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The chemical characteristics of the waters of the Middle Rio Grande Conservancy District.

John D. Clark

Harry Mauger

John G. Koogler

The University of New Mexico Bulletin

THE CHEMICAL CHARACTERISTICS OF THE WATERS OF THE MIDDLE RIO GRANDE CONSERVANCY DISTRICT

By JOHN D. CLARK *and* HARRY MAUGER

With an Appendix

METHODS OF REMOVING "ALKALI" FROM FARM LANDS

By JOHN G. KOOGLER

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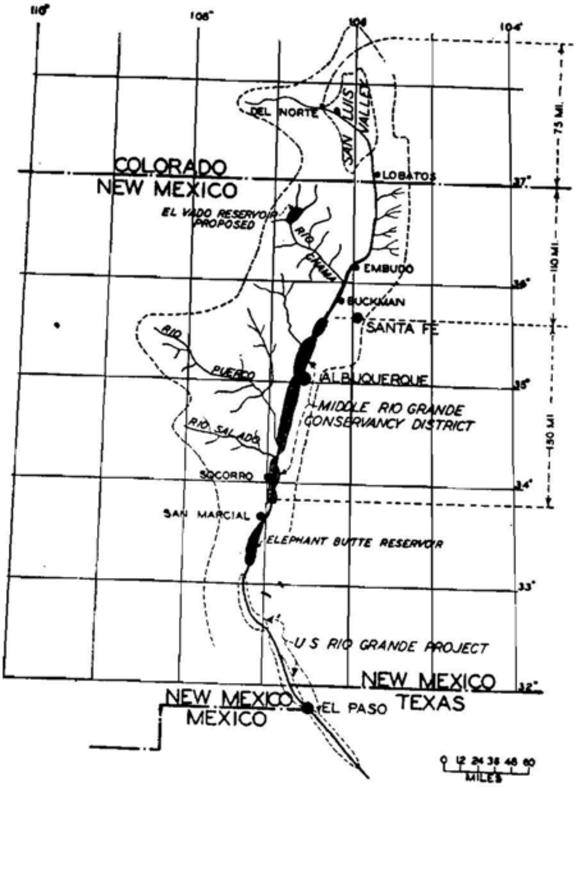

110°
108°
106
104°
DEL NORTE
SAN LUIS VALLEY
75 MI.
COLORADO
NEW MEXICO
LOBATOS
37°
EL VADO RESERVOIR PROPOSED
RIO CHAMA
EMBUDO
110 MI.
36°
BUCKMAN
SANTA FE
RIO PUERCO
ALBUQUERQUE
35°
MIDDLE RIO GRANDE CONSERVANCY DISTRICT
RIO SALADO
150 MI.
SOCORRO
34°
SAN MARCIAL
ELEPHANT BUTTE RESERVOIR
33°
U S RIO GRANDE PROJECT
NEW MEXICO
32°
NEW MEXICO
MEXICO
EL PASO
TEXAS
0 12 24 36 48 60
MILES

Introduction

The drainage and reclamation project in the Middle Rio Grande Valley in the State of New Mexico has a significance quite different from that of most of the drainage projects yet undertaken in that the valley which is being so greatly improved, lies in a part of the world where mild climate prevails, and where persons past the prime of life, or persons of lowered vigor, have settled in steadily increasing numbers during the past two decades. In the Middle Rio Grande Valley there is an increasing demand for small farms from those who wish to supplement small fixed incomes with the produce of small farms.

While the agriculture of the Rio Grande Valley is conducted on a large scale by many farmers, whose land is being improved by the project, the small farm meets the requirements of the most of the newcomers, whose numbers are increasing. There is a pronounced movement under way for persons to spend the declining years of life in parts of the country where the winters are mild. California has grown phenomenally because of this. Though temporarily halted, the exodus to Florida has not reached its peak. The movement to the Middle Rio Grande Valley will be rapid in the near future.

Low-priced land, dependable water supplies for irrigation, and a very long growing season, together with the fact that the residents enjoy full sunshine 300 of the 365 days of the year, make the valley very attractive.

This study covers one phase of the project's success—that of removing undesirable minerals from the

soil. Drainage ditches have developed a greater supply of water than was expected of them, and much of it is, even now, satisfactory for irrigation. The tractor is following the drag line excavator; cottonwood groves are being converted into farms; and much new building is taking place on the newly opened tracts.

Chemical analyses reported in this paper are given in greatest detail (parts per million, graphs showing parts per million at each analysis, milligrams per liter in reacting value, alkaline coefficients and character formulae) in a thesis bearing the title, "Waters of the Middle Rio Grande Conservancy Project," by the junior author, filed in the library of the University of New Mexico. These analyses were made in the chemical laboratories of the University. Samples and field data were supplied by H. F. Robinson, whose assistance is gratefully acknowledged. The authors also gratefully acknowledge financial assistance given by the District, through the courtesy of J. L. Burkholder, which made this work possible.

History of the Rio Grande Valley

The Rio Grande Valley was first explored by the Spaniards in 1540. The Indians at the time, had their small irrigation systems. Traces of these ancient canals are found in many localities, indicating that prehistoric peoples were using the Rio Grande for irrigation. The Rio Grande then must have supported a population of at least 25,000 in its 13 pueblos.

Each town that was settled by the Spaniards built its own irrigation ditch. Today there are nearly seventy such ditches in the middle valley, with a consequent waste of water. The increased use of Rio Grande water in Colorado has diminshed the flow of the river in New Mexico, and at the same time the area of irrigated land decreased because of the rising river bed accompanied by greater seepage. In the Middle Rio Grande Valley one effect concealed the other. As the area of irrigated land decreased, there was less demand for water. The shortage in the lower valley was acute, however, and in 1895 Mexico protested against the immoderate use of the waters of the Rio Grande by New Mexico and Colorado. The outgrowth of this controversy was the construction of the Elephant Butte Dam and the United States Rio Grande Project. Mexico was allotted 60,000 acre-feet of water per year. The flow record of the Rio Grande is shown in Table 1.

The situation in the middle valley had not been helped, and a report was made to the New Mexico Interstate Compact Commission by C. R. Hedke, civil engineer, in December, 1924, entitled, *A Report on the Irrigation Development and Water Supply of the Middle Rio Grande Valley, New Mexico, as it Relates to the Rio Grande Compact.* Data from this report are given in Table 2, which was confirmed by the results of a survey by the State of New Mexico in 1918. Sixty-five ditches were found with a carrying ca-

TABLE 1

Flow Records of the Rio Grande

Station	*Period of Record*	*Mean Annual Flow in A. F.*	*Max. Flow in A. F.*	*Min. Flow in A. F.*
Lobatos Colo.-New Mexico Interstate Line	1899—date	627,000	1,040,600 (1920)	98,700 (1902)
Embudo	1899—date	855,000	1,579,000 (1920)	281,000 (1902)
Buckman	1895—date	1,400,000	2,359,000 (1920)	425,000 (1902)
San Marcial	1895—date	1,180,000	2,422,000 (1905)	201,000 (1902)
Chamita	1914—date	525,000	787,000 (1920)	258,000 (1918)
El Vado	1912-1916 1920 to date	315,000	530,000 (1916)	89,000 (1904)

This table is taken from *The Report of the Chief Engineer*, Joseph L. Burkholder, page 83.

TABLE 2

Middle Rio Grande Developments

Time of Construction	*No. of Ditches*	*Sec. Ft. Cap.*	*1910 Irrigation (Acres)*	*Additional Possible (Acres)*	*Total Under Ditch (Acres)*
Ancient and very old	15	405	11,100	7,830	18,930
Old	40	946	20,285	25,815	46,100
About 1700	2	40	1,300	1,300	2,600
Before 1800	6	221	4,500	7,400	11,900
Before 1850	5	143	3,000	5,350	8,350
To 1880	6	184	3,500	10,000	13,500
To 1910	5	197	1,535	21,885	23,420
Totals	79	2,145	45,220	79,580	124,800

(This table is given by Mr. Hedke as a summary of an investigation made in 1910 by Mr. H. W. Yeo of the United States Reclamation Service, at present State Engineer of New Mexico.)

TABLE 3

"Table Showing the Progress of Irrigation Developments in the Middle Rio Grande Valley based on the reports of: W. W. Follett, Engineer, International Boundary Commission; H. W. Yeo, Engineer, United States Reclamation Service; State of New Mexico, 1918 Drainage Survey."

Time Up to	*No. of Ditches*	*Sec. Ft. Cap.*	*Acres Under Development*	*Acres Failed*	*Remarks*
1600	22	537	25,555		Indian development.
1700	61	1,445	73,580		Indian with Spanish.
1800	70	1,808	100,380		Above with Spanish grants.
1850	80	2,099	123,315		Natural increase.
1880	82	2,145	124,800		Trancontinental traffic and Civil war demand, completed developments.
1896	71	1,779	50,000	74,800	Due to short water supply rising water table, R. R. supply competition and R. R. labor demand.
1910	79	2,121	45,220	79,580	Further shortage and further rising water table.
1918	65	1,957	47,000	77,800	War period
1925	60	1,850	40,000	84,800	Estimated present condition.

pacity of 1,957 second-feet, for irrigating 47,007 acres. It is calculated that 115,000 acres could be irrigated. These data, as shown in Table 3, are corroborated by surveys of the Middle Rio Grande Conservancy District in 1926-27. Maximum development of the middle valley was 125,000 acres in 1880, after which a retrogression took place. In 1925, only 40,000 acres were under cultivation. Principal causes for this decrease are increased height of the water table and increasing water shortage.

Swamps, salt grass, and "alkali"[1] are visual evidence of what the rising water table of the middle valley is doing to cultivated fields. The silt-carrying capacity of the river has decreased. As the bed of the river has been built up, seepage from the river to the land has become greater. The

1. The word "Alkali" is used here to mean the salts carried by the water and not true caustic.

river bed is now from two to four feet higher than the valley floor in many places, and as much as twelve feet at San Marcial. The amount of silt has been increasing constantly because of land erosion, and amounts now to 20,000 acre-feet annually. Half of this comes from the Rio Puerco, which, in fifty years, has moved 400,000 acre-feet of soil.

Irrigation ditches have been used in the middle valley for at least two hundred years without any kind of regulation, and it is probable they have helped to raise the water table through seepage. Test wells have been maintained in the valley since 1918. They show that over 72 per cent of the valley floor, the water table is less than four feet below the ground surface. Most crops require at least four feet of unsaturated soil. The total area in "alkali," salt grass and swamp is more than 50,000 acres. In a large part of the valley the crops are poor, due to excessive soil alkalinity. At present there are about 2,000 acres free from "alkali." Drainage is imperative both to reclaim abandoned areas and to prevent spread of the "alkali" condition.

THE RIO GRANDE BASIN

The drainage basin of the Rio Grande comprises 26,696 square miles, divided into the Colorado area, the New Mexico East Side Area, and the New Mexico West Side Area, as shown in the accompanying sketch map. The drainage basin in Colorado covers 7,700 square miles, 1,400 in the mountain area above Del Norte, at elevations ranging from 8,000 to 14,000 feet. In the New Mexico East Side Area, the drainage basin comprises 2,600 square miles on the west slope of the Sangre de Cristo range, and 2,400 square miles in the Manzano and Sandia ranges. The latter area is subiect to violent floods.

The New Mexico West Side Area is drained by four principal streams:

1. The Rio Chama drains an area of 3,150 square miles. The upper Chama is pure mountain water, but the lower Chama is sulfate water due to its contact with recent sedimentary deposits.

2. The Rio Jemez drains about 1,000 square miles. The Rio Salado, a tributory of the Jemez, drains about 1,150 square miles. Because of the high mineral content of the Rio Salado it is unfit for irrigation. The total solids in parts per million vary from 5,000 to 21,000. The Jemez, below San Ysidro, cannot be used for irrigation because of the waters of the Rio Salado. Heavy rains in the Rio Salado region will sometimes wash enough salts into the Jemez and Rio Grande to lower the alkaline coefficient and make the water poor for irrigation just below Bernalillo, if the Rio Grande is low.[2]

The salines of the Rio Salado originate in the red beds, exposed on the western boundary of the Nacimiento mountains. Thick beds of gypsum and shale are found with the red beds. The Rio Salado shows an excellent example of the effect of leaching and washing of geological deposits impregnated with salines. It also shows why the composition of small streams reflect the type of country in which they rise.

3. The drainage basin of the Rio Puerco is estimated at 5,700 square miles. The region is about 5,000 feet to 6,000 feet in elevation. The Rio Puerco is usually dry, but is subject to floods following summer and fall rain storms. These floods transport large quantities of silt to the Rio Grande. Overgrazing in the region has made great erosion possible. The Rio Puerco has cut a canyon about fifty feet deep through the soil of the valley.

4. The Rio Salado which enters the Rio Grande below the Rio Puerco (not the Rio Salado which flows to the

2. *The Saline Springs of the Rio Salado.* John D. Clark. Bulletin, University of New Mexico, No. 163, 1929.

Jemez) has a drainage area of one-fifth that of the Rio Puerco. The floods in the Rio Salado are nearly as large as those of the Rio Puerco.

THE MIDDLE RIO GRANDE VALLEY

The Middle Rio Grande Valley is located in the counties of Sandoval, Bernalillo, Valencia, and Socorro, extending from Cochiti at the mouth of White Rock Canyon, on the north, to San Marcial, at the upper end of Elephant Butte Reservoir, on the south, a distance of more than 150 miles. The valley is from one to five miles wide. The river meanders through it, forming a series of natural districts. The gross area of the valley floor to the base of the hills is about 210,000 acres. Elevation ranges from 4,460 feet at San Marcial, to more than 5,200 feet at Cochiti. The valley is protected on both sides by hills and mountains. Rainfall is light. A forty-year mean at Albuquerque is 7.59 inches, and at Socorro, the 28-year mean is 11.09 inches. This rainfall classifies the valley as semi-arid. At Albuquerque, the mean annual temperature is 55.7. The mean maximum of temperature is 70.1 and the mean minimum is 41.60. The average growing season varies from 189 days in the northern part of the valley to 198 days in the southern part. The soils of the Rio Grande Valley are of river bottom alluvium. The soil is of a sandy texture and is very fertile where properly drained and irrigated. For a detailed discussion of these soils see *Soil Survey of the Middle Rio Grande Valley Area, New Mexico* by the United States Bureau of Soils, 1912. Soil analyses are given in Table 4.

The principal crops are alfalfa, corn, grain, fruits, celery, and garden truck. Some cotton and tobacco also are grown. The classification of valley land is given in Table 5.

TABLE 4

Soil Analyses

%	*Fine Gravel*	*Coarse Sand*	*Medium Sand*	*Fine Sand*	*Very fine Sand*	*Silt*	*Clay*
Soil	0.0	1.3	2.3	15.5	14.7	35.3	30.9
Subsoil	0.3	1.3	4.0	29.8	26.5	17.2	16.2
Lower Subsoil	0.3	4.7	14.6	55.1	17.6	3.7	4.1

Average results of mechanical analyses for Gila clay loam soils of the Middle Rio Grande Valley as given in the 1912 Soil Survey Bulletin.

TABLE 5

Classification of Valley Lands

Areas shown are total lands under constructed canals or possible extensions of existing canals. All roads and ditch rights of way excluded. Date from survey and inspection by District Engineers.

Classification 1926-1927	*Acres*	*Total Acres*	*Per Cent*	*Per Cent*
Orchard and Garden	3,408		2.28	
Alfalfa and Grain	40,001		26.69	
Pasture and Hay	1,355		.90	
Homesites	820		.55	
Total Irrigated		45,584		30.42
Salt Grass	48,603		32.43	
Bosque	37,821		25.24	
Swamp and Lake	3,324		2.21	
River Wash and Arroyo Wash	1,290		.86	
Barren Alkali	275		.18	
Sand Dunes and Gravel	4,400		2.94	
Fallow Land	4,980		3.32	
Homesites	3,588		2.40	
Total Non-Irrigated		104,281		69.58
Totals	149,865	149,865	100.00	100.00

This table is taken from *Report of the Chief Engineer,* Joseph L. Burkholder. Page 41.

FLOOD PROTECTION

In 1874 the present site of Albuquerque was flooded by a break in the levees north of Alameda. The records of floods previous to 1874 are unreliable. The capacity of the river channel north of Alameda is only about 25,000 second feet, up to the elevation of the old dike. Since the *Report of the Chief Engineer* of the Middle Rio Grande Conservancy District has been printed, the town of San Marcial has been flooded twice, and is now abandoned. Floods in the Rio Grande and its tributaries are likely to occur at any time and are caused by melting snow in the early summer, or by heavy rains.

The danger of floods has been increased because silt is gradually raising the river bed. The deposits are thickest at San Marcial and gradually thin out to the north. At Albuquerque, the river channel carries a maximum of 12,000 second feet without overflowing.

Silt control is necessary to conserve the soil of the valleys and to decrease the amount of material being deposited in the Elephant Butte Reservoir. If the amount of silt now carried by the river is not decreased, it will be only about fifty years before additional water storage space will have to be created.

At the present time (1932) there is very little danger of floods in most of the valley. On May 17, 1932, the flow of the river was 12,000 second feet and had not damaged the levees constructed on the river side of the drainage ditches. Permeable jetties have straightened the channel of the Rio Grande, thus, in a measure, protecting the banks.

THE IRRIGATION SYSTEM

The ditches forming the present irrigation system are inadequate because they were constructed only to serve some samll communities. All the structures are primitive including the diversion dams on the river. A comprehensive system is needed to regulate and stabilize the water

supply. Seventy per cent of the annual flow of the river occurs in the spring of the year, while during the late summer months the river may be dry at Albuquerque, and in the lower end of the valley the water shortage becomes acute.

The middle valley is divided into four districts from north to south as follows: Cochiti, Albuquerque, Belen, and Socorro. Each of these four divisions derives its water supply from a main canal heading into the river at one of the four diversion dams, located at Cochiti, Angostura, Isleta, and San Acacia. "Low line" canals will distribute the water in the Cochiti, Albuquerque, and Socorro divisions. "High line" canals will be used in the Belen division. The following acreage of land will be irrigated in each division:

Cochiti Division	13,000 acres
Albuquerque Division	37,205 acres
Belen Division	57,399 acres
Socorro Division	15,663 acres
Total Irrigable area	123,267 acres

Tables 6 and 7 give the proposed main canals and laterals. Whenever possible existing ditches will be used in distributing the water. In many cases this will necessitate enlarging the present ditches and the placing of new structures, such as head gates.

Farm laterals will not be constructed by the Conservancy District, but the district works will generally carry water to within a half mile of each farm.

TABLE 6

Proposed Main Canals

Name of Canal	*Length in Miles*	*Capacity Sec. Ft.*
Cochiti	24.8	200
Albuquerque	34.3	550
Belen High Line	32.2	1000
Peralta	15.7	300
San Juan	17.7	170
Socorro	28.0	276
Total	168.6	

TABLE 7

Laterals by Divisions

Division	*Length in Miles*
Cochiti Laterals	38.7
Albuquerque Laterals	114.3
Belen Laterals	147.5
Socorro Laterals	55.8
Total	378.2

These tables are taken from *Report of the Chief Engineer*, by Joseph L. Burkholder, Pages 121 and 125.

THE DRAINAGE SYSTEM

The drains of the Conservancy District are of two general types, riverside drains which closely parallel the river and provide outlets for interior drains, and interior drains which branch from the riverside drains, generally following the lower portions of the valley. All drains are of the open type similar to the Isleta Pueblo drains, and those constructed on the Rio Grande Project near El Paso, Texas.

The drainage system is not designed to control floods from side arroyos, but wherever possible the flood waters

will be turned into the drains through openings small enough to prevent damage and overflow of the drains.

The drainage system is designed to provide a normal water table under all irrigated land varying from four feet under lands distant from drains to about six feet below the land close to the drains.

The construction of the drains proceeds from the outlet toward the upper end in such a manner as to provide drainage when the lower portion of each drain is completed.

The material excavated from riverside drains is deposited on the side toward the river for the construction of the levee system. The riverside drains have a depth of six to eight feet below the normal ground surface except at points near the outlets where the grades are flattened to meet the elevation of the river bed. The widths at the bottom of the drains vary from ten feet to twenty feet, depending upon the quantity of water to be discharged. The side slopes are planned one and a half to one in all cases, but because of the saturated and unstable conditions of the banks this slope will not be obtained generally.

The land between the riverside drains and the river belongs to the district and is to be used as part of the river channel.

The interior drains discharge through the riverside drains into the river at designated outlets. The interior drains have depths of about ten feet below normal ground surface, except at the outlets to the riverside drains. At these points the grades of the interior drains are flattened to meet the shallower riverside drains. The widths of the bottoms of the interior drains are eight to fourteen feet, depending upon the amount of water to be carried. The side slopes are the same as for the riverside drains.

The interior drains are located in accordance with the water table and soil conditions which have been studied for this special purpose. The drains are spaced so that the greatest distance from any point to a drain will not be over one-half mile.

These drains, in general, will greatly improve surface water conditions, because drainage will provide a soil reservoir which may be temporarily filled with arroyo flood waters without damage at the surface.

There are about 1,277 acres in the valley that have only partial drainage. This is due to the flattening of the grade of the drains at the outlets to the river.

TABLE 8

Length of riverside and interior drains in miles

Division	Riverside Drains	Interior
Cochiti	22.08 miles	7.52 miles
Albuquerque	59.37 miles	61.97 miles
Belen	77.14 miles	80.42 miles
Socorro	40.12 miles	31.10 miles

The estimated drainage return in the Middle Rio Grande Valley is given in Table 9.

The entire amount of drainage for the Socorro division comes in below the lower diversion dam, and is not subject to re-diversion or re-use, but flows into the Elephant Butte Reservoir with the winter flows of the drains from the other three districts. The total annual winter flow to the Elephant Butte Reservoir is estimated at 94,849 acre feet. The total drainage water to Elephant Butte Reservoir is given in Table 10.

TABLE 9

Estimated Drainage Return Middle Rio Grande Valley

Division	Acre Feet
Cochiti	21,900
Albuquerque	89,292
Belen	137,757
Socorro	37,591
Estimated Total Annual Drainage Return	286,540

TABLE 10

Total Drainage Water to Elephant Butte Reservoir

Division		Acre Feet
Cochiti	Nov.-Feb. 23% of 21,900	5,037
Albuquerque	Nov.-Feb. 23% of 89,292	20,537
Belen	Nov.-Feb. 23% of 137,757	31,684
Socorro	All 100% of 37,591	37,591
Total		94,849

These tables are taken from *The Report of the Chief Engineer*, by Joseph L. Burkholder, Page 205.

THE ALKALINE COEFFICIENT AND THE CLASSIFICATION OF IRRIGATION WATERS

The alkaline coefficient and the class of the water in each drain was determined, each month, while the study was in progress. The drainage waters of the conservancy district are to be used for irrigation to supplement the water from the Rio Grande. This chapter, therefore, is devoted to the classification of the drainage waters according to best standards.

An excess of "alkali" in the soil is detrimental to the growth of crops. Water used in irrigation may seriously impair the fertility of the land by increasing its "alkali" content. The best of natural waters probably would injure land if irrigation were continued for a long time without natural or artificial drainage. All irrigation waters contain "alkali," and evaporation in and from the soil results in a gradual accumulation of toxic salts. In order that waters may readily be compared with respect to their suitability for irrigation, a simple index of their irrigating value, such as the "alkali" coefficient, is needed. The "alkali" coefficient is an arbitrary quantity and may be defined as the depth in inches of water which, on evaporation, would yield sufficient "alkali" to render a four foot depth of soil injurious to the most sensitive crops. If the "alkali" coefficient of water is found to be seventeen, seventeen inches in

depth of that water contains sufficient "alkali" to render injurious to sensitive crops the soil on which it is applied. However, the "alkali" coefficient does not take into consideration the method of irrigating, the crops grown, the character of the soil, or the drainage.

Hilgard[3] quotes results of investigations by R. H. Loughridge showing the greatest amount of various alkali compounds found in soils in which crops were not injured. Forty cultures were made and the results showed great diversity for the relative toxicity of the compounds toward the different cultures. The mean results for several cultures of about the same degree of sensitiveness, indicate with marked uniformity, the relative toxicity of the "alkalies" toward common cultures to be about as follows: sodium as Na_2CO_3, ten; sodium as NaCl, five; and sodium as Na_2SO_4, one. Fifteen thousand pounds of sodium with a relative toxicity of one in four feet depth of soil is barely sufficient to effect injuriously the more sensitive crops.

Practically all the alkali salts of the Rio Grande Valley are sodium sulfate and have a relative toxicity of one.

In general, injurious results from the use of a water for irrigation depend largely on drainage conditions and soil texture. Waters with low alkaline coefficients may be used successfully in a loose soil with free drainage. The following approximate classification, which is based on ordinary irrigation practice in the United States, indicates in a general way the customary limitations in the use of waters having various alkaline coefficients. Table 11 shows this classification.

3. Hilgard, E. W., *Soils*, Page 467, 1906.

TABLE 11

Classification of Irrigation Waters

Alkali Coefficient	Class	Remarks
More than 18	Good	Have been used successfully for many years without special care to prevent alkali accumulation.
18 to 6	Fair	Special care to prevent gradual alkali accumulation has generally been found necessary except on loose soils with free drainage.
5.9 to 1.2	Poor	Care in selection of soils has been found to be imperative and artificial drainage has frequently been found to be necessary.
Less than 1.2	Bad	Practically valueless for irrigation.

Taken from *Manual of Industrial Chemistry*, Allen Rogers, Page 65.

THE CLASSIFICITION OF DRAINAGE WATERS

Samples were collected once a month from the drains at gauging stations near their outlets, where an aggregate of waters of the drains is available. The drains from which samples were collected afford a representative sampling for the valley. Results of 169 analyses are included in this report. One analysis each of the Domingo and San Francisco drains, was made, but are not included. Table 12 gives the number of samples collected and the period over which collections were made. Table 13 gives the average constituents in parts per million of the waters of the Rio Grande, the riverside drains, and the interior drains.

The average amount of total solids in the water of the Rio Grande was 383; in the riverside drains, 428;

TABLE 12

Number of Samples Taken and Time Periods

Rio Grande	No. of Samples	Time Period From	to
At Bernalillo	4	2-12-31	6-16-31
At Isleta	4	2-21-31	5-22-31
At Socorro	4	2-19-31	5-22-31
Total	12		
Riverside Drains			
Algodones	12	8-11-30	7-13-31
Bernalillo	13	8-11-30	8-13-31
Corrales	6	2-26-31	8-17-31
Albuquerque	16	6- 7-30	8-13-31
Albuquerque Barr	11	7- 7-30	8-13-31
Atrisco	7	2-26-31	3-13-31
Peralta	12	9-12-30	8-15-31
Belen	9	10-13-30	8-13-31
San Juan	11	10- 9-30	8-17-31
Lemitar	12	8-14-30	8-14-31
San Antonio	11	8-14-30	8-14-31
Total	120		
Interior Drains			
Alameda	9	9-10-30	6-23-31
Isleta	15	7- 9-30	8-13-31
Bosque	13	8-12-30	8-14-31
Total	37		

TABLE 13
Average Constituents in Parts per Million

Rio Grande	Total Solids	SiO_2	Fe_2O_3 and Al_2O_3	Ca	Mg	SO_4	Na and K	CO_3	HCO_3	Cl
At Bernalillo	400	60	5	47	20	120	60	17	122	38
At Isleta	316	27	5	44	16	89	50	6	143	25
At Socorro	445	39	6	62	20	110	55	3	174	48
Average	383	41	5	51	18	113	56	9	148	39
Riverside Drains										
Algodones	380	47	5	56	20	88	40	19	166	15
Bernalillo	374	31	9	55	21	103	33	18	160	30
Corrales	352	28	4	55	14	84	53	6	160	28
Albuquerque	349	29	5	49	14	91	37	16	144	21
Albuquerque Barr	431	34	6	65	20	126	42	8	195	33
Atrisco	436	36	3	59	21	120	71	18	157	28
Peralta	422	27	6	59	22	118	59	14	182	30
Belen	425	34	7	66	22	141	44	7	181	28
San Juan	383	32	4	62	20	125	62	15	160	29
Lemitar	550	37	6	76	25	186	83	17	177	63
San Antonio	608	36	6	64	20	167	109	16	201	72
Average	428	34	5	61	20	123	58	13	171	34
Interior Drains										
Alameda	941	51	7	131	33	305	145	5	272	96
Isleta	680	50	5	99	21	247	125	11	230	51
Bosque	1,756	66	18	160	40	605	298	7	261	236
Average	1,125	55	10	130	31	385	189	7	257	128

TABLE 14

Constituents in Parts Per Million. A, First Half of Period of Study; B, Second Half of Period of Study

Riverside Drains		Total Solids	SiO_2	Fe_2O_3 and Al_2O_3	Ca	Mg	SO_4	Na and K	CO_3	HCO_3	Cl
Algodones	A	412	52	8	55	21	103	39	22	171	17
	B	347	42	3	57	19	73	41	15	159	14
Bernalillo	A	368	35	11	57	25	104	33	11	147	31
	B	377	28	8	53	18	102	33	23	172	29
Corrales	A	352	29	3	65	14	101	58	6	185	38
	B	352	27	4	44	14	67	48	6	135	19
Albuquerque	A	340	36	8	53	16	91	28	13	147	20
	B	351	23	3	47	13	91	45	20	142	24
Atrisco	A	459	41	3	54	23	130	82	14	188	32
	B	419	32	2	62	27	112	63	21	142	24
Albuquerque Barr	A	396	38	6	62	23	127	35	6	193	30
	B	473	28	5	65	16	122	51	9	201	38
Peralta	A	636	34	8	68	28	122	33	9	208	27
	B	409	24	6	53	18	114	76	19	157	33
Belen	A	436	34	6	72	27	167	33	3	182	27
	B	416	34	7	59	18	114	55	16	181	29
San Juan	A	390	42	6	60	25	151	64	15	175	29
	B	377	29	3	62	17	109	61	19	148	29
Lemitar	A	574	38	9	82	26	196	66	17	173	65
	B	542	37	3	71	24	176	101	17	180	61
San Antonio	A	561	43	6	59	22	171	91	11	218	47
	B	647	29	5	71	18	161	130	21	185	96

and in the interior drains, 1,125. The relative values of these waters for irrigation are clearly indicated by the average alkaline coefficients as follows: river waters 57, waters of the riverside drains 53, and waters of the interior drains 14. The first two waters are classed as good for irrigation. The waters of the interior drains, however, are classed as fair.

Tables 14 and 15 give the constituents in parts per million for the first and second halves of the period of study,

TABLE 15

Constituents in Parts Per Million. A, First Half of Period of Study; B, Second Half of Period of Study

Interior Drains		Total Solids	SiO_2	Fe_2O_3 and Al_2O_3	Ca	Mg	SO_4	Na and K	CO_3	HCO_3	Cl
Alameda	A	1020	60	9	140	38	370	146	1	321	104
	B	842	45	6	124	28	257	144	8	211	86
Bosque	A	689	54	6	80	21	238	130	11	244	48
	B	669	43	5	128	24	261	111	11	211	55
Isleta	A	1878	72	19	164	42	584	293	7	300	247
	B	1652	61	16	156	38	627	304	8	242	227

showing the changes in the concentration of the salts. The Algodones riverside drain, for example, averaged 412 parts per million total solids for the first half of the period and 347 parts per million total solids for the second half of the period.

The analyses of the waters of the Rio Grande and the drains of the Middle Rio Grande Valley Conservancy District indicate that sulfates and chlorides are in excess of carbonates. Calcium is the dominant metal.

The alkaline coefficient decreases from 66 at Bernalillo to 43 at Socorro, a distance of nearly 100 miles. This is in accord with the increase in total solids. The change is due to leaching of the lands in the valley. The river samples were collected at the Bernalillo, Isleta, and Socorro bridges from February, 1931, through June, 1931. After this date the river became dry.

The sampling of all drains was completed by August 15, 1931. So far as this report is concerned the gauge readings of the drains ceased at the same date. The flow of water in the drainage canals is given in table 16.

The following is a description of the drains: The Algodones riverside drain was about four miles in length when the last sample was taken. This is a short drain on the east side of the river between San Felipe Pueblo and the town of Algodones. The average alkaline coefficient from August, 1930, to February, 1931, was 88; from February through July the alkaline coefficient was 77, which is a decrease of ten, showing an increased amount of salts in the water. The water, nevertheless, is classed as good for irrigation. The average flow of water in this drain was thirteen second feet. There is no cultivated land along the Algodones drain. The land, however, is subject to overflow from the river.

The Bernalillo riverside drain was about twelve miles in length when the last sample was taken. This is a long drain on the east side of the river. The average alkaline

TABLE 16

Flow of Water in Drainage Ditches
Flow in Second Feet

Riverside Drains	A	B	C	Increase	Decrease
Algodones	13	9	11		2
Bernalillo	38	37	37		1
Corrales	21	15	18		6
Albuquerque	74	94	84	20	
Albuq. Barr	25	47	36	22	
Atrisco	16	24	20	4	
Peralta	51	50	50		1
Belen	32	27	28		5
San Juan	21	13	17		8
Lemiter	15	24	19	9	
San Antonio	15	24	19	9	
Average	30	31	30		
Interior Drains					
Alameda	9	14	11	5	
Isleta	22	25	23	3	
Bosque	15	18	16	3	
Average	15	18	16		

A=First Half of Period of Study.
B=Second Half of Period of Study.
C=Average of A and B.

coefficient from August, 1930, to February, 1931, was 72; from February through August, 1931, the alkaline coefficient was 49, a decrease of 23, showing that there was quite an increase in salts. The waters in this drain are classed as good for irrigation. The average flow of water was 36 second feet. There is more or less cultivated land between Algodones, where the Bernalillo drain heads, and Sandia where it ends.

The Corrales riverside drain was seven miles in length when the last sample was taken. This is a comparatively short drain on the west side of the river opposite Corrales. The average alkaline coefficient from February, 1931, through May, 1931, was 51. The water is classed as good for irrigation. The average flow of water in this drain was 18 second feet. The Corrales drain traverses swamps and bosque along the river. The cultivated lands are away from the river and near the western foothills of the valley.

The Albuquerque riverside drain was about fourteen miles long when the last sample was taken. This is one of the long drains, and is located on the east side of the river, extending from above Alameda to the Old Town Bridge at Albuquerque. The average alkaline coefficient of this drain from June, 1930, to January, 1931, was 90; from January, 1931, through August, 1931, it was 64, a decrease of 26. The water is classed as good for irrigation. The average flow of water in this drain was 84 second feet. The Albuquerque riverside drain traverses land which at one time was under cultivation, but was ruined by the rising water table. South of the Alameda Bridge, the drain flows through bosque land to its termination.

The Albuquerque-Barr riverside drain was twelve miles in length at the time the last sample was taken. This drain is on the east side of the river and extends from the Old Town Bridge to a point just north of Isleta. The average alkaline coefficient from July, 1930, to February, 1931, was 61; from February through August, the average alkaline coefficient was 45. This is a decrease of 16, indicat-

ing an increased amount of salts in the water. The water is classed as good for irrigation. The average flow in this drain was 36 second feet. Standing water, the flow of the Alameda interior drain, and treated sewage from the Albuquerque sewage disposal plant, enter this drain. The upper portion of the Albuquerque-Barr drain passes through cultivated lands, the lower portion through bosque and swamps.

The Atrisco riverside drain was about five and one-half miles long when it was last sampled. This drain is on the west side of the river and extends from Albuquerque to Isleta. The average alkaline coefficient from February, 1931, through May, 1931, was 29; from May through August it was 47. There was an increase of 18 showing the concentration of the salts was decreasing. The water is classed as good for irrigation. The average flow in this drain was 20 second feet. The Atrisco drain traverses cultivated land that is constantly being leached by irrigation.

The Peralta riverside drain was over twelve miles in length when the last sample was taken. This drain is located on the east side of the river, and extends from Isleta to a point opposite Belen. The average alkaline coefficient from September, 1930, to March, 1931, was 59; from March, 1931, through August, 1931, the alkaline coefficient was 44, or a decrease of 15. The water is classed as good for irrigation. The average flow of water in this drain was 50 second feet. The Peralta riverside drain carries a large amount of surface water along with waste irrigation water. The flow varies from day to day and month to month during the irrigating season. There are irrigated tracts mingled with swamps and bosque along this drain.

The Belen riverside drain when last sampled, was over eight miles in length. This drain is located on the west side of the river and extends from three miles below Isleta to a point about two miles below Belen. The average alkaline coefficient from October, 1930, to February, 1931, was 62; from February, 1931, through August, 1931, the alkaline

coefficient was 67, or an increase of five. The water is classed as good for irrigation. The average flow of this drain was 28 second feet. This drain traverses an area of land that was formerly under cultivation, but which has been made unproductive by the rising water table. The Belen riverside drain cuts through swamps and sections of bosque.

The San Juan riverside drain when last sampled was over four miles in length. This drain is located on the east side of the river and extends from the San Juan siphon to a point about two miles above La Joya, where it enters the river. The average alkaline coefficient from October, 1930, to March, 1931, was 52; from March, 1931, through August, 1931, the alkaline coefficient was 48, or a decrease of four, which may be considered as no change. The water is classed as good for irrigation. The average flow of water in this drain was 17 second feet. The San Juan riverside drain traverses a cultivated region which is continually being leached by irrigation.

The Lemitar riverside drain when last sampled was over nine miles in length. This drain is located on the west side of the river, and extends from just below San Acacia to Pueblitos. The average alkaline coefficient from August, 1930, to February, 1931, was 38; from February, 1931, through August, 1931, the average alkaline coefficient was 27, or a decrease of eleven, which indicates an increase of the content of salts. The water is classed as good for irrigation. The average flow of water in this drain was 32 second feet. This drain traverses swamps and bosques with small areas of cultivated land.

The San Antonio riverside drain when last sampled was about twelve and one-half miles in length. This drain is located on the east side of the river, opposite Elmdorf. The average alkaline coefficient from August, 1930, to February, 1931, was 23; from February, 1931, through August, 1931, the average alkaline coefficient was 18, or a decrease of four, which may be considered as no change. The water

is classed as good for irrigation. The average flow of water in this drain was 20 second feet.

The Alameda interior drain was last sampled in June, 1931; at that time it was about five miles in length. This drain is located near the eastern foothills of the valley and extends from Alameda to the Old Town bridge. The average alkaline coefficient from September, 1930, to February, 1931, was 12; from February, 1931, through June, 1931, the average alkaline coefficient was 16 or an increase of four, which shows a smaller concentration of salts in the water. The water is classed as fair for irrigation. The average flow of water in this drain was eleven second feet. This drain traverses cultivated lands, and swampy areas.

The Isleta interior drain when last sampled was sixteen miles long. This drain extends from a point near the Old Town bridge, down the valley near the western foothills, to Isleta. The average alkaline coefficient from July, 1930, to February, 1931, was 20; from February, 1931, through August, 1931, the average alkaline coefficient was 22, an increase of two, but the water may be considered as remaining constant. This water is classed as good for irrigation. The average flow of the water in this drain was 21 second feet. The Isleta interior drain traverses an area of cultivated land mingled with swamps. The Gun Club Lake and swamp was drained by the conservancy project.

The Bosque interior drain when last sampled had reached a length of about twelve miles. This drain heads just south of Belen and enters the river at a point nine miles south of Belen. The average alkaline coefficient from August, 1930, to February, 1931, was 7; this figure remained constant through August, 1931. The water is classed as fair for irrrigation. The average flow of the water in this drain was 9 second feet. The Bosque interior drain traverses some land under cultivation, but large tracts are swamps, due to the rising water table.

Tables 17 and 18 show the average of the alkaline coefficients and the classification of the waters, and the length

of the drains and the condition of the adjacent land, respectively.

The average alkaline coefficient of the Algodones riverside drain is 82; that of the San Antonio riverside drain is 20. The difference, which is 62, is to be noted because it

TABLE 17
Alkaline Coefficients and Classification of Water
Alkali Coefficients

Rio Grande	A	B	C	Increase	Decrease	Class
At Bernalillo	66					Good
At Isleta	62					Good
At Socorro	43					Good
Average	57					Good
Riverside Drains						
Algodones	88	77	82		11	Good
Bernalillo	72	49	68		23	Good
Corrales	51	51	51	No Change		Good
Albuquerque	90	64	77		26	Good
Albuquerque-Barr	61	45	54		16	Good
Atrisco	29	47	39	18		Good
Peralta	59	44	52		15	Good
Belen	62	67	65	5		Good
San Juan	52	48	50		4	Good
Lemitar	38	27	32		11	Good
San Antonio	23	18	20		5	Good
Average	57	19	53			Good
Interior Drains						
Alameda	12	16	14	4		Fair
Isleta	20	22	21	2		Good
Bosque	7	7	7	No Change		Fair
Average	13	15	14			Fair

A=First Half of Period of Study.
B=Second Half of Period of Study.
C=Average of and B.

indicates a great change in the condition of the valley lands from north to south. In the upper end of the middle valley, the concentration of salts in the water is low compared with the higher concentration of the salts in the lower end of the valley. The increase in the alkaline coefficient is not regular

TABLE 18
Lengths of Drains and Condition of Adjacent Lands

Riverside Drains	Length in Miles 8-15-31	Length in Miles above Gauging Sta.	Remarks
Algodones	3.94	1.84	Lands subject to overflow
Bernalillo	11.82	10.42	Mostly cultivated land
Corrales	7.10	6.70	Bosque lands and swamps
Albuquerque	13.89	13.02	Drain land formerly under cultivation
Albuquerque-Barr	12.18	10.58	Drains swamps. Receives water from Alameda Int. Drain, also treated sewage
Atrisco	5.63	4.90	Mostly cultivated land
Peralta	12.30	11.60	Carries surface and waste irrigation water. Swamp and Bosque land
Belen	8.20	7.00	Drains land formerly under cultivation
San Juan	4.25	3.55	Mostly cultivated land
Lemitar	9.41	9.01	Mostly swamps and Bosque
San Antonio	12.47	11.07	Bosque lands and swamps
Interior Drains			
Alameda	4.96	4.96	Mostly cultivated land, some swamps
Isleta	16.10	11.14	Mostly cultivated land, some swamps
Bosque	11.73	11.73	Drains land formerly under cultivation Belen sewage. Bosque and swamps

but varies slightly with the drain. This variation is due to the length of the drain and the condition of the land through which it passes. A short drain, for example, the Algodones riverside, reflects the character of uncultivated land subject to flooding from the river.

The Albuquerque riverside drain flows a long distance through bosque, cultivated land, and land that was formerly cultivated but is now swampy. The waters of this drain are the leachings of a long strip of land and are therefore an aggregate unlike the waters of the Algodones drain. However, the waters of the Algodones drain are only slightly better than the waters of the Albuquerque drain.

The Corrales riverside drain is short but it drains an area of swamps and bosques. The alkaline coefficient is lower than for either the Algodones or the Albuquerque riverside drain.

The flow of water in these drains gives us another aspect in relation to the classes of the waters. The average flow in the Algodones riverside drain was eleven second feet; in the Corrales riverside drain the average flow was eighteen second feet. There is very little difference in the flows of these two drains but there is a great difference in the alkaline coefficients, which is due to the type of country drained. The average flow of the Albuquerque riverside drain was 84 second feet. There is very little difference between this water and that of the Algodones riverside drain, indicating that the location of the drain in the valley, the length of the drain, and the type of land drained have to be considered in classifying the waters of the drains.

The waters of the interior drains, which are away from the river, indicate that the concentration of salts is high in the valley lands. The average of the waters of these drains is fair. It is to be noted that the waters of the Isleta interior drain are classed as good for irrigation. This drain is longer than either the Alameda or Bosque drains, and flows through large areas of cultivated lands which are continually being leached. There is far more uncultivated land

and swamps along the other two interior drains. The flow of water in the Isleta drain is larger than that of the other two drains. It cannot be said, therefore, that the flow of water in a drain controls the concentration of the salts in a water without taking into consideration the factors already mentioned. Table 19 gives a comparison of average drain flows, parts per million, and alkali coefficients.

The "alkali," or salts, are found mostly in the first two feet of soil. These salts are deposited by the evaporation of ground water. If an area of land is allowed to lie fallow the concentration of salts in the drainage waters from the area will gradually decrease. As soon as the land is again cultivated and irrigated, the concentration of salts in the drainage waters will increase. In time, leaching by irrigation waters removes the accumulation of salts if the drainage is adequate.

TABLE 19

Comparison of Average Drain Flows, Parts Per Million and Alkali Coefficients

Riverside Drains	Flow in Sec. Ft. A	Flow in Sec. Ft. B	Parts Per Million A	Parts Per Million B	Alkali Coefficient A	Alkali Coefficient B
Algodones	13	9	412	347	88	77
Bernalillo	38	37	368	377	72	49
Corrales	21	15	352	352	51	51
Albuquerque	74	94	340	351	90	64
Albuquerque-Barr	25	47	396	473	61	45
Atrisco	16	24	459	419	29	47
Peralta	51	50	636	409	59	44
Belen	32	27	436	416	62	67
San Juan	21	13	390	377	52	48
Lemitar	15	24	574	642	38	27
San Antonio	15	24	561	647	23	18
Interior Drains						
Alameda	9	14	1020	842	12	16
Isleta	22	25	689	669	20	22
Bosque	15	18	1878	1652	7	7

A=First Half of Period of Study.
B=Second Half of Period of Study.

The nearly equal time division of the periods of study shows the difference between the drainage waters from the summer of 1930 through the summer of 1931.

During the second half of the period, from January, 1931, through August, 1931, eight or 73 per cent of the eleven riverside drains showed a decrease in the alkaline coefficient. In two, or 25 per cent, there was an increase in the alkaline coefficient, and in two there was no change. During the same period, there was a slight increase in the alkaline coefficients of the Alameda and Isleta interior drains. There was no change in the alkaline coefficient of the Bosque interior drain.

The increase in the concentration of salts in the drains may be explained by the movement of the ground water through the porous alluvium soils of the valley. The irrigation water that seeps into the soil and leaches the salts does not reach the drains for several months. Therefore, the effects of irrigation from the summer months are not noticed until the following spring and summer, when the alkaline coefficient is lowered by the increased salt content of the drainage waters.

The increases in the alkaline coefficients of the two riverside and the two interior drains was probably due to local irrigation and drainage conditions.

The waters of the Corrales riverside drain and the Bosque interior drain did not show any change in the average alkaline coefficient due to local conditions.

CONCLUSIONS REGARDING THE DRAINAGE WATERS OF THE CONSERVANCY DISTRICT

The analyses of the drainage waters of the Middle Rio Grande Conservancy District indicate that the waters of the river, and the drains, both riverside and interior, are typical of all Southwestern waters; in that sulfates and chlorides exceed the carbonates, and that calcium may or may not be the dominant metal.

The river is supplying water with an alkaline coefficient of 57, which, according to the classification of irrigation waters, can be used successfully for irrigation since there is an effective drainage system. The calcium sulfate in the river water should now be of good use in correcting the "alkali" conditions in the valley.

The waters of the riverside drains have an average alkaline coefficient of 53 which is little lower than that of the river. The water of every riverside drain is classed as good. The alkaline coefficient can be raised by the addition of river water when the drainage water is used for irrigation. The addition of river water is especially recommended for the riverside drains of the Belen and Socorro divisions.

The waters of the interior drains have an average alkaline coefficient of 14 which classes the water as only fair for irrigation. However, the waters of the Isleta drain average 21, which is good. The Alameda drain averages 14, which is fair, and the Bosque drain averages seven, which is fair but very close to poor. If the waters of the interior drains are to be used for irrigation, additions of river water will have to be made so that the alkaline coefficient will be raised. If this is not done the land might be damaged.

The analyses have proved that the water from the drains can be used for irrigation to augment the flow from the river, without damage to the land. It has also been proved that effective leaching of the land is being made possible by the drains, and that the lowered water table is allowing the reclamation of land which has been waterlogged for years.

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APPENDIX

Methods of Removing "Alkali" from Farm Lands

By JOHN G. KOOGLER
Bernalillo County Agricultural Agent

RECLAIMING ALKALI LANDS

The alkali problem in the reclaimed soils of the Middle Rio Grande Conservancy District concerns many farmers. Efforts are being made to bring back land that once was productive, but which during the last fifty years, has succumbed to waterlogging and alkali. White alkali is the chief concern in Bernalillo County, and practically all of the soil of the valley contains some of this class of salt. In small amounts and dilute form it may be beneficial, since some of the constituents of common alkali are essential to plant growth. In general, soils may contain about 5 per cent of alkali before harmful effects appear. Soils more strongly impregnated will have varying effects upon the germination of the seed or the growth of the plant; and frequently plants die because the salt prevents the normal utilization of water.

CONTROL

Further accumulation of the alkali salts has been prevented over most of the area by installation of the drainage system. Farmers are working on more than 3,800 acres of newly-plowed land, some of which has an accumulation of salt in excess of the toxic limit. Good drainage is essential to alkali reclamation. Methods of reclamation described herein are contingent upon such drainage, the effect of which can be determined easily by test borings made in advance of reclamation. Leaching probably is the only satisfactory method of removing these salts from the soil.

LEACHING METHODS

Porous soils lend themselves more readily to leaching operations than the tighter, impervious soils, since they allow more rapid percolation of the free water which carries the dissolved salts. Prèparation of the field is worthy of careful consideration. A field or block of land which is to be leached should be inclosed within borders or dikes. The land within these borders should be level. If a field contains high spots, salts may not be leached from them. Even percolation of the water applied is important. Uneven percolation results in uneven leaching, which will necessitate the use of additional water. Where the land to be leached has considerable slope the borders should be located on contour lines and the field prepared as a series of terraces. Then the areas to be leached usually will be in the form of long, narrow strips. Occasionally small irregular permeable spots are found in a field, and it may be necessary to leach these separately.

The method of applying the water depends upon circumstances. Fields impregnated with white alkali and composed of coarse porous soils, can usually be leached, with one or two applications of water; that is, the water should be turned into the basin formed by the borders and allowed to collect there until it is ten, twelve, or fifteen inches deep. This depth should be maintained for several days before the water is shut off. When the water in the basin has percolated through the soil and drained away, soil samples should be taken and tested for their salt content. If sufficient of the salts have not been washed out, the procedure should be repeated. Waters which carry a large amount of silt may prove unsatisfactory for leaching because of the difficulty of obtaining deep penetration.

Some soil may require several applications of leaching water, two or three years of cultivation, and the use of manures before they return to their normal state of productivity. It is impossible to state the exact amount of water required for leaching the soil because this depends

upon the kind and quantity of accumulated salts, the texture of the soil, preparation of the field, and the quality of leaching water used. Some authorities maintain that light and frequent applications should be given, while others say that water should be turned into the basins formed by the surrounding dikes and kept several inches deep until several feet have been applied. The principal point to keep in mind is that sufficient water should be put on the land and allowed to percolate through the soil until the excess harmful accumulation of salts has been carried down below the root zone.

The cost of leaching may or may not be excessive and depends upon the problems involved. The cost of leveling the land cannot rightly be charged entirely to the leaching because the field should be placed in good condition for proper irrigation; the dikes used for leaching will be larger and more expensive than those used for ordinary irrigation. Under the Elephant Butte Reclamation Project in southern New Mexico, soils containing from 0.78 per cent to 1.80 per cent alkali, required from two to five acre feet of water and cost from $10.00 to as high as $46.00 per acre to level and leach. Alfalfa, corn, and cane were used as reclamation crops, and in most cases they paid for the leaching operation the first year.

Leaching operations should be carried on during the fall or early spring, generally slack times for farm labor, and this will reduce the cost. Irrigation water is usually more plentiful and cheaper during the spring and fall than in the summer months. When land is leached in the fall it is sometimes possible to grow small grain crops on it during the following spring. Sweet clover is a good crop to grow immediately after leaching. It is possible that, because of increased temperatures of soil and water, better percolation will be obtained in the spring than in the late fall, but the amount of evaporation would be increased. So far as results are concerned, one time of the year is probably as good as another.

Leaching by normal irrigation is slower and, in the end, more costly, due to waste of effort and poor crop stands, and the length of time it takes. Flushing of surface salts from the top of the soil is sometimes effective when a good head water is used, but is usually a slow process, and frequently returns some of the salts to the soil.

CHOICE OF CROPS

The farmer who is reclaiming alkali land and who wishes to select crops to use during this period, has a selection of forage crops which have considerable tolerance for alkali. Alfalfa, milo, wheat, and oats are tolerant up to 0.4 per cent; wheat, clover, rye and barley up to 0.6 per cent; the sorgos frequently up to 0.8 per cent; sugar beets and sometimes carrots and onions are tolerant up to 1 per cent, although the quality of the crop is badly impaired. Our native grapes are known to withstand very high percentages, although it is not known just what percentage they will stand.

The alkali problem need not be a serious one in Bernalillo County as a whole, but every farmer should have the soil analyzed, and then take the necessary steps to remove the excess salts where they exist.