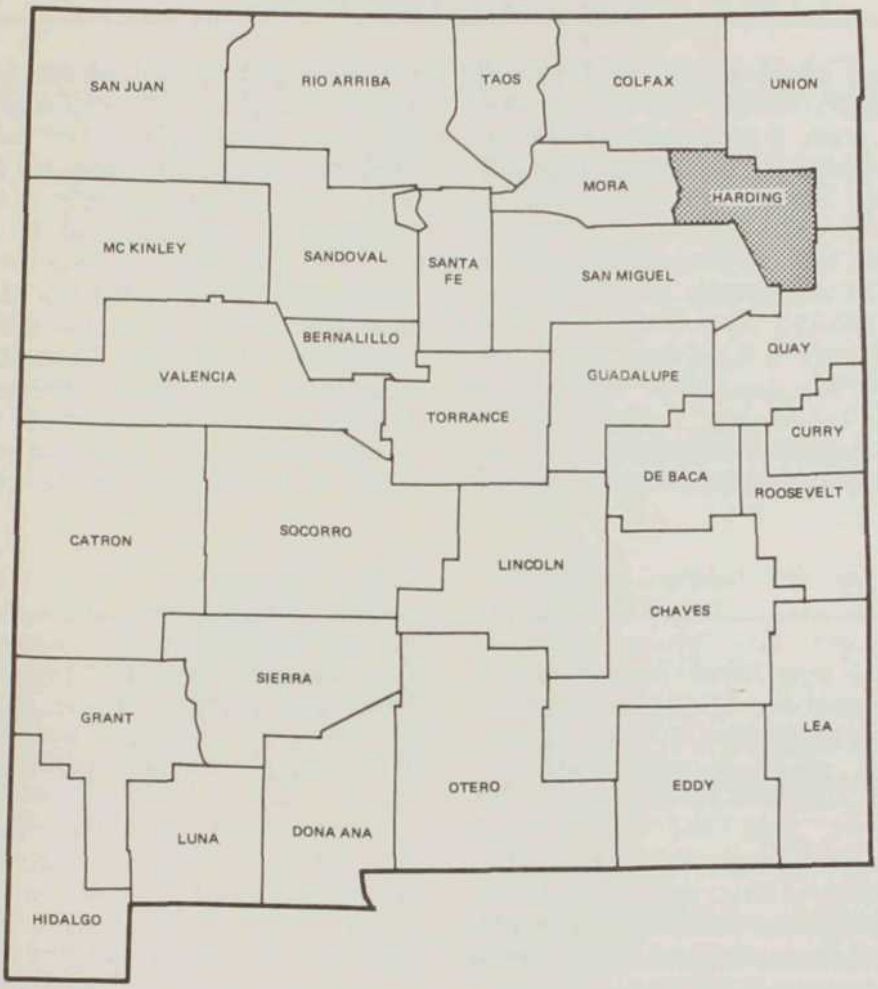
# SOIL ASSOCIATIONS AND LAND CLASSIFICATION FOR IRRIGATION HARDING COUNTY

*Agricultural Experiment Station*
*in cooperation with*
*Water Resources Research Institute*
*and*
*Soil Conservation Service*


**AGRICULTURAL EXPERIMENT STATION RESEARCH REPORT 165**




The work upon which this publication is based was supported by funds provided by the U.S. Department of the Interior as authorized under the Water Resources Act of 1964, Public Law 88-379; the United States Water Resources Planning Act of 1965; and the New Mexico Water Resources Research Institute in cooperation with New Mexico State University, Agricultural Experiment Station.

## Summary

Harding County has a total land area of about 1,368,300 acres. Approximately 67 percent of this, or about 918,523 acres, is considered suitable for irrigation. The potential for expanding irrigation, therefore, is limited by a lack of water and by economic restrictions rather than by a shortage of suitable soils. About 160,385 acres are in irrigation land class 1; 353,373 acres in class 2; 358,733 acres in class 3; and 146,032 acres in class 4. The remaining 449,777 acres in the county are in land class 6, which is not considered suitable for irrigation.

The data are organized and presented on the basis of the soil associations shown on the general soil map. (See figure 1 on the center pages.) The irrigation land classification map (figure 2) shows the approximate distribution of land classes in Harding County according to its suitability for irrigation based on the dominant irrigable classes or non-irrigable class in each of the areas as outlined.

The soils have been classified in the American Association of State Highway Officials (AASHO) and Unified systems to facilitate use of the soil association information by engineers and others acquainted with these groupings. Information relative to the suitability of the soils for a variety of engineering uses and specific factors limiting their use are also given in the engineering section.

## Contents

# SOIL ASSOCIATIONS AND LAND CLASSIFICATION FOR IRRIGATION HARDING COUNTY

H. J. Maker[1], D. S. Pease[2], and J. U. Anderson[1]

An essential criterion for planning the best possible use of land and water resources in New Mexico is information on the capability of soils for the numerous present and potential uses. One such land use is irrigated agriculture, and it is important that the many kinds of soil occurring within the state be evaluated for this land use. The interest in the expansion of irrigated land in New Mexico also adds to the importance of determining the suitability of the various soils for irrigation. The water required for the new irrigated land, if expansion should occur, would have to be developed locally, transferred from other sections of the state, or brought in from distant sources.

The primary purpose of this report is to present information on the suitability of soils in Harding County for irrigation. The acreage, general location, and relative capability of the soils for such use are given. This information can be used in appraising the value or suitability of large tracts of land for irrigation. For a satisfactory income to operators on irrigated land, it is essential that only soils capable of high productivity under sustained irrigation be developed for this use. Obviously, limited or expensive irrigation water should be used on soils that are the most productive and have the fewest limitations. The extent, location, and the relative suitability of land for irrigation in Harding County are presented in the map showing land classification for irrigation (see figure 2 on the center pages of this report). The general soils map (figure 1) and a detailed soil survey provided the information needed for the classification for irrigation.

The general soil map is also useful in community or broad area planning. It provides information on soil resources of large tracts that can be used for preliminary planning for irrigated agriculture, forestry, range, urban, engineering, recreation, and wildlife uses. For example, from the general soil map of Harding County, information can be obtained relative to the location of large tracts of land with soils suitable for the development of irrigated land. It will also show those areas with soils best suited to range, recreation, wildlife or other uses, as well as the general location of soils that will present problems in the construction of roads or building foundations.

The general soil map of Harding County does not replace the need for detailed soil maps for operational planning on individual farms and ranches or the planning of specific locations for houses, roads, parks, and other items of this nature. General soil maps are suitable *only* for *general or broad area planning*. They can, however, serve a very useful purpose in the planning process.

---

[1]Soil Scientist and Professor, respectively, Department of Agronomy, New Mexico Agricultural Experiment Station.

[2]Soil Scientist, Soil Conservation Service, U.S. Department of Agriculture.

## Procedures

A detailed soil survey and preliminary report made by the Soil Conservation Service[3] provided the soils information used in this study, including descriptions with information about limitations and recommendations for the best use of each soil.

The general soil map (figure 1), which is small-scale and shows only general soil areas or soil associations, was prepared by grouping geographically associated soils shown on the detailed soil maps into 14 general soil areas. These 14 map units, which are referred to as "soil associations" are landscapes, or geographic areas, that have a distinctive proportional pattern of soils. Inasmuch as each kind of soil normally occurs in comparatively small rather than large areas, the map units on the general soil map of Harding County are generally made up of two or more kinds of soil. In addition, land types and a number of minor soils are commonly components of the map units in this county. The kinds of soil included in each soil association are not necessarily similar. In fact, they often are of contrasting characteristics that influence their use and management.

When the soil data were assembled, the major soils and miscellaneous land types within each soil association were placed into one of five classes of land depending upon their productive capacity under irrigated agriculture (table 5). The criteria used in the placement of soils in the irrigation land classes are those proposed at the 1967 conference organized by the Federal Water Resources Council[4] and as modified by a committee of this conference on January 12, 1968. These criteria were agreed upon by authorities from several organizations concerned with land classification and appear to have a particularily high reliability. For uniform and consistent application of these criteria and standards, the New Mexico Soils Work Group have issued guidelines and clarifications as needed and appropriate. The classification system establishes four classes of irrigable land and one class of non-irrigable land. The limitations for use under irrigation increases from class 1 through 4. Class 1 has few or no limitations for use as cropland under irrigation. It is land that is productive and well adapted to irrigation. High yields of most climatically adapted crops can be obtained on these lands with good management. Class 2 land, although well suited to irrigation, has slight to moderate limitations for sustained use under irrigation. These are moderately productive lands, or are lands that require more than average management to obtain high yields of climatically adapted crops. Class 3 land, which has moderate to severe limitations for sustained use under irrigation, is generally not as suitable for the production of as wide a range of the climatically adapted crops as land in classes 1 and 2. These lands also have a more limited productivity for many of the climatically adapted crops, or are lands that require a very high level of management to obtain moderate to high yields. Class 4 land has a very severe limitation for sustained use under irrigation. The lands included in this class are usually adapted only to a relatively few of the climatically adapted crops. Some of these lands may be adapted or used for the production of specialized crops under a very high level of management. Class 6 land is not suitable for irrigation.

The lands in Harding County were placed in the various irrigation land classes on the basis of soil properties and qualities that affect their suitability for continued use under irrigation. The availability, or the cost of pumping and conveying irrigation water does not enter into the classification. Nor was the shape, size, and location of lands with respect to other lands to be developed for irrigation considered in this classification. The detailed criteria used in the placement of land in the various irrigation land classes are listed in table 1.

The major soil properties and qualities and related land factors that affected the placement of land in the various irrigation land classes were: soil texture, effective soil depth, available water-holding capacity, permeability, erosion, surface smoothness, slope, internal soil drainage, and surface drainage. The Pastura soils, for example, are classed as non-irrigable because of the limited effective soil depth and very low moisture retention capacity. The Mansker soils were placed in class 3 primarily because of the high lime content and the limited effective soil depth over soil layers with a very high lime content.

---

[3]Pease, Douglas S. Soil Survey of Harding County, New Mexico. U.S. Department of Agriculture. Unpublished. Copies of field sheets and interim report available for review at Roy, New Mexico, Office of Soil Conservation Service.

[4]Proceedings Water Resources Council, Irrigation Land Classification Seminar, Salt Lake City, Utah. July 1967.

Table 1. Land classification specifications for Pacific Southwest Basin irrigation land classes[1]

| Land Characteristics | Class 1 | Class 2 | Class 3 | Class 4 | Non-irrigable Class 6 |
|---|---|---|---|---|---|
| Soils | | | | | |
| Texture (Surface 12")[2] | LVFS-CL | LS-C Peat, Muck | MS-C | MS-C | All other lands not meeting |
| Moisture Retention (AWHC-48")[3] | > 6.0" | 4.5" 6.0" | 3.0" 4.5" | 2.5" 3.0" | criteria for |
| Effective Depth (inches) | > 40[4] | 30- 40 | 20 - 30 | 10 - 20 | arability |
| Salinity ($EC_e \times 10^3$ - equil.) | < 4 | 4 - 8 | 8 - 12 | 12 - 16 | |
| Sodic Conditions[5] | | | | | |
| Percent area affected | < 5 | 5 -15 | 15 - 25 | 25 - 35 | |
| Severity of problem[6] | Slight | Moderate | Moderate | Moderate | |
| Permeability (in place - in/hr) | 0.2-5.0 | 0.05-5.0 | 0.05-10.0 | Any | |
| Permissible coarse fragments (% by vol.) | | | | | |
| Gravel | 15 | 35 | 55 | 70 | |
| Cobbles | 5 | 10 | 15[7] | 35[7] | |
| Rock Outcrops (distance apart in feet) | 200 | 100 | 50 | 30 | |
| Soil Erosion (for all classes) | Severely eroded soils will be downgraded one class. Less severely eroded soils may be downgraded one class, depending on other conditions. | | | | |
| Topography (or land development items)[8] | | | | | |
| Stone for Removal (cubic yards per acre) | 10 | 25 | 50 | 70 | |
| Slope (percent) | | | | | |
| Moderately to severely erodible | < 2 | 2 - 5 | 5 - 10 | 10 - 20 | |
| Slightly erodible | < 4 | 4 - 10 | 10 - 20 | 20 - 25 | |
| Surface Leveling or Tree Removal (amount of cover) | Light | Medium | Medium heavy | Medium heavy | |
| Irrigation Method | Lands unsuited to gravity irrigation where land grading would permanently reduce soil fertility below arable limits or exceed permissible costs, or field pattern too complex, may be considered for sprinkler. Land must meet other requirements for arability. Designate by "S" - example, 3-S. | | | | |
| Drainage | | | | | |
| Soil Wetness (depth to water table during growing season with or without drainage) | | | | | |
| Loam or finer | > 60" | 40" - 60" | 20" - 40" | 10" - 20" | |
| Sandy | > 50" | 30" - 50" | 20" - 30" | 10" - 20" | |
| Surface Drainage | Good | Good | Restricted | Restricted | |
| Depth to Drainage Barrier (in feet) | > 7 | 6 - 7 | 5 - 6 | 1.5 - 5 | |
| Air Drainage[9] | No Problem | Minor | Restricted | Restricted | |

[1]Specifications are representative of conditions after land is developed for irrigation. Each individual factor represents a minimum requirement, and unless all other factors are near optimum two or more interacting deficiencies may result in land being placed in lower class or designated class 6 -- non-irrigable.

[2]Finer textures may be required than those indicated for each class in areas subject to critical hot spells or wind; coarser textures may sometimes be permissible.

[3]In areas of very warm growing season 3" may be required for class 4 and in cold areas as little as 5" may be permitted for class 1.

[4]Depth of 60" or more is required for class 1 where deep-rooted crops are important.

[5]More extensive and severe sodic problems may be tolerated in areas of wide crop adaptability.

[6]Severity of problem: **Slight** - ESP less than 15% or less than 25% if dominated by nonswelling clays; **moderate** - ESP less than 20% or less than 30% if clay minerals favorable; **severe** - ESP less than 30%; with certain soil minerals may range above 50% as measured by usual techniques.

[7]May range above 50% in subsoil for certain crops if surface soil is favorable.

[8]Special crop and management practices may justify exceeding the limits for stone removal or slope in class 4; irregularity of slope may necessitate downgrading of class unless deficiency is compensated for by possibility of sprinkler irrigation.

[9]Air drainage is a consideration mainly in areas adapted to fruit or to early or late vegetables.

Abbreviations:

LVFS - loamy very fine sand
LS - loamy sand
MS - medium sand
CL - clay loam
C - clay
AWHC - available water holding capacity
ESP - exchangeable sodium percentage

## Location and Topography

Harding County comprises an area of 1,368,300 acres in northeastern New Mexico. Its eastern boundary is 18 to 19 miles west of the New Mexico-Texas state line. From this point it continues westward to the Canadian River which forms its western boundary. On the north, Colfax and Union counties lie between Harding County and the Colorado-New Mexico state line.

A number of different types of topography occur within the county. The western part of the county is a relatively high mesa on which the gently sloping, smooth-lying surface is broken only by a few drainage depressions and minor areas with undulating or dunelike topography. Except on the margins of this extensive plain, drainage goes into shallow depressions or playas.

The High Plains or mesa area of this county is separated from the extensive erosional valley of the Ute Creek drainage system by a very steep escarpment. Furthermore, steep and precipitous canyon walls and breaks occur adjacent to the Canadian River.

The intermediate plains and valleys of the Ute Creek drainage system have landscapes that range from nearly level or gently sloping to those that have a rolling topography. The differences in the erodability of the parent materials in which the soils of this area are developing has contributed significantly to variations in local relief. Many of the lower lying broad valleys and plains occur where the erodable "red bed" geologic formations are common. This is in contrast to the higher surfaces which have been stabilized by erosion-resistant sandstone bedrock. In addition to the intermediate plains and valleys, nearly level to gently sloping flood plains contiguous to Ute Creek and other intermittent drainages are common.

The sandy soil areas in the southeastern part of the county are characterized by undulating to gently rolling or dune topography. The larger or more pronounced dune areas are usually elongated in an east-west direction. This area with dune topography gradually grades into nearly level to gently sloping plains in the northeastern part of the county.

The Canadian River, which forms the western boundary of Harding County, is the principal stream in the area. Essentially all surface runoff from this county eventually enters the Canadian River drainage system. With the exception of the Canadian River, all the drainages in the county are intermittent and flow only following periods of heavy precipitation. The Ute Creek, which is the largest of the intermittent streams, traverses the county in a north-south direction to its confluence with the Canadian River in Quay County just south of the boundary between Harding and Quay counties.

Elevations in the county range from about 3900 feet in the southeast corner to slightly over 6000 feet in the north-central part. The elevations at Roy and Mosquero, which are 5880 and 5500 feet, respectively, are representative of those occurring on the high mesa in the western part of the county. In the eastern part of the county, elevations commonly range between 3900 and 5000 feet.

## Climate[5]

Harding County has a semi-arid, continental climate. Summers are generally mild and receive most of the annual precipitation. Moisture for summer rains comes by way of the southeasterly air circulation from the Gulf of Mexico, about 600 miles away. Condensation is caused by convective air currents which result from strong surface heating and lifting of the air as it moves over higher terrain. Winter precipitation falls from storms moving west to east from the Pacific Ocean moisture source. Because a large quantity of this Pacific Ocean moisture has already been precipitated as rain or snow during its passage over the coastal and inland mountains, only light precipitation falls over eastern New Mexico.

The annual patterns of temperature and precipitation for Roy, shown in table 2, are representative of climate at other Harding County locations for which selected annual averages are listed in table 3. The highest temperature measured in Harding County was 104°F and the lowest temperature was -19°F at both Mosquero and Roy. An average of 29 days a year may be expected to have high temperatures of 90 degrees or greater, mainly in June, July, and August. The high temperature may be expected to remain below 32°F on an average of 8 days a year. The temperature drops to 32°F or below on an average of 143 days a year, and to zero or below on an average of 2 days a year, usually in January and

[5]This section was prepared by Frank E. Houghton, ESSA, Weather Bureau State Climatologist.

Table 2. Monthly temperatures (1931-1960) and precipitation (1949-1960), Roy, Harding County, New Mexico, elevation 5884 feet

| Item | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperatures (F°) | | | | | | | | | | | | |
| Average daily maximum | 49 | 52 | 56 | 65 | 75 | 85 | 87 | 86 | 80 | 69 | 58 | 50 |
| Average daily minimum | 21 | 22 | 26 | 34 | 44 | 54 | 58 | 57 | 49 | 38 | 26 | 21 |
| Daily mean | 35 | 37 | 41 | 50 | 59 | 70 | 73 | 71 | 65 | 54 | 42 | 35 |
| Extreme maximum | 75 | 75 | 78 | 86 | 95 | 101 | 101 | 102 | 96 | 88 | 78 | 74 |
| Extreme minimum | -11 | -8 | 2 | 10 | 25 | 35 | 50 | 45 | 33 | 16 | -4 | -1 |
| Precipitation | | | | | | | | | | | | |
| Average (inches) | .41 | .43 | .63 | .91 | 2.50 | 1.62 | 2.32 | 2.22 | 1.72 | 1.40 | .43 | .53 |
| Average days 0.10 inch or more (no.) | 1 | 1 | 1 | 3 | 4 | 4 | 5 | 5 | 3 | 3 | 1 | 1 |
| Average snowfall (inches) | 3.4 | 4.7 | 4.8 | 2.1 | 0.9 | T | 0 | 0 | 0.2 | 0.5 | 2.9 | 5.5 |

T = Trace, amount too small to measure

Table 3. Annual averages of selected climatological data, Harding County, New Mexico, for period of record through 1960 (except through 1952 at Abbott)

| Station | Elevation | Temperature: Mean maximum | Temperature: Mean minimum | Temperature: Yrs. of record | Precipitation: Mean annual | Precipitation: Yrs. of record | Last 32° F or Lower in Spring | First 32° F or Lower in Fall | Time Between Dates |
|---|---|---|---|---|---|---|---|---|---|
| | feet | F° | F° | no. | in. | no. | - - - average date - - - | | days |
| Mosquero | 5500 | 67.8 | 37.8 | 27 | 16.15 | 29 | May 4 | Oct. 11 | 160 |
| Roy | 5888 | 67.6 | 37.5 | 8 | 15.46 | 52 | April 30 | Oct. 15 | 168 |
| Abbott | 5771 | | | | 14.75 | 44 | | | |
| Bueyeros | 5000 | | | | 14.40 | 30 | | | |
| Solano | 5600 | | | | 15.93 | 51 | | | |
| Yates 6S | 5600 | | | | 14.16 | 26 | | | |

6S indicates distance in miles and direction from the postoffice.

February, but occasionally in November and December.

Average annual rainfall in Harding County ranges from 15 to 17 inches. Extremes of precipitation include an annual total of 47.02 inches at Yates in 1941, a monthly maximum of 13.88 inches near Mosquero in September 1941, and a 24-hour total of 6.45 inches at Bueyeros on September 22, 1941. Nearly three-fourths of the annual average rainfall occurs during the growing season, mostly from brief, but often heavy, thunderstorms during the late afternoon and evening hours.

Annual snowfall in Harding County localities averages from 19 to 26 inches. Extremes of snowfall include an annual total of 67.0 inches at Roy.

An average wind speed of 12 miles per hour is estimated for the area, predominantly from the southwest. Winds are stronger in the spring and ligher in the fall. Winds of 25 miles per hour or greater occur for 5 percent of the hours and, with dry ground, may cause blowing dust and soil erosion.

## Land Use

The Homestead Act of 1909, which provided for homesteading of 320 acres where land was not irrigated, contributed significantly to the settlement of the area now included in Harding County. Following the passage of this act, many homesteads were established throughout the plains sections of the central, northeastern, and southeastern parts of the county. Dry farming was practiced extensively in these homestead areas until the 1930's. Following the drought in the 1930's and again in the 50's much of the dry cropland was abandoned or returned to range use. Now, only about 50,000[3] acres of dry cropland remain under cultivation. Farming without irrigation is hazardous under the prevailing climatic conditions in this county. Profitable dryland crop yields can be expected only during those years when average or above average precipitation is obtained. In addition to the dry cropland, the State Conservation Needs Committee estimates that about 2600[6] acres were irrigated by ground water in 1966. The underground water supplies of sufficient quantity for irrigation appear to be limited in Harding County. It is doubtful, therefore, if there will be an appreciable expansion of irrigated land until other sources of irrigation water are located and developed for this use.

Ranching is the principal type of agricultural enterprise in this county. In 1967, the county's

[6]New Mexico Soil and Water Conservation Needs Inventory, Soil Conservation Service. 1966. Unpublished.

rangeland supported about 34,000[4] cattle and 1000 sheep[7]. Although moisture is definitely a limiting factor in dry farming, it is generally of sufficient amount to produce moderate to high yields of native forage when soils, slopes, and other factors are favorable.

The use of land for wildlife and recreational purposes is also of considerable importance in Harding County. The steep and precipitous canyon walls and breaks adjacent to the Canadian River, as well as the High Plains escarpments, provide good habitat for many species of wildlife.

The present use of the land in each soil association is shown in the list. A land use is shown only when it appears to apply to at least 1 percent of the association. Although much land is used for recreation, this is not included because of the difficulty of accurately determining its extent.

| Soil Map Symbol and Soil Association | Present Land Use |
|---|---|
| 1 Dumas-Dioxice-La Brier | Dry farming, range |
| 2 Litle-Berthoud-Penrose | Range |
| 3 Berthoud-Kinkead | Range |
| 4 Quay-Ima-Tucumcari | Range |
| 5 Church-Karde | Range |
| 6 Campus-Dean | Range |
| 7 Mansker-Portales | Range, irrigated farming |
| 8 Otero-Dalhart | Range, dry farming |
| 9 Amarillo | Range, dry and irrigated farming |
| 10 Springer-Tivoli-Amarillo | Range, irrigated farming |
| 11 Pastura-Apache-Dioxice | Range |
| 12 Travessilla-Carnero | Range |
| 13 Gallegos | Range |
| 14 Rough Broken and Stony Land | Range |

## Description of Soils

There are 14 soil associations on the general soil map for Harding County. Each of these general soil areas or soil associations includes soils that are geographically associated and indicate, in a general way, the soils of the area. The soil associations are named for the major soil series and land types that occur within each of the mapping units. Selected soil characteristics and qualities of major soils in each soil association are summarized in table 4. A description of each of the soil associations follows:

### 1. Dumas-Dioxice-La Brier association

This association encompasses an area of about 183,285 acres on the High Plains in the west-central and northeastern parts of Harding County. A characteristic feature of this unit is the nearly level to very gently sloping topography. Although the generally smooth landscape is undoubtedly controlled by the underlying Ogallala formation, the soils of this unit are forming dominantly in parent materials of eolian origin deposited on the Ogallala surface. It supports a relatively dense cover of grass and, under good management, moderate to high forage yields are obtained. The principal grasses include blue grama, western wheatgrass, galleta, ring muhly, and buffalograss. This association was formerly a major area for dry farming, but much of it has now been returned to range use because of the prevailing unfavorable climatic conditions. Nevertheless, it is still the most extensively dry-farmed part of Harding County. Wheat, millet, and other small grains are the principal crops.

Wind erosion hazard is moderate to severe on dry-farm land and range areas in poor condition. Maintaining maximum plant cover on range and using soil and water conservation practices on cropland will minimize damage from wind erosion.

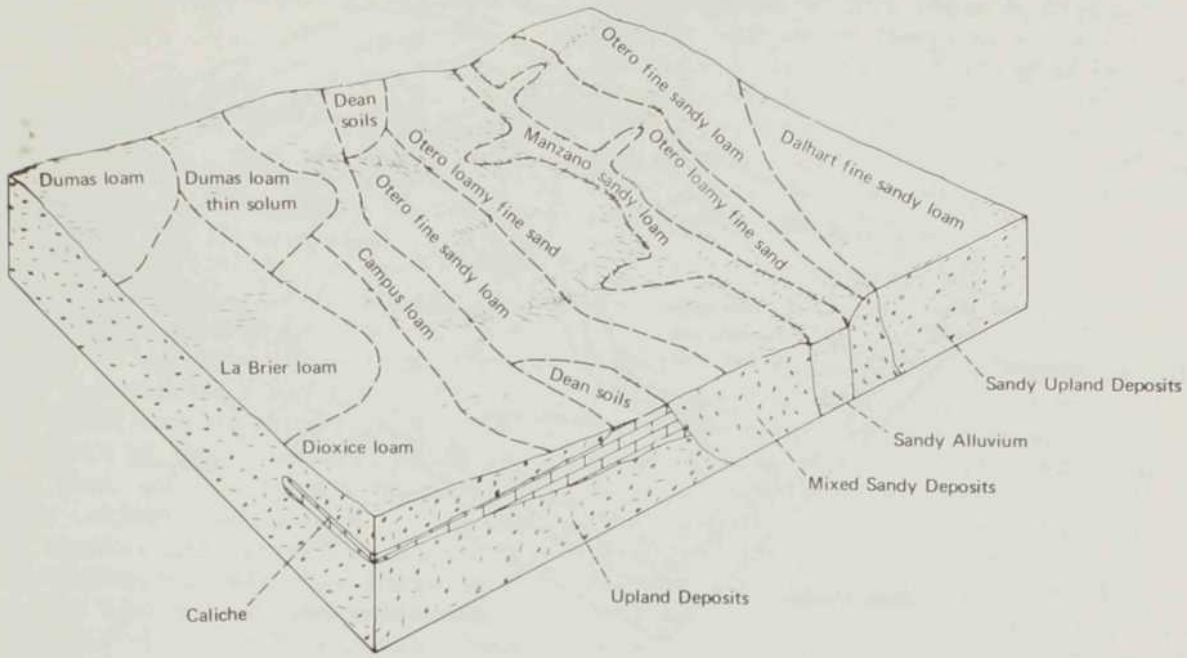
*Soil Characteristics.* Dumas soils, the most extensive, have a thin surface layer of brown loam over a thick subsoil of brown to yellowish-red clay loam. The substratum below an average depth of about 48 inches consists of a pinkish-white loam high in lime. These soils, which are moderately permeable, have a high water-holding capacity. They are typically noncalcareous to depths ranging from 15 to 40 inches.

A thin solum phase also occurs in association with Dumas loam. It is similar to Dumas loam except that it has a thinner subsoil. The pinkish-white substratum high in lime is encountered at depths ranging from 20 to 36 inches.

The Dioxice soils, which are moderately deep, are underlain by soft caliche at depths ranging from 24 to 40 inches. They usually have a moderately thick surface layer of dark grayish-brown loam. It is typically noncalcareous to a depth of three to five inches, but locally is calcareous to the surface. The subsoil is a

[7]New Mexico Agricultural Statistics, Vol VI–Supplement I. 1968.

Fig. 3. The loamy soils in the Dumas-Dioxice-La Brier association are extensive on the mesa between Roy and Mosquero. The soils in the Otero-Dalhart association, in the north central part of the county are more sandy.




grayish-brown to brown calcareous clay loam. This is underlain by a pinkish-white loam substratum high in lime. These soils, which are moderately permeable, have a moderate available water-holding capacity.

Also extensive in this association are the La Brier soils. They normally have a surface layer of very dark grayish-brown loam or light clay loam, over thick clayey subsoils. The upper part of the subsoil is a grayish-brown clay. This is underlain by a light brown calcareous clay loam. These soils, although slowly permeable, have a high available water-holding capacity. They normally are noncalcareous to depths ranging from 15 to 24 inches.

Soils of minor extent in this association include those of the Manzano and Tricon series. The Manzano soils, which occur on flood plains and in swales, are deep, dark-colored, and moderately fine-textured. Tricon soils are underlain by indurated caliche at depths ranging between 20 and 60 inches.

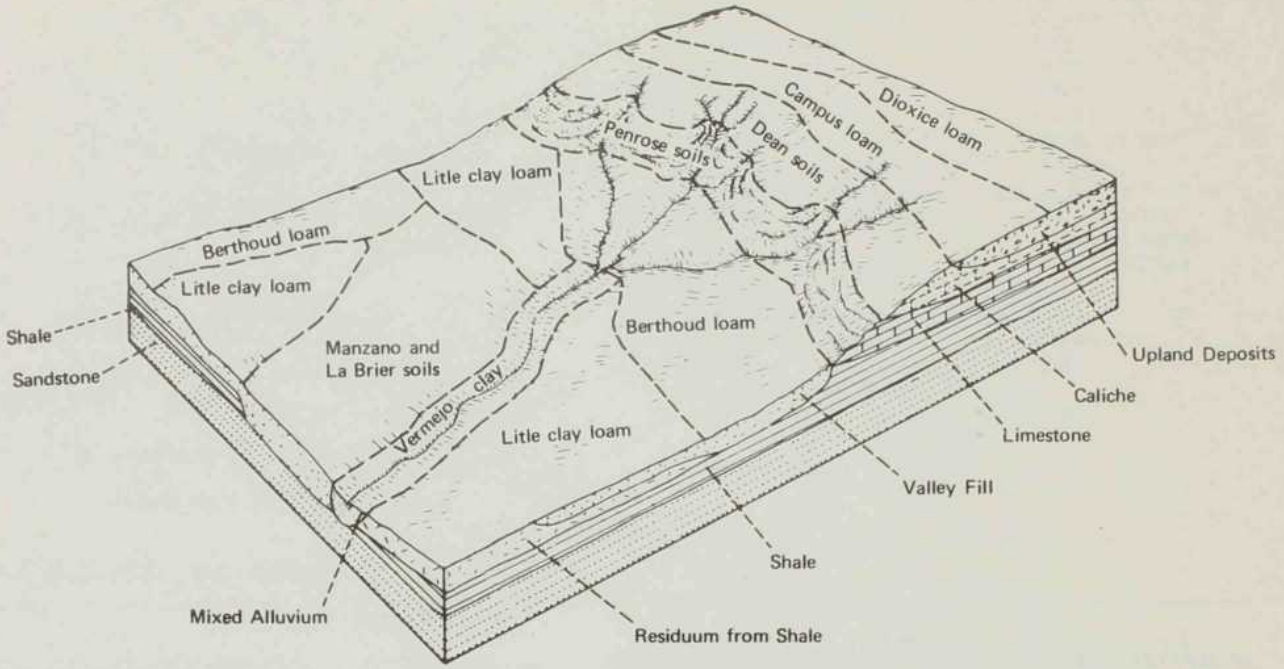
*Irrigation Potential.* There is a high potential for development of irrigated land in this association. The soils of this unit, which are dominantly in irrigation land classes 1 and 2, have suitable properties and characteristics for use as cropland under irrigation. The irrigable soils occur in relatively large tracts with little or no interspersed non-irrigable land. They have sufficient productive capacity, if provided with essential improvements of leveling and irrigation, to support sustained irrigation.

### 2. Litle-Berthoud-Penrose association

This association includes an area of approximately 53,105 acres in the northwestern part of the county. Although geographically associated, the soils included in this unit have highly contrasting characteristics. They range from shallow soils developing over thinly bedded limestone and shale, to deep medium-textured soils forming in alluvium. Topography, which is also varied, includes gently sloping and undulating uplands, gently to strongly sloping fans, and gently rolling uplands. This association comprises about 4 percent of the county.

Western wheatgrass, vine mesquite, galleta, alkali sacaton, and blue grama are the principal grasses on the clayey soils. In addition to these grasses, the strongly sloping, shallow, and gravelly

Fig. 4. Typical patterns of soils in the northwest portion of Harding County. These soils occur mainly in the Litle-Berthoud-Penrose association and the Campus-Dean association.




soils commonly support little bluestem, sideoats grama, New Mexico needlegrass, big bluestem, and threeawns.

*Soil Characteristics.* Litle soils, most extensive in the association, occur on gently sloping to gently undulating uplands. They are developing in fine textured material weathered residually from the underlying shale. The depth to shale varies from 20 to 40 inches. These soils usually have a thin surface layer of grayish-brown calcareous clay loam and a subsoil of grayish-brown clay or silty clay. Thin threads of lime and gypsum crystals are common in the subsoil immediately above the underlying shale.

Berthoud soils occur on gently to strongly sloping fans and valley-filling slopes along the margins of the High Plains. These deep moderately permeable soils are developing in calcareous, medium-textured alluvium. They have calcareous grayish-brown surface layers, light brownish-gray calcareous clay loam subsoils, and pale-brown loam or sandy clay loam substrata.

Penrose soils, the least extensive of the major soils of the association, are on gently sloping crests and strongly sloping side slopes of ridges. They normally consist of less than 15 inches of light brownish-gray calcareous channery loam or clay loam over interbedded limestone and shale. A distinguishing feature of the Penrose soil is the relatively high content of angular shale and limestone fragments (channery) on the surface and throughout the soil profile.

Manzano, La Brier, and Vermejo soils comprise the remainder of this association. The Manzano soils, which occur in narrow drainageways, are deep, dark colored, and moderately fine textured. La Brier and Vermejo are deep soils with loam or clay loam surface layers and slowly permeable clay subsoils.

*Irrigation Potential.* The association offers limited opportunity for the development of irrigated land. The Berthoud and Manzano soils are well suited for use as cropland under irrigation when they occur in areas of sufficient size to merit consideration for this purpose. They often occur, however, in relatively small tracts intermingled with class 4 land or non-arable land. The Litle soils, which are included in irrigation land class 4, have severe limitations for sustained use under irrigation. These fine textured and slowly permeable soils are underlain by shale at moderate depths. In addition to the limitation of depth and texture, the underlying shale will tend to restrict the free movement of water through these soils.

Localized salinity and drainage problems can therefore be expected to develop. The Penrose soils, due to their shallow depth, are not suitable for irrigation.

### 3. Berthoud-Kinkead association

This association, which includes an area of about 92,550 acres, or 7 percent of the county, occurs on gently to strongly sloping fans and plains in the east-central part of Harding County. (See figure 7.) In general, the area occupied by this unit, as well as those of closely associated mapping units, consists of a relatively broad valley area intermediate in elevation between the flood plains of the Ute Creek drainage system and the High Plains. The soils of this association, which are dominantly deep, are developing in medium to fine-textured calcareous alluvium. It is used for grazing of livestock and supports a moderately dense cover of short and mid grasses. The principal grasses on the Kinkead soils and other closely associated moderately fine-textured include tobosa grass, alkali sacaton, mat muhly, blue grama, and vine mesquite. Blue grama, sideoats grama, little bluestem, and sand dropseed are common on the soils with sandy surface layers.

*Soil Characteristics.* Berthoud soils occupy the gently to strongly sloping fans and valley filling slopes immediately below escarpments or other steeply sloping areas. They have moderately thick surface layers of grayish-brown calcareous loam or fine sandy loam. The subsoil is a light brownish-gray strongly calcareous clay loam. This is underlain by pale brown sandy clay loam. A few threads and nodules of lime commonly occur in the subsoil and substratum.

The Kinkead soils occur on nearly level to gently sloping broad alluvial fans. They typically have a thin surface layer of dark grayish-brown clay loam over a thick subsoil of grayish-brown clay. The substratum is a brown calcareous sandy clay loam. These soils are usually noncalcareous to depths ranging from 10 to 22 inches.

Also in this association are soils of the Bippus and Guadalupe series. They occur in swales and on flood plains of intermittent drainages. Bippus soils are deep, dark-colored, and moderately fine-textured. The Guadalupe soils differ from the Bippus soils in that they have sandy loam surface layers and subsoils.

*Irrigation Potential.* A relatively high percentage of the soils in this association have properties suitable for their use as cropland under irrigation. Approximately 88 percent of the land in this association has been placed in irrigation land class 2. The major exception to this general evaluation involves the small acreage of saline- and alkali-affected soils included in the association. These soils, which have been placed in land class 4, have moderate to severe limitations and will require careful evaluation prior to being developed for irrigation.

### 4. Quay-Ima-Tucumcari association

This association occurs on fans and valley filling slopes below erosional escarpments in the east-central part of Harding County. A gently to moderately sloping topography with smooth, nearly level areas bordering the drainages prevails throughout this unit. (See figure 7.) The soils are developing dominantly in medium to moderately fine-textured alluvial sediments originating from "red bed" formations. They are very susceptible to water erosion, hence numerous areas in this association are dissected by arroyos or gullies. This association comprises an area of about 87,720 acres, or 6 percent of the county.

The dominant use of the soils in this association is for grazing of livestock. Erosion, particularly gully erosion, is a problem on these soils under misuse. The deep silty and fine-textured soils contiguous to intermittent drainages are particularly susceptible to gully erosion if the vegetative cover is depleted or destroyed. The vegetation on the soils of this unit is quite variable. The more common grasses on the loam, silt loam, and clay loam types include alkali sacaton, tobosa grass, blue grama, switchgrass, and vine mesquite. Blue grama, sideoats grama, sand dropseed, and some little bluestem are dominant on the sandy soils.

*Soil Characteristics.* Quay soils occur mainly on gently sloping fans extending from the base of escarpments and breaks to the lower lying valleys. These soils have reddish-brown calcareous loam or fine sandy loam surface layers, reddish-brown calcareous light clay loam subsoils, and pinkish-white loam substrata high in lime. The pinkish-white lime zone normally occurs at depths of 15 to 40 inches.

The Ima soils occur on gently sloping and undulating fans in close association with the soils of the Quay series. They have thin surface layers of reddish-brown fine sandy loam over reddish-brown calcareous fine sandy loam subsoils. The

substratum is similar, except that it ranges in texture from sandy loam to very fine sandy loam. A few fine streaks and small soft masses of lime are common in the lower part of the subsoil and substratum. Clayey shales may occur locally below a depth of 40 inches.

Also extensive in this association are Tucumcari soils, which are on nearly level to very gently sloping landscapes. They have a thin surface layer of reddish-brown noncalcareous loam, over a thick subsoil of reddish-brown calcareous heavy clay loam or clay. Below this is a light reddish-brown clay loam that contains a few small masses and streaks of lime.

Guadalupe, Lacita, Montoya, Latom and Vernon soils comprise the remainder of this association. The Latom and Vernon soils are shallow over sandstone and shale, respectively. Guadalupe, Lacita, and Montoya soils, which are deep, differ primarily in texture. Guadalupe soils are sandy, Lacita soils silty and medium-textured, and Montoya soils fine-textured.

*Irrigation Potential.* With the exception of Latom and Vernon soils, which are in irrigation land class 6, the soils in this association have been placed dominantly (69%) in irrigation land class 2, with lesser amounts in classes 3 and 4. In addition to the normal good farming and conservation practices, some of the land in this unit will require protection from overflow from higher lying lands.

### 5. Church-Karde association

This association includes four widely separated areas on the High Plains in the west-central part of the county. A characteristic feature is the enclosed depressions or playas which normally occur in the central part of the areas included in this association. In addition to the playas, this unit includes the nearly level terraces and benches that surround the playas, as well as the gently to strongly sloping and undulating sideslopes. The soils, which are dominatly deep, are developing in very calcareous alluvial and eolian sediments. This association includes an area of about 19,540 acres, or slightly over one percent of the county.

Most of it is used as native rangeland and, when properly managed, affords good grazing. Native vegetation on the Church soil is principally western wheatgrass, alkali sacaton, and inland saltgrass. Blue grama, galleta, buffalograss with minor amounts of sideoats grama, and needlegrass are the dominant grasses on the other soils.

*Soil Characteristics.* The Church soils occur on nearly level to very gently sloping low terraces or benches that surround depressional areas or playas. They have a thin surface layer of gray calcareous clay loam. This is underlain to a depth of five feet or more by a strongly calcareous, light gray, or light olive-gray clay. Brownish-yellow and yellowish-brown mottles indicating restricted drainage are common below a depth of two feet.

Karde soils are developing in calcareous eolian sediments on the leeward side of playas or enclosed depressions. They dominantly occur on that part of the association which has an undulating or duny topography. These soils have a thin surface layer of grayish-brown limy loam. It is underlain to a depth of five feet or more by light gray or light brownish-gray loam that has a high content of lime.

Other soils of importance in this association include those of the Campus, La Brier, and Manzano series. The Campus soils are shallow over a pinkish-white substratum high in lime. The La Brier soils occur on nearly level landscapes intermediate in elevation between the Church and Karde soils. They are deep and have fine-textured subsoils. The Manzano soils, which occur in swales and on flood plains are deep, dark-colored, and moderately fine-textured.

*Irrigation Potential.* The major soils of this association have moderate to severe limitations for use as cropland under irrigation. Although this association contains a relatively high percentage of land classified as irrigable, the majority of it is in classes 3 and 4. The Karde soils, for example, in addition to occurring on undulating or duny topography, contain much lime. Moderate to high yields can be expected only on these soils when lime-tolerant crops are produced. The fine-textured and slowly permeable Church soils are susceptible to seepage and drainage from higher lying lands. It will be extremely difficult under irrigation to provide adequate drainage.

### 6. Campus-Dean association

This association, similar to Dumas-Dioxice-La Brier association, is also extensive on the High Plains in the west-central and northeastern parts of Harding County. It includes those areas where calcareous soils developing over relatively thick beds of caliche are dominant. Although these soils normally occupy gently sloping to undulating landscapes they do occur on nearly level areas. (See figure 4.) Approximately 166,645 acres, or 12

percent of the county, is included in this association (figure 2).

Most of this association is in range use, and, with good management, moderate yields of forage are obtained during years of average or above precipitation. The native vegetation consists of a mixture of mid and short grasses with a scattered stand of shrubs. The more common grass species are blue grama, hairy grama, sideoats grama, sand dropseed, and little bluestem.

*Soil Characteristics.* Campus soils, the most extensive in the association, occur on nearly level to gently sloping uplands. They are strongly calcareous to the surface. In general, they have a moderately thick surface layer of grayish-brown loam. This layer grades through light brownish-gray and a light gray loam to pinkish-white loam high in lime at depths of 15 to 20 inches. Nodules and fragments of cemented caliche are common in the substratum.

Dean soils typically occupy the gently to moderately sloping crests and side slopes of upland ridges and knolls. They have a surface layer of grayish-brown loam or fine sandy loam over caliche at depths ranging from 5 to 15 inches. The underlying caliche, which is often weakly cemented in the upper part usually becomes less cemented and more permeable with increase in depth. Cemented fragments of caliche are common on the surface as well as throughout the surface layers.

Included in this association are small acreages of Dioxice, Dumas, Manzano, and Pastura soils. The Dioxice soils are moderately deep and medium-textured, the Dumas and Manzano soils are deep and medium to moderately fine-textured, and the Pastura soils are shallow over indurated caliche.

*Irrigation Potential.* Although class 3 and 4 land is relatively extensive, approximately one-fifth of the land in this association is in classes 1 and 2. There is, therefore, some opportunity for expansion of irrigated land in the areas occupied by this association. The suitability of the soils for irrigation is well reflected in the irrigation land classification, as about 6 percent of the land in this unit has been included in class 1; 13 percent in class 2; 21 percent in class 3; 34 percent in class 4 and the remaining 32 percent in class 6. The Dumas, Dioxice, and Manzano soils account for the majority of the land placed in irrigation land classes 1 and 2.

Campus soils, the most extensive in the association, are also classified as irrigable. These soils, which have moderate to severe limitations for use as cropland under irrigation, are in irrigation land classes 3 and 4. They are susceptible to wind erosion because of their fine granular and strongly calcareous surface soils. In addition, they have a relatively low water-holding capacity and limited depth of effective soils over the high lime zone. These soils, therefore, will require above-average soil management practices for satisfactory yields of adapted crops under irrigation.

Dean soils are not recommended for irrigation.

### 7. Mansker-Portales association

This association includes a number of widely separated areas in the eastern part of the county. A gently sloping to undulating type of topography prevails throughout the areas included in this unit. The soils, which have calcareous fine sandy loam surface layers, are developing in calcareous alluvial and eolian materials overlying caliche or alluvial sediments with a high lime content. Approximately 34,305 acres, or three percent of the land area in the county, is included in this association.

In common with the other soil associations occurring in the broad alluvial valley bottoms and plains of the Ute Creek drainage system, the soils of this unit are used principally as rangeland. These soils support a mixture of mid and short grasses and under good management moderate forage yields are obtained. The more common grasses are blue grama, sideoats grama, sand dropseed, little bluestem, hairy grama, and threeawns.

In addition to the range use, a very small acreage in this association is farmed under irrigation. Water for irrigation is obtained entirely from wells. Forage and grain sorghums are the principal crops produced.

*Soil Characteristics.* Mansker fine sandy loam comprises slightly more than 50 percent of soils in this association. These soils, which occur on gently to strongly sloping and undulating landscapes, generally are on steeper slopes than the associated Portales soils. The Mansker soils in this association usually have a thin surface layer of brown calcareous fine sandy loam. Their subsoil is a brown strongly calcareous loam. This grades into a pinkish-white loam with a high lime content at depths ranging from 15 to 24 inches.

The associated nearly level to gently sloping and undulating Portales soils have moderately thick surface layers of dark grayish-brown calcareous fine sandy loam. The subsoil is a grayish-brown calcareous loam or sandy clay loam. This grades

into a pinkish-white loam or caliche substratum at depths ranging from 20 to 35 inches.

In addition to the Mansker and Portales soils, approximately 15 percent of this association is comprised of a number of other soils and miscellaneous land types. Potter soils, which are shallow over weakly cemented caliche, are the most extensive of the minor soils. Small and widely separated areas of wet alluvial land are also of importance in this unit. This wet alluvial land occurs in depressional areas and along intermittent drainageways that drain in a westerly direction into Ute Creek. Although the soils are variable, wetness or high watertables are common features. They are usually dark colored, calcareous, and slightly to moderately saline.

*Irrigation Potential.* Portales soils, which have been placed in irrigation land class 2, are suitable for use as cropland under irrigation. These moderately deep soils have a moderate water-holding capacity and wind erosion hazard. Soil management practices to control damage from wind erosion will be essential due to the sandy texture of the surface layers. The Mansker soils, although suitable for use as cropland under irrigation, are not as well adapted to this use as the Portales soils. The limitations for this use are relatively severe due to their shallow depth over a high lime zone, moderately low water-holding, high lime content, and wind erosion hazard. The nearly level to gently sloping Mansker soils have been placed in land class 3 and those strongly sloping in class 4.

### 8. Otero-Dalhart association

This association comprises an area of about 36,285 acres on the High Plains in the north-central part of the county. The soils, which are generally deep and sandy, are developing in alluvial and eolian sediments. Although the topography ranges from nearly level to gently rolling, an undulating to gently rolling landscape is the most common. (See figure 3.)

This association is used mainly as native range. The ranges that are in good condition support a good cover of vegetation consisting dominantly of mid and tall grasses. The more common grasses are little bluestem, sand bluestem, sideoats grama, sand dropseed, and blue grama. In addition to range use a small acreage of Dalhart fine sandy loam is dry-farmed. Grain and forage sorghum, millet, and sudangrass are the main crops produced.

*Soil Characteristics.* Otero soils, the most extensive, usually occupy the undulating to gently rolling landscapes in this association. They normally have a moderately thick surface layer of grayish-brown loamy fine sand or fine sandy loam over a similar, but more calcareous subsoil. The substratum is a pale brown loamy sand. It typically contains a few small soft masses and threads of segregated lime.

The Dalhart soils, although not as extensive as the Otero soils, are nevertheless an important component of this association because of their more favorable characteristics. These soils, which occur on nearly level to gently undulating landscapes, have grayish-brown fine sandy loam surface layers over thick, brown sandy clay loam subsoils. The substratum is a very pale brown heavy loam that is moderately high in lime. They typically are noncalcareous to depths ranging from 15 to 30 inches.

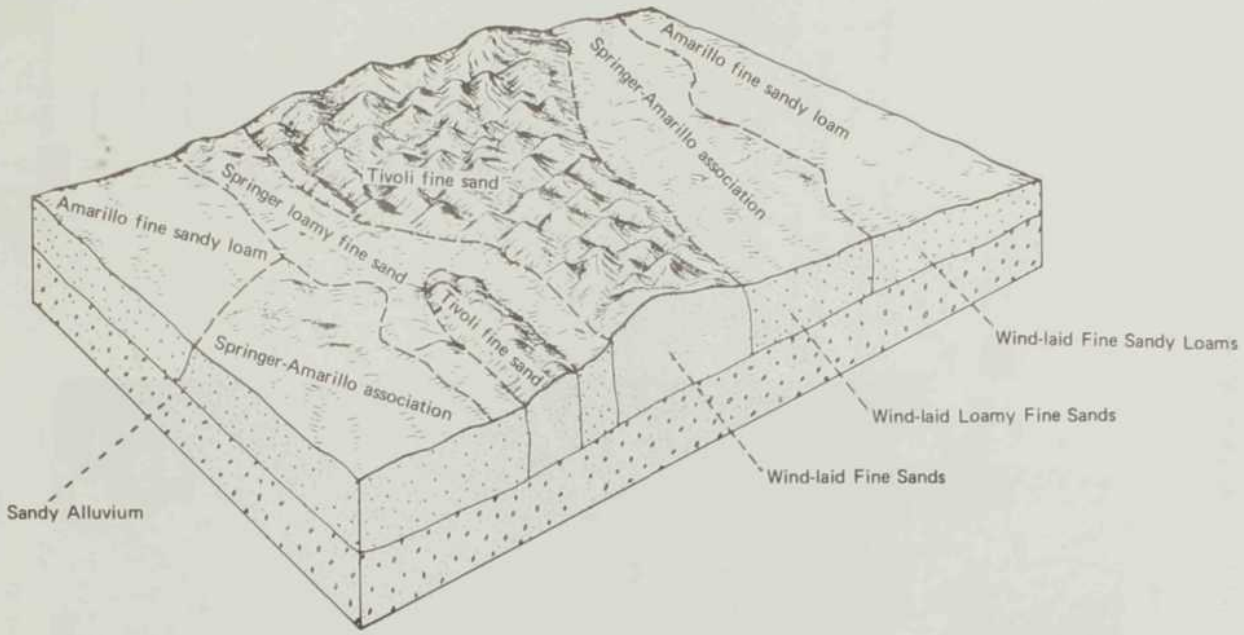
Also of importance in this association are soils of the Manzano, Tapia, and Campus series. The Manzano soils, which occur in swales and drainageways are deep and moderately fine-textured. The Tapia soils have brown, noncalcareous fine sandy loam surface layers over reddish-brown or brown sandy clay loam subsoils. They are underlain by strongly cemented caliche at depths ranging from 20 to 30 inches. The Campus soils are shallow over a pinkish-white substratum high in lime.

*Irrigation Potential.* The major soils of this association are suitable for use as cropland under irrigation. The Otero soils, which have been placed in irrigation land class 3, have moderate to severe limitations for use under irrigation, due to their low water-holding capacity, sandy texture, undulating topography, and wind erosion hazard. The dominant limitation of the Dalhart soils is a slight to moderate wind erosion hazard.

### 9. Amarillo association

This association includes a number of relatively small and widely separated areas in the eastern part of Harding County. In general, it occurs on the nearly level to very gently undulating landscapes near the outer fringes of the associated Springer-Tivoli-Amarillo association which is characterized by rolling and duny topography. The included soils are deep, well-drained, and have moderately coarse-textured surface soils. This unit supports a good cover of grass with bluegrama, hairy grama, little bluestem, and sand dropseed

Fig. 5. Springer-Tivoli-Amarillo association and Amarillo association are extensive in eastern Harding County.




being the more common species. Although the dominant use is range, a limited acreage on this association is cultivated under irrigated and dry farming. Grain and forage sorghums, broomcorn, and sudangrass are the main crops produced. In addition to range and cropland uses, this soil area provides good wildlife habitat, particularly for game birds. Approximately 57,020 acres or four percent of the county is included in this association.

*Soil Characteristics.* Amarillo soils, which are dominant, comprise 85 to 95 percent of this association. They have a surface layer of brown fine sandy loam that is leached free of lime. Their subsoil is a thick reddish-brown to yellowish-red sandy clay loam that is typically free of lime in the upper part. This is underlain by a light reddish-brown sandy clay loam with a high lime content. The lime or calcium carbonate below an average depth of 40 inches is typically visible in the form of threads and small soft masses.

Small areas of Springer, Mansker, and Portales soils are also included in this association. The Springer soils are deep and sandy, the Portales soils are moderately deep and medium-textured, and the Mansker soils are shallow and medium-textured. The Portales and Mansker soils are underlain by soft or weakly cemented lime zones.

*Irrigation Potential.* The soils of this unit are well suited to cropland use under irrigation. This suitability for irrigation is well reflected in the irrigation land classification as 75 percent of the land in this association has been placed in class 1; 10 percent in class 2; 10 percent in class 3; and 5 percent in class 4. The major limitation is the moderate susceptibility to wind erosion. Soil management practices to prevent damage from wind erosion will be essential.

### 10. Springer-Tivoli-Amarillo association

This general soil area, often referred to locally as the "Sandhills," has a total acreage of 278,640 acres. It occurs in the eastern part of the county. A characteristic feature of this soil association is the undulating to gently rolling or duny landscape. A few of the dunes are bare of vegetation and actively erode during windy periods. The soils, which are dominantly deep and sandy, are developing in sandy eolian materials. Small areas of soils shallow over caliche or very limy sediments occur locally in the interdune areas. The native ranges in this general soil area that are in good condition support a mixture of tall and mid grasses including such species as little bluestem, big bluestem, sideoats grama, Indian grass, switch grass, giant sandreed, and black grama. Sandsage, yucca, wild plum, and mesquite are the common shrubs. This association, the largest in the survey area, comprises about 20 percent of the county.

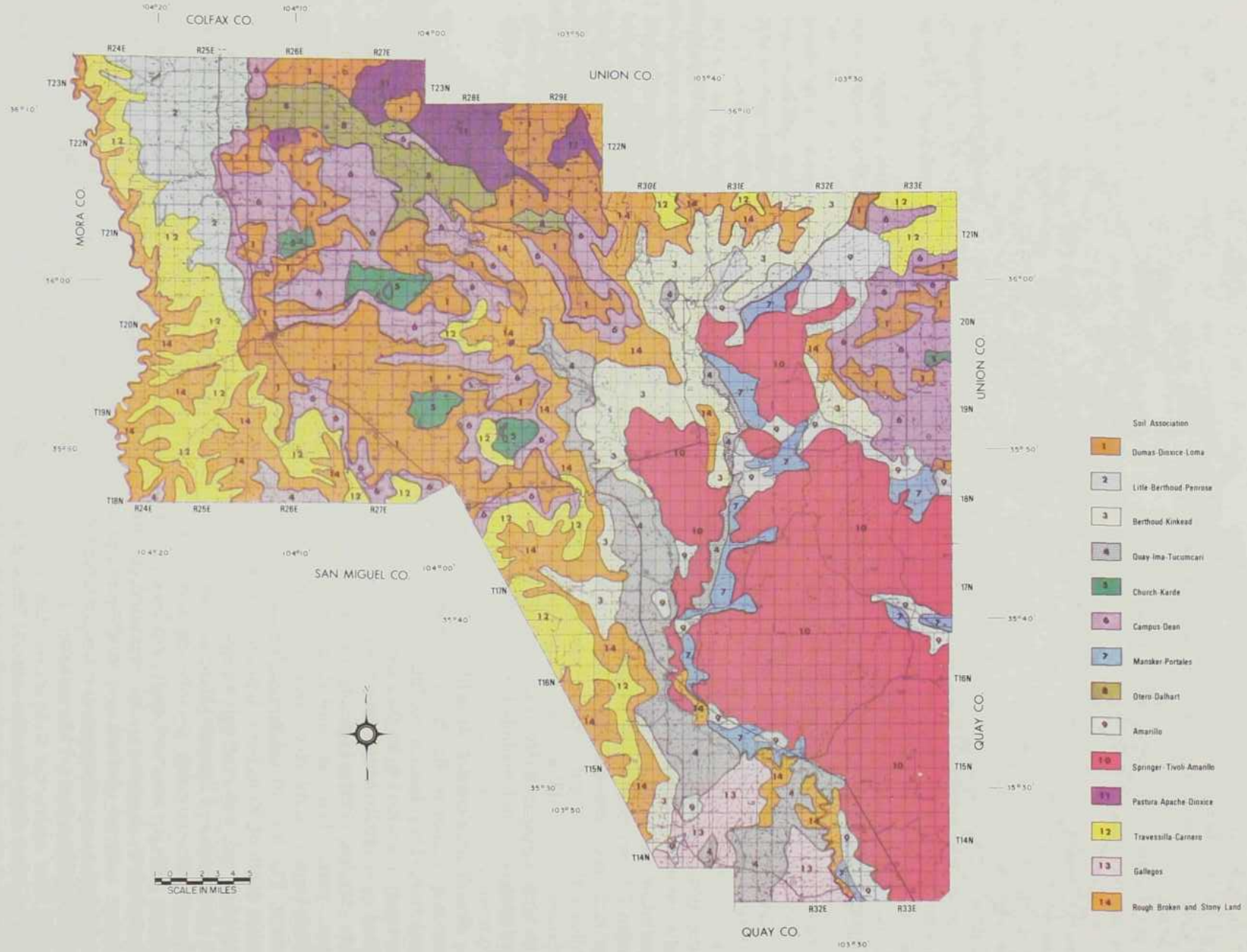



Figure 1. General soil map of Harding County, New Mexico

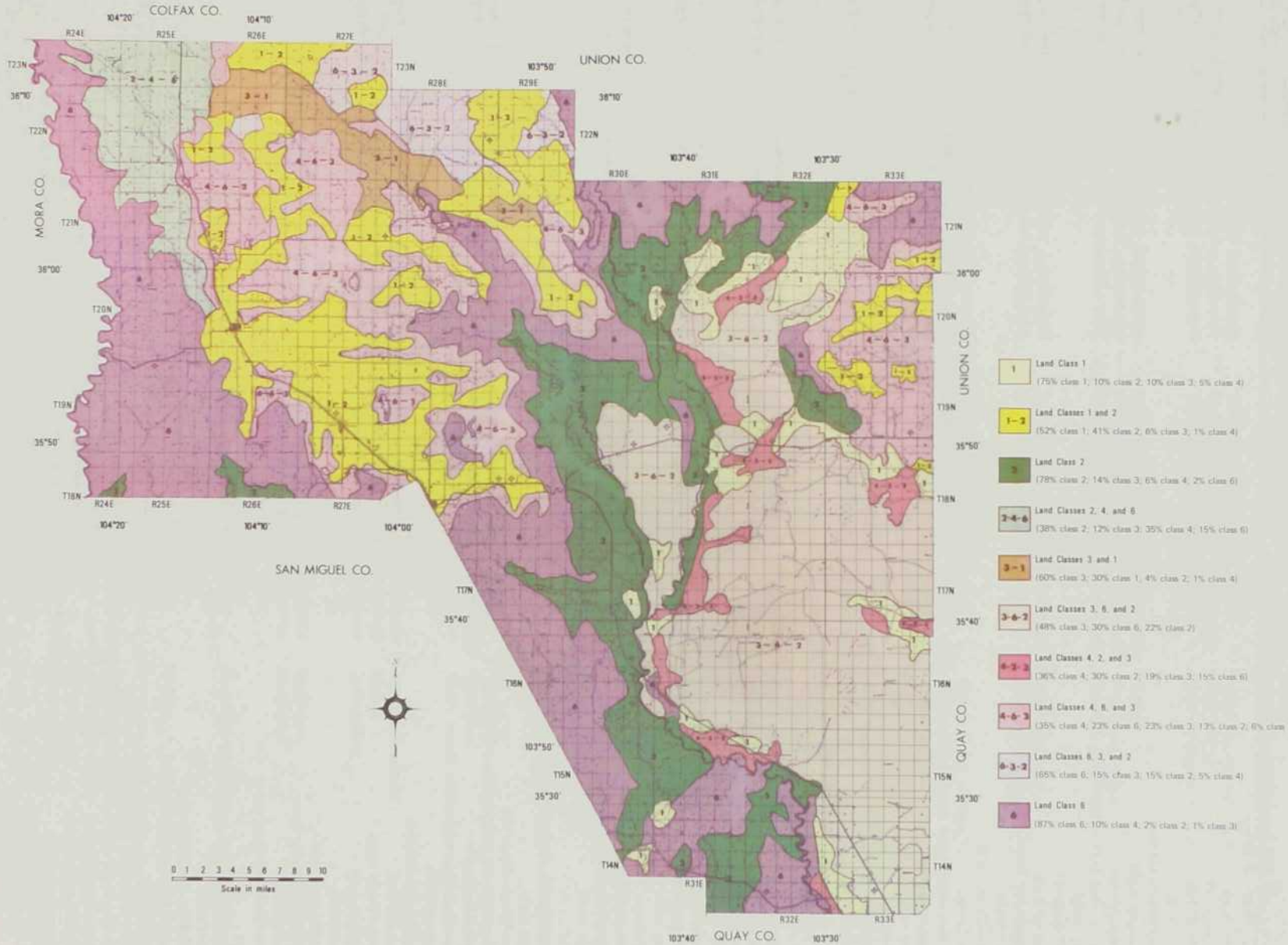



Figure 2. Classification of land for irrigation in Harding County, New Mexico

Table 4. Soil characteristics and qualities of major soils in each soil association, Harding County, New Mexico

| Soil Map Symbol and Soil Association | Slope (percent) | Percent of Association | Pedologic Classification | | Texture |
|---|---|---|---|---|---|
| | | | Subgroup | Family | |
| 1 Dumas-Dioxice-La Brier | | | | | |
| Dumas loam | 0-3 | 35 | Aridic Argiustoll | Fine-loamy, mixed, mesic | Loam |
| Dioxice loam | 0-3 | 25 | Aridic Calciustoll | Fine-loamy, mixed, mesic | Loam |
| La Brier loam | 0-1 | 25 | Torrertic Argiustoll | Fine, mixed, mesic | Loam;cl |
| Other soils | | 15 | | | |
| 2 Litle-Berthoud-Penrose | | | | | |
| Litle clay loam | 0-5 | 35 | Ustollic Camborthid | Fine, mixed, mesic | cl |
| Berthoud loam | 0-9 | 30 | Typic Ustochrept | Fine-loamy, mixed, mesic | Loam;fsl |
| Penrose channery clay loam | 0-12 | 15 | Lithic Ustic Torriorthent | Fine-carbonatic, mesic | ch.cl |
| Other soils | | 20 | | | |
| 3 Berthoud-Kinkead | | | | | |
| Berthoud loam | 0-9 | 60 | Typic Ustochrept | Fine-loamy, mixed, mesic | Loam;fsl |
| Kinkead clay loam | 0-3 | 30 | Aridic Argiustoll | Fine, mixed, thermic | cl |
| Other soils | | 10 | | | |
| 4 Quay-Ima-Tucumcari | | | | | |
| Quay loam | 1-3 | 25 | Ustochreptic Calciorthid | Fine-silty, mixed, thermic | Loam;fsl |
| Ima fine sandy loam | 1-5 | 20 | Ustochreptic Camborthid | Coarse-loamy, mixed, thermic | fsl |
| Tucumcari loam | 0-1 | 20 | Ustollic Haplargid | Fine, mixed thermic | Loam |
| Other soils | | 35 | | | |
| 5 Church-Karde | | | | | |
| Church clay loam | 0-1 | 35 | Aquic Camborthid | Fine, mixed, mesic | cl |
| Karde loam | 1-9 | 35 | Ustic Torriorthent | Fine, carbonatic, mesic | Loam |
| Other soils and miscellaneous land types | | 30 | | | |
| 6 Campus-Dean | | | | | |
| Campus loam | 0-9 | 55 | Aridic Calciustoll | Fine-loamy, mixed, mesic | Loam;fsl |
| Dean gravelly loam | 0-9 | 25 | Ustollic Calciorthid | Fine-carbonatic, mesic | gr.l;fsl |
| Other soils | | 20 | | | |
| 7 Mansker-Portales | | | | | |
| Mansker fine sandy loam | 0-9 | 50 | Aridic Calciustoll | Fine-carbonatic, thermic | fsl |
| Portales fine sandy loam | 0-5 | 35 | Aridic Calciustoll | Fine-carbonatic, thermic | fsl |
| Other soils | | 15 | | | |
| 8 Otero-Dalhart | | | | | |
| Otero loamy fine sand | 1-9 | 60 | Ustic Torriorthent | Coarse-loamy, mixed, calcareous, mesic | fsl;lfs |
| Dalhart fine sandy loam | 0-5 | 30 | Aridic Haplustalf | Fine-loamy, mixed, mesic | fsl |
| Other soils | | 10 | | | |
| 9 Amarillo | | | | | |
| Amarillo fine sandy loam | 0-3 | 75 | Aridic Haplustalf | Fine-loamy, mixed, thermic | fsl |
| Other soils | | 25 | | | |
| 10 Springer-Tivoli-Amarillo | | | | | |
| Springer loamy fine sand | 1-9 | 40 | Udic Paleustalf | Coarse-loamy, mixed, thermic | lfs |
| Tivoli fine sand | 1-9 | 25 | Typic Ustipsamment | Siliceous, thermic | fs |
| Amarillo loamy fine sand | 0-3 | 25 | Aridic Haplustalf | Fine-loamy, mixed, thermic | fsl;lfs |
| Other soils | | 10 | | | |
| 11 Pastura-Apache-Dioxice | | | | | |
| Pastura loam | 1-5 | 40 | Ustollic Paleorthid | Loamy, mixed, mesic, shallow | Loam |
| Apache stony loam | 1-9 | 25 | Aridic Lithic Haplustoll | Loamy, mixed, mesic | st.l |
| Dioxice loam | 0-3 | 15 | Aridic Calciustoll | Fine-loamy, mixed, mesic | Loam |
| Other soils | | 20 | | | |
| 12 Travessilla-Carnero | | | | | |
| Travessilla stony loam | 0-9 | 65 | Lithic Ustic Torriorthent | Loamy, mixed, calcareous, mesic | st.l;fsl |
| Carnero loam | 0-5 | 25 | Aridic Agriustolls | Fine-loamy, mixed, mesic | Loam |
| Other soils and land types | | 10 | | | |
| 13 Gallegos | | | | | |
| Gallegos gravelly sandy loam | 3-35 | 90 | Ustollic Camborthid | Loamy-skeletal, mixed, thermic | gr.sl |
| Other soils | | 10 | | | |
| 14 Rough broken and stony land | | | | | |
| Rough broken and stony land | 25-75 | 90 | Miscellaneous land type | | |
| Other soils | | 10 | | | |

[1]Abbreviations used for textural classes:

fs-fine sand; lfs-loamy fine sand; fsl-fine sandy loam; sl-sandy loam; gr.scl-gravelly sandy clay loam; gr.l-gravelly loam; st.l-stony loam; scl-sandy clay loam; cl-clay loam; ch.cl-channery clay loam; sicl-silty clay loam; sic-silty clay

[2]Calc. -- calcareous

[3]Permeability classes and approximate rates per hour

Very slow - less than 0.20 inches
Slow - 0.20 to 0.63 inches
Moderate - 0.63 to 2.00 inches
Rapid - 2.00 to 6.30 inches
Very rapid - More than 6.30 inches

| Surface Soil Features | | Subsoil Features | | | | Soil Depth[4] | AWHC[5] |
|---|---|---|---|---|---|---|---|
| Color | Carbonates[2] | Texture[1] | Color | Permeability[3] | Substratum | (inches) | (inches) |
| Brown | Non-calc. | Loam;cl | Brown to yellowish-red | Slow | Calc. loamy sediments | 40 to 60 | 6 to 8 |
| Dark grayish-brown | Weakly calc. | cl; loam | Grayish-brown | Moderate | Soft caliche | 24 to 40 | 4 to 6 |
| Very dark grayish-brown | Non-calc. | Clay | Dark grayish-brown | Slow | Calc. loamy sediments | 60 | 8 |
| Grayish-brown | Calc. | Clay;sic | Grayish-brown | Very slow | [illegible] | 20 to 40 | 3 to 6 |
| Grayish-brown | Weakly calc. | Loam;cl | Light brownish-gray | Moderate | [illegible]ndy clay loam | 60 or more | 7 |
| Light brownish-gray | Calc. | cl | Light brownish-gray | Moderate | Limestone and shale | 6 to 20 | 1 to 3 |
| Grayish-brown | Weakly calc. | Loam;cl | Light brownish-gray | Moderate | Sandy clay loam | 60 or more | 7 |
| Dark grayish-brown | Non-calc. | Clay | Grayish-brown | Slow | Sandy clay loam | 60 or more | 7 |
| Brown | Calc. | Loam;cl | Reddish-brown | Slow | Calc. loamy sediments | 60 | 7 |
| Reddish-brown | Calc. | sl;fsl | Reddish-brown | Rapid | Sandy loam and clay shale | 40 to 60 | 4 to 5 |
| Reddish-brown | Weakly calc. | cl;sicl;clay | Reddish-brown | Slow | Clay loam | 60 or more | 8 |
| Gray | Strongly calc. | Clay | Light gray | Very slow | Clay loam and clay | 60 or more | 7 |
| Light brownish-gray | Strongly calc. | Loam | Light gray | Moderate | Calc. loamy sediments | 60 or more | 6 |
| Grayish-brown | Strongly calc. | Loam | Light brownish-gray | Moderate | Soft caliche | 14 to 20 | 2 to 3 |
| Grayish-brown | Strongly calc. | gr.l | Pale brown | Moderate | Soft and cemented caliche | 5 to 14 | 1 to 2 |
| Brown | Strongly calc. | Loam | Brown | Moderate | Soft caliche | 15 to 20 | 2 to 3 |
| Dark grayish-brown | Calc. | Loam | Grayish-brown | Moderate | Soft caliche | 24 to 40 | 4 to 5 |
| Grayish-brown | Calc. | fsl;lfs | Pale brown | Rapid | Sandy loam and loamy sand | 60 or more | 4 |
| Dark grayish-brown | Non-calc. | scl | Brown | Moderate | Calc. loamy sediments | 60 or more | 5 to 7 |
| Brown | Non-calc. | scl | Reddish-brown | Moderate | Calc. loamy sediments | 40 to 60 | 5 to 7 |
| Reddish-brown | Non-calc. | fsl | Yellowish-red | Rapid | Loamy fine sand | 60 or more | 4 |
| Pale brown | Non-calc. | fs | Light yellowish-brown | Very rapid | Fine sand | 60 or more | 3 |
| Brown | Non-calc. | scl | Reddish-brown | Moderate | Calc. loamy sediments | 40 to 60 | 6 to 7 |
| Grayish-brown | Calc. | gr.l | Grayish-brown | Moderate | Indurated caliche | 6 to 19 | 1 to 3 |
| Dark grayish-brown | Calc. | st.l | Grayish-brown | Moderate | Basalt | 8 to 19 | 1 to 3 |
| Dark grayish-brown | Weakly calc. | cl;loam | Grayish-brown | Moderate | Soft caliche | 21 to 40 | 4 to 6 |
| Brown | Weakly calc. | st.l | Pale brown | Moderate | Sandstone | 4 to 15 | 1 to 2 |
| Brown | Non-calc. | cl | Brown | Moderate | Sandstone | 20 to 40 | 3 to 6 |
| Brown | Non-calc. | gr. scl | Reddish-brown | Rapid | Very gravelly sands | 13 to 26 | 1 to 2 |

[4]Depth in inches from surface of effective soil

[5]AWHC - Available water-holding capacity (estimated to a depth of 4 feet or for the effective soil depth if less than 4 feet)

*Soil Characteristics.* Springer soils, the most extensive in the association, occur dominantly on gently undulating landscapes. They have brown to reddish-brown loamy fine sand surface layers, yellowish-red fine sandy loam subsoils, and brown loamy fine sand substrata.

Tivoli soils, another major component of this association, occupies the gently rolling to duny terrain. These duned areas are usually elongated in an east-west direction. Tivoli soils are characterized by their very rapidly permeable, loose, and extremely sandy profiles. They typically consist of a pale brown or light yellowish-brown noncalcareous fine sand to a depth of six feet or more.

Amarillo soils, although locally slightly hummocky or undulating, usually occur on nearly level to gently sloping landscapes. They have a surface layer of brown fine sandy loam or loamy fine sand that is leached free of lime. Their subsoil is a reddish-brown sandy clay loam that is usually free of lime in the upper part. This is underlain by a light reddish-brown sandy clay loam with a high lime content.

Also in this association are Mansker and Potter soils, which are shallow, and Portales soils which are moderately deep. These soils are underlain by soft or weakly cemented caliche.

*Irrigation Potential.* Amarillo and Springer soils are in irrigation land classes 1 and 3, respectively. The Amarillo soils are well suited to cropland use under irrigation. Their major limitation is a moderate susceptibility to wind erosion. The sandy Springer soils have a high water intake rate, rapid permeability, and low to moderate water-holding capacity. Wind erosion is a moderate to severe hazard under cultivation, so management practices to minimize damage by wind erosion will be needed. The Tivoli soils are not suitable for use as irrigated cropland, because of their low water-holding capacity, sandy texture, and very high susceptibility to damage by wind erosion.

Although there are limitations, there is some potential for development of irrigated land in this association. Irrigable and non-irrigable land is interspersed in many parts of the association. This will often limit the size of the areas with suitable soils that can be developed for irrigation.

### 11. Pastura-Apache-Dioxice association

This association includes soils developing on lava flows in the north-central part of the county. In addition to mixed alluvial and eolian sediments, materials of volcanic or basic igneous origin have therefore contributed to the parent materials in which these soils are forming. Although nearly level to gently sloping and undulating landscapes are dominant, strongly sloping to rolling areas occur, particularly near the volcanic cones. The soils shallow over basalt bedrock are usually stony. They support a relatively dense cover of grasses including sideoats grama, little bluestem, big bluestem, western wheatgrass, New Mexico feathergrass, and blue grama. The non-stony soils of the Dioxice series support a vegetation cover dominated by short grasses. The principal grasses are blue grama, galleta, buffalograss, and western wheatgrass. Approximately 33,620 acres, or 3 percent of the land area in the county, is included in this association.

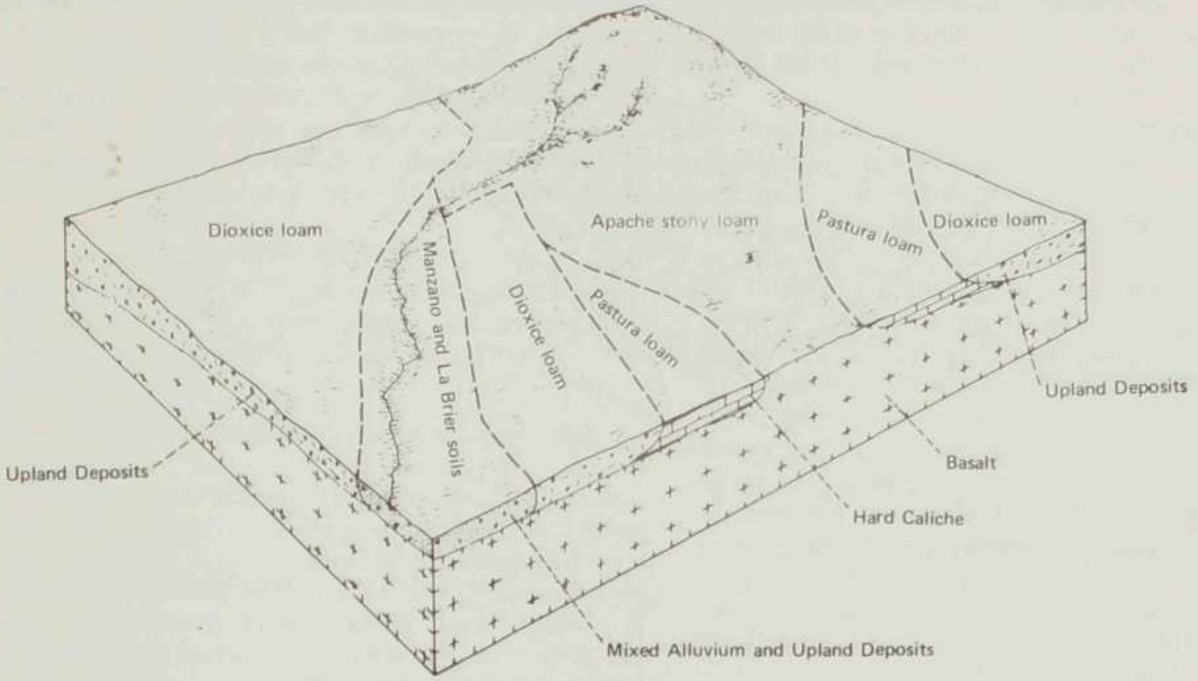
*Soil Characteristics.* Pastura soils, the most extensive, occur on both the nearly level crests and gently sloping sides of upland plains and ridges. These soils have thin grayish-brown calcareous loam surface layers and pale brown calcareous loam subsoils. They are underlain by indurated caliche at depths ranging from 6 to 20 inches. This in turn is often underlain by basalt bedrock at undetermined depths. Angular fragments of caliche range from few in the surface layer to many in the subsoil just above the indurated caliche.

Apache soils, which are also extensive in this association, occur on gently sloping to rolling landscapes around volcanic cones. They are typically stony and shallow over basalt bedrock. The grayish-brown granular loam or clay loam surface layers contain variable amounts of angular and semi-rounded fragments of basalt. These basalt fragments commonly increase with depth, and unweathered basalt bedrock is usually encountered within a depth of 18 to 20 inches. The lower part of the subsoil just above the bedrock typically contains a moderate to high amount of segregated lime.

Dioxice soils, the least extensive of the major soils of the association, occur on nearly level to very gently sloping uplands. They have a moderately thick surface layer of dark grayish-brown loam. It is commonly noncalcareous to a depth of three to five inches, but in places may be calcarous to the surface. The subsoil is a grayish-brown to brown calcarous clay loam. This is underlain by a pinkish-white loam substratum in lime at depths ranging from 24 to 40 inches.

Also in this association are soils of the Manzano and La Brier series. These soils occupy the nearly level or very gently sloping valley bottoms. These soils are deep and dark-colored,

Fig. 6. Typical pattern of soils around an old volcanic cone in north central Harding County. These soils occur in the Pastura-Apache-Dioxice association.




but differ in that the Manzano soils are moderately fine-textured while those of the La Brier are fine-textured.

*Irrigation Potential.* The potential for development of irrigated land in this association is limited. The two most extensive soils, Apache and Pastura, are not suitable for use as cropland under irrigation. The remainder of the soils in this association are, in general, suitable for such use. They, however, commonly occur as small areas interspersed with large tracts of non-irrigable land. This will undoubtedly tend to restrict their development for irrigation.

### 12. Travessilla-Carnero association

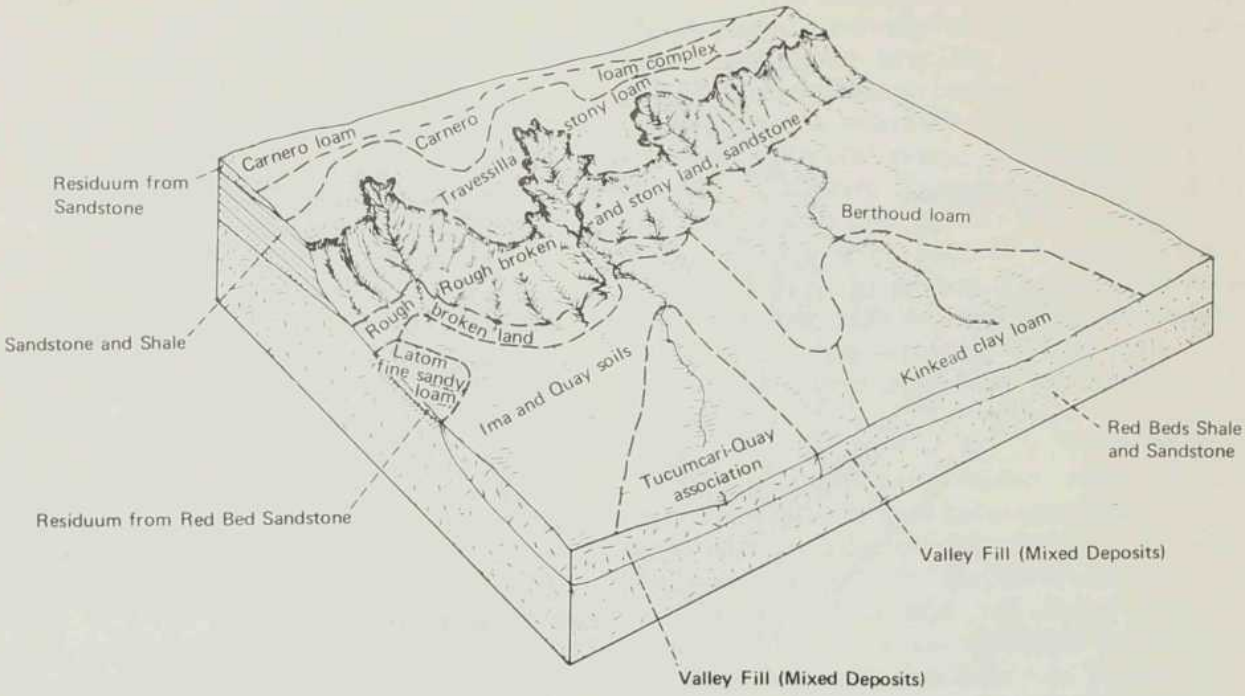
This association occurs dominantly on the gently sloping to rolling uplands underlain by sandstone bedrock along the western margin of the county. A few relatively small areas are also located in the northeastern part of the county where they join more extensive areas of this association in Union County. The soils in this unit, for the most part, are developing residually in materials weathered from sandstone. Locally, and particularly where the soils are of moderate depth or deeper, there have been additions of eolian materials.

Soils of this association are in native range, and under good management fair to good forage yields are obtained. They support a relatively complex mixture of mid and short grasses, including such species as blue grama, sideoats grama, sand dropseed, galleta, and little bluestem. Thin stands of juniper trees are also common on the Travessilla soils and near the outer fringes of this unit where it adjoins the Rough Broken and Stony Land association. This association comprises an area of approximately 121,695 acres or 9 percent of the county.

*Soil Characteristics.* Travessilla soils, the most extensive, are shallow, gently to strongly sloping soils developing on sandstone mesas and breaks. They have a surface layer of brown stony loam or stony fine sandy loam. This is underlain by sandstone bedrock at depths ranging from 4 to 15 inches. In addition to the small angular sandstone fragments which are common on the surface and throughout the soil, sandstone bedrock outcrops occasionally.

Carnero soils, the other principal member of this association, occupies gently sloping and undulating uplands. They generally have a thin surface layer of brown noncalcareous loam over a subsoil of brown clay loam that is free of lime in the upper part. This grades through a light-brown sandy clay loam or loam in which threads and

Fig. 7. Typical pattern of soils west of Ute Creek and Tequesquite Creek in the central portion of the county. These soils occur mainly in the Travessilla-Carnero association, Berthoud-Kinkead association, Quay-Ima-Tucumcari association, and Rough Broken and Stony Land association.




small masses of lime are common to sandstone bedrock at depths ranging from 20 to 40 inches.

Minor soils include those of the Berthoud, Manzano, and La Brier series. The Berthoud soils are deep and medium-textured, the Manzano soils deep and moderately fine-textured, and the La Brier deep and fine-textured. These soils account for only a small acreage in this association. Also included are small acreages of rough broken and stony land.

*Irrigation Potential.* The potential for development of irrigated land in this association is very limited. Travessilla, the most extensive soil in this association, is unsuitable for use as cropland under irrigation. Carnero soils, although classified as irrigable, have moderate to severe limitations due primarily to their moderate depth over sandstone bedrock. Due to these characteristics, Carnero soils have been placed in irrigation land class 4.

### 13. Gallegos association

This general soils area includes an area locally known as the "Palomas Hills" in the extreme southern part of the county. Although this association is characterized by moderately steep and hilly topography, small areas of valley bottoms, alluvial fans and other tracts of land with nearly level to gentle relief are included. It comprises an area of about 26,860 acres, or 2 percent of the county.

This unit, in places, supports a thin stand of pinyon and juniper. Short and mid grasses, however, are the more common ground cover. The principal grasses include blue grama, black grama, sideoats grama, galleta, tobosa, little bluestem, and threeawns.

Although the percentage of sand and gravel and the thickness of the deposits are quite variable, this association does offer a potential source for sand and gravel.

*Soil Characteristics.* Gallegos soils, the most extensive, are developing in gravelly alluvium on old dissected stream terraces. They typically have thin, brown very gravelly sandy loam surface layers and reddish-brown very gravelly sandy clay loam subsoils. A distinct zone of lime accumulation occurs at a depth of 12 to 25 inches.

Rough, broken land and soils of the Ima and Quay series also comprise a small percentage of this association. The rough, broken land which occupies the steep slopes and breaks, is dominated

by outcrops of "red bed" shales and sandstone. The Ima and Quay occur on gently to strongly sloping fans and valley filling slopes. These soils, which are deep, differ primarily in texture, permeability, and lime content. The Ima soils are moderately coarse-textured and rapidly permeable, while the Quay soils are medium-textured and slowly permeable. In addition, the Quay soils have distinct lime zones at a depth of 15 to 36 inches.

*Irrigation Potential.* There is very little, if any, potential for the development of irrigated land in this association. The steep slopes and shallow soils will tend to preclude its use for irrigation.

### 14. Rough Broken and Stony Land association

This association includes the steep and precipitous canyon walls and breaks adjacent to the Canadian River, as well as the steep and very steep escarpments between the High Plains uplands and the lower lying valleys and plains. A characteristic feature of this unit, therefore, is the rough broken topography and relatively narrow valley floors and upland summits separated by steep canyon walls and escarpments. (See figure 7.) It includes an area of about 177,030 acres, or 13 percent of the county.

The soils land types of this association are used principally for grazing by livestock and wildlife. Although the density of vegetation is restricted due to rock outcrops, thin soils, and steep slopes, this unit supports a wide variety of grasses and shrubs. Blue grama, galleta, sideoats grama, switchgrass, sand dropseed, and threeawns are the principal grasses. The more common shrubs and woody species include pinyon, juniper, bigsage, bitterbrush, serviceberry, snakeweed, rabbit brush and cactus. This association provides a good habitat for many species of wildlife.

*Soil Characteristics.* Rough broken and stony land is dominant in this association. It is a complex of shallow soils, outcrops of sandstone, and other types of sedimentary rocks. A few localized areas of basalt outcrops are also included. The outcrops of bedrock commonly occur as vertical or nearly vertical exposures or ledges. A thin mantle of rocky or stony soil material generally occurs between the ledges or outcrops of bedrock. Although shallow soils and rock outcrops are dominant, small isolated pockets of moderately deep to deep stony soils do occur on the escarpments where benches or areas with a lesser slope gradient have formed.

Exposures of "red bed" shales and clays with some interbedded sandstone occur in the southeastern part of the county along the creek. The ridges above the steep and very steep escarpments are often covered with water-worn gravel. These areas, which are erodable, are commonly dissected by gullies.

Deep alluvial soils contiguous to the narrow drainageways and shallow soils of the Vernon and Latom series also comprise a small acreage in this association.

*Irrigation Potential.* Due to the dominance of shallow soils, rock outcrops, and steep rough broken landscapes, there is little, if any, opportunity to develop irrigated land in this association.

## Interpretation of Soils for Irrigation

The acreage of irrigable land in each of the 14 soil associations in Harding County is shown in table 5. The extent of the land in each of the five land classes was determined on the basis of the kinds of soils occurring in the soil associations. The acreage (table 6) of each soil and land type from the detailed soil survey also serve as a guide in arriving at these estimates.

In addition to the data given in table 5, the approximate distribution of the various land classes in Harding County is shown on the irrigation land class map (figure 2). In the construction of this map, the data on acreages in each of the land classes as listed in table 5 was used as a guide. The land class or classes shown indicate that they comprise more than 75 percent of the delineated area. No land class was shown that did not comprise at least 15 percent or more of the area as identified on the map. Where more than one land class is shown, the dominant or the most extensive class is indicated first, followed in order by those of lesser extent. The small scale of the irrigation land class map precludes the possibility of showing small areas of land with different capabilities for irrigation. For example, the large and extensive areas of class 6 land map may, and often do, contain small tracts of land suitable for irrigation. Therefore, because of the limitation of map scale, these small tracts that differ in capability for irrigation are not shown.

Table 5. Estimated acreage and percentage of land in each irrigation land class by soil association, Harding County, New Mexico

| Soil Map Symbol and Soil Association | Class 1 | | Class 2 | | Class 3 | | Class 4 | | Total of Classes 1 to 4 | | Class 6 | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | Acres |
| 1 Dumas-Dioxice-La Brier | 96,000 | 52 | 75,273 | 41 | 10,162 | 6 | 1,850 | 1 | 183,285 | 100 | | | 183,285 |
| 2 Litle-Berthoud-Penrose | | | 20,233 | 38 | 6,320 | 12 | 18,586 | 35 | 45,139 | 85 | 7,966 | 15 | 53,105 |
| 3 Berthoud-Kinkead | | | 80,977 | 88 | 7,493 | 8 | 4,080 | 4 | 92,550 | 100 | | | 92,550 |
| 4 Quay-Ima-Tucumcari | | | 60,518 | 69 | 17,544 | 20 | 6,500 | 7 | 84,562 | 96 | 3,158 | 4 | 87,720 |
| 5 Church-Karde | | | 1,954 | 10 | 6,839 | 35 | 8,793 | 45 | 17,586 | 90 | 1,954 | 10 | 19,540 |
| 6 Campus-Dean | 10,734 | 6 | 22,006 | 13 | 35,085 | 21 | 57,159 | 34 | 124,984 | 68 | 41,661 | 32 | 166,645 |
| 7 Mansker-Portales | | | 10,291 | 30 | 6,468 | 19 | 12,400 | 36 | 29,159 | 85 | 5,146 | 15 | 34,305 |
| 8 Otero-Dalhart | 10,886 | 30 | 3,265 | 9 | 21,771 | 60 | 363 | 1 | 36,285 | 100 | | | 36,285 |
| 9 Amarillo | 42,765 | 75 | 5,700 | 10 | 5,700 | 10 | 2,855 | 5 | 57,020 | 100 | | | 57,020 |
| 10 Springer-Tivoli-Amarillo | | | 61,301 | 22 | 133,921 | 48 | | | 195,222 | 70 | 83,481 | 30 | 278,640 |
| 11 Pastura-Apache-Dioxice | | | 5,043 | 15 | 5,044 | 15 | 1,680 | 5 | 11,767 | 35 | 21,853 | 65 | 33,620 |
| 12 Travessilla-Carnero | | | 3,699 | 3 | 2,386 | 2 | 30,423 | 25 | 36,508 | 30 | 85,187 | 70 | 121,695 |
| 13 Gallegos | | | 1,343 | 5 | | | 1,343 | 5 | 2,686 | 10 | 24,174 | 90 | 26,860 |
| 14 Rough Broken and Stony Land | | | 1,770 | 1 | | | | | 1,770 | 1 | 175,260 | 99 | 177,030 |
| Grand Total | 160,385 | 12 | 353,373 | 26 | 258,733 | 19 | 146,032 | 10 | 918,523 | 67 | 449,777 | 33 | 1,368,300 |

## Irrigation Land Classes

Approximately 67 percent (918,500 acres) of the land in Harding County has been classified as suitable for irrigation. Although widely distributed throughout the county, slightly less than 600,000 acres out of the total of 918,500 acres of irrigable land occurs in the following four soil associations:

1. Dumas-Dioxice-La Brier association
3. Berthoud-Kinkead association
6. Campus-Dean association
10. Springer-Tivoli-Amarillo association

Dumas-Dioxice-La Brier association (Number 1) undoubtedly offers the best possibilities for expansion of irrigated land in Harding County. The irrigable soils of this unit, which are dominantly in classes 1 and 2, occur in relatively large tracts with little or no interspersed non-irrigable land. Because they occur on nearly level to very gently sloping landscapes, they will require only a minimum amount of land leveling and conditioning in preparation for irrigation.

Campus-Dean association (Number 6) also occurs on nearly level to gently sloping landscapes in association with the Dumas-Dioxice-La Brier unit. In contrast to the Dumas-Dioxice-La Brier association, where classes 1 and 2 were dominant, class 3 and 4 land constitutes more than 50 percent of the land in this association. The Campus soils are the principal soils in land classes 3 and 4. These soils, particularly when they are in class 3 and occur in association with better soils, can be profitably used for the production of lime-tolerant crops under irrigation.

About 70 percent (195,200 acres) of the land in the Springer-Tivoli-Amarillo association is suitable for irrigation. The soils of this unit, which are included in land classes 2 and 3, present moderate to severe limitations for use under irrigation. The surface of these areas is uneven, hummocky, or so sloping that they will require considerable leveling and land preparation before they can be profitably utilized for irrigation. In addition to the hummocky topography, low to moderate moisture retention capacity, and moderate to severe wind erosion hazard, non-irrigable land often occurs interspersed with the irrigable land. This will tend to limit the size of some tracts that can be developed for irrigation.

It is estimated that slightly over 92,000 acres of land in the Berthoud-Kinkead association (Number 3) is suitable for irrigation. This association occurs as a number of separate delineations throughout the east-central part of the county. Although some of the delineations are relatively small, there is little or no interspersed non-irrigable land within this mapping unit. The shape, location, and size of these units, therefore should have only a minor effect in the determination as to whether it is feasible to develop these lands for irrigation.

Soil associations 4, 7, and 9, which often adjoin the Berthoud-Kinkead association, also contain high percentages of land suitable for irrigation. This will tend to add to the size of the tracts that can be developed for irrigation in the areas occupied by the four soil associations previously discussed.

Otero-Dalhart association in the north-central part of the county was estimated to contain about 36,000 acres of irrigable land. The Otero soils

Table 6. Irrigation land class, approximate acreage, and proportionate extent of soils in Harding County, New Mexico

| Soil Mapping Unit | Irrigation Land Class | Acres | Percent |
|---|---|---|---|
| Active duneland | 6 | 4,910 | 0.4 |
| Amarillo fine sandy loam | 1 | 43,119 | 3.2 |
| Apache stony loam, 1 to 9 percent slopes | 6 | 12,535 | 0.9 |
| Berthoud fine sandy loam, 1 to 5 percent slopes | 2 | 8,769 | 0.7 |
| Berthoud fine sandy loam, 5 to 9 percent slopes | 3 | 8,500 | 0.6 |
| Berthoud loam, 1 to 5 percent slopes | 2 | 59,656 | 4.4 |
| Bippus loam, 0 to 3 percent slopes | 2 | 2,652 | 0.2 |
| Campus fine sandy loam, 0 to 9 percent slopes | 4 | 5,935 | 0.4 |
| Campus loam, 0 to 3 percent slopes | 3 | 17,473 | 1.3 |
| Campus loam, 0 to 3 percent slopes, eroded | 3 | 4,115 | 0.3 |
| Campus loam, 3 to 9 percent slopes | 4 | 16,693 | 1.2 |
| Campus loam, 3 to 9 percent slopes, eroded | 4 | 1,193 | 0.1 |
| Campus loam, 0 to 9 percent slopes | 4 | 25,078 | 1.8 |
| Campus loam, 0 to 9 percent slopes, eroded | 4 | 2,295 | 0.2 |
| Campus-Dean association, gently sloping | | | |
| Campus loam, 0 to 5 percent slopes | 3 | 21,720 | 1.6 |
| Dean loam, 0 to 9 percent slopes | 6 | 11,696 | 0.8 |
| Campus gravelly loam, 1 to 25 percent slopes | 6 | 2,420 | 0.2 |
| Carnero loam | 4 | 15,259 | 1.1 |
| Carnero loam, eroded | 4 | 1,189 | 0.1 |
| Carnero loam, complex | 4 | 22,735 | 1.7 |
| Carnero loam, eroded complex | 4 | 1,447 | 0.1 |
| Church clay loam | 4 | 7,930 | 0.6 |
| Dalhart fine sandy loam | 1 | 12,164 | 0.9 |
| Dalhart severely eroded complex | 2 | 2,043 | 0.1 |
| Dean soils, 0 to 9 percent slopes | 6 | 28,665 | 2.1 |
| Dioxice loam, 0 to 3 percent slopes | 2 | 48,079 | 3.5 |
| Dioxice loam, 0 to 3 percent slopes, eroded | 3 | 10,980 | 0.8 |
| Dioxice loam, 3 to 5 percent slopes | 3 | 3,318 | 0.2 |
| Dumas loam, 0 to 3 percent slopes | 1 | 54,794 | 4.0 |
| Dumas loam, 3 to 5 percent slopes | 2 | 1,227 | 0.1 |
| Dumas loam, thin solum, 0 to 3 percent slopes | 2 | 5,302 | 0.4 |
| Dumas complex, 0 to 3 percent slopes, eroded | 2 | 11,266 | 0.8 |
| Gallegos gravelly sandy loam, 3 to 35 percent slopes | 6 | 17,915 | 1.3 |
| Guadalupe fine sandy loam | 2 | 8,280 | 0.6 |
| Ima and Quay soils | 2 | 27,390 | 2.0 |
| Karde loam, 1 to 9 percent slopes | 3 | 7,542 | 0.6 |
| Kinkead clay loam | 2 | 25,218 | 1.8 |
| Kinkead clay loam, alkali | 4 | 4,120 | 0.3 |
| La Brier loam | 1 | 36,739 | 2.7 |
| La Brier loam, eroded | 1 | 13,569 | 1.0 |
| La Brier clay loam | 2 | 6,526 | 0.5 |
| Lacita loam, 1 to 9 percent slopes | 3 | 8,768 | 0.6 |
| Latom fine sandy loam | 6 | 5,012 | 0.4 |
| Litle clay loam | 4 | 19,504 | 1.4 |
| Mansker-Portales association | | | |
| Mansker fine sandy loam, 1 to 9 percent slopes | 4 | 15,414 | 1.1 |
| Portales fine sandy loam, 1 to 5 percent slopes | 2 | 12,625 | 0.9 |
| Mansker-Potter association | | | |
| Mansker fine sandy loam, 1 to 9 percent slopes | 4 | 6,816 | 0.5 |
| Potter fine sandy loam, 1 to 9 percent slopes | 6 | 3,673 | 0.3 |
| Manzano loam | 2 | 10,100 | 0.7 |
| Manzano, water table variant | 4 | 424 | <0.1 |
| Manzano sandy loam | 2 | 2,213 | 0.2 |
| Manzano and La Brier soils | 2 | 17,928 | 1.3 |
| Montoya clay | 3 | 2,452 | 0.2 |
| Otero fine sandy loam | 3 | 13,893 | 1.0 |
| Otero loamy fine sand, 1 to 9 percent slopes | 3 | 11,786 | 0.9 |
| Pastura loam | 6 | 17,636 | 1.3 |
| Pastura fine sandy loam | 6 | 649 | <0.1 |
| Penrose soils, 0 to 12 percent slopes | 6 | 8,646 | 0.6 |
| Rough broken and stony land | 6 | 132,698 | 9.7 |
| Rough broken land | 6 | 10,103 | 0.7 |
| Riverwash | 6 | 7,945 | 0.6 |
| Springer loamy fine sand, 1 to 9 percent slopes | 3 | 52,978 | 3.9 |
| Springer-Amarillo association | | | |
| Springer loamy fine sand | 3 | 82,686 | 6.0 |
| Amarillo loamy fine sand, 0 to 3 percent slopes | 2 | 55,121 | 4.0 |
| Springer-Amarillo association, severely eroded | 3 | 3,779 | 0.3 |
| Tapia fine sandy loam complex | 3 | 2,090 | 0.2 |
| Tivoli fine sand | 6 | 59,000 | 4.3 |
| Tivoli-Springer complex | 6 | 14,333 | 1.0 |
| Travessilla stony loam, 0 to 9 percent slopes | 6 | 99,934 | 7.3 |
| Tricon loam | 2 | 13,572 | 1.0 |
| Tricon loam, complex | 3 | 7,394 | 0.5 |
| Tricon soils, eroded | 3 | 1,396 | 0.1 |
| Tucumcari-Quay association | | | |
| Tucumcari loam, 0 to 2 percent slopes | 2 | 16,143 | 1.2 |
| Quay loam, 2 to 3 percent slopes | 2 | 10,763 | 0.8 |
| Vermejo clay | 3 | 6,373 | 0.5 |
| Vernon-shale outcrop complex, 1 to 9 percent slopes | 6 | 5,368 | 0.4 |
| Wet alluvial land | 6 | 3,025 | 0.2 |
| Miscellaneous (gravel pits, intermittent lakes, lakes, etc.) | 6 | 3,613 | 0.3 |
| Total | | 1,368,300 | 100.0 |

which are dominant have moderate to severe limitations for use under irrigation due to their low moisture retention capacity, undulating, and wind erosion hazard.

In soil associations 11, 12, 13 and 14, the percentage of irrigable land ranges from little or no irrigable land in soil association 14 to 35 percent in soil association 11.

The potential for expansion of irrigable land in Harding County is large, insofar as the suitability of soils is concerned. In many of the soil associations, such as soil association 1, the irrigable land occurs in relatively large tracts with little or no interspersed non-irrigable land. The quality of the potential irrigable land also compares favorably with that in the adjoining counties of northeastern New Mexico. Of the 918,500 acres of land considered suitable for irrigation, about 18 percent is class 1; 38 percent class 2; 28 percent class 3; and 19 percent class 4. The approximate acreage and irrigation land class for each soil in the county is shown in table 6.

## Engineering Uses of Soil[8]

In this section information is provided on engineering properties and uses of soils as construction material and as a support for various kinds of structures. The information is in tabular form and in accordance with the soil associations shown on the small-scale soil map accompanying this report. Selected engineering properties, engineering classifications, and estimates on the suitability of soils for specified engineering uses are indicated for the major soils in each soil association. This correlation of engineering data and soil properties according to soil associations, or general soil areas, can be useful in estimating the suitability of certain areas for engineering purposes. The information on general soil problems, limitations, and hazards can also be helpful in the selection of areas for various engineering structures or practices.

The information provided here will not eliminate the need for on-site sampling and testing of sites for design and construction of specific engineering works and uses. This is particularly true at those sites of specific engineering works involving heavy loads or where excavations are deeper than the depths of the soil layers here reported. In addition, the general soil map accompanying this report does not delineate or show the individual kind of soils. Regardless of these conditions, the general soil map is useful for planning more detailed investigations and for suggesting the kinds of problems that may be expected in each of the soil associations.

In table 7 are indicated some estimated soil properties of importance in engineering. Also shown are the estimated unified and AASHO classifications for the major soils in each soil association. Information taken from the detailed soil survey, knowledge of the individual soils of the county, and a limited amount of laboratory test data were used as a basis for making these estimates.

A brief explanation of some of the terms used in table 7 follows:

The "USDA texture" is determined by the relative proportions of sand, silt, and clay in the soil mass. It is the standard procedure used by the U.S. Department of Agriculture to classify soils according to texture.

Two systems of classifying soils, the AASHO and the Unified, are in general use among engineers.

Highway engineers generally classify soil materials in accordance with the system approved by the American Association of State Highway Officals.[9] In this system (AASHO) classification is based on the gradation, liquid limit, and plasticity index of the soil. Highway performance has been related to this system of classification. All soil materials are classified in seven principal groups. The groups range from A-1 (gravelly soils of high bearing capacity, the best soils for subgrades) to A-7 (clay soils having low strength when wet, the poorest soils for subgrades).

Some engineers prefer to use the Unified soil classification system established by the Waterways Experiment Station, Corps of Engineers.[10] This system is based on identification of soils according to their texture and plasticity and their

[8] Compiled from a chapter on "Soils in Engineering" prepared by Wiley Miller, area engineer, Soil Conservation Service in the Harding County soil survey report. Unpublished.

[9] American Association of State Highway Officials, 1955 Standard Specifications for Highway Materials and Methods of Sampling and Testing. Ed. 7, part 1, 257 pp., illus.

[10] Waterways Experiment Station, Corps of Engineers. 1953. The Unified Soil Classification System. Tech. Memo. 3-357, 2V. and Appendix.

performance as engineering construction materials. Soil materials are identified as coarse-grained (8 classes), fine-grained (6 classes), or highly organic.

The estimated percentages of soil material passing sieves No. 4, No. 10, and No. 200 are in the columns headed by these sieve numbers. These percentages reflect the normal range for the soil series, and most soils within a series will fall within that range. The grain size of some soils may vary, so it should not be assumed that all samples of a specific soil will fall within the given range.

Permeability as indicated in table 7 relates to the rate water moves through undisturbed and uncompacted soil. The estimates are based on the texture, structure, and porosity of the soil.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates hazards to the maintenance of structures constructed in, on, or with such materials.

Salinity of the soil is based on the electrical conductivity of the saturated soil extract, as expressed in milliohms per centimeter at 25°C. Salinity affects the suitability of a soil for crop production, its stability when used as a construction material, and its corrosiveness to other materials.

## Interpretation of Soils for Engineering and Related Uses

Table 8 contains selected information useful to engineers and others who plan to use soils as a support for various structures, or as soil material in the construction of highways, farm facilities, sewage disposal systems, and other engineering structures.

Although limiting or undesirable soil features are emphasized, favorable soil features may also be listed. The ratings and other interpretations in this table are based on estimated soil properties for engineering uses as listed in table 7, on available test data, and on field experience.

Topsoil is a term used to designate a fertile soil or soil material of favorable texture, structure, and organic matter content, which can be used as a topdressing for lawns, roadbanks, and various other engineering structures. The ratings of poor, fair, or good indicate the general suitability for such use.

Suitability ratings of poor, fair, or good for road fill are given for the major soils in each soil association. The ratings are based on the performance of the soil material when excavated and used as borrow for highway subgrade.

Sewage filter fields are affected mainly by permeability, depth to water table, depth to bedrock or indurated caliche, and susceptibility to flooding. The degree of limitations and principal reasons for assigning moderate to severe limitations are given.

A corrosion potential of low, moderate, or high is indicated for the major soils in each soil association. Corrosivity, as used here, indicates the potential danger that uncoated steel pipe will corrode or become weakened through chemical action. Among the features considered in rating corrosion potential are soil drainage, presence of soluble salts, and frequency of wetting and drying. The texture, structure, and porosity of the soil are also important because of their effect on aeration, moisture-holding capacity, and movement of water.

Foundations for low buildings are affected chiefly by features of the undisturbed soil that influence its capacity to support low buildings that have normal foundation loads. Although specific values of bearing capacity and shear strength are not assigned, general values are indicated.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. The soil features, favorable as well as unfavorable, are the principal ones that affect geographic location of highways.

Farm pond reservoir areas are affected mainly by seepage loss of water, and the soil features are those that influence such seepage.

Farm pond embankments serve as dams. The soil features, of both subsoil and substratum, are those important to the use of soils for constructing embankments.

Terraces and diversions are low structures designed to retain or direct water. Pitting, chiseling, and contour furrowing serve to loosen the soil and retain water from rainfall and snow melt. The intake rate, permeability, stability of clods, and the use of the soil material for embankments are the soil features considered.

Table 7. Engineering soil groups and estimated soil properties, Harding County, New Mexico

| Soil Map Symbol and Soil Association | Depth from Surface | Classification | | | Percentage Passing Sieve-- | | | Range in Permeability | Shrink-swell Potential |
|---|---|---|---|---|---|---|---|---|---|
| | | USDA texture | Unified | AASHO | No. 4 (4.7mm) | No. 10 (2.0mm) | No. 200 (0.074mm) | | |
| | in. | | | | | | | in/hr | |
| 1 Dumas-Dioxice-La Brier | | | | | | | | | |
| Dumas loam | 0-7 | Loam | ML or CL | A-4 | 100 | 100 | 90-95 | 0.63 - 2.0 | Low |
| | 7-48 | Clay loam | CL | A-6 | 100 | 100 | 90-95 | 0.20 - 0.63 | Moderate |
| Dioxice loam | 0-8 | Loam | ML or CL | A-4 or A-6 | 100 | 100 | 90-100 | 0.63 - 2.0 | Low |
| | 8-35 | Clay loam | ML or CL | A-6 | 100 | 100 | 90-100 | 0.63 - 1.5 | Moderate |
| La Brier loam | 0-8 | Loam | ML or CL | A-4 | 100 | 100 | 90-100 | 0.63 - 2.0 | Low |
| | 8-31 | Clay | CH | A-7 | 100 | 100 | 90-100 | 0.05 - 0.63 | High |
| | 31-72 | Silty clay loam | CL | A-7 | 100 | 100 | 90-100 | 0.20 - 0.63 | Moderate |
| 2 Litle-Berthoud-Penrose | | | | | | | | | |
| Litle clay loam* | 0-10 | Clay loam | CL | A-6 | 100 | 100 | 90-100 | 0.20 - 0.63 | Moderate |
| | 10-24 | Clay | CL | A-7 | 100 | 100 | 90-100 | < 0.20 | High |
| Berthoud loam | 0-12 | Loam | ML | A-4 | 100 | 95-100 | 50-65 | 0.63 - 2.00 | Low |
| | 12-50 | Light clay loam | CL | A-6 | 100 | 95-100 | 60-75 | 0.63 - 2.00 | Moderate |
| Penrose channery clay loam | 0-10 | Clay loam | ML or CL | A-6 | 100 | 90-100 | 60-70 | 0.63 - 2.00 | Moderate |
| 3 Berthoud-Kinkead | | | | | | | | | |
| Berthoud loam | 0-12 | Loam | ML | A-4 | 100 | 95-100 | 50-65 | 0.63 - 2.00 | Low |
| | 12-50 | Light clay loam | CL | A-6 | 100 | 95-100 | 60-75 | 0.63 - 2.00 | Moderate |
| Kinkead clay loam | 0-7 | Clay loam | CL | A-6 | 100 | 100 | 95-100 | 0.63 - 1.50 | Moderate |
| | 7-42 | Clay | CH | A-7 | 100 | 100 | 95-100 | 0.05 - 0.20 | High |
| | 42-55 | Sandy clay loam | CL | A-6 | 100 | 100 | 95-100 | 0.63 - 1.50 | Low |
| 4 Quay-Ima-Tucumcari | | | | | | | | | |
| Quay loam | 0-42 | Loam | ML or CL | A-4 | 100 | 100 | 60-75 | 0.20 - 0.63 | Low |
| Ima fine sandy loam | 0-47 | Fine sandy loam | SM or SC | A-4 | 100 | 100 | 35-50 | 2.00 - 6.30 | Low |
| Tucumcari loam | 0-8 | Loam | ML or CL | A-4 | 100 | 100 | 95-100 | 0.63 - 2.00 | Low |
| | 8-60 | Clay loam | CL | A-6 | 100 | 100 | 95-100 | 0.05 - 0.63 | Moderate |
| 5 Church-Karde | | | | | | | | | |
| Church clay loam* | 0-11 | Clay loam | ML or CL | A-6 | 100 | 100 | 95-100 | 0.05 - 0.63 | Moderate |
| | 11-60 | Clay | CH | A-7 | 100 | 100 | 95-100 | < 0.06 | High |
| Karde loam* | 0-60 | Loam | ML or CL | A-6 | 100 | 100 | 50-70 | 0.63 - 2.00 | Low |
| 6 Campus-Dean | | | | | | | | | |
| Campus loam | 0-18 | Loam | ML or CL | A-4 | 100 | 100 | 70-80 | 0.63 - 2.00 | Low |
| | 18-60 | Clay loam | CL | A-6 | 100 | 100 | 70-80 | 0.63 - 2.00 | Low |
| Dean gravelly loam | 0-6 | Gravelly loam | SM | A-4 | 70-80 | 60-70 | 40-50 | 0.63 - 2.00 | Low |
| | 6-18 | Gravelly loam | ML or CL | A-4 | 40-50 | 35-45 | 25-35 | 0.63 - 2.00 | Low |
| 7 Mansker-Portales | | | | | | | | | |
| Mansker fine sandy loam | 0-5 | Fine sandy loam | SM | A-2 | 100 | 100 | 35-50 | 2.00 - 6.30 | Low |
| | 5-60 | Loam | ML or CL | A-4 | 100 | 100 | 60-75 | 0.63 - 2.00 | Low |
| Portales fine sandy loam | 0-10 | Fine sandy loam | SM | A-2 | 100 | 100 | 40-50 | 2.00 - 6.30 | Low |
| | 10-60 | Loam | ML or CL | A-4 | 100 | 100 | 50-60 | 0.63 - 2.00 | Low |
| 8 Otero-Dalhart | | | | | | | | | |
| Otero loamy fine sand | 0-10 | Loamy fine sand | SM | A-2 | 100 | 100 | 20-35 | 2.00 - 6.30 | Low |
| | 10-28 | Fine sandy loam | SM | A-2 | 100 | 100 | 30-50 | 2.00 - 6.30 | Low |
| | 28-60 | Loamy sand | SM | A-2 | 100 | 100 | 15-30 | 2.00 - 6.30 | Low |
| Dalhart fine sandy loam | 0-6 | Fine sandy loam | SM | A-2 | 100 | 100 | 25-40 | 2.00 - 6.30 | Low |
| | 6-50 | Sandy clay loam | SC or CL | A-4 or A-6 | 100 | 100 | 45-90 | 0.63 - 2.00 | Low to moderate |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9 Amarillo | | | | | | | | | |
| Amarillo fine sandy loam | 0-8 | Fine sandy loam | SM | A-2 | 100 | 100 | 20-35 | 2.00 - 6.30 | Low |
| | 8-48 | Sandy clay loam | SC or CL | A-6 | 100 | 100 | 40-55 | 0.63 - 2.00 | Low to moderate |
| | 48-60 | Sandy clay loam | CL | A-6 | 100 | 100 | 50-70 | 0.63 - 2.00 | Low to moderate |
| 10 Springer-Tivoli-Amarillo | | | | | | | | | |
| Springer loamy fine sand | 0-65 | Loamy fine sand | SM | A-2 | 100 | 100 | 15-25 | 2.00 - 6.30 | Low |
| Tivoli fine sand | 0-65 | Fine sand | SP or SM-SP | A-3 | 100 | 100 | 0-15 | > 6.30 | Low |
| Amarillo loamy fine sand | 0-10 | Loamy fine sand | SM | A-2 | 100 | 100 | 15-25 | 2.00 - 6.30 | Low |
| | 10-48 | Sandy clay loam | SC or CL | A-6 | 100 | 100 | 40-55 | 0.63 - 2.00 | Low to moderate |
| | 48-60 | Sandy clay loam | CL | A-6 | 100 | 100 | 50-70 | 0.63 - 2.00 | Low to moderate |
| 11 Pastura-Apache | | | | | | | | | |
| Pastura loam | 0-7 | Loam | ML or CL | A-4 or A-6 | 65-80 | 60-75 | 50-65 | 0.63 - 2.00 | Low |
| Apache stony loam | 0-12 | Stony loam | GM | A-4 | 50-60 | 50-60 | 40-50 | 0.63 - 2.00 | Low to moderate |
| Dioxice loam | 0-8 | Loam | ML or CL | A-4 or A-6 | 100 | 100 | 90-100 | 0.63 2.00 | Low |
| | 8-35 | Clay loam | ML or CL | A-6 | 100 | 100 | 90-100 | 0.63 - 1.50 | Moderate |
| 12 Travessilla-Carnero | | | | | | | | | |
| Travessilla stony loam | 0-8 | Stony loam | GM or GC | A-2 | 85-95 | 75-85 | 35-50 | 0.63 - 2.00 | Low |
| Carnero loam | 0-6 | Loam | ML or CL | A-4 | 100 | 100 | 90-100 | 0.63 - 2.00 | Low |
| | 6-36 | Clay loam | CL | A-6 | 100 | 100 | 90-100 | 0.63 - 2.00 | Moderate |
| 13 Gallegos | | | | | | | | | |
| Gallegos gravelly sandy loam | 3-21 | Very gravelly sandy clay loam | GC | A-1 | 40-45 | 25-35 | 15-20 | 2.00 - 6.30 | Low |
| 14 Rough broken and stony land | (No estimates made) | | | | | | | | |

*Soil slightly to moderately saline

Table 8. Interpretation of soil properties for engineering uses, Harding County, New Mexico

| Soil Map Symbol and Soil Association | Suitability as a Source of -- Topsoil | Road fill | Degree of Limitation for Septic Tank Filter Fields | Corrosion Potentia (untreated steel pip |
|---|---|---|---|---|
| 1 Dumas-Dioxice-La Brier | | | | |
| Dumas loam | Good to depth of 6 to 10 inches | Fair; moderate shrink-swell | Moderate; moderately slow permeability | Moderate |
| Dioxice loam | Fair to good 6 to 8 inch surface layer | Fair; moderate shrink-swell | Moderate; high lime zone 24 to 40 inches with moderately slow permeability | Moderate |
| La Brier loam | Good to a depth of 6 to 10 inches | Poor; high shrink-swell | Severe; slow permeability | Moderate |
| 2 Litle-Berthoud-Penrose | | | | |
| Litle clay loam | Poor; high clay content | Poor; high shrink-swell | Severe; slow permeability; shale at 20 to 40 inches | High |
| Berthoud loam | Fair to good surface layer; 10 to 12 inches thick | Fair; moderate shrink-swell | Slight to moderate | Low |
| Penrose channery loam | Poor; channery and high lime content | Fair; limited quantity | Severe; shale or bedrock at 6 to 20 inches | Moderate to high |
| 3 Berthoud-Kinkead | | | | |
| Berthoud loam | Fair to good surface layer; 10 to 12 inches thick | Fair; moderate shrink-swell | Slight to moderate | Low |
| Kinkead clay loam | Poor; high clay content | Poor; high shrink-swell; high plasticity | Severe; slow permeability | Moderate to high |
| 4 Quay-Ima-Tucumcari | | | | |
| Quay loam | Fair; moderately erodible | Fair; slight to moderate plasticity | Moderate; slow permeability | Moderate |
| Ima fine sandy loam | Fair; sandy; moderate fertility | Good | Slight | Low |
| Tucumcari loam | Five to 8 inch surface layer fair to good | Poor to fair; moderate shrink-swell | Severe; slow permeability | Moderate |
| 5 Church-Karde | | | | |
| Church clay loam | Poor; high clay content | Poor; high shrink-swell | Severe; very slow permeability; occasional flooding; watertable | High |
| Karde loam | Poor; high lime content; erodible | Fair | Moderate; moderately permeable | Moderate |
| 6 Campus-Dean | | | | |
| Campus loam | Six to 8 inch surface layer fair; erodible and limy | Fair | Moderate; lime zone with moderately slow permeability | Moderate |
| Dean gravelly loam | Poor; limy; some caliche fragments | Good; very high lime content | Moderate to severe; shallow to high lime zone; some fractured caliche | Moderate |
| 7 Mansker-Portales | | | | |
| Mansker fine sandy loam | Poor; limy; erodible | Fair | Moderate, lime zone with moderately slow permeability | Moderate |
| Portales fine sandy loam | Poor to fair; sandy, limy; erodible | Fair | High lime zone; moderately slow permeability | Moderate |

*Soil features favorable

**Unsuitable or practices not applicable

| Soil Features Affecting -- | | | | |
|---|---|---|---|---|
| | | Farm ponds | | Terraces, diversions, contour furrows, and pitting |
| Foundation support | Highway location | Reservoir area | Embankment | |
| Fair bearing capacity; moderate shrink-swell | Fine-grained material with medium plasticity | * | Fair stability; moderate plasticity | * |
| Fair bearing capacity; low to moderate shrink-swell | Fine-grained material with slight to medium plasticity | Subject to seepage if lime zone exposed | Fair stability if compacted; erodible if lime zone is exposed | Subject to wind erosion if limy material is exposed |
| Fair bearing capacity; high shrink-swell | Fine-grained material; high plasticity | * | Difficult to compact | Low intake rate; slow permeability |
| Fair bearing capacity; high shrink-swell | Fine-grained material; high plasticity; shale at 20 to 40 inches | Clayey shale at 20 to 40 inches | Difficult to compact; erodible | Clayey material; slow permeability |
| Fair to good bearing capacity; low to moderate shrink-swell | Fine-grained material; slight to medium plasticity | * | * | Moderately sloping |
| Interbedded shale and limestone at 6 to 20 inches | Sloping; shale and limestone at 6 to 20 inches | Subject to seepage; limited soil depth | Limited borrow materials | ** |
| Fair to good bearing capacity; low to moderate shrink-swell | Fine-grained material; slight to medium plasticity | * | * | Moderately sloping |
| Fair bearing capacity; high shrink-swell | Fine-grained material with high plasticity | * | Difficult to compact; subject to cracking | Low intake rate; slow permeability |
| Fair bearing capacity; poor to fair shear strength | Fine-grained material; slight to medium plasticity; erodible | * | Erodible; fair stability if compacted | Erodible; subject to siltation of channels |
| Good bearing capacity, and shear strength | * | Subject to seepage; rapidly permeable | Subject to wind erosion; fair stability if compacted | ** |
| Fair bearing capacity and shear strength; moderate shrink-swell | Fine-grained material; medium plasticity | * | May be difficult to compact | Slow intake rate; slow permeability |
| Poor bearing capacity; high shrink-swell | Fine-grained material with high plasticity; subject to flooding; seasonal watertable | Occasional flooding; seasonal watertable | Difficult to compact; moderate dispersion | ** |
| Fair bearing capacity; low shrink-swell | Moderately sloping; erodible; high lime content | Sloping; subject to seepage unless compacted | Subject to wind erosion; difficult to vegetate | ** |
| Fair bearing capacity and shear strength | Exposed caliche subject to wind erosion | Shallow to a lime zone; moderate permeability | Limy material; erodible; difficult to vegetate | ** |
| Fair bearing capacity and shear strength | Exposed caliche subject to wind erosion | Shallow to a lime zone or caliche; subject to seepage | Limy material erodible; difficult to vegetate | ** |
| Fair bearing capacity and shear strength | Subject to wind erosion | Shallow to a lime zone; moderate permeability | Limy material; erodible; difficult to vegetate | ** |
| Fair bearing capacity and shear strength | Fine-grained material with slight to medium plasticity | Subject to seepage if lime zone exposed | Limy material; erodible; difficult to vegetate | Subject to wind erosion if limy material is exposed |

Table 8. Continued

| Soil Map Symbol and Soil Association | Topsoil | Road fill | Degree of Limitation for Septic Tank Filter Fields | Corrosion Potentia (untreated steel pip |
|---|---|---|---|---|
| 8 Otero-Dalhart | | | | |
| Otero loamy fine sand | Poor; sandy and erodible | Good | Slight; permeable | Low |
| Dalhart fine sandy loam | Fair; sandy and erodible | Fair; moderate shrink-swell | Moderate to slight; moderately permeable | Moderate |
| 9 Amarillo | | | | |
| Amarillo fine sandy loam | Fair; sandy and erodible | Fair; moderate shrink-swell | Moderate to slight; moderately permeable | Moderate |
| 10 Springer-Tivoli-Amarillo | | | | |
| Springer loamy fine sand | Poor; very sandy; erodible | Good | Slight; rapidly permeable | Low |
| Tivoli fine sand | Poor; very sandy and erodible | Good if confined or soil binder added | Moderate hazard of contamination | Low |
| Amarillo loamy fine sand | Poor; very sandy and erodible | Surface layers good; subsoil fair | Moderate to slight; moderately permeable | Moderate |
| 11 Pastura-Apache-Dioxice | | | | |
| Pastura loam | Poor; thin surface layer with caliche fragments | Good; limited material, unless caliche is crushed | Severe; very shallow to cemented caliche | Moderate |
| Apache stony loam | Poor; stony | Good; material limited | Severe; shallow to bedrock | Moderate |
| Dioxice loam | Fair to good 6 to 8 inch surface layer | Fair; moderate shrink-swell | Moderate; high lime zone 24 to 40 inches with moderately slow permeability | Moderate |
| 12 Travessilla-Carnero | | | | |
| Travessilla stony loam | Poor; coarse fragments | Good; material very limited | Severe; shallow to bedrock | Low |
| Carnero | Fair to good; 6 to 8 inches thick | Fair; moderate shrink-swell | Severe; moderate depth to bedrock | Moderate |
| 13 Gallegos | | | | |
| Gallegos gravelly sandy loam | Poor; gravelly | Good | Moderate; hilly topography | Low |
| 14 Rough broken and stony land | No interpretations made | | | |

*Soil features favorable

**Unsuitable or practices not applicable

| Soil Features Affecting -- | | | | |
|---|---|---|---|---|
| | | Farm ponds | | Terraces, diversions, contour furrows, and pitting |
| Foundation support | Highway location | Reservoir area | Embankment | |
| Good bearing capacity and shear strength; low shrink-swell | Sandy materials; susceptible to wind erosion | Subject to seepage; rapidly permeable | Sandy material; erodible | ** |
| Fair bearing capacity and shear strength | Fine-grained material with slight to medium plasticity | Moderately permeable; will require compaction | Fairly stable if compacted | Sandy surface layers; moderately permeable; subject to wind erosion |
| Good bearing capacity and shear strength | Fine-grained material with slight to medium plasticity; surface layers erodible | Moderately permeable; will require compaction | Fairly stable if compacted | Surface layers sandy and subject to wind erosion; moderately permeable |
| Good bearing capacity and shear strength; low shrink-swell | Sandy materials subject to wind erosion | Subject to seepage; rapidly permeable | Sandy material; erodible | ** |
| Subject to under-cutting by wind; requires confinement | Very susceptible to wind erosion; unstable unless confined | ** | ** | ** |
| Good bearing capacity and shear strength | Surface layers erodible; slight to moderately plastic subsoil | Subject to seepage; will require compaction | Surface layer sandy and permeable; subsoil fairly stable if compacted | ** |
| Shallow to indurated caliche with good bearing capacity | Shallow to cemented caliche | Subject to seepage; shallow to caliche | Very limited material | ** |
| Shallow to bedrock | Shallow to bedrock | ** | ** | ** |
| Fair bearing capacity; low to moderate shrink-swell | Fine-grained material with slight to medium plasticity | Subject to seepage if lime zine exposed | Fair stability if compacted; erodible if lime zone is exposed | Subject to wind erosion if limy material is exposed |
| Shallow to bedrock | Shallow to bedrock; moderate slopes | ** | ** | ** |
| Fair bearing capacity and shear strength | Fine-grained material with slight to medium plasticity | Subject to seepage; moderately deep | Fairly stable material; good if compacted | Moderately deep to bedrock; stable material |
| | Undulating to hilly topography | ** | ** | ** |

New Mexico State University's Agricultural Experiment Station publishes many bulletins and research reports of interest to residents of New Mexico. You may obtain a copy of the latest list of such publications by contacting the County Extension Office in your county, or by writing to:

Bulletin Office
Department of Agricultural Information
New Mexico State University
Drawer 3A1
Las Cruces, New Mexico 88001