranch, community, watershed, or county — provide fundamental information needed in recreation planning.

The same soil properties that affect engineering and agricultural uses of soil are the ones that affect their use for recreation (Table X). The interpretations are different but they go back to the same basic principles of water movement, shrink-swell potential, fertilizer use efficiency, susceptibility to erosion, and others. Just as with the engineering interpretations data presented in Table IX, the soil limitations for recreational uses of areas are indicated by the ratings slight, moderate, and severe. The ratings in Table X have the same meanings as those in Table IX.

Soils subject to flooding have severe limitations for use as sites for camps and recreation buildings. If soils subject to flooding are not protected by dikes, levees, or other flood prevention structures, they should not be developed for campsites or vacation cottages. These soils are better suited for hiking or nature study areas, or for greenbelt open space, if the flooding is not too frequent.

Soils that are wet all year, even if not flooded, have severe soil limitations for campsites, recreational roads and trails, playgrounds, and picnic areas. Soils that are wet only part of the year or those that have a water table that moves up and down without reaching the surface are not easily detected by most people. These soils have severe limitations for most recreational uses. Soils that dry out slowly after rains present problems where intensive use is contemplated.

Droughty soils also have limitations for many recreational uses. On such sites, grass cover needed for playing fields is difficult to establish and maintain. Access roads may be excessively dusty. Vehicles are easily mired down in sandy soils and soil blowing is common. Knowledge of these soil problems enables planners to use corrective conservation practices, such as irrigation, or to choose alternative locations.

The ability of a soil to support a load is important in many kinds of recreational activities. Some soils when wet fail to support structures such as access roads, trails, and buildings.

Slope affects the use of soils for recreation. Nearly level, well drained, permeable, stone-free soils have few or no limitations for use as playgrounds, campsites, sites for recreational buildings,

TABLE VIII.

ESTIMATES OF SOIL PROPERTIES SIGNIFICANT IN ENGINEERING

Soil Series	Depth (cm)	USDA Texture	Classification: Unified	Classification: AASHO	Fraction >7.6 cm (%)	Percent of Material <7.6 cm Passing Sieve No. 4 (4.7 mm)	10 (2.0 mm)	40 (0.42 mm)	200 (0.074 mm)	Liquid Limit % Water	Plasticity Index	Permeability (cm/hr)	Available Water Capacity (cm/cm)	Soil pH	Shrink-Swell Potential	Risk of Corrosion to: Uncoated Steel	Concrete	K	T	Wind Erodibility Group	Hydrologic Group	Potential Frost Action
Caryo	0 - 10	loam, very fine sandy loam	CL-ML, ML	A-4	0	100	100	85 - 95	60 - 75	25 - 35	5 - 10	1.5 - 5.0	0.15 - 0.18	6.3 - 7.3	Low	Low	Low	0.28	1	3	C	Low
	10 - 50	clay loam, clay	CL, ML	A-6, A-7	0	100	100	90 - 100	70 - 95	35 - 45	10 - 20	0.15 - 0.5	0.14 - 0.21	6.6 - 7.3	Moderate	High	Low	0.32				
	50 - 63	very fine sandy loam	CL, CL-ML	A-4	0	100	100	85 - 95	50 - 65	20 - 30	5 - 10	1.5 - 5.0	0.15 - 0.17	7.4 - 7.8	Low	Low	Low	0.24				
Frijolas	0 - 5	loam, very fine sandy loam	CL-ML, ML	A-4	0	100	100	85 - 95	50 - 75	25 - 35	5 - 10	1.5 - 5.0	0.16 - 0.18	6.6 - 7.3	Low	Low	Low	0.28	1	3	B	Low
	5 - 30	very gravelly clay loam	GC, GM	A-2	0	30-40	25 - 35	20 - 35	20 - 30	35 - 40	10 - 15	0.51 - 1.5	0.13 - 0.15	6.6 - 7.3	Low	High	Low	0.15				
	30 - 46	very gravelly sandy clay loam	GC, GM	A-2	0	30-40	25 - 35	20 - 30	10 - 20	30 - 35	5 - 10	1.5 - 5.0	0.08 - 0.10	7.4 - 7.8	Low	Low	Low	0.15				
	46 - 152	gravel	GP	A-1	0	15-25	10 - 20	5 - 10	0 - 5	<20	NP*	>51	0.02 - 0.04	8.5 - 9.0	Low	Low	Low	0.15				
Hackroy	0 - 8	sandy loam	SM, SM-SC	A-2, A-4	0	100	100	60 - 70	30 - 40	<25	NP-5	5.0 - 15	0.11 - 0.13	6.6 - 7.8	Low	Low	Low	0.20	1	3	C	Low
	0 - 8	loam, very fine sandy loam	ML, CL-ML	A-4	0	100	100	85 - 95	50 - 75	25 - 35	5 - 10	1.5 - 5.0	0.14 - 0.21	6.6 - 7.8	Low	Low	Low	0.28	1	3		
	8 - 30	clay loam, clay	CL	A-6, A-7	0	95-100	95 - 100	85 - 95	70 - 90	35 - 45	15 - 25	0.15 - 0.50	0.13 - 0.20	6.6 - 7.8	Moderate	High	Low	0.32				
Nyjack	0 - 8	sandy loam	SM, SM-SC	A-2, A-4	0	100	100	60 - 70	30 - 40	<25	NP-5	5.0 - 15	0.11 - 0.13	6.1 - 7.3	Low	Low	Low	0.20	3	3	C	Low
	0 - 8	loam, very fine sandy loam	ML, CL-ML	A-4	0	100	100	85 - 95	50 - 75	25 - 35	5 - 10	1.5 - 5.0	0.14 - 0.21	6.1 - 7.3	Low	Low	Low	0.28	3	3		
	8 - 61	clay loam	ML, CL	A-6	0	100	100	90 - 100	70 - 80	35 - 40	10 - 15	1.5 - 15	0.19 - 0.21	6.6 - 7.8	Moderate	Moderate	Low	0.32				
	61 - 99	sandy loam, gravelly sandy loam	SM, SM-SC	A-2, A-4	0	55-100	50 - 100	30 - 70	15 - 40	<25	NP-5	5.0 - 15	0.07 - 0.13	7.4 - 7.8	Low	Low	Low	0.20				
Penistaja	0 - 10	fine sandy loam, sandy loam	ML, SM	A-4	0	100	100	90 - 100	40 - 60	20 - 25	NP-4	1.5 - 5.0	0.13 - 0.15	6.6 - 7.3	Low	Low	Low	0.24	5	3	B	Low
	0 - 10	loamy fine sand	SM	A-2	0	100	100	85 - 95	15 - 30	20 - 25	NP	5.0 - 15	0.09 - 0.11	6.6 - 7.3	Low	Low	Low	0.17	5	2		
	10 - 71	sandy clay loam	CL-ML, CL, SC	A-4, A-6	0	100	100	95 - 100	45 - 70	25 - 25	5 - 15	1.5 - 5.0	0.14 - 0.16		Moderate	Moderate	Low	0.32				
	71 - 152	sandy loam, fine sandy loam, sandy clay loam	SM, SM-SC, CL	A-2, A-4	0	100	100	70 - 95	30 - 55	20 - 30	NP-10	1.5 - 15	0.12 - 0.14	7.9 - 8.4	Low	High	Low	0.24				
Pugsa	0 - 30	fine sandy loam, sandy loam	SM-SC, SM	A-2, A-4	0	100	100	60 - 85	30 - 50	<25	NP-5	5.0 - 15	0.11 - 0.15	6.1 - 7.3	Low	Low	Low	0.24	1	3	C	Moderate
Potrillo	0 - 15	loam	CL-ML, CL	A-4	0	90-100	85 - 100	80 - 90	55 - 70	20 - 30	5 - 10	1.5 - 5.0	0.16 - 0.18	6.6 - 7.8	Low	Moderate	Low	0.28	5	5	B	Low
	0 - 15	sandy loam, fine sandy loam	SM, SM-SC	A-2, A-4	0	90-100	85 - 100	55 - 65	30 - 40	<25	NP-5	5.0 - 15	0.11 - 0.13	6.6 - 7.8	Low	Moderate	Low	0.20	5	3		
	0 - 15	gravelly sandy loam	SM, SM-SC	A-2	0	65-85	60 - 80	40 - 55	20 - 30	<25	NP-5	5.0 - 15	0.09 - 0.11	6.6 - 7.8	Low	Moderate	Low	0.20	5	3		
	15 - 152	loam, fine sandy loam, sandy loam	SM-SC, SC, CL-ML, CL	A-2, A-4	0	90-100	85 - 100	55 - 90	25 - 70	20 - 30	5 - 10	1.5 - 5.0	0.12 - 0.18	6.6 - 7.8	Low	Moderate	Low	0.28				
Prieta	0 - 10	stony loam	GM-GC, GM, SM-SC, SM	A-2, A-4	40-50	55-80	50 - 75	45 - 65	30 - 45	25 - 35	5 - 10	1.5 - 5.0	0.08 - 0.11	6.6 - 7.8	Low	Moderate	Low	0.17	1	8	D	Low
	0 - 10	stony silt loam, stony silty clay loam	GM, ML	A-4, A-6	40-50	55-80	50 - 75	50 - 75	40 - 70	30 - 40	5 - 15	0.15 - 0.50	0.08 - 0.11	6.6 - 7.8	Moderate	Moderate	Low	0.17	1	8		
	10 - 38	stony silty clay loam, stony clay loam, stony clay	GC, CL, CH	A-7	40-50	55-80	50 - 75	50 - 75	45 - 70	40 - 55	15 - 30	0.15 - 0.50	0.08 - 0.11	7.4 - 8.4	High	High	Low	0.17				

TABLE VIII (cont)

ESTIMATES OF SOIL PROPERTIES SIGNIFICANT IN ENGINEERING

Soil Series	Depth (cm)	USDA Texture	Classification: Unified	Classification: AASHO	Fraction >7.6 cm (%)	Percent of Material <7.6 cm Passing Sieve No.: 4 (4.7 mm)	10 (2.0 mm)	40 (0.42 mm)	200 (0.074 mm)	Liquid Limit % Water	Plasticity Index	Permeability (cm/hr)	Available Water Capacity (cm/cm)	Soil pH	Shrink-Swell Potential	Risk of Corrosion to: Uncoated Steel	Concrete	K	T	Wind Erodibility Group	Hydrologic Group	Potential Frost Action
Puye	0 - 152	sandy loam	SM, SM-SC	A-2, A-4	0	100	100	60 - 70	30 - 40	<25	NP-5	5.0 - 15	0.12 - 0.14	6.1 - 7.3	Low	Low	Low	0.20	5	3	B	Moderate
	0 - 152	fine sandy loam, loam	ML, CL-ML	A-4	0	100	100	85 - 95	50 - 75	25 - 35	5 - 10	5.0 - 15	0.14 - 0.18	6.1 - 7.3	Low	Low	Low	0.28	5	3		
Seaby	0 - 13	loam	CL-ML, CL	A-4	0	100	100	85 - 95	60 - 75	20 - 30	5 - 10	1.5 - 5.0	0.16 - 0.18	6.6 - 7.3	Low	Low	Low	0.28	2	5	B	Moderate
	0 - 13	sandy loam	SM, SM-SC	A-2, A-4	0	100	100	60 - 70	30 - 40	<25	NP-5	5.0 - 15	0.11 - 0.13	6.6 - 7.3	Low	Low	Low	0.20	2	3		
	13 - 30	gravelly clay loam, very gravelly clay loam	GM, GC	A-2	0	20-50	15 - 45	15 - 45	10 - 35	30 - 40	10 - 15	1.5 - 5.0	0.13 - 0.17	6.6 - 7.3	Low	Moderate	Low	0.15				
	30 - 60	gravel	GP	A-1	0	15-25	10 - 20	5 - 10	0 - 5	<20	NP	>51	0.02 - 0.04	6.6 - 7.3	Low	Low	Low	0.15				
Servilleta	0 - 8	silty clay loam, silt loam	CL-ML, CL	A-4, A-6	0	95-100	90 - 100	80 - 100	65 - 95	25 - 35	5 - 15	0.50 - 5.0	0.19 - 0.21	6.6 - 7.8	Moderate	High	Low	0.37	2	5	C	Low
	0 - 8	loam	CL-ML, ML	A-4	0	95-100	90 - 100	75 - 95	55 - 75	25 - 35	5 - 10	1.5 - 5.0	0.16 - 0.18	6.6 - 7.8	Low	High	Low	0.37	2	6		
	8 - 64	clay, silty clay loam, clay loam	CL	A-6, A-7	0	95-100	95 - 100	85 - 100	65 - 95	35 - 45	15 - 25	0.15 - 1.5	0.18 - 0.20	7.4 - 8.4	High	High	Low	0.37				
	64 - 86	silty clay loam, loam	CL, ML	A-6	0	95-100	95 - 100	90 - 100	75 - 95	30 - 40	5 - 15	0.50 - 1.5	0.19 - 0.21	7.9 - 9.0	Moderate	High	Low	0.37				
Tocal	0 - 13	sandy loam	SM, SM-SC	A-2, A-4	0	100	100	60 - 70	30 - 40	<25	NP-5	5.0 - 15	0.11 - 0.13	6.6 - 7.3	Low	Low	Low	0.20	1	3	C	Low
	0 - 13	loam, very fine sandy loam	ML, CL-ML	A-4	0	100	100	85 - 95	50 - 75	25 - 35	5 - 10	1.5 - 5.0	0.14 - 0.21	6.6 - 7.3	Low	Low	Low	0.28	1	3		
	13 - 28	clay, clay loam	CL	A-6, A-7	0	100	100	90 - 100	70 - 95	35 - 45	15 - 25	0.50 - 1.5	0.13 - 0.20	6.6 - 7.3	Moderate	High	Low	0.32				
	28 - 36	silt loam	ML	A-4	0	100	100	90 - 100	70 - 90	30 - 35	5 - 10	1.5 - 5.0	0.19 - 0.21	6.6 - 7.3	Low	Low	Low	0.28				
Totavi	0 - 152	gravelly loamy sand	SP-SM, SM	A-2	0	75-85	70 - 80	35 - 60	10 - 25	<20	NP	>51	0.06 - 0.08	6.6 - 7.8	Low	Low	Low	0.17	5	2	A	Low
Unnamed soils																						
Typic Eutroboralfs, clayey-skeletal	0 - 15	silt loam	CL-ML, ML	A-4	0-10	90-100	85 - 95	80 - 90	60 - 80	25 - 35	5 - 10	1.5 - 5.0	0.19 - 0.21	6.6 - 7.3	Low	Moderate	Low	0.28	3	5	C	Low
	15 - 30	very gravelly loam	GM, GM-GC	A-2	10-15	30-40	25 - 35	20 - 35	15 - 25	25 - 35	5 - 10	1.5 - 5.0	0.10 - 0.12	5.6 - 6.0	Low	Moderate	Moderate	0.15				
	30 - 122	very gravelly clay, very gravelly clay loam	GC	A-2	20-30	20-40	15 - 35	15 - 35	10 - 35	40 - 55	20 - 35	0.15 - 0.50	0.07 - 0.08	5.6 - 6.0	Moderate	High	Moderate	0.15				
Typic Eutroboralfs, fine	0 - 18	sandy loam	SM, SM-SC	A-2, A-4	0	100	100	60 - 70	30 - 40	<25	NP-5	5.0 - 15	0.11 - 0.13	6.1 - 7.3	Low	Low	Low	0.20	3	3	C	Low
	0 - 18	very fine sandy loam	CL-ML, ML	A-4	0	100	100	85 - 95	50 - 75	25 - 35	5 - 10	1.5 - 5.0	0.14 - 0.17	6.1 - 7.3	Low	Low	Low	0.28	3	3		
	18 - 51	clay	CL, CH	A-7	0	100	100	90 - 100	85 - 95	45 - 55	20 - 30	0.15 - 0.50	0.14 - 0.16	6.6 - 7.3	Moderate	High	Low	0.37				
	51 - 94	sandy clay	ML, CL	A-7	0	100	100	85 - 95	50 - 60	40 - 50	15 - 25	0.15 - 0.50	0.15 - 0.17	6.6 - 7.3	Moderate	High	Low	0.32				
Typic Eutroboralfs, fine-loamy	0 - 8	loam, very fine sandy loam	ML, CL-ML	A-4	0	100	100	85 - 95	50 - 75	25 - 35	5 - 10	1.5 - 5.0	0.14 - 0.21	6.1 - 7.3	Low	Low	Low	0.28	3	3	C	Moderate
	0 - 8	sandy loam	SM, SM-SC	A-2, A-4	0	100	100	60 - 70	30 - 40	<25	NP-5	5.0 - 15	0.11 - 0.13	6.1 - 7.3	Low	Low	Low	0.20	3	3		
	8 - 36	silt loam	CL-ML, ML	A-4	0	100	100	90 - 100	70 - 90	30 - 35	5 - 10	1.5 - 5.0	0.19 - 0.21	6.1 - 6.5	Low	Low	Low	0.28				
	36 - 64	clay loam	CL	A-6	0	100	100	90 - 100	70 - 80	30 - 40	10 - 15	0.50 - 1.5	0.19 - 0.21	6.1 - 7.3	Moderate	Moderate	Low	0.32				
	64 - 91	gravelly clay loam	GC, CL	A-2, A-6	0	40-80	35 - 75	30 - 75	25 - 60	30 - 40	10 - 15	0.50 - 1.5	0.15 - 0.17	6.6 - 7.8	Moderate	Moderate	Low	0.15				
	91 - 203	clay loam, clay	CL, CH	A-6, A-7	0	100	100	90 - 100	70 - 80	35 - 55	15 - 30	0.50 - 1.5	0.19 - 0.21	6.6 - 7.8	Moderate	Moderate	Low	0.32				

*NP signifies nonplastic.

TABLE IX

ENGINEERING INTERPRETATIONS OF SOIL SURVEY AREA

	Degree and Kind of Limitation for					
	Sanitary Facilities			Community Development		
Soil Series	Septic Tank Absorption Field	Sewage Lagoons	Sanitary Landfill	Shallow Excavation	Foundations for Low Buildings Without Basements	Local Roads and Streets
Carjo	Severe: bedrock too near surface; water moves through soil too slowly	Severe: bedrock too near surface; slope too great when >7%	Slight	Moderate: bedrock too near surface	Moderate: bedrock too near surface; soil expands on wetting and shrinks on drying; slope too great when 4-8%	Moderate: bedrock too near surface; soil expands on wetting and shrinks on drying; low strength to support loads
Frijoles	Slight	Severe: water moves through soil too quickly; slope too great when >7%	Slight	Slight	Slight	Slight: moderate when slope >4%
Hackroy	Severe: bedrock too near surface	Severe: bedrock too near surface; slope too great when >7%	Slight	Moderate: bedrock too near surface; soil slippery and sticky when wet and slow to dry	Moderate: bedrock too near surface soil expands on wetting and shrinks on drying; slope too great when >4%	Severe: low strength to support loads
Nyjack	Severe: bedrock too near surface	Severe: bedrock too near surface	Slight	Moderate: bedrock too near surface	Moderate: bedrock too near surface; soil expands on wetting and shrinks on drying; slope too great when >4%	Moderate: bedrock too near surface, soil expands on wetting and shrinks on drying; low strength to support loads
Penistaja	Slight	Moderate: water moves through soil too quickly; slope too great when >2%	Slight	Slight	Moderate: soil expands on wetting and shrinks on drying; slope too great when >4%	Moderate: soil expands on wetting and shrinks on drying; low strength to support loads
Pogna	Severe: bedrock too near surface	Severe: bedrock too near surface; water moves through soil too quickly; slope too great when >7%	Severe: water moves through soil too quickly	Moderate: bedrock too near surface; slope too great when >8%	Moderate: bedrock too near surface; slope too great when 4-8% Severe: slope too great when >8%	Severe: bedrock too near surface
Potrillo	Moderate: soil temporarily flooded by stream overflow or runoff	Severe: soil temporarily flooded by stream overflow or runoff	Moderate: soil temporarily flooded by stream overflow or runoff	Moderate: soil temporarily flooded by stream overflow or runoff	Severe: soil temporarily flooded by stream overflow or runoff	Moderate: soil temporarily flooded by stream overflow or runoff; low strength to support loads
Prieta	Severe: bedrock too near surface; water moves through soil too slowly	Severe: bedrock too near surface; slope too great when >7%	Severe: bedrock too near surface	Severe: bedrock too near surface	Severe: bedrock too near surface; slope too great when >8%	Severe: bedrock too near surface; low strength to support loads

	Suitability as a Source of			Soil Features Affecting Water Management			
Soil Series	Roadfill	Sand and Gravel	Topsoil	Pond Reservoir Area	Embankments Dikes and Levees	Drainage	Irrigation
Carjo	Poor: soil not thick enough; borrow areas difficult to reclaim and revegetate	Unsuited	Poor: soil not thick enough	Depth to bedrock; slope	Depth to bedrock	Depth to bedrock; water moves through soil too slowly	Soil holds too little water for plants during dry periods; erodes easily; inadequate rooting depth
Frijoles	Good	Unsuited for sand; good for gravel	Poor: too many small stones	Water moves through soil too quickly; slope	Water moves through soil too quickly	Favorable	Soil holds too little water for plants during dry periods; water moves through soil too quickly inadequate rooting depth
Hackroy	Poor: soil not thick enough; borrow areas difficult to reclaim and revegetate; low strength to support loads	Unsuited	Poor: borrow areas difficult to reclaim and revegetate	Depth to bedrock; slope	Depth to bedrock; water moves through soil too quickly; low strength to support loads	Not needed	Soil holds too little water for plants during dry periods; water moves through soil too quickly; inadequate rooting depth
Nyjack	Poor: soil not thick enough; borrow areas difficult to reclaim and revegetate	Unsuited	Fair: soil not thick enough	Depth to bedrock	Depth to bedrock	Depth to bedrock	Depth to bedrock
Penistaja	Fair: soil expands on wetting and shrinks on drying; low strength to support loads	Unsuited: too much silt and clay	Fair: soil slippery and sticky when wet and slow to dry	Water moves through soil too quickly; slope	Soil is susceptible to formation of tunnels or pipelike cavities by moving water; low strength to support loads	Short and irregular slopes make water-control measures difficult; soil easily moved and deposited by wind	Erodes easily; short and irregular slopes make water control measures difficult
Pogna	Poor: soil not thick enough; borrow areas difficult to reclaim and revegetate	Unsuited: soil not thick enough	Poor: soil not thick enough; borrow areas difficult to reclaim and revegetate	Depth to bedrock; water moves through soil too quickly	Depth to bedrock; water moves through soil too quickly	Not needed	Soil holds too little water for plants during dry periods; inadequate rooting depth; water moves through soil too quickly
Potrillo	Fair: low strength to support loads	Unsuited	Good (loam, sandy loam, fine sandy loam) Poor (gravelly sandy loam): too many small stones	Water moves through soil too quickly; slope	Soil is susceptible to formation of tunnels or pipe-like cavities by moving water; low strength to support loads	Favorable	Favorable
Prieta	Poor: soil not thick enough; low strength to support loads; borrow areas difficult to reclaim and revegetate	Unsuited	Poor: too many large and small stones; borrow areas difficult to reclaim and revegetate	Depth to bedrock; slope	Thin soil layer; large stones; soil is susceptible to formation of tunnels or pipe-like cavities by moving water	Depth to bedrock	Depth to bedrock

TABLE IX (cont)

ENGINEERING INTERPRETATIONS OF SOIL SURVEY AREA

Soil Series	Degree and Kind of Limitation for — Sanitary Facilities: Septic Tank Absorption Field	Sewage Lagoons	Sanitary Landfill	Community Development: Shallow Excavation	Foundations for Low Buildings Without Basements	Local Roads and Streets
Puye	Moderate: soil temporarily flooded by stream overflow or runoff	Severe: soil temporarily flooded by stream overflow or runoff	Severe: water moves through soil too quickly	Moderate: soil temporarily flooded by stream overflow or runoff	Severe: soil temporarily flooded by stream overflow or runoff	Moderate: soil temporarily flooded by stream overflow or runoff; low strength to support loads; freezing and thawing may damage structures
Seaby	Severe: bedrock too near surface	Severe: bedrock too near surface; water moves through soil too quickly; slope too great when >7%	Slight: (3-8% slope) slope too great when >8%	Moderate: bedrock too near surface; too many small stones; slope too great when >8%	Moderate: bedrock too near surface; slope too great when >4%	Moderate: bedrock too near surface; freezing and thawing may damage structures; slope too great when >8%
Servilleta	Severe: bedrock too near surface; water moves through soil too slowly	Severe: bedrock too near surface	Slight	Severe: bedrock too near surface	Severe: soil expands on wetting and shrinks on drying	Severe: soil expands on wetting and shrinks on drying; low strength to support loads
Tresl	Severe: bedrock too near surface	Severe: bedrock too near surface; slope too great when >7%	Slight	Moderate: bedrock too near surface; soil slippery and sticky when wet and slow to dry	Moderate: bedrock too near surface; soil expands on wetting and shrinks on drying; slope too great when >4%	Moderate: bedrock too near surface; soil expands on wetting and shrinks on drying; low strength to support loads
Totavi	Moderate: soil temporarily flooded by stream overflow	Severe: water moves through soil too quickly	Severe: soil temporarily flooded by stream overflow or runoff; water moves through soil too quickly	Severe: walls of cuts are not stable and soil sloughs easily	Severe: soil temporarily flooded by stream overflow or runoff	Moderate: soil temporarily flooded by stream overflow or runoff
Unnamed soils						
Typic Eutroboralfs, clayey skeletal	Severe: water moves through soil too slowly	Severe: too many small stones; slope too great when >7%	Slight	Severe: too many small stones; soil slippery and sticky when wet and slow to dry	Moderate: soil expands on wetting and shrinks on drying; slope too great when >4%	Moderate: soil expands on wetting and shrinks on drying; low strength to support loads
Typic Eutroboralfs, fine	Severe: bedrock too near surface; water moves through soil too slowly	Severe: bedrock too near surface; slope too great when >7%	Slight (3-8% slope) Moderate: slope too great when >8%	Severe: soil slippery and sticky when wet and slow to dry	Moderate: bedrock too near surface; soil expands on wetting and shrinks on drying; slope too great when 4-8% Severe: slope too great when >8%	Severe: low strength to support roads
Typic Eutroboralfs, fine-loamy	Severe: water moves through soil too slowly	Slight (1-2% slope) Moderate: slope too great when >2%	Slight	Moderate: soil slippery and sticky when wet and slow to dry	Moderate: soil expands on wetting and shrinks on drying; slope too great when >4%	Moderate: soil expands on wetting and shrinks on drying; low strength to support loads; freezing and thawing may damage structures

Soil Series	Suitability as a Source of — Roadfill	Sand and Gravel	Topsoil	Soil Features Affecting Water Management: Pond Reservoir Area	Embankments Dikes and Levees	Drainage	Irrigation
Puye	Fair: low strength to support loads; freezing and thawing may damage structures	Unsuited	Good	Water moves through soil too quickly	Water moves through soil too quickly; soil is susceptible to formation of tunnels or pipe-like cavities by moving water; low strength to support loads	Favorable	Favorable
Seaby	Poor: soil not thick enough; borrow areas difficult to reclaim and revegetate	Unsuited: soil not thick enough	Poor: too many small stones	Depth to bedrock; water moves through soil too quickly	Depth to bedrock; water moves through soil too quickly	Not needed	Soil holds too little water for plants during dry periods; inadequate rooting depth
Servilleta	Poor: soil expands on wetting and shrinks on drying; low strength to support loads; soil not thick enough	Unsuited	Poor: soil slippery and sticky when wet and slow to dry	Depth to bedrock	Soil is susceptible to formation of tunnels or pipe-like cavities by moving water; low strength to support loads	Depth to bedrock; water moves through soil too slowly	Water infiltrates slowly into soil; inadequate rooting depth
Tresl	Poor: soil not thick enough; borrow areas difficult to reclaim and revegetate	Unsuited	Poor: borrow areas difficult to reclaim and revegetate	Depth to bedrock; slope	Water moves through soil too quickly; depth to bedrock; low strength to support loads	Not needed	Soil holds too little water for plants during dry periods; inadequate rooting depth
Totavi	Good	Fair for sand; unsuited for gravel	Poor: too sandy	Water moves through soil too quickly	Water moves through soil too quickly	Favorable	Water infiltrates rapidly into soil and moves through the soil too quickly
Unnamed soils							
Typic Eutroboralfs, clayey skeletal	Fair: soil expands on wetting and shrinks on drying; low strength to support loads	Unsuited	Poor: too many small stones; soil slippery and sticky when wet and slow to dry	Small stones; slope	Favorable	Not needed	Soil holds too little water for plants during dry periods water moves through soil too slowly
Typic Eutroboralfs, fine	Poor	Unsuited	Poor: soil slippery and sticky when wet and slow to dry	Depth to bedrock; slope	Soil is susceptible to formation of tunnels or pipe-like cavities by moving water; low strength to support loads	Depth to bedrock; water moves through the soil too slowly	Water moves through the soil too slowly; slope; inadequate rooting depth
Typic Eutroboralfs, fine-loamy	Fair: soil expands on wetting and shrinks on drying; low strength to support loads; freezing and thawing may damage structures	Unsuited	Fair: soil not thick enough	Favorable (1-2% slope) Slight: slope too great when >2%	Soil is susceptible to formation of tunnels or pipe-like cavities by moving water; low strength to support loads	Water moves through soil too slowly	Slope

RECREATION INTERPRETATIONS OF SOIL SURVEY DATA

Soil Series	Degree and Kind of Limitation for: Camp Areas	Picnic Areas	Playgrounds	Paths and Trails
Carjo	Moderate: water moves through soil too slowly	Slight	Moderate: water moves through soil too slowly; bedrock too close to surface; slope too great when 2-6% Severe: slope too great when >6%	Slight
Frijoles	Moderate: water moves through soil too slowly	Slight	Moderate: water moves through soil too slowly; slope too great when 2-6% Severe: slope too great when >6%	Slight
Hackroy	Moderate: water moves through soil too slowly	Slight	Severe: bedrock too close to surface; slope too great when >6%	Slight
Nyjack	Slight	Slight	Moderate: bedrock too close too surface; slope too great when >2%	Slight
Penistaja	Slight (fine sandy loam or sandy loam, 0-8% slope) Moderate (fine sandy loam, sandy loam): slope too great when >8% Moderate (loamy fine sand): too sandy; slope too great when >8%	Slight (fine sandy loam or sandy loam, 0-8% slope) Moderate (fine sandy loam, sandy loam): slope too great when >8% Moderate (loamy fine sand): too sandy; slope too great when >8%	Slight (fine sandy loam or sandy loam, 0-2% slope) Moderate (fine sandy loam or sandy loam): slope too great when 2-6% Severe (fine sandy loam, sandy loam): slope too great when >6%	Slight (fine sandy loam, sandy loam) Moderate (loamy fine sand): too sandy
Pogna	Slight (0-8% slope) Moderate: slope too great when >8%	Slight (0-8% slope) Moderate: slope too great when >8%	Severe: bedrock too close to surface; slope too great when >6%	Slight
Potrillo	Moderate: soil temporarily flooded by stream overflow or runoff	Slight	Moderate: soil temporarily flooded by stream overflow or runoff; slope too great when >2%	Slight
Prieta	Severe: too many large and small stones	Severe: too many large and small stones	Severe: bedrock too close to surface; too many large and small stones; slope too great when >6%	Severe: too many large and small stones
Puye	Moderate: soil temporarily flooded by stream overflow or runoff	Slight	Moderate: soil temporarily flooded by stream overflow or runoff; slope too great when >2%	Slight
Seaby	Slight (3-8% slope) Moderate: slope too great when >8%	Slight (3-8% slope) Moderate: slope too great when >8%	Moderate: bedrock too close to surface; slope too great when 2-6% Severe: slope too great when >6%	Slight
Servilleta	Moderate (silt loam, loam): dusty, water moves through soil too slowly Moderate (silty clay loam): water moves through soil too slowly; soil slippery and sticky when wet and slow to dry	Moderate (silt loam, loam): dusty Moderate (silty clay loam): soil slippery and sticky when wet and slow to dry	Moderate: bedrock too close to surface; water moves through soil too slowly; slope too great when 2-6%	Moderate (silt loam, loam): dusty Moderate (silty clay loam): soil slippery and sticky when wet and slow to dry
Tocal	Moderate: water moves through soil too slowly	Slight	Severe: bedrock too close to surface; slope too great when >6%	Slight
Totavi	Severe: soil easily blown by wind; too sandy	Severe: soil easily blown by wind; too sandy	Severe: soil easily blown by wind; too sandy	Moderate: soil easily blown by wind; too sandy
Unnamed soils				
Typic Eutroboralfs, clayey-skeletal	Moderate: water moves through soil too slowly	Slight	Moderate: water moves through soil too slowly; slope too great when 2-6% Severe: slope too great when >6%	Slight
Typic Eutroboralfs, fine	Moderate: water moves through soil too slowly; slope too great when >8%	Slight (0-8% slope) Moderate: slope too great when >8%	Moderate: water moves through soil too slowly; slope too great when 2-6% Severe: slope too great when >6%	Slight
Typic Eutroboralfs, fine-loamy	Moderate: water moves through soil too slowly	Slight	Moderate: water moves through soil too slowly; slope too great when >2%	Slight

roads, and trails. Soils with steep slopes often have severe limitations for most recreational uses. On the other hand, steeply sloping soils are essential for ski runs and are desirable for hiking areas, scenic values, and homesites "with a view." Of course, deep, gently sloping, and moderately sloping soils can be leveled for campsites, playgrounds, and building sites where the cost is justified. Where this is done it is especially urgent that effective soil conservation practices be applied and maintained based on the specific conditions.

Soil depth affects many uses. Soils underlain by bedrock to shallow depths cannot be leveled for playgrounds and campsites except at high cost. Roads, trails, and basements are very difficult to construct on these soils. It is difficult to establish vegetation on soils shallow to impervious soil layers or rock thus making them poor locations for playing fields and other intensive use areas.

Surface texture is an important soil property to consider. High sand or clay content in the surface soils is undesirable for playgrounds, campsites, or other uses that involve heavy foot traffic by people or horses. Soils high in clay become sticky when wet and do not dry out quickly after rains. On the other hand, loose sandy soils are undesirable as they are unstable when dry. Sandy loam and loam surface soils that also have other favorable characteristics are the most desirable for recreational uses involving heavy use by people.

The presence of stones, rocks, cobbles, or gravel limits the use of some soils for recreational uses. Very stony, stony, rocky, or gravelly soils have severe to moderate limitations for use as campsites and playgrounds. In some instances it is feasible to remove the stones, thus eliminating the hazard. Rounded gravels and stones present hazards on steeply sloping soils used for foot trails.

Sanitary facilities are essential for most modern recreational areas and septic tanks are often the only means of waste disposal. Some soils absorb septic tank effluent rapidly and other soils absorb it very slowly. Soils that are slowly permeabile, poorly drained, shallow to rock, subject to flooding, or steeply sloping all have severe limitations for septic tank filter fields. In some cases where soils cannot handle the volume of waste involved, sewage lagoons can be used. These also are feasible only in soils that meet the special requirements for sewage lagoons.

Productive capacity of soils for vegetation of different kinds is closely related to the feasibility of many recreation enterprises. The ability of soils to grow sods that can take concentrated human traffic has already been noted as a factor in such areas as playgrounds and campsites. The development of such vegetative conservation practices as shade tree plantings, living fences, plant screens, and barriers to trespass is guided by soil conditions. The capacity of an area to produce economically harvestable crops of game is dependent, in part, on the productive ability of its soils.

The suitability of the soil for impounding water reflects, in considerable measure, the kind of soil at the impoundment site as well as in the watershed above the impoundment. Fertile soils, or soil capable of effective use of artificial fertilizers, generally make fertile waters, and fertile waters produce good fish crops which, with good management, produce good fishing. On the other hand, extremely acid soils associated with a proposed water impoundment may be a critical limitation to the development of good fishing.

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GLOSSARY

Available water capacity (available water holding capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at the wilting point. It is estimated from the texture and depth of the solum and may be modified according to the effective rooting depth of the soil profile. It is commonly expressed as centimeter of water per centimeter of soil in the profile. Four terms used to describe available water capacity classes are:

High	>19cm
Moderate	13-19 cm
Low	9.5-13 cm
Very Low	0-9.5 cm

Caliche. A more or less cemented deposit of calcium carbonate found in many soils of warm temperature areas. The material may consist of soft, thin layers in the soil or of hard thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Clay. As a soil separate, the mineral particles less than 0.002 mm in diameter. As a soil textural class, soils material that is 40% or more clay, less than 45% sand and less than 40% silt.

Clay films. A soil morphological characteristic described by recording the frequency of occurrence and thickness of films of clay in the soil mass. The frequency classes of clay films are based on the per cent of the ped faces or pores covered by films:

Very few	<5%
Few	5-25%
Common	25-50%
Many	50-90%
Continuous	>90%

The thickness of clay films is described as:

Thin	Very fine sand grains are readily apparent in the clay film and/or sand grains are only thinly coated and held together by weak bridges.
Moderately thick	Very fine sand grains are enveloped by the clay film or their outlines are indistinct.
Thick	Clay films and their broken edges are readily visible without magnification; where the colloid is in bridges, the bridges hold the soil mass firmly together.

Cobble (Cobblestone). A rounded or partly rounded rock fragment, 7.6 to 25 cm in diameter.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. This soil property varies with the water content of the soil and is measured under moist and wet conditions. The terms used to describe moist soil consistence are:

Loose	Noncoherent.
Very Friable	Crushes under gently pressure.
Friable	Crushes easily under gentle to moderate pressure.
Firm	Similar to friable but noticeable resistance.
Very Firm	Crushes only under strong pressure.
Extremely firm	Cannot be crushed between thumb and forefinger.

Wet soil consistence is described as:

Nonsticky.	
Slightly sticky	After pressure, soil adheres to fingers but comes off cleanly.
Sticky	After pressure, soil adheres to fingers and tends to stretch somewhat before pulling apart.
Very sticky	After pressure, soil adheres strongly to fingers and is markedly stretched when fingers separated.
Slightly plastic	Wire forms when soil is rolled, but soil mass is easily deformed.
Plastic	Same as slightly plastic, but moderate pressure required to deform soil mass.
Very plastic	Same as slightly plastic but much pressure is required to deform soil mass.

Depth class, soil. Depth to bedrock is described in four soil depth classes as:

Very shallow	0-25 cm
Shallow	25-51 cm
Moderately deep	51-102 cm
Deep	>102 cm

Effective rooting depth. The depth to which a soil is readily penetrated by plant roots and utilized for extraction of water and plant nutrients.

Erosion hazard rating. A potential soil loss rate from an unprotected bare soil surface. Ratings are expressed as:

Low	0-0.64 cm soil/yr
Moderate	0.65-1.8 cm soil/yr
High	>1.8 cm soil/yr

Gravel. Coarse fragments that are from 0.2 to 7.6 cm in diameter.

Horizon boundary, soil. The lower boundary of a soil horizon is described as to its distinctness and topography. The distinctness of a horizon boundary is classified relative to the thickness of the transition zone:

Abrupt	<2.5 cm
Clear	2.5-6.3 cm
Gradual	6.3-13 cm
Diffuse	>13 cm

The topography of this boundary is described as:

Smooth	Boundary parallel to soil surface.
Wavy	Boundary pockets wider than their depth.
Irregular	Irregular pockets are deeper than their width.
Broken	Parts of a horizon are unconnected with other parts.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Permeability. The rate at which water may penetrate or pass through a soil mass or soil horizon. Permeability classes are described as:

Very slow	<0.15 cm/h
Slow	0.15-0.50 cm/h
Moderately slow	0.50-1.6 cm/h
Moderate	1.6-5.0 cm/h
Moderately rapid	5.0-16 cm/h
Rapid	16-50 cm/h
Very rapid	>50 cm/h

Plant roots. The relative numbers of various-sized roots per unit are described for soil horizons. The four sizes of roots are classified relative to their diameters as:

Very fine	<1 mm
Fine	1-2 mm
Medium	2-5 mm
Coarse	>5 mm

The three root abundance classes are:

Few	<10 very fine or fine roots/dm^2; <1 medium or coarse root/dm^2.
Common	10-100 very fine or fine roots/dm^2; 1-100 medium roots/dm^2; 1-5 coarse roots/dm^2.
Many	>100 very fine, fine or medium roots/dm^2; >5 coarse roots/dm^2.

Pores, soil. Space not occupied by soil particles or coarse fragments in a bulk volume of soil. Soil pores are described in terms of the numbers of various-sized pores per unit area and pore shape. The size classes of pores are determined by the pore diameter as:

Very fine	0.1-0.5 mm
Fine	0.5-2 mm
Medium	2-5 mm
Coarse	>5 mm

The three soil pore abundance classes are:

Few	<25 very fine pores/dm^2; <10 fine pores/dm^2.
Common	25-200 very fine pores/dm^2; 10-50 fine pores/dm^2; 1-5 medium pores/dm^2; 1-2.5 coarse pores/dm^2.
Many	>200 very fine pores/dm^2; >50 fine pores/dm^2; >5 medium pores/dm^2; >2.5 coarse pores/dm^2.

Soil pore shapes are:

Vesicular	approximately spherical or elliptical.
Interstitial	irregular in shape and bounded by curved or angular surfaces of mineral grains or peds.
Tubular	approximately cylindrical.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acidic nor alkaline. The soil reaction or pH classes are described as:

Medium acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Mildly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff classes. Potential runoff classes for soils are influenced by the soil's ability to take in precipitation, moisture retention, vegetative cover and size and intensity of rain storms. Soil mapping units fall into one of three runoff classes based on the soil loss from a bare soil during an average 2-year, 30 minute precipitation event:

Low	0.0-0.13 cm
Moderate	0.14-0.51 cm
High	>0.52 cm

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 mm. Most sand grains consist of quartz, but may be of any mineral composition. The textural class name of any soil that contains 85% or more sand and not more than 10% clay.

Series, soil. A group of soils developed from a particular type of parent materials and having genetic horizons that, except for the texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Shrink-swell potential. The extent to which the soil shrinks as it dries out and swells when it gets wet. The magnitude of change is influenced by the amount and kind of clay in the soil.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very fine sand (0.05 mm). Soil of the silt textural class is 80% or more silt and less than 12% clay.

Slope class. Land placed in various slope classes has the following dominant slopes:

Level	0%
Nearly level	1%
Very gently sloping	1-3%
Gently sloping	3-8%
Moderately sloping	8-15%
Moderately steep	15-30%
Very steep	30-50%
Extremely steep	>50%

Stones. Rock fragments greater than 25 cm in diameter if rounded, and greater than 31 cm along the longer axis if flat.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. Soil structure is described in terms of its grade, size and form. The four structural grades are:

Structureless	No observable aggregation.
Weak	Poorly-formed indistinct peds, moderately durable and evident.
Moderate	Well-formed distinct peds, moderately durable and evident.
Strong	Durable peds that are quite evident in undisplaced soil and adhere weakly to one another.

The principal forms of soil structure are:

Platy	Laminated.
Prismatic	Vertical axis of aggregates longer than horizon axis.
Columnar	Prisms with rounded tops.
Angular blocky	Blocklike with all 3 dimensions of same order of magnitude, faces flattened and most vertices sharply angular.
Subangular blocky	Similar to angular blocky but both rounded and flattened faces occur with many vertices.
Granular	Nonporous and spherical.
Crumb	Porous and spherical.

The size limits for various forms of structure are shown in the following table.

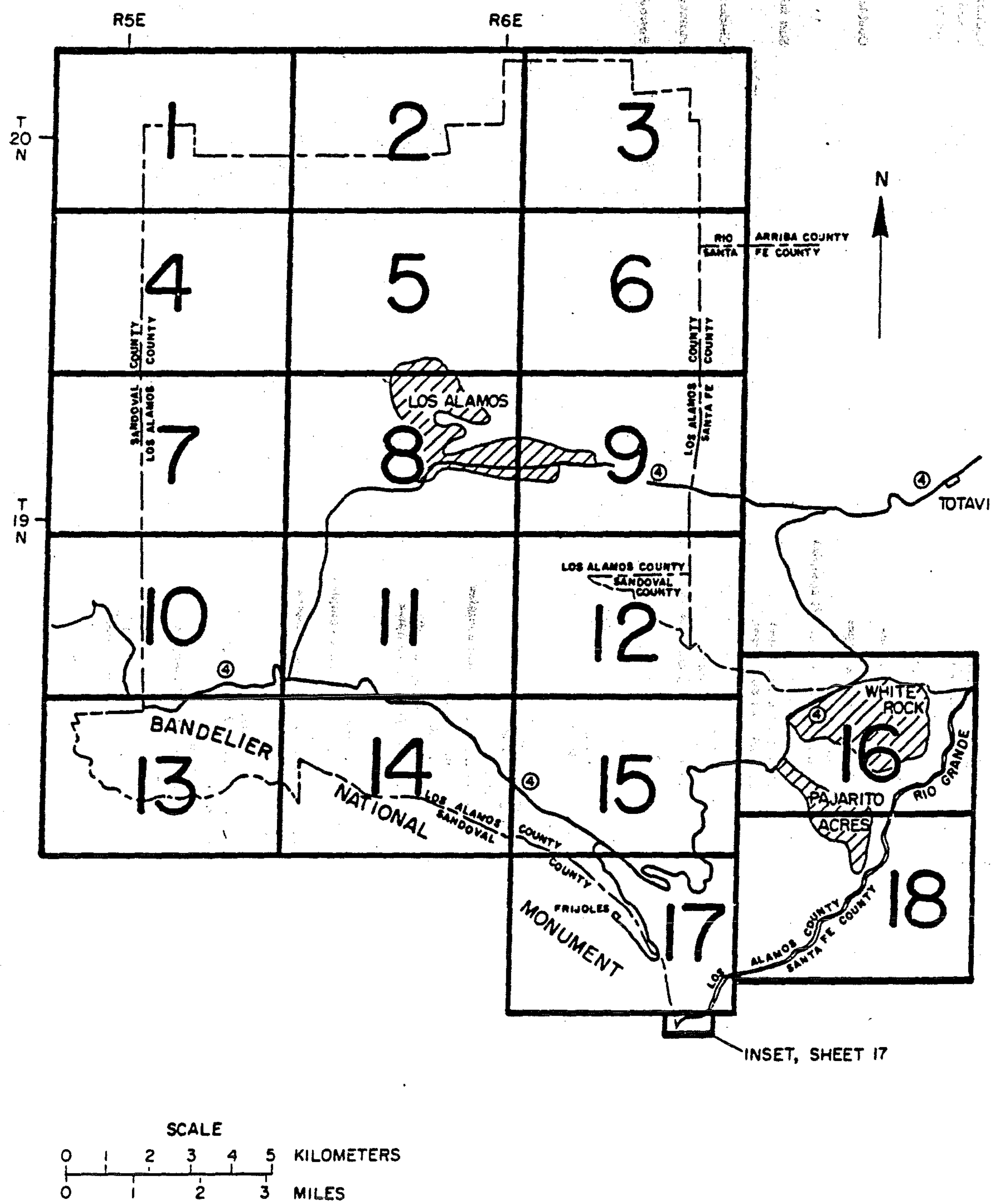
Texture, soil. The relative proportions of sand, silt and clay particles in a mass of soil. The basic textural classes are quantitavely described in Fig. 8 and may be further divided by specifying prefixes of coarse, fine, or very fine.

*U.S. Government Printing Office: 1978-778-298

SIZE LIMITS FOR VARIOUS FORMS OF STRUCTURE

Size	Form of Soil Structure						
	Platy	Prismatic	Columnar	Angular Blocky	Subangular Blocky	Granular	Crumb
Very fine or very thin	Very thin platy; <1 mm	Very fine prismatic; <10 mm.	Very fine columnar; <10 mm	Very fine angular blocky; <5 mm	Very fine subangular blocky; <5 mm	Very fine granular; <1 mm	Very fine crumb; <1 mm
Fine or thin	Thin platy; 1 to 2 mm	Fine prismatic; 10 to 20 mm	Fine columnar; 10 to 20 mm	Fine angular blocky; 5 to 10 mm	Fine subangular blocky; 5 to 10 mm	Fine granular; 1 to 2 mm	Fine crumb 1 to 2 mm
Medium	Medium platy; 2 to 5 mm	Medium prismatic; 20 to 50 mm	Medium columnar; 20 to 50 mm	Medium angular blocky; 10 to 20 mm	Medium subangular blocky; 10 to 20 mm	Medium granular; 2 to 5 mm	Medium crumb; 2 to 5 mm
Coarse or thick	Thick platy; 5 to 10 mm.	Coarse prismatic; 50 to 100 mm	Coarse columnar; 50 to 100 mm	Coarse angular blocky; 20 to 50 mm	Coarse subangular blocky; 20 to 50 mm	Coarse granular; 5 to 10 mm	
Very coarse or very thick	Very thick platy; >10 mm	Very coarse prismatic; >100 mm	Very coarse columnar; >100 mm	Very coarse angular blocky; >50 mm	Very coarse subangular blocky; >50 mm	Very coarse granular; >10 mm	

INDEX TO MAP SHEETS
LOS ALAMOS COUNTY, NEW MEXICO



SOIL LEGEND

SYMBOL	NAME
AB	Abrigo loam
AC	Arriba-Copar complex
AR	Armstead loam
BA	Barrancas-Sanjue-Jemell complex
BR	Boletas-Rock outcrop complex
CB	Comada-Bayo complex
CD	Cabra stony loam, 0-15% slopes
CE	Cabra stony loam, 16-40% slopes
CL	Cuervo gravelly loam, 0-15% slopes
CR	Carjo loam
CS	Cuervo gravelly loam, 16-40% slopes
EM	Emod stony sandy loam
EU	Eutrandepts-Ustipsamments-Haplustalfs complex
FR	Frijoles very fine sandy loam
GR	Griegos cobbly loam, 16-40% slopes
GS	Griegos cobbly loam, 41-80% slopes
GT	Griegos-Rock outcrop complex
HA	Hackroy sandy loam
HR	Hackroy-Rock outcrop complex
KW	Kwage-Pelado-Rock outcrop complex
LA	Latas gravelly sandy loam
NJ	Nyjack loam
PB	Pueblo stony loam
PG	Pogna fine sandy loam
PL	Pelado cobbly loam
PN	Penistaja sandy loam
PO	Potrillo loam
PR	Prieta silt loam
PS	Dacite sandy loam
PT	Potrillo gravelly loam
PU	Puye sandy loam
QU	Quemazon-Arriba-Rock outcrop complex
RA	Rock outcrop-Bayo complex
RB	Rock outcrop, basalt
RD	Rock outcrop, Pelado-Kwage complex
RE	Rock outcrop-Pines-Tentrock complex
RF	Rock outcrop, frigid
RM	Rock outcrop, mesic
RN	Rendija-Bayo complex
RO	Rock outcrop-Colle-Painted Cave complex
RS	Rock outcrop, steep
RT	Rabbit-Tsankawi-Rock outcrop complex
RU	Rock outcrop-Cone-Stonelion complex
RV	Rock outcrop, very steep
SA	Sanjue-Arriba complex
SC	Santa Klara-Armstead complex
SE	Seaby loam
SH	Shell-Anesa complex
SI	Shell-Anesa-Rock outcrop complex
SR	Servilleta loam
TA	Talus slopes, cryic
TC	Typic Eutroboralfs, clayey-skeletal
TE	Turkey-Cabra-Rock outcrop complex
TK	Atomic-Korral complex
TL	Typic Eutroboralfs, fine-loamy
TO	Tocal very fine sandy loam
TR	Typic Ustorthents-Rock outcrop complex
TS	Typic Eutroboralfs, fine
TV	Totavi gravelly loamy sand
UR	Ustochreptic Camborthids-Rock outcrop complex

CONVENTIONAL SIGNS

BOUNDARIES

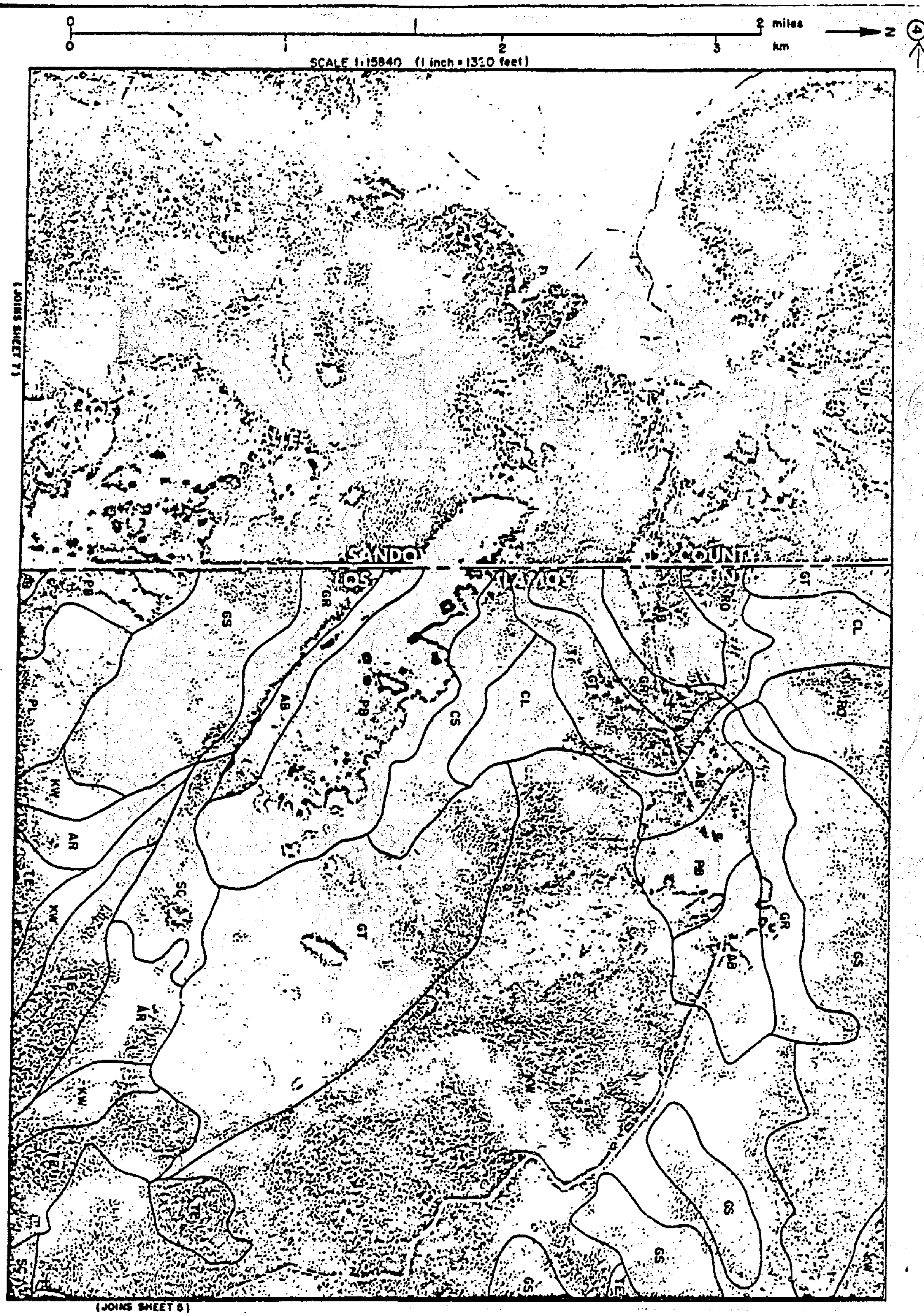
County	— — —
Boundary of Forest Service or Soil Conservation Service Soil Surveys	— · — · —

ROADS

Dual-lane Roads	———

SOIL SURVEY DATA

Soil boundary and symbol	AB
Cinders	⊕
Pumice deposit	○
Borrow Pit	#



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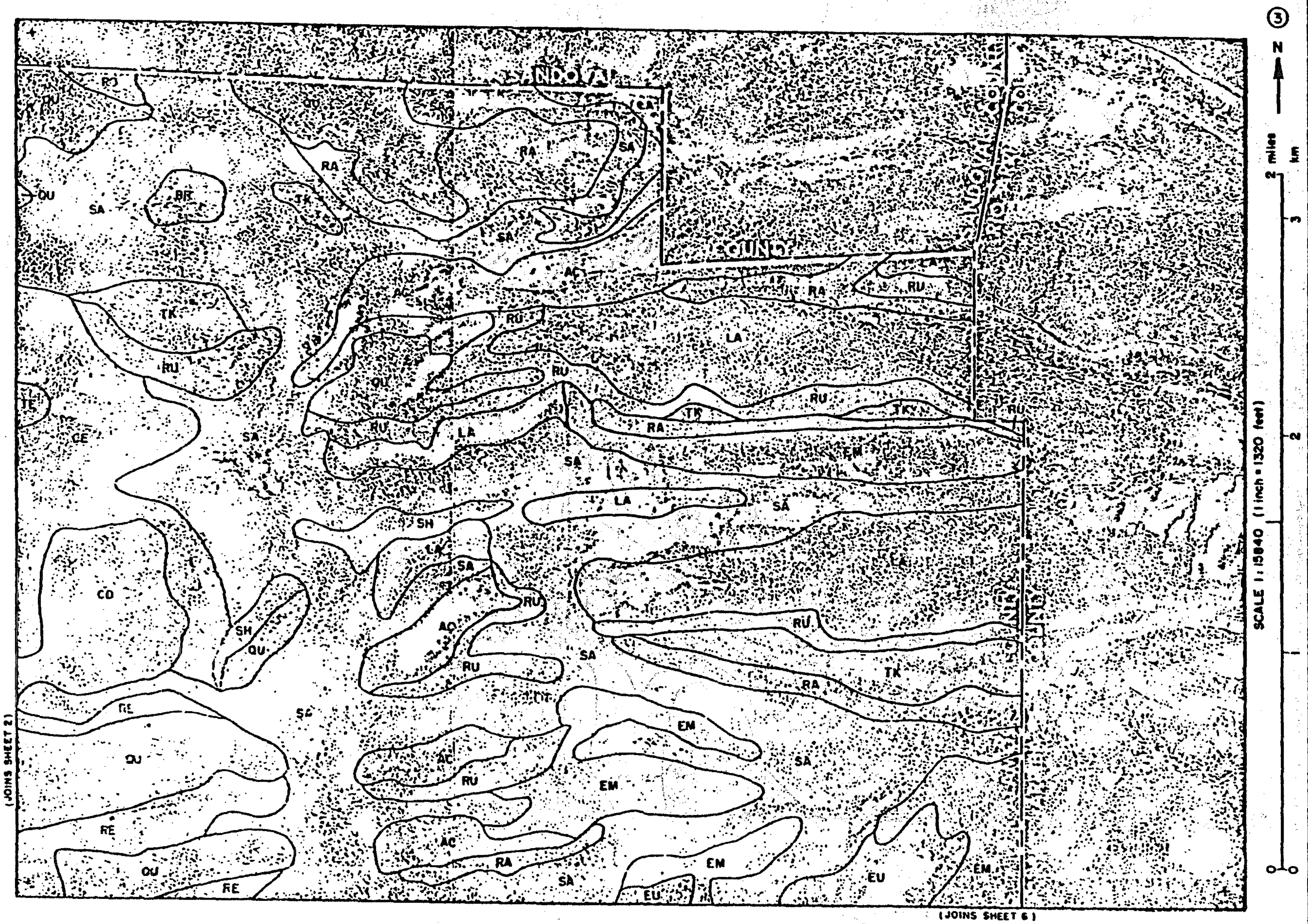
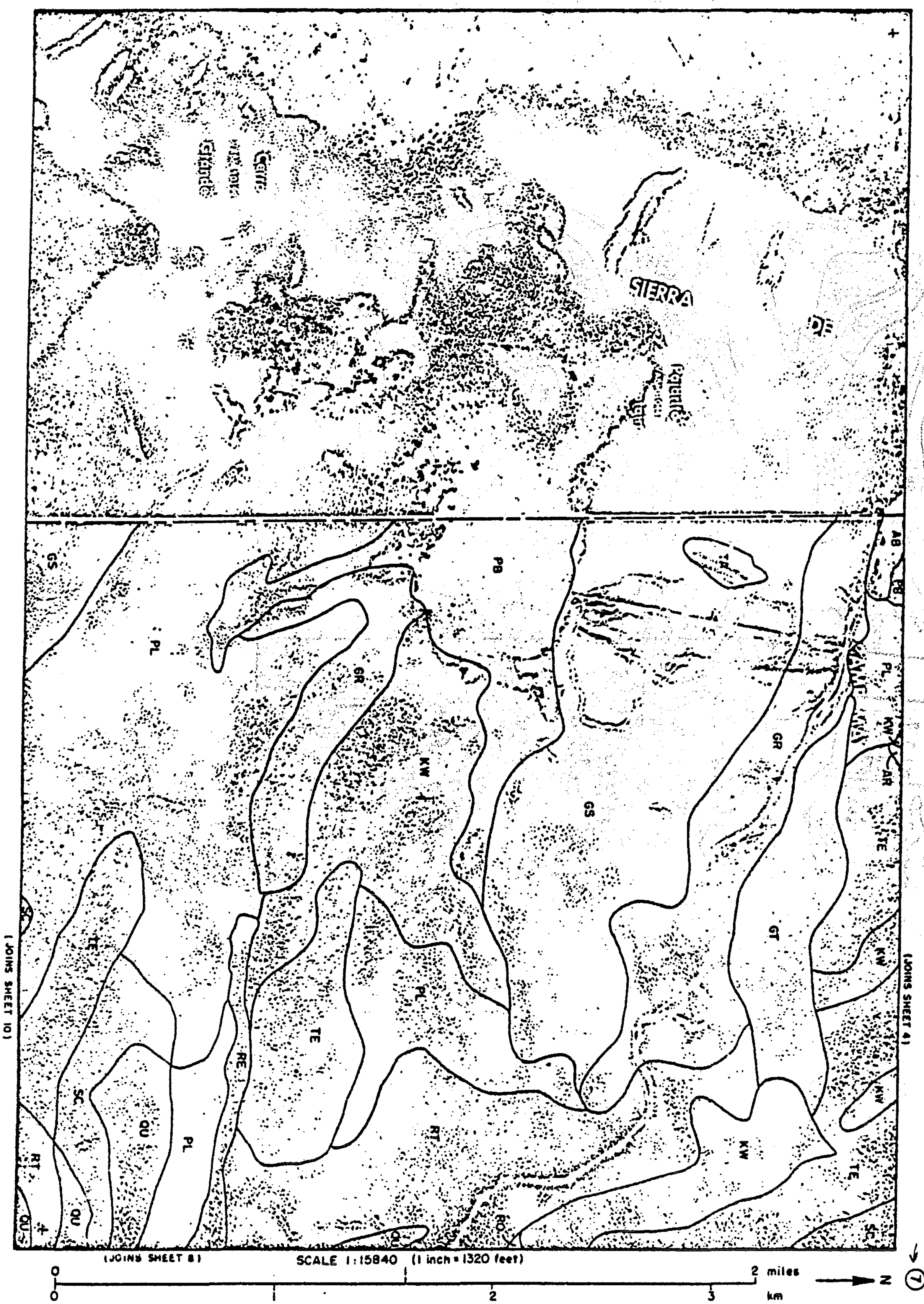
N
4
SCALE 1:15840 (1 inch = 1320 feet)
(JOINS SHEET 7)
(JOINS SHEET 6)
GS
GR
AB
PB
CS
CL
GT
RO
KW
AR
SC
PL
TE

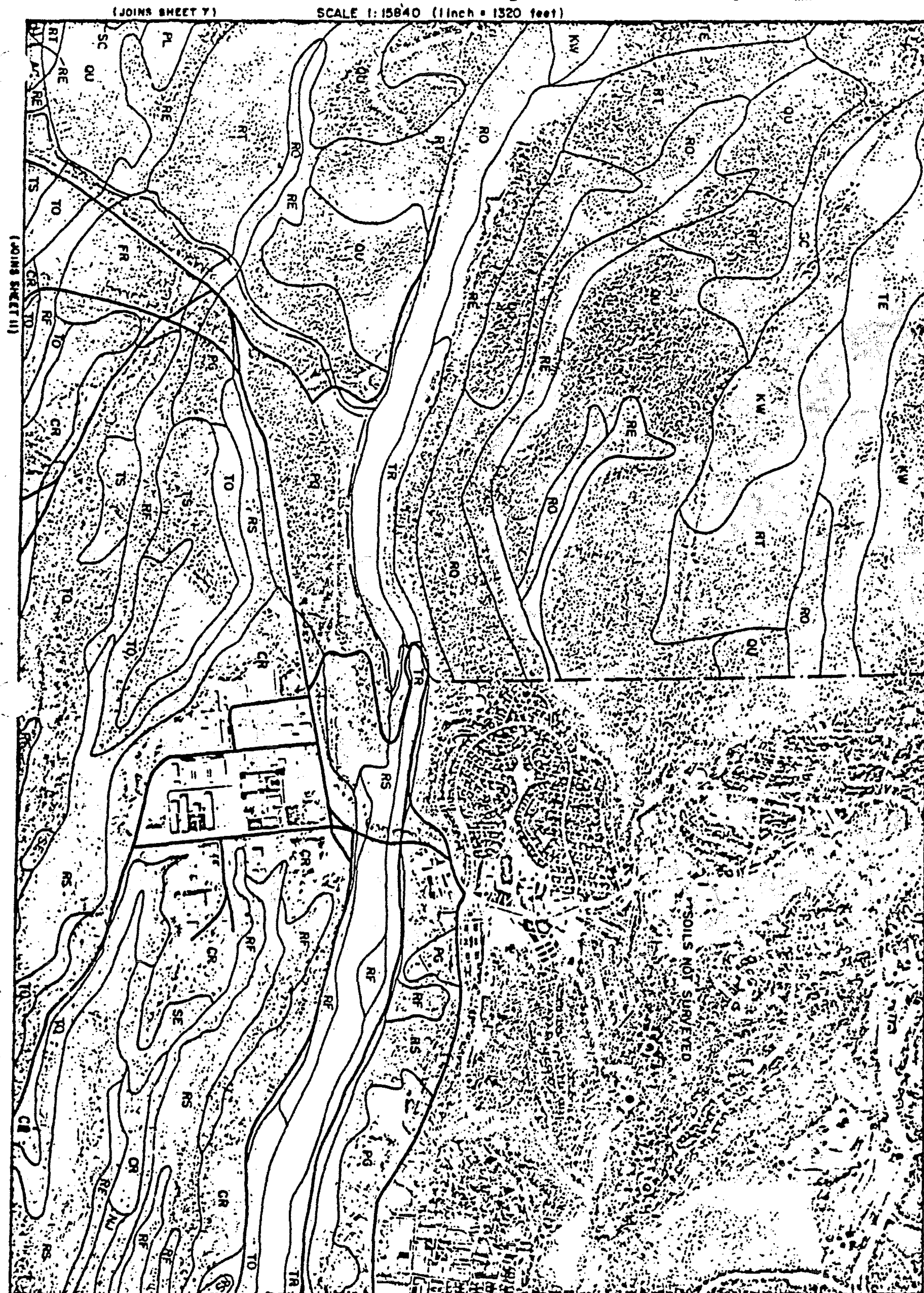


③
N
SCALE 1:15840 (1 inch = 1320 feet)
0
1
2
3
2 miles
km
(JOINS SHEET 2)
(JOINS SHEET 6)
SA
RA
TK
RU
LA
AC
QU
SH
EM
EU
CO
RE
BR
CE
TE

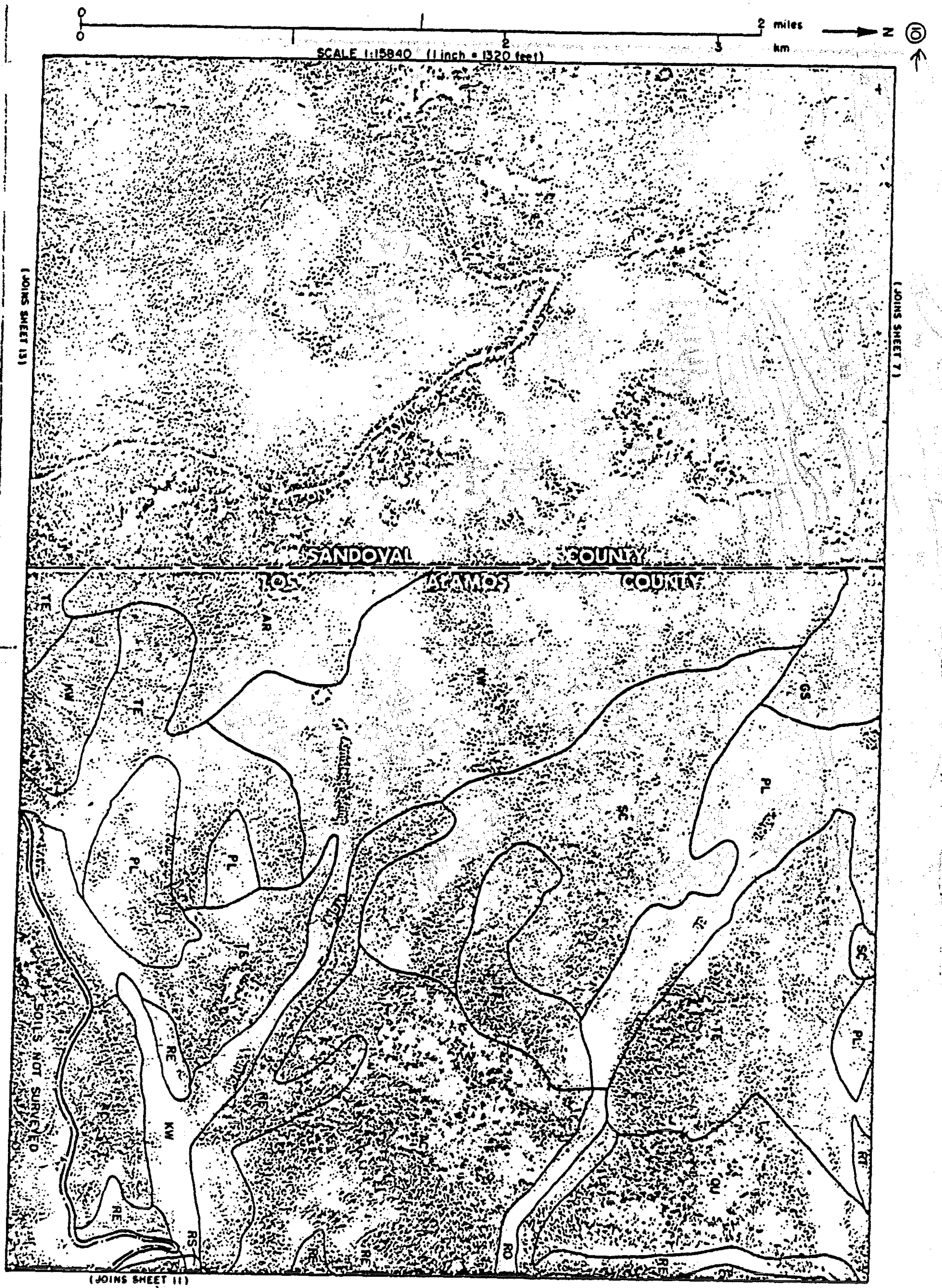

SIERRA
PB
AB
PL
GS
GR
KW
AR
TE
GT
RE
SC
QU
RT
RO
(JOINS SHEET 10)
(JOINS SHEET 4)
(JOINS SHEET 8)
SCALE 1:15840 (1 inch = 1320 feet)
0
1
2 miles
0
1
2
3
km
N
7

0 1 2 miles
0 1 2 3 km
N ⑧

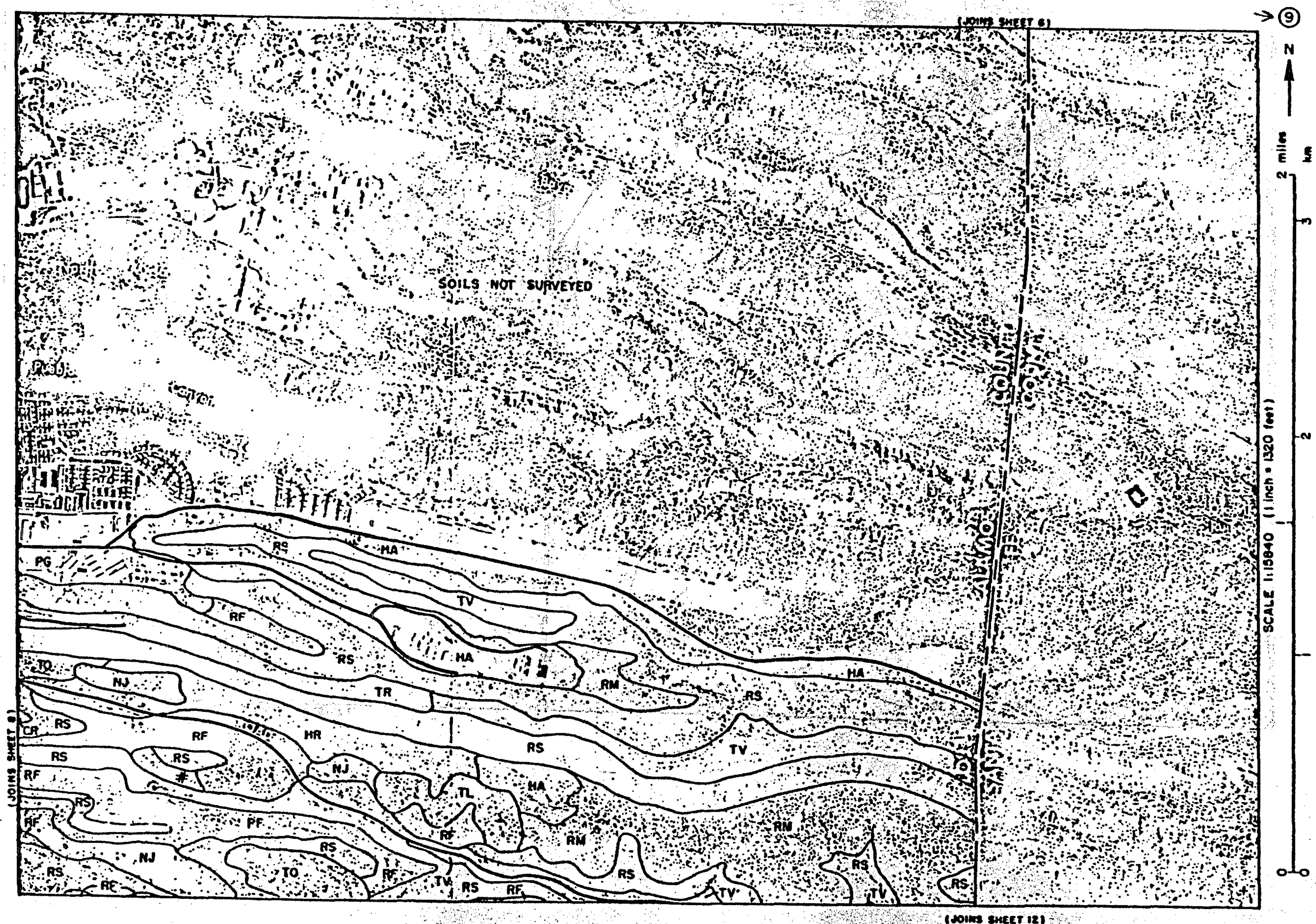
(JOINS SHEET 7) SCALE 1:15840 (1inch = 1320 feet)



(JOINS SHEET 9)



0
1
2 miles
0
1
2
3
km
SCALE 1:15840 (1 inch = 1320 feet)
N
10
(JOINS SHEET 13)
(JOINS SHEET 7)
(JOINS SHEET 11)
SANDOVAL COUNTY
LOS ALAMOS COUNTY
SOILS NOT SURVEYED
TE
KW
AR
GS
PL
SC
RE
RS
RO
QU
RT



9
(JOINS SHEET 6)
(JOINS SHEET 8)
(JOINS SHEET 12)
N
SCALE 1:15840 (1 inch = 1320 feet)
0
2 miles
0
1
2
3
km
SOILS NOT SURVEYED
PG
RS
HA
TV
RF
RS
HA
RM
HA
RS
TO
NJ
TR
CR
RS
RF
HR
RS
TV
RS
RS
NJ
RF
TL
HA
RS
RF
PF
RF
RM
RM
RS
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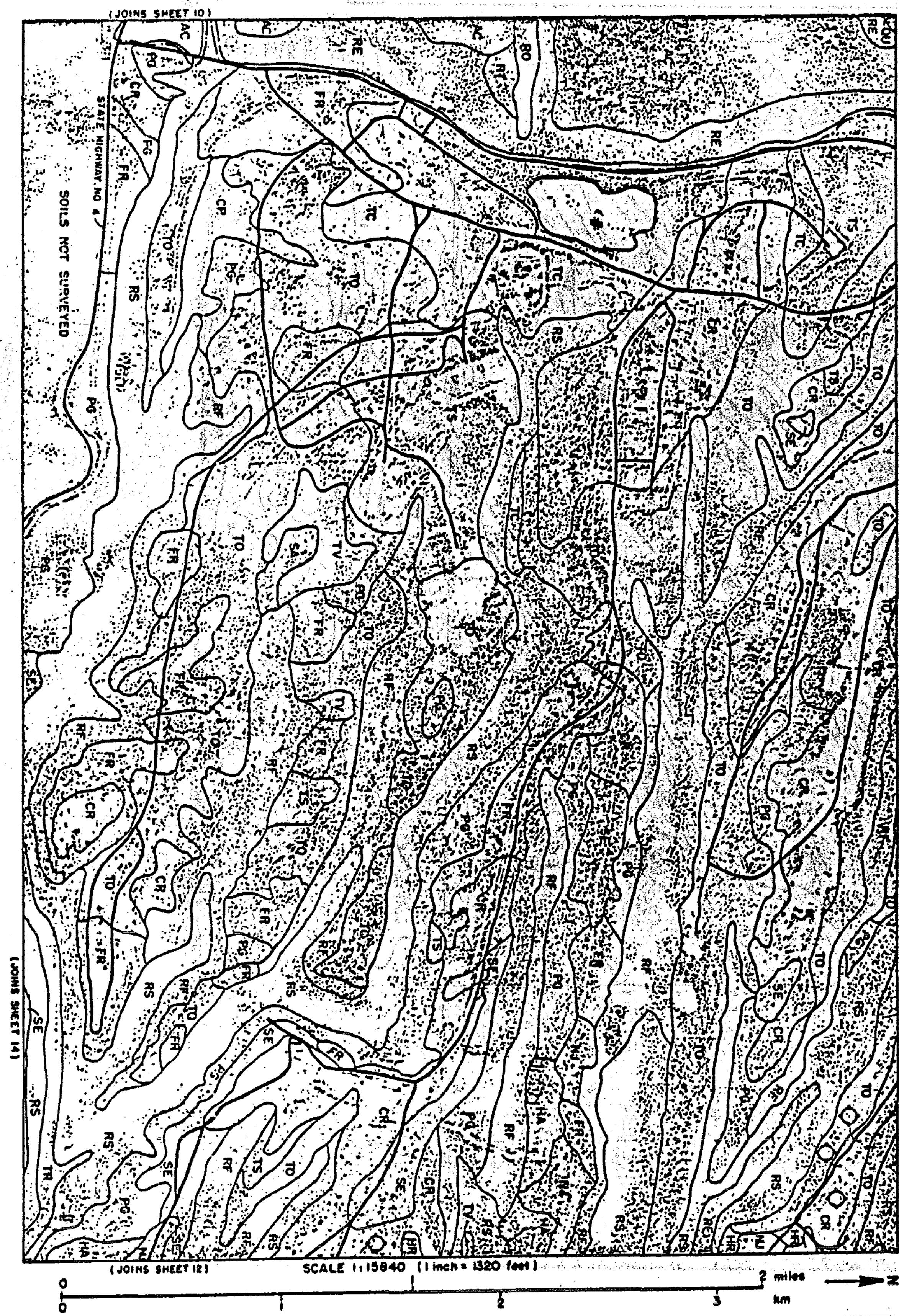
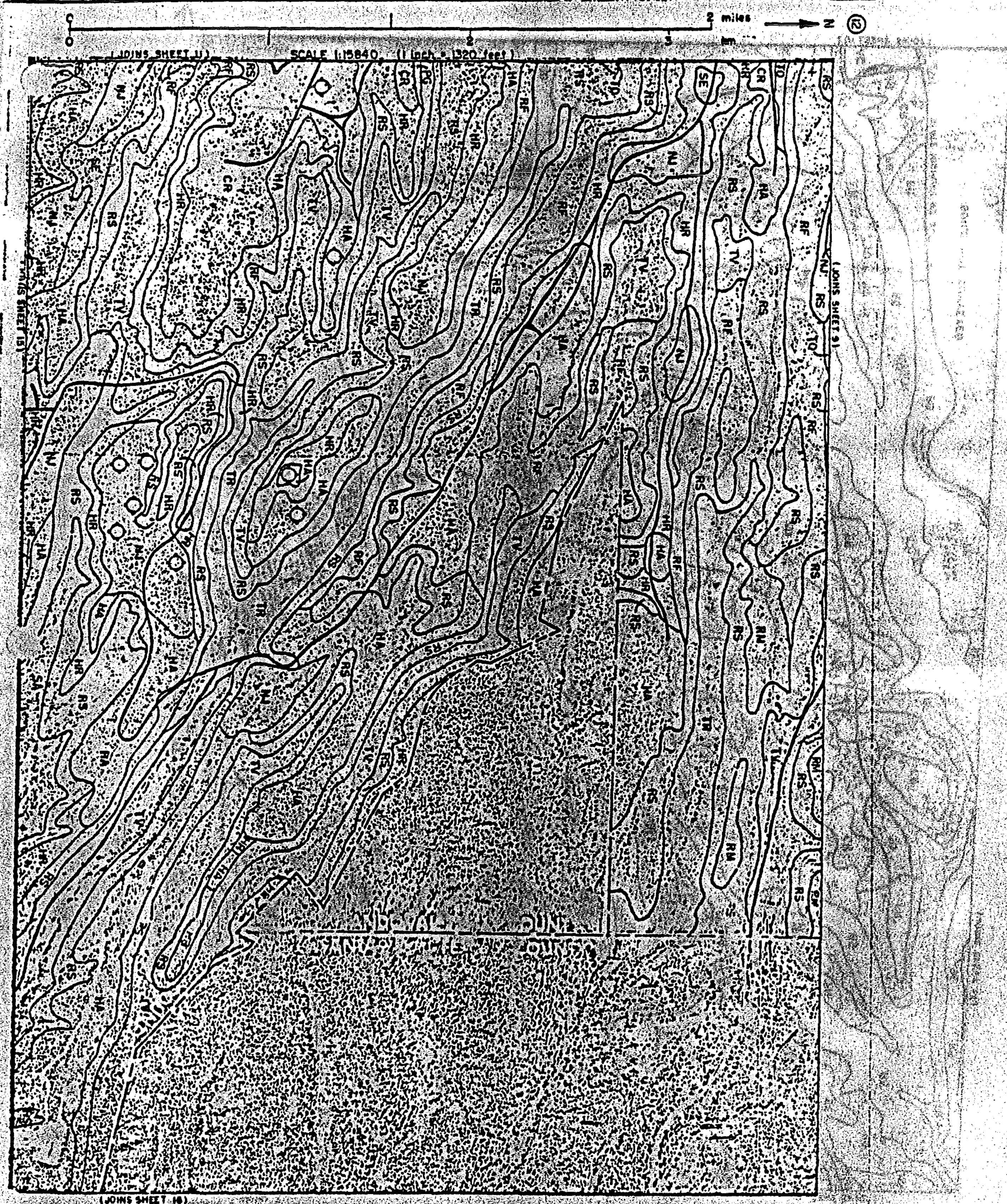
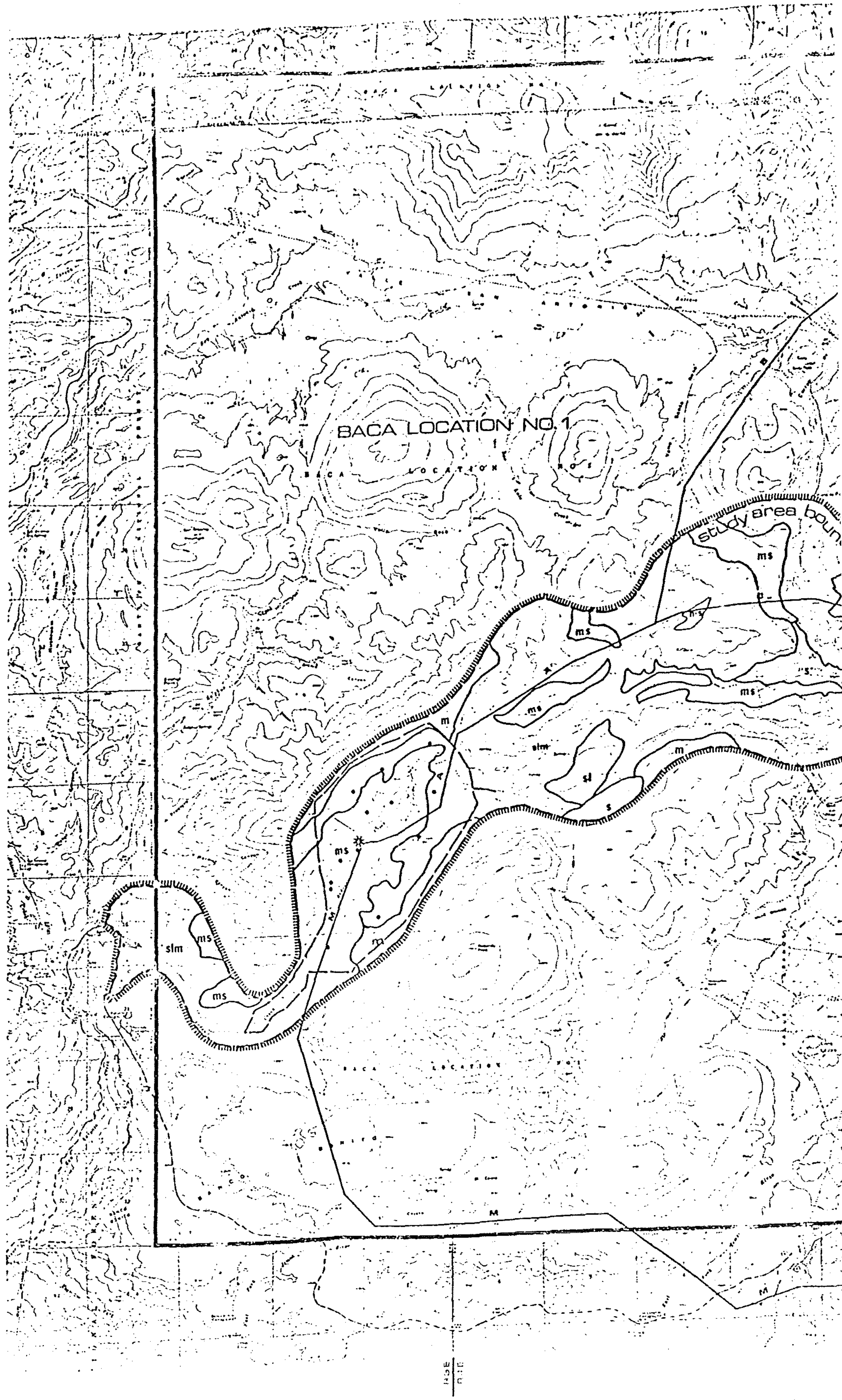
TV
RS
TV
RS
RC

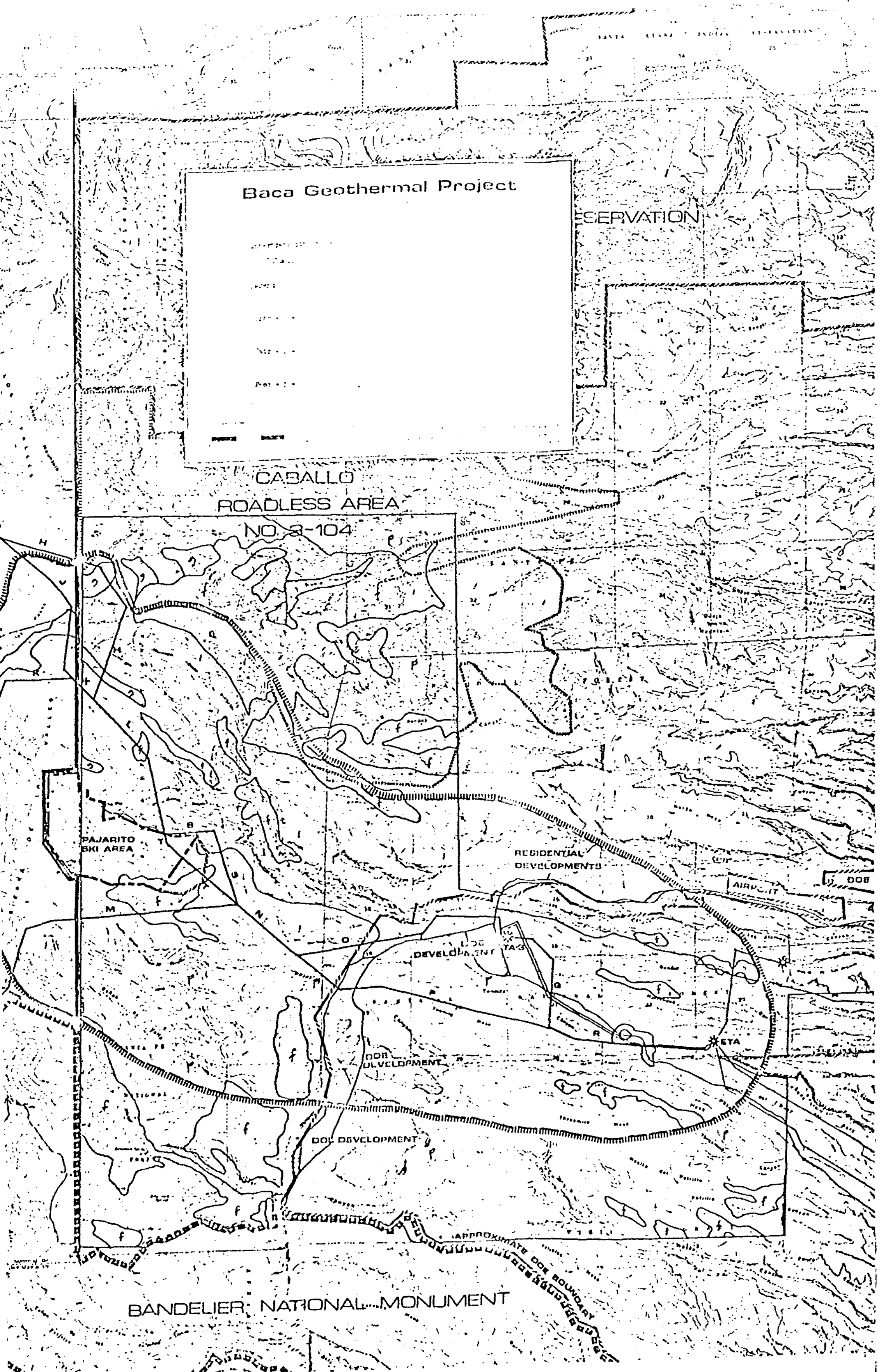


(JOINS SHEET 10)
SOILS NOT SURVEYED
STATE HIGHWAY NO 4
(JOINS SHEET 14)
(JOINS SHEET 8)
(JOINS SHEET 12)
SCALE 1:15840 (1 inch = 1320 feet)
0
1
2 miles
0
1
2
3
km
N

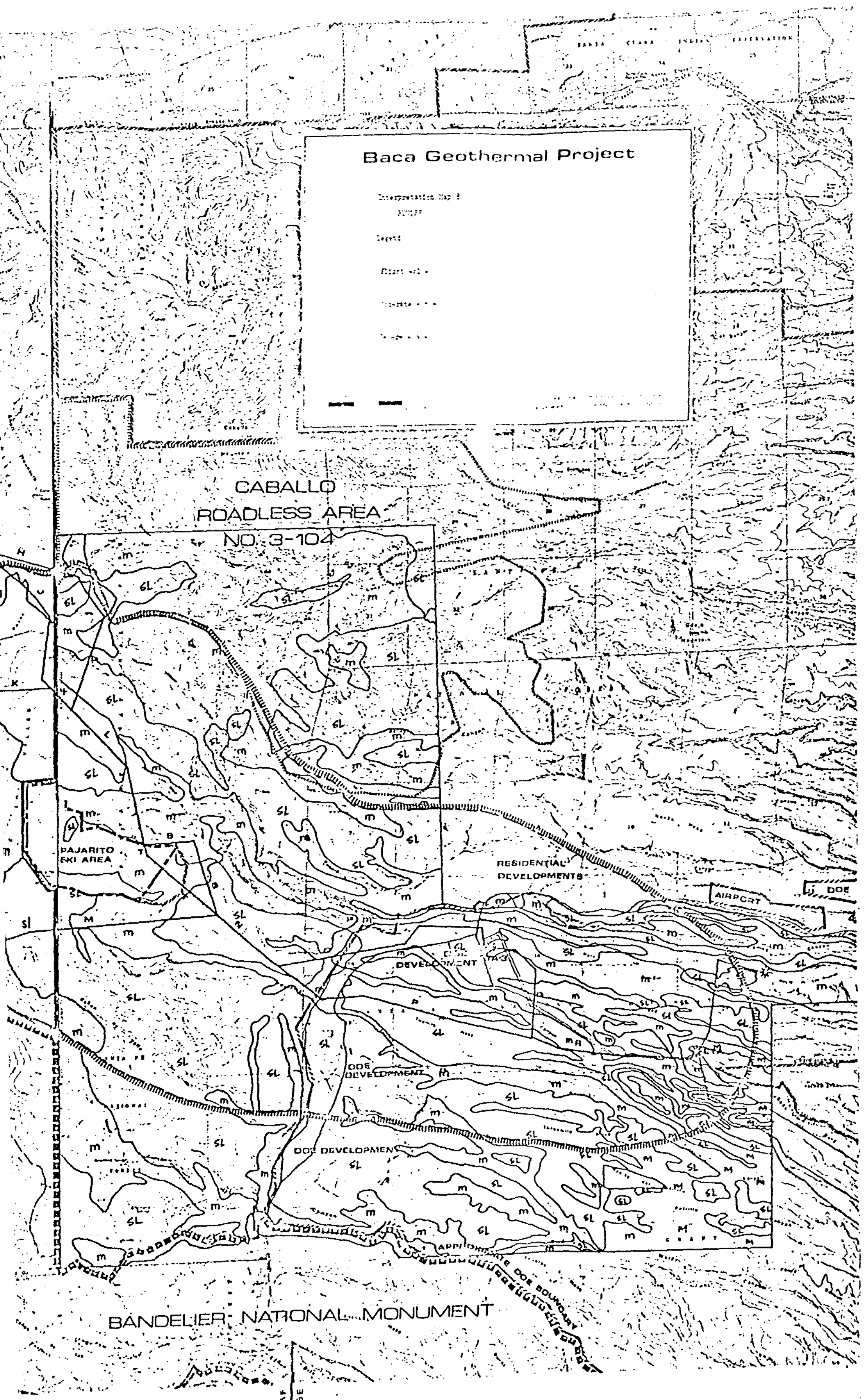

(JOINS SHEET 11)
SCALE 1:15840 (1 inch = 1320 feet)
0 1 2 3 miles
N
12
(JOINS SHEET 9)
(JOINS SHEET 16)
(JOINS SHEET 13)

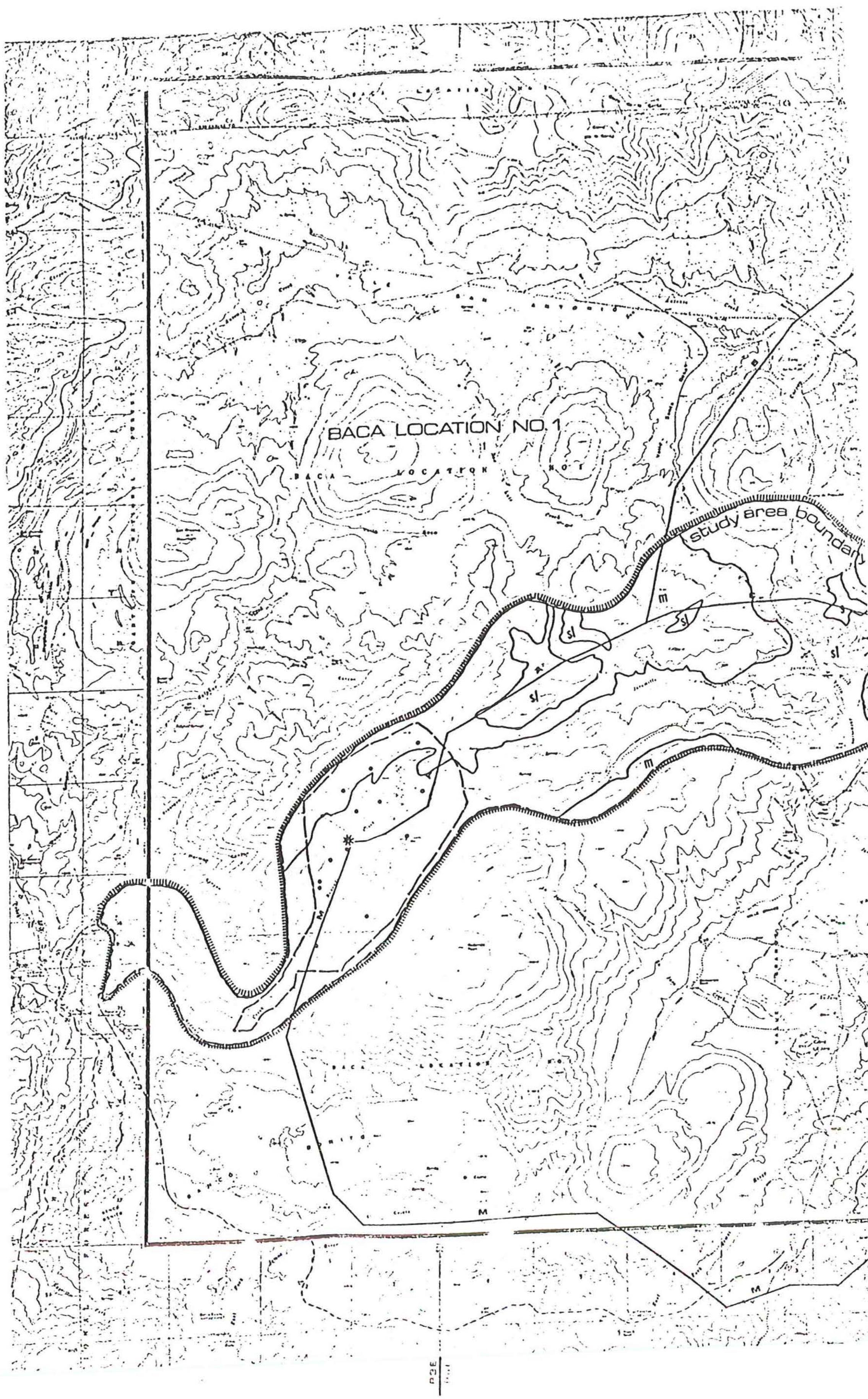


BACA LOCATION NO. 1
study area boun
ms
slm
sl
s
m
M



Baca Geothermal Project
SERVATION
CABALLO
ROADLESS AREA
NO. 3-104
PAJARITO
SKI AREA
RESIDENTIAL
DEVELOPMENTS
AIRPORT
DOE
DOE
DEVELOPMENT
TA-3
ETA
DOE
DEVELOPMENT
DOE DEVELOPMENT
APPROXIMATE DOE BOUNDARY
BANDELIER NATIONAL MONUMENT


Baca Geothermal Project
CABALLO
ROADLESS AREA
NO. 3-104
PAJARITO
SKI AREA
RESIDENTIAL
DEVELOPMENTS
AIRPORT
DOE
DOE
DEVELOPMENT
DOE DEVELOPMENT
APPROXIMATE DOE BOUNDARY
BANDELIER NATIONAL MONUMENT
R6E


BACA LOCATION NO. 1
study area boundar
m
sl
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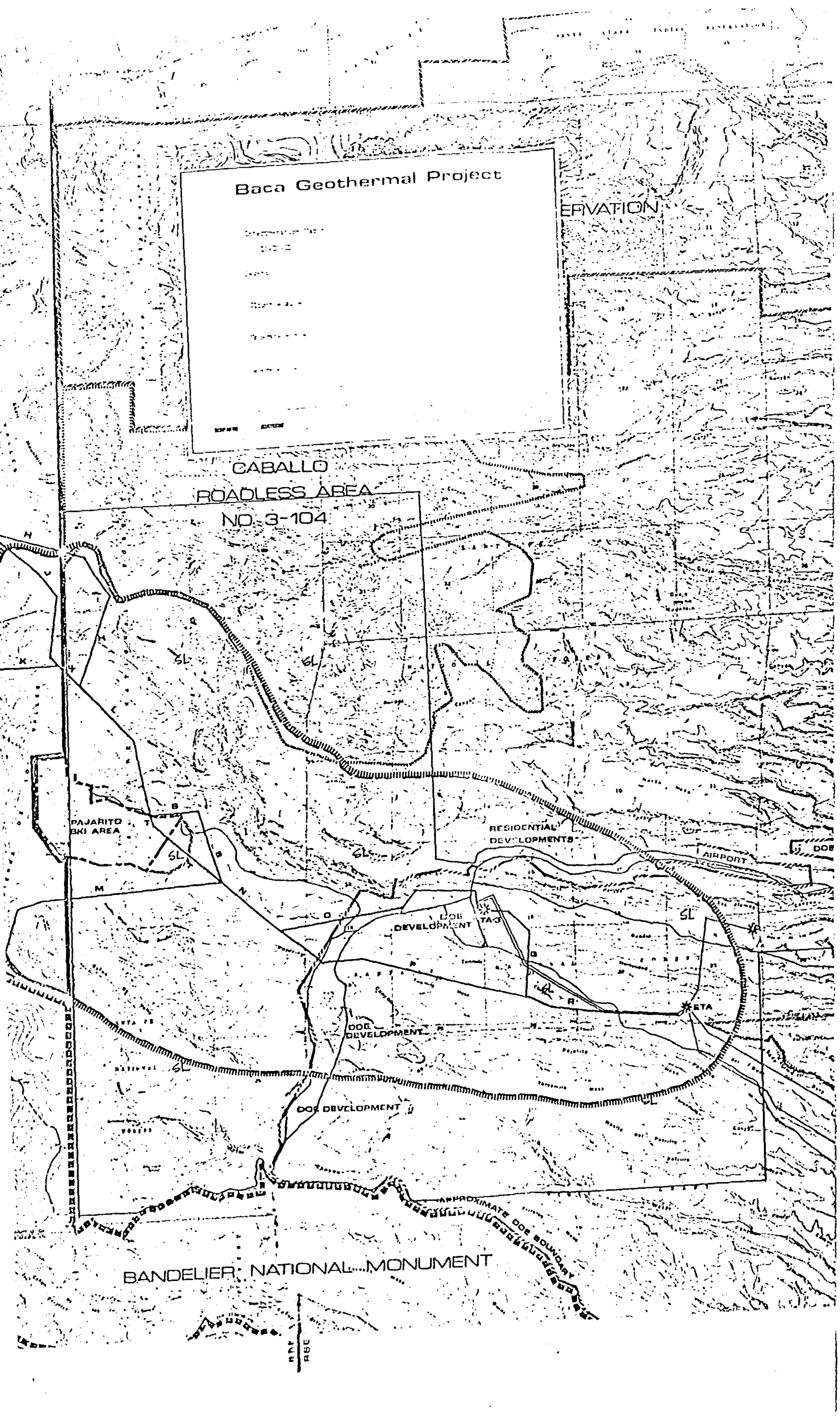
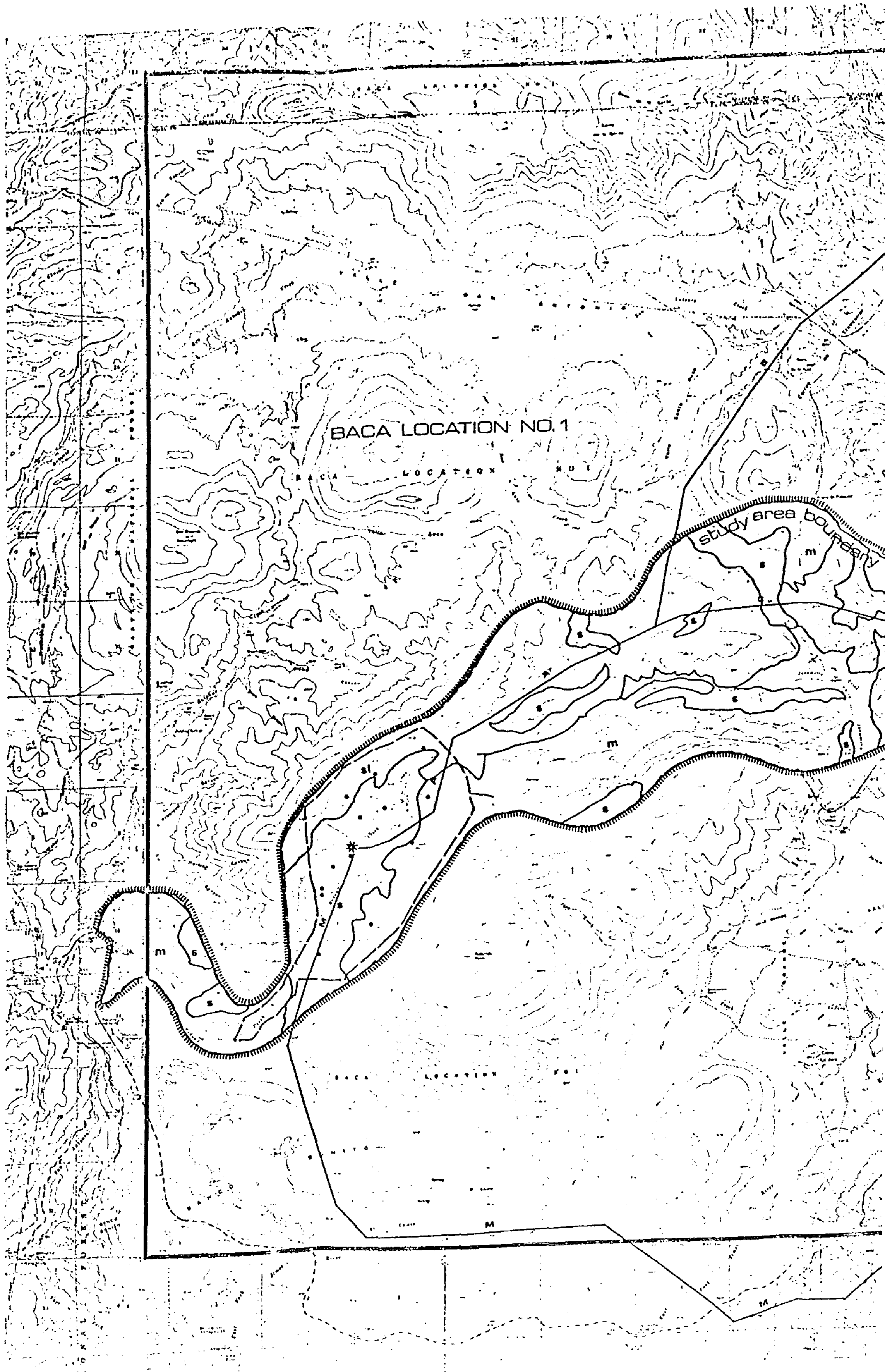
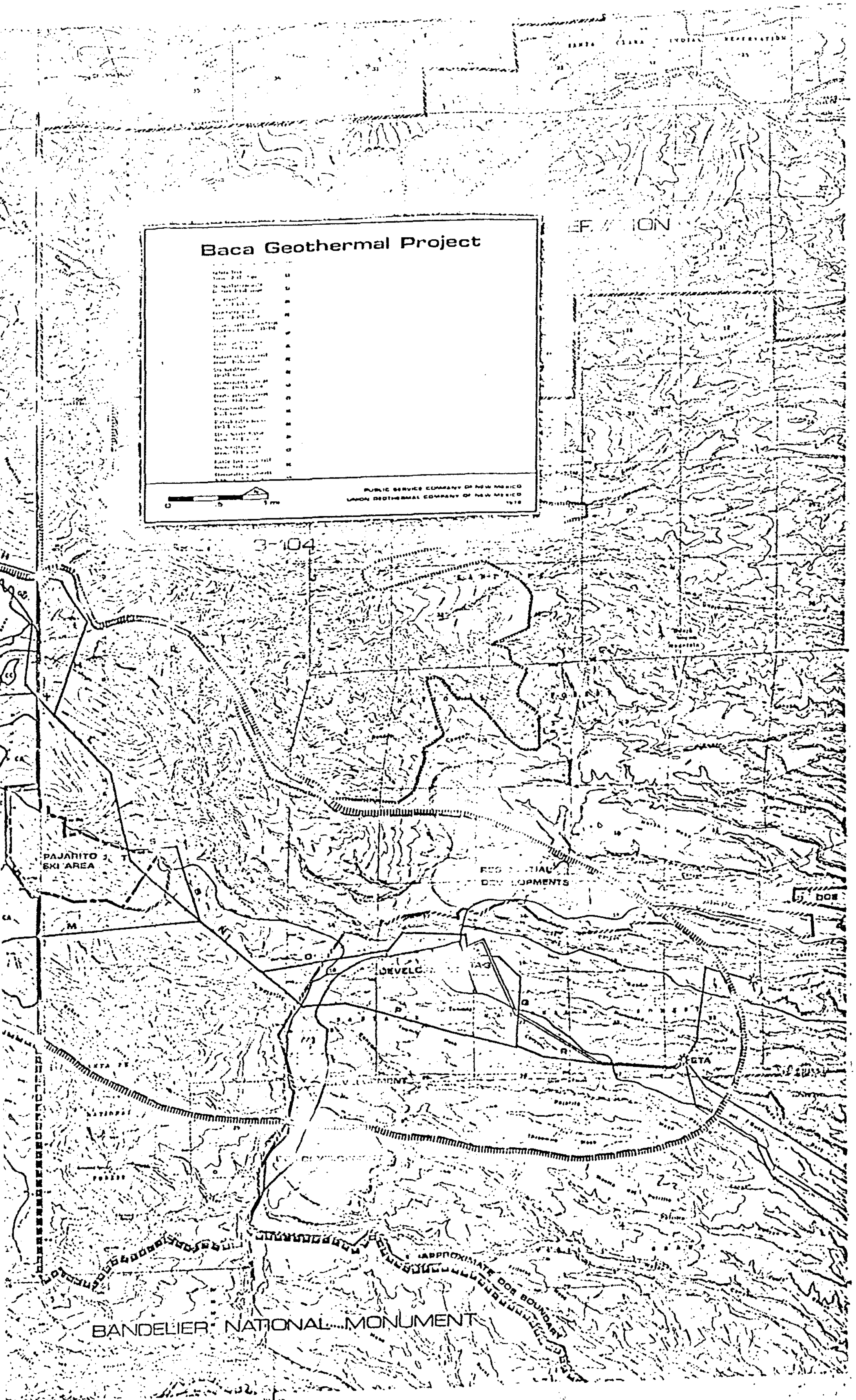
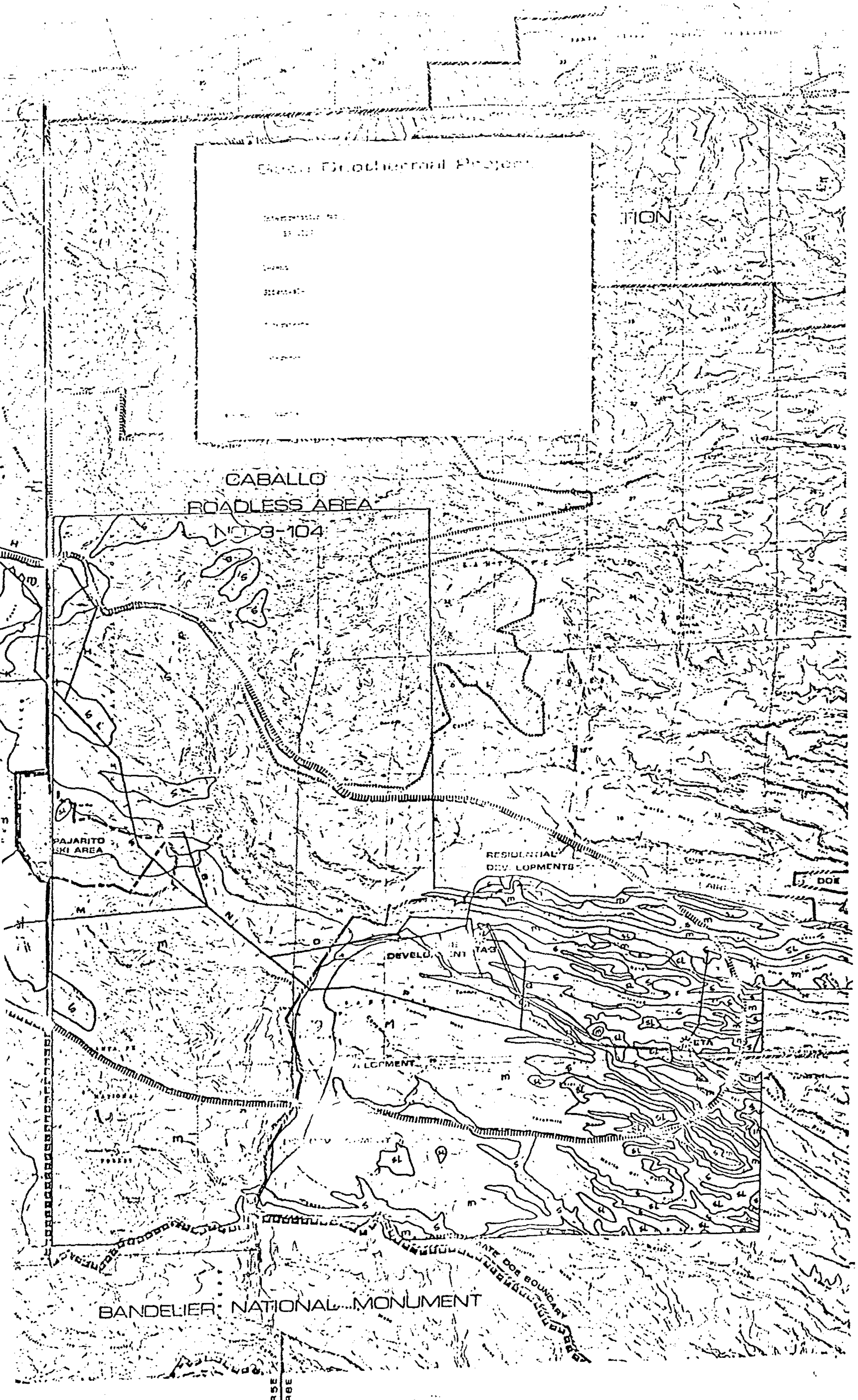


Baca Geothermal Project
ERVATION
CABALLO
ROADLESS AREA
NO. 3-104
PAJARITO
SKI AREA
RESIDENTIAL
DEVELOPMENTS
AIRPORT
DOE
DEVELOPMENT
TA-3
ETA
DOE DEVELOPMENT
APPROXIMATE DOE BOUNDARY
BANDELIER NATIONAL MONUMENT
R6E

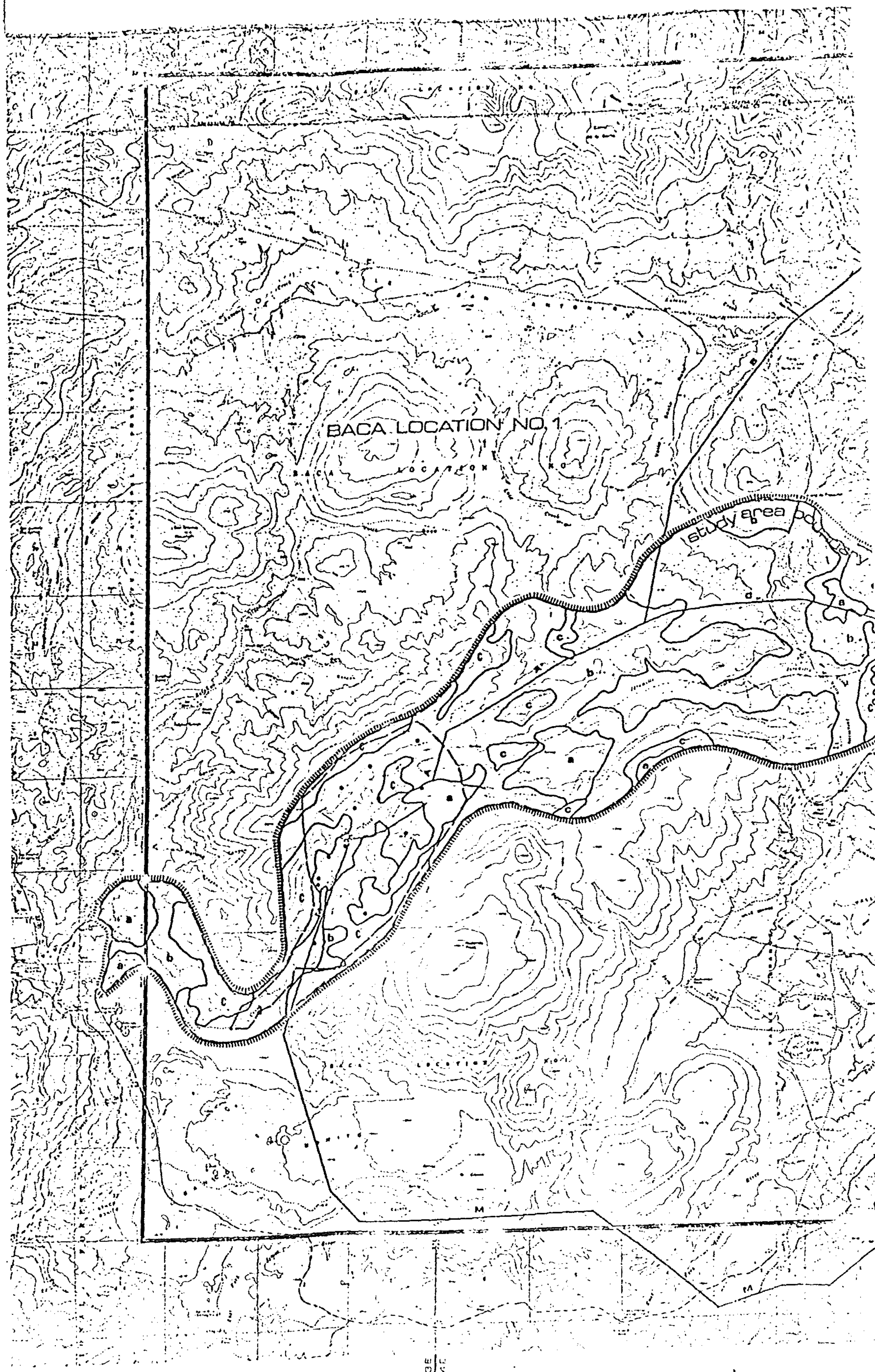

BACA LOCATION NO.1
study area boundary



Baca Geothermal Project
PUBLIC SERVICE COMPANY OF NEW MEXICO
UNION GEOTHERMAL COMPANY OF NEW MEXICO
3-104
PAJARITO SKI AREA
RESIDENTIAL DEVELOPMENTS
DOE
APPROXIMATE DOE BOUNDARY
BANDELIER NATIONAL MONUMENT
SANTA CLARA INDIAN RESERVATION
R5E R6E



CABALLO
ROADLESS AREA
BANDELIER NATIONAL MONUMENT
PAJARITO
SKI AREA
RESIDENTIAL
DEVELOPMENTS
DOE
R5E
R6E


BACA LOCATION NO. 1
study area