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Management Practices and Crop Yields on the Lower Yellowstone Project--1949

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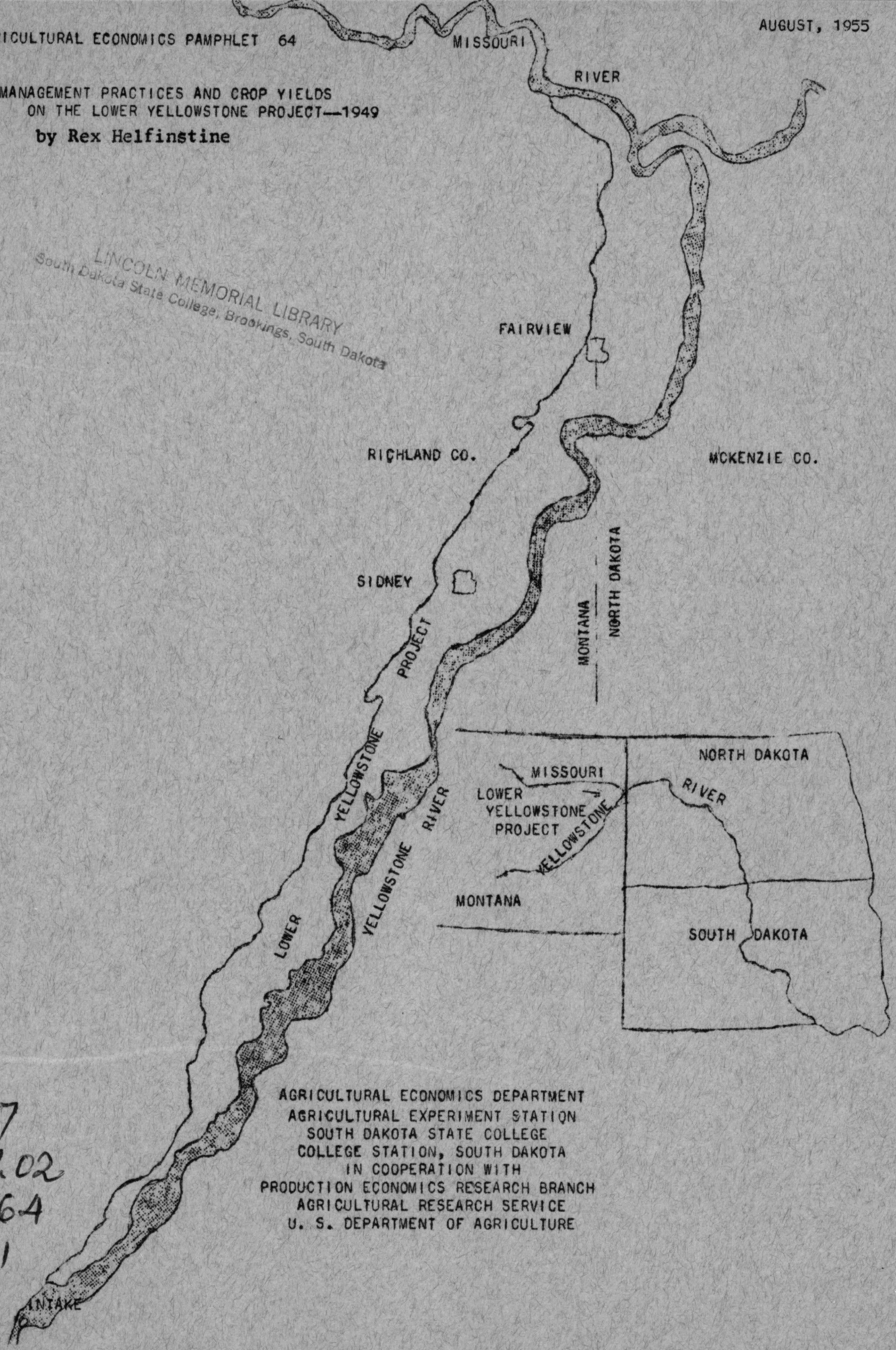
MANAGEMENT PRACTICES AND CROP YIELDS ON THE LOWER YELLOWSTONE PROJECT—1949

by Rex Helfinstine



AGRICULTURAL ECONOMICS DEPARTMENT
AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE
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IN COOPERATION WITH
PRODUCTION ECONOMICS RESEARCH BRANCH
AGRICULTURAL RESEARCH SERVICE
U. S. DEPARTMENT OF AGRICULTURE

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South Dakota Agricultural Experiment Station
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MANAGEMENT PRACTICES AND CROP YIELDS ON THE LOWER YELLOWSTONE IRRIGATION PROJECT - 1949

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INTRODUCTION

Irrigation has been proposed for more than a million acres of land in North Dakota and South Dakota under the Pick-Sloan plan. 2/ What results have been obtained from irrigation of comparable areas? What were the experiences of farmers in these areas? The Lower Yellowstone Irrigation Project in western North Dakota and eastern Montana, which has been under irrigation since 1909, is comparable in many respects to the areas proposed for new irrigation. Knowledge of the results of irrigation on the Lower Yellowstone will be helpful in determining the economic justification for irrigating other areas in the Dakotas. The purpose of this report is to present information on crop yields, management practices, and other data for the Lower Yellowstone Irrigation Project and for selected farms on the project.

THE LOWER YELLOWSTONE AREA

The Lower Yellowstone Irrigation Project is located in McKenzie County, N. Dak., and Dawson and Richland Counties, Mont. Lands under

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1/ Acknowledgement is given to LeRoy W. Schaffner, Assistant Economist, North Dakota Agricultural Experiment Station, for help in making the survey described in this study.

2/ Senate Document 247, 78th Congress, 2nd Session, November, 1944, for description of the Pick-Sloan plan.

irrigation include the bottom lands and more level benchlands along the Yellowstone River, from Intake, Mont., to its junction with the Missouri River in western North Dakota. The project covers 57,200 acres; of these 54,000 are classed as irrigable. However, only 47,500 are usually irrigated. 3/ The Bureau of Reclamation surveyed the project in 1903, began construction in 1905, delivered the first water in 1909, and completed construction in 1912. Before 1932, the project was operated by the Bureau of Reclamation; later a water-users association was organized and took over the operation. 4/

Development of irrigation on this project lagged until 1930, partly because most of the farmers were dryland operators who had had little experience in irrigation farming. These farmers frequently operated their irrigated farms as sidelines to large-scale dryland farming. The droughts of the 1930's and a new generation of operators with more training and experience in irrigation brought about more rapid development of irrigation. Dryland and irrigation farming are now almost entirely separated. Few farmers at present carry on both kinds of farming on the same farm. Integration of dryland range with irrigated farming, however, is a significant recent development.

In 1949 the major crops grown on the irrigated land were wheat, oats, alfalfa, and sugar beets. Smaller acreages of barley, pasture,

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3/ U. S. Bureau of Reclamation, "Crop Summary and Related Data, Federal Reclamation Projects," U. S. Department of Interior, Bureau of Reclamation, Operation and Maintenance Division, Washington, 1949, (processed.)

4/ For a more detailed history of the project see the Annual Project Histories in the project office at Sidney, Mont. For legal reasons the project is nominally divided into two districts on state lines, but it is administered as a single project through a joint board of control which appoints a single project manager.

corn, and potatoes were grown. 5/ Livestock-raising and feed lot fattening of beef cattle and sheep are important in the area. Dairying has increased; the area now produces most of the milk needed locally.

Climate

The climate of the Lower Yellowstone area is characteristic of the northern Great Plains -- hot in summer, cold in winter, and limited but variable rainfall from year to year (Table 1).

Table 1. Comparative Climatic Conditions between Sidney, Mont. in the Yellowstone Project Area, and Selected Stations in the Western Dakotas. a/

	July average temperature b/	Length of growing season c/	Average annual precipitation d/	Average May and June precipitation d/
	Degrees F	Days	Inches	Inches
Sidney, Mont. (Lower Yellowstone)	68.8	126	14.9	5.5
Williston, N. Dak. (Williston, N. Dak.)	69.4	133	14.1	5.0
Mandan, N. Dak. (Heart River)	71.7	138	15.2	5.4
Carson N. Dak. (Cannonball)	70.5	119	15.7	6.0
Minot, N. Dak. (Missouri-Souris)	68.6	116	15.5	5.2
Redfield, S. Dak. (Missouri-Oahe)	73.3	140	18.7	5.7

a/ Source: "Climate and Man," U. S. Department of Agriculture.
b/ Average of highest and lowest daily temperature.
c/ Represents, in general, the length of frost-free time between the last freezing temperature in the spring and the first freezing temperature in the fall.
d/ Reported in hundredths, rounded to nearest tenth.

5/ See footnote 3.

Soils

In general, the Yellowstone River valley is a fairly level plain sloping toward the north and east. 6/ The valley is old geologically. It was little changed by glaciation. Underlying the area are alternating beds of sandstone and shale of different formations. Benches or terraces border the recent alluvial bottoms on each side of the river. These terraces have resulted from successive cutting of the river. The lower or more recent alluvial bottoms of the main valley are fairly flat. There are many miniature terraces and low swales; they indicate former overflow channels of the river. In many places the land must be graded before it can be irrigated properly.

Natural drainage ranges from good to excessive throughout the project, except in certain depressions where the soil is heavy and seepage has taken place. The project now has an excellent drainage system, but considerable damage from seepage and alkali occurred before drainage was provided. It has been estimated that about 8,000 acres in the entire project were badly damaged by seepage. However, around 75 to 80 percent of this has been reclaimed. About 2 percent of the entire project is affected by alkali. This land is used only for pasture; no water is applied.

In general, the irrigated soils of the Lower Yellowstone project are adapted to irrigation, as they are well-drained and porous. The

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6/ William DeYoung, F. K. Nunns, and L. H. Smith, "Soil Survey of the Lower Yellowstone Valley Area, Montana," U. S. Department of Agriculture Series 1932, No. 38, Washington: U. S. Government Printing Office, 1939: also M. J. Edwards, and J. K. Ableiter, "Soil Survey of McKenzie County, North Dakota," U. S. Department of Agriculture Series 1933, No. 37, Washington: U. S. Government Printing Office, 1942. Twelve important soil types are described on pages 22-25 of the appendix.

organic matter content of the soils is naturally low. Use of legumes, green-manure crops in rotation, and crop residues as well as commercial fertilizers, usually give good response under these conditions.

THE SAMPLE FARMS

Information was obtained in 1950 from 77 farmers in the Lower Yellowstone Irrigation Project, 45 in North Dakota, and 32 in Montana. Only farmers having soils comparable to those in other areas proposed for irrigation were selected for interview. Practically all of the farmers located on such soils were visited. Consequently, the sample cannot be considered representative of the Lower Yellowstone Project as a whole. However, the crop organization of the surveyed farms did not differ significantly from that of all farms in the project (Table 2).

Table 2. Use of Cropland, Lower Yellowstone Irrigation Project, 1949

Crop	Survey Farms a/	All Farms b/
	Percent	Percent
Wheat	28.8	21.3
Oats	9.4	11.1
Corn	7.2	2.5
Other small grain	4.5	4.4
Sugar beets	20.5	21.7
Alfalfa	19.4	21.4
Pasture	4.6	4.4
Fallow	0.8	1.8
Other	4.8	11.4

a/ 1950 economic survey of 77 farms on selected soils.
b/ U. S. Brueau of Reclamation, "Crop Summary and Related Data, Federal Reclamation Projects," U. S. Department of Interior, Bureau of Reclamation, Operation and Maintenance Division, Washington, mimeo., 1949.

The emphasis on production of small grains may be a result of the relatively high prices for grain and the shortage of sugar beet labor in 1949 and 1950. Before 1947 emphasis was less on production of grain and more on sugar beets (Table 3).

The crop yields reported by the operators for the survey appear to be significantly higher than those reported by all farmers on the project to the Bureau of Reclamation (Table 4). Soils and methods of reporting may have differed significantly between the survey farms and all farms on the project.

The cropping pattern of the survey farms shows no evidence of consistent differences according to size of farm (Table 5). Both dry and irrigated lands were found on approximately a fifth of the farms surveyed, but most of the dry land was native pasture. Operation of both dry and irrigated cropland by the same farmer was infrequent. Only 3 of the 77 operators had dry cropland. One of these had 21, another 9, and the other 160 acres. The latter reported little labor conflict between his dry-land and his irrigated farming operations. Use of native pasture along with irrigation farming was somewhat more prevalent among survey operators, 19 of which had an average of 90 acres. This native pasture was ordinarily used for beef cattle or sheep.

The raising and fattening of livestock are important enterprises on some farms on the Lower Yellowstone Project (Table 6). Thus, 18 farms reported an average of 24 head of beef cows, and 13 reported an average of 65 head of ewes. Cattle feeding was reported by 22 operators. An average of 41 head was fed. Lamb feeding was also reported by 22 operators, with an average of 873 head fed. Operators on 20 farms reported an average of 4 sows, and 59 operators reported an average of 5 milk cows. However, there were a few specialized

Table 3. Production of Principal Crops, Lower Yellowstone Irrigation Project, 1912-53 a/

Year	Wheat		Oats		Barley	
	Acreage	Yield per acre bu.	Acreage	Yield per acre bu.	Acreage	Yield per acre bu.
1912	960	21.0	815	45.2	752	31.4
1913	3136	17.6	1160	31.0	1027	22.5
1914	1071	20.0	575	31.0	407	20.0
1915	4518	18.2	1320	37.7	750	28.6
1916	1251	13.8	528	27.7	488	20.2
1917	2963	14.1	1526	25.9	798	18.4
1918	6288	15.8	2247	32.1	1321	22.5
1919	6335	13.7	1666	28.0	780	16.2
1920	6042	18.4	2141	34.5	519	26.3
1921	5100	11.4	1513	23.3	325	15.2
1922	3317	18.5	1296	35.3	116	21.2
1923	2986	9.4	1253	25.0	400	17.9
1924	90	25.0	316	43.0	159	32.1
1925	981	23.9	269	23.6	398	33.2
1926	4136	21.9	1590	32.3	1500	35.1
1927	3064	17.8	742	36.2	1365	34.7
1928	4044	20.9	987	27.1	2250	31.8
1929	3280	25.0	1285	40.5	2856	22.3
1930	2042	20.0	1136	27.0	3827	21.1
1931	878	14.8	1193	26.8	3813	20.2
1932	1955	24.9	1725	34.8	3945	33.7
1933	2252	19.5	2689	32.8	2686	22.4
1934	2355	22.3	4420	43.3	2295	28.3
1935	4702	20.0	5135	40.9	1326	28.7
1936	4256	16.1	5021	30.2	1331	23.0
1937	5260	18.9	4932	18.4	1613	17.6
1938	5381	12.3	3447	19.8	3119	12.1
1939	4281	25.4	2941	38.5	4586	39.2
1940	4634	25.9	3756	41.6	3372	29.5
1941	4163	22.0	5574	45.1	3241	33.6
1942	3215	31.9	4606	58.0	2820	38.0
1943	3275	31.4	5472	55.3	5259	40.5
1944	4029	30.6	6536	54.2	4296	41.2
1945	3506	26.4	7094	44.4	3672	33.4
1946	5604	27.2	5944	51.9	3764	34.4
1947	6643	30.7	8380	55.9	3142	39.5
1948	10539	28.3	7386	47.1	4260	34.2
1949	10443	24.6	5426	43.0	1988	31.0
1950	8796	26.8	7252	52.6	2153	36.6
1951	12043	28.7	5334	47.9	2179	37.2
1952	10327	24.6	5473	48.2	2367	36.3
1953	7908	24.8	5142	52.5	2334	29.9

(continued)

Table 3. Production of Principal Crops, Lower Yellowstone Irrigation Project, 1912-53 a/ (continued)

Year	Corn		Sugar Beets		Alfalfa		Pasture
	Acreage	Yield per acre bu.	Acreage	Yield per acre ton	Acreage	Yield per acre ton	Amount acres
1912					972	2.1	
1913					1407	2.3	
1914	107	33.0			2884	2.5	
1915	0	0			4404	2.3	
1916	46	28.3			3208	2.4	
1917	156	27.3	307	8.0	6505	2.2	
1918	136	32.9	500	6.6	6920	2.1	
1919	174	29.4	380	9.2	9696	2.2	
1920	289	29.5	658	10.0	7030	2.0	
1921	490	31.0	1533	8.3	7401	1.8	
1922	972	28.8	1107	10.8	6463	1.9	
1923	1196	25.6	3110	10.5	6356	1.8	
1924	370	23.9	6590	9.7	4275	2.6	
1925	865	23.4	6952	8.7	5292	2.2	
1926	961	18.7	5180	9.7	6352	2.4	
1927	175	30.9	3439	9.9	4575	1.8	
1928	121	26.2	4987	7.9	4907	1.6	
1929	748	21.3	5911	9.8	5352	1.9	
1930	749	24.5	7402	12.4	5290	1.9	
1931	1522	20.6	10002	11.0	6215	1.9	
1932	2373	27.5	9095	13.0	6753	1.9	1579
1933	1540	29.7	11544	13.0	4692	1.3	1895
1934	1317	22.3	12081	11.4	3818	2.2	1845
1935	570	25.0	13536	11.7	4959	2.1	1361
1936	1120	28.0	12275	10.2	6362	2.4	1945
1937	1486	23.3	12331	12.3	6850	2.0	2432
1938	1047	18.7	13049	13.0	6614	1.3	1691
1939	2582	32.2	12271	14.3	6552	1.8	1514
1940	2103	27.4	15868	15.9	7804	2.1	1579
1941	2896	35.2	12306	11.8	7883	2.4	1602
1942	1684	31.9	15284	12.6	10199	2.2	1621
1943	852	32.1	11843	10.0	9606	2.1	1747
1944	908	34.9	14009	11.1	9982	2.1	1664
1945	788	19.4	16445	9.6	8909	1.9	1449
1946	444	27.5	14753	11.2	8980	2.1	1558
1947	571	35.2	15273	11.3	6848	1.9	1417
1948	842	33.3	9195	12.6	9278	2.3	1797
1949	849	34.4	10695	10.5	10554	2.4	2135
1950	275	29.1	10830	10.3	10476	2.2	3216
1951	445	24.9	7579	9.9	11219	2.1	4884
1952	363	43.9	7731	13.8	11898	2.6	4352
1953	401	39.4	9928	11.7	12412	2.3	4037

a/ Source: Bureau of Reclamation, "Crop Summaries and Related Data."

Table 4. Average Crop Yields per Acre, Lower Yellowstone Irrigation Project, 1949

Crop	Unit	Survey farms a/	Project farms b/
Wheat	bu.	37	25
Oats	bu.	64	43
Beets	ton	12.7	10.5
Alfalfa	ton	3.4	2.4

a/ 1950 economic survey of 77 farms on selected soils.
b/ U. S. Bureau of Reclamation, "Crop Summary and Related Data, Federal Reclamation Projects," U. S. Department of Interior, Bureau of Reclamation, Operation and Maintenance Division, Washington, mimeo., 1949.

Table 5. Crops Grown on Various Sizes of Farms Lower Yellowstone Irrigation Project, 1949 a/

		Size of Farm					
	Unit	Under 90 acres	90-129 acres	130-169 acres	170-249 acres	Over 250 acres	All farms
Farms	No.	22	14	26	10	5	77
Average size of farm	acre	81	119	144	297	300	152
Irrigated							
Corn	acre	2.5	8.3	7.1	19.0	30.8	9.1
Oats	acre	7.0	12.1	16.2	13.7	8.2	12.0
Wheat	acre	15.5	33.0	36.7	72.7	65.4	36.5
Other small grain	acre	2.6	4.6	5.6	10.4	13.2	5.7
Sugar beets	acre	14.3	19.5	35.5	37.9	22.8	26.0
Alfalfa	acre	13.0	19.2	27.4	32.5	59.6	24.5
Irrigated pasture	acre	5.6	2.8	3.9	12.3	12.4	5.8
Fallow	acre	0	0.8	1.3	2.0	0	0.9
Other	acre	1.9	6.0	7.6	0.6	30.0	6.1
Total	acre	62.3	106.3	141.3	201.1	242.4	126.6
Dry Cropland	acre	0	1.5	0.3	0	32.0	2.5
All crops	acre	62.3	107.9	141.7	201.1	274.4	129.2
Native pasture and wild hay	acre	18.7	10.8	2.6	96.3	25.6	22.4

a/ From economic survey of farms on selected soils.

Table 6. Livestock on Hand and Fed, Various Sizes of Farms, Lower Yellowstone Irrigation Project, 1949 a/

Item	Unit	Under 90 acres	90-129 acres	130-169 acres	170-249 acres	Over 250 acres	All farms
Farms	No.	22	14	26	10	5	77
Size of farm	Acres	81	119	144	297	300	152
Beef cows							
Farms rptg.	No.	5	5	4	3	1	18
Average b/	No.	22.2	18.8	18.8	42.7	33.0	24.5
Other beef							
Farms rptg.	No.	1	5	5	4	0	15
Average b/	No.	1.0	11.6	17.2	78.8	0	30.7
Dairy cows							
Farms rptg.	No.	16	13	19	7	4	59
Average b/	No.	4.6	2.8	3.0	13.6	3.8	4.7
Other dairy							
Farms rptg.	No.	14	9	8	5	1	37
Average b/	No.	5.9	2.8	5.0	9.4	5.0	5.4
Sows							
Farms rptg.	No.	3	7	4	5	1	20
Average b/	No.	9.3	2.0	2.8	4.4	2.0	3.8
Other hogs							
Farms rptg.	No.	2	7	7	6	0	22
Average b/	No.	17.5	8.3	7.9	18.8	0	11.9
Ewes & rams							
Farms rptg.	No.	6	0	5	2	0	13
Average b/	No.	74.0	0	50.4	76.5	0	65.3
Other sheep							
Farms rptg.	No.	2	2	5	2	2	13
Average b/	No.	20.5	13.0	130.2	9.0	93.5	71.0
Hens							
Farms rptg.	No.	15	10	14	6	3	48
Average b/	No.	63.1	50.5	69.6	190.0	86.7	79.8
Chicks							
Farms rptg.	No.	8	5	7	3	1	24
Average b/	No.	93.2	144.0	80.7	500.0	200.0	155.5
Cattle fed							
Farms rptg.	No.	9	3	5	4	1	22
Average b/	No.	37.9	29.3	50.4	41.8	50.0	40.8
Lambs fed							
Farms rptg.	No.	3	4	10	3	2	22
Average b/	No.	480.0	392.5	967.2	1241.7	1400.0	873.0
All livestock	A.U. c/	19.3	18.1	26.6	59.3	36.2	27.8

a/ From economic survey of farms on selected soils.
b/ Of those reporting.
c/ A. U. (animal unit) defined as 1 mature cow, 2 young cattle, 4 calves, 5 sows, 10 pigs, 7 sheep, 14 lambs, or 100 chickens. It is assumed that 3 other cattle, 14 other sheep, 4 cattle fed, or 28 sheep fed equals 1 A. U.

dairy farms on the project. One had a herd of 105 purebreds. Two others had herds of 32 and 29 head, respectively. Chickens were of minor importance.

Most of the farms surveyed are not organized primarily as livestock farms. An average of only 28 animal units was kept on the 77 farms. Examination of the individual schedules indicates that livestock raising or fattening in the area tends to be specialized. Certain operators specialized in livestock-fattening, buy the feed, use the feed lots and barns of other farmers, and leave the manure. Information as to contract feeding and feeding by outside operators, both reported to be important in the area, was not obtained in the survey.

SOILS AND CROP YIELDS

Farms on land classes 2 and 3 appear to be farmed more intensively than those on class 1 land. They had more sugar beets and alfalfa but less grain (Table 7). Several factors may explain this. The farms on classes 2 and 3 land are smaller (107 vs. 138 acres), and the land classification may not indicate the present crop-producing potential. 7/ The Yellowstone River, from which irrigation water is diverted, is heavily laden with clay and silt. This has tended to modify the soil characteristics during the 40 years the project has been operated. Light soils have become heavier, thus being improved relative to the heavy soils. Apparently, yields of sugar beets vary with class of land or preceding crop (Table 8). Yields of wheat do not vary with class of land, but the small number of instances precludes definite conclusions (Table 9).

7/ In general, the lands were classified by soil specialists according to original fertility and crop adaptability of the soil type present. For details concerning the basis of land classification, see the appendix, page 22.

Table 7. Use of Cropland on Lower Yellowstone Irrigation Project, by Class of Land, 1949 a/

	Unit	Land Class 1	Land Classes 2 & 3
Corn	Percent	7.8	5.2
Oats	"	8.2	13.0
Wheat	"	30.9	18.4
Other small grain	"	4.4	4.7
Sugar beets	"	16.8	28.5
Alfalfa	"	18.2	22.6
Irrigated pasture	"	4.8	4.5
Fallow	"	0.9	0.3
Other	"	5.7	1.5
Total Irrigated	"	97.7	98.7
Dryland crops	"	2.3	1.3
All crops	Acres	137.9	106.8
Farms	No.	51	22

a/ From economic survey of farms on selected soils.

Table 8. Average Yield of Sugar Beets on Various Land Classes and Following Various Crops, Lower Yellowstone Irrigation Project, 1949 and 1945-49 a/

	No. of Fields	1949 Yields		1945-49 Yields	
		Range	Average	Range	Average
Preceded by cultivated crop					
Class 1 land	5	12.5--15	14.0	11.5--14.5	13.2
Class 2, 3, 4 land	2	14.0--17	15.5	12.0--14.0	13.0
Preceded by non-clutivated crop					
Class 1 land	6	9 -- 15	13.0	12 -- 16	14.5
Class 2, 3, 4 land	4	10 -- 13	11.9	12 -- 13.5	12.9

a/ From economic survey of farms on selected soils.

Table 9. Average Yield of Wheat on Various Land Classes and with Various Quantities of Fertilizer, Lower Yellowstone Irrigation Project, 1949 and 1945-49 a/

	No. of Fields	1949 Yields		1945-49 Yields	
		Range	Average	Range	Average
No fertilizer within 2 years					
Class 1 land	6	16--56	37.8	30--50	38.3
Class 2, 3, 4 land	1		10		30
Fertilized within 2 years					
Class 1 land	7	30--50	38.0	33--50	39.9
Class 2, 3, 4 land	4	27--43	36.2	25--40	32.5

a/ From economic survey of farms on selected soils.

FUEL CONSUMPTION OF TRACTORS AND PERFORMANCE IN FIELD OPERATIONS

Rates of performance, together with the quantity of fuel used per acre, were obtained for those implements in general use in the area (Table 10 and Appendix Table III). Some of the factors that may explain these high inputs for irrigated land in comparison with dry land are smaller fields, heavier soils, and more intensive cultivation. For example, it was observed that on irrigated land plowing ordinarily is deeper than on dry land.

Certain limitations of these performance rates and fuel consumption figures should be pointed out. Thus the size classification of tractors is arbitrary because of lack of information on the schedules. Tractors are listed on the schedules according to make and model, but no designation is made as to whether they are high-compression models

Table 10. Average Tractor and Machinery Use in Growing Crops, Lower Yellowstone Irrigation Project, 1949 a/

Operation	Size of equipment	Times over	Tractor time per acre total b/	Tractor fuel per acre total
		No.	Hours	Gal.
Small grain (preceded by cultivated crop)				
Duckfoot	12-foot	1	0.4	1.1
Harrow	20-foot	2	0.4	1.0
Level	various		0.4	1.1
Clean ditches	various	1	0.3	0.6
Drill	10-foot	1	0.4	1.0
Binding grain	8-foot	1	0.6	0.9
Threshing	22-inch	1	0.4	1.4
Total			2.9	7.1
Small grain (preceded by noncultivated crop)				
Plow	2-14-inch	1	1.1	3.5
Disk (tan)	10-foot	1	0.4	0.8
Harrow	20-foot	2	0.4	1.0
Level	various		0.4	1.1
Clean ditches	various	1	0.3	0.6
Drill	10-foot	1	0.4	1.0
Binding grain	8-foot	1	0.6	0.9
Threshing	22-inch	1	0.4	1.4
Total			4.0	10.3
Corn				
Plow	2-14-inch	1	1.1	3.5
Disk (tan)	10-foot	1	0.4	0.8
Harrow	20-foot	2	0.4	1.0
Level	various		0.4	1.1
Clean ditches	various	1	0.3	0.6
Plant	2-row	1	0.6	1.3
Cultivate	2-row	4	2.4	5.2
Field chop		1	1.3	2.9
Total			6.9	16.4

a/ From economic survey of farms on selected soils.

b/ Using 3-plow tractor, which was the usual size.

High compression may increase the power sufficiently to place a tractor in a larger size category. However, it was assumed for this study that the use of gasoline implied a high-compression model. Information on the schedules also failed to indicate year of manufacture, which frequently affected power ratings. This study assumed that all tractors were of recent manufacture. Finally, farmers had no reliable basis for estimating consumption of fuel because tractor fuel tanks were usually refilled with a hose from overhead storage tanks.

LABOR REQUIRED IN IRRIGATION

The labor required for each irrigation on various crops grown in the Lower Yellowstone Project was estimated by the farmers interviewed in the survey (Table 11). Apparently, both the crop grown and the type of irrigation are associated with differences in man-labor requirements. For example, corn required an average of 1.1 man-hours per acre while alfalfa required 2.1 man-hours. The wide range in observations may have arisen from variations in irrigation layout and leveling and type of soil, as well as from errors in observation.

IRRIGATED PASTURES

Irrigated pastures were used by almost half (35) of the 77 farmers on the Lower Yellowstone Irrigation Project from which schedules were obtained. A few reported up to 12 years' experience with irrigated pasture, but the experience of most was limited to 2 or 3 years. Many new pastures were seeded in 1950 because of the relatively high prices of livestock and the anticipated high returns.

The usual method followed in establishing an irrigated pasture was to fall plow, then disk, harrow, and level in early spring. The

Table 11. Average Labor Requirements for Each Application of Water, for Various Crops Grown on the Lower Yellowstone Irrigation Project, 1949 a/

Crop	Type of Irrigation	No. of instances	Range	Average Labor per Acre Man-hours
Alfalfa	Ave. all types	7	0.3-4.0	2.1
Pasture	Border ditch	4	0.3-1.7	0.9
Corn	Row	6	0.6-1.4	1.1
Sugar Beets	(1st Irr.) Row	13	1.0-3.2	1.8
	(2nd-3rd Irr.) Row	6	0.7-2.0	1.2
Grain	Border ditch	7	0.8-4.2	2.1
	Border dike	7	0.5-2.1	1.3
	Not specified	9	0.2-5.6	2.2

a/ From economic survey of farms on selected soils.

necessity for preparing a firm seedbed was mentioned frequently. When the field sloped uniformly it was usually border-disked for irrigation; that is, low ridges were thrown up parallel to the slope so that water turned in at the high side would spread out and flow to the lower side. 8/

Border ditches, which are adapted to uniform slopes of less than 2 percent and preferred for comparatively level fields, light soils, or slightly uneven fields, were used frequently by other operators. Using border ditches means that the ditches must either be cleaned out before

8/ For a more complete discussion of irrigation techniques see: H. L. Dusenberry, "Irrigation," Montana Extension Service Bul. 259, Bozeman, 1950.

seeding or new ones must be plowed out. In irrigating from border ditches, the water must be turned out of the ditches by means of temporary dams so it will flood between and parallel to the ditches.

If slopes are more than 2 percent, contour ditches may be used. These should be surveyed and spaced according to the slope; the steeper the slope the closer the spacing. This gives better control of the water. Contour ditches may be plowed out either before or after the pasture is seeded.

A companion crop of small grain, wheat, or oats was usually seeded with the pasture mixture, frequently by mixing the two in the drill. Sometimes the rate of seeding the companion crop was reduced below that used when grown for grain alone. The rate of seeding the pasture mixture varied from 10 to 20 pounds per acre, with 12 pounds the usual rate. The Huntley mixture, which varies in composition, was used by many farmers, but most farmers could not give its precise content of clovers and grasses. Two successful operators had developed their own mixtures. One was composed of 2 pounds alfalfa, 2 pounds ladino, 2 pounds alsike, 4 pounds fescue (probably meadow), 8 pounds brome, and 2 pounds timothy. The other operator used a mixture of equal parts of weight of red clover, alsike, timothy, and brome. The latter mixture is favored by many farmers in the Lower Yellowstone area as well as in other irrigated areas of the region.

The more productive pastures were fertilized frequently with barnyard manure and sometimes with commercial fertilizer. Some farmers used phosphate fertilizer, either alone or with banyard manure. Fertilizer was applied both at time of seeding and annually thereafter.

It was not the general practice in the Yellowstone area to "irrigate up" the new seedings. This was avoided if possible, as irrigation frequently resulted in crust formation on their heavy soils, and it was difficult for the seedlings to emerge. Rains usually can be depended upon to bring up the new seedlings. The number of irrigations per season varies from two to five, according to rainfall. They are spaced from 10 days to 2 weeks apart. Most farmers remove their livestock during and after irrigation in order to reduce damage from tramping. When the irrigated pasture is fenced into two or three fields to permit alternate grazing, this is no problem. Farmers frequently reported that alternate grazing resulted in more pasturage.

A few farmers successfully fall-seeded their pasture mixtures without a companion crop. In August they drilled the seed into small grain stubble that had had no previous preparation and then irrigated. One dairyman told about seeding a barley stubble field to pasture in August of 1940. The only field operation was to drill in the pasture mixture and then turn on the water. This farmer mentioned that two or three neighbors had seeded pastures at the same time, but that they had plowed and worked the ground before seeding. They failed to obtain a stand of grass but he got an excellent stand. This pasture still looked productive in June of 1950. Perhaps a factor in this farmer's success was his annual application of 125 pounds of phosphate and about 14 loads of manure per acre.

The beginning of the pasture season for this area varies from May 1 to June 1, according to the season, the type of grass mixture used, and the soil. The end of the pasture season ranges from October 1 to November 1.

Few farmers kept records of their use of pasture. As a result, little specific information was gathered on grazing capacity. One dairyman grazed 68 milk cows and 20 heifers on 30 acres of pasture, but supplemented the pasture with grain and hay. Another farmer pastured 300 head of yearling steers in the summer of 1950 on a 63-acre pasture divided into two fields for alternate grazing. He estimated that the steers gained 2 pounds per head per day. In 1949 this farmer carried 231 ewes and 270 lambs on the same fields from May 5 to June 7. On June 10, 225 ewes and 225 lambs were placed on the pasture. The lambs (creep-fed on grain) were removed September 1. They averaged 91 pounds. The ewes were taken off on October 15. This farmer believed that his irrigated pasture made him more more money than any other crop.

MANAGEMENT PRACTICES ON OTHER CROPS

The Lower Yellowstone Irrigation Project has been in operation for the last 40 years. Consequently, the better adapted practices should have come into use here. General observation indicated that the level of technical efficiency was high, except for the irrigated pasture enterprise, which was comparatively new in the area.

Production of small grain has been emphasized in the farm organization during the last few years. Perhaps this may be explained by the relatively high grain prices combined with the high cost of labor for more intensive crops. Irrigation specialists usually do not consider production of small grain an efficient use of irrigation water. However, small grain appears to have a place in the rotation in maintaining good tilth and condition of the soil.

On the Lower Yellowstone Project two techniques were in general use for small grain production, depending upon whether or not the preceding crop was a cultivated one. If the preceding crop was cultivated, the usual sequence of field operations for small grain included duckfooting, harrowing twice, leveling, cleaning ditches, drilling, irrigating twice, binding, and threshing. Departures were made from these practices according to weather and soil as well as from individual preference. This was particularly true of the number and date of irrigations. Usually irrigation was not necessary to germinate grain. Preirrigation is avoided if possible, because of the tendency for unprotected heavy soils to bake and crust after irrigation. Binders instead of combines were commonly used to cut small grain, probably because the straw is needed for feed or bedding.

When the small grain crop was preceded by a noncultivated crop, fall plowing followed by disking in spring replaced duckfooting. This substitution materially increased the tractor and man-labor requirements charged to the small grain crop.

The usual operations for production of sugar beets include fall plowing, disking, harrowing twice, leveling twice, ditch cleaning, planting and fertilizing, irrigating three times, cultivating five times, thinning, hoeing and weeding by hand, and harvesting with a mechanical harvester. In the Lower Yellowstone area, as well as in other farming areas, weeds are a perennial problem despite the introduction of new weed sprays. Thus, a crop of sugar beets kept free from weeds by hand labor helps to control weeds on the farm. As with other crops, the number of irrigations depends to a large extent on soils and weather. Usually however, the beets are not"irrigated up"because

of possible crust formation and consequent difficulties in emergence of seedlings. Although beets were harvested by hand in a few instances, this is not the usual practice. Mechanical harvesting has become the generally accepted practice.

Corn usually is grown in this area for silage rather than grain, chiefly because of the relatively short growing season and the need for forage in livestock feeding. Production practices usually include fall plowing, disking, harrowing twice, leveling, ditch cleaning, planting, irrigating twice, cultivating four times, and field chopping.

Establishing a stand of alfalfa usually involves fall plowing, disking in spring, harrowing, leveling, cleaning ditches or establishing border dikes, drilling the alfalfa with a small grain companion crop, and irrigating. Some farmers had an alternative method of establishing a stand, which included drilling the alfalfa seed directly into a small grain stubble field in the fall without other preparation. If this method is followed, the seeding is usually "irrigated up."

APPENDIX

Description of Soil Types on Lower Yellowstone Irrigation Project 1/

Havre silty clay loam is a medium-heavy bottom land soil with a brown or dark brown surface. It ranges in depth from 6 to 20 inches. This layer tends to be faintly prismatic, platy, and slightly calcareous. It is underlain by stratified silts and very fine sands to a depth of 24 to 30 inches. The lower part is gray, calcareous, very fine sand.

Farland silty clay loam is a terrace soil with a dark grayish-brown, friable, silty clay loam surface soil about 3 or 4 inches in depth. A 4- or 6-inch, dark grayish-brown, noncalcareous, silty clay loam, or silty clay underlies this. At greater depths it becomes more friable and strongly calcareous. The soil is sticky when wet and forms large clods when dry. Internal drainage is slow.

Banks very fine sandy loam varies considerably in characteristics on both bottom lands and uplands. The surface is light-brown very fine sandy loam, which is underlain at a depth of about 7 inches with yellow fine sand in most instances. In some places, the subsoil is made up of alternate layers of sand and clay. Carbonates occurr at or within a few inches of the surface. The surface of this soil may be slightly hummocky, with narrow ridges of loamy fine sand separated by shallow troughs of heavier soil.

1/ William DeYoung, F. K. Nunns, and L. H. Smith, "Soil Survey of the Lower Yellowstone Valley Area, Montana," U. S. Department of Agriculture Series 1932, No. 38, Washington: U. S. Government Printing Office, 1939; and M. J. Edwards and J. K. Ableiter, "Soil Survey of McKenzie County, North Dakota," U. S. Department of Agriculture Series 1933, No. 37, Washington: U. S. Government Printing Office, 1942.

Cheyenne fine sandy loam is a terrace soil characterized by a 3- or 4-inch surface layer of laminated, grayish-brown, fine sandy loam. Below this for a depth of 12 inches the soil material is dark grayish-brown granular fine sandy loam. Below this second layer comes a layer of light olive-brown, mildly calcareous, very fine sandy loam, which gives way to grayish-yellow, strongly calcareous, silt loams or very fine sandy loams. Underlying this to a depth of 24 to 48 inches is gray calcareous sand.

Cheyenne loam also is a terrace soil with about a 2-inch surface layer of brown sandy loam, underlain to a depth of 7 to 10 inches by a dark brown, friable, weakly prismatic loam with fair organic content. Next occurs a layer of lighter grayish-brown, compact, prismatic, non-calcareous loam, which overlies a strong lime zone about 12 inches thick. Alternating layers of gravel and sand underlie this. This is one of the better soils of the Valley.

Farland silt loam is a terrace soil with a 4- or 5-inch surface layer of dark grayish-brown, friable silt loam, underlain by a 4- to 6-inch layer of noncalcareous material with a poorly defined nut structure. This grades into a light grayish-brown, mellow, almost structureless loam or silt loam. Farland silt loam has a smooth, level surface. It is an excellent soil.

Savage silt loam is also a terrace soil. It is a 7- or 8-inch very dark grayish-brown, noncalcareous, silt loam, with an underlying layer of lighter grayish-brown, mildly calcareous, silty clay loam of no definite structure. At a depth of 16 to 24 inches, the subsoil is light olive-yellow, strongly calcareous, silty clay, and to a depth of 48 inches it is light olive-gray silt loam containing lenses of sand.

This is one of the more productive irrigated soils, except where salts and lack of drainage are factors.

Havre silt loam, the most important irrigated soil of the valley bottoms, has a surface soil which ranges from grayish-brown to brown and from heavy to mellow silt loam. The depth varies greatly; it averages about 11 inches. A light-gray, very fine sandy loam or very fine sandy subsoil is generally calcareous. At depths of 2- to 3-feet incoherent sands or gravels occur. Some areas of this soil have been affected by accumulations of salt. Otherwise, it has excellent physical characteristics.

Banks loamy fine sand occurs adjacent to the Yellowstone River. It was only recently formed. The light grayish-brown surface soil is fine or very fine sand, only about 3 inches thick, which contains little organic matter and is weakly calcareous. Gray, loose, very slightly calcareous, fine sands grading into sand or gravel below a depth of 1 foot make up the subsoil. With a low natural fertility and low water-holding capacity, this soil has only limited agricultural value, especially as it usually requires considerable leveling and clearing before irrigation is possible.

Bowdoin clay, probably the heaviest and most difficult soil in the area to handle, is an immature soil which is found in the low places. The surface soil of about 12 inches is composed of a dark olive-gray, massive, calcareous clay with a gray, intractable, massive, noncalcareous, clay subsoil. In general, this soil is used chiefly to produce native hay and pasture, although the better drained areas may produce fair crops of alfalfa, sugar beets, and grain.

Cherry silt loam occurs in the valley slopes. It has a 7- to 10-inch surface soil that is grayish-brown or moderately dark grayish-brown, smooth, friable, silt loam, mildly calcareous. This is underlain by light yellowish-brown, calcareous, friable silty clay loam to a depth of 22 inches. A light olive or yellowish-gray, friable silt or silty clay loam occurs in the lower part of the subsoil. The entire soil developed over the colluvial wash derived from the gray and light grayish-brown beds of shale and sandstone of the Lance and Fort Union formations. With attention to maintenance of organic matter in which this soil is deficient, good crops can be produced on irrigated land.

Havre very fine sandy loam is similar to Havre silt loam with which it is associated, except for a higher proportion of fine and very fine sand in the surface. The surface soil is a grayish-brown, very fine sandy loam of single-grain structure, occurring to a depth of 7 to 10 inches. For a depth of 20 to 30 inches, the upper part of the subsoil is coherent, very fine or fine sand, which contains thin stratifications of silty material in places. Rather loose incoherent sands and gravels make up the lower part of the subsoil. Although not quite so productive as Havre silt loam, as it is less retentive of moisture and lower in organic matter, it is an excellent soil.

Appendix Table I. Soil Types Occurring on Survey Farms, Lower Yellowstone Irrigation Project a/

Soil Type	Farms with predominate soil type
	No.
Havre silty clay or silty clay loam	27
Farland silty clay loam	13
Banks very fine sandy loam	8
Cheyenne fine sandy loam	6
Cheyenne loam	5
Farland silt loam	5
Savage silt loam	4
Havre silt loam	3
Banks loamy fine sand	3
Bowdoin clay	3
Cherry silt loam	2
Havre very fine sandy loam	1

a/ From: William DeYoung, et al., "Soil Survey of the Lower Yellowstone Valley Area, Montana," U. S. Department of Agriculture Series 1932, No. 38, Washington: U. S. Government Printing Office, 1939; and M. J. Edwards and J. K. Ableiter, "Soil Survey of McKenzie County, North Dakota," U. S. Department of Agriculture Series 1933, No. 37, Washington: U. S. Government Printing Office, 1942.

Appendix Table II. Classification of Soil Types, Lower Yellowstone Irrigation Project for Irrigation Suitability a/

Class 1 - Best Quality

Havre very fine sandy loam
Havre silt loam
Havre silty clay and silty clay loam
Farland silt loam
Farland silty clay loam
Savage silt loam

Class 2

Banks very fine sandy loam

Class 3

Cheyenne loam
Cheyenne fine sandy loam

Class 4

Banks loamy fine sand

a/ Classified by Professor Gordon Johnsgard, Soils Department, North Dakota Agricultural Experiment Station.

Appendix Table III. Average Tractor Time and Fuel Consumption for Field Operations, Lower Yellowstone Irrigation Project, 1949 a/

Operation	Size of tractor b/	No. of cases	Time per acre		Fuel per acre	
			Range	Mean	Range	Mean
			Hrs.	Hrs.	Gal.	Gal.
Plowing						
2 bottom	2 pl.	5	0.7-1.4	1.1	2.0-4.5	2.9
2 bottom	3 pl.	11	1.0-1.7	1.1	2.0-6.2	3.5
1 bottom	2 pl.	6	1.5-3.3	2.4	2.2-7.1	4.3
Disking						
10 ft. tandem	3 pl.	4	0.3-0.5	0.4	0.5-1.0	0.8
9 ft. tandem	2 pl.	4	0.1-0.4	0.3	0.3-1.3	0.8
8 ft. tandem	2 pl.	5	0.3-0.6	0.4	0.7-1.2	1.0
Harrowing						
15 ft. harrow	2 pl.	9	0.1-0.3	0.2	0.1-1.0	0.4
20 ft. harrow	2 pl.	13	0.1-0.5	0.3	0.2-1.0	0.6
20 ft. harrow	3 pl.	9	0.1-0.3	0.2	0.2-0.8	0.5
Duckfoot						
12 ft.	3 pl.	2	0.3-0.4	0.4	1.0-1.2	1.1
Leveling						
Various sizes	2 pl.	13	0.2-0.8	0.4	0.2-2.1	0.8
Various sizes	3 pl.	20	0.2-0.7	0.4	0.4-1.7	1.1
Drilling grain						
12 ft.	2 pl.	3	0.3-0.5	0.4	0.6-1.2	0.8
12 ft.	3 pl.	6	0.3-0.5	0.4	0.8-1.2	1.0
10 ft.	2 pl.	6	0.2-0.7	0.4	0.2-1.2	0.6
10 ft.	3 pl.	6	0.3-0.5	0.4	0.8-1.2	1.0
Planting						
2 row corn	2 pl.	5	0.3-0.8	0.6	0.6-2.1	1.3
4 row corn	2-3 pl.	3	0.2-0.7	0.4	0.4-1.3	0.7
4 row beet	2-3 pl.	10	0.5-0.9	0.6	0.2-1.4	0.8
Cultivating						
2 row corn	2-3 pl.	8	0.3-1.0	0.6	0.6-2.5	1.3
1st 4 row beet	2-3 pl.	10	0.5-2.0	1.0	0.2-3.2	1.2
2nd 4 row beet	2-3 pl.	10	0.4-0.9	0.6	0.2-1.4	0.8
Binding grain						
7 ft.	2-3 pl.	4	0.5-1.0	0.7	1.5-2.5	1.8
8 ft.	1-3 pl.	5	0.4-0.7	0.6	0.3-1.7	0.9
10 ft.	1-3 pl.	3	0.4-0.7	0.6	0.4-0.7	0.6

(continued)

Appendix Table III. Average Tractor Time and Fuel Consumption for Field Operations, Lower Yellowstone Irrigation Project, 1949 a/ (continued)

Operation	Size of tractor b/	No. of cases	Time per acre Range	Time per acre Mean	Fuel per acre Range	Fuel per acre Mean
			Hrs.	Hrs.	Gal.	Gal.
Threshing grain						
22 inch	3 pl.	3	0.4-0.5	0.4	1.0-1.8	1.4
Mowing hay						
	2-3 pl.	4	0.2-0.5	0.3	0.3-1.0	0.6
Field Chopping						
Corn	2-3 pl.	4	0.8-2.0	1.3	2.0-4.0	2.9
Ditch Cleaning						
	2-3 pl.	19	0.1-1.5	0.3		

a/ From economic survey on selected soils.

b/ Tractor size groupings:
3 plow (24-30 hp) = International Harvester "M", gas (19); John Deere "A", gas (11); John Deere "G", distillate (1); Caterpiller "D2", (3); International Harvester "MD", (1); John Deere "D", (1).
2 plow (16-23 hp) = John Deere "B", dist. (12); John Deere "B", gas (5); Ford gas (3); Caterpiller C-22, gas (3); John Deere "A", dist. (16); Case "SC", gas, (1); Cockshutt "30". (1); International Harvester "H", gas (9).
1 plow (8-15 hp) = John Deere "H", (1); International Harvester "A", (1).