

Series 1955 No. 2

SOIL SURVEY

Bluewater Area New Mexico



UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
NEW MEXICO AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

THIS SURVEY of the Bluewater Area will help you plan the kind of farming that will protect your soils and provide good yields. It describes the soils; shows their location on a map; and tells what they will do under different kinds of management.

Find Your Farm on the Map

In using this survey, start with the soil map, which consists of the 11 sheets bound in the back of this report. These sheets, if laid together, make a large photographic map of the Area as it looks from an airplane. You can see fields, roads, creeks, and many other landmarks on this map.

To find your farm on the large map, use the index to map sheets. This is a small map of the Area on which numbered rectangles have been drawn. Each rectangle corresponds to a sheet of the large map.

Suppose you have found on your farm an area marked with symbol *S_a*. You learn the name of the soil this symbol represents by looking at the map legend. The symbol *S_a* identifies San Jose loam, 0 to 1 percent slopes.

Learn About the Soils on Your Farm

San Jose loam, 0 to 1 percent slopes, and all other soils mapped are described in the section, *Descriptions of Soils*. Soil scientists walked over the fields, dug holes, and examined sur-

face soils and subsoils. Slopes were measured with a hand level. Differences were noted in moisture content, in growth of crops, weeds, or brush; and, in fact, in all the things about the soils that might affect their suitability for farming.

After they had studied the soils, talked with farmers, and read research reports on similar soils, the scientists placed each soil in a capability unit. A capability unit is a group of similar soils that need and respond to about the same kind of management.

San Jose loam, 0 to 1 percent slopes, is in capability unit I-1. Turn to the section, *Suggestions for Use and Management*, and read what is said about soils of capability unit I-1.

Make a Farm Plan

Look at your fields for signs of dryness, over-irrigation, poor tilth, or accumulation of salts. Then decide whether or not you need to change your methods. The choice, of course, must be yours. This survey will aid you in planning new methods, but it is not a plan of management for your farm or any other farm in the Area.

If you find that you need help in farm planning, consult the local representative of the Soil Conservation Service or the county agricultural agent. Members of your State experiment station staff and others familiar with farming in your area will also be glad to help you.

Contents

	Page		Page
General nature of the Area	1	Irrigation—Continued	
Location and extent	1	Salinity of irrigation water	9
Soils of the Bluewater Area	1	Methods of irrigation and their effect on	
Descriptions of soils	1	salt distribution	9
Ladrillo series	2	Salt tolerance of crops	9
Ladrillo clay, 0 to 1 percent slopes	2	Amendments for controlling alkali	9
Preston series	3	How to use the soils	10
Preston fine sand, 0 to 5 percent slopes....	3	Capability classification	10
Preston-San Mateo complex	3	Suggestions for use and management	10
Prewitt series	3	Capability unit I-1	10
Prewitt clay, 0 to 1 percent slopes	3	Capability unit II-1	10
Prewitt clay loam, 0 to 1 percent slopes...	3	Capability unit III-1	11
Prewitt clay loam, sandy substratum,		Capability unit III-2	11
0 to 1 percent slopes	4	Capability unit IV-1	11
Prieta series.....	4	Capability unit VII-1	11
Prieta stony loam, 0 to 5 percent slopes	4	Capability unit VII-2	12
Puerco series	4	Capability unit VII-3	12
Puerco clay, sandy substratum,		Capability unit VIII-1	12
0 to 1 percent slopes	4	Yields and management	12
San Jose series	5	History of crops and marketing methods	13
San Jose loam, 0 to 1 percent slopes	5	Geology	14
San Jose loam, sandy substratum,		Stratigraphy	15
0 to 1 percent slopes	5	Formation and classification of soils	16
San Mateo series	5	Soil-forming factors	16
San Mateo sandy clay loam	5	Soil materials	16
Irrigation	6	Climate	17
Characteristics of soils that affect irrigation	6	Relief	17
Sources of water	6	Vegetation	17
Irrigation practices	7	Time	17
When to irrigate	7	Classification of soils in great soil groups	18
How much water to apply	8	How a soil survey is made	18
Effect of irrigation on soil structure	8	Laboratory determinations	18

SOIL SURVEY OF BLUEWATER AREA, NEW MEXICO

Soil survey by JAMES J. FOLKS and ROBERT O. RICKETTS, soil scientists, Soil Conservation Service

Report by JAMES J. FOLKS, Soil Conservation Service

Correlation by ARVAD J. CLINE, soil scientist, Soil Conservation Service

United States Department of Agriculture in cooperation with New Mexico Agricultural Experiment Station

General Nature of the Area

MORMONS settled the area around Bluewater in about 1880. They irrigated their farms with water from Bluewater Creek. Little farming was done, however, until 1927, when an irrigation district was formed and Bluewater Dam was built. Vegetable growers, who came into the Area in the late 1930's, introduced intensive vegetable farming. Water from the Bluewater Reservoir had to be supplemented, and the first irrigation wells were drilled in 1945-46.

Intensive farming under irrigation is developing some problems that must be solved if cultivation is to continue over a long period. To help the farmers meet these problems, the Soil Conservation Service, in cooperation with the New Mexico Agricultural Experiment Station, made a survey of the soils of this area. Fieldwork was completed in the spring of 1955 and the results of that survey are reported here.

Location and Extent

The Bluewater Area, totaling 9,720 acres, is part of Valencia County in northwestern New Mexico (fig. 1). The Area is irregular in shape and covers only the valley lands lying along Bluewater Creek and the San Mateo flood plain in the north-central part of Valencia County.

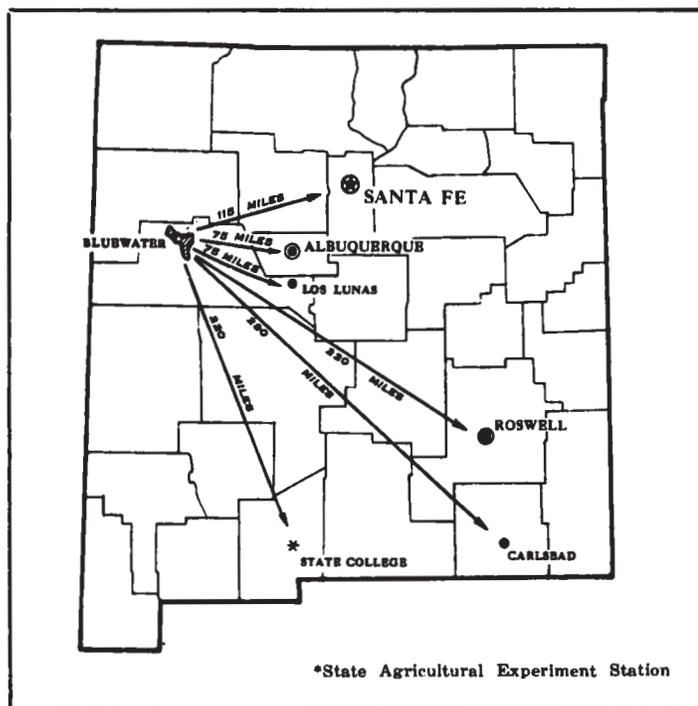


Figure 1.—Location of Bluewater Area, New Mexico.

Parts of Bluewater and Grants townships are included in the Area.

The Area lies north and west of the town of Grants, New Mexico, which serves as the principal supply and marketing center. United States Highway 66 and the main line of the Atchison, Topeka and Santa Fe Railway cross the Area.

Soils of the Bluewater Area

The Bluewater Area lies in a valley formed at the junction of the Bluewater and San Mateo drainage systems (fig. 2). The soils are calcareous and low to very low in organic matter. Except for the Preston and Prieta, all the soils are deep, young, alluvial soils. All occur within an area having a uniform climate, and the differences among the soils are therefore caused mainly by differences in parent materials, drainage, and topography. Most of the alluvial soils are of mixed mineralogical origin and have not been in place long enough to have developed distinct profiles.

The alluvial soils, which cover most of the Area, have been laid down by water. They are variable. Minor variations are likely to occur within each kind of soil that is shown on the map. In some places, Preston fine sand, which is not an alluvial soil, is so intermixed with an alluvial soil, San Mateo clay loam, that it was not practicable to map them separately. They are shown on the map as the Preston-San Mateo complex.

Water erosion is not great, but the Preston and other lighter textured soils are susceptible to wind erosion. Within the Area there are many small, bare outcrops of basalt rock, which together occupy 0.2 percent of the total area. This dark-colored rock came from volcanoes that were active ages ago.

Descriptions of Soils

The soil series and mapping units of the Bluewater Area are described in this section. For each series, a typical soil profile is described, and the location of a typical profile is given. Analytical data for five of the soil series are provided in tables 7 and 8. A soil series, as explained in the section, How a Soil Survey is Made, consists of one or more soil types, and in each soil type there may be one or more soil phases. Soil types and phases, together with Basalt outcrops and the Preston-San Mateo complex, are the units shown on the soil map in the back of this report. They are the mapping units for which use and management are given in the section, How to Use the Soils. The approximate acreage and proportionate extent of the soils shown on the detailed soil map are listed in table 1.

TABLE 1.—Approximate acreage and proportionate extent of the soils

Soil	Area	
	Acres	Percent
Basalt outcrops	18	0.2
Ladrillo clay, 0 to 1 percent slopes.....	87	.9
Preston fine sand, 0 to 5 percent slopes.....	334	3.4
Preston-San Mateo complex	1,259	13.0
Prewitt clay, 0 to 1 percent slopes	237	2.4
Prewitt clay loam, 0 to 1 percent slopes.....	2,483	25.6
Prewitt clay loam, sandy substratum, 0 to 1 percent slopes	1,395	14.4
Prieta stony loam, 0 to 5 percent slopes	289	3.0
Puerco clay, 0 to 1 percent slopes	271	2.8
Puerco clay, sandy substratum, 0 to 1 percent slopes	1,003	10.3
San Jose loam, 0 to 1 percent slopes	1,934	19.8
San Jose loam, sandy substratum, 0 to 1 percent slopes	404	4.2
San Jose loam, sandy substratum, 1 to 3 percent slopes	6	(1)
Total	9,720	100.0

¹ Less than 0.1 percent.

Ladrillo Series

The soils of the Ladrillo series, in this Area represented by Ladrillo clay, 0 to 1 percent slopes, are on immature outwash materials that were derived principally from highly colored shales and sandstones of the Chinle formation and were deposited by very slowly moving water. They occur in smooth areas that are commonly dissected by narrow, deeply depressed intermittent watercourses. They are mildly saline to highly charged with alkali salts. A considerable acreage is bare of vegetation; some areas support thin stands of sagebrush and grasses.

Ladrillo clay, 0 to 1 percent slopes (SW $\frac{1}{2}$ SE $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 19, T. 12 N., R. 10 W.) (capability unit IV-1):

Ap₁ 0 to 3 inches, dark reddish-gray (5YR 4.5/2.5, dry; to 5YR 4/2.5, moist) clay; very hard when dry, friable when moist; weak medium platy to weak coarse granular structure; calcareous; lower boundary clear and smooth.

Ap₂ 3 to 7 inches, reddish-gray (5YR 5/2, dry), dark reddish-gray (5YR 4/2, moist) clay; extremely hard when dry, very firm when moist; massive to very weak coarse subangular blocky structure;

Symbols in parentheses are Munsell color notations.

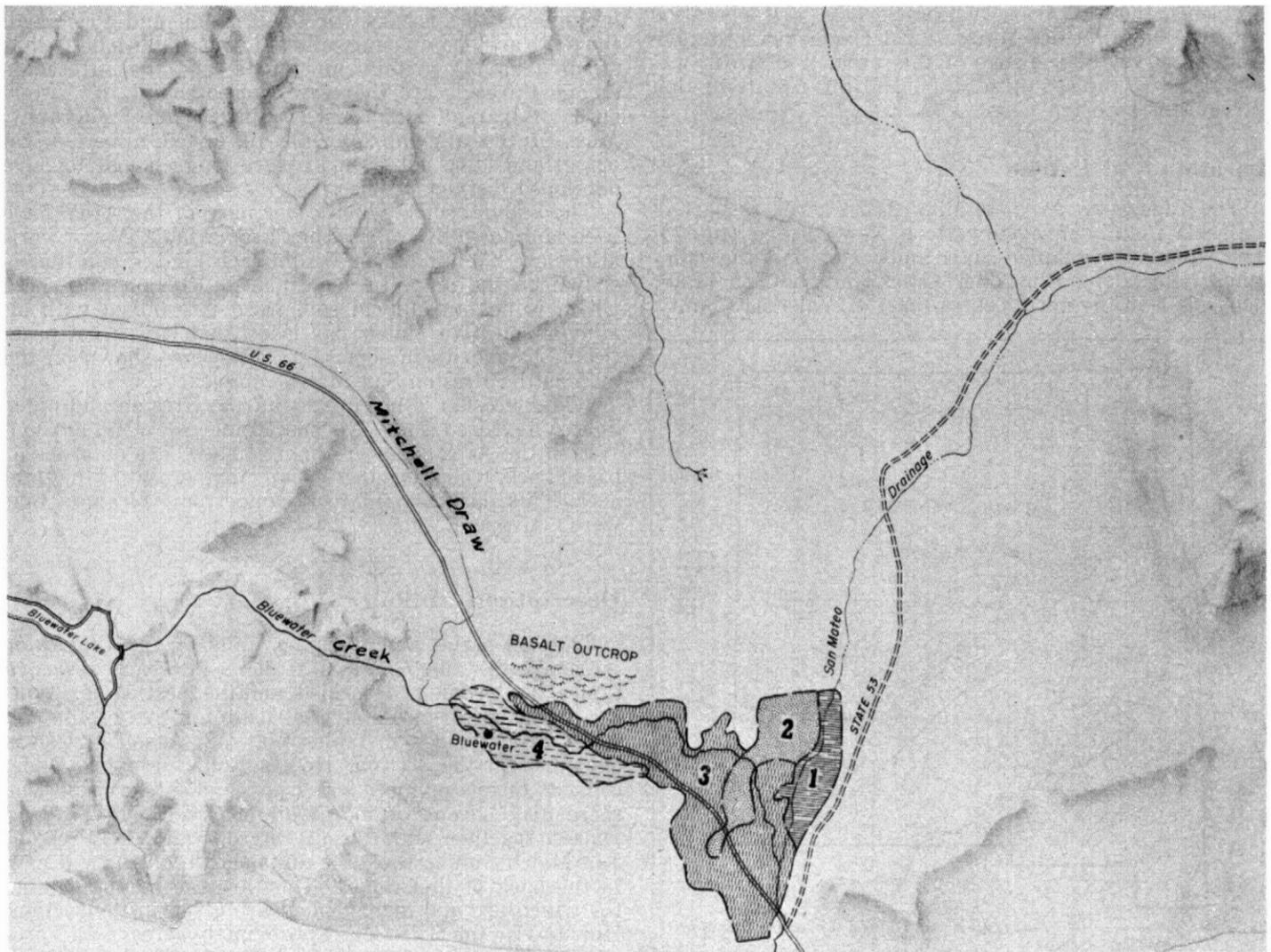


Figure 2.—Main soils and the drainage pattern of the Bluewater Area: 1, Puerco; 2, Preston; 3, Prewitt; and 4, San Jose.

calcareous; horizon contains a few partially decomposed shale particles; lower boundary clear and smooth.

- C₁ 7 to 11 inches, dark reddish-gray (5YR 4/2, dry), dark reddish-brown (5YR 3/2, moist) clay; extremely hard when dry, very firm when moist; massive to weak coarse subangular blocky structure; calcareous; horizon has a few slickensides (polished or slickened surfaces caused by sliding); lower boundary clear and smooth.
- C₂ 11 to 14 inches, reddish-brown (5YR 4/3, dry), dark reddish-brown (5YR 3/3, moist) clay; extremely hard when dry, very firm when moist; calcareous; massive to very weak coarse subangular blocky structure; horizon has a few distinct slickensides; lower boundary gradual and smooth.
- C₃ 14 to 22 inches, reddish-brown (5YR 4/3, dry), dark reddish-brown (5YR 3/3, moist) clay; extremely hard when dry, very firm when moist; massive to very weak coarse subangular blocky structure; calcareous; horizon has a few distinct slickensides; lower boundary is gradual and wavy.
- C₄ 22 to 30 inches, reddish-brown (5YR 5/3, dry, 5YR 4/3, moist) heavy silty clay loam; very hard when dry, firm when moist; massive to very weak coarse subangular blocky structure; calcareous; contains a few basalt fragments and a few small lime concretions; has a few distinct slickensides; lower boundary is abrupt and smooth.
- D 30 inches +, lime-coated basalt; rock shows little evidence of weathering.

Preston Series

The Preston series, in this Area represented by Preston fine sand, 0 to 5 percent slopes, are sandy soils without developed profiles. The soils are porous, calcareous, and grayish brown; they consist of transported material of mixed geological origin that has been deposited by wind. Preston soils occur in the arid regions where the average yearly temperature is about 50° F.

Preston fine sand, 0 to 5 percent slopes (SW½SE¼ sec. 28, T. 12 N., R. 10 W.) (capability unit VII-2):

- A 0 to 4 inches, light yellowish-brown (10YR 6/4, dry), brown (10YR 5/3, moist) fine sand; loose when dry and moist; single grained; calcareous; lower boundary gradual and smooth.
- AC 4 to 12 inches, light yellowish-brown (10YR 6/4, dry), brown (10YR 4/3, moist) loamy fine sand; soft when dry, loose or very friable when moist; single grained; calcareous; lower boundary gradual and smooth.
- C₁ 12 to 36 inches, light yellowish-brown (10YR 6/4, dry), brown (10YR 4/3, moist) loamy fine sand; soft or loose when dry, loose to very friable when moist; single grained; calcareous; appears to be somewhat more strongly calcareous than the horizon above; lower boundary gradual and smooth.
- C₂ 36 to 54 inches, very pale brown (10YR 7/4, dry), brown (10YR 5/3, moist) fine sand; loose when dry and moist; single grained; calcareous; approximate pH, 8.2; lower boundary gradual and smooth.
- C₃ 54 to 62 inches +, very pale brown (10YR 7/4, dry), brown (10YR 5/3, moist) fine sand; loose when dry and moist; single grained; calcareous; approximate pH, 8.2; the horizon contains a few calcium carbonate mycelia.

Preston-San Mateo complex: In this mapping unit Preston and San Mateo soils are so intricately mixed it was not practical to map them separately. A profile of the San Mateo soil is discussed under the San Mateo Series.

Prewitt Series

This series is represented in the Area by Prewitt clay, Prewitt clay loam, and Prewitt clay loam, sandy sub-

stratum. All of these soils have slopes of 0 to 1 percent. Soils of the Prewitt series are well-drained, reddish-brown, calcareous, alluvial soils developing on flood plains and low terraces. The parent material is stratified, but predominantly moderately fine textured, calcareous alluvium. The soils resemble those of the San Jose series but differ from them in having moderately fine textured materials. They are coarser textured than the Ladrillo soils.

Prewitt clay, 0 to 1 percent slopes (NE¼NE¼ sec. 17, T. 11 N., R. 10 W.) (capability unit III-1):

- A_p 0 to 5 inches, dark reddish-gray to reddish-brown (5YR 4/2.5, dry), dark reddish-brown (5YR 3/2.5, moist) clay; hard when dry, friable when moist; weak coarse subangular blocky structure that breaks to weak coarse granular; calcareous; lower boundary clear and smooth.
- AC 5 to 17 inches, dark reddish-gray to reddish-brown (5YR 4/2.5, dry), dark reddish-brown (5YR 3/2.5, moist) heavy silty clay loam or light clay; very hard when dry, firm when moist; weak medium subangular blocky structure; calcareous; lower boundary clear and smooth.
- C₁ 17 to 21 inches, pale-brown (10YR 6/3, dry), brown (10YR 4/3, moist) clay loam; hard when dry, friable when moist; massive; calcareous; lower boundary gradual and smooth.
- C₂ 21 to 28 inches, brown to light-brown (7.5YR 5.5/4, dry), dark-brown (7.5YR 4/3, moist) fine sandy clay loam; hard when dry, friable when moist; massive; calcareous; lower boundary abrupt and smooth.
- A_b 28 to 31 inches, brown (7.5YR 4.5/2, dry), dark-brown (7.5YR 3/2, moist) silty clay; very hard when dry, firm when moist; weak fine subangular blocky structure that breaks to very coarse granular; calcareous; contains a few small lime concretions; lower boundary clear and smooth.
- B_{ab} 31 to 38 inches, brown (7.5YR 4.5/2, dry), dark-brown (7.5YR 3/2, moist) silty clay; extremely hard when dry, very firm when moist; moderate medium angular blocky structure; calcareous; contains a few small lime concretions; lower boundary clear and smooth.
- BC_b 38 to 48 inches, strongly stratified horizon made up of thin lenses of fine sandy loam and silty clay loam averaging a clay loam in texture; colors range from brown (7.5YR 5/2, dry), very pale brown (10YR 7/3, dry) or dark brown (7.5YR 4/2, moist), to light yellowish brown (10YR 6/4, moist); hard when dry, friable when moist; weak coarse subangular blocky structure; calcareous; lower boundary abrupt and smooth.
- D 48 to 60 inches, reddish-brown (5YR 5/4, dry), dark reddish-brown (5YR 3/4, moist) fine sandy loam; slightly hard when dry; loose when moist; massive; calcareous.

Prewitt clay loam, 0 to 1 percent slopes (NE¼SE¼SW¼ sec. 15, T. 12 N., R. 11 W.) (capability unit II-1):

- A_{p1} 0 to 5 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3/3, moist) light clay loam; slightly hard when dry, very friable when moist; weak very fine subangular blocky to weak very fine crumb structure; calcareous; lower boundary is gradual and smooth.
- A_{p2} 5 to 11 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3/3, moist) light clay loam; slightly hard when dry, very friable when moist; weak fine subangular blocky structure that breaks to weak very coarse granular; calcareous lower boundary is gradual and smooth.
- BC 11 to 21 inches, reddish-brown (5YR 5/4, dry), dark reddish-brown (5YR 3.5/4, moist) light sandy clay loam; slightly hard when dry, very friable when moist; weak coarse subangular blocky structure; calcareous; lower boundary gradual and smooth.
- C₁ 21 to 28 inches, light-brown (7.5YR 6/4, dry), brown (7.5YR 5/4, moist) heavy fine sandy loam;

- slightly hard when dry, very friable when moist; massive; calcareous; the horizon contains a few small, faint mottles of light reddish brown (2.5YR 6/3, dry); lower boundary gradual and smooth.
- CG 28 to 36 inches, pale-yellow (2.5Y 7/3, dry), light olive-brown (2.5Y 5/3, moist) clay loam; hard when dry, friable when moist; weak medium subangular blocky structure; calcareous; lower boundary abrupt and smooth.
- C(D) 36 to 41 inches, weak-red (2.5YR 4/2, dry), dusky red (2.5YR 3.5/2, moist) heavy silty clay loam; very hard when dry, firm when moist; weak coarse subangular blocky structure; calcareous; contains a few small faint mottles of light olive brown (2.5Y 5/3, dry); lower boundary clear and smooth.
- C(D) 41 to 58 inches, weak-red (2.5YR /4.2, dry), dusky red (2.5YR 3/2, moist) light clay; extremely hard when dry, very firm when moist; massive; calcareous; contains a few small concretions of calcium carbonate; lower boundary clear and smooth.
- C(D) 58 to 62 inches +, reddish-brown (5YR 5/3, dry, 5YR 4/3, moist) fine sandy loam; slightly hard when dry, very friable when moist; massive; calcareous; contains a few small calcium carbonate concretions.

Prewitt clay loam, sandy substratum, 0 to 1 percent slopes (NW¼NW¼SE¼ sec. 32, T. 12 N., R. 10 W.) (capability unit II-1):

- A, 0 to 10 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3/3, moist) clay loam; soft when dry, very friable when moist; weak medium subangular blocky structure that breaks to fine crumb; strongly calcareous; lower boundary clear and smooth.
- BC 10 to 18 inches, brown (10YR 5/3, dry), dark reddish-brown (5YR 3/3, moist) clay loam; hard when dry, friable when moist; massive to very weak coarse subangular blocky structure; calcareous; lower boundary gradual and smooth.
- C, 18 to 32 inches, reddish-brown (5YR 5/3, dry, 5YR 4/3, moist) fine sandy loam; slightly hard when dry, friable when moist; massive; strongly calcareous; lower boundary gradual and smooth.
- D, 32 to 60 inches +, light yellowish-brown (10YR 6/4, dry), yellowish-brown (10YR 5/4, moist) fine sand; loose when dry, nonsticky when wet; single grained; calcareous; contains a few very thin strata of finer textured material.

Prieta Series

The soils of the Prieta series have developed in place on basic igneous materials (basalt). Prieta stony loam, 0 to 5 percent slopes, is the only soil of this series mapped in the Area.

Prieta stony loam, 0 to 5 percent slopes (SW¼NW¼SE¼ sec. 15, T. 12 N., R. 11 W.): (capability unit VII-1):

- A, 0 to 3 inches, reddish-brown (5YR 5.5/3, dry), dark reddish-brown (5YR 3.5/3, moist) loam; very soft when dry, very friable when moist; weak coarse platy structure that breaks to weak very fine subangular blocky; weakly calcareous; lower boundary clear and smooth.
- B, 3 to 7 inches, reddish-brown (5YR 4/3, dry), dark reddish-brown (5YR 3/3, moist) heavy loam; slightly hard when dry, friable when moist; weak coarse prismatic structure that breaks to moderate medium subangular blocky; weakly calcareous; lower boundary clear and smooth.
- B, 7 to 13 inches, brown (7.5YR 4/2, dry), dark-brown (7.5YR 3/2, moist) clay loam; hard when dry, friable when moist; weak to moderate coarse subangular blocky structure; calcareous; lower boundary clear and smooth.

- C, 13 to 18 inches, brown (10YR 5/3, dry), dark-brown (10YR 4/3, moist) light clay loam; slightly hard when dry, friable when moist; massive to weak coarse subangular blocky structure; strongly calcareous; the horizon contains moderate amounts of accumulated calcium carbonate, chiefly in the form of lime nodules; lower boundary abrupt and smooth.
- D 18 inches +, lime-coated hard basalt rock; appears to be practically unweathered.

Puerco Series

In the Puerco series are soils derived largely from argillaceous shales but also from some sandstones. In this Area the members are Puerco clay and Puerco clay, sandy substratum. Both soils have slopes of 0 to 1 percent. The Puerco soils occur on the flood plains of intermittent streams. They have unusually hard, dense subsoils, which often have pronounced vertical shrinkage cracks. The subsoils are normally uniform in texture, but in places they contain thin strata of darker colored coarser materials.

Puerco clay, sandy substratum, 0 to 1 percent slopes (SW¼NE¼SE¼ sec. 34, T. 12 N., R. 10 W.) (capability unit IV-1):

- A, 0 to 3 inches, pale-brown (10YR 6/3, dry), brown (10YR 4.5/3, moist) clay; soft when dry, very friable when moist; weak to moderate coarse platy structure; calcareous; very vesicular; lower boundary abrupt and smooth.
- A, 3 to 8 inches, pale-brown (10YR 6/3, dry), brown (10YR 5/3, moist) clay; hard when dry, friable when moist; weak coarse subangular blocky structure; calcareous; lower boundary clear and smooth.
- BC 8 to 17 inches, pale-brown (10YR 6/3, dry), brown (10YR 5/3, moist) clay; extremely hard when dry, very firm when moist; weak coarse angular blocky structure; calcareous; lower boundary gradual and smooth.
- BC, 17 to 23 inches, grayish-brown (10YR 5/2.5, dry), dark grayish-brown (10YR 4/2, moist) clay; extremely hard when dry, very firm when moist; weak coarse subangular blocky structure; calcareous; contains some accumulated calcium carbonate, chiefly in the form of nodules; lower boundary abrupt and smooth.
- C, 23 to 28 inches, grayish-brown (2.5Y 5/2, dry), very dark grayish-brown (2.5Y 3/2, moist) heavy clay loam; very hard when dry, friable when moist; weak fine subangular blocky to very coarse granular structure; calcareous; contains moderate amounts of accumulated calcium carbonate and calcium sulfate, chiefly in the form of mycelia; lower boundary gradual and smooth.
- C, 28 to 35 inches, gray (10YR 5/1, dry), very dark gray (10YR 3/1, moist) clay loam; very hard when dry, firm when moist; weak medium angular blocky structure; calcareous; moderate to strong accumulation of calcium carbonate and calcium sulfate, chiefly in the form of mycelia; lower boundary gradual and smooth.
- C, 35 to 41 inches, pale-yellow (2.5Y 7/3, dry), light yellowish-brown (2.5Y 6/3, moist) sandy clay; extremely hard when dry, very friable when moist; weak coarse subangular blocky structure; calcareous; contains moderate amounts of accumulated calcium sulfate and calcium carbonate; contains a few specks and stains of gray (5Y 6/1) and moderate amounts of very thin strata, or lenses; lower boundary gradual and smooth.
- D, 41 to 48 inches, pale-yellow (5Y 7/3, dry), pale-olive (5Y 6/3, moist) sandy loam; hard when dry, friable when moist; massive; calcareous; contains specks and stains of gray (5Y 6/1); lower boundary gradual and smooth.
- D, 48 to 52 inches, pale-yellow (2.5Y 8/3, dry), light yellowish-brown (2.5Y 6/3, moist) loamy sand; soft when dry, very friable when moist; single grained, or structureless; calcareous; horizon

contains moderate amounts of accumulated calcium carbonate and calcium sulfate, mainly in the nodular form.

Puerco clay, 0 to 1 percent slopes (capability unit IV-1): Similar to Puerco clay, sandy substratum, 0 to 1 percent slopes. The difference is only in depth to loamy sand, which is at a depth of more than 5 feet in this soil.

San Jose Series

These are well-drained, reddish-brown, calcareous, alluvial soils that developed on flood plains and low terraces. The parent material is stratified, but predominantly medium textured, calcareous alluvium. In this Area the members of this series are one mapping unit of San Jose loam and two units of San Jose loam, sandy substratum. Slopes range from 0 to 3 percent. San Jose soils resemble those of the Prewitt series but are predominantly medium textured. They have redder hues and are coarser textured than the San Mateo soils.

San Jose loam, 0 to 1 percent slopes (NE½SE¼NW¼ sec. 23, T. 12 N., R. 11 W.) (capability unit I-1):

- A₁ 0 to 4.5 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3/3, moist) loam; soft when dry, very friable when moist; weak fine crumb structure; calcareous; lower boundary gradual and smooth.
- AC 4.5 to 12 inches, light reddish-brown (5YR 6/3, dry), reddish-brown (5YR 4/3, moist) heavy very fine sandy loam or light loam; slightly hard when dry, very friable when moist; very weak very coarse subangular blocky structure; calcareous; lower boundary abrupt but wavy.
- C₁ 12 to 15 inches, light reddish-brown (5YR 6/3, dry), reddish-brown (5YR 4/3, moist) loamy fine sand; loose when dry, very friable when moist; single grained, or structureless; calcareous; lower boundary abrupt and broken.
- C₂ 15 to 20 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3/3, moist) very fine sandy loam or light loam; hard when dry, friable when moist; massive, calcareous; lower boundary abrupt and wavy.
- C₃ 20 to 25 inches, light-brown (7.5YR 6/4, dry), brown (7.5YR 4/3, moist) loamy fine sand; loose when dry or moist; single grained, or structureless; calcareous; lower boundary abrupt and smooth.
- A_{1b} 25 to 31 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3/3, moist); clay loam; hard when dry, firm when moist; massive; calcareous; lower boundary gradual and smooth.
- AC₁ 31 to 38 inches, reddish-brown (5YR 5/2.5, dry), dark reddish-brown (5YR 3/2.5, moist) heavy loam; hard when dry, friable when moist; massive; calcareous; lower boundary gradual and smooth.
- C 38 to 59 inches, reddish-brown (5YR 4/2.5, dry), dark reddish-brown (5YR 3/2.5, moist) silty clay loam; hard when dry, firm when moist; massive; calcareous; lower boundary gradual and smooth.

San Jose loam, sandy substratum, 0 to 1 percent slopes (NE½SE¼SW¼ sec. 5, T. 11 N., R. 10 W.) (capability unit I-1):

- A_p 0 to 3 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3.5/3, moist) fine sandy loam; soft when dry, very friable when moist; weak very coarse platy structure that breaks to weak very fine granular; strongly calcareous; a few pebbles and some larger rounded stones on the surface; lower boundary clear and smooth.
- AC 3 to 11 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3.5/3, moist) heavy loam or light fine sandy clay loam; slightly hard when dry; friable when moist; very weak coarse sub-

angular blocky structure; strongly calcareous; lower boundary gradual and smooth.

- C₁ 11 to 16 inches, reddish-brown (5YR 5/3.3, dry), (5YR 4/3.5, moist) heavy loam or light fine sandy clay loam; slightly hard when dry, very friable when moist; massive; strongly calcareous; lower boundary clear and smooth.
- C_{ca1} 16 to 25 inches, reddish-brown (5YR 5/3, dry), dark reddish-brown (5YR 3.5/3, moist) light clay loam; slightly hard when dry, very friable when moist; weak medium prismatic structure that breaks to weak medium subangular blocky; very strongly calcareous; this is a weak lime horizon containing a few medium-sized, soft lime concretions; lower boundary gradual and smooth.
- C_{ca2} 25 to 34 inches, light-brown to brown (7.5YR 5.5/3, dry); brown to dark-brown (7.5YR 4/3, moist) loam; slightly hard when dry, very friable when moist; very weak coarse prismatic structure that breaks to very weak medium subangular blocky; very strongly calcareous; this is a weakly developed lime horizon containing a few small lime concretions; lower boundary gradual and smooth.
- C₂ 34 to 42 inches, reddish-brown to brown (5YR 5/3, dry), dark reddish-brown or dark-brown (5YR 3.5/3, moist) loamy fine sand; slightly hard when dry, very friable when moist; massive; strongly calcareous; horizon contains a few very small lime concretions.
- C₃ 42 to 45 inches, thin layers of stratified sand and gravel.
- C₄ 45 to 60 inches, reddish-brown to brown (5YR 5/3, dry), dark reddish-brown to dark brown (5YR 3.5/3, moist) sandy loam; slightly hard when dry, very friable when moist; massive; strongly calcareous.

San Mateo Series

The San Mateo soils are mapped with the Preston soils as a complex because, in places, they are so intricately associated that it is not practical to map them separately. The San Mateo series consists of well-drained, calcareous, stratified alluvial soils occurring on the flood plains and low terraces along streams and rivers. They show little evidence of soil development, other than slightly darker surface horizons, weak structure, or very weak and discontinuous horizons of lime accumulation.

San Mateo sandy clay loam (SE½SE¼SW¼ sec. 33, T. 12 N., R. 10 W.) (capability unit VII-3; Preston-San Mateo complex):

- A₁ 0 to 2 inches, reddish-brown (5YR 5/3, dry, 5YR 4/3, moist) light fine sandy clay loam; slightly hard when dry, very friable when moist; weak medium subangular blocky structure that breaks to weak fine and medium granular; calcareous; lower boundary gradual and smooth.
- AC 2 to 9 inches, reddish-brown (5YR 5/3, dry, 5YR 4/3, moist) clay loam or sandy clay loam; hard when dry, friable when moist; weak coarse prismatic structure that breaks to weak coarse subangular blocky; strongly calcareous; lower boundary clear and smooth.
- C₁ 9 to 13 inches, pale-brown (10YR 6/3, dry), brown (10YR 5/3, moist) silty clay loam stratified with thin lenses of fine sandy loam; hard when dry, friable when moist; very weakly developed coarse subangular blocky structure; strongly calcareous; lower boundary gradual and smooth.
- C₂ 13 to 21 inches, very pale brown (10YR 7/3.5, dry), brown to yellowish-brown (10YR 5/3.5, moist) very fine sandy loam; slightly hard when dry, very friable when moist; massive; strongly calcareous; lower boundary gradual and smooth.
- C₃ 21 to 25 inches, very pale brown (10YR 7/4, dry), brown (10YR 5.5/3, moist) silty clay loam; slightly hard when dry, very friable when moist; massive strongly calcareous; lower boundary gradual and smooth.

- C. 25 to 34 inches, light yellowish-brown (10YR 6/4, dry), dark yellowish-brown (10YR 4/4, moist) stratified loam, and very fine sandy loam; slightly hard when dry, very friable when moist; massive; strongly calcareous; lower boundary gradual and smooth.
- C₂ 34 to 50 inches, pale-brown (10YR 6/3, dry), brown (10YR 5/3, moist) silty clay stratified with silty clay loam; hard when dry, firm when moist; massive; strongly calcareous; lower boundary clear and smooth.
- C₃ 50 to 56 inches, reddish-brown (5YR 4/3, dry), dark reddish-brown (5YR 3/3, moist) silty clay loam; hard when dry, firm when moist; massive; strongly calcareous; lower boundary gradual and smooth.
- C₄ 56 to 60 inches, reddish-brown (5YR 5/3, dry), (5YR 4/3, moist) fine sandy clay loam; slightly hard when dry, friable when moist; massive; strongly calcareous.

applied. Table 2 summarizes these characteristics for the soils of the Bluewater Area.

Sources of Water

The Bluewater Reservoir and drilled wells are the main sources of irrigation water in the Area.

Ground water.—The water comes from precipitation which seeps downward to aquifers. In the Bluewater Valley, ground water occurs in fairly large quantities in the alluvial valley fill and in the San Andres limestone. Minor quantities are in the lower sandstones of the Chinle formation.

The wells that yield best are drilled in the San Andres formation. The water lies in joint cracks, solution cavities, and in the interbeds of sandstone that occur in the San Andres formation. Sometimes successful irrigation wells are not obtained because other wells, even though they are fairly distant, interfere with the supply of water.

Water-level fluctuation.—Recharge to the ground water is derived principally from surface water that leaks from the lower end of Bluewater Canyon and the canals, after it has been released from Bluewater Reservoir. Precipitation in the Zuni Mountains, and upon the alluvium and lava in the valley also recharges the ground water. Some recharge is derived from the return of irrigation water applied to the land.

Precipitation in 1952 in the Grants-Bluewater Area was about 75 percent of the normal of 10.0 inches. During the growing season (April to September) it was about 85 percent of the normal of 7.2 inches. But in April alone, as recorded at Bluewater, it was 1.65 inches, or 1.16 inches above the normal for the month.

About 6,000 acre-feet of surface water was released for irrigation from Bluewater Reservoir in 1952 from May 21 to August 19, according to records at the gaging station on Bluewater Creek near Bluewater. Of this

Irrigation

The agriculture of the Bluewater Area depends on irrigation. The critical problem is that of applying water at the time and in the amount that will obtain best yields without damaging the soils. Farmers must guard against accumulation of salts in the soils, the overirrigating that damages crops and impairs soil tilth, and the planting of crops on a soil that will not tolerate the kind of irrigation those crops must have. The purpose of this section is to point out the characteristics of the soil that affect their suitability for irrigation farming, the sources of water, and the practices of irrigation now used and how they can be improved.

Characteristics of Soils That Affect Irrigation

The suitability of a soil for irrigation depends on many characteristics, chief among which are permeability of the subsoil and substratum, amounts of salts in the profile, and workability of the soil when water is

TABLE 2.—Permeability, salinity, and workability of the soils

Soil	Permeability of subsoil ¹	Permeability of substratum ²	Salinity hazard	Workability
Ladrillo clay, 0 to 1 percent slopes	Slow to very slow.	Slow to very slow.	Moderate to severe.	Poor.
Preston fine sand, 0 to 5 percent slopes	Rapid to very rapid.	Rapid to very rapid.	None	Good.
Preston-San Mateo complex	Slow to rapid	Slow to rapid	Slight to none.	Good to fair.
Prewitt clay, 0 to 1 percent slopes	Slow	Slow	Moderate	Poor.
Prewitt clay loam, 0 to 1 percent slopes	Slow	Slow	Slight to moderate.	Fair.
Prewitt clay loam, sandy substratum, 0 to 1 percent slopes.	Slow	Rapid	Slight	Fair.
Prieta stony loam, 0 to 5 percent slopes	(3)	(3)	None	Hazardous
Puerco clay, 0 to 1 percent slopes	Slow to very slow.	Slow to very slow.	Moderate to severe.	Poor.
Puerco clay, sandy substratum, 0 to 1 percent slopes	Slow to very slow.	Rapid	Slight to moderate.	Poor.
San Jose loam, 0 to 1 percent slopes	Moderate to slow.	Slow	Slight	Good.
San Jose loam, sandy substratum, 0 to 1 percent slopes	Moderate to rapid.	Rapid	None	Good.
San Jose loam, sandy substratum, 1 to 3 percent slopes	Moderate to rapid.	Rapid	None	Good.

¹ Subsoil is the layer of soil material at depths of 12 to 36 inches.

² Substratum is the layer of soil material at depths of 36 to 60 inches.

³ Permeability not rated because soil is shallow to bedrock.

amount, about 2,600 acre-feet was released in June. Surface water was not available in 1950 and 1951.

Water levels in observation wells in the Area have been measured periodically since 1946². In February 1952, water levels were measured in 34 wells, and in about 29 of these wells at bimonthly intervals thereafter. The records reported do not include the few wells that were measured in February only.

Ground-water levels in the wells near Bluewater showed net rises during 1952, but those in the irrigated area southeast of Bluewater to near Grants showed net declines to new low levels. In the area near Bluewater, the rises were associated with the availability of surface water, and they ranged from less than 0.1 foot to 4.7 feet. The greatest rise occurred in a well near the mouth of Bluewater Canyon. Because of the increase in pumpage in this part of the Area in 1952, the rises were less than those that occurred in 1948 and 1949 when a comparable amount of surface water was available. By the end of 1952, the water levels in this area were about 30 feet lower than in February 1946. In the irrigated area southeast from Bluewater, during this period, the net declines in water level ranged from 0.4 foot to 1.0 foot. These contrast with declines of 3 to 4 feet in the Area during 1950 and 1951 when surface water was not available and pumpage was somewhat greater. Ground-water levels in this area were from 15 to 20 feet lower at the end of 1952 than when records began in 1946.

The 1952 records obtained from the recording gage on a well about 2.5 miles northwest of Bluewater and about 0.25 miles east from Bluewater Creek show that from January until April 15 the water level rose about 2 feet. Pumping began April 15, and from then until May 21 the water level declined 9 feet. Between May 21 and June 20, the water level rose 10 feet in response to release of surface water from Bluewater Reservoir. From June 20 to about mid-September, the water level declined about 4 feet in response to pumping. Pumpage decreased at the end of the growing season in mid-September. The water level began to rise and by the end of December was 4.4 feet above the level recorded at the beginning of 1952.

Electric power records, for 21 of the 23 irrigation wells used in 1952, indicate that 10,400 acre-feet of ground water was used for irrigation. This was a decrease of nearly 2,000 acre-feet from that pumped in 1951. Pumpage in the upper part of the district near Bluewater, however, where most of the surface water was applied, increased from about 600 acre-feet in 1951 to almost 1,000 acre-feet in 1952.

Irrigation Practices

The primary objective of most irrigation is to fill the root zone of the soil without excessive waste of water. To do this effectively, we should know how much water is needed to refill the soil when alfalfa or a similar crop needs irrigation to maintain rapid growth. For soils such as the Prewitt clay loams and San Jose loams, a 5-inch irrigation will ordinarily be ample to wet the soil to a depth of about 5 feet. You may need an additional

inch, or a total of 6 inches, to take care of evaporation and ditch loss. If more water than this is applied, the soil may be moistened below a depth of 5 feet, but field crops in the Bluewater Area remove very little water below a depth of 5 feet. The water below 5 feet is therefore wasted.

For carrots the first few irrigations in the season are made to obtain and maintain a stand. The length of time for such irrigations usually is determined by the rate at which the water moves (subbing) into the seed-bed. This irrigation procedure is inefficient, and appreciable quantities of water pass beyond the root zone. Later in the season, to maintain a rapid growth of carrots, a 3- to 4-inch refill irrigation will usually be ample. The first irrigation for carrots requires an acre-foot or more of water per acre, under the present practice of planting on 40-inch beds. As carrots are grown on 90 percent of the cultivated lands, any reduction in the amount of water used would be a considerable saving.

The carrots are ordinarily planted in 2-row beds, 40 inches wide. They are watered from furrows on both sides of the beds. Unpublished studies show that from 10 to 20 hours are required to wet completely through the beds on Prewitt clay loams and San Jose loams. (This wetting of the beds is known as subbing; it is a movement of soil water by capillarity, not gravity—a creeping movement.) From 10 to 15 inches of water are applied to beds ranging from 430 to 530 feet in length. Some growers report using more water than this to insure uniform stands.

The amount of water required can be reduced by applying the following conservation practices:

1. Speeding up the rate of subbing by improving the soil structure. Soil structure may be improved by a crop rotation that includes irrigated pasture or grasses.
2. Preparation of deep, wide furrows so that a larger flow of water reaches the end of the furrows in 2 hours or less. Then cut back the flow to reduce the amount of excess water, or waste water, at the end of the furrows.
3. Level the land so that the entire irrigation is uniform and subbing may be complete throughout the length of the run.
4. Stop irrigating as soon as the soil has subbed across the beds. Studies show that, at this time, the soil is saturated and cannot hold more water.
5. Gypsum may be applied to improve soils having excessive amounts of exchangeable sodium; it improves the permeability of the soil.

When to irrigate

When do you need to irrigate? To what level should the "readily available" moisture in the crop root zone drop before you put on water?

For most row crops, you can delay irrigation for several days if the readily available moisture is more than half the total amount that can be held in the soil to a depth of 6 to 12 inches. In contrast, growth has slowed and you have missed the best time to irrigate if the level of readily available moisture is lower than one-fourth of the amount that can be held to a depth of 6 to 12 inches. What is readily available moisture?

² For further information see: WATER LEVELS AND ARTESIAN PRESSURES IN OBSERVATION WELLS IN THE UNITED STATES IN 1952. U. S. Geol. Survey Water Supply Paper 1226, 237 pp., 1956.

It is the moisture in the soil in the range between field capacity, which is all the water the soil can hold, and the level at which plants with mature root systems begin to show drought symptoms.

The best way to keep plants growing rapidly is to irrigate when the level of readily available moisture in the top 6 to 12 inches is between one-fourth and one-half. The spade is perhaps the most satisfactory tool for examining moisture in the surface foot of soil. For greater depths, a soil tube or an auger is helpful. These are the steps to take in establishing the amount of readily available moisture in the samples dug from the soil:

1. Take a handful of soil from a depth of between 6 and 12 inches.
2. Squeeze the handful of soil very firmly three or four times. Use just about the pressure you would on a hard-milking cow, not too much, not too little.
3. If the soil is too dry to form a ball, it contains less than one-fourth as much readily available moisture as it would at field capacity.
4. If the soil forms a ball, it contains at least one-fourth the amount of readily available moisture it would have at field capacity.
5. Toss the moist ball about 1 foot into the air, and catch it just as you would catch a baseball.
6. If the ball breaks within five tosses or less, it is *fragile*. A fragile ball contains from one-fourth to one-half the total readily available moisture. If the ball is fragile, the soil is at the best moisture content for irrigation.
7. If the ball is still intact after it has been tossed five times, it is *durable*. A durable ball contains more than one-half the total amount of readily available moisture. You do not need to irrigate if the ball is durable.
8. If, after you have squeezed the soil firmly, some sticks to your hand, the readily available moisture is between 75 and 100 percent of field capacity.

Except for the sandy soils, the ball test is a sound, proven guide for the farmer who wants to apply water efficiently. Balls of sandy soil are usually fragile for the entire range from one-fourth of available moisture to field capacity.

The ball test is also useful in determining time of tillage. Tillage pans are probably created when the moisture content is more than 50 percent of field capacity. One-way disks are especially likely to create tillage pans.

How much water to apply

After you have made the ball test, you need to decide how many inches of water to apply. The following list shows the number of inches of water to apply to most soils of the Area to bring the moisture content of the surface foot to field capacity.

	Inches of water per foot of soil
Medium to fine textured soils	2.1
Sandy loams containing more than 70 percent sand	1.2
Loamy sands containing up to 85 percent sand	1.2
Loamy sands containing 85 to 95 percent sand	1.0
Sands (more than 95 percent sand)	0.7

The values are based on irrigations trials, and they cover the ranges of soil texture common in the Area. They represent the average depth of water that the soils of various textures will hold in readily available form.

With this information, you can estimate, within 1 inch, the depth of water needed to fill the root zone. If you want to apply an inch of water, you will need to apply more than 1 inch to compensate for the inefficiency of irrigation.

Effect of Irrigation on Soil Structure

Soil structure has deteriorated in the Bluewater Area because: (1) Water from wells with a high sodium content has been used; (2) crops have not been systematically rotated so as to include green-manure crops; (3) the supply of organic matter has been depleted by continued cropping; and (4) harvesting and tilling have been done when the soils were too wet. The decline in soil structure has reduced intake of irrigation water and made it more difficult and expensive to prepare seedbeds.

Some farmers have tried soil amendments, mainly gypsum, as a way of improving structure. One farmer reported that he used 20 percent less water on San Jose

TABLE 3.—Analyses of water from 4 wells in the Bluewater Area

Location ¹	Laboratory No.	Electrical conductivity (EC X 10 ⁶)	Dissolved solids ²		Percentage sodium	Milliequivalents per liter						
			Parts per million	Tons per acre foot		Calcium	Magnesium	Sodium ³	Chloride	Sulfate	Carbonate	Bicarbonate
Sec. 4, T. 11 N., R. 10 W.	894	850	444	0.60	8.9	6.3	2.9	0.9	0.9	4.9	0.0	4.3
Sec. 29, T. 12 N., R. 10 W.	887	1,300	728	.99	23.8	7.9	3.3	3.5	1.8	8.7	.0	4.2
Sec. 15, T. 12 N., R. 11 W.	891	2,000	1,240	1.69	33.9	11.2	4.0	7.8	3.7	11.5	.0	7.8
Sec. 23, T. 21 N., R. 10 W.	722	2,400	1,084	1.47	79.7	5.4	.8	24.4	7.5	18.3	.3	4.5

¹ Section, township, and range.

² Determined by evaporation.

³ Sodium values obtained by calculation.

loam after adding a ton of gypsum per acre to the irrigation water. Among farmers, opinions vary considerably on the merits of gypsum as a soil conditioner. Its use needs to be further investigated before recommendations can be made.

Salinity of Irrigation Water

When water for irrigation came only from Bluewater Reservoir, salts were not a problem. Now, some of the soils irrigated from wells are becoming saline. Salts, whether they come from irrigation waters or from the parent material of the soil, have a bad effect on plant growth. They influence the osmotic pressure of the soil solution. The higher the concentration of dissolved salt, the greater the osmotic pressure of the soil solution, and the more difficult it is for plants to get water from the soil. If the salt concentration in a soil is high, a plant may actually wilt while its roots are in water.

Table 3 lists four wells in the Bluewater Area and gives for each of the wells the electrical conductivity, dissolved solids, and the amount of the various kinds of salts.³ This table indicates the range of concentration in the Area. The electrical conductivity, a measure of salt concentration, ranged from 850 micromhos for the best well, to 2,400 for the well that produced the water with the highest salt concentration. The measurement of salt, converted to tons per acre-foot of water, ranged from 0.6 ton for the best well to 1.69 tons for the most salty well. For assistance in judging the suitability of water for irrigation, consult your local representative of the Soil Conservation Service or your county agent.

Methods of Irrigation and Their Effect on Salt Distribution

With furrow and border-check irrigation methods, the length of the run, size of the stream, slope of the land, and time of application govern the depth to which water is applied and the uniformity with which it is spread. These factors determine the amount of leaching and the extent to which salinity is controlled. If salts are not removed through leaching, they accumulate in the soil in direct proportion to the amount of salt in the irrigation water and to the depth to which the water is applied.

Furrow irrigation, though well suited to row crops, encourages accumulation of salt on the ridges between the furrows. Leaching of salt therefore occurs only in the furrows. Wide-bottomed furrows that resemble narrow border strips have certain advantages in wetting the surface of the soil uniformly, and because of the more even wetting, they help distribute salt to a larger part of the root zone.

Where furrow irrigation is practiced for row crops, plowing mixes the top part of the surface soil, the place where salts tend to accumulate, with the soil material lower down. The mixing minimizes the effect of the salts by distributing them more uniformly. But when excess salts accumulate, cultivation is no longer an

³ For further information see: Dregne, H. E., and Maker, H. J., IRRIGATION WELL WATERS OF NEW MEXICO, CHEMICAL CHARACTERISTICS, QUALITY, AND USE. Agr. Expt. Sta. and New Mexico Col. Agr. and Mech. Arts Bul. 386, 29 pp. 1954.

answer to the problem. Crops need to be changed, and the method of irrigation altered to flooding or ponding. The flooding and ponding will leach out the salts, if the soil has good drainage.

Salt Tolerance of Crops

Crops vary in their ability to grow under saline conditions. The crops that are grown or can be grown in the Bluewater Area are listed according to salt tolerance as follows:

High salt tolerance	Medium salt tolerance	Low salt tolerance
Spinach	Tomatoes	Field beans
Asparagus	Broccoli	Green beans
Barley	Cabbage	Radishes
Western wheatgrass	Cauliflower	Celery
Garden beets	Lettuce	Alsike clover
	Potatoes	Ladino clover
	Carrots	
	Onions	
	Peas	
	Rye	
	Wheat	
	Oats	
	Sweetclover	

Amendments for Controlling Alkali

If drainage is good, salt can be flushed from the soil by heavy irrigations. Sodium is more difficult to remove because it is held by the clay particles and must be replaced by some other element before it can be washed out of the soil.

Gypsum and sulfur are the two amendments most commonly used to improve soil affected by sodium salts. Gypsum can be used on any soil. Sulfur is effective only on the soils that contain free lime (calcium carbonate). Gypsum is moderately soluble and therefore can be applied by dissolving it in irrigation water that is spread over the field. Sulfur is not soluble in water, so it must be applied directly to the soil and mixed into it. Before it can be effective, the sulfur in the soil must be converted to sulfate by microbial action. Table 4 gives amounts of gypsum and sulfur needed to replace indicated amounts of exchangeable sodium.

TABLE 4.—Gypsum or sulfur required to replace indicated amounts of exchangeable sodium

	Exchangeable sodium (Milliequivalents per 100 grams of soil)	Gypsum ¹ (CaSO ₄ ·2H ₂ O)	Sulfur (S)
		Tons per acre for 6 inches of soil ²	Tons per acre for 6 inches of soil ²
1.	0.9	0.16
2.	1.7	.32
3.	2.6	.48
4.	3.4	.64
5.	4.3	.80
6.	5.2	.96
7.	6.0	1.12
8.	6.9	1.28
9.	7.7	1.44
10.	8.6	1.60

¹ Amounts of gypsum rounded to the nearest 0.1 ton.

² An acre of soil, to a depth of 6 inches, weighs about 2 million pounds.

How to Use the Soils

This section explains the system of land-capability classification; places the soils in capability units and suggests management for each unit; and provides yield estimates for carrots under two levels of management. The practices of management suggested for the various capability units are guides to farm management, not a plan of management for any farm. The reader will want to study the section on irrigation along with this section, as methods of applying water to soils are extremely important in the agriculture of the Bluewater Area.

Capability Classification

Capability classification is helpful in choosing good uses for each soil and good combinations of practices for it and in estimating the responses of crops or other plants grown on it. In grouping soils according to their capability, each soil is placed in one of eight general classes according to the degree of its natural limitations—that is, its suitability for crops, grazing, or other uses; the risk of erosion or other damage when it is used; and the management that it needs. Classes are numbered by Roman numerals.

Within each class there are capability units, or groups of similar soils. Capability units are groups of soils for which practical systems of management can be suggested. The soils of the Bluewater Area are listed by class and capability unit as follows:

Class I.—Soils that have few limitations for cropping or other uses.

I-1: Deep loamy soils:

San Jose loam, 0 to 1 percent slopes.

San Jose loam, sandy substratum, 0 to 1 percent slopes.

Class II.—Soils that have moderate limitations for use as cropland, or moderate risks of damage if not protected.

II-1: Soils subject to salt accumulations:

Prewitt clay loam, 0 to 1 percent slopes.

Prewitt clay loam, sandy substratum, 0 to 1 percent slopes.

Class III.—Soils that have severe limitation for use as cropland, or severe risks of damage if not protected.

III-1: Clay soil subject to salt accumulations:

Prewitt clay, 0 to 1 percent slopes.

III-2: Loam soil:

San Jose loam, sandy substratum, 1 to 3 percent slopes.

Class IV.—Soils suitable for only a few crops or for occasional cultivation and requiring extreme care if cultivated.

IV-1: Saline clay soils:

Ladrillo clay, 0 to 1 percent slopes.

Puerco clay, 0 to 1 percent slopes.

Puerco clay, sandy substratum, 0 to 1 percent slopes.

Class VII.—Soils not suitable for cultivation and subject to severe limitations or risks when used for grazing or woodland.

VII-1: Very shallow soil on basalt:

Prieta stony loam, 0 to 5 percent slopes.

VII-2: Sandy soil with low water-holding capacity:

Preston fine sand, 0 to 5 percent slopes.

VII-3: Complex of sandy and medium-textured soil: Preston-San Mateo complex.

Class VIII.—Soils not suitable for cultivation, grazing, or woodland.

VIII-1: Basalt outcrops.

Suggestions for Use and Management

Capability unit I-1.—The two soils in this unit are deep, loamy, and moderately permeable. They have good moisture-holding capacity. The soils are:

San Jose loam, 0 to 1 percent slopes.

San Jose loam, sandy substratum, 0 to 1 percent slopes.

When these soils are used for crops, they need practices to maintain good fertility and structure, especially crop rotation, cover crops, green-manure crops, and such commercial fertilizers as are needed to furnish those plant nutrients deficient in the soils.

The soil with a sandy substratum must be leveled with care to avoid leaving a surface soil that is too sandy. Care must be taken to avoid overirrigation and leaching of plant nutrients.

Suitable crops are carrots, onions, broccoli, cauliflower, lettuce, other truck crops, small grains, alfalfa, and pasture plants. The cropping system should be one that uses residues or green-manure crops to build up organic matter. Early carrots can be followed by fall-sown grain, which is plowed under in spring and followed by carrots again. If carrots are not grown, the cropping system should include soil-building crops such as alfalfa for 3 to 5 years for each 3 years that vegetables or other soil-depleting crops are grown.

Capability unit II-1.—In this group are well-drained, reddish-brown, calcareous alluvial soils on flood plains and low terraces. The soils are:

Prewitt clay loam, 0 to 1 percent slopes.

Prewitt clay loam, sandy substratum, 0 to 1 percent slopes.

These soils are susceptible to salt accumulation, so irrigation water must be applied carefully (fig. 3). Heavy irrigation late in fall and early in spring is needed to fill the root zone with water and to remove the salts. The soils dry slowly after irrigation, and they become cloddy as they dry. Tight layers in the subsoil or substratum impede movement of air and moisture, but the soils have a high moisture-holding capacity and hold large amounts of plant nutrients.

The soils especially need organic matter, which can be obtained by plowing under crop residues and barnyard manure. Work the soils when they are dry; otherwise they will become compact. If tillage pans develop, break them by chiseling or ripping when the soils are dry. To obtain a good stand, apply water frequently but lightly. Heavy irrigation after planting a crop will cause a crust that will interfere with emergence of seedlings or kill the fine roots of young plants. The soils respond to commercial fertilizer, which can be applied in the amounts determined by making soil tests and using trial plots.

Soils of this capability unit are well suited to alfalfa and small grains. To maintain production, use a cropping system that includes 3 to 5 years of soil-improving crops to balance 3 years or less of soil-depleting crops. If carrots are to be grown, a good sequence is early carrots, a winter cover crop of rye or some other small grain plowed down in spring, and then a crop of late carrots.



Figure 3.—Salt accumulation caused this poor stand of carrots on Prewitt clay loam.

Capability unit III-1.—This unit has one soil, Prewitt clay, 0 to 1 percent slopes. It is a calcareous alluvial soil on the flood plains and low terraces. The surface soil, a deep layer of clay, is difficult to work, stays wet and sticky long after irrigation, and crusts and forms huge clods readily when it dries.

Salt accumulation makes it difficult to establish even stands. Water soaks in slowly, but the soil has a high water-holding capacity once it has been saturated.

To improve the tilth and workability, plow down plant residues and manure. Avoid working or grazing the soil when it is wet, as it will become compact. If small grains or row crops are to be grown, plow in fall or early in winter and leave the surface rough until planting time in spring. To maintain production, use a cropping sequence that keeps soil-improving crops on the soil 4 to 6 years for every 2 years in soil-depleting crops. Deep-rooted crops ought to be included in the cropping system, for continuous cultivation may result in poor tilth and formation of a tillage pan. Apply commercial fertilizers in amounts shown necessary by soil tests and field trials.

This soil is best suited to irrigated pasture and small grains. It is not well suited to carrots, though they can be grown under good management.

Capability unit III-2.—This unit contains one soil, San Jose loam, sandy substratum, 1 to 3 percent slopes. This well-drained, reddish-brown, calcareous alluvial soil occupies about 10 acres on a small knoll believed to be the remnants of a much older terrace or alluvial fan.

The soil is not now irrigated, because of its high position. The slopes of 1 to 3 percent would require deep cuts for leveling. The soil would grow all the crops adapted to the climate. It could be irrigated by a sprinkler system if that should prove economically feasible.

Without water, this soil is suitable only for use as range. It is now in grass.

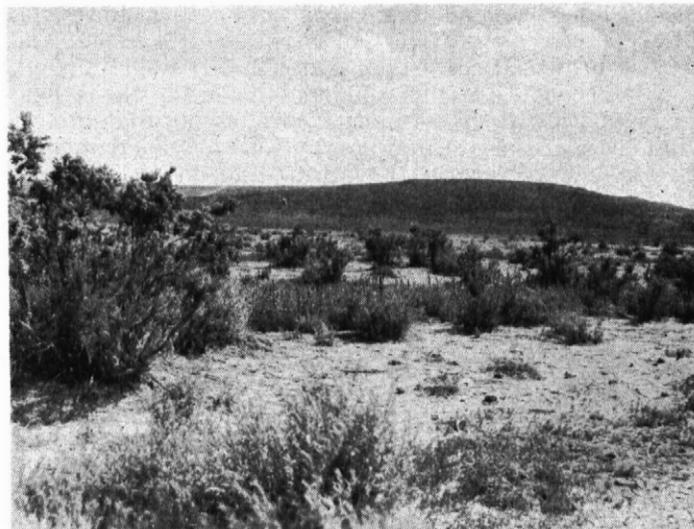


Figure 4.—Native vegetation on Puerco clay, which has a saline and alkali subsoil and substratum.

Capability unit IV-1.—The soils of this unit are saline clays along intermittent streams (fig. 4). They transmit water and air slowly, are difficult to work, and crust readily. They take up water slowly, stay wet a long time after irrigation, and often become compacted. The soils of this unit are:

Ladrillo clay, 0 to 1 percent slopes.

Puerco clay, 0 to 1 percent slopes.

Puerco clay, sandy substratum, 0 to 1 percent slopes.

Alfalfa, small grains, and irrigated pasture are best for these soils. They require crops that need limited cultivation and have vigorous root systems that will penetrate the tight subsoil. A desirable cropping sequence will keep soil-improving crops on the soils 5 to 6 years for each 2 years of vegetables or other soil-depleting crops.

Plowing under crop residues will improve tilth and workability of the soils. Tillage pans form easily if the soils are grazed when wet. Plowing and cultivating at different depths will help in avoiding tillage pans. Fall plowing is needed, and the land should be left rough until spring.

A heavy irrigation in fall will fill the root zone and leach out salts. In spring, light and frequent irrigation is preferable during the time stands are becoming established. Heavy irrigation causes crusting. Commercial fertilizer, applied according to needs shown by soil tests and trial plots, will increase yields.

Capability unit VII-1.—The soil of this unit, Prieta stony loam, 0 to 5 percent slopes, is shallow over basalt rock. Numerous basalt stones and cobbles are on the surface and scattered throughout the soil. The depth to the underlying basalt ranges from a few inches to about 18 inches. The soil is mapped where the basalt

flow that forms part of the valley floor is near or at the surface.

Because of stoniness and shallow depth, this soil is not suitable for cultivation. For production of grass, however, it compares favorably with other soils in the Area. It is best used for permanent grass, and if it has been plowed, reseeding to grass is suggested.

Capability unit VII-2.—This unit contains one sandy soil of low water-holding capacity, Preston fine sand, 0 to 5 percent slopes. The soil is porous, calcareous, and grayish brown. It consists of material deposited by wind.

Water penetrates this soil rapidly, but little is held for plant growth. If permanent cover is not maintained, wind erosion is severe and nearby soils may be damaged. Alfalfa can be grown, but it is difficult to obtain a stand or to irrigate once the stand is established. Alfalfa is best seeded by growing a small grain 1 year and seeding the alfalfa in the grain stubble. Avoid over-irrigation, as too much water will carry plant nutrients down below the zone where plants can reach them.

This soil is best used for permanent grass. If it has been plowed, reseeding to grass is suggested.

Capability unit VII-3.—This unit consists of one mapping unit, the Preston-San Mateo complex. The Preston soil is a porous, calcareous soil deposited by wind, and the San Mateo is a well-drained, calcareous, stratified alluvial soil. The sandy Preston soil, intricately associated with the San Mateo, limits use of the complex. In some areas, leveling for irrigation has so intermixed the two soils that they no longer retain the characteristics of either.

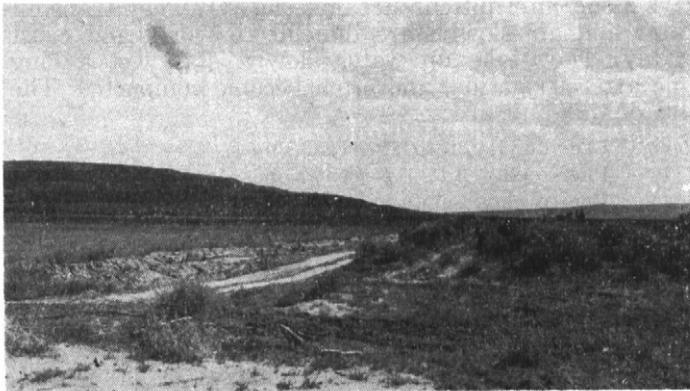


Figure 5.—Preston-San Mateo complex, showing leveled area on left, and unlevelled sand dunes on right.

This complex is best kept in permanent cover because of the danger of wind erosion (fig. 5). Before any area is plowed out for cropping, thorough investigation of leveling, irrigation layouts, and cropping system ought to be made. Leveling, through mixing of the two soils, may improve texture, but the need for control of wind erosion is still great. Control of wind erosion benefits this complex and protects soils nearby. Permanent grass is the best use for this mapping unit. Reseeding of plowed areas to grass is suggested.

Capability unit VIII-1.—In this unit is Basalt outcrops, a miscellaneous land type (fig. 6). The areas occupied by the outcrops are bare or have only a thin covering of soil material. This land has no value for crops, pasture, or trees.

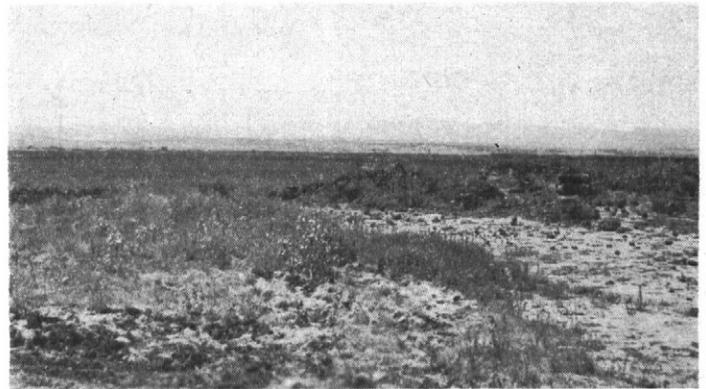


Figure 6.—Numerous small Basalt outcrops such as this occur on cultivated land.

Yields and Management

Information on yields and the management used to get them are extremely limited in the Bluewater Area. On the basis of data obtained from farmers and the New Mexico College of Agriculture and Mechanic Arts, acre yields for carrots are estimated for four soils in table 5. Data that would allow making estimates for other crops were not available.

In column A of table 5 are estimates of yields that can be obtained, over a period of years, under the system of management now practiced. In column B are estimates of yields that can be obtained under improved management. The practices used at the two levels are as follows:

TABLE 5.—Estimated average yields of carrots under different levels of management

Soil	Yield per acre	
	A (prevailing management)	B (improved management)
	Pounds	Pounds
Prewitt clay, 0 to 1 percent slopes	18,000	30,000
Prewitt clay loam, 0 to 1 percent slopes	20,000	34,000
Prewitt clay loam, sandy substratum, 0 to 1 percent slopes	22,000	38,000
San Jose loam, 0 to 1 percent slopes	24,000	42,000

PRESENT MANAGEMENT.—Under this level of management, carrots are not systematically rotated with green-manure crops. Normally, carrots are planted for several years in succession. The land generally is leveled, but overirrigation is common. Variable amounts of commercial fertilizer are used. Usually the fertilizer contains phosphorus and nitrogen.

IMPROVED MANAGEMENT.—The management practices believed necessary to get yields comparable to those in column B of table 5 include leveling to a grade suitable for the particular soil and for the amount of water available.

The supply of organic matter needs to be improved through turning under of cover crops once every 2 years. The cover crop can be winter rye, spring oats, or barley.

Fumigate the soil as needed, which normally will be every 2 or 3 years (fig. 7). Keep salts to a minimum through improved management of irrigation. A heavy application of water in spring or fall will leach out the salts.



Figure 7.—Fumigating for root-knot nematode. Farmers report the effect lasts for only 2 years.

Use good seed on a well-prepared seedbed and apply fertilizer in the kinds and amounts shown to be needed by soil tests and field trials. Laboratory tests show that crops in this area should respond to added phosphorus. Their need for potassium is questionable. Some farmers say they get good response from carrots, especially in color, when potash is added. Others see no response. Crop residues and green manure will supply nitrogen, and this should be taken into account in applying fertilizer.

Greater diversification of crops would simplify the problem of improving management. Farmers state that they must grow enough carrots each year to support their packing sheds. They consider the present system of farming an economic necessity. Each of the soils farmed will produce several crops other than carrots, but any crop selected apparently will have to be one of high value per acre. Pumping costs would prohibit using the irrigated land for crops that have a low acre value.

History of Crops and Marketing Methods ⁴

The Bluewater Area was recognized as a possible vegetable producing area as early as 1923. In 1927, the Bluewater Dam was built and water became available for irrigation (fig. 8). The State experiment station set up a cooperative Irish potato project to obtain in-

⁴ Adapted from an article by W. A. Wunsch, Supervisor, Fruit and Vegetable Service, State College, New Mexico.

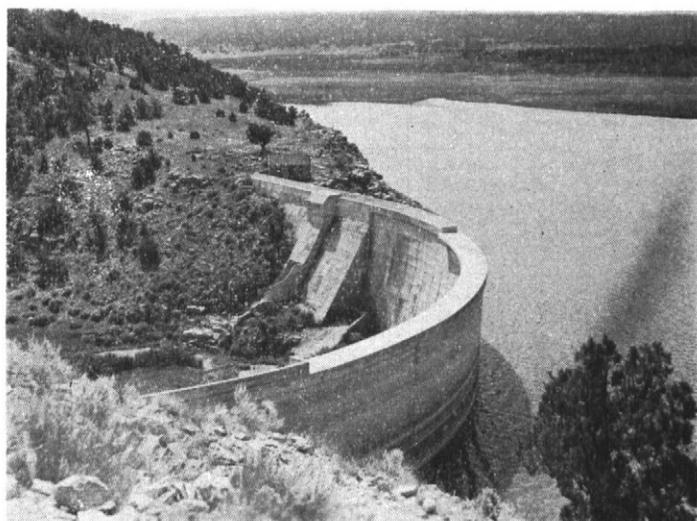


Figure 8.—Bluewater Dam. The irrigation district sold the bottom 20 feet of water to the State Game and Fish Department, and that part cannot be released for irrigation.

formation on the suitability of different varieties and the amount of water needed to produce potatoes.

The experiments clearly demonstrated that good-quality potatoes could be grown successfully, and a number of farmers grew them. Some produced potatoes for seed, and the cool weather in fall made it possible to store seed potatoes economically. As new varieties of potatoes were established, tests continued. By 1943, however, carrot production had increased to such an extent that most of the irrigated land was planted to carrots.

The potato project definitely established that fall plowing, before freezing weather set in, was necessary for successful crop production. If the soils were plowed in spring, it was difficult to prepare a seedbed properly for planting the spring crops.

In 1939, a company having a small acreage in Bluewater started commercial carrot production. It used the Bluewater freight station as a packing shed and shipped out crated carrots. In 1941 approximately 700 acres were planted to carrots. Sheds were built and leased to the carrot-growing companies in the Bluewater Area. Companies came in from California and Arizona and brought in all their own equipment for harvesting and packaging their carrots. Ice needed for packing was hauled by rail from Arizona and California, as not enough ice was supplied by the plant in Belen, N. Mex., to meet the demand.

Carrot planting started the first of May, and staggered plantings were made until about June 20. Harvest of the first crops of carrots started the first of August. The carrots were harvested with the tops on. Quality carrots were put in bunches in the field, placed in a field crate, and hauled to the packing shed (fig. 9).

At the shed the carrots were washed in large tanks, taken out of the tanks by hand, and placed on belts.

Packers sorted the bunches into uniform size and put the bunches into paper-lined crates. After the crates were lidded they were conveyed to the car and loaded by hand in tiers.

As production increased and new methods developed, improvements were made in harvesting, loading, and

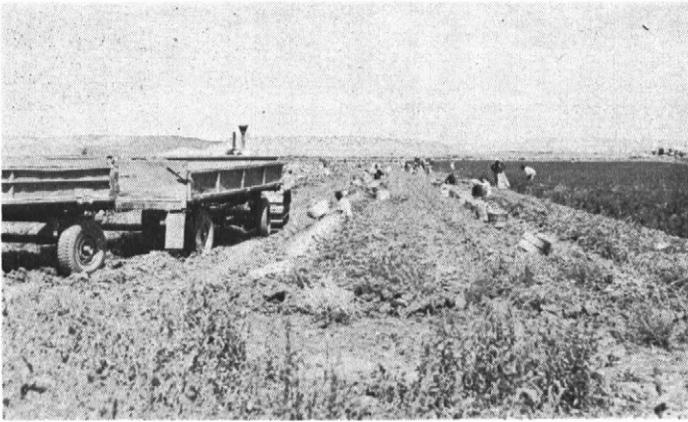


Figure 9.—Navajo Indians harvesting carrots.

packaging. At the present time, less hand labor is used. In 1955, there were four mechanical toppers in use.

The 700 acres of carrots planted in 1941 produced more than 700 carloads of carrots. In 1942 more than 1,000 acres of carrots were planted and more than 1,100 carloads were shipped. Because of the shortage of water in 1943, only a little more than 900 carloads of carrots were produced. The shortage of water continued because, since 1943, there had not been enough water in the dam to irrigate 1,000 acres of carrots.

The first well, drilled in 1945, proved so successful that other wells were drilled. By 1951, there were 19 wells in the Bluewater Area. Approximately 1,000 carloads of carrots were harvested annually during the years 1944 through 1947. By 1948 the wells had made more water available, and more than 1,200 carloads of carrots were shipped that year. In 1949, 1950, and 1951 more than 1,500 cars of carrots were shipped annually. In 1952 and 1953 more than 1,500 acres of carrots were planted, but rains during harvest cut shipments to 1,200 cars.

By 1953 some of the shippers had begun to top their carrots and ship them out in crates and sacks. Two companies packed the topped carrots in cellophane bags (fig. 10). This method of packing increased and, in 1954,



Figure 10.—Packaging carrots in cellophane bags in a packing shed typical of those owned by most farmers in the Area.

three out of the seven companies shipped all their carrots without tops. About 60 percent of the total crop was topped. In 1955 all the companies shipped mostly topped carrots in cellophane bags. A few also shipped out topped carrots in sacks to be packaged at the receiving points, but only a limited number of carloads were shipped.

When bunched carrots were shipped, the trade objected to long tops. To prevent too much top growth, the growers had to be very careful about the amount of nitrogen applied. Now that the tops are discarded, the quality of the roots can be improved and the yields increased by using more nitrogen fertilizer (fig. 11).



Figure 11.—Applying nitrogen to a field of carrots by injecting the fertilizer in the irrigation water. Gypsum can be applied in the same way.

Control of Weeds and Nematodes.—In 1950 the root-knot nematode was damaging carrots in some fields. Experiments showed that nematode damage could be controlled by fumigating the soil with 83-percent dibromide at a rate of $4\frac{1}{2}$ gallons an acre. For effective control the soil has to be treated at least every other year. Complete control cannot be expected.

As the production of carrots increased, weeds became more numerous in the fields. To reduce the cost of weed control, scientists conducted experiments with oil sprays such as Stoddards solvents. Nearly all growers now control weeds and grasses by spraying their fields after the carrots have come up.

Geology

The Bluewater Valley is on the north flank of the Zuni uplift, which forms the south-central margin of the San Juan basin. The rock formations underlying the valley and bordering hills are shown in figure 12.

The valley is bounded on the south by the San Andres formation of Permian age. This formation dips 2 to 6 degrees toward the north, beneath the valley. The Chinle formation underlies part of the valley and outcrops to the north at the base of the escarpment. Scattered remnants of the Chinle formation occur on the San Andres dip slope.

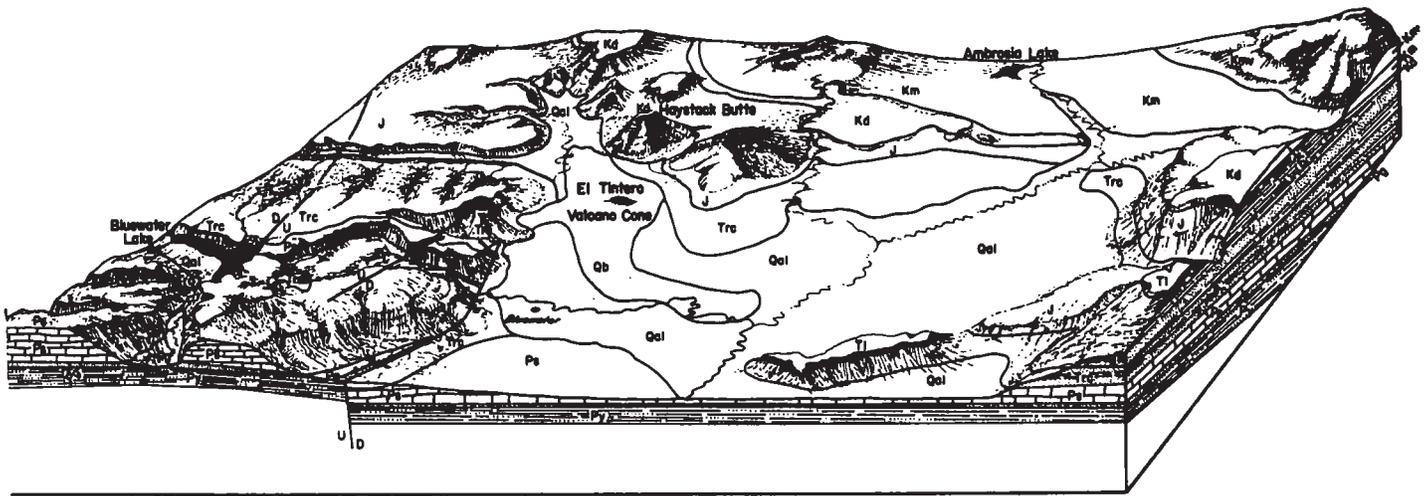


Figure 12.—Geology of the Bluewater Valley:

Quaternary-Tertiary
 Qal=Alluvium
 Qb=Basalt flow
 Tl=Basalt flow

Triassic
 Trc=Chinle formation

Cretaceous
 Kmv=Mesaverde formation
 Km=Mancos shale
 Kd=Dakota sandstone

Permian
 Ps=San Andres formation
 Pg=Glorieta sandstone
 Py=Yeso formation

Jurassic
 J=Jurassic formation, undifferentiated
 U/D=Fault

In the valley, alluvium covers the rock formations. The escarpment around the valley exposes the entire sequence of Jurassic rocks in the Area, but sediments from these rocks have contributed only a small part of the parent material for the soils in the valley. The formations near the valley that have exerted the greatest influence on development of the soils are the San Andres formation of Permian age and the Chinle formation of Triassic age.

Bluewater Creek flows northeastward down the slope of the Zuni Mountains until it enters Bluewater Reservoir. From the Bluewater Dam it flows eastward through a rock-walled canyon for about 5 miles. It then breaks through the escarpment of the Big-Draw fault zone into the Bluewater Valley.

Drainageways that contribute sediments to the farmlands of the valley flow past rocks ranging in age from the pre-Cambrian granite of the Zuni Mountains to the Mesaverde formation. Rocks of Upper Cretaceous age—Dakota sandstone, Mancos shale, and Mesaverde—are important contributors of parent materials for soils along the upper and middle reaches of the San Mateo drainage and in the valley of Bluewater Creek below its confluence with the San Mateo drainage. The Mesaverde formation is exposed near the headwaters of the San Mateo.

Most of the sediments deposited along Bluewater Creek originated from the Chinle formation of Upper Triassic age, though there are admixtures of materials from formations of Jurassic and Permian age. The Triassic and Jurassic rocks are predominantly red, pink, or olive-gray clay shales, siltstones, and sandstones, with some interbedded limestone. The San Andres formation is only thinly exposed in the survey area. As the nature of the parent rock indicates, the sediments themselves are predominantly reddish brown and strongly calcareous and are of variable texture.

In the survey area, the parent rocks bordering the San Mateo drainage are similar to those just described. The upper part of the drainage basin, however, is strongly influenced by Cretaceous sediments (from the Mancos shale and Mesaverde formation). Sediments deposited by these drainages consequently are less red. The upper sediments are generally of fine texture, brown, strongly calcareous, and often saline. The lower strata, below 3 or 4 feet, are usually redder or sandier.

Recent basalt flows occur adjacent to nearly all of the survey area. Basalt exposures are common throughout the entire valley. The extent of the basalt below the alluvial sediments is not known precisely; apparently it is not continuous in all areas. The extent to which the basaltic materials have influenced the parent materials is obscure. Examinations of the basaltic rocks show very little evidence of superficial weathering. It is possible that ash and tuff deposited during volcanic activity may have exerted some influence on parent materials of the soil, but ash and tuff are not now recognizable in the materials.

Stratigraphy

Permian Rocks.—The area that drains into the valley from the south and east is underlain by the San Andres formation. This formation ranges from about 100 to 150 feet in thickness and is readily divided into three parts.

The lower limestone member is massive, and blue gray, white, or gray. It is sandy near the base. The transition from sandy material to limestone is gradual. The limestone contains nodules and small veins of calcite, and a few chert fragments.

The middle member is sandstone. It is gray to yellow, medium grained, and friable. The sandstone is massive, although some cross lamination occurs.

The upper member is massive gray limestone, which is very cherty near the top. In places it contains thin sandstone lenses resembling those in the middle member.

The San Andres formation probably exerts its greatest influence on the soils of the Area in the upper, or western, part of the valley and along the southern margin where the valley fill is generally in direct contact with it.

The Glorieta formation is conformable with the overlying San Andres formation. The upper part of the formation is hard and resistant to erosion. Steep cliffs or long, persistent dip slopes characterize outcrops of the Glorieta formation. The formation consists of massive, white to buff, cross-bedded sandstone, which is friable in the lower part but hard and well cemented with silica in the upper part.

Triassic Rocks.—The lower member of the Chinle formation is thin-bedded, fine-grained, purple to white silty sandstone and massive chocolate-brown to purple siltstone and mudstone. Thin, lenticular, pebble conglomerates and coarse-grained sandstone occur throughout the section. At many places, the surface of the San Andres dip slope, south of the valley, is strewn with residual pebbles from these conglomerates. The thickness of the lower member ranges from about 300 to 500 feet. The variation in thickness is caused by the irregular surface of the San Andres limestone.

The middle member of the Chinle formation consists of medium- to thick-bedded, yellow to gray, hard sandstone and pebble conglomerate, strongly cross bedded. It contains thin lenticular partings of purple to gray siltstone and mudstone. Fragments of petrified wood and fossil bone are common in the conglomerate zones. This member averages about 200 feet thick.

The upper member includes almost all of the formation that is exposed. It is north of United States Highway 66. It consists of red, brown, and purple siltstone alternating with reddish-brown mudstone and red clay shales. In the upper part lenses and nodules of red, purple, brown, and gray limestone are abundant. Near the top a bed of limestone occurs. It is composed of cobblestones and fragments of limestone that are cemented by sandy and silty calcareous mudstone. In this area, this upper member is nearly 1,000 feet thick.

Jurassic Rocks.—Formations of Jurassic age outcrop along the cliffs and the lower slope that form the physiographic boundary of the Bluewater Valley to the north. The Jurassic formations exposed, in ascending order, include the Wingate (?) formation, Entrada sandstone, Todilto limestone, Thoreau formation, and the Morrison formation. The Jurassic rocks consist of red, white, and orange-red sandstones, siltstones, and sandstone conglomerates. They contain small amounts of shale and limestone. The combined thickness of Jurassic rocks is about 1,000 feet. They are not considered to contribute greatly to the formation of the soils of the irrigated farmland.

Upper Cretaceous Rocks.—These rocks are confined to the middle and upper reaches of the San Mateo drainage, and to a lesser extent to the Bluewater Valley below its junction with the San Mateo drainage.

Dakota sandstone consists of massive, cross-bedded, buff to brown conglomerate sandstone. It contains some coal and thin gray layers of shale. The sandstone commonly is separated into two cliffs by a narrow zone of thin-bedded sandstone and shale. The Dakota sandstone

is about 140 feet thick and is economically important because of its uranium content.

Mancos shale is about 800 feet thick and underlies part of the middle and the upper reaches of San Mateo Creek, which makes it an important source of soil. It is gray-black marine shale in which there are a few thin-bedded silty and sandy lenses. In many places the sandy beds abound with fossils.

The Mesaverde formation is exposed as high cliffs along the upper reaches of San Mateo Creek. About 1,800 feet of alternating buff to brown sandstones and gray shales make up the formation. The members of Mesaverde contain important coal deposits.

Quaternary Rocks.—Quaternary rocks consist of basalt flow and valley fill material of several alluvial stages. The alluvium was derived from nearby parent material. It varies from a few feet to as much as 200 feet in thickness and consists of grains ranging in size from clay to coarse gravel.

Basalt flows extensively overlie the alluvium north of United States Highway 66. Over much of the Area they are interbedded with the alluvium. They are considered recent in age, and because of this and their high resistance to weathering, they have probably not contributed significantly to the soils of the Area.

Formation and Classification of Soils

Soil-Forming Factors

Parent material, climate, vegetation, and relief, interact, through periods of time, to form soils. The nature of the soil at any point on the earth depends upon the combination of the five major factors at that point. All five factors come into play in the formation of every soil, but the relative importance of each differs from place to place.

Soil Materials

Mineral soil materials come from rocks. Wind and water wear away material, some material peels off in thin layers as the rocks expand and contract from heat and cold, chemical reactions dissolve material, and the pressure of probing plant roots contributes to the weathering process.

Parent material affects the texture, structure, color, natural fertility, and many other properties of the soil. Soils differ partly because their parent materials differ. In many properties, a soil formed from fine-grained shale will differ from a soil formed from sandstone.

The soils of the Bluewater Area were derived from shales, sandstones, limestones, and, to some extent, basalt. They have formed from alluvial, or water-laid, material carried from the Bluewater and San Mateo drainage basins. Probably the alluvial deposits on the San Mateo flood plain were laid down during two distinct cycles of erosion. The earliest deposits, predominantly sandy material, were laid down on the flood plains and fans at the junction of the San Mateo and San Jose valleys. As they were being deposited, these sandy materials probably were reworked by the wind.

The more recent materials, those of the second cycle, were of finer texture than the sands, and they covered the sands.

Climate

Climate affects formation of soils in several ways. Temperature affects the rate at which organic matter decomposes. Temperature and moisture affect the kind and amount of vegetation and, therefore, indirectly influence the kind and amount of organic matter in the soils. Rainwater penetrating the soils affects the rate at which minerals leach out and the downward movement of fine particles. Climate differs in different regions, so the soils differ in those regions. Climate is the same throughout the small Bluewater Area, so it does not contribute to differences among the soils.

Climatic data from the weather station at Bluewater are given in table 6. The elevation of the valley is high and winters are cold. Frost during the latter part of the growing season sometimes affects the marketability of carrots. The average length of the growing season is 118 days, or from May 28 to September 23. The average winter temperature, as shown in table 6, is 29.3° F. The average summer temperature is 66.5°. Annual rainfall averages 10.1 inches. In the driest year recorded, however, rainfall was only about 5 inches. In the wettest, the rainfall was about 18½ inches.

Summer is the wettest season. A total of about 6 inches of rain falls in July, August, and September. Rains sometimes cause flooding, interfere with cultivation, and favor the spread of plant diseases. Early in spring, evaporation is rapid because high winds are frequent and the humidity is low.

Relief

Relief, or lay of the land, generally influences the type of soil formed, but it does not concern us much in this area because the slopes do not exceed 5 percent and most of them do not exceed 1 percent.

Vegetation

Most of the soils have been leveled, so the organic matter and the water-stable soil aggregates that were formed under native vegetation have been destroyed.

Time

It takes time for soils to develop, that is, to form horizons that differ from one another. Water moves through the soil profile, and gradually lime and fine particles are leached from the surface and deposited in the subsoil. The amount of leaching depends upon the length of time that elapses and amount of water that penetrates the soil. As the fine particles are deposited in the subsoil, a characteristic kind of soil structure is usually developed. In the Bluewater Area, as is common in all alluvial areas, only moderate development has taken place. Prieta stony loam, 0 to 5 percent slopes, is the most developed of the soils in this area.

TABLE 6.—Normal monthly, seasonal, and annual temperature and precipitation at Bluewater, Valencia County, N. Mex.

[ELEVATION, 6,650 FEET]

Month	Temperature ¹			Precipitation ²			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1912)	Wettest year (1931)	Average snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	28.3	68	—28	0.45	0.16	0.25	3.6
January	27.2	68	—29	.44	(3)	.22	4.2
February	32.3	75	—22	.48	.31	.55	4.6
Winter	29.3	75	—29	1.37	.47	1.02	12.4
March	38.5	87	— 6	.46	.53	1.24	2.4
April	47.1	88	— 1	.42	.67	2.43	.8
May	54.9	100	12	.59	(3)	.92	.6
Spring	46.8	100	— 6	1.47	1.20	4.59	3.8
June	64.4	103	23	.56	.30	1.05	(8)
July	68.7	105	31	2.01	1.14	4.12	(8)
August	66.4	99	33	2.21	1.78	3.11	(8)
Summer	66.5	105	23	4.78	3.22	8.28	(8)
September	59.3	94	12	1.39	(8)	2.40	(3)
October	49.0	85	10	.09	.25	.28	.2
November	36.7	80	—25	.40	(3)	1.90	2.1
Fall	48.3	94	—25	2.48	.25	4.58	2.3
Year	47.7	105	—29	10.10	5.14	18.47	18.5

¹ Average temperature based on a 45-year record, through 1953; highest temperatures based on a 43-year record, and lowest temperatures based on a 42-year record, through 1952.

² Average precipitation based on a 44-year record, through

1953; wettest and driest years based on a 48-year record, in the period 1896-1955; snowfall based on a 43-year record, through 1952.

³ Trace.

Classification of Soils in Great Soil Groups

The soil series of the Bluewater Area are classified according to great soil groups as follows:

<i>Alluvial soils</i>	<i>Regosols</i>	<i>Brown soils</i>
Ladrillo	Preston	Prieta
San Jose		
Puerco		
Prewitt		
San Mateo		

How a Soil Survey Is Made

The scientist who makes a soil survey examines soils in the field, classifies them in accordance with facts that he observes, and maps their boundaries on an aerial photograph or other map.

FIELD STUDY.—The soil surveyor bores or digs many holes to see what the soils are like. The holes are spaced irregularly according to the lay of the land. Usually they are not more than a quarter of a mile apart, and sometimes they are much closer. In most soils each boring or hole reveals several distinct layers, called horizons, which collectively are known as the soil profile. The profile is studied to see how the horizons differ from one another and to learn the things about the soil that influence its capacity to support plants.

Color is usually related to the amount of organic matter. The darker the surface soil, as a rule, the more organic matter it contains. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration.

Texture, or the proportion of sand, silt, and clay, is determined by the way the soil feels when rubbed between the fingers and is later checked by laboratory analysis. Texture determines how well the soil retains moisture, plant nutrients, and fertilizer, and whether it is easy or difficult to cultivate.

Structure, which is the way the individual soil particles are arranged in aggregates and the amount of pore space between aggregates, gives us clues to the ease or difficulty with which the soil is penetrated by plant roots and by moisture. The aggregates may have prismatic, columnar, blocky, platy, or granular structure.

Consistence, or the tendency of the soil to crumble or to stick together, indicates whether it is easy or difficult to keep the soil open and porous under cultivation.

Other characteristics observed in the course of the field study and considered in classifying the soil include the following: The depth of the soil over bedrock or compact layers; the presence of gravel or stones in amounts that will interfere with cultivation; the steep-

ness and pattern of slopes; the degree of erosion; the nature of the underlying parent material from which the soil has developed; and acidity or alkalinity of the soil as measured by chemical tests.

CLASSIFICATION.—On the basis of the characteristics observed by the survey team or determined by laboratory tests, soils are classified by series, types, and phases.

As an example of classification, consider how the Prewitt series of the Bluewater Area is separated into types and phases.

<i>Series</i>	<i>Type</i>	<i>Phase</i>
Prewitt.....	{ Clay.....	{ 0 to 1 percent slopes.
	{ Clay loam.....	{ 0 to 1 percent slopes. Sandy substratum, 0 to 1 percent slopes.

Soil series.—Soils similar in kind, thickness, and arrangement of layers are normally designated as a soil series. In a given area, however, a soil series may have only one soil.

Soil type.—Within a soil series, there may be one or more soil types. The soil types are determined by the texture of the surface layer.

Soil phase.—Soil types are divided into soil phases because of differences other than those of kind, thickness, and arrangement of layers. Slope variations, frequency of rock outcrops, degree of erosion, depth of soil over the substratum, or natural drainage are examples of characteristics that suggest dividing a soil type into phases.

The soil phase, or the soil type if it has not been subdivided, is the mapping unit on the soil map. It is the unit that has the narrowest range of characteristics. Use and management therefore can be specified more easily than for soil series or yet broader groups that contain more variation.

Miscellaneous land types.—Fresh stream deposits and rough, stony, or severely gullied land are not classified by types and series. They are identified by a descriptive name. Basalt outcrops is a miscellaneous land type in the Bluewater Area.

Soil complex.—When small areas of two or more soils are so intricately associated that it is not feasible to show them separately on the soil map, they are mapped together and called a soil complex. The only complex mapped in the Bluewater Area is the Preston-San Mateo complex.

Laboratory Determinations

The amount of moisture held in fine soils of the Bluewater Area at tensions of one-third and 15 atmospheres and at saturation are given in table 7. Given in table 8 are chemical and mechanical analyses of fine soils.

TABLE 7.—Moisture held in five soils at tensions of $\frac{1}{8}$ and 15 atmospheres and at saturation

Soil, location, and sample No.	Depth	Moisture held at tensions of		Moisture held at saturation
		$\frac{1}{8}$ atm.	15 atm.	
	Inches	Percent	Percent	Percent
Prewitt clay loam (NE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 15, T. 12 N., R. 11 W.):				
127	0 - 5	25.5	13.15	39.5
128	5 -11	26.8	13.77	43.5
129	11 -21	15.9	11.81	33.7
130	21 -28	13.7	7.72	34.5
131	28 -36	26.7	13.81	46.7
132	36 -41	29.8	19.33	57.3
133	41 -58	28.2	17.19	54.3
134	58 -70	14.0	12.96	34.0
135	70 -90+	29.7	16.43	50.0
Prewitt clay (NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 17, T. 11 N., R. 10 W.):				
140	0 -17	32.59	15.51	49.3
141	17 -21	25.55	11.64	44.5
142	21 -30	18.44	8.32	39.0
143	30 -38	29.72	18.51	69.0
144	38 -50	23.47	9.13	42.0
145	50+	11.46	8.72	35.0
Puerco clay, sandy sub- stratum (SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 34, T. 12 N., R. 10 W.):				
180	0 -2 $\frac{1}{2}$	37.47	20.19	55.5
181	2 $\frac{1}{2}$ -10	38.65	22.02	56.7
182	10 -20	37.45	22.39	58.3
183	22 -30	7.47	4.65	24.2
184	30 -35	10.45	5.27	26.9
185	35 -52	7.71	4.20	28.1
San Jose loam NE $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 23, T. 12 N., R. 11 W.):				
136	0 -12	14.61	6.63	31.0
137	12 -23	8.94	6.70	28.5
138	23 -59	25.61	13.10	40.3
139	59 -76	18.42	9.32	40.0
San Jose loam, sandy substratum (SE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 25, T. 12 N., R. 11 W.):				
186	0 -3	8.89	5.20	28.1
187	3 -11	12.09	6.22	30.3
188	11 -16	18.91	8.63	39.0
189	16 -25	27.80	10.49	44.0
190	25 -34	22.89	9.86	42.0
191	34 -42	10.53	4.94	21.2

TABLE 8.—Analytical data for five soils

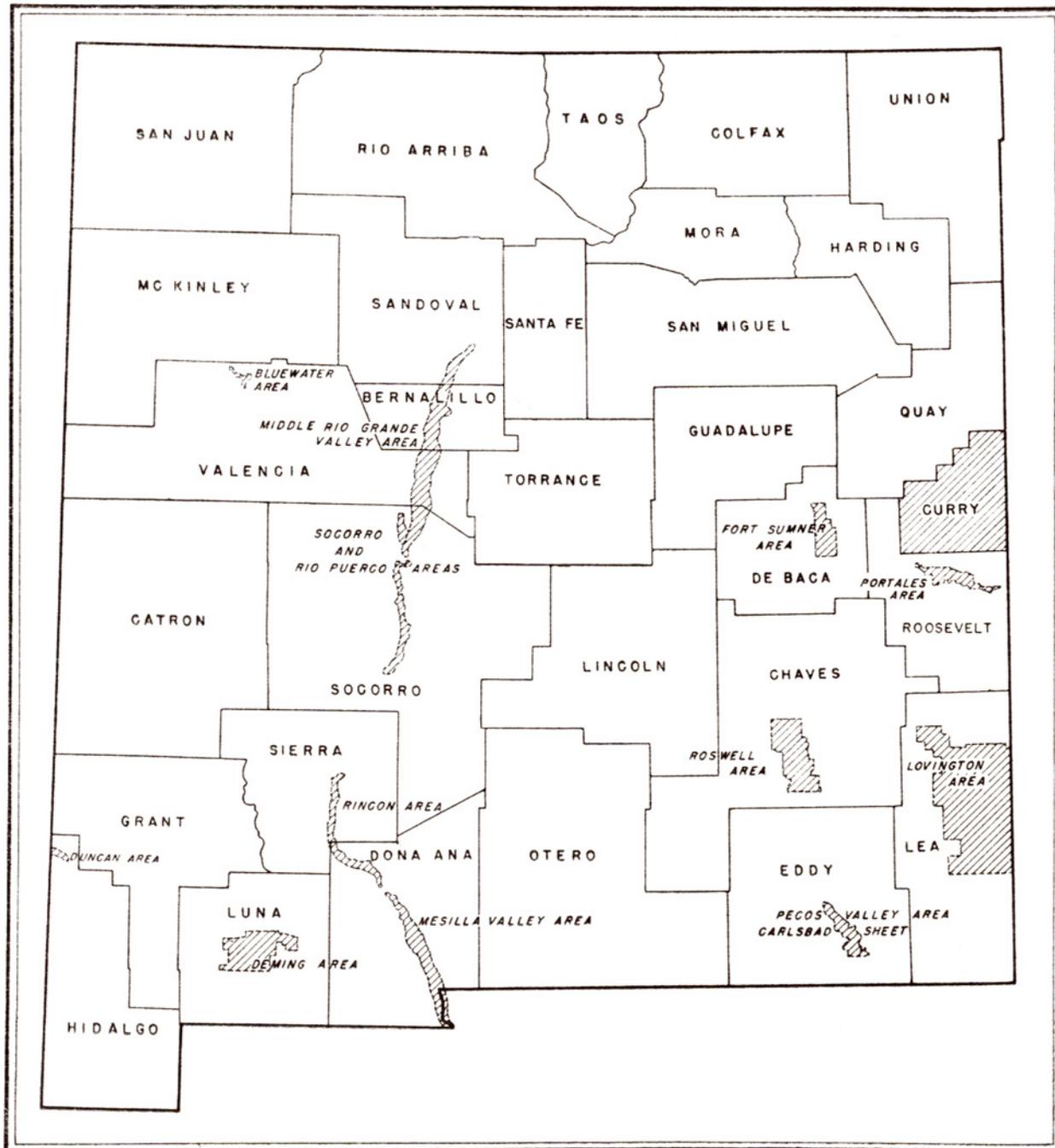
Soil, location, and sample No.	Depth	Exchangeable sodium	Estimated salt (Bureau of Soils Cup)	Organic carbon ¹	pH of 1:5 soil-water suspension ²	Size class and diameter of particles ³		
						Sand (2.0-0.05 millimeters)	Silt (0.05-0.002 millimeters)	Clay (less than 0.002 millimeters)
	Inches	Percent of exchange capacity	Percent	Percent		Percent	Percent	Percent
Prewitt clay loam (NE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 15, T. 12 N., R. 11 W.):								
127	0-5	3.1	0.14	1.13	8.8	26.6	42.2	31.2
128	5-11	4.1	.17	1.17	8.8	25.4	42.9	31.7
129	11-21	4.5	.13	.53	9.0	59.8	17.6	22.6
130	21-28	4.9	.12	.45	9.1	61.4	20.3	18.3
131	28-36	1.7	.14	.88	8.9	21.2	44.1	34.7
132	36-41	2.1	.17	.43	8.7	21.6	30.3	48.1
133	41-58	1.5	.15	.43	8.7	24.7	34.7	40.6
134	58-70	2.8	.13	.35	8.6	52.6	31.9	15.5
135	70-90+	1.5	.14	.31	8.6	34.2	26.8	39.0
Prewitt clay (NE$\frac{1}{4}$NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 17, T. 11 N., R. 10 W.):								
140	0-17	1.3	.13	.74	8.8	12.6	38.4	49.0
141	17-21	1.6	.14	.66	8.6	73.2	39.2	34.0
142	21-30	1.7	.13	.58	8.8	34.8	39.6	25.6
143	30-38	1.6	.13	.58	8.8	4.9	38.2	56.9
144	38-50	2.3	.11	.66	8.9	21.1	51.4	27.5
145	50+	3.9	.05	.20	9.1	43.2	27.5	15.7
Puerco clay, sandy substratum (SW $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 34, T. 12 N., R. 10 W.):								
146	0-3	9.3	.14	.39	9.3	9.2	37.4	53.4
147	3-8	13.5	.14	.37	9.4	8.4	34.2	57.4
148	8-17	8.9	.33	.45	9.2	12.4	29.7	57.9
149	17-23	38.7	.52	.23	8.7	15.6	28.1	56.3
150	23-28	43.1	.53	.51	8.5	30.2	21.7	48.1
151	28-35	46.4	.56	.47	8.4	39.8	18.9	41.3
152	35-41	42.3	.43	.20	9.1	60.9	15.0	24.1
153	41-48	58.0	.19	.08	9.6	84.6	6.2	9.2
154	48-59	31.6	.12		9.6	95.9	.3	3.8
San Jose loam (NE$\frac{1}{4}$SE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 23, T. 12 N., R. 11 W.):								
136	0-12	4.8	.18	.42	8.6	55.4	26.3	18.3
137	12-23	4.1	.12	.27	8.9	68.7	20.3	11.0
138	23-59	2.3	.14	.70	8.7	37.9	29.3	32.8
139	59-76	15.2	.12	.62	8.9	41.0	36.5	22.5
San Jose loam, sandy substratum (SE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 25, T. 12 N., R. 11 W.):								
186	0-3	1.6	.02	.48	8.9	70.7	17.9	11.4
187	3-11	1.4	.02	.47	8.8	69.1	17.5	13.4
188	11-16	1.9	.05	.71	8.7	42.0	38.0	20.0
189	16-25	1.3	.07	.77	8.7	26.1	48.7	25.2
190	25-34	1.5	.08	.65	9.0	33.2	45.6	21.2
191	34-42	3.3	.02	.32	9.1	65.6	23.4	11.0

¹ Organic carbon determined by the chromic-acid titration method, based on 77 percent recovery calculated to 100 percent. See Peech, M., Dean, L. A., and Reed, J. F. METHODS OF SOIL ANALYSIS FOR SOIL FERTILITY INVESTIGATIONS. U. S. Dept. Agr. Cir. 757, 25 pp. 1947.

² pH determined by the glass-electrode method.

³ Mechanical analyses by pipette method, using hydrogen

peroxide to destroy organic matter. Used as a dispersing agent, 10 milliliters of solution made by dissolving 50 grams of sodium-hexa-meta-phosphate in a liter of water. Percentages expressed on an oven-dry basis. For description of pipette method see: Kilmer, V. J., and Alexander, L. T., METHODS OF MAKING MECHANICAL ANALYSES OF SOILS. Soil Sci. 68: 15-24. 1948.



Areas surveyed in New Mexico shown by shading.

Accessibility Statement

This document is not accessible by screen-reader software. The U.S. Department of Agriculture is committed to making its electronic and information technologies accessible to individuals with disabilities by meeting or exceeding the requirements of Section 508 of the Rehabilitation Act (29 U.S.C. 794d), as amended in 1998. Section 508 is a federal law that requires agencies to provide individuals with disabilities equal access to electronic information and data comparable to those who do not have disabilities, unless an undue burden would be imposed on the agency. The Section 508 standards are the technical requirements and criteria that are used to measure conformance within this law. More information on Section 508 and the technical standards can be found at www.section508.gov.

If you require assistance or wish to report an issue related to the accessibility of any content on this website, please email Section508@oc.usda.gov. If applicable, please include the web address or URL and the specific problems you have encountered. You may also contact a representative from the [USDA Section 508 Coordination Team](#).

Nondiscrimination Statement

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint_filing_cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by:

- (1) mail: U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410;
- (2) fax: (202) 690-7442; or
- (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.