IRRIGATION PRACTICE

AND

WATER REQUIREMENTS

OF

LANDS SERVED BY

THE

ASSOCIATED CANALS

BY

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Note

This report is a part of the Board of Canal Presidents Investigations of the Use of Water in Salt Lake County conducted during 1937 to 1940.

Included in this report are quotations from reports which were prepared by Mr. David I. Gardner covering the irrigation practice in this area.

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INTRODUCTION

The Associated Canals consist of the Utah and Salt Lake Canal, the East Jordan Canal, the South Jordan Canal, the North Jordan Canal and the Jordan and Salt Lake City or City Canal. The water used by the first four of these canals is diverted from Jordan River. The City Canal also diverts from Jordan River but the lands it serves receive water also from creeks draining areas above the east side of Salt Lake Valley. The water used from Jordan River is regulated by storage in Utah Lake; the Associated Canals own and operate a pumping plant at the outlet of the Lake which pumps water from the Lake into Jordan River when the Lake is too low for the natural outflow to equal the demand. This is the prevailing condition and the pumps are normally operated during the main irrigation season.

The lands served lie on both sides of Jordan River in Salt Lake County. The Associated Canals do not serve all lands supplied by Jordan River. There are several smaller canals serving lands adjacent to the River, these are mainly supplied by return flow in the River and require little pumping from Utah Lake. The Draper Canal diverts through the East Jordan Canal and pumps to the lands it serves; it is not a member of the Associated Canals, however. Other uses of Jordan River include that of the Kennecott Copper Co., successor to the Utah Copper Co., and the sugar factory at South Jordan.

The water supply of the Associated Canals is well regulated by Utah Lake. Dependable estimates of the water supply available can be made for each year at the beginning of the crop season. The water that may be available can be regulated for use at the time desired. The supply is generally adequate; shortages have occurred in only a few of the years of record. Usually the water supply does not act as a restriction on use or the selection of the crops to be grown. Use is governed by crop needs, although in occasional years the crops grown may be affected by the available water supply. In years of shortage more grain is grown to reduce the water requirements.

The first need of the Associated Canals in the pending adjudication proceeding covering rights to the use of the waters of Utah Lake and Jordan River is the proof for the need for the amount of water which each of these Canals will claim. Such claims requre support to show that the amounts of water so claimed is reasonably required for the proper irrigation of the lands served. This is, of course, fundamental and well recognized as all rights by appropriation are limited to the requirements for beneficial use.

The first investigations undertaken by the Board of Canal Presidents for the pending litigation was directed toward securing records needed in the proof of the use by the Associated Canal. During the season of 1937 measurements of the water used with records of the results of such use were conducted on fields of selected soils and crops. In 1938 and to a lesser extent in 1939 measurements of the amounts of water used under selected laterals were made. During these years seepage measurements were also secured. These field records were obtained by Mr. David I. Gardner. The results have been assembled in two detailed reports entitled

Report on Board of Canal Presidents Water Application Investigations in Salt Lake County, Season of 1937, by David I. Gardner and S. T. Harding, 153 pages

and

Board of Canal Presidents Investigations of the Use of Water, Salt Lake County, Seasons of 1938 and 1939, by David I. Gardner and S. T. Harding, Feb. 1940, 90 pages

These two reports were prepared as references covering the results of the observations made. Conclusions from the observations and applications of the results to the determination of the water requirements of these canals were not attempted in these reports.

In addition to the records secured in the field work covered in these reports, the preparation of the support for the claims that may be made for the water requirements of each of the Associated Canals requires consideration of general factors such as climatic conditions, types of crop grown, length of irrigation season, as well as the location, area, and type of soils served. These items are assembled in this report.

This report has been prepared at the conclusion of the investigations conducted under the author's direction from

1937 to 1940. Its principal purpose is to bring together for future use the material that will be needed when the final preparations for the showing of the Associated Canals may be undertaken. While the work outlined and programmed on these subjects for these investigations has been carried out and completed there are still some items which will be required before final conclusions regarding the total requirements of each of the Associated Canals can be prepared. The material supporting the author's conclusions regarding the reasonable rates of use for different soils and crops and for conveyance losses has been secured and assembled and conclusions regarding the reasonable rates of use have been reached. Before these conclusions regarding the reasonable rates of use can be used to prepare the author's estimate of the total water requirements of each of the Associated Canals, it is necessary to have each canal define and locate the area which they will claim as served by their canal. The rates of use per acre can then be applied to such defined areas by determining the extent of each of the soil types served and compiling the total requirements for the entire area.

Each of the Associated Canals has assembled material on the areas served which, while subject to some future change, is generally representative of the final claims that will be made. Such present areas can be used to prepare the estimated water requirements of each of these canals with sufficient closeness to the final results to meet the needs for any present discussions.

Such estimates of the total diversion requirements of each of the Associated Canals are not included in the reports prepared by the author at the present time. There are several reasons for this. It is always confusing to prepare and use one set of figures and later make revisions that may result in changes. There are no immediately pending and urgent negotiations or procedure requiring the use of such conclusions at this time and some additional records may become available which will later be useful. The results of the soil survey of the U. S. Dept. of Agriculture and the Utah Agriculture Experiment Station are available in preliminary form with the soils designated by numbers. This will be revised and the soils designated by names. A report using the present numbers prepared at this time would need to be rewritten later to conform with the published report when this may be issued.

Should a report covering the author's conclusions on the reasonable water requirements of each of the Associated Canals be desired at any time it can be prepared readily and promptly from the material now available provided each canal makes available the area it will use for its area irrigated. This has already been done by the four canals other than Salt Lake City insofar as each of these four canals has such areas defined. Surveys of the areas served by Salt Lake City are understood to have been made but the results have not, as yet, been made available to the author of this report.

RECORDS AVAILABLE

Conclusions regarding the reasonable water requirements of any area should be based on a consideration of all available records. The material available in regard to the lands served by the Associated Canals is adequate to enable reliable conclusions to be reached.

Records of actual diversions by each canal are available since 1901. Where such diversions include uses other than irrigation the records enable the different uses to be segregated. This represents an unusually long and complete record of use. Some records prior to 1901 are also available but this was before the operation of pumps from Utah Lake and use was largely controlled by natural outflow from the Lake. The compilation of the records of diversion is contained in a separate report entitled

"Diversions by the Associated Canals 1901 to 1939,"

35 pages and 15 tables, dated April 1940;

the results of this compilation have been used herein.

Direct observations of the use of water have been made on selected areas as a part of the investigations in the pending case. In 1937 the use of water was carefully determined on selected fields of typical crops and soils. In 1938, and to alesser extent in 1939, records were secured on the use under a selected group of laterals under the different canals. These results are presented in the reports listed in the introduction to this report. There are also some records of conveyance losses on the canals.

The areas irrigated have been carefully surveyed and this information is available in more than usually accurate and complete detail. The areas in different crops have also been determined for sufficient years to enable the normal crop distribution to be estimated. Climatic records are adequate to show rainfall, temperature and length of growing season. The soils of the areas served were included in the area surveyed in the recent soil survey of Salt Lake County by the U. S. Dept. of Agriculture and the Utah Agriculture Experiment Station. Available map s indicate the topographic conditions adequately.

The records available are more than usually complete for the determination of the r easonable water requirements of this area. All records have been utilized in reaching the conclusions herein later expressed. The support for these conclusions has also been described. It is considered that the available records are adequate to support the conclusions reached.

GENERAL IRRIGATION PRACTICE

The areas served by the Associated Canals represent an old and highly developed irrigation practice. Land values are relatively high, general farming standards are good, and the land owners and irrigators are generally skilled and experienced. Farm sizes are small and cultivation is intensive. All local conditions favor a good standard of practice in both irrigation and in other items of agriculture. Such standards are realized. Local methods have been adapted to local conditions and can be supported readily in comparison with standards in other similar areas.

Mr. David I. Gardner has prepared a discussion of the history and practice for these areas which describes local conditions and methods very clearly. It is as follows.

IRRIGATION PRACTICE IN SALT LAKE COUNTY

by David I. Gardner

History

Irrigation practice began in Salt Lake County in 1947, immediately upon the arrival of the Pioneers. The first systems were, of course, merely short ditches diverting directly to the lands immediately adjacent to the streams, and located adjacent to the most accessible farming ground.

As the population increased and spread throughout the valley, other streams were used. Jordan River, because of its size, was not used extensively until two or three years later. At this time small ditches were taken from the river to irrigatate the bottom lands. Beginning in about 1860, larger and longer canals were diverted to take the water higher on the bench lands. By virtue of the topography of the land, some of the better lands required long canals, constructed into what is known as Jordan Narrows. At this early date construction of the canals in the narrows was slow and expensive. The earlier ditches were supplied probably to a great extent from seepage gain in the river, but the larger canals were dependent on Utah Lake for their supply.

It developed as time went on that the natural outflow from Utah Lake was not at all times dependable in sufficient quantity to supply these larger canals. In the year 1902 the pumping plant was constructed on Utah Lake at the head of the Jordan River in order to make available a more dependable water supply for the canals in the valley. From time to time as the pumping equipment bacame obsolete or worn, new pumps were installed. In 1920 the present pumping plant at the head of the Jordan River was constructed. The only additions or improvements to this plant since its construction have been a 100 and a 50 second foot unit capacity pump. The present capacity of the North Pumping Plant is 950 second feet at a static head of 6 feet. In 1934, due to the low stage of the lake, sufficient water would not reach the North Plant to supply the needs of the valley. In this year the Pelican Point Plant was constructed at a rated capacity of 380 second feet. The Pelican Point Plant since its construction has been operated only at the times when the North Plant was unable to deliver the required quantity of water.

Each of the larger canals in the valley are capitalized for so many shares of stock. This stock is owned by the water users under the canals at about one share per acre irrigated. There seems to be little differentiation in stock ownership relative to soil types. Clay soil and gravel soil usually carry about the same number of shares per acre. A group of farmers under a lateral will join together and pool their stock ownership in a weir. This weir is set so as to deliver the proper percentage of the total water in the canal that the number of shares in the weir represent after the losses from the canal have been deducted. The land holders under this weir then take its whole stream in their turns in rotation. It is under this system that the irrigation practice in Salt Lake Valley has been built up, since its inception in about 1850.

IRRIGATION PRACTICE

The usual method of irrigation in Salt Lake Valley is the furrow method. This method, is, of course, essential in the irrigation of sugar beets, and is generally followed for the irrigation of grain. The usual procedure is to plant alfalfa with one of the small grains as a nurse crop. The field is furrowed or marked off for the irrigation of the grain, but further marking for the irrigation of the alfalfa is not attempted. As a result of this practice after the first year's irrigation the irrigation of alfalfa is under the wild flooding method. Border method of irrigation for alfalfa would probably reduce the length of time necessary to irrigate a given acreage, but it has never been followed. The length of run varies, depending on the size of the farm, contour of the ground, and on the individual farmer. The tendency in the past few years has been for shorter length runs.

From 500 to 800 feet is considered a good average run for the irrigation of row crops. However, runs of 1000 to 1320 feet are not uncommon. These long runs are usually found where the proper slope of the ground surface permits.

As a general rule under local practice, irrigations are probably more frequent than would be necessary under a call system, as farmers frequently irrigate land from two to five days earlier than may be necessary for the reason that their crop may suffer if irrigation was delayed until the following turn. This frequent use of irrigation does not seem to have damaged the land nor the crops in the valley. Practically all farms in the valley have been producing a crop annually for the past sixty years. Where the proper farming methods have been followed production has not diminished. From this record along it would appear that the irrigation practice has not been injurious.

IRRIGATION INTERVAL

Under the rotation method, as practiced by practically all the canal companies in the valley, any individual farmer receives his water supply in rotation. The size of the stream depends on the number of shares in a given weir. The irrigators under each lateral usually determine among themselves the period of rotation of the stream. The most common period is seven to eight days, but on some of the larger weirs the period between turns may run to twelve days. The usual practice is to irrigate approximately one half the land on a given farm in any one turn. The alternate half is irrigated the following turn. When turns occur from seven to eight days apart, the maximum time between irrigations is approximately fifteen days. Where the turns are a longer interval twenty-four days may lapse between turns. This longer period is sometimes detrimental to crops expecially in the hottest part of the season. So as a general rule, shorter turns are encouraged, and a longer period of rotation is only practiced where the streams in the weir run up to five or more second feet.

On a farm of forty acres there is usually sufficient water delivered at the farm headgate to irrigate approximately one-half the land during the farmer's turn. Under this method there is approximately fifteen to twenty days between irrigations. From my experience I would say that crops that are not watered with each alternate turn are adversely affected. It frequently happens that in grain, beets, and alfalfa spots that are missed during any one irrigation turn wilt before the next irrigation to the field is applied. This is especially true on gravelly or sandy soil. On most of the land in the valley there appears to be very little lateral movement of the water, regardless of what quantity is applied, and it frequently is seen that rows of beets or grain two feet from a wet furrow will wilt, this was apparent on soil which the ground water table was only 3 feet below the surface.

There are probably irrigation practices more highly developed and more efficient than the practice in Salt Lake County, namely the furrow method, but this practice was developed in Utah and will be probably continued since it seems to be working satisfactorily. I do not question that with more energetic irrigators crops could be produced with less water per acre than was applied in 1939, but the farmers prefer apparently from an economic standpoint to pay for the additional water and not watch their water so closely during irrigation turns, but spend their time more profitably at other farm work."

CLIMATE AS A FACTOR IN WATER REQUIREMENTS

The climatic conditions in the irrigated areas of Salt Lake County are a factor in the amount of water required for irrigation. Local climatic records are useful directly in connection with local practice and generally for comparison with other areas.

The climatic items usually considered in describing a local climate in relation to irrigation are rainfall, temperature, and evaporation. Both annual and monthly rainfalls are useful. For temperature the monthly and annual means and the dates of the last and the first killing frosts with the resulting length of season between frosts are the usual items. The evaporation from a water surface is a good index of the climatic factors affecting transpiration from plants.

The records of the U. S. Weather Bureau applicable to the irrigated area of Salt Lake County are Salt Lake City, Saltair, Utah Lake (Lehi), Midvale, Cottonwood Weir, Lower Mill Creek and Salt Lake Airport. Of these only Midvale is located directly within the irrigated area. Salt Lake City, Salt Lake Airport, and Saltair are located along the northern edge of the irrigated area. Cottonwood Weir and Lower Mill

Creek are located above the irrigated areas in the lower portions of the Wasatch Mountains. Utah Lake (Lehi) is at the North Pumping Plant on Utah Lake and outside the areas surveyed but it is the nearest available record at the south end of the county. While not as centrally located as would be desired, these records are adequate to show the climatic conditions in relation to the irrigation needs of these lands. The records are of sufficient length to indicate the long time means. The mean temperature and precipitation from the records are shown in Table 1.

The records in Table 1 indicate a mean annual precipitation of about 15 inches on the areas served by the Associated Canals. This is fairly well distributed through the year. About 8 inches occur in the main growing season from April to October. June to August has the lowest rate of rainfall with only April and May having an average monthly rainfall of over 1 inch. While individual storms, particularly in the early season, may affect the time of an occasional irrigation, the summer rainfall is not sufficient in amount or regular enough in occurrence to be a material factor in the amount of irrigation water used. Winter rainfall is generally sufficient to moisten the ground so that irrigation for spring plowing or irrigating up crops is not usual but may be required in some years. Fall rainfall on sugar beets assists in digging; in some years failure to receive such rains results in the need for an additional irrigation on the beets to assist in their harvest.

Not only is the summer rainfall inadequate for crop

Table 1 - Mean Temperature and Precipitation for Stations Representative of the Areas Irrigated from Jordan River.

Records of U.S. Weather Bureau

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
	Mean Temperature - Degrees Fahrenheit												
Midvale	27.1	34.1	41.0	49.4	58.5	67.2	75.0	72.9	62.9	51.2	39.6	28.7	50.6
Lower Mill Creek	28.8	34.1	40.6	48.6	57.5	66.8	75.6	73.1	64.3	52.9	40.1	29.9	51.0
Salt Lake City	29.2	33.8	41.7	49.6	57.4	67.4	75.7	74.5	64.4	52.5	41.1	31.9	51.6
Saltair	27.9	33.3	41.1	49.7	58.5	68.4	76.1	73.8		51.0	39.6	29.8	
Salt Lake Airpt.	24.8	32.0	40.8	50.0	58.3	68.0	76.9	74.4	64.4	52.6	37.6	29.5	50.8
Utah Lake (Lehi)	24.7	31.7	39.4	47.8	56.3	64.9	72.5	69.5	60.2	49.5	37.3	26.1	48.3
	Mean Precipitation - Inches												
Midvale	1.13	1.49	1.80	1.79	1.77	.75	.63	.82	1.00	1.43	1.29	1.13	15.03
Cottonwood Weir	1.55	1.98	2.76	2.64	2.49	1.16	.86	1.26	1.37	2.15	1.56	1.47	21.25
Lower Mill Creek	1.83	2.24	2.69	2.43	2.70	1.38	.68	1.14	1.50	2.03	1.90	1.76	22.28
Salt Lake City	1.31	1.51	1.98	2.05	1.92	.80	.51	.85	.98	1.44	1.35	1.43	16.13
Saltair	.97	1.02	1.53	1.49	1.59	.91	.54	.81	.98	1.50	1.30	.97	13.61
Salt Lake Airport	1.07	1.29	1.44	1.48	1.21	.51	.61	.98	.69	1.20	1.11	1.08	12.67
Utah Lake (Lehi)	1.25	1.36	1.27	1.24	1.47	.58	.74	1.01	.96	1.18	.88	1.13	13.07

growth but the occurrence of individual storms is irregular. Summer rains are largely local and one part of Salt Lake Valley may receive a good rain while almost none falls a few miles away. Such variations tend to equalize over a season but affect single storms. Some hail storms also occur.

The American Smelting and Refining Co. maintain a precipitation station at their Asarco Farm near Magna. This company has very kindly made these records available. The results in Table 2 were copied from their records by Mr. D. I. Gardner. These have been compared with similar records at Salt Lake and Midvale.

For the 6 seaaons shown there is little average difference in the rainfall at the three stations, the averages for the 6 months being 5.03, 5.08, and 5.27 inches for Salt Lake City, Midvale, and Asarco. In individual years larger differences may occur.

Table 2 also compares some individual storms. Rains of 1 inch may occur at one of these stations with only a shower at the others.

On the general map of the U. S. Weather Bureau showing mean annual temperatures the area around Salt Lake and around Carson Lake in Nevada are the only intermountain areas having mean annual temperatures as high as 50°. Pacific Coast and southwestern areas have mean annual temperatures from 50° to 70°. Other intermountain areas vary generally from 45° to 50°. The higher Great Plains areas vary generally from 40° to 45°. This higher mean annual temperature indicates a somewhat more rapid rate of transpiration than in

Table 2 - Comparison of Rainfall at Salt Lake City, Midvale and Asarco.

Rainfall in Inches

Month	Salt Lake City	Midvale	Asarco Farm	Month	Salt Lake City	Midvale	Asarco Farm
1934				1939			
Apr	0.46	.32	0.34	Apr	.92	.72	.86
May	.01	T	–	May	1.12	.94	1.18
June	0.82	1.18	.41	June	1.31	.85	1.11
July	.68	1.44	.59	July	.11	.14	0.21
Aug	1.01	.28	1.98	Aug	.26	.92	.13
Sept	.40	.44	.59	Sept	.58	.74	1.29
Total	3.38	3.66	3.91	Total	4.30	4.31	4.78
1935							
Apr	2.89	2.91	2.51	1937			
May	3.68	3.04	3.28	July 5	.04	.04	T
June	.13	.10	0.08	6	.26	.30	1.04
July	.01	.02	0.28	7			
Aug	.88	.46	1.21	8	.14	.19	.48
Sept	.53	.39	.86	9	T	.01	T
Total	8.12	6.92	8.22	Total	0.44	0.54	1.52
1936				1937			
Apr	.89	.94	1.20	Sept 22	.13	.27	0
May	.34	.39	0.10	23	.24	.44	.52
June	1.20	.50	1.35				
July	1.70	1.29	1.81	1938			
Aug	.93	2.24	3.54	Apr 5	.91	.27	.31
Sept	.14	.14	0.20	6	.13	0	.85
Total	4.20	5.50	5.20				
1937				1938			
Apr	1.15	1.17	.92	May 1	.03	.01	.18
May	1.17	.92	1.03	2	.91	.87	.91
June	.26	.30	T	3	.02	.01	.04
July	1.23	.97	2.28	4	.32	.69	–
Aug	.51	.55	.13	5	.03	.05	.40
Sept	.68	1.39	.55	6	.05	.02	.05
Total	5.00	5.30	4.91	Total	1.36	1.65	1.58
1938				1938			
Apr	1.78	.76	1.58	May 15	.04	.04	
May	2.09	2.40	2.33	16	.11	.07	
June	.53	.50	0.10	17	.49	.61	.52
July	.29	.44	0.24	18	.05	.03	.08
Aug	.48	.69	0.35	19	T		.05
Sept	.09	.04	T	20	T		T
				21	.03		T
Total	5.26	4.83	4.60	Total	.72	.75	.65

other Great Basin areas. While the differences resulting from this higher temperature are relatively small, any effect is in the direction of increasing the irrigation requirements in this area in comparison with other adjacent valleys.

The records of the dates of killing frosts have been summarized to 1930 in publications of the U. S. Weather Bureau. These with the records for the years since 1930 are shown in Table 3.

These records show a shorter average season between frosts on lower lands as at Midvale than at Salt Lake City or Lower Mill Creek. The season at Saltair is affected by the nearness to Salt Lake. A general average for the irrigated area appears to be about 150 to 160 days.

The season between frosts varies widely in different years as is shown by the records for the years since 1930.

These records can be compared with other western areas. The average length of the crop-growing season over the United States is shown on Chart V of Bulletin V of the U. S. Weather Bureau. This is the same as the period between frosts. The Newlands Project, Nevada, shows 128 days, the Minidoka project 104 days, the Sacramento Valley 254 days, the Sunnyside area, Washington, 121 days.

While the season between killing frosts is not a rigid measure of the growing season it is a general index that is useful in comparing different areas. The season here is longer than is usual in other intermountain areas. Any effect of such longer growing season is in the direction of increasing the water requirements.

Table 3 -

Length of Season between Killing Frosts

Years	Midvale			Saltair			Salt Lake City			Lower Mill Creek		
	Last in Spring	First in Fall	Season in Days	Last in Spring	First in Fall	Season in Days	Last in Spring	First in Fall	Season in Days	Last in Spring	First in Fall	Season in Days
Mean to 1930												
Number of Years of Record	19			26			56			16		
Mean	May 23	Sept 24	124	Apr. 11	Oct 22	194	Apr. 18	Oct. 19	184	May 5	Oct 14	162
1931	May 19	Sept 24	128	Apr. 4	Oct 27	205	Apr 4	Oct 27	206		Oct 27	
1932	May 7	Oct 4	150	Apr 9	–		Apr 6	Oct 20	197	Apr 9	Oct 19	193
1933	May 11	Oct 16	158	May 11	Nov. 2	175	Apr 14	Nov 2	203	Apr 14	Nov 2	202
1934	Apr 6	Oct 23	200	Mar 18	Oct 20	217	Apr 2	Sept 27	177	Mar 24	Sept 26	186
1935	Apr 29	Oct 17	171	Mar 31	Oct 17	200	Mar 28	Oct 17	203	Apr. 11	Oct. 22	194
1936	May 22	Sept 28	129	May 7	Oct 29	175	Apr 6	Oct 23	200	Apr 6	Oct 23	200
1937	May 1	Sept 25	147	Apr 4			Apr 24	Nov 8	198	Apr. 24	Oct 19	178
1938	May 19	Oct 19	153	Apr. 7	Nov 7	183	Apr 2	Oct 19	200	May 7	Oct 19	165
1939	Apr 26	Sept 15	142	–	–	–	Apr 6	Nov 10	218	Apr 17	Nov 10	207
1940	Apr 30	Nov 5	190	–	–	–	Mar 19	Nov 3	229	Apr 14	Nov 5	205

There are no U. S. Weather Bureau records of evaporation from water surfaces taken within the area irrigated from Jordan River. There is the record with the U. S. Weather Bureau Class A pan at the North Pumping Plant, called Utah Lake (Lehi) in the Weather Bureau reports. This pan is maintained for the Weather Bureau by the Associated Canals. Its record is available for the non-freezing months since 1923. This record together with other records applicable to Utah Lake have been discussed at length in the watersupply reports on Utah Lake. The average observed evaporation with the Class A pan from 1923 to 1938 has been as follows.

	feet
March	.278
April	.492
May	.741
June	.862
July	.912
August	.802
September	.597
October	.343
November	.105
total	5.132

These records are the evaporation from the Class A pan. Evaporation from a large water surface will be less than the loss from this type of pan. The different years varied from 12% below to 19% above the mean; monthly variations were from minus 48 to plus 46 per cent.

CROPS

In fixing the water requirements of any area it is necessary to consider the crops which are being and will be grown. The difference in the water requirements of different crops is well recognized. It would not be equitable to determine the water requirements on the basis of the use for either the crops of least or of largest needs. It is regognized that the crops actually grown should be used.

The crop distribution in any area is not fixed and changes occur with fluctuations in crop prices, development of new crops or provision for new market outlets. These changes are usually gradual and limited in their effect on the average use of water. The larger the area the smaller are the relative effects of such changes. An individual owner may change the crops on his whole area in some years but similar changes do not occur on all farms.

The principal crops in the areas irrigated by the Associated Canals include alfalfa, pasture, grain, sugar beets, potatoes, and truck. Some orchards are grown but not on an extensive market basis. The water requirements well be determined mainly by the needs for forage, grain, and root crops.

There are differences in the frequency of irrigation and depth of each application for alfalfa, cut for hay, or where used for pasture without much difference in the total use per season. Alfalfa is an important crop in this area on the higher and drained lands. Some of the lower lands with high ground water are used in various types of grass pasture. These can all be grouped as forage crops having a similar use of water.

Grain is also grown as a regular part of the crop practice. It is used to nurse new alfalfa seedings, such grain and alfalfa seeding has a water requirement larger than that of grain alone as irrigations are required for the seeding aftar grain has been harvested. Grain is also grown as a separate crop, although the area of grain alone is not usually large except in years when a shortage in water supply is expected. In such years grain may be matured before the shortage becomes too large. Such grain has the smallest water requirement of any of the important local crops.

The root crops consist of sugar beets and potatoes. Their water requirements are similar. The area of sugar beets exceeds that of potatoes; beets have been used as representative of this group.

In local surveys the areas in Buildings and Yards has been segregated. Due to the small average size of farms in this area the proportion of such buildings and yards are larger than usual. Such areas have been classified as non-irrigated in some surveys. Actually water is used for lawns, gardens, and stock purposes at a rate similar to that for cropped areas.

Among the crops of smaller area are corn, truck gardens, and orchards. Corn is a cereal but its season is longer than that of the other grains. Truck includes the commercial plantings of vegetables and bush fruits including tomatoes and celery. Gardens are the home plantings. Orchards have been only a minor crop in this area. The total area in orchards has diminished in recent years as many plantings were pulled out during the drought years.

The best basis for determining the division of area between the different crops is the actual record obtained from crop surveys. When adjusted for any special conditions that may have affected the practice at the time of the survey such surveys furnish a definite showing of actual practice. Several sources of such information are available. One is the survey of all lands under the Associated Canal made for the State Engineer by the Utah Agricultural College. This was complete but was made in a year of water shortage when the area in grain was larger than usual and some land usually cropped was idle. The other records are the detail surveys made for the Board of Canal Presidents in 1938 and 1939 of areas under selected laterals on which the water used was measured. Some general results can be secured from the U. S. Census reports. Crop maps have also been prepared by some of the canals in their determination of their irrigated areas.

RESULTS FROM THE 15TH U. S. CENSUS

The Fifteenth Census reports the irrigated crops in Salt Lake County as a whole. The total area irrigated in 1929 for the County is given in the Census as 93,633 acres. The similar total for 1919 was 102,051 acres. This includes much land under other canals than those of the Associated Canals but the distribution of crops should be representative of the Associated Canal area. The Census figures for the more essential crops are as follows.

Cereals	acres	acres	% of Total
Wheat	8393		
Oats	1748		
Barley	1576		
Rye	25		
Total		11742	24

	acres	acres	% of Total
Hay			
Alfalfa	27049		
Alfalfa seed	331		
Misc.	300		
Total		27680	57
Sugar beets	2924		
Potatoes	1417		
Total Root Crops		4341	9
Vegetables		1781	4
Orchards		2138	4
Corn		946	2
Total of above crops		48628	100

These results are not complete. Irrigated pasture is not included. The total area segregated to crops is only about ½ the total irrigated area reported; pasture would not account for all of this difference.

Some relative results can be found in these figures. In 1929 Utah Lake was generally at a stage of from -2 to -4 and the water shortage of the 1930s had not been reached. The grain area was only 42% of the area in alfalfa hay whereas it has been nearly equal to the hay area in recent years. Sugar beets and potatoes were about 16% of the alfalfa hay area; it has been about 45% of this area recently.

SURVEY OF 1934-35

The results of the survey of the irrigated areas made for the State Engineer by the Utah Agricultural College are given in the 20th Biennial Report of the State Engineer (1934-36).

This report gives the results for the Associated Canals. shown in Tables 4 and 5. In Table 4 the results are shown in acres. In Table 5 these are expressed in terms of percentages of the total area.

These results are affected by the standards of classification used. The items included in the irrigated area all represent cropped land except the fallow area. It was proper to include this fallow land as irrigated in these years as this represents land normally cropped but idle at the time of this survey due to shortage of water. In determining percentage distribution of crops however this fallow area has been omitted as it does not represent any single crop. When placed in irrigation it will be in all of the crops similarly to the other areas.

This survey excluded the buildings and yards. These are the home sites. Many of the holdings which are one acre or less retain canal stock and receive service. The yards on larger holdings also receive water. These are irrigated areas using water beneficially. The percentage of crops has been computed in Table 5 both with and without the area in buildings and yards.

The remaining areas classified as not irrigated do not receive service although they are usual and essential parts of irrigated areas. Roads and lanes average 5% of the gross area; this is larger than usual due to the inclusion of lands in Salt Lake City. Canal rights of way are a usual amount. The waste land is a small percentage. The area covered has few cross washes or other unusable land. The area classified as virgin pasture is unusually large. This is a major item for the North Jordan Canal and large for the Utah and Salt Lake Canal. This is the result of extending the survey outside of the areas served by these canals to the lower lands

Table 4 - Results of Survey of Irrigated Areas Served by the Associated Canals in 1934 + 1935. Made for the State Engineer by the Utah Agricultural Experiment Station. Acres.

Areas	Utah + Salt Lake Canal	South Jordan Canal	North Jordan Canal	East Jordan Canal	Jordan + Salt Lake City = All Exchanges	Total for Associated Canals	Per Cent of Total Area
Alfalfa	3491.1	2194.0	1181.5	1836.1	4052.5	12755.2	
Corn	160.5	254.1	183.7	260.0	664.4	1522.7	
Grain	5009.5	2789.8	981.6	1872.7	2571.7	13225.1	
Beets	368.7	515.3	541.6	575.4	667.0	2668.0	
Potatoes	151.3	233.8	123.6	136.5	521.4	1166.6	
Orchard	458.1	203.4	41.9	83.6	799.3	1586.5	
Gardens	317.9	121.1	214.2	112.9	1990.7	2756.8	
Fallow	485.6	573.6	482.8	559.7	960.0	3062.0	
Permanent Pasture	220.7	266.3	428.8	61.9	1029.1	2006.8	
Rotation	54.3	33.7	26.1	73.3	101.1	288.5	
Total	10717.3	7185.1	4205.6	5572.1	13357.3	41037.4	66
Buildings + Yards	709.4	287.9	191.0	248.3	3203.6	4640.2	8
Total	11426.7	7473.0	4396.6	5820.4	16560.9	456776	74
Roads + Lanes	624.5	361.4	266.0	402.3	1549.3	3203.5	5
Canal Rights of Way	168.9	104.6	25.5	185.4	126.1	610.5	1
Large Ditches	8.1	13.1	11.1	3.0	46.9	82.2	
Pasture: Nat. Subbed	13.5	376.8	234.3	222.7	1051.5	1898.8	3
Dry Farm	60.9	8.7	38.7	1.8	79.2	189.3	
Virgin	1919.1	377.1	4240.7	991.7	1411.0	8939.6	14
Waste	56.7	199.1	695.1	297.9	419.4	1668.2	3
Total Area Surveyed	14278.7	8913.6	9908.0	7925.2	21246.8	62272.3	100
Total Area Irrigated	10717.3	7185.1	4205.6	5572.1	13357.3	41037.4	66
Total Irrigated incl. Buildings and Yards less Fallow	10941.1	6899.4	3913.8	5260.7	15600.9	42615.6	68

Table 5 – Results of Survey of Irrigated Areas Served by the Associated Canals in 1934 + 1935. Made for the State Engineer by the Utah Agricultural Experiment Station.

Per Cent of Total Area

Crop	Utah + Salt Lake Canal ①	②	South Jordan Canal ①	②	North Jordan Canal ①	②	East Jordan Canal ①	②	Jordan + Salt Lake City & All Exchange		Total for Associated Canals	
	% of Area	% of Area	% of Area	% of Area	% of Area	% of Area	% of Area	% of Area	% of Area ①	% of Area ②	% of Area ①	% of Area ②
Alfalfa	32	34	32	33	30	32	35	37	26	33	30	34
Corn	1	2	4	4	5	5	5	5	4	5	4	4
Grain	47	49	41	42	25	26	35	37	16	21	31	35
Beets	3	4	7	8	14	15	11	11	4	5	6	7
Potatoes	1	1	3	4	3	3	2	3	3	4	3	3
Orchard	4	4	3	3	1	1	2	2	5	7	4	4
Gardens	3	3	2	2	5	6	2	2	13	16	6	7
Pasture	3	3	4	4	12	12	3	3	7	9	5	6
Buildings + Yards	6		4		5		5		22		11	
Total	100	100	100	100	100	100	100	100	100	100	100	100
General Grouping of Areas Receiving Water.												
Forage, Alfalfa, + Pasture	35		36		42		38		33		35	
Grain	47		41		25		35		16		31	
Root Crops	4		10		17		13		7		9	
Buildings + Yards	6		4		5		5		22		11	
Miscellaneous	8		9		11		9		22		14	

Note:

① = Per Cent based on inclusion of Buildings + Yards Area.

② = " " " " exclusion of " " "

on the north. If such areas are actually virgin pasture they are not a part of the service area of these canals, if they receive irrigation they belong with the irrigated pastures. There is no harm in their inclusion in the survey as long as they are understood; their inclusion gives an apparent per cent of area irrigated that is lower than the actual. Including the virgin pasture gives 74% of the surveyed area as receiving service; excluding the virgin pasture the per centage irrigated becomes 86%.

Four of the Associated Canals show fairly small variations in the proportion of the crops. The City Canal has a much larger percentage of buildings and yards and miscellaneous crops than the other systems. This is natural as the exchange areas include lands in Salt Lake City where much of the area is in yards and gardens. This in turn reduces the percentage of other crops. Grain is a relatively smaller area under the North Jordan Canal and root crops larger in these years as this canal had less shortage in water supply.

SURVEYS UNDER SELECTED LATERALS, 1938-39

Measurements of the use of water under selected laterals were made in 1938 and 1939. The areas irrigated were carefully surveyed and the crop acreages determined. These laterals were selected to be representative of the soils and crops of the area as a whole. The total irrigated was about 3400 acres under the 8 laterals covered, the gross area was somewhat larger. These 8 laterals were distributed equally with 2 each under the 4 Associated Canals other than Salt

Table 6 - Crop Distribution under Laterals

1938 Crops except Rupp Lateral = 1939

Acreage of Crops under Measured Laterals

Crop	Utah & Salt Lake Canal		South Jordan Canal		North Jordan Canal		East Jordan Canal		Total	Per Cent of Total
	Bluff-dale Lateral	Winder Lateral	Harker Lateral	Drake Lateral	Redwood Lateral	Rupp Lateral	Sandy Lateral	Atwood Lateral		
Alfalfa	92.2	105.5	231.3	76.0	267.8	93.0	113.8	150.1	1129.7	33.0
Sugar beets	11.3	23.0	105.2	37.0	151.8	46.0	34.6	57.7	466.6	13.6
Corn	1.9	2.6	7.7	5.4	3.5	8.7	2.4	1.6	33.8	1.0
Gardens	8.9	2.1	9.8	0.9	5.3	3.4	2.5	2.4	35.3	1.0
Grain	62.0	147.0	235.0	131.2	162.1	125.0	139.1	137.6	1139.0	33.3
Orchards	4.9	15.5	7.3	3.1	4.2	2.0	0	14.7	51.7	1.5
Pasture	5.9	6.8	7.7	12.2	122.5	40.9	41.1	34.0	271.1	7.9
Potatoes	7.8	0	7.1	1.0	4.8		8.2	0.7	28.9	0.8
Tomatoes			2.4				3.0		5.4	0.2
Celery					24.1				24.1	0.7
Lots	18.6	12.0	22.8	18.0	114.3	16.7	26.5	11.9	240.8	7.0
Total	213.4	314.6	636.2	284.6	860.3	335.6	371.2	410.6	3426.5	100.0
Forage	98.1	112.2	239.0	88.2	390.3	133.9	154.9	184.2	1400.8	40.9
Grain	62.0	147.0	235.0	131.2	162.1	125.0	139.1	137.6	1139.0	33.2
Root Crops	19.0	23.0	112.3	38.0	156.6	46.0	42.8	58.3	496.0	14.5
Miscellaneous	15.7	20.3	27.1	9.3	37.0	14.0	7.9	18.7	150.6	4.4
Lots	18.6	12.0	22.8	18.0	114.3	16.7	26.5	11.9	240.8	7.0
Per Cent of Total										
Forage	46.0	35.7	37.6	31.0	45.4	39.9	41.7	44.8		40.3
Grain	29.0	46.7	37.0	46.1	18.8	37.2	37.5	33.5		35.7
Root Crops	8.9	7.3	17.6	13.3	18.2	13.7	11.6	14.2		13.1
Miscellaneous	7.4	6.5	4.2	3.3	4.3	4.2	2.1	4.6		4.6
Lots	8.7	3.8	3.6	6.3	13.3	5.0	7.1	2.9		6.3

Lake City. Similar measurements under the City system were made by the City Engineer; the results have not as yet been made available to the author.

The results under these eight laterals are shown in Table 6. They show generally similar proportions of the different crops. The percentage of grain is still relatively high. Some increase in alfalfa and beets since 1935 is shown. The high percentage of grain is due in part to further alfalfa seedings growing a nurse crop of grain in these years.

SUMMARY

These various records may be assembled for comparison and a conclusion reached regarding the normal crop distribution on which the water requirements should be based. This is done in Table 7.

TABLE 7

Distribution of Crops under Associated Canals.

Crop	In Per Cent of Total Area Irrigated				
	Estimate based on 1929 Census	State Engineer's Survey 1934	Survey of Laterals 1938-39	Estimated Normal Crop Distribution Four Out-side Canals	City Ex-change Areas
Forage	57	35	40.9	50	34
Grain	24	31	33.2	20	15
Root Crops	9	9	14.5	15	8
Corn	2	4	1.0	2	4
Orchard	4	4	1.5	1	4
Gardens	4	6	1.9	5	13
Lots		11	7.0	5	22

In the estimated normal crop distribution shown in Table 7 the areas served by Salt Lake City have been listed separately from those under the other four Associated Canals due to the differences in the conditions under the City system. No such distribution will represent the actual crops grown in any year exactly but the results shown do represent a sound basis to use for average conditions in considering the resulting water requirements of these areas. Differences in the area in various crops affect the resulting water requirement only insofar as the water requirements for each crop differs. As discussed later the differences in the water requirements of these crops are not large so that the estimated distribution of the area between different crops could be varied materially without resulting in a large change in the total water requirements.

RELATIVE WATER REQUIREMENTS OF DIFFERENT CROPS

In applying the estimated division of crops on which it is considered the determination of water requirements should be based it is necessary to determine the relative requirements of each crop in order to derive a value for the average use. This is most readily done by estimating the use for other crops as a percentage of that for some crop of large area such as alfalfa. This gives the average use in terms of the use that would be required if the entire area was in alfalfa. This procedure does not include variations in the use required for alfalfa on different soils as the various crops are affected proportionally by such factors as soils, drainage, and topography. As alfalfa is the crop of largest water use, this method results in the average use always being less than that for the selected reference crop.

Comparisons of the relative use for different crops are available from several sources. These are discussed with the results considered applicable to these lands summarized at the end.

LOCAL EXPERIENCE

Mr. David I. Gardner has furnished the following report based on local experience. The first comments were prepared in Feb. 1940; the second portion reports the results of further inquiries during 1940.

"Using alfalfa as one hundred in working up the relative percentages of other crops my best judgment would be as follows:

a. Grain--60%. In a normal year on sandy loam irrigation begins about June 1. Three irrigations are usually sufficient, and the last irrigation is applied about July 8 to July 15.

b. Grain as nurse for alfalfa--100%. The usual practice in this case is to apply sufficient water to mature the grain and after the grain is hauled begin irrigation of the young alfalfa, and continue to irrigate it much the same as if it were the mature plant. In plowing the land and working it up for a seed bed, it usually requires heavier first turn irrigation due to the loose nature of the soil. This loose soil requires smaller streams to prevent washing, so that the absorption for the first turn is usually greater than is the case in old alfalfa ground.

c. Sugar Beets--110%. Normally sugar beets do not require irrigation until about June 15, however it frequently happens that it is necessary to irrigate the land prior to planting which would be in the latter part of April, or immediately after planting in order to germinate the seed. In either of the above cases one extra irrigation is required. It is the usual practice to irrigate beets immediately before digging, this latter irrigation being necessary to soften the ground for digging and add weight or water content to the crop.

Beginning in 1937, the Board of Canal Presidents and other agencies conducted an investigation in Salt Lake Valley relative to the water use on the different types of soil with different crops. An extensive investigation was made in 1937 by the Board of Canal Presidents, and in 1938 the East Jordan Irrigation Company also conducted their own investigation along similar lines. The results of these two investigations vary widely, but in general they are good criterion of the relative use by different crops. Throughout the season of 1939-40 several farmers in Salt Lake Valley were contacted in an effort to determine what they considered the relative use by the different crops. Using alfalfa as a base 100, the following table shows some of the representative results of this investigation:

	East Jordan Irrig. Co.	Report by Harmon Day	Report by Vern Morgan	Report by Roy Cook
Alfalfa	100	100	100	100
Beets	120	110	140	125
Grain	76	80	80	75
Grain as Nurse for Alfalfa		100	100	100

	Report by Fred Nielsen	Reported Average
Alfalfa	100	100
Beets	110	121
Grain	80	78
Grain as Nurse for Alfalfa	100	100

The average estimate by those quoted gives higher relative use on beets and grain than Mr. Gardner's own estimate. The larger use on beets tends to balance the smaller use on grain grown alone so that the average use for the entire area will be represented fairly closely bythe use for alfalfa.

EXPERIMENTS IN CACHE VALLEY

The Utah Agricultural Experiment Station has conducted a great many experiments on the use of water on their experiment farm at Logan. A deep retentive soil was used. The conditions of these observations were as nearly uniform as it is practicable to secure in such work. Small flat areas were used, the work extended over many years and all items were closely controlled and measured. The results should be representative of the relative needs of these crops for the conditions of this work.

The actual results of these experiments are not applicable to the water requirements under the conditions facing the owners under the Associated Canals. The experiments were under controlled conditions on small areas where water can be distributed more evenly and economically than on commercial areas. Time and labor in applying water and other cost items are not controlling in such research work. Climatic conditions at Logan are favorable to the use of less irrigation as the rainfall is larger and occurs so as to meet a larger part of the crop needs particularly for early maturing crops such as grain.

Comparisons may be made from several of the publications of the Experiment Station. Many results are summarized in their Bulletin 173, by F. S. Harris, published in 1920. This includes diagrams showing the relationship of the yield and water used for different crops. The amounts of water used for maximum yields of these crops are as follows.

	acre inches per acre	per cent of use for alfalfa
Alfalfa	50	100
Potatoes	36	72
Sugar Beets	32	64
Corn	25	50
Wheat	36	72
Oats	28	56

Further results of 28 years experiments are discussed in Bulletin 219 published in 1930. These are not presented in a form which permits as ready comparison between the crops as does Bulletin 173. The conclusions state that there was little increase in yield of sugar beets, potatoes, alfalfa, corn, or small grains with irrigations of over 20 or 25 acre inches per acre per season and that more than 30 acre inches usually reduced the yields of all crops except alfalfa which continued to return increased yields up to 60 or more inches of applied water. These two conclusions are not self-consistent. From the first all crops, including alfalfa, would appear to need 20 to 25 inches depth of irrigation; from the second for maximum yield alfalfa appears to need about twice as much water as other crops.

RESULTS IN SEVIER VALLEY

In Bulletin 182 entitled "The Net Duty of Water in Sevier Valley" bu Israelsen and Winsor, published in 1922, the results of seven years work are reported. The experiments were made on plats of generally less than 1 acre in area. Surface run-off from the plats was not included in the amount of use reported. The conclusions state that the results suggest that 27 to 33 inches depth of water applied in 4 or 5 irrigations will insure economical returns for sugar beets on the soil used. Similar figures for potatoes were 21 to 27 inches and for alfalfa 30 to 36 inches. The soils used were gravelly sandy loam and fine sandy loam. While larger amounts of use would be needed for farm conditions, these results indicate that for these experiments sugar beets needed about 90% and potatoes about 70% as much water as alfalfa.

RESULTS OF LOCAL MEASUREMTNS IN 1927

The water used on 16 fields was measured in 1937 in the investigations by the Board of Canal Presidents. These included different crops and soils. While the number of observations on each crop were not sufficient to establish general average relationships, these results furnish some comparisons that assist in determining the relative use by different crops.

The fields used included alfalfa owned by Andrew Sjoblom and sugar beets owned by Harmon Day. These were adjacent areas of similar soil, had the same length of run and similar slopes. The use on the alfalfa was 3.60 acre feet per acre and on the beets 3.54 acre feet per acre. The alfalfa received its first irrigation May 13 and its last Sept. 22. The beets received 6 irrigations, the first on June 23 and the last on Sept. 29. The alfalfa received 12 separate deliveries of water but it was not all irrigated at each delivery. The beets used less water prior to August than the alfalfa and more in August and September. This comparison shows little difference in the total amount of water used with some difference in the time at which it is needed. Both fields were well handled.

The smallest amount of water used was on an area of wheat having a fairly high water table. This field, owned by Walter Mabey, received four irrigations between May 16 and July 18 and used 2.13 acre feet per acre. There was some sweet clover in parts of this field in the grain but it was irrigated as a grain crop only. On the Hill field wheat was grown on drained land with a use of 2.78 acre feet per acre. This received six irrigations from May 26 to Sept. 21; three of these were applied before harvesting the grain and three afterward for the alfalfa seeding which had been planted with the grain. Grain on a light and shallow soil over tufa on the Ridd place used 3.29 acre feet per acre for nine irrigations from May 15 to Sept. 6, the last two coming after harvest for fall plowing. On the Nelson and Godfrey tracts both alfalfa and grain as a nurse crop for new seeding were grown.

While the water used on these two crops was not separately measured, there was no essential difference in the frequency of irrigation or the amounts applied.

Sugar beets were also grown on the Mackay tract. The first irrigation was on May 29 and the last on Oct. 5. There were 15 deliveries of water to this field but it was not all irrigated at each delivery; an equivalent of nine full irrigations was used with a total delivery of 2.87 acre feet per acre.

REQUIREMENTS FOR EACH CROP

Local practice in the irrigation of different crops supports the following conclusions.

ALFALFA

This crop has the longest season and largest use of any of the crops grown extensively here. Irrigation may begin in late April and continue well into September. The amounts and freqmency of each irrigation vary with the soil conditions. The local soils generally have textures which result in shorter periods between irrigations than is usual in many other areas. As a consequence the amount of water used tends to be larger than that in such other areas.

GRAIN

Grain as grown in this area falls into two classes; grain grown alone and grain grown as a nurse crop. The grain area may be about equally divided between the two types for the amount grown under conditions of normal water supply. In years of water shortage both the total area of grain and the percentage of grain alone increase.

Grain grown alone requires somewhat fewer irrigations than when grown as a nurse crop for alfalfa seeding. The use of water is not materially different up to the time of grain harvest. After harvest the seeding requires additional irrigations. It is usual also to give at least one heavy Fall irrigation on grain stubble land as a preparation for plowing so that the difference in use is not as large as would be expected.

All grain starts its irrigation season later than alfalfa. Irrigating up is not required to an extent that it is a part of local practice. Grain irrigation is not usually needed until after May 15. Then use on the growing grain will be at about the same rate as alfalfa for the rest of May, June, and nearly through July. For grain alone use ends before harvest with the irrigation for plowing about equal to a month's use on alfalfa. For alfalfa seeding, use after harvesting the grain will be nearly as large as on old alfalfa stands as more frequent applications are needed for the more shallow rooted new stand.

Grain alone should use less water than alfalfa for the same soil conditions by the amount of the alfalfa use prior to May 15 plus the alfalfa use for about 30 days over August 1. Alfalfa uses about 5% of its seasonal use prior to May 15th and about 25% in the period between grain harvest and irrigation for fall plowing. This results in grain alone needing about 70% as much irrigation as alfalfa. Grain as a nurse crop for alfalfa seeding would need less early irrigation with a somewhat longer period between irrigations at harvest time than old alfalfa giving a seasonal use of about 90% of that for old alfalfa. For ½ of the grain as seeding this gives an average use for grain of about 85% of that for alfalfa. With a normal total percentage of grain of 20% of the irrigated area and 50% for old alfalfa this represents an average life of stand of five years. The use of 20% of the irrigated area in grain with an average requirement of 85% that of alfalfa is equivalent to a reduction in the average requirement of the whole area of 3 per cent below the requirement for the whole area in alfalfa.

SUGAR BEETS

Sugar beets do not require irrigation until about a month after the irrigation season for alfalfa has started. Use is at about similar rates for these two crops through the summer months, the beets generally being given irrigations somewhat more frequently with a somewhat smaller average depth per irrigation. Toward fall use on beets exceeds that on alfalfa. Sugar beets in years of low fall rainfall are the last crop to be irrigated, an irrigation being given to enable the beets to be plowed out.

For similar soil conditions, sugar beets will generally need as much water as old alfalfa. Individual areas will vary. As the beets are the main cash crop on many farms they are frequently given first preference in irrigation and may receive more irrigation than alfalfa. It is noticeable that all expressions of opinion secured from local irrigators by Mr. Gardner list beets as requiring more water than alfalfa. As the water used is not measured, such expressions may reflect the irrigators' views on the frequency of irrigation rather than records of the amount of water used. The average depth applied per irrigation on beets is generally less than that used on alfalfa and the relative use reported may be larger than the usual practice. In other areas beets do not generally receive as much water as old alfalfa.

For local conditions and practice it is concluded that sugar beets have a water requirement sufficiently similar to that for old alfalfa so that no difference needs to be made between the use on these two crops. For the limited percentage of area in beets it is not necessary to make any allowance for any difference in use here. Such differences would not exceed 10 or 20 per cent increase in use for beets. This will tend to balance the less use on grain so that areas containing alfalfa, grain and beets can be considered to have the same use of water that they would have if the entire area was in alfalfa.

POTATOES

The water requirements of potatoes are sufficiently similar to those for sugar beets that they have been grouped in the general class of root crops. The area in potatoes here is also so small relative to that in beets that no separate consideration is needed. Potatoes do not require early irrigation and the last irrigation in the fall is usually earlier than for beets. During the season frequent light irrigations are usual. The large furrows resulting from the rowing out of the crop enable light irrigations to be applied effectively.

CORN

Corn has a total water requirement similar to that for other grain but requires water later in the season. The water used on corn will usually be about 80% of that for old alfalfa under similar soil conditions. The area in corn is relatively small and recognition of its difference in requirement is not important.

ORCHARDS

Orchards do not rate as a commercial crop in the areas served by the Associated Canals. There are many home orchards of small area. These were some larger orchards, mainly of apples, but many of these were pulled during and following the recent dry years. Where cover crops are maintained in the orchards the use of water is similar to that for alfalfa. For the small area of orchards under these canals no separate consideration of their water requirements is needed.

GARDENS

This classification includes the home gardens and the areas raising truck crops commercially. It is a small proportion of the total area irrigated except under the City system where commercial truck raising for the Salt Lake City market is important.

Home gardens require frequent irrigation. The different crops grown are not usually rotated as systematically on home gardens as in commercial practice so that the land may not be as fully used for the entire season. Commercial truck growing is usually based on intensive cultivation with crops grown continuously during the season, a new crop following the harvesting of each vegetable as it matures. Such intensive use of the land is maintained by a heavy fertilization program.

For home gardens, use may be somewhat less than for alfalfa. For commercial truck crops the seasonal use will be about the same or slightly larger than for alfalfa. For a general average, use for gardens and truck can be considered to be equal to that on old alfalfa under similar soil conditions. Only the better grades of soil are used for commercial truck crops.

BUILDINGS AND YARDS

This classification is much more important in this area than is usual. This is the result of the small average size of farms and the inclusion under the City system of much urban and suburban development. Even on the west side there are many acre or less holdings where the lot area is used for gardens or lawns, the owners securing their livelihood by outside employment.

Water from the irrigation systems is generally used on these areas. Stock in the irrigation companies is maintained by their owners and water deliveries taken on turn similarly to the larger areas. The water received is used for some stock watering, for irrigation of trees, gardens, and lawns. While much of this use is for ornamental rather than agricultural purposes, it represents a beneficial and a legitimate appropriation of water.

There are no records of use on such areas. Relatively frequent irrigations are usual. Lawns will use water at a similar rate to pasture or alfalfa. There is not much bare area in these holdings; driveways, actual building sites, etc., are small in individual sizes.

The average amount of water delivered to such buildings and yard area is probably about 80% of the average delivery to alfalfa.

AVERAGE REQUIREMENTS

The discussion of the water requirements of different crops in relation to the use for alfalfa with the estimated proportion of the area in each crop can be combined to give the average use in comparison with the use for alfalfa. This is done in Table 8.

TABLE 8 -- ESTIMATED RELATIVE USE OF WATER BY DIFFERENT CROPS

	Four Outside Canals			City Exchange Area		
Crop	% of Area in Each Crop	Use in % of Use on Alfalfa	% of Use for Whole Area in Alfalfa	% of Area in Each Crop	Use in % of Use on Alfalfa	% of Use for Whole Area in Alfalfa
Alfalfa	50	100	50	34	100	34
Grain	20	85	17	15	85	12.75
Root Crops	15	110	16.5	8	110	8.8
Corn	2	80	1.5	4	80	3.2
Orchard	1	100	1	4	100	4.0
Gardens	5	100	5	13	100	13.0
Lots	5	80	4	22	80	17.6
Total	100		95	100		93.35

These comparisons indicate that the diversity of crops found in this area results in a reduction of the average water requirement less than 10% below the requirement if all the land was in alfalfa. While the details of the basis used for each crop may be varied in accordance with individual judgments, the net results, within the limits of such variation, will still indicate an average use of over 90% of that for alfalfa. This in turn means that if the water requirements of the different soils are estimated on the basis of the use for alfalfa the conclusions reached will not need to be reduced by more than about 5% to give the average use for the average crop conditions found here. The amount of this reduction is so small that it has been made only in giving general weight to these conditions without applying a specific reduction in the estimated water requirements.

EFFECT OF DEPTH TO GROUND WATER ON THE AMOUNT OF IRRIGATION

Mr. David I. Gardner has prepared the following comments on the Ground Water Effect.

"There are several areas in Salt Lake Valley where the ground water table is within one to three feet of the surface. The owners of this type of soil are faced with two serious problems. The first is the encroachment of alkali to such an extent as to be detrimental to crops; the other is the water-logging of the land itself. Practically all the land in the valley where the ground water situation is acute has been drained. The slope of the valley is conducive to good drainage. The general irrigation practice on lands tending toward alkalinity is to apply sufficient surface water to permit deep percolation. In this way the percolating water will carry much of the alkali to the drain, and thus prevent its reaching the surface to the detriment of crops.

"As to the effect of high ground water; one would be led to the assumption that a high ground water table would reduce the irrigation requirements and as a usual practice I believe it does, for example the Mabey tract required only about 1 acre ft. per acre to produce the crop of grain. The general practice on alkali land especially around Taylorsville and lower lands under the South Jordan Canal is to apply heavy irrigations to all crops, on adequately drained grounds, for the sole purpose of keeping the alkalinity of the soil to a minimum. Farmers in the Taylorville area report that if this practice were not followed, capillary action would bring salts into the root zones in such quantities as to render the land barren. Dr. O.W. Israelson in his conclusions in a paper given before the Am. Soc. of Agri. Eng., Volume 20, No. 11, says, 'By decreasing the water application efficiency for a period of a few years and thus causing deep percolation losses in artificially drained Class 3 soil, irrigators may contribute to the conservation of these soils and thus justify water losses.'"

The effect of the ground water on irrigation is not uniform nor is it always in the direction of a reduction in the amount of water used. Where the ground water is deep, irrigation usually results in deep percolation and a gradual ground water rise. The depth to ground water has little effect on irrigation until the water table has risen within 6 to 8 feet of the ground surface. For lands not artificially drained a further rise in the watertable tends to reduce the amount of surface irrigation. A ground water rise to 3 or 4 feet depth begins to restrict the types of crops that can be grown and to reduce the amount of irrigation needed. Further rise to 18 to 24 inches limits crops to pasturage.

The quality of water and the alkali content of the soil also are factors. A water table above about 5 feet depth results in an increase in soil moisture evaporation with an alkali accumulation in the surface soil if there is much alkali in the soil or water. This further restricts the crops that can be grown.

Drainage of high water table lands results in increased use of water due to the increased crop demands and the ability of the drains to remove excess water. Lands containing alkali need heavy irrigations to remove the alkali by leaching through the drainage system. If the irrigation water is akaline some excess must continue to be used to prevent alkali accumulation in the soil.

In the areas served by the Associated Canals much of the irrigated area has had or still has ground water within 6 feet of the ground surface. Some lands have been injured by the rise of the ground water. Much land has been drained with generally successful results. There is much high water table and alkali land in this area but little of it occurs under these canals. Such lands lie in the lower areas near Salt Lake or along Jordan River and extend into this irrigated area only to a limited extent.

No detail surveys are available showing the depth to the ground water. The Soil Survey segregates soils which it considered to be poorly drained, distinguishing them by adding D to the Soil Number. This means ground water within the 6 foot profile, generally within 4 feet.

With a water table at 4 feet less frequent irrigations are usually required and each irrigation may be of lighter amount on good land with good water. The crops can secure part of their water needs by capillary rise from below. In general such conditions may result in a reduction in the amount of irrigation of 20 to 25 per cent.

As discussed elsewhere the quality of Utah Lake water is such that some leaching is required to prevent alkali accumulations. Where the water table has risen to within 4 or 5 feet of the surface, drainage has usually been installed. This drainage permits the removal of some soil water and can prevent alkali increase. Some excess use is essential under such conditions.

Except for some low-lying lands, the amount of water used under the Associated Canals is not reduced by the height of the water table. On the soils marked "D" on the soil map, sufficient water needs to be used to maintain a favorable alkali balance. This results in the percolation loss required equaling the water obtained by the crops by sub-irrigation. On any such lands which have been drained this practice should be followed. This is recognized by the irrigators and is practiced as indicated in Mr. Gardner's comments. No changes have been made in the estimates of the water requirements of these canals for lands having water tables at 3 to 6 feet. In areas using water of better quality some reduction in irrigation could be made on such lands.

Further adjustment in use are needed for the lower lying lands having a water table within less than 3 feet of the surface. Some irrigation may be needed on such lands but the amount is not as large as for deeper ground water. Crop returns are also reduced on such lands. While less water may be needed in their present condition, these lands may require larger amounts of water in the future if they should be successfully drained. Examples of such lands occur under the Redwood Lateral of the North Jordan Canal. The measured use by this canal in 1938 was about $\frac{3}{4}$ of the amount that would have been expected for the same area if it had been fully drained. About one-half of this area had ground water sufficiently close to the ground to reduce the amount of surface irrigation below that for ground water at 3 feet depth. These lands having ground water at an average depth of 2 feet probably had a water requirement of about 2/3 of that of the same soils with ground water below 6 feet.

The areas of such undrained land with water tables within 3 feet are limited although no definite survey of their extent is available. The present condition of these lands may be improved by drainage although some of these lands have such heavy soils that drainage may be difficult. While their present use may be reduced by their present ground water conditions it is considered that these lands are entitled to a water supply adequate for their use when drained. Their water right should not be reduced because of their present ground water condition.

In the estimates of the water requirements of the lands served by the Associated Canals no reduction has been made because of the elevation of the ground water. For all except the low-lying lands with ground water within 3 feet, actual use is not reduced because of the height of the ground water; lands having ground water within 3 feet of the surface may be drained and then require a full irrigation supply.

QUALITY OF THE IRRIGATION SUPPLY

The quality of irrigation water may affect the amount of water used. While most irrigation waters are of sufficiently good quality so that their chemical content can be disregarded, some waters contain sufficient alkali that their continued use may prove harmful to the crop and soil.

As Utah Lake discharges in all years there is little tendency toward concentration of its waters by evaporation. While a considerable proportion of the inflow is evaporated the outflow does not become concentrated by evaporation sufficiently to make its use undesirable.

The inflow to Utah Lake comes mainly from the larger streams during their high water stages. Analyses of the waters of these streams made by the Experiment Station of the Utah Agricultural College in 1916 and published in Bulletin 163 show their quality to be very good.

The outflow from Utah Lake contains more alkalis of various forms than the inflowing surface streams. The analyses in Bulletin 163 are limited to waters in the surface streams. Drainage inflow is not included. The present inflow includes the Provo sewer and the water used in the mills of the Columbia Steel Co. There are also many drains which discharge varying amounts into the Lake. All of these used and drain waters would be expected to have higher alkali contents than the surface streams although no systematic analyses of such waters have been made.

The springs arising in Utah Lake do not have a large discharge but their quality differs somewhat in some cases from that of the average lake water. Some analyses of such springs are available.

The bed of Utah Lake is composed of fine clay. The depth varies from shallow margins to a maximum of about 15 feet. The Lake is exposed to wind action so that thorough stirring takes place to the full depth. This results in the whitish color of the Lake water, the clays taken into suspension being so fine that they remain in suspension with little deposition until the water reaches the irrigated lands.

While the Utah Lake water does not contain sufficient alkali to make its use detrimental to the lands on which it is used, its quality makes it advisable to use it more liberally on lands containing alkali in order to prevent further alkali accumulations. Fairly strong alkali waters may be used successfully if drainage conditions permit some of the water applied to pass through the soil and sufficient water is used to result in enough drainage to carry off at least as much alkali as the incoming water brings to the land. If the drainage water has an alkali concentration 5 times as great as the irrigation water then the irrigation should be applied so that at least 1/5 of the water used drains from the land. On the drained lands under the Associated Canals it is recognized that irrigation should be applied so as to result in discharge from the drains. When drained such lands are given larger amounts of irrigation than would be used otherwise. That these problems can be and have been met is indicated by the present productivity of these lands after having been under irrigation for over 60 years.

The effect of the quality of Utah Lake water was recognized in Bulletin 163 which contains the following statements.

"There is a marked difference in the composition of Utah Lake and the waters flowing into it. The waters entering are low in salts and from 70 to 98% of the total salt carried by the stream is in the form of bicarbonates of calcium and magnesium, and in the Lake only 30% of the total salt is bicarbonate. Both waters contain large quantities of sulphates and chlorides, the Jordan River being slightly higher in both constituents than is the water in the Lake. The monthly variation in the composition of the waters is great. During June, 1916, the water contained 880 parts per million of total salts, and in September of the same year it contained 951.0 parts per million. Both of these waters would carry large quantities of injurious salts to the soil as may be seen from Table XI."

"It is evident from these figures that the application of one-acre-foot of these waters to the soil carries with it over three-fourths of a ton of injurious 'alkalies.' When we remember that many farmers use even three or four times this quantity of water on their soils yearly we readily recognize that the quantity of saline constituents carried to the soil is going to make itself felt in ruined soil sooner or later. Where the soil is light and fairly free from soluble salts with a good under-drainage, the water may be used without severe injury for a considerable or even indefinite time if judiciously used. But when the soil is tight with poor underdrainage or already heavily charged with saline material, the use of the water presents more serious problems. Moreover, it is quite possible that the salts reaching the soil with an acre-foot of these waters in the future will increase and not decrease."

The results of the analyses of the waters of Utah Lake and its tributares have been presented in a separate report. In addition to the results of all of the earlier analyses which were found, samples of inflow streams, springs in the Lake and the outflow were secured during these investigations. Present analyses show a more strongly alkaline water now than in the samples taken in earlier years. In addition to an increase in total salt content, changes have occurred in the character of the alkali, represented particularly by an increase in the sodium content.

The best basis for a conclusion regarding the suitablity of the waters from Utah Lake for irrigation is the actual results of its use. This water meets all the requirements of this test from the past results. The west side lands receive no other irrigation water; these areas have been irrigated for over 60 years and are still highly productive. Some areas which became water logged became alkaline until drainage was provided. There are many examples of successfully reclained lands here where drainage has been provided.

While the present quality of these waters is not as good as some earlier samples indicate it has been it is still fully usable. The increase in salt content and the change in its character emphasize the comments in Bulletin 163. These waters should be used liberally enough to be sure to maintain a downward and outward moisture movement so that at least as much alkali is removed as is added in the irrigation water. This is readily accomplised where there is natural or artificial drainage and where the lands are irrigated so that some percolation occurs.

The quality of the water of Utah Lake and Jordan River justifys a claim for larger amounts of irrigation use than would be needed if better water was available and used. Some percolation will occur on practically all of the soils irrigated here even with careful irrigation practice. For the use of the available water here from 0.5 to 1.0 acre feet per acre per season larger use of irrigation water is advisable than would be needed where better water is used. The maintenance of their productivity in the future is just as essential to these lands and as much a part of their present beneficial use as the production of good present crops.

SURFACE WASTE

An item in the amount of water needed by lands is the surface waste that may escape from the areas irrigated. It is recognized that while careful use of water will reduce the amount of such waste, all waste cannot be prevented.

A large part of the lands served by the Associated Canals has fairly steep slopes. This makes it more difficult to avoid surface waste particularly on the heavier soils.

Records of the amount of surface waste in this area are limited. Observations were made in 1937 on the fields of the special investigations; the general amounts of such waste was very small. Surface waste from one field or farm is frequently used on lower lands.

General observations show that the local practice in controlling surface waste fully meets usual standards of practice. Water will occasionally escape from farms and reach roads or other outlets. Such waste is always noticed and the impression created frequently exaggerates its amount.

Some drainage occurs from the areas served by the Associated Canals. Such drainage includes water removed by subsurface drainage, both natural and artificial, as well as any surface waste that is not reused. This occurs particularly on the east side of the valley where much natural drainage collects in the lower local stream channels.

It is considered that local practice in controlling surface waste meets required standards; that the amount of such waste leaving the irrigated areas is not excessive under usual local practice; that the standards used in this report in estimating the water requirements of these areas include any surface waste that may occur with reasonable care in handling water; that with such rates of use future surface waste will not be excessive.

WATER REQUIREMENTS BASED ON SOILS

The water requirements of any area vary with the soil texture. This has been recognized in many water right determinations. Allowance for such variations requires a classification of the soils irrigated, estimates of the water requirements of each soil. The total requirement can then be based on the area and rate of use of each soil.

Soils may vary widely within small areas. A large number of variations in soil texture usually occur in any large area. In working out the water requirements based on a soil classification it is essential for practical purposes to group soils having similar water requirements. The usual soil survey as practised by the U. S. Dept. Agric. segregates soils on the basis of their origin as well as their texture. Differences in origin are not important in relation to water requirements and soils of different origin but similar texture can be combined.

The unpublished soil survey of this area has been made available for use in this work. The field sheets recognize 66 soil types. Many of these are further divided into phases so that a total of 400 separate segregations are included in the table of textual descriptions.

These are grouped in the soil survey into 27 series. The separate phases recognized have areas varying from 4 to 11,777 acres with two segregations of wet and of rough land including over 20,000 acres. It is probable that this number of segregations will be reduced in the final published Soil Survey of this area.

The area covered by the soil survey is much larger than that served by the Associated Canals. The larger number of the agricultural soils segregated by the soil survey are found within the Canal served area, however.

For the soil numbers shown on the soil map, the Utah

Agric. Exp. Station has also furnished a soil description consisting of the soil profile to a depth of 6 feet. These were examined and soils having similar texture grouped into classes having different amounts of estimated water requirements. The groups used were those having water requirements of 3.0, 3.5, 4.0, 4.5, 5.0, and 6.0 acre feet per acre. These rates of use represent the writer's conclusions on the reasonable water requirements for these soil groups based on the results of the local records secured in these investigations, past records of canal use and his general experience in similar work in other areas. The soil profiles of the soil survey were compared with the writer's own field observations of the same soils. Only those soils found within the areas served by the Associated Canals were included in these groups.

The general segregation of soils into the groups having the different rates of estimated reasonable use are shown in Table 9. This table does not show the areas of each soil and consequently does not indicate its relative importance. Some of the soils listed are shown on the soil map for only small areas and are not important. The soil numbers used are those of the advance maps and descriptions furnished by the Utah Agricultural Experiment Station and are subject to revision in numbers and names. The same physical descriptions will remain, however.

Profiles of typical soils in the different water requirement groups are shown in Figs. 1 and 2. These are generally the soils in each group representing larger areas under the Associated Canals.

TABLE 9: SOILS HAVING DIFFERENT AMOUNTS OF ESTIMATED REASONABLE WATER REQUIREMENTS.

Soil Numbers used are those shown on advance field sheets of the Soil Survey.

Soils having a Reasonable Water Requirement of Acre-feet per Acre

3.0	3.5	4.0	4.5	5.0	6.0
5, 5D	36, 36D	6L	33	7	2, 2L
5t	36R	12, 12D	34	9	2C, 2G
6, 6D	38, 38D	14, 14D	350D	11	4, 4C
14h	38h	16, 16D	43h	17, 17D	7G
15	41	20, 20D	44D	18	8
29, 29D	46h	23	46, 46L	20G	10
30, 30D	49	26, 26D	54, 54D	21	13
39	56h	31, 31D	55	24, 24D	17G
41h		32D	56	24c&s	25
42h		35, 35D	56D	28, 28D	27, 27C
50h		42, 42D		43, 43D	37, 37E
		42E		45	37R
		48		47	40
		50, 50D		48G	42G
		51		54E	43G
		52			60
		53, 53D			
		57			
		58			

Fig. 1 - Profiles of Soils of Areas Irrigated by the Associated Canals. Taken from Descriptions of Soil Profiles of Soil Survey by U.S. Dept. Agric. and Utah Agric. Exp. Sta. Grouped in accordance with Water Requirements

Soils having a Water Requirement of 3.0 acre-feet per Acre

Depth ft.	No. 5	No. 6 or 6D	No. 29	Depth ft.
1	clay loam	silty clay loam	silty clay	1
2	light clay	silty clay loam or silty clay	silty clay loam loam	2
3	heavy	black clay	silty clay loam or clay	3
4	heavy	clay	joint clay	4
5	heavy	wet @ 36"		5
6	heavy		joint clay	6

Soils having a Water Requirement of 3.5 acre-feet per Acre

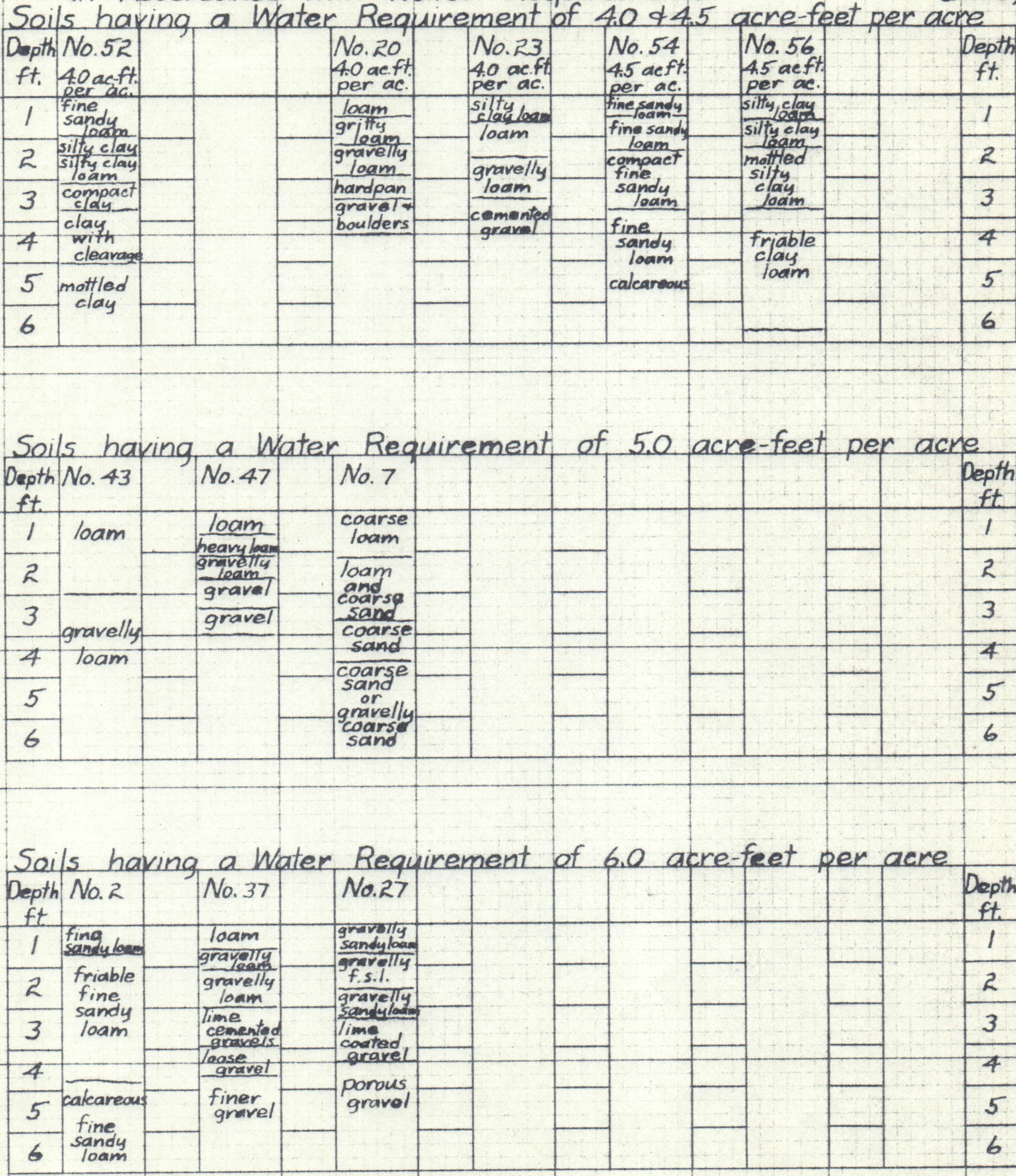
Depth ft.	No. 36	No. 41	No. 38	No. 49	Depth ft.
1	clay loam silty clay loam	loam	loam	silt loam clay loam clay	1
2	clay loam	loam to clay loam	loam to clay loam	white clay clay hdpn.	2
3		silty clay loam	compact loam to clay	sticky clay	3
4	varies silt loam to sandy loam	silty clay loam or clay	f.s.l. platy clay		4
5		wet fine sand to silty clay			5
6			heavy clay loam to clay		6

Soils having a Water Requirement of 4.0 acre-feet per Acre

Depth ft.	No. 14	No. 16	No. 31	No. 52	No. 26	No. 42	No. 50	Depth ft.
1	silty clay loam	friable loam	gritty loam	fine sandy loam	sandy loam	loam	silt loam	1
2	heavy silty clay loam	clay loam silty clay	loam or clay loam	silty clay silty clay loam	gritty loam	heavy loam loam	loam calcareous loam	2
3	compact silty clay	silty clay	clay loam platy clay	compact clay	loamy sand	f.s.l. or silty loam	friable loam	3
4	platy clay loam or clay	joint clay	clay	clay with cleavage	compact loam	very fine sandy loam		4
5	heavy silty clay loam or platy silty clay		joint clay with cleavage	mottled clay	stratified fine loam to sand			5
6		seamy clay				mottled	loam—a little gravel	6

TRADE STANDARD MARK
REG. U.S. PAT. OFF.
CROSS SECTION 10 X 10
100% RAG PAPER
MADE IN U.S.A.

Fig. 2 – Profiles of Soils of Areas Irrigated by the Associated Canals. Based on Descriptions of Soil Profiles of Soil Survey by U.S. Dept. of Agriculture & Utah Agric. Exp. Station. Grouped in Accordance with Water Requirements. (cont'd)



SOILS HAVING AN ESTIMATED REASONABLE WATER REQUIREMENT OF 3.0 ACRE FEET PER ACRE

These soils consist generally of a medium heavy to heavy surface so il underlain with a heavy subsoil. It includes the soils 5, 6, 14h, 15, 29, 30, 41h, 42h, and 50h of the Soil Survey. The letter h designates a heavier phase of the soil of the same number. Soil 29 occurs on the largest area of this group, the areas of the other soils are all relatively small. There are other soils having a heavy subsoil that are not included in this group due to the lighter texture of their surface soil.

Soil 29 is one of the soils in this area developed from old lake-laid deposits of fine texture. The top soil is calcareous and a layer of high lime concentration may occur at a depth of about 18 inches. The lower suboil is generally a blocky clay with both vertical and horizontal cleavage, locally called Joint clay. Soil 29 is described as a heavy silty clay loam or silty clay surface underlaid with the joint clay at about 36 inches. Soil 5 is a clay loam surface and heavy subsoil. Soil 6 is a silty clay loam or clay with a clay subsoil. Soils 5 and 6 are located on the poorly drained bottom lands along Jordan River and its tributaries. Soil 14h is a heavy phase of Soil 14; Soil 14 has been included in the 4.0 acre foot group of soils. Soil 15 is a gritty clay loam. Soil 30 is also a slity clay loam with an overwash of granitic surface material. Soil 42h is a heavy phase of Soil 42 which is a loam. Soil 50h is a heavy textured phase of Soil 50 which is a silt loam placed in the 4.5 acre feet group. Profiles of Soils 5, 6, and 29 are shown in Fig. 1.

This group of soils require the least water of any of those occurring in this area. Their heavy surface soil retards penetration but generally the surface is not too heavy to permit a good depth of irrigation to be applied. No fields in this group were included in the 1937 investigations and no direct records have been secured of the amount of water used. By comparison with other soils of lighter texture it is concluded that this group can be adequately irrigated with a use of 3 acre feet per acre per season.

SOILS HAVING AN ESTIMATED REASONABLE WATER REQUIREMENT OF 3.5 ACRE FEET PER ACRE

This group is intermediate between the soils in the 3.0 and 4.0 acre feet per acre groups. It represents a rather fine degree of distinction. Soils too coarse to belong in the 3.0 acre feet per acre group would usually be placed in the 4.0 group. There are a few soils described in the Soil Survey which fall properly in this group and it has been used. Their area is relatively small. The 3.5 acre feet per acre soils differ principally from the 3.0 group in having a lighter textured subsoil. The surface soils are medium to heavy with generally medium subsoils. It includes soils 36, 38, 41, and 49. Profiles of these four soils are shown in Fig. 1. These soils have been formed from the coarser marginal lake deposits. Soils 36 is described as a silty clay loam becoming silt loam to sandy loam below 3 feet. The heavier phases of Soils 46 and 56 are also placed in this group.

SOILS HAVING AN ESTIMATED REASONABLE WATER REQUIREMENT OF 4.0 ACRE FEET PER ACRE

This rate of use has been applied to four groups of soil that have similar water requirements. The soil differences in these groups balance in relation to their irrigation needs so that their seasonal use is equal. These groups are

1- Soils with medium surface soils and heavy subsoil of platy or joint clay.
2- Soils of generally medium texture.
3- Soils of medium texture underlaid with porous tufa or travertine.
4- Soils of medium texture underlaid with cemented gravel.

The largest areas of these groups falls in Number 1 as described above.

The first group of these soils includes soils 12, 14, 16, 31, 32, 35, and 52. Of these soils 14, 16 occur on the largest areas under the Associated Canals. Profiles of soils 14, 16, 31, and 52 are shown in Figs. 1 and 2. Several of the fields used in the 1937 investigations fall in this group. These include parts or all of the Jensen, Hill, Gardner, Neilson, and Lozos areas.

Soil 14 is developed from old lake bed deposits and has a joint clay subsoil; it is described as a silty clay loam of cloddy structure, the upper subsoil being a silty clay streaked with white carbonate and rather compact and platy.

The deeper subsoil has a hard platy stucture. Soil 16 has a friable granular loam surface underlaid with a heavier subsoil which becomes a jointed clay with more or less twisted vertical seams and plates at a depth of about 30 inches. Soil 12 is a loam with a clay subsoil and soil 31 is a gritty loam over a similar platy clay subsoil. Soil 32 is a loam with a subsoil similar to that of soil 14; soil 52 is a fine sandy loam with a clay subsoil. Soil 35 is a loam or clay loam with a clay below 4 feet depth.

The heavier subsoils of this group might be expected to retain moisture effectively; results on the experimental fields, however, showed that frequent irrigations were required and that the total seasonal requirement placed these soils in this group. Such results apply particularly to Soils 14 and 16 which are represented in several of the experimental fields.

The second group includes soils 6L, 26, 42, 48, 50, and 53. Of these soil 42 has the largest area. Profiles of soils 26, 42, and 50 are shown in Fig. 1. Parts or all of the Sjoblom, Day, Mabey, Mackay, and Asarco fields of the 1937 investigations are on these soils.

Soil 42 is a loam becoming a very fine sandy loam below 3 feet; soil 50 is a silt loam with a loam subsoil. Soil 26 is a gritty sandy loam becoming compact at about 3½ feet; the deeper subsoil varies from a clean sand to fine lake-laid sediments. Soil 53 is a deep surface phase of soil 38 and will require somewhat more water than soil 38 which is placed in the 3.5 acre feet per acre group. Soil 48 is variable, having surfaces soils of loam to silty clay loam with a generally silty clay loam having gravel at about 4 feet.

The third group of soils having an estimated water requirement of 4.0 acre feet includes Soil 20 and small areas of Soils 57 and 58. Soil 20 is on areas developed from old spring deposits or calcareous tufa; it consists of a stony or gritty loam with such tufa at 1½ to 2'. At depths of about 3 feet the tufa is underlain with gravel or boulders. Soil 57 is a silty clay loam underlaid with lime hardpan; Soil 58 is a loam over tufa.

The Ridd field, on Soil 20 used in the 1937 investigations is used in this group. A profile os Soil 20 is shown in Fig. 2.

The fourth group of the 4 acre foot per acre classification consists of Soils 23, and 51. Soil 23 is a silty clay loam with a cemented or lime coated gravel at depths of 2½ to 3 feet. Its profile is shown in Fig. 2.

These groups of soils having an estimated water requirement of 4.0 acre feet per acre represent the average or median soils in this area. There are more soils included in this group and they represent a larger part of the area irrigated under the Associated Canals than the soils having other amounts of water requirement.

Four acre feet per acre delivered is larger than the average water requirement in some areas where conditions are more favorable. This amount of use for these soils is supported here by the local conditions and the results of our own investigations.

SOILS HAVING AN ESTIMATED REASONABLE WATER REQUIREMENT OF 4.5 ACRE FEET PER ACRE

This is another intermediate group of small total area; the soils placed here could be placed in either the 4.0 or 5.0 groups without materially affecting the total results. This group includes soils of generally medium to light texture. The soils in this group include soils 33, 34, 350D, 43h, 44D, 46, 54, 55, and 56. Soil 56 has the largest area. Profiles of soil 54 and 56 are shown in Fig. 2.

Soil 43h is a slightly heavier phase of soil 43 which is a deep loam. Soil 44 is a loam with a lighter subsoil. Soil 46 is a silty clay loam with a clay loam subsoil. Soil 56 is a deep silty clay loam.

Of the fields included in the 1937 ivestigations the Morgan area consists of soil 56, and the McKean field of soil 54. The Nelson field is a mixture of soils 14 and 47, with an average reasonable use of 4.5 acre feet per acre although these two soils fall in the 4.0 and 5.0 groups respectively.

From its texture soil 56 might be placed in groups having smaller water requirements. The results on the Morgan field indicate that some areas of this soil are of lighter texture than the type description.

SOILS HAVING AN ESTIMATED REASONABLE WATER REQUIREMENT OF 5.0 ACRE FEET PER ACRE

This group includes the lighter textured soils in which the proportion of gravel is generally smaller than in those soils classified as gravelly types. It includes Soils 7, 9, 11, 17, 18, 20G, 21, 24, 24c&s, 28, 43, 45, 47, 48G, and 54E. Soils 43 and 47 have the largest areas in this group; profiles of these soils and soil 7 are shown in Fig. 2.

Soil 7 is a coarse sandy loam with a coarse sand subsoil. Soil 17 is a granular and gritty loam becoming gravelly with a loam filler at about 1 foot depth and a gravelly coarse sand at 18 to 30 inches depth. Soil 24 is a fine sandy loam becoming gravelly at about 2 feet depth. Soil 24c&s is a slightly coarser phase of Soil 24. Soil 43 is a deep gravelly loam; the surface soil of loam is usually over 2 feet in depth. Soil 45 is a loam with a sound subsoil; Soil 47 is a gravelly loam.

Parts of the Gardner and Winder fields of the 1937 investigations are included in this group.

SOILS HAVING AN ESTIMATED REASONABLE WATER REQUIREMENT OF 6.0 ACRE FEET PER ACRE

This group includes the areas having the largest water requirement considered to represent a reasonable use in this area. It includes the coarser textured types of soil requiring frequent irrigation which are difficult to cover without large percolation losses.

This group includes Soils 2, 4, 7G, 8, 10, 13, 17G, 25, 27, 40, 42G, 43G, and 60. The largest areas are in Soils 2 and 37. Profiles of soils 2, 27, and 37 are shown in Fig. 2.

Soil 2 is a friable fine sandy loam with little change with depth. Soil 7G is a coarse gravelly sand. Soil 27 is a gravelly fine sandy loam with a gravelly loam subsoil below 1 foot depth. Soil 37 is a gravelly loam with usually over 50% gravel. Soil 42G is a gravelly phase of Soil 42 which is a granular loam. Soil 43G is a deep loam with gravel.

The Godfrey and McDonald fields of the 1937 investigations were on Soil 2.

CONVEYANCE LOSSES

The Associated Canals operate their main Canals and deliver water to their users at the canal bank. Laterals are built and operated by the landowners under each lateral. Consequently conveyance losses fall into two classes; those in the main canals and those in the laterals.

The Canals are well constructed and fully representative of usual good practice. Utah Lake water contains a fine whitish clay which remains in suspension through the canals. Seepage from the canals and some settlement of this clay result in coating the canals with a fine layer of relatively tight clay. When Canals are not cleaned for some time they become well sealed with a relatively small conveyance loss. Weed growth requires occasional cleaning even if the volume of silting is small. Such cleaning disturbs the clay seal and results in increased loss until further sealing takes place.

Records of conveyance loss are limited. There are some early figures of general losses and some test runs were made as a part of these investigations.

LOSSES IN MAIN CANALS

The following list represents the available records of the conveyance loss in the main canals.

Canal	% Conveyance Loss	Source of Information
Utah and Salt Lake		
	17.2	Results of measurements by Milligan in 1933.
	11.65	Results of measurements by Gardner and Holt, July 28, 1938
	8.75	Measurements Sept. 6 & 7, 1938 Gardner, Holt, and Morgan
South Jordan		
	20.0	General basis used by the superintendent in distributing water to laterals.
	14.5	Measurements Aug. 24-26, 1937, by Gardner and Neilson.
North Jordan		
		No direct records. Estimated loss 15%
East Jordan		
	17.0	Quotation from Kenneth Borg by Gardner.
City Canal		
	12.0	Towler quoted by Gardner; applies when not influenced by surface waste from higher lands.

In his report on the measurements on the Utah and Salt Lake Canal on July 28, 1938, Mr. Gardner included the following comments.

"This loss appears too low considering other canal losses in the valley and especially in relation with the South Jordan Canal. This small loss might, however, be accounted for by virtue of the fact that it has been several years since the bottom of the canal has been disturbed. There are checks in the canal at frequent intermals which retard the velocity and permit the finer sediments usually carried in suspension in the water of the canal to precipitate. These fine materials have a decided tendency to seal the canal. During the past few years there have been several floods reach the canal which no doubt carried large quantities of fine silt, the most recent flood being last spring. This flood carried materials from a Tailings Pond above the canal and deposited several thousand yards of fine clay like material in the canal bed. It was necessary to remove some of this deposit with a drag line. The remaining material was conveyed down the canal and probably aided in further sealing. If it ever becomes necessary to again disturb the bottom and sides in cleaning operations greater losses might be anticipated."

Mr. Gardner summarized the conditions on the South Jordan Canal in his report dated Sept. 22, 1937 on the seepage measurements made in August 1937 as follows.

"In this investigation careful measurements were made and wherever possible results were checked with different methods of measurement. The flow at the head of the canal was for all practical purposes constant. The results were as would be expected so far as loss was concerned. The section from the Head to Beckstead Hollow is constructed largely in cut on a side hill in gravel, of very coarse texture and a heavy loss would be expected.

"The section from Beckstead to Brigham Creek is mostly cut through relatively level country except a short distance near the South Jordan meeting house. Borings through this section reveal that clay subsoil predominates. The section from Brigham Creek to the end of the canal is cut through sand and around what is known as the sand ridge which, as at the Head, allows free passage of the seepage water away from the canal."

The losses found were as follows.

	sec. ft.
Head to Beckstead Hollow	11.31
Beckstead Hollow to Brigham Creek Flume	1.43
Brigham Creek Flume to end of canal	5.43
	18.17

The diversion was 126.20 sec. ft. and the total loss 14.5%.

LOSSES FROM LATERALS

Mr. Gardner made a few measurements of losses from laterals on the South Jordan Canal, and Mr. Kenneth Borg has similar records on the East Jordan. It is understood that the City has records of loss on some of their deliveries but these have not, as yet, been secured.

Mr. Gardner has reported as follows on his measurements on the South Jordan system in August 1937.

"Another investigation was conducted on the South Jordan canal to determine the loss in the laterals from the canal to the lowest diversion thereon. Although these results are not conclusive, they indicate that there is a heavy loss in the laterals. Some laterals badly grown to weeds and constructed partially on fill showed extremely heavy losses. The Jackson weir showed 2.59 c.f.s. near the canal while ¾ of a mile below the measured discharge was 0.82 c.f.s. The Drake weir showed 4.32 at the head and 2.18 one and ½ mile below. We have on the Cannon weir a Parshall flume approximately one mile below a similar Parshall flume installed near the canal by the canal company. Several checks between these two flumes show that the loss in the ditch is about 0.25 sec. ft. per mile. This ditch, however, is well kept and on a relatively steep grade."

Mr. Kenneth Borg has made measurements of losses in some of the laterals under the East Jordan Canal. His report for 1938 gives the loss for three dates on the Spencer lateral of 32.5, 40.5, and 26.8%; on the Nelson lateral of 37.0, 34.7, and 23.4%; and on the Gelta lateral of 31.5, 33.2, 15.6, and 9.0%.

In the measurements of the water used under selected laterals in 1938 and 1939, the water delivered was measured at the heads of the laterals. No separate measurements of lateral losses were secured but estimates were made based on general judgment. The amounts of estimated loss used for the laterals in this work were as follows.

Utah and Salt Lake Canal	
Bluffdale Lateral	15 to 20%
Winder Lateral	10 to 15%

South Jordan Canal	
Harker Lateral	10 to 15%
Drake Lateral	15%
North Jordan Canal	
Redwood Lateral	10%
Rupp Lateral	10%
East Jordan Canal	
Sandy Lateral	10 to 15%
Atwood Lateral	10%

CONCLUSIONS

While the records of conveyance losses are not as extensive as might be desired, the results available are generally consistent. The following amounts of conveyance loss in the main canals are considered to represent the probable loss and the amounts which should be used in determining the water requirements of the Associated Canals.

Loss in Main Canal of the:	Conveyance Loss in % of the Water Diverted:
Utah and Salt Lake Canal	15%
South Jordan Canal	15
North Jordan Canal	15
East Jordan Canal	17
City Canal	12

These amounts of loss are conservative. At times following canal cleaning they will be exceeded. Measurements under present conditions probably represent about the minimum losses that may occur on these canals as none have been thoroughly cleaned recently. The City Canal should be entitled to its own loss without reduction for any waste it may receive from higher lands. It cannot depend on the occurrence of such waste and its own requirements are not reduced permanently by its occasional occurrence.

All of these rates of loss are relatively low for the conditions under these canals. The loss used for the Utah and Salt Lake Canal represents an average of about ½ of 1% per mile. Canals carrying 200 second feet in medium soils usually lose about 1% per mile and in heavy soils about ½ of 1% per mile. The soils along this canal are not heavy. The results of the measurements in 1938, while correct for the time of the measurement, are considered to represent a more favorable condition than the average and to be less than this canal can expect to secure for average conditions.

As the water requirements for the lands served have been worked out for the amounts to be delivered to the land it is necessary to use a value for the loss in the laterals. There is little definite record material on which to base estimates of the losses in the laterals.

Each of the Associated Canals serve lands in a generally narrow strip so that laterals are usually less than 2 miles in length. Losses are probably 10 to 15 per cent with some exceeding these amounts. For well maintained laterals the average loss is probably about 10 to 15 per cent of the delivery to the lateral; the loss in terms of the diversion at the head of the canal will be somewhat smaller. Some of the areas served by the City Canal are further from the main canal. This with the coarser soils in some of such areas justifies using a larger lateral loss on this system.

These estimates can be combined to give the following total conveyance losses for each of the Associated Canals.

Conveyance Loss in Per Cent

Canal	In Main Canal	In lateral of delivery to Laterals	In Lateral of diversion at head of Canal	Total of diversion at head of Canal
Utah and Salt Lake	15	10-15	10	25
South Jordan	15	10-15	10	25
North Jordan	15	10-15	10	25
East Jordan	17	10-15	10	27
City	12	15	13	25

These results are relatively favorable. Losses from the diversion to each farm of 25% for canals of the lengths required here are less than are found in many systems. These losses can be supported as representing results with a good standard of earth ditch construction and maintenance.

PAST DIVERSIONS

Use on the areas served by each of the Associated Canals began over 50 years ago. While no detail records have been found of the areas served in the earlier years, the canals were built to capacities similar to their present sizes and to their present lengths. In Salt Lake City v Gardner 114 Pac 147 in 1911 the court found that in 1882 the plaintiffs (the present Associated Canals) had built canals with combined capacities of 828 sec. ft. This is similar to the capacity now used for irrigation. There have been some enlarge-

Table 10 - Diversions for Irrigation by the Associated Canals for Seasons - November to October.

Acre-Feet per Season

Period	Utah and Salt Lake Canal	East Jordan Canal	South Jordan Canal	North Jordan Canal	Total for 4 Canals	City Canal	Total for 5 Canals
1907-09	73760	31950	40320	16520	162550	11350	173900
1910-14	87510	41660	41420	20060	190650	15520	206170
1915-19	105240	25340	42730	17770	191080	15270	206350
1920-24	123770	50580	44710	17570	236630	16510	253140
1925-29	79040	37460	39170	15670	171340	29830	201170
1930-35	45050	23870	22500	14480	105900	27600	133500
1936	47220	24790	30110	19530	121650	33590	155240
1937	61780	34500	36600	21560	154440	44240	198680
1938	65890	39190	38250	21020	164350	43860	208210
1939	66370	40579	39031	21020	167000	45750	212750
1940	60224	35550	35400	31376	162550	53250	215800

ments made under exchange agreements which do not affect the capacity for irrigation of the lands directly served by each canal.

No records have been found of any extensions of the present canals. Each canal appears to have been built to cover the area now served at the time of the original construction.

While there are no detailed records of the areas actually irrigated in the earlier years, these areas appear to have been the same areas now served and the early records of diversion have been assumed to apply to an area equal to that now irrigated.

There are some grounds for a conclusion that the areas served in the earlier years may have been larger than that served in recent periods. Drainage has been required on much of the land served. Between the time when the need for drainage developed and its actual construction some land may have gone out of cultivation. Drainage has been provided now for lands needing it within the main areas and such lands are restored to use. There are some lower lands not now irrigated which may have been served in the past.

The differences in the area served are not large enough to require adjustment of the past diversions for changes in area. The actual diversions have been taken as representing the use on the areas now served.

In considering past records of diversion in relation to the water requirements of the lands served, selection of the records representative of the needs of the lands is required. Diversions in 1935 or other years of shortage do not measure irrigation needs. Diversions 30 years ago may be indicative of use then but may be of little help in estimating present needs after drainage has been provided and crops may have changed. For purposes of comparison , different periods have been selected. These represent means for consecutive five-year periods in order to reduce the effect of annual variations. These periods are as follows. Each season is from Nov. 1 to Oct. 31.

Period	
1907-09	Winter diversions are not recorded prior to 1907. It is understood they were zero. Records prior to 1907 were not included in this summary.
1910-14 1915-19 1920-24 1925-29	For each of these five year periods the water supply available was generally adequate.
1930-35	This six-year period was used to span the main years of deficient water supply.
1936 1937 1938 1939 1940	These years were used separately as they represent recent practice and are the years in which more information on use is available.

The results of applying these periods to the records of diversion are shown in Table 10. Table 10 shows only the diversions by each canal for its own lands. Allowances have been made for exchanges between canals. The results shown do not represent the total diversions by these canals where diversions for other uses were also made.

The City Canal has been shown separately of the other four canals as it does not supply water for the full requirements of the lands it serves. The diversions by the City

Table 11 - Monthly Distribution of Diversions by Associated Canals for Irrigation Only for Selected Years. In Per Cent of Total for the Season.

Canal	Apr	May	June	July	Aug	Sept	Oct	Total Diversion Apr.-Oct. ac-ft.
Utah & Salt Lake								
1923-24	4.0	17.2	18.4	20.5	19.6	15.1	5.2	90479
1929-30	10.8	17.8	20.9	19.6	16.6	13.7	0.6	71140
1936-37	0	23.3	19.0	19.0	18.0	16.2	4.5	61729
1937-38	4.0	15.7	22.4	18.4	17.0	15.1	7.4	65361
1938-39	7.6	21.4	19.8	16.9	16.9	14.2	3.2	67518
Mean	5	18	20	19	18	15	4	
East Jordan								
1923-24	0	17.3	16.5	18.7	20.2	19.2	8.1	51264
1929-30	2.9	16.3	25.6	21.2	17.6	16.1	0.3	33786
1936-37	0	16.6	17.6	20.4	21.0	18.3	6.1	34452
1937-38	0	9.7	21.7	22.4	20.9	18.7	6.6	38940
1938-39	3.9	21.3	18.6	20.4	19.1	14.8	1.9	40518
Mean	1	16	20	21	20	17	5	
South Jordan								
1923-24	2.8	17.8	19.7	21.4	20.6	13.3	4.4	40873
1929-30	6.5	18.2	21.7	21.4	18.1	12.7	1.4	36866
1936-37	0	20.0	19.8	20.6	20.7	15.2	3.7	36600
1937-38	0.1	15.3	21.9	20.6	17.9	18.5	5.7	37778
1938-39	4.1	21.0	18.3	20.6	19.7	13.2	3.1	38714
Mean	2	18	20	21	20	15	4	
City Canal								
1923-24	0	15.2	21.9	23.8	22.9	15.7	0.5	19568
1929-30	9.8	16.9	20.5	20.6	18.5	13.7	0	19617
1936-37	0	6.7	14.9	24.6	26.1	23.7	4.0	20402
1937-38	3.5	9.6	13.1	23.7	24.7	18.9	6.5	20056
1938-39	3.5	14.9	18.8	21.3	21.3	16.1	4.1	20111
Mean	3	12	18	23	23	18	3	
North Jordan								
1923-24	0	20.6	20.7	20.6	20.3	12.9	4.9	19602
1929-30	6.5	19.2	22.5	21.2	18.0	12.6	0	16961
1936-37	0	17.8	20.0	17.5	19.8	17.5	7.4	21775
1937-38	0	14.0	21.5	16.7	17.9	18.2	11.7	21020
1938-39	0.7	20.1	16.5	16.7	18.1	16.5	11.4	23457
Mean	1	18	20	19	19	16	7	
Mean of All	3	17	20	20	19	16	5	

Canal are less than the water requirementsof the lands receiving water from this system.

The results in Table 10 show that use in recent years when water was available is fully supported by the records of use in earlier years. The total use has exceeded 200,000 acre feet per year when water has been available.

MONTHLY IRRIGATION DEMAND

In setting up the water requirements for any irrigation project it is usually necessary to show the total seasonal requirement in acre feet and the maximum rate at which water will be required at any time. The first item represents the volume of water needed per season and the second determines the size of the canal needed.

For water supplies secured from storage where the water is on hand and can be drawn as used the rate of monthly demand is less important than where the canal depends on direct stream flow and the demand has to be adjusted to the time of occurrence of the run-off. Utah Lake permits the requirements of the Associated Canals to be taken as desired and the seasonal distribution of the demand is relatively less important than it is for usual conditions. Such monthly demands are needed in connection with matters of pump capacity, water supply studies of Utah Lake, etc. The records of use furnish an adequate basis for determining the relative demands of the Associated Canals in different months.

Monthly demands can be derived by different methods. The proportion of the area in each crop can be estimated and the time and amount of its demand determined. The total demand can then be computed. This method may need to be used in forecasting the demand for new systems where there is no record of actual use. Where there is a long record of actual use, such use represents an adequate and convenient basis for determining the relative monthly demand. Such records are available for the Associated Canals. By selecting years in which the use was not limited by shortages in supply, the natural crop demands can be derived from the records of actual use.

Local practice has fixed the irrigation season from April to October. Pumping usually begins in April and may be delayed to May 1 in some years. Pumping is usually ended for irrigation by Oct. 15 although a small amount of later draft may occur for use by the Utah-Idaho Sugar Co.

The records of the diversions of each of the Associated Canals from 1901 to date have been assembled in a report entitled "Diversions by the Associated Canals, 1901 to 1939," prepared in April 1940. In this report the records of each canal were segregated to show diversions for irrigation separately from those for other purposes or areas such as the use by the predecessors of the Kennecott Copper Co. or for irrigation through the East Jordan Canal by the Draper Irrigation Company.

The Utah and Salt Lake and the South, East, and North Jordan Canals supply all the irrigation that is used by the lands which they serve. The City Canal delivers a supply to land that may also receive other water and its draft on Utah

Lake and Jordan River does not represent a full irrigation service or a complete natural demand. The lands served by the City generally get their earlier season supply from other sources.

While some winter diversions are shown in the records of these canals, they are usually small except when Utah Lake is spilling. It is assumed that there will be no diversions from the Lake from November to March in any year when the water supply is limited.

From the report on canal diversions by each of the Associated Canals the monthly distribution for the irrigation use only was computed for five selected years. One year (1923-24) was selected as representing conditions well before recent shortages; 1929-30 as a year just before recent shortages, and the three years 1936-37, 1937-38, and 1938-39. These last three years represent conditions following the worst of the recent shortages but were years without direct shortage. The earlier years were included as there may have been some changing of crops during the years of shortage. The results are shown in Table 11.

As usual the monthly distribution of use is not uniform in the different years but a rounded mean can be derived which represents the probable seasonal use closely enough for the purposes of water supply studies. Placing draft earlier or later in the season affects the water supply study on Utah Lake only as it shifts the evaporation. Delaying draft late in the season would result in a somewhat larger average area of evaporation for a longer time but the difference would be small in relation to the total amount of inflow to the Lake.

From the results for each of the five canals a general mean was derived. While the mean for each canal varies somewhat the differences do not justify weighting each result to secure the average for the total draft. From these results the monthly percentages which appear to be representative of the probable draft from Utah Lake for irrigation by the Associated Canals have been selected. Use for other purposes is assumed not to occur except when surplus water may be available.

From the records in Table 11 the following distribution of monthly demand has been selected as representative of the average use by the Associated Canals for irrigation. This is considered to represent a normal irrigation demand for the crops and climate of this area.

April	3%
May	17
June	20
July	20
August	19
September	16
October	5
Total	100%

In the thesis of Jacobson and Peterson on Utah Lake, prepared in 1932, the monthly demand shown below was used. This work was done with the assistance of the U. S. Bureau of Reclamation and should reflect their views.

May	17%
June	27
July	24
August	18
September	10
October	4
Total	100%

These results differ from that derived from the Associated Canal records by having a relatively larger use to July (68% as against 60%) and a correspondingly smaller use after July. The U.S.B.R. results would be representative of practice where the water supply was not fully regulated by storage and had to be used as it came in the earlier part of the season. The results derived from the Associated Canals' actual records are considered to be a better basis for use in studying their draft on Utah Lake than these figures from the U.S.B.R. These U.S.B.R. results would be better adapted for systems using the inflow streams above Utah Lake where their water supplies are less fully stored than is the case for those using water from Utah Lake.