SOILS OF THE SAN JUAN BRANCH AGRICULTURAL EXPERIMENT STATION

Agricultural Experiment Station
in cooperation with
Soil Conservation Service,
U.S. Bureau of Reclamation
and
Bureau of Indian Affairs

NEW MEXICO STATE UNIVERSITY

AGRICULTURAL EXPERIMENT STATION RESEARCH REPORT 180

Contents

Acknowledgments

The information reported here is the result of investigations by representatives of the Soil Conservation Service of the U.S. Department of Agriculture, the Bureau of Reclamation of the U.S. Department of Interior, the Bureau of Indian Affairs, also of the USDI, and the Agricultural Experiment Station of New Mexico State University. Contributions from specific agencies are identified in the METHODS section.

DECEMBER 1970 LAS CRUCES, NEW MEXICO

SOILS OF THE SAN JUAN BRANCH AGRICULTURAL EXPERIMENT STATION

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The San Juan Branch Agricultural Experiment Station occupies 254 acres about six miles southwest of Farmington in San Juan County. Irrigation is being developed in this area by the Bureau of Reclamation and the Bureau of Indian Affairs as part of the Navajo Indian Irrigation Project. The first water delivery from this project is scheduled for 1971.

The climate is semiarid. At the Farmington airport, the average annual precipitation is 8.12 inches, the mean summer temperature is 72.5 degrees, and the mean winter temperature is 31.9 degrees. At the weather station in Farmington, the average frost-free season is 146 days (2,3). The station is in Climatic Zone 6, according to the climate classification of Major and Driggs (4).

The native vegetation is shortgrass prairie, with blue grama the climax species. The present vegetation is mostly Indian ricegrass and galleta, although snakeweed and Mormon tea also occur.

The entire experimental farm is underlain by the Farmington sandstone member of the Kirtland Shale formation (2). The overlying surface deposits consist of alluvium, which has been reworked by wind. This alluvium has apparently come from the Farmington and other sandstones and, to a lesser extent, from shales.[1]

Methods

The soils of the farm were described and mapped in detail by the Soil Conservation Service of the U.S. Department of Agriculture and by the Bureau of Reclamation of the U.S. Department of Interior. The aerial topography at two-foot contour intervals was provided by the Bureau of Reclamation.

Eight profiles representing the soils of the station were sampled from backhoe pits dug by the Bureau of Indian Affairs. Each profile was precisely located by the Bureau of Reclamation, and samples were taken by genetic horizons to maximum depths of 62 to 85 inches. The locations of these pits are shown in figures 1, 2, and 3. Each sample was thoroughly mixed, and aliquots were distributed to the laboratories for analyses.

The mechanical analyses and pH data were supplied by the BIA. The mechanical analyses were made with the hydrometer method without removing organic matter and with sodium metaphosphate as the dispersing agent. The pH values were measured by glass electrode on saturated pastes.

Cation and anion analyses, cation exchange capacity measurements, determinations of gypsum, calcium carbonate, and organic carbon, and estimations of clay mineralogy were made at New Mexico State University. The calcium carbonate and organic carbon contents were determined by the method of Anderson and Hanks (1). Clay mineralogy was estimated from X-ray diffraction, and other determinations were made by the methods described in the USDA Handbook 60 (7).

[1] Personal communication with J.W. Hawley, Geologist, New Mexico Bureau of Mines and Mineral Resources, Las Cruces, New Mexico.

Fig. 1. Aerial Topography Map

Fig. 2. Soil Survey Map

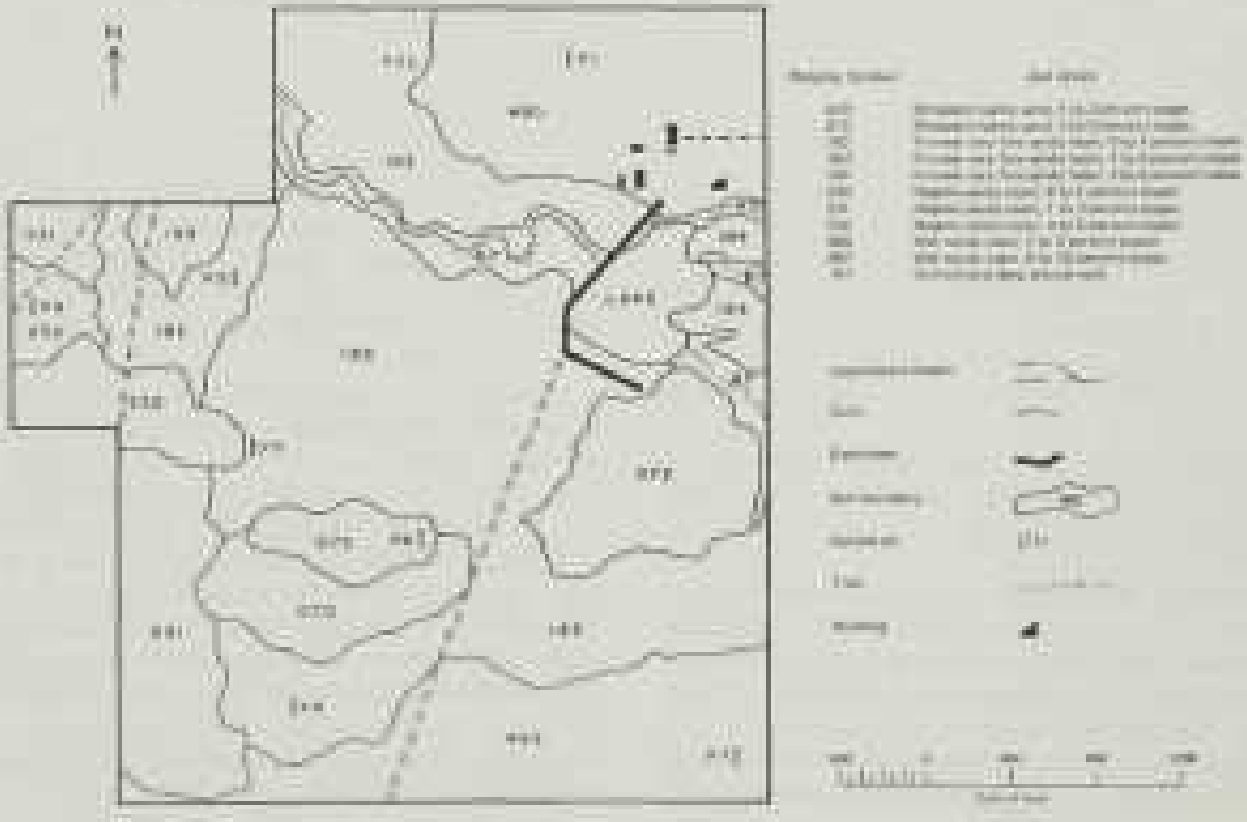
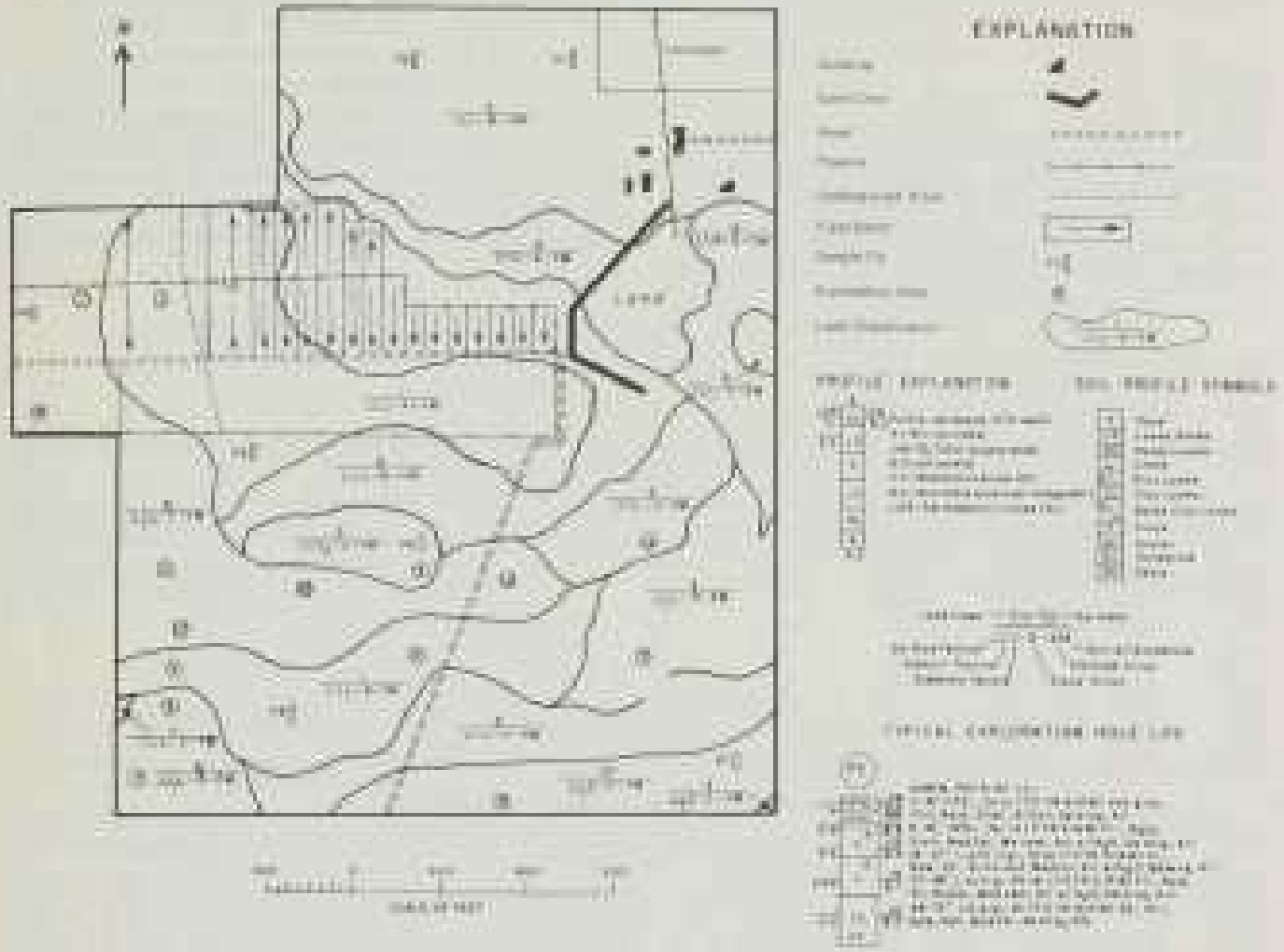


Fig. 3. GSSR Land Classification Map



Results

Field Studies

The soils of the station have been tentatively classified as belonging to the Kinmar, Wall, Napier, and Sheppard series, and a small remaining area was classified as gullied land. The most extensive of these soils, Kinmar very fine sandy loam, is deep and moderately permeable. It has formed from old mixed alluvium from sandstone and shale. The surface horizons are very fine sandy loams, and the subsoil ranges in texture from loam to light clay loam.

The less extensive Wall sandy loam is a deep, moderately to rapidly permeable soil which has also formed from old alluvium which comes from sandstone and shale. It has slightly coarser textures than the Kinmar series.

The Napier sandy loam is similar to the Wall series in texture, but is moderately permeable and moderately deep, and is underlain by a strong calcic horizon, or zone of lime accumulation.

The Sheppard loamy sand has a coarser texture than the other soils and is rapidly permeable.

Detailed profile descriptions of these soils appear in Appendix A. A map showing their distribution on the branch station is shown as figure 2. A map showing the original topography of the station is shown in figure 3.

Laboratory Studies

The results of particle size and various chemical analyses of the genetic horizons of eight soil profiles representing the four soil series occurring on the station are shown in tables 1 through 8. Available moisture in Wall sandy loam is reported in table 9. The clay mineralogies of Wall

sandy loam and Kimmar very fine sandy loam are reported in table 10.

Irrigability Classification

The classification of these soils on the basis of suitability for irrigation is shown two ways. First, the soil series described in this report are classified on the basis of suitability for irrigation by the standards of the Pacific Southwest Interagency Committee (6). These standards, which have also been used to classify the soils of San Juan County (5) and other counties in New Mexico, are reproduced in Appendix B. The resulting irrigation land classes are shown in table 11, which also lists the factors which limit their irrigation suitability.

The Bureau of Reclamation land classification is shown in figure 3. The chart is based on the detailed land classification specifications for the Navajo project which are reproduced as Appendix C.

Table 1. Laboratory data for Nageezi sandy loam

Pit 1. 3100 ft, T., 30 ft. S of NE corner, T 29N, R14W, San Juan County, New Mexico (Latitude 3, 11N, long. Departure 30, 10S)

Depth	Horizon	Sand	Silt	Clay	Textural Class	pH	Organic Carbon	$CaCO_3$ Equivalent	Gypsum	Moisture at Saturation
Inches		percent	percent	percent			percent	percent	mm/100g	percent
0-4	A11	84	10	16	LFSL	7.9	0.37	3.3	0.0	26
4-11	A12	88	07	05	LFSL	7.8	0.25	1.2	0.0	29
11-18	C1	91	03	06	FSL	7.9	0.18	0.9	0.0	20
18-33	C2	89	03	08	FSL	7.9	0.19	1.0	0.0	80
33-47	C2ca	89	03	08	FSL	7.8	0.09	6.0	0.0	29
47-60	C3	88	07	05	LFSL	7.8	0.08	3.8	0.0	29

	Extractable Cations				Cation Exchange Capacity	Exchangeable Na	Saturation Extract Conductivity	Soluble Cations			
	Ca	Mg	Na	K			EC x 10^3	Ca	Mg	Na	K
	meq/100g				meq/100g	percent		meq/liter			
0-4	38.9	2.0	0.2	0.7	9.9	1.1	1.04	8.0	3.4	6.8	0.2
4-11	40.0	2.0	0.2	0.6	12.2	1.2	0.86	6.2	0.4	6.4	0.1
11-18	37.0	1.2	0.1	0.3	15.5	1.3	0.78	3.0	1.2	3.0	1.0
18-33	45.0	2.4	0.7	0.4	13.5	6.4	3.45	11.0	9.0	22.0	1.4
33-47	36.4	8.0	1.3	0.5	11.3	1.3	7.30	30.0	22.0	12.0	2.2
47-58	46.0	2.4	1.4	0.2	6.0	6.7	7.40	41.0	28.0	19.0	0.4

[Abbreviations used for textural classes: LFSL=very fine sandy loam; FSL=fine sandy loam]

Discussion

The analyses reported here support the field classification of these soils as members of calcareous fine loamy, coarse loamy, and sandy families of mixed mineralogy. The potential of these soils for irrigated agriculture appears to be limited primarily by their texture and depth. All except the Nageezi are deep, and can safely be leveled for irrigation, although some become more sandy with depth. The underlying horizons of the Sheppard series are particularly sandy. In the profile of this series, the 47- to 75-inch horizon contained 92 percent sand. If this soil horizon were exposed by leveling, the resulting surface would be highly susceptible to wind erosion, and it would have very low water- and nutrient-holding capacities. This soil would be much better suited for irrigated agriculture if not leveled. The depth of the Nageezi sandy loam is limited by a highly calcareous layer which becomes massive and essentially impenetrable to plant roots at about 24 inches. This, in turn, is underlain by sandstone bedrock which is weathered in the upper part. Leveling of this soil can also be expected to limit its productivity, especially if the cuts extend into the light lime layer. Where this occurs, yield reductions can be expected due to phosphorus,

Table 4. Laboratory data for [illegible] very fine sandy loam

Pit 1: [illegible] ft. N., [illegible] ft. E. of SE corner, S. [illegible], T[illegible]N, R[illegible]W, San Juan County, New Mexico
(Latitude [illegible]; Departure [illegible])

Depth	Horizon	Sand	Silt	Clay	Textural Class*	pH	Organic Carbon	$CaCO_3$ Equivalent	Gypsum	Moisture at Saturation
inches		percent	percent	percent			percent	percent	meq/100g	percent
0-6	A1	57	24	19	VFSL	7.9	0.32	5.0	0.4	33
6-19	C1	53	32	18	SCL	8.0	0.28	4.5	0.6	38
19-27	C2ca	57	28	15	VFSL	8.3	0.32	4.2	0.2	27
27-46	C3ca	41	33	26	FSL	7.8	0.16	5.0	0.6	38
46-72	IIC	92	4	4	LS	8.0	0.06	3.1	0.3	27

Depth	Extractable Cations Ca	Mg	Na	K	Cation Exchange Capacity	Exchangeable Na	Saturation Extract Conductivity EC x 10^3	Ca	Mg	Na	K
	meq/100g				meq/100g	percent		meq/liter			
0-6	27.3	2.1	0.3	0.7	14.4	1.3	1.09	5.8	3.5	1.6	0.4
6-19	41.8	6.3	0.4	0.6	22.0	1.4	1.07	6.3	2.2	3.8	0.1
19-27	46.7	5.5	0.8	0.3	9.9	8.5	1.60	8.8	3.5	10.8	0.1
27-46	45.3	6.6	1.3	0.3	9.7	5.9	4.70	18.5	4.3	35.8	0.3
46-72	60.8	7.7	1.6	0.6	5.9	2.9	9.00	36.0	13.8	60.0	0.9

*Abbreviations used for textural classes: VFSL-very fine sandy loam, SCL-sandy clay loam, FSL-fine sandy loam, LS-loamy sand.

Table 5. Laboratory data for [illegible] very fine sandy loam

Pit 2: [illegible] ft. N., [illegible] ft. E. of SE corner, S. [illegible], T[illegible]N, R[illegible]W, San Juan County, New Mexico
(Latitude [illegible]; Departure [illegible])

Depth	Horizon	Sand	Silt	Clay	Textural Class*	pH	Organic Carbon	$CaCO_3$ Equivalent	Gypsum	Moisture at Saturation
inches		percent	percent	percent			percent	percent	meq/100g	percent
0-9	A1	39	33	28	VFSL	7.7	0.35	6.1	0.2	39
9-27	C1ca	35	33	32	CL	8.2	0.30	5.0	0.5	45
27-46	C2	48	33	19	VFSL	7.8	0.11	6.5	0.1	33
46-60	IIC3	90	3	7	S	8.2	0.01	8.7	0.0	22

Depth	Extractable Cations Ca	Mg	Na	K	Cation Exchange Capacity	Exchangeable Na	Saturation Extract Conductivity EC x 10^3	Ca	Mg	Na	K
	meq/100g				meq/100g	percent		meq/liter			
0-9	28.3	1.8	0.3	1.3	15.3	3.1	1.21	4.0	3.0	3.0	0.3
9-27	48.8	5.6	0.3	0.5	21.4	3.5	1.15	0.0	5.0	6.8	0.3
27-46	46.3	6.3	1.4	0.3	10.6	2.1	7.70	42.0	41.0	44.0	0.3
46-60	20.9	3.0	0.7	0.6	5.8	3.9	3.40	10.6	3.2	20.8	0.2

*Abbreviations used for textural classes: VFSL-very fine sandy loam, CL-clay loam, S-sand.

iron, and zinc deficiencies and to poor soil physical conditions. The nutrient deficiencies can be eliminated by fertilization, and the soil physical condition will gradually improve with the incorporation of organic materials and consequent improvement of soil structure.

The coarse texture of the Sheppard loamy sand can be viewed as either limiting its productivity or necessitating particularly good management. Two problems result from this coarse texture: a serious wind-erosion hazard and limited water-holding capacity. The wind-erosion hazard can best be handled by keeping the soil surface protected with crop residues when dry. The limited available water-holding capacity (generally about three inches to a depth of four feet) cannot be

Table 6.—Laboratory data for Tipperah sandy loam

[Profile 6. SE¼ SE¼ sec. 9, T. 10 S., R. 1 E. of the Mount Diablo base and meridian, Contra Costa County, Soil Conservation Service, Soil Survey Investigations Report No. 1]

Depth	Horizon	Sand	Silt	Clay	Textural class[1]	pH	Organic carbon	$CaCO_3$ equivalent	Organic matter	Retention of moisture
inches		percent	percent	percent			percent	percent	meq/100g	percent
0–4	A1	60	27	14	Sandy clay loam	7.4	0.32	0.1	0.4	22
4–17	C1ca	71	17	12	Sandy loam	7.9	0.23	2.0	0.5	23
17–28	C2ca	70	9	22	Sandy clay loam	8.4	0.27	2.0	0.9	29
28–40	C3ca	40	20	39	Clay loam	8.4	0.59	26.4	1.0	39
40–54	II	52 [2]	14	34	Sandy clay loam	7.5	0.19	0.1	0.3	27

Depth	Extractable Cations				Cation Exchange Capacity	Exchangeable Na	Conductivity	Saturation Extract			
	Ca	Mg	Na	K				Ca	Mg	Na	K
inches	meq/100g				meq/100g	percent	$EC \times 10^3$	meq/liter			
0–4	27.5	2.9	0.5	0.9	13.4	3.7	1.11	25.0	4.1	1.2	0.8
4–17	46.2	4.3	0.3	0.4	11.4	2.6	0.89	4.5	3.3	2.0	0.3
17–28	37.0	4.1	0.6	0.4	9.1	6.6	0.78	3.8	3.7	5.3	0.3
28–40	31.5	4.4	0.9	0.3	9.4	9.7	1.18	3.8	4.3	8.7	0.4
40–54	30.2	4.7	0.6	0.3	12.7	4.9	0.93	27.4	2.5	33.0	0.4

[1] Abbreviations used for textural classes: SCL=sandy clay loam, CL=clay loam, SL=sandy clay loam.

Table 7.—Laboratory data for Sunnyvale very fine sandy loam

[Profile 7. NE¼ SE¼ sec. 9, T. 10 S., R. 1 E. of Mount Diablo base and meridian, 0.25 mile south of Tipperah, Contra Costa County, Soil Conservation Service, Soil Survey Investigations Report No. 1]

Depth	Horizon	Sand	Silt	Clay	Textural class[1]	pH	Organic carbon	$CaCO_3$ equivalent	Organic matter	Retention of moisture
inches		percent	percent	percent			percent	percent	meq/100g	percent
0–7	A11	74	16	8	SL	6.5	0.36	0.1	0.6	26
7–17	A12	74	16	9	SL	6.5	0.23	0.0	0.6	26
17–33	C1ca	66	16	18	SCL	6.9	0.40	0.0	1.2	33
33–46	C2ca	77	13	10	SL	7.9	0.34	2.0	0.3	24
46–62	C3ca	77	12	11	SL	7.9	0.41	2.0	0.4	23

Depth	Extractable Cations				Cation Exchange Capacity	Exchangeable Na	Conductivity	Saturation Extract			
	Ca	Mg	Na	K				Ca	Mg	Na	K
inches	meq/100g				meq/100g	percent	$EC \times 10^3$	meq/liter			
0–7	16.0	3.0	0.3	0.7	10.1	3.0	1.32	5.0	6.4	0.9	0.3
7–17	22.0	3.0	0.2	0.8	13.1	1.5	0.99	6.0	5.0	0.5	0.4
17–33	42.1	5.5	0.3	0.9	8.6	3.5	1.04	1.7	1.9	5.7	0.7
33–46	42.5	4.5	0.9	n.d.[2]	8.1	11.1	1.05	45.0	30.0	35.8	0.7
46–62	38.0	5.2	1.0	n.d.[2]	7.0	14.3	1.10	48.0	33.0	36.0	0.7

[1] Abbreviations used for textural classes: SL=fine sandy loam.

[2] n.d. = not determined.

altered humility. However, if light and frequent irrigations are used, the soil can be highly productive. The profile of this soil sampled from Pit 6 is somewhat finer in texture than most of the series and would be expected to hold about four inches of available water to a depth of four feet.

The laboratory data reported in tables 1 through 8 do not present any great surprises, but rather confirm and refine the observations made in the field. In addition, they supply data which can be used to evaluate changes which occur as these soils are irrigated.

Organic carbon contents are low and generally represent less than 0.5 percent organic matter in the surface horizons. Cation exchange capacities are low but are somewhat higher than expected for

Table 6. Laboratory data for Sheppard loamy sand

[illegible]

Depth	Horizon	Sand	Silt	Clay	Textural Class*	pH	Organic Carbon	$CaCO_3$ Equivalent	Gypsum	Moisture at Saturation
inches		percent	percent	percent			percent	percent	meq/100g	percent
0-10	A1	92	8	0	LS	7.6	0.11	0.6	0.0	22
10-18	C1	94	7	0	LS	7.8	0.18	0.8	0.0	22
18-30	C2ca	78	10	12	FSL	7.8	0.30	3.5	0.4	28
30-47	C3ca	95	5	0	LS	8.2	0.07	5.8	0.0	22
47-72	C4	90	2	8	S	9.2	0.03	0.4	0.0	22

Depth	Exchangeable Cations: Ca	Mg	Na	K	Cation Exchange Capacity	Exchangeable Na	Conductivity EC x 10^3	Saturation Extract: Ca	Mg	Na	K
	meq/100g				meq/100g	percent		meq/liter			
0-10	33.0	0.8	0.1	0.4	6.7	1.0	0.70	4.6	1.4	0.4	0.3
10-18	33.7	0.3	0.2	0.3	5.0	0.3	0.38	3.6	2.5	1.0	0.3
18-30	38.0	1.6	0.3	0.2	5.9	5.2	0.78	2.2	2.5	1.4	0.3
30-47	35.0	3.3	0.1	0.2	6.9	2.2	1.00	6.6	1.8	6.2	0.3
47-72	16.0	4.7	0.6	0.3	2.3	6.6	1.07	1.4	6.4	10.4	0.1

*Abbreviations used for textural classes: LS—loamy sand, FSL—fine sandy loam, S—sand

Table 7. Laboratory data for Wall sandy loam

[illegible]

Depth	Horizon	Sand	Silt	Clay	Textural Class*	pH	Organic Carbon	$CaCO_3$ Equivalent	Gypsum	Moisture at Saturation
inches		percent	percent	percent			percent	percent	meq/100g	percent
0-2½	A11	74	14	12	FSL	8.0	0.22	0.7	0.0	31
2½-8	A12	72	14	14	FSL	8.0	0.28	4.4	0.0	27
8-15	C1ca	74	11	15	FSL	8.1	0.24	3.1	0.0	26
15-28	IIC2ca	95	4	1	LS	8.2	0.20	3.0	0.0	25
28-72	IIIC3ca	95	4	11	LS	8.4	0.11	9.0	0.2	22

Depth	Exchangeable Cations: Ca	Mg	Na	K	Cation Exchange Capacity	Exchangeable Na	Conductivity EC x 10^3	Saturation Extract: Ca	Mg	Na	K
	meq/100g				meq/100g	percent		meq/liter			
0-2½	54.0	2.5	0.2	0.5	8.5	1.8	0.66	5.2	1.0	0.3	0.2
2½-8	46.0	2.3	0.2	0.4	8.0	1.8	0.72	6.2	1.9	0.6	0.1
8-15	61.0	0.4	0.3	0.2	7.6	1.8	0.88	6.8	0.3	3.8	0.2
15-28	56.7	0.0	0.3	0.2	8.9	2.8	1.08	4.9	2.4	2.8	0.2
28-72	61.2	4.0	0.6	0.2	2.3	6.8	1.78	6.8	2.3	10.8	0.2

*Abbreviations used for textural classes: FSL—fine sandy loam, LS—loamy sand

soils with such low clay contents. At least a partial explanation can be found in table 10, which shows the Wall to be high in montmorillonite, and the Kinnear soil to be high in allophane. Both allophane, an amorphous soil clay, and montmorillonite, a crystalline clay, have moderate to high cation exchange capacities, and are thus desirable minerals in soils with low clay contents. The high allophane content may, however, reduce the availability of phosphorus. This could create minor phosphorus nutrition problems, especially if coupled with a high lime content. All soils classified as the Kinnear series may not have this mineralogy, and other series may have it.

Table 9 shows the amounts of moisture held by the various horizons of Wall sandy loam. The

Table 8. Laboratory data for Kimmel very fine sandy loam

Pit 3: [illegible] (Latitude [illegible])										
Depth	Horizon	Sand	Silt	Clay	Textural Class*	pH	Organic Carbon	$CaCO_3$ Equivalent	Gypsum	Moisture at Saturation
inches		percent	percent	percent			percent	percent	meq/100g	percent
0-2	A1C	61	22	15	VFSL	7.6	0.39	0.4	0.1	59
2-10	A12	63	18	16	VFSL	7.6	0.28	0.1	5.6	38
10-24	C1ca	48	30	24	L	8.1	0.19	0.6	1.8	27
24-38	C2ca	53	30	15	L	7.8	0.27	8.3	0.3	34
38-60	C3ca	64	23	13	VFSL	7.7	0.13	3.4	0.6	23

	Extractable Cations				Cation Exchange Capacity	Exchangeable Na	Saturation Extract				
	Ca	Mg	Na	K			Conductivity $EC \times 10^3$	Ca	Mg	Na	K
	------ meq/100g ------				meq/100g	percent		------ meq/liter ------			
0-5	15.8	0.7	0.9	1.1	18.4	1.8	1.04	4.0	3.2	0.9	0.1
5-11	30.6	5.0	0.6	0.5	12.9	2.2	2.42	5.7	4.1	8.8	0.8
10-24	43.6	5.0	1.0	0.4	14.0	6.3	5.93	3.0	0.1	15.8	0.1
24-38	40.6	5.0	2.2	0.2	13.5	6.4	8.38	58.0	11.0	40.6	0.2
38-60	30.7	5.2	1.6	0.2	7.1	9.2	4.33	38.0	20.6	46.6	0.1

*Abbreviations used for textural classes: VFSL–very fine sandy loam, L–loam

Table 9. Readily available moisture in Wall sandy loam, Pit 7

Depth	Total Moisture Retained 1/10 Atm.	Total Moisture Retained 1/3 Atm.	Total Moisture Retained 15 Atm.	Bulk Density	Readily Available Moisture 1/10 Atm.	Readily Available Moisture 1/3 Atm.
inches	percent	percent	percent		-- inches/foot --	
0-12	21.9	15.9	5.8	1.48	3.01	1.89
12-30	23.5	14.7	4.7	1.38	3.35	1.66
30-48	23.1	15.4	4.9	1.63	3.78	1.89
48-72	16.3	9.8	3.4	1.41	2.47	1.43

Table 10. Clay Mineralogy

Depth	Particle Size	Montmorillonite	Chlorite	Illite	Kaolinite	Allophane	Vermiculite	Quartz
inches	microns							
			Wall sandy loam, Pit 7					
0-4	<.2	XXX	XX	XX				
0-4	.2-2	XX	XX	XX	XX			X
4-11	<.2	XX	XXX	XX				
4-11	.2-2	XXX		XX	XX			X
11-25	<.2	XXX	XX	XXX				
11-25	.2-2	XX		XXX	XX		X	XX
25-47	<.2	XXX	XX	XXX				
25-47	.2-2	XX	XX	XX	XX			X
			Kimmel very fine sandy loam, Pit 3					
0-2	<.2	XX	XX			XXX		
0-2	.2-2	XX		XXX	XX			XX
2-11	<.2	XX	XX	XXX				
2-11	.2-2	XX		XXX	XX			XX
12-25	<.2-2	XX	XXX	XX		XX		
12-25	.2-2	XX	XX	XX	X	XX		X
25-48	<.2	XX	XXX	X		XX		
25-48	.2-2	XX	XX	XX	XX			XX

XXX = 40% or more XX = 10% to 40% X = 10% or less

Table 11. Irrigation land classes

Mapping Unit	Class	Limiting factor
Shagnuk loamy sand, 1–15% slopes	4	AWHC[1]
Shagnuk loamy sand, 3–8% slopes	4	AWHC
Kinnear very fine sandy loam, 1–15% slopes	1	None
Kinnear very fine sandy loam, 3–8% slopes	0	None
Kinnear very fine sandy loam, 3–8% slopes	0	None
Shagnuk sandy loam, 0–15% slopes	3	AWHC, depth
Shagnuk sandy loam, 3–8% slopes	3	AWHC, depth
Shagnuk sandy loam, 3–8% slopes	3	AWHC, depth
Wall sandy loam, 3–8% slopes	2	AWHC
Wall sandy loam, 3–8% slopes	2	None
Dalbert Land	4	Poor drainage

[1]Available water holding capacity

moisture held against a pressure of 1/3 atmosphere called a 1/3 atmosphere percentage, approximates the amount of water a soil can store after the very loosely held gravitational water has drained away. The 15 atmosphere percentage approximates the moisture which is held so tightly by the dry soil that plants cannot use it. The moisture held at more than 1/3 but less than 15 atmospheres tension is available to plants. This is shown as inches of water per foot of soil depth. The water held between 1/10 and 15 atmospheres is also shown, because sandy soils can hold a large amount of water against a pressure of 1/10 atmosphere. Most of this is held only for a very short time before it drains away as gravitational water, and measurements at 1/10 atmosphere are not commonly used to predict the capacity of soils to hold readily available moisture.

Appreciable concentrations of soluble salts were found in the subsoil horizons of six of the eight soil profiles studied.

Because these occur deep in the soil profiles, and because the soils are rapidly to moderately permeable, these conditions do not appear to present any threat to agriculture unless brought much closer to the surface by deep cutting and leveling. Even if so exposed, they could be removed by leaching.

Summary and Conclusions

Laboratory and field data for the soils of the San Luis Branch Experiment Station show that the major factors limiting agricultural productivity are available water-holding capacity in the soil profiles, soil depth, and wind-erosion hazard. Important differences are shown to exist among the soils. A possible phosphorus fixation problem in one series is indicated by the clay mineralogy of the soil from one sample pit. Phosphorus, iron, and zinc fertility problems may occur if high lime soil horizons are exposed.

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Sheppard loamy sand, 1 to 3 percent slopes (0170)

This mapping unit occurs on gentle slopes in eolian mesa deposits. The soil has formed from calcareous sand derived from sandstone and it is more than 1[illegible] inches deep over bedrock. The erosion hazard is severe if the soil is disturbed. Inclusions of Kinwar and Nagosa soils make up less than 10 percent of the mapping unit and occur mainly along drainageway lines.

Vegetation: Indian ricegrass, snakeweed, some galleta.

Drainage and Runoff: Well to excessively drained, slow runoff.

Classification: Typic Torripsamments, mixed, mesic family.

Location: 1873 feet W, 2486 feet S of NE corner of Section 33, T29N R14W.

Elevation: 5645 feet.

Permeability: Rapid to very rapid.

Soil Profile:

A1 — 0 - 10": Strong brown (7.5YR5/6) loamy sand, brown (7.5YR5/4) moist; single grade, loose, very friable, nonsticky and nonplastic; plentiful fine roots; interstitial pores; non-calcareous, moderately alkaline; clear smooth boundary.

C1 — 10 - 19": Reddish yellow (7.5YR6/6) loamy sand, strong brown (7.5YR5/6) moist; massive, soft, very friable, nonsticky and nonplastic; moderately alkaline; clear smooth boundary.

C2ca 19 - 30": Strong brown (7.5YR5/6) sandy loam, dark brown (7.5YR4/4) moist; massive; slightly hard, friable, slightly sticky and non-plastic; very few fine roots; few fine pores; moderately calcareous, moderately alkaline; clear wavy boundary.

C3ca 30–47": Light brown (7.5YR6/4) loamy fine sand, brown (7.5YR5/4) moist; massive; slightly hard, very friable, nonsticky and nonplastic; very few fine roots; interstitial pores; moderately calcareous, moderately alkaline; clear smooth boundary.

C4 47-75": Reddish Yellow (7.5YR6/6) sand, brown (7.5YR5/4) moist; single grain; loose, very friable, nonsticky and nonplastic; very few fine roots; interstitial pores; slightly alkaline.

Range in Characteristics: Texture of the control section (10-30 inches) is typically loamy sand, but ranges to sandy loam. Depth range is more than 60 inches. Color hue from 7.5YR to 10YR. Color is brownish.

Sheppard loamy sand, 3 to 5 percent slopes (0172)

This mapping unit is similar to Sheppard loamy sand, 1 to 3 percent slopes (0170) in all respects except slope, which ranges from 3 to 5 percent.

Kinwar very fine sandy loam, 1 to 3 percent slopes (1813)

This mapping unit occurs on gently sloping fans and valley filling side slopes in river valleys and on mesa tops. Parent material is mixed alluvial derived from sandstone and shale. Soil depth is 75 inches or more over bedrock. Erosion is slight. Inclusions of Sheppard, Nagosa, and Wall soils make up less than 15 percent of the mapping unit and occur as pockets or small areas along de-lineation lines.

Vegetation: Snakeweed, galleta.

Drainage and Runoff: Well drained, medium to slow runoff.

Classification: Typic Camborthid, fine loamy, mixed, calcareous mesic family.

Location: 1808 feet W, 257 feet S of NE corner of Sec 13, T29N R14W.

Elevation: 5616 feet.

Permeability: Moderate.

Soil Profile:

A1 — 0 - 8": Brown (7.5YR5/4) very fine sandy loam, brown to dark brown (7.5YR4/4) moist, weak fine granular structure; soft, friable, slight-ly sticky and slightly plastic; few fine roots; few fine pores, slightly calcareous, moderately alka-line; clear smooth boundary.

C1 – 8 – 18" Yellowish red (5YR5/6) very fine sandy loam, yellowish red (5YR4/6) moist; massive; slightly hard, friable, sticky and nonplastic; plentiful fine roots; few fine pores; moderately calcareous; moderately alkaline; gradual smooth boundary.

IIC2ca 18 – 27" Reddish yellow (7.5YR6/6) loam, strong brown (7.5YR5/6) moist; massive; slightly hard, friable, sticky and slightly plastic; few fine roots; few fine pores; lime blotches the size of dimes. Moderately calcareous; moderately alkaline; abrupt wavy boundary.

IIC3ca 27 – 48" Reddish yellow (7.5YR7/6) loam, reddish yellow (7.5YR6/6) moist; massive; hard, friable, sticky and slightly plastic; very few fine pores; strongly calcareous; moderately alkaline; abrupt wavy boundary.

IIC4 48 – 75" Reddish yellow (7.5YR6/6) loamy sand to coarse sand, brown (7.5YR5/4) moist; single grain; loose, very friable, nonsticky and nonplastic; interstitial pores; moderately calcareous; moderately alkaline.

Range in Characteristics: Surface texture is typically a very fine sandy loam, but ranges from a sandy loam to a loam. Slopes range from 1 to 3 percent. Texture of the control section (10-30 inches) may range from heavy sandy loam to light clay loam. Color hue ranges from 7.5 YR to 10 YR. Color is brownish.

Kinnear very fine sandy loam, 0 to 1 percent slopes (182)

This mapping unit is similar to Kinnear very fine sandy loam, 1 to 3 percent slopes (183) in all respects except slope which is 0 to 1 percent, and texture of the control section which is a light clay loam.

Classification: Typic Camborthid, fine loamy, mixed, calcareous mesic family.

Location: 2730 feet W, 1262 feet S of NE corner of Sec. 35, T29N, R14W.

Elevation: 5600 feet.

Soil Profile

A1 0 – 5" Strong brown (7.5YR5/6) very fine sandy loam, dark brown (7.5YR4/4) moist; weak fine granular structure; soft, friable, slightly sticky and nonplastic; plentiful fine and medium roots; few fine pores; slightly calcareous; moderately alkaline; gradual smooth boundary.

C1ca 8 – 27" Light brown (7.5YR6/4) light clay loam, strong brown (7.5YR5/6) moist; massive; hard, firm, sticky and slightly plastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline; gradual wavy boundary.

C2 27 – 48" Reddish yellow (7.5YR6/6) very fine sandy loam, brown (7.5YR5/4) moist; massive; slightly hard, friable, slightly sticky and nonplastic; very few fine roots; few fine pores; moderately calcareous; moderately alkaline; clear smooth boundary.

IIC3 48 – 75" Reddish yellow (7.5YR7/6) sand, reddish yellow (7.5YR6/6) moist; single grain; loose, very friable, nonsticky and nonplastic; slightly calcareous; moderately alkaline.

Kinnear very fine sandy loam, 3 to 5 percent slopes (184)

This mapping unit is similar to Kinnear very fine sandy loam, 1 to 3 percent slopes (183) in all respects except slope, which is 3 to 5 percent.

Nagesi sandy loam, 0 to 1 percent slope (230)

This mapping unit occurs as gently sloping fans, terraces, and mesas. Parent material is sandy calcareous alluvium derived from sandstone and shale. Erosion is slight.

Inclusions of Kinnear soils make up less than 5 percent of the mapping unit and occur mainly along delineation lines.

Range in Characteristics: Slope range is 0 to 1 percent. Surface texture is typically a sandy loam, but may be fine sandy loam.

Vegetation: Indian ricegrass, snakeweed, mormon tea.

Drainage and Runoff: Well drained. Slow runoff.

Classification: Typic calciorthid, Coarse loamy mixed, mesic family.

Location: 3671 feet W, 1394 feet S of NE corner of Sec. 33, T29N, R13W.

Elevation: 3609 feet.

Permeability: Moderate to rapid.

Soil Profile:

A1 0-8" - Reddish yellow (7.5YR6/6) sandy loam; strong brown (7.5YR5/6) moist; weak fine granular structure; soft, very friable, slightly sticky and nonplastic; plentiful fine roots; very few fine pores; slightly calcareous; moderately alkaline; clear smooth boundary.

C1ca 8-18" - Reddish yellow (7.5YR6/6) fine sandy loam; strong brown (7.5YR5/6) moist; massive; slightly hard, friable, slightly sticky and nonplastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline; clear smooth boundary.

C2ca 18-24" - Yellow (10YR7/6) sandy loam; light yellowish brown (10YR6/4) moist; massive; slightly hard, very friable, nonsticky and nonplastic; few fine pores; moderately calcareous; strongly alkaline; clear smooth boundary.

C3ca 24-56" - White (10YR8/1) loam; light gray (10YR7/1) moist; massive; hard, friable, sticky and slightly plastic; very few fine roots; few fine pores; strongly calcareous; moderately alkaline; clear wavy boundary.

R 56-72"+ Unconsolidated sandstone.

Remarks: Pockets of unconforming material occur within the C3ca horizon.

Range in Characteristics: Texture of the control section (10-30 inches) ranges from sandy loam to loam. Depth ranges 50 or more inches over sandstone. Color is brownish, with hues of 7.5YR and 10YR.

Nagosa sandy loam, 1 to 3 percent slope (231)

This mapping unit is similar to Nagosa sandy loam, 0 to 1 percent slopes (230) in all respects except slope, which ranges from 1 to 3 percent.

Nagosa sandy loam, 3 to 8 percent slope (232)

This mapping unit is similar to Nagosa sandy loam, 0 to 1 percent slopes (230) in all respects except slope which ranges from 3 to 8 percent.

Wall sandy loam, 1 to 3 percent slopes (480)

This mapping unit occurs as gently sloping fan and valley filling side slopes in river valleys and on mesa tops. Parent material is sandy, calcareous alluvium derived from sandstone and shale. Erosion is slight, but a few shallow gullies occur.

Inclusions of Sheppard, Nagosa, and Kempas soils make up less than 15 percent of the mapping unit and occur as pockets or small areas along drainage lines.

Range in Characteristics: Surface texture is typically a sandy loam, but may range to very fine sandy loam. Textural stratification is common within the profile.

Vegetation: Snakeweed, galleta.

Drainage and Runoff: Well drained, medium to slow runoff.

Classification: Typic Camborthid, coarse loamy, mixed, calcareous, mesic family.

Location: 1160 feet W, 240 S of SE corner of Sec. 33, T29N, R14W.

Elevation: 5631 feet.

Permeability: Moderate to rapid.

Soil Profile:

A11 0-4" - Light brown (7.5YR6/4) sandy loam, brown (7.5YR5/4) moist; single grain; loose, very friable, nonsticky and nonplastic; few fine roots; interstitial pores; slightly calcareous; moderately alkaline; clear smooth boundary.

A12 4-11" - Brown (7.5YR5/4) fine sandy loam, dark brown (7.5YR4/4) moist; weak fine grained structure; soft, friable, slightly sticky and nonplastic; plentiful fine roots; few fine pores; moderately calcareous; moderately alkaline; clear wavy boundary.

C1 11-18" - Strong brown (7.5YR5/6) sandy loam, dark brown (7.5YR4/4) moist; massive; slightly hard, friable, slightly sticky and nonplastic; few fine roots; few fine pores; slightly calcareous; moderately alkaline; gradual smooth boundary.

C2 18-35" - Strong brown (7.5YR5/6) sandy loam, dark brown (7.5YR4/4) moist; massive; slightly sticky and nonplastic; very few fine roots; few

fine pores; slightly calcareous; moderately alkaline; gradual wavy boundary.

C3ca 35-47" Light brown (7.5YR6/4) very fine sandy loam, brown (7.5YR5/4) moist; massive; slightly hard, friable, slightly sticky and non plastic; very few fine roots; many fine pores; moderately calcareous; moderately alkaline; abrupt smooth boundary.

C4 47-70" Reddish yellow (7.5YR6/6) sandy loam, dark brown (7.5YR4/4) moist; massive; hard, friable, slightly sticky and nonplastic; very few fine roots; very few fine pores; slightly calcareous; moderately alkaline; abrupt smooth boundary.

IIC5 70-80" + Sand

Range in Characteristics: Texture of the control section (10 - 30 inches) ranges from sandy loam to fine sandy loam. Color is brownish, with hues of 7.5YR and 10YR.

Will sandy loam, 5 to 9 percent slopes (WtC)

This mapping unit is similar to Will sandy loam, 1 to 3 percent slopes (4800) in all respects except slope, which ranges from 5 to 9 percent.

Vegetation: Indian ricegrass, snakeweed, mormon tea

Drainage and Runoff: Well drained; medium to rapid runoff.

Classification: Type: Camborthid, coarse loamy, mixed, calcareous, mesic family

Location: 398 feet W. 3509 feet S of NE corner of Sec. 33, T29N, R14W

Elevation: 5692 feet

Permeability: Rapid

Soil Profile:

A11 0 - 2½" Reddish yellow (7.5YR6/6) light sandy loam, strong brown (7.5YR5/6) moist; single grain; loose, very friable, nonsticky and nonplastic; slightly calcareous; moderately alkaline; clear smooth boundary.

A12 2½ - 9" Light brown (7.5YR6/4) sandy loam, brown (7.5YR5/4) moist; weak fine granular structure; soft, friable, slightly sticky and nonplastic; plentiful fine roots; few fine pores; moderately calcareous; moderately alkaline; clear wavy boundary.

C1ca 9 - 18" Pink (7.5YR7/4) sandy loam, light brown (7.5YR6/4) moist; massive; slightly hard, friable, slightly sticky and nonplastic; few fine roots; few fine pores; strongly calcareous; moderately alkaline; clear smooth boundary.

IIC2ca 18-28" Reddish yellow (7.5YR7/6) loamy sand, reddish yellow (7.5YR6/6) moist; massive; soft, very friable, nonsticky and nonplastic; very few fine roots; interstitial pores; strongly calcareous; strongly alkaline; clear wavy boundary.

IIIC3ca 28-75" Pink (7.5YR7/4) sandy loam, light brown (7.5YR6/4) moist; massive; slightly hard, friable, slightly sticky and nonplastic; very few fine roots; few fine pores; strongly calcareous; strongly alkaline.

Gullied Land, Deep Alluvial Soils

This mapping unit comprises the waterways within the boundary of the experiment farm. It is mixed fluvial land and includes deep, mixed alluvial soils, gullies, and a dam constructed across the waterway.

Appendix B.— Land classification specifications for Pacific Northwest basin irrigation land classes[1]

Land characteristics	Class 1	Class 2	Class 3	Class 4	Non-irrigable Class 6
Soils					
Texture surface (0"-7")[2]	LVFS-CL	LS-C Peat Muck	SG-C	SG-C	All other soils not meeting criteria for irrigation
Moisture Retention (AWSC-in/ft)[3]	≥0.10	0.07 - 0.09	0.04 - 0.1	0.02 - 0.9	
Effective Depth (inches)	≥40[4]	30 - 40	20 - 30	10 - 20	
Salinity (EC_e x 10^3 - mmhos)	<4	4 - 8	8 - 12	12 - 16	
Soils Conditions[5]					
Percent area affected	≤5	5 - 10	15 - 25	25 - 50	
Severity of problem[6]	Slight	Moderate	Moderate	Moderate	
Permeability (in/hour - in 5ft)	0.2-2.0	0.06-0.2 2.0-6.0	0.06-0.2 6.0-20.0	Any	
Permeability coarse fragments (3/4 in+)					
Gravel	15	35	65	70	
Cobbles	5	15	15[7]	15[7]	
Root restrictions shallower than (in feet)	200	100	50	30	
Soil erosion (for all classes)	Severely eroded soils will be downgraded one class. Less severely eroded soils may be downgraded one class, depending on other conditions.				
Topography or land development (slope)[8]					
Rocks for Removal (cubic yards per acre)	10	25	50	100	
Slope (percent)					
Moderately to severely erodible	≤2	2 - 5	5 - 10	15 - 25	
Slightly erodible	≤5	5 - 15	15 - 30	20 - 35	
Surface Leveling or Tree Removal (amount of cover)	Light	Medium	Medium heavy	Medium heavy	
Irrigation Method	Lands planned to receive irrigation where land grading would permanently reduce soil horizon below arable limits or extent permissible under farm pattern too complex, may be considered for sprinkler. Land must meet other requirements for sprinkler. Example for "5" - example 3-6				
Drainage					
Soil bottom depth to water table during growing season with or without drainage					
Limit or liner	≥60'	40' - 60'	20' - 40'	10' - 20'	
Safety	≥10'	20' - 30'	10' - 20'	10' - 20'	
Surface Drainage		Good	Moderate	Restricted	
Depth to Drainage Barrier (in feet)	≥5	4 - 5	3 - 4	1.5 - 3	
Air Drainage[9]		No Problem	Minor	Moderate	Restrictive

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

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

[3]In areas of very warm growing season (>) may be required for class 1 and in cool areas as little as may be permitted for class 4.

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

[5]Areas of moderate and severe soils problems may be identified as areas of wide crop adaptability.

[6]Severity of problem: **slight** - [illegible] less than 10% or less than 5% if classified by controlling slope; **moderate** - 10% less than 20% or less than 10% if slope presents hazards; **severe** - [illegible] less than 10%, with certain soil materials over range above 10%, as measured by visual inclusions.

[7]This range above 10% is allowed for certain areas of surface soil is favorable.

[8]Special crop and management practices may justify exceeding the limits for stone removal or slope in class 4, irrigation of steep land necessitates downgrading of class unless deficiency is compensated for by possibility of extensive irrigation.

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

Abbreviations

LVFS - loamy very fine sand
LS - loamy sand
SG - sandy gravel
CL - clay loam
C - clay
AWSC - available water holding capacity
EMF - exchangeable sodium percentage

Appendix C—

LAND CLASSIFICATION SPECIFICATIONS
DETAILED LAND CLASSIFICATION
Navajo Indian Irrigation Project, New Mexico

Item No.	Characteristics	Class 1	Class 2	Class 3	Nonarable
1	Texture	VFSL, FSL, VL, SiL, L, SCL, and friable C	LVFS, VFSL, SiCL, SiC, SCL, C, VFSL, CL, and permeable clays	LS, LFS, VFSL, SiCL, SiC, SCL, C, FSL, VL, SiL, L, and slowly permeable clays	LS, LFS, VFSL, FSL, SiL, L, SiCL, SCL, C, in slowly permeable clays
2	Available moisture	Soil will hold a maximum of 3 inches of readily available moisture per 5-foot depth	Same as Class 1	Same as Class 1	Same as Class 1
3	Depth to clean sand, gravel or cobble	40" minimum for lenses of fine textures; 60" minimum for sand lenses	30" minimum for lenses of fine textures; 40" minimum for sand lenses; 60" minimum for loamy fine sands	15" minimum for lenses of fine textures; 30" minimum for sand lenses; 60" minimum for loamy fine sands	15" minimum for lenses of fine textures; 30" minimum for sand lenses; 60" minimum for loamy fine sands
4	Depth to barrier	Minimum of 5' depending on drainage characteristics of the area	Same as Class 1	Same as Class 1	Same as Class 1
5	Salinity	Combustible sodium not to exceed 15% under long-term equilibrium conditions	Same as Class 1	Same as Class 1	Same as Class 1
6	Safety	Subsurface drainage such that the soluble salt content can be maintained at a level not to exceed 4 millimhos/cm under intensive irrigation	Subsurface drainage such that the soluble salt content can be maintained at a level not to exceed 8 millimhos/cm with normal leaching requirements under intensive irrigation	Subsurface drainage such that the soluble salt content can be maintained around a millimhos/cm with more normal leaching requirements under intensive irrigation	Same as Class 1
		TOPOGRAPHY AND DRAINAGE			
7	Slope (uniform)	Less than 2% in general gradient	4% or less in general gradient	7% or less in general gradient	7% or less in general gradient

*All nonarable lands shall be upgraded or reverted to Class 6.

Note: The above land classification standards have been prepared by Bureau of Reclamation quality land surveyors of the lands. They do not consider economic factors. However, in accordance with the requirements of the Bureau of Indian Affairs, the land development, which includes land leveling (including land forming), lateral pads, and shaping of subsurface drainage, laterals and structures including land leveling (type and extent), removal of unacceptable, uniform subsurface drainage relocation of small gas and oil pipelines, shall not exceed $100 per acre. The soil type will determine the minimum length of run.