THE DRAINAGE PROBLEM IN THE LEWISTON AREA, UTAH

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THE DRAINAGE PROBLEM
IN THE LEWISTON AREA, UTAH

by
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INTRODUCTION

Often where water is artificially applied to land, means must be provided for removal of some of this water. Too much water is just as bad as too little.

The increased use of irrigation water in Utah has caused an increased need for drainage. Some irrigated lands are poorly drained. With high water table, yield of crops has been materially decreased, and with present drainage methods only a part of possible production has been attained.

The above conditions influenced the Utah Agricultural Experiment Station, with cooperation from the Utah Power and Light Company, to set up an experimental drainage project, (Utah Agricultural Experiment Station Project 285, "The Drainage of Irrigated Lands"). Its objectives are:

1. To develop new and improved methods of design, operation, and maintenance of drainage systems; both gravity and pumping.

2. To develop improvements in the design, the placing and maintenance of drainage tile, with special reference to prevention of inflow of excessive sand, silt and clay which clogs tile drains and necessitates very costly cleaning or abandonment.

3. To develop a clear understanding, by field inspection and experimentation, of the reason for successful drainage of 100,000 acres of Utah irrigated land, now well drained, and of the reasons for failure of the drainage systems covering an additional 100,000 acres.

4. To find the conditions under which, and the extent to which, drainage by pumping is preferable to drainage by gravity systems and to design, locate, drill and develop drainage wells so as to obtain maximum yield per foot of drawdown, and thus decrease drainage cost.
The Utah Power and Light Company also provided, as part of their cooperation, a fund for research fellows. The policy of assigning an area to each research fellow was adopted. The first study outlined covered the Lewiston Utah Area located between the Bear River and the Cub River, south to where they join and north to the Utah-Idaho state line, (see map, Fig. 1) containing approximately 18,000 acres. This thesis is a consideration of the drainage problems and their possible solution in the above area.
PART I

HISTORY OF IRRIGATION AND DRAINAGE IN LEWISTON AREA, UTAH

GENERAL

The first inhabitants moved into the Lewiston Area from Franklin, Idaho in 1871. Previously, the area which was covered by a species of sand brush, had been used for grazing. The first settlers were Peter E. Van Orden and a brother Everett C. Van Orden, a brother-in-law, John M. Bernhiesl and Robert Wall. All brought families except Mr. Bernhiesl. Most of the men were familiar with the area as they had pastured cattle there.

Crops

The first year, rye was raised, the second year, wheat and rye were grown, and the third year, these two crops and oats were grown all on dry land. Alfalfa was first grown in 1876.

Irrigation Started

Work was started in 1874 to divert water from Warm Creek, a tributary of Cub River. By 1878 enough water was available for gardens, but no water for crops was available until later.

History of Cub River Irrigation Company

The company was organized before any canal was built. In 1860, prior to the organization of the company, a survey was made to locate a canal

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1. Most of the information for the history of the Lewiston Area, Utah was obtained from Mr. E. M. Van Orden of Lewiston, Utah. He is a grandson of Everett C. Van Orden. His father is Peter Van Orden, Jr., son of Everett C. and nephew of Peter C. Mr. E. M. Van Orden obtained much information from his father who came to Lewiston as a boy.

2. The History of Cub River Irrigation Company was taken from an unpublished report by Mr. E. M. Van Orden, Water Master of Cub River Irrigation Company, to Prof. A. A. Bishop, which is on file in his office at the U.S.A.C., Logan, Utah.
to irrigate some land in Idaho. This canal was to be built near the present canal location and divert the waters of Cub River, but it was never started. In 1874, people from Lewiston, Utah, organized and incorporated the present company under the laws of Idaho, and obtained permission to do business in Utah. They made a new survey and began construction work.

The canal was built by the stockholders themselves, who were paid principally in company stock. The original canal was small, and in 1878 some water was turned into it. During the years 1879 and 1880 considerable work was done. The canal was enlarged and extended, and has been used since that time, to convey the irrigation water.

The farmers soon discovered that the area would be better served by dividing the canal at a point approximately five miles from the point of diversion. This change was made and the canals were located practically as they are at the present time. The amount of stock outstanding at the beginning of the century was 10,400 shares and has always been "floating" stock, that is not appurtenant to land.

During the development period, water users in other areas filed on the waters of Cub River. Much confusion and contention resulted, and litigation followed. The Cub River Irrigation Company filed suit against the Cub River Middle Ditch Company, a corporation, et al (Intervenors). A Decree, handed down by Alfred Budge, District Judge, January 26, 1906, defined and dated the water rights in Cub River ... Book "B" of Judgements, Page 418, Records of Oneida County, State of Idaho.

These water rights were also defined July 9, 1924 ... McEwan vs. Franklin County Sugar Company, City of Preston, Cub River Irrigation Company, et al, District Court, Fifth Judicial District, Franklin County, Idaho, Judge Terrill.
Cub River water was ample for the irrigation of the acreage irrigated during the months of April, May and June. However, by July 1, the natural flow decreases to approximately fifty second feet. The Cub River Irrigation Company has first right to 42.5 second feet, which is not sufficient for their need, and leaves users with very little water. Many attempts were made to locate a place for a reservoir on the Cub River but no site was found.

During 1914, a group of Lewiston people became interested in another source of water supply to supplement the Cub River and on December 11, 1914, an application was made by George A. Corey of Preston, Idaho to the State Engineer of Idaho to appropriate 100 second feet of the public waters of the State of Idaho, to be diverted from Bear River ... Application for Permit No. 15943. This application, which listed estimated costs of diversion works, distribution canal etc., was approved by the State Engineer ... Permit No. 10883, December 11, 1914, Book 36, Page 10883.

Some of the stockholders in the Cub River Irrigation Company, organized the Lewiston-Bear Lake Irrigation Company, incorporated under the laws of Utah. This company acquired Permit No. 10883 to divert waters from Bear River, from George A. Corey on April 7, 1916. Work on the project, which was estimated to cost $100,000.00, was started. A contract was entered into with the Utah Power and Light Company for 20,000 acre feet per year from Bear River storage. By 1918 the project was practically completed. Proof of the Completion of Works was made December 9, 1919, and Certificate of Completion of Works was issued November 17, 1920. The canals of the Cub River Irrigation Company were used to distribute this water. Considerable trouble developed in working out a satisfactory distribution
program, and on December 5, 1923, the Lewiston-Bear Lake Irrigation Company assigned all its rights, permits, appurtenances, etc., to the Cub River Irrigation Company. A satisfactory exchange of stock was made and a much improved irrigation system resulted.

The Cub River Irrigation Company sold one eighteenth of its primary right to waters in Cub River, granted by the Decree of January 26, 1906, to Preston City, Idaho, February 27, 1920. This was done to avoid a suit to condemn the right of Cub River Irrigation Company to the water from Ranger Spring, a tributary of Cub River. Preston City needed the water for domestic and culinary purposes.

The Cub River Irrigation Company re-incorporated in Idaho, March 6, 1931, and received permission to do business in Utah, March 30, 1931. The Company has operated since that date with no changes.

**Area Served**

The Cub River Irrigation Company serves a gross area of approximately 28,000 acres, of which 13,000 acres are in Idaho and 15,000 acres are in Utah. Total water delivered in 1946 was 26,683 acre-feet, of which 17,190 acre-feet were gravity water and 9,493 acre-feet pumped water. This indicates that less than 1 acre-foot per acre gross acreage is applied. Mr. Van Orden reports that between 1.5 and 2 acre-feet per acre were actually applied to the irrigated land.

**HISTORY OF DRAINAGE DISTRICTS**

**East Lewiston Drainage District**

East Lewiston Drainage District, organized in 1914, was the first

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3. The History of Drainage Districts was taken from information in footnote 2, unpublished U.S.A.C. Experiment Station Bulletin, 256, on file in the office of Eldon G. Hanson, U.S.A.C., Logan, Utah.
organized district in the Lewiston Area. It is located in the north-east Lewiston area (see Fig. 1), and comprises about 1,000 acres. The first drains were very shallow to take care of surface runoff, and were constructed by plow and team. The drains were later made deeper by use of a power shovel.

East Lewiston Drainage District has approximately 5.3 miles of open drains. Maximum depth is 7 feet, minimum depth is ¾ feet, and average depth about 5.5 feet. The spacing of these drains is approximately three-eights of a mile. Water served to East Lewiston Drainage District comes from the Cub River Irrigation Company canals through the East Lewiston branch, built in 1875.

**Cache County Drainage District No. 3**

Cache County Drainage District No. 3, comprising 1,150 acres of land in the southwest Lewiston area (see Fig.1), was organized in 1921. The drains of District No. 3 are open drains, constructed with a power shovel. There is 5.75 miles of drains, maximum depth is 7 feet, minimum depth is 3 feet and an average depth is 5 feet. Spacing averages approximately one-fourth of a mile. Water is served by the Cub River Irrigation Company Canal. No information on the date of building is available.

**Cache County Drainage District No. 5**

Cache County Drainage District No. 5 comprising 2,460 acres of land in the northwest (see Fig. 1) Lewiston area, was organized in 1921. The drains are open drains constructed with a power shovel. This district has 9.6 miles of drain, maximum depth is 6 feet, minimum depth is 3.5, and average depth is 4.5 feet. Average spacing is three-fourths of a mile. This area is served water by the Cub River Irrigation Company canals built about 1900.
Cache County Drainage District No. 6

Cache County Drainage District No. 6, comprising 1,450 acres in the southeast Lewiston area (see Fig. 1), was organized in 1928. Open drains were constructed with a power shovel. The total length of the drains is approximately 10 miles; the maximum depth is 7.5 feet, minimum depth is 2.5 feet, and average depth is about 4.5 feet. The average spacing is approximately one-half mile.

The water for Drainage District No. 6 comes from the Cub River Irrigation canals through the Hyer and Hogan ditches, built 1885 or earlier.

WATER TABLE

Mr. Van Orden reports that before any irrigation water was applied, the depth of the ground water table in the spring was about 6 feet, and that it would fall to approximately 8 feet during the summer.

No great difficulty was encountered until about 1921 when water was first pumped. Cub River supplies the water for irrigation in the early part of the season and additional water is pumped for the late-season irrigation.

With the addition of late-season water, the water table remained high all season. The situation in early spring was described by Mr. S. H. Pond, Secretary and Treasurer of Drainage District No. 5, as follows:

"A person could row a boat over inundated farm land during 'spring flooding' from a point one-half mile north of the Idaho border south along a course through the northeast area of District No. 5, and the central area of District No. 6. Cultivation was delayed several weeks each spring and visible alkali accumulations were found on a considerable portion of the land."

The water table, before open drains were constructed, would vary from the surface to a depth of 3 or 4 feet in the summer and fall. This
trouble led to the installation of the open drains. The open drains seemed to greatly assist the removal of early spring water. Very little difference was made in the water table of the summer and spring, as it still averaged 3 to 4 feet in most places.

CROP YIELDS

The yield of crops greatly increased after late irrigation water became available to the area, until the time when the water table was built up, then greatly decreased. Opinion varies some about how much the increase of yield was after the open drains were installed. Some believe the yield was back to 100 percent while others claim only a small amount. Mr. D. E. Smith, Manager of Amalgamated Sugar Company in Lewiston, stated that Lewiston once had the highest yield of sugar beets per acre in Cache Valley. Now it has the lowest.
PART II

PRESENT DRAINAGE SITUATION

CAUSE FOR HIGH GROUND WATER TABLE

Rainfall

One aspect of the waterlogging problem in these areas is the effect of natural precipitation and runoff. Fig. 2 shows the annual precipitation at the Lewiston Station, Utah, from 1925 to 1940 and at Logan Station, Utah, from 1892 to 1940. Assuming that the data from the Logan Station reflects the variation of annual precipitation in the Lewiston area, and those areas tributary to the streams which supply irrigation water to Lewiston area, and further, that streamflow in the above areas varies with the precipitation, Fig. 2 indicates that the water supply was above normal during 14 of the 18 years between 1905 and 1923. These are the years during which the serious drainage problem in the area developed.

Canal Seepage Losses

A large proportion of the excess ground water probably comes from canal seepage losses, since the soil in many parts of these districts is sufficiently permeable to permit the use of the subirrigation method.

The effect of canal seepage losses on the ground water table is shown in Fig. 3. Profile "A" shows a fall of 1.5 feet in the ground water table away from the canal in a distance of approximately 400 feet; profile "B" indicates a fall of nearly 2.0 feet in approximately 700 feet. These show a very definite movement of water from canals. Figs. 4, 5 and 6 show how the canals in many sections are elevated above the natural surface of the soil. This produces a greater hydraulic gradient to force more water from the canals into the subsoil.
During pumping of test well No. 1/2 a hole 1-foot square was dug 15 feet from the flow of well water. Many tests showed it took approximately 1 minute and 40 seconds for the water to flow from its position in the ditch to the 1-foot square hole. This is a velocity of .15 feet per second, an almost open-stream velocity. Probably, channels had been cut from the ditch to the hole, but nevertheless this shows the great possibility of flow from canals into the subsoil.

Application of Irrigation Water

Approximately 1.5 to 2 acre-feet of water per acre were applied to the lands of the area. This amount is not excessive, as many areas apply this much water to their lands. No measure of the amount of water leaving the area is obtainable. However, this is probably very small. Deep percolation is probably insignificant. Some water is observed leaving by the drain, but it too is a very small flow.

Subirrigation is the common method of application. Water is run down small ditches spaced at intervals of from 100 to 300 feet. The water is left in these furrows for several days until sufficient water seeps from the ditches to raise the ground water level near the surface, then the water is taken out for a time. When the soil moisture has been depleted the process is repeated. Fig. 7 shows a sugar beet field in Lewiston, Utah, with a subirrigation ditch up through the field.

PRESENT DRAINS

Description

A few pipe or tile drains have been constructed by individuals, but only open drains have been constructed by the four drainage districts.

1. Pumping of test well No. 1 will be explained in detail in Part III of this thesis.
Fig. 8 shows a typical open drain recently constructed. Figs. 9 and 10 show drains constructed sometime earlier. The depth of open drains varies greatly depending on length of time since cleaning. Fig. 8, showing a drain constructed for only a short time reveals sloughing of banks into the bottom of the drain. Width of drains greatly increases, depending upon the number of times they have been cleaned. Figs. 9 and 10 show drains four to five times as wide as originally constructed.

Obstructions in Drains

Cattails as shown in Fig. 11 are a main source of obstruction in drains. Tumble weeds (Fig. 12) and willows, etc., (Fig. 13) also retard the flow of water. The open drains catch any blowing material.

Fence lines across drains and the use of drains for cattle watering holes are constant sources of trouble. Many other obstructions in open drains could be enumerated, and all are costly to remove.

Maintenance of Drains

In general, the drains are maintained by use of drag line excavators. Cost of maintenance is variable because, in general, drains have not been maintained as they should have been, due to the high cost of cleaning. The large amount of sand filling up the bottom of the drain from the sides must be removed with a drag line.

Reasons for the Use of Open Drains

The open drains are very effective in the spring to remove large amounts of water from the surface and from near the surface.

It is the general opinion in the area that tile or pipe drains will clog with sand and not operate. This is believed to be due to the large amounts of quicksand. The quicksand flows very readily as it is a fine sand supersaturated with water.
The open drains were originally designed to be deeper but could not be so constructed because the quicksand would flow into the drain so fast that it was impossible to maintain the designed depth.

Adequacy of Open Drains

The present drains, hampered by obstructions, and in many cases, by lack of adequate slope, do not utilize even the full depth they have. The obstructions and lack of slope cause the water level to rise in the drains, and they are effective to only the depth of the water surface.

CONDITIONS OF OTHER FACTORS

Alkali Conditions

In all districts, the supervisors report that an appreciable accumulation of alkali appeared on the ground surface as the waterlogging condition developed. The concentration of alkali was greater in the lower land and along swales. Since the construction of the drainage systems, the surface indications of alkali have largely disappeared. At the present time there are relatively few accumulations of noticeable surface alkali except in the following areas:

1. District No. 5 (especially in the northwest part of the district).
   a. Central area of Section 6. Some of the open drain banks in this area are coated with salt. Several alkali spots devoid of vegetation were observed.
   b. Northwest quarter of Section 1.

2. District No. 6.
   a. South half of the Northwest quarter of Section 20. A narrow alkali strip approximately 30 to 40 feet wide extends across the extreme southwest corner of the district.

5. Many actual designs required a depth of 10 feet.
Chemical analyses made in 1946-47 reveal that the salt content in the upper 6 feet of the soil profile varies from a "trace" to 0.13 percent with an average content of 0.05 to 0.08 percent; the pH values range between 7.2 to 9.1 with an approximate average of 7.8 to 8.4. These data were obtained from a soil survey by the U. S. Bureau of Reclamation, made during the summer months of 1946 to 1947.

There is no record available showing the variation of alkali content in the soil throughout the general period of drainage activities in this area.

The water discharging from the pipe drain (see Part IV of this paper) contains from 1,000 to 1,100 parts per million of soluble salts, indicating some salinity in the soil.

**Ground Water Conditions**

According to general opinion, the ground-water table depth ranges from about 1 to 5.5 feet, with the average depth between 3 and 4 feet. This has been verified by measurements in many places. Fig. 14 shows the water surface profile on the Amalgamated Sugar Company farm in July 1947. Measurements on the Sugar Company farm showed the water table at about 3-feet depth, or less, during the summer of 1947. In one test hole near the north end of the profile, Fig. 14, the water was never lower than 0.9 feet below the ground surface.

**Crop Yields**

Crop yields increased to some degree after the installation of open drains, but in most instances not to the high production that once prevailed, or the production that is obtainable if properly drained, from these highly fertile soils. Lowering the ground-water table would help increase the yield from these soils.
Local Opinion on Need for Drainage

The following quotations are from men familiar with this area:

Mr. E. M. Van Orden (Water Master of Cub River Irrigation Company):

"The high water table was caused mainly by the late water pumped from the Bear River. The high water table kills out the alfalfa the second year and reduces the sugar beet production. The water brings up the salt and that decreases crop yield. The open drains do a lot of good, but are not properly maintained. Drains must be deeper to lower the water table to where it should be."

Mr. C. Jay Van Orden (Mayor of Lewiston City):

"Our very existence depends on removing the excess water from our soil."

Mr. Henry Johnson (President, East Lewiston Drainage District and director of Cub River Irrigation Company):

"Our alfalfa kills out the first and second years. Our present drainage system helps us but we have got to get the water table lower."

Many other individuals in the Lewiston area express this same sentiment and desire to improve drainage conditions.
PART III
DRAINAGE BY PUMPED WELLS

Possibility of Drainage by Pumping (4)

Many areas have been reclaimed by pumping ground water from wells. Water users in the Salt River Valley in Arizona pump 600,000 to 700,000 acre-feet of water per year. They have lowered the water table to an average depth of about 45 feet. In this area, in 1903, when irrigation was started, the ground water table was approximately 45 feet from the surface, and very little trouble was experienced due to excess water or saline accumulations. By 1919, with the addition of irrigation water, the water table had raised to an average depth of about 15 feet; thousands of acres had a very shallow water table, and serious conditions existed. By 1924, extensive pumping was underway and the water table had been lowered to such a depth that greatly improved conditions resulted.

A similar condition existed in many parts of Central Valley in California. Pumping for both irrigation and drainage has solved the drainage problem in most areas in California.

Methods of Drainage

Generally, two methods are used, depending upon the geologic formation (1) pumping "confined" water from a permeable subsurface stratum. The hydrostatic pressure in this stratum is decreased by removal of the water. This permits water to drain slowly from the overlying material of lower permeability and results in a lowering of the water table. (2) Pumping "free" water from permeable surface strata. Excess water in surface strata moves essentially horizontal into the well due to the

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differential pressure resulting from the removal of water from the well.

Other methods and variations of these have been used and are being developed.

**Use of Water for Irrigation**

In most cases the water pumped for drainage purposes can be used for irrigation (7). Sometimes it is necessary to waste pumped water to remove salt from the soil. Pumped water in one area supplied at least one-third of the total water.

**PRELIMINARY INVESTIGATIONS**

**Eleven-foot Well**

A search of the Lewiston area revealed only two shallow dug wells. One of these could not be used in this investigation because it was close to the Bear River and not in typical formations. Study was conducted on a shallow well designated 11-foot well on map, Fig. 1. A picture of this well is shown in Fig. 15. The casing of the well was wood 2.5-feet square, it was 11-feet deep and in sand the entire depth. Water stood in the well approximately 9 feet from the surface. The water was lowered to 10 feet, and after 24 hours had raised back to 9 feet.

The discharge is then,

\[ Q = 2.5 \times 2.5 \times 1 = 6 \text{ cu ft in 24 hours}, \]

or

\[ Q = \frac{6 \times 62.5}{8.5 \times 24} = 1.83 \text{ gal per hr, or } .0305 \text{ gpm} \]

This amount of water is too small to attempt to calculate the permeability of the sand. The water just outside the well was 3.5 feet from the ground surface. This indicated that the well casing was probably holding the water out of the well.
To increase the flow in the well, 2 feet of muck was removed from the bottom of the well and 30- to 40-one-half-inch holes were bored in the wood casing. The well is now 12.7-feet deep.

A layer of gravel from 11 to 12 feet was reported by the owner, but only a small trace of it was found.

The first observations, after the well had been developed, showed a discharge of

\[ Q = 2.5 \times 2.5 \times 0.62 = 3.87 \text{ cu ft per hr} \]

or

\[ Q = 3.87 \times 7.48 \times 0.48 \text{ gpm or 28.5 gph} \]

The permeability \( k \) of the sand can now be calculated by use of formula from Etcheverry's (3) "Land Drainage and Flood Control."

Fig. 6 shows symbols and values for the formula.

\[ Q = \pi k \frac{H^2 - h^2}{\frac{R}{r}} \]

Solve for \( k \)

\[ k = \frac{Q \log e^{\frac{R}{r}}}{\pi \times \frac{H^2 - h^2}{r}} \]

Check physical units

\[ k = \frac{L^3}{T} \times \frac{L}{L} = \frac{L}{T} \]

\[ Q = 3.87 \times 24 = 92.8 \text{ cu ft per day} \]

\[ r = 1.25 \text{ feet} \]
\[ R = 26.4 \text{ feet} \]
\[ H = 8.63 \text{ feet} \]
\[ h = 5.5 \text{ feet} \]

\[ \log e = 2.303 \log 10 \]
\[
k = \frac{92.8 \times 2.303 \log_{10} \frac{26.4}{1.25}}{(8.63^2 - 5.5^2)}
\]
\[
k = \frac{92.8 \times 2.303 \times 1.334}{(60 - 30)} = 2.52 \text{ ft per day}
\]
\[
k = \frac{2.52}{60 \times 60 \times 24} = 2.91 \times 10^{-5} \text{ ft per day}
\]

In a second test to find discharge, a hand pump was used to remove the water from the well, and buckets were used to measure the water pumped. The average discharge for several hours of pumping was 52.8 gph.

Again computing \(k\) with the above formula and the new values.

\[
Q = \frac{52.8}{60 \times 60 \times 7.48} = .002 \text{ cfs}
\]

\(Q\) in cfs \(k\) will be in feet per second

\[
R = 26.4 \text{ feet}
\]
\[
r = 1.25 \text{ feet}
\]
\[
H = 7.64 \text{ feet}
\]
\[
h = 3.64 \text{ feet}
\]

\[
Q = \frac{.002 \times 2.303 \log_{10} \frac{26.4}{1.25}}{(7.64^2 - 3.64^2)}
\]
\[
k = \frac{.002 \times 2.303 \times 1.334}{(58.2 - 13.2)} = .00615
\]
\[
k = 4.35 \times 10^{-5} \text{ ft per sec}
\]

Compare results

Trial 1 \(k = 2.91 \times 10^{-5} \text{ ft per sec}\)

Trial 2 \(k = 4.35 \times 10^{-5} \text{ ft per sec}\)

These results are fairly close, but show a substantial increase.

In the second trial, a more accurate measurement of the water was obtained and the water level in the well was kept constant.

**Probable Water Yield of a One-Hundred Foot Well in the Same Material**

The known permeability of the sand gives a basis for estimating the discharge from a contemplated well 100-feet deep in the same material.
Using the same formula as before and the values indicated, the probable discharge is estimated for two cases, first, a 66-foot drawdown and second, a 36-foot drawdown. For both cases:

\[ k = 4.35 \times 10^{-5} \text{ ft per sec} \]
\[ H = 100 - 4 = 96 \text{ feet} \]
\[ R = \text{Use } 400 \text{ feet which would be a minimum} \]
\[ r = \text{Use } .5 \text{ feet} \]

**Case 1**

For \( h = 30 \) feet or a drawdown of 66 feet

\[ Q = \pi k \frac{H^2 - h^2}{2.303 \log_{10} \frac{R}{r}} = \pi x 4.35 \times 10^{-5} \times \frac{(96^2 - 30^2)}{2.303 \log_{10} \frac{400}{.5}} \]

\[ Q = \pi x 4.35 \times 10^{-5} \times \frac{8220}{6.71} = .167 \text{ cfs} = 74.0 \text{ gpm} \]

**Case 2**

For \( h = 60 \) feet or 36 feet drawdown

\[ Q = \pi x 4.35 \times 10^{-5} \times \frac{5520}{6.71} = .113 \text{ cfs} = 49.6 \text{ gpm} \]

The above results obtained during July, 1947 seemed to indicate that a large diameter well 100 to 200-feet deep would be feasible.

Little or no information as to subsurface material was then available. A U.S. Bureau of Reclamation test hole drilled by hand with a soil auger and located toward the south side of Section 16, Township 14 North, Range 1 East, Salt Lake Base Meridian reported 22 feet of sand. There had been no attempt to measure permeability in this area; and no information concerning water bearing strata or depth to that stratum. Information concerning specific capacity of wells was also lacking. So rather than drill a large diameter well to a depth of 100 feet at a cost of approximately $4,000, a small diameter (3-inch) test well would be driven at a cost of approximately $300 to determine strata.
TEST WELL NO. 1

Location

Lewiston area 3-inch diameter test well No. 1 was located on the Amalgamated Sugar Company farm (see Fig. 1) at a point 150 rods south and 1 rod east of the northwest corner of Section 10, Township 14 North, Range 1 East, Salt Lake Base Meridian. This well was located on the Amalgamated Sugar Company farm because of their interest, supported by donation, to further research in the Utah State Agricultural College Experiment Station Project 285.

Drilling

A jet type well drilling machine, Fig. 17, owned by Mr. Robert Johnson of Logan, Utah, was used to drill the test well. Water is forced down a three-fourths-inch pipe. The water, and the "up and down" action of the wash rods, with a drill on the end, loosen the material which is washed to the surface.

Test well No. 1 was drilled quite rapidly because the material broke up and washed out very easily.

Log of Test Well No. 1

The log of test well No. 1 is shown in Fig. 18 and a picture of test well No. 1 is Fig. 19.

As shown by the log of test well No. 1, the first 15 feet is sand, then blue clay practically all the way to 118 feet. The next 6 feet was an extremely hard layer of mixed material. Below this layer was 4 feet of water bearing gravel. Below this was 6 feet of hard material, and 6 feet of mixed sand and gravel. This last layer did not yield as much water as the layer between 124 feet and 128 feet. No water bearing material of high permeability was encountered below
140 feet. The casing was put down to a depth of 136 feet, and the bottom 12 feet was perforated. The blue clay is material deposited by old Lake Bonneville. It is very fine and of very low permeability.

Testing

The log of this test well is not favorable for drainage by pumping from the lower strata. However, it was considered worth while to test the extent and possibilities of the gravel strata.

In the first test, water was pumped from the canal into the well. It was found that the well would "take" only 4.5 gallons per minute. This indicated that the perforations in the pipe were clogged, because the well took more than 15 gallons per minute (the amount the wash rods carried) when the stratum was first tapped.

An air lift pump was used for testing the well, as indicated by Fig. 20. This consists of a three-fourths-inch air discharge pipe with nozzle, and an air compressor. The nozzle is placed near the bottom of the well to give maximum submergence. The nozzle is designed to break up the air jet into small bubbles with an initial upward velocity component. For measuring the effective water level in the well, a one-fourth-inch airline is put down the well to a depth below the air nozzle. This pipe is attached to a specially calibrated pressure gage which indicates the level of water in the well, when the gage dial is set on the length of the air line. The difference in the gage reading before pumping is started, and while pumping is in progress, is the drawdown of the well. The air compressor used in pumping is shown in the background, Fig. 19.

The well was pumped for 4 hours the first day. The water cleared of sand in about 2 hours and stayed clear the rest of the time. Four days later, the well was pumped again for 1 hour, and the water cleared
in about 5 minutes and stayed clear. Four days later, or 8 days from the first test, the well was pumped for 5 hours. The water again cleared in about 5 minutes and remained clear. A picture of actual pumping is shown in Fig. 21.

Several conductivity tests of the water pumped from the strata at the 124-foot depth showed 1,400 parts per million of soluble salts present.

**Permeability**

The permeability of the lower layer of water bearing material can be calculated from the formula,

\[
Q = \frac{2\pi k t (H - h)}{\log_e \frac{R}{r}}
\]

in which \( t \) is the thickness of the strata being tested and all other symbols are as indicated below.

\[
Q = 80 \text{ gpm} = 0.18 \text{ cfs}
\]

\[
H - h = 15 \text{ feet}
\]

\[
r = 2 \text{ inches} = 1/6 \text{ feet}
\]

\[
R = 100 \text{ (conservative estimate)}
\]

\[
t = 10 \text{ feet} \text{ (length of perforations)}
\]

\[
k = \frac{0.18 \times 2.303 \times 2.778}{2 \times \pi \times 10 \times 15} = 12 \times 10^{-4} \text{ ft per sec}
\]

This is approximately 35 times the permeability of the sand of the top strata and it compares quite favorably with permeability of several wells in the Malad area, Idaho. In these wells, the permeability ranged from \( 5.48 \times 10^{-4} \text{ ft per sec} \) to \( 13.2 \times 10^{-4} \text{ ft per sec} \).

---

Specific Capacity

The specific capacity (gallons per minute per foot of drawdown) of the test well No. 1 is

\[ \text{Sp. Cap.} = \frac{80}{15} = 5.9 \text{ gpm per ft of drawdown} \]

The Malad area wells have a specific capacity range from 16 to 114. This result does not compare as favorably as the permeability results.

**TEST WELL NO. 2**

The first well did not show the extent of the underground strata, and observations seem to indicate that the upper stratum of sand was deeper farther away from the Cub River. With this in mind, and in order to properly explore the subsurface in the Lewiston area, another test well was drilled on the L. D. Bodily farm, approximately 200 feet west of the northeast corner of Section 17, Township 14 North, Range 1 East, Salt Lake Base Meridian (see Fig. 1).

**Log of Test Well No. 2**

The first 19 feet was sand with some clay, and from there to a depth of 225 feet the formation was all the same blue clay encountered in Test Well No. 1. The drill was in blue clay when drilling was discontinued. Log of the well is shown in Fig. 22, and picture of drilling the well is shown in Fig. 23.

**TEST WELL NO. 3**

Test well No. 3 was located on the Lorain Karren farm approximately three-eighths mile west of the southeast corner of Section 6, Township 14 North, Range 1 East, Salt Lake Base Meridian.
Log of Test Well No. 3

Results were much the same as for Test Well No. 2. Sand with some clay to 22 feet, then blue clay to 255, where the driller was stopped. The log of test well No. 3 is Fig. 24 and the picture of drilling is Fig. 25.

DRAINAGE BY DEEP WELL PUMPING

The results of the three test wells prove that there is no possibility of drainage by pumping from the lower strata. It appears that no artesian basin exists here. The pressure head in the gravel stratum at the 124-feet depth caused the water to stand in the well casing at 25 feet from the ground surface, while the water just outside the casing is 3 feet from the ground surface, a difference of 22 feet. This indicates a vertical gradient of $\frac{22}{121} = 0.182$, with the movement in a downward direction. This gradient can be increased by pumping, but only a limited amount; i.e., assume a drawdown in the well of an additional 22 feet, then the gradient would be doubled.

Possible drainage by pumping shallow surface wells will be discussed later.
PART IV

DRAINAGE BY PIPE DRAINS

NEW EXPERIMENTS

Three test wells seemed to indicate that drainage could not be accomplished by pumping from deep wells. The next experiments were conducted on a gravity pipe drain.

An agreement was made between the Utah Agricultural Experiment Station, the Utah Power and Light Company, and the Amalgamated Sugar Company to construct a drain on the Amalgamated Sugar Company farm at Lewiston, Utah.

CONCRETE PIPE EXPERIMENTAL DRAIN

The pipe drain, which was constructed for both practical and experimental purposes, consisted of 3200 feet of standard tongue and groove concrete irrigation pipe, part of which was 8 inches in diameter and part 6 inches.

Location and Description

The outlet for the drain is into the Cub River at a point approximately 750-feet south and 900-feet west of the northeast corner of the northwest quarter of Section 10, Township 1½ North, Range 1 East (see Fig. 1). From the outlet, the drain extends 1360-feet west, thence 1800-feet south.

Depth and Slope

The drain ranges in depth from 5 feet near the outlet to a maximum of 7.4 feet near station 10+00, and the slope is 3 feet per 1000 feet.
Methods of Construction

The drain trench was constructed largely by use of a rotating drainage machine excavator. Hand excavation was adopted only for a section of the trench near the intersection of the drain line with a city pipe line.

SPECIFICATIONS

The quality of pipe used, together with methods of placing and stabilizing the pipe, are described in the specifications which follow.

"All of the materials used for the drainage system, and all of the work done under these specifications, shall be inspected and approved by the engineer representing the cooperating agencies, or by his agent. Defective or broken tile, or cracked drainage pipe, or pipe or tile having chipped ends shall be rejected by the engineer. Defective or unsatisfactory workmanship of any type or kind shall be corrected and made satisfactory to the engineer.

Steel Pipe

"From the outlet of the concrete pipe at Station 0+00, a 6-inch diameter, 12-gauge spi-weld steel pipe shall be placed by the Amalgamated Sugar Company (landowner) down to the Cub River to convey the drainage water without eroding the sidehill soil.

Concrete Pipe

"The concrete pipe shall be Standard Concrete Tongue and Groove Irrigation Pipe constructed under A.S.T.M. designation C 118-39. The groove-end of the pipe shall be placed downstream and the tongue-end shall be placed upstream. From Station 0+00 to Station 13+60, at the point of the proposed sandbox, 8-inch I.D. pipe shall be used. The length of each section of pipe from Station 0+00 to Station 8+00 shall be not less than 3 feet. For Stations above 8+00, the length of each section may be 2 or 2.5 feet.

Placing the Pipe

"Special care shall be used to place the concrete pipe on uniform grade and uniform line. The groove-end of each length of concrete pipe shall be placed closely over the tongue-end next below.

8. From Specifications of Pipe Drain on file in the office of O. W. Israelson, U.S.A.C., Logan, Utah
"A gravel envelope consisting of 1 cu ft of pea gravel, diameter from one-eighth inch to one-fourth inch, furnished by the Sugar Company, shall be placed in the hopper of the trenching machine by the Sugar Company men, at each joint of the 8-inch diameter pipe. For the 6-inch-diameter concrete pipe, a gravel envelope of three-fourth cu ft of fine gravel shall be placed at each joint.

"Wrapping of the entire pipe at each joint with asphalt paper, satisfactory to the engineer, will be required of the contractor wherever the stability of the soil foundation indicates the necessity of such wrapping. Decision of the engineer in charge will be final with respect to the requirements for wrapping.

Sandboxes

"At Station 13+60, at the upper end of the E-W line, a reinforced concrete sandbox, rectangular in shape, 4 feet by 4 feet inside dimensions, shall be constructed by the Sugar Company according to details presented in Figs. 26 and 27. The thickness of the walls shall be increased to 9 inches provided steel is not available for reinforcement. Clean water, sand, and gravel shall be used. The ratio of cement to sand and gravel by volume shall be 1:2:4.

Crossing City Water Line

"At the intersection of the drain line with Lewiston City water line at a point approximately 900-feet south of the Sandbox, hand excavation will be required of the contractor at a distance approximately 30-feet north and 30-feet south of the water main. Immediately under the water main for a distance of approximately 10 feet, the contractor shall tunnel the trench by hand and place the concrete pipe and fine gravel in the tunnel. Contractor shall be responsible for any damage that may occur to the city water line while the concrete drainage pipe is being placed."

CONSTRUCTION

Contract for Trenching, Laying, Blinding, etc.

The Sumner G. Margetts Engineering Company of Salt Lake City, Utah was employed to dig the trench, lay the pipe and take care of blinding.2/

---

9. Blinding consists of a cover of about 2 feet of soil over the pipe for protection and holding in place.
Equipment

Equipment owned by Margetts Company consists of a large self designed machine for digging the trench and laying the pipe in one operation. Pictures of the machine are shown in Figs. 28 and 29. A man works in a rear compartment of the machine placing the pipe. As each length of pipe was placed it was forced into position by means of a hydraulic plunger with a total force of from 60 to 100 pounds, insuring tight joints. Figs. 30 and 31 show the opening where the pipe layer works. In Fig. 30 the worker at the extreme left is looking into the pipe layer's compartment.

The gravel shute, also extreme rear, Figs. 30 and 31, is kept full of pea gravel (1/4 to 1/8 in diameter), as the machine moves along the trench this shute covers the pipe on the top and sides with from 2 to 3 inches of gravel. The gravel forms a filter around the pipe to keep out the sand and to let water through to the pipe.

The pipe and gravel are laid out along the trench site as indicated by the picture, Fig. 32. The machine is kept accurately on line and grade by means of targets set at 100-foot intervals ahead of the machine as also shown in Fig. 32.

Pipe

Concrete pipe, as described in specifications, was furnished by the Utah-Idaho Concrete Pipe Company of Salt Lake City, Utah.

Gravel

Gravel was furnished by the Kloepfer Sand and Gravel Company of Logan, Utah.

Digging Trench and Laying Pipe

The machine for digging the trench and laying the pipe moved to the Amalgamated Sugar Company property on December 11, 1947 and started
to work December 12, 1947. The first 600 feet of the trenching and laying was accomplished very rapidly. The soil moved had very little water in it and the trenching machine made a clean cut and proceeded with little difficulty. Fig. 33 shows how the trench is left when digging in this type of material, as for example, on the afternoon of December 12th, the machine moved almost 300 feet in two hours.

After 600 feet of construction had been completed, difficulty was encountered. The sand had water in it and was not very stable, (see Fig. 34). The banks of the trench would cave (see Fig. 35) and the machine would have to lift out about five times as much material as would otherwise have been necessary. The elevator of the machine would not move the soil back far enough from the edge to keep it from falling back into the trench. This obstacle greatly hampered progress.

The greatest trouble occurred when the depth was increased. The operator of the machine believed that the depth of the trench should be decreased for proper progress. The operator agreed to try to keep to grade until station 13+60 was reached. If grade was changed before the turn was reached, the pipe might fill with sand where the change in slope occurred. Station 13+60 was finally reached at grade, as shown by Fig. 36.

The owner of the machine, Mr. Margetts, as his contribution to the success of the drainage system, agreed to extend the east-west line to the fence, another 380 feet, at his expense if the Experiment Station and the Amalgamated Sugar Company would furnish the pipe and gravel.

The decrease in depth from 7.5 to 6.5 feet seemed to solve, to some extent, the problem of quicksand. The machine moved much faster and more steadily at this depth. This indicated that the machine was designed for depths less than about seven feet.
Only one other obstacle caused difficulty on the north-south line, this was crossing the city water main at the intersection of the trench and the east-west road. This job necessitated a great deal of hand labor. The trenching and pipe laying was completed December 27, 1947.

The location of the pipe drain is shown on a map of the Sugar Company farm, Fig. 38. Profiles of completed trench are shown in Figs. 36 and 37. Fig. 39 shows the outlet of the drain just after completion and Fig. 40 shows the outlet of the drain after completion of the receiving box. Fig. 41 shows the inside of the receiving box.

**COST DATA**

Trenching, Laying Pipe, Blinding, etc.

<table>
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<tr>
<th>Depth</th>
<th>Station</th>
<th>Distance</th>
<th>Cost per ft</th>
<th>Total Cost</th>
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<td>Ft</td>
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<td></td>
</tr>
<tr>
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<td>$ .46</td>
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<tr>
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<tr>
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<td>840</td>
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<td></td>
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Right angle turn

Under water main

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<tr>
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</tr>
<tr>
<td>1700.90</td>
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</table>
Totals

1. Digging, right turn, blinding, etc. $1700.90
2. Concrete pipe 1265.34
3. Gravel 176.32
4. Labor - hauling gravel and pipe 492.50
5. Backfill with bulldozer 100.00

TOTAL $3735.06

Cost per Acre Total Farm

The Sugar Company farm drained by this pipe line is approximately 100 acres (see Fig. 38). Cost per acre $3735.06 = $37.35

Cost per Acre of Influence Radius

If we assume that the drain had an influence for a distance on each side of only 400 feet, then the area would be

\[
\frac{1360 \times 800 + 1800 \times 800 - 400 \times 400}{43,680} = 55 \text{ acres, and the cost} = \frac{3735.06}{55} = $70.00 \text{ per acre, approximately.}
\]

RESULTS

Studies were made of the ground water table during the summer and just before trenching was begun. Fig. 14 shows a profile of the north-south line near where the trench was constructed. These results compare quite favorably with the line marked O.W.S. (original water surface) on the profiles, Figs. 42 to 49, taken just before trenching started.

Readings on the ground water table were made by boring four-inch holes at 50-foot intervals on lines perpendicular to the trench. The depths to water were measured, then, in the 4-inch holes. The profiles, Figs. 42 to 49, on stations indicated on map, Fig. 38, show results of

10. Approximate, not finished yet.
the pipe drain. The ground surface is marked G.S., the original water surface is marked O.W.S. The drawdown curves are shown on various dates when readings of ground water surface were made.

These results prove conclusively the effectiveness of depletion of ground water and lowering of water table over short periods of time. The weather has not permitted a long period study of the ground water table.
Other possible methods of removing the excess ground water from the Lewiston area soils have been considered. Some of them are outlined here.

Shallow Large-Diameter Well

This method would be to construct a large-diameter (20- to 40-inch) hole with casing on the sides. A small diameter pipe (6- to 12-inches) would be put on the inside and a graded gravel envelope placed between the two casings. The outside casing would be retracted approximately half way. The depth of the well would vary, being driven to the clay in each case. After the outside casing is retracted, the well would be pumped and developed. (4) (5)

This method does not appear to be promising because of the small amount of water that might be obtained. Using the formula, Fig. 16

\[
k = 4.35 \times 10^{-5} \text{ as calculated}
\]

\[
H = 17 \text{ feet}
\]

\[
h = 5 \text{ feet}
\]

\[
r = .5
\]

\[
R = 400
\]

the discharge of well \( Q_w \) is then,

\[
Q_w = \frac{17 \times 4.35 \times 10^{-5} (17^2 - 5^2)}{2.303 \log_{10} \frac{400}{15}}
\]

\[
Q = .00795 \text{ cfs} = 3.85 \text{ gpm}
\]

Further and more extensive study of permeability (k) may justify increased estimates of flow in wells and drains.
This amount of water appears to be too small to do very much drainage.

Variations of Larger-Diameter Wells

As was shown in previous paragraphs, the large diameter well alone might not yield enough water to do much good. It may be possible to construct some drains leading into the well. If we assume two lines, one on either side of the well, 500-feet long, and using Hogentogler's (5) formula to compute the discharge,

\[
Q = \frac{m k h_l^2}{R}
\]

- \(Q\) = discharge of line
- \(m\) = the width of vertical face, or in this case the length of line.
- \(k\) = coefficient of permeability
- \(h_l\) = distance from bottom of pipe to ground water table
- \(R\) = distance influenced on either side of the drain

\[k = 4.35 \times 10^{-5}\text{ ft per sec}\]
\[m = 1,000\text{ feet}\]
\[h_l = 15\text{ feet}\]
\[R = 400\text{ feet}\]
\[
Q = \frac{1000 \times 4.35 \times 10^{-5} \times 15^2}{400}
\]
\[
Q = 0.025\text{ cfs or 12 gpm}
\]

total
\[
Q = Q_{\text{well}} + Q_{\text{line}}
\]
\[
Q = 3.85 + 12 \text{ or approximately 16 gpm}
\]

The result of 12 gpm per 1000 feet of line checks fairly closely with the present drainage system already installed, which yields from 30 to 40 gpm for 3650 feet of line or approximately 10 gpm per 1000 feet. The flow from the assumed situation should be greater because it is assumed to be at a depth of about 20 feet while present drain is approximately 6.5 feet.
It may be possible to drain quite large areas of land with such a system of drains and wells. Any number of arrangements of wells and drains could be tried. The best arrangement could only be determined by experiment.

Collecting Basins

Any of the preceding suggestions may be used in connection with a collecting basin at the bottom of the well. By using a float that would start and stop the pump automatically the pump would drain the collecting basin, then turn off until more water had been collected to pump, then the float would automatically turn the pump on again and the procedure would be repeated.

Large Main Drains

The best solution may be large deep drains for main drains emptying either into the Cub River or into the Bear River. Small lateral drains could then discharge into the main drains for disposal of the water. The problem is how to get the drains (either open or closed) to a depth capable of adequate drainage. A machine such as was used on the Amalgamated Sugar Company farm could be designed to go several feet deeper. By making it larger so it could move the spoil bank back farther from the trench, it could trench and lay pipe as it went to a greater depth.

A representative of the Johansen Construction Company of Salt Lake City maintains that pipe drains have been put to a depth of twelve feet in the worst kind of quicksand by use of two draglines, one to dig and one to lay pipe.

RECOMMENDATIONS

Canals

Investigations should be made as to possible lining of canals to
prevent seepage. Low cost lining now being tested should be considered for this area. Lining as was used in the Delta area, Utah (6), might be used.

Application of Water

A change in method of application of irrigation water from sub-irrigation to flooding, using the check method or possibly furrows in some cases, to eliminate the necessity of building up the water table to irrigate.

Open Drains

Open drains will be needed for some time even if another system of drainage is installed. They will continue to remove surface water and a certain amount of ground water.

The open drains should be properly maintained. Periodic cleaning by use of V-ditchers would help keep down moss and tend to keep an open channel through cattails, and would also remove trash and dry weeds that have blown in. Chemical means may be adviseable for use in eliminating vegetation in drains. The slope of the drain in many cases, should be increased. Some drains are just catch pools that hold water a while and it moves on through to the land below.

Closed Drains

Closed drains should be installed wherever outlets and slope are adequate. It may be found possible to put them over the entire area by having them dump into large closed drains. Closed drains have the advantage of less maintenance and do not take the land out of production.

---

12. Many low cost linings are now being tested by Dr. C. W. Lauritzen in Utah Experiment Station Project 211, U.S.A.C., Logan, Utah

13. Closed drain here refers to pipe or tile drains put into the ground and covered up.
as open drains do. This fact is brought out by comparing Fig. 10, open drain, and Figs. 50 and 51, closed drains just completed. By using proper care to install drains, and proper gravel filters around the pipe, a closed drain has the advantage of efficiency and low maintenance, among other important factors. It may be found necessary by experiment to completely surround the pipe or tile with gravel.

**Wells**

Further study should be made on large diameter shallow wells or a variation of them. The installation of a large-diameter well would provide a method of measuring the permeability of the soil in place. To know the permeability, as could be determined by several tests on a large-diameter well, would be valuable as an aid in solving the drainage problem in the Lewiston area. A large-diameter well would allow the determination of the radius of influence, an all important factor as to the success of drainage by wells.

The value of the information acquired from a large-diameter well, even though now there appears to be a question as to its feasibility, would justify the cost of construction and testing.

**SUMMARY**

1. Early water from Cub River applied to Lewiston area farms was not enough to raise the water table to a detrimental stage.

2. Late season water pumped from Bear River starting in 1918 put more water on the Lewiston flat than was leaving by deep percolation, runoff, transpiration and evaporation.

3. Application of late season water, applying water by use of sub-irrigation methods, seepage from canals, and very little opportunity for
ground water to escape from the Lewiston area soils have all contributed to a rise in the water table to a point where it is detrimental to the crops, and only a portion of the possible yield can now be attained.

4. Open drains have helped the drainage situation some, but they are not deep enough and not properly maintained. They do not lower the water table sufficiently to permit maximum production.

5. Test wells indicate that it is impossible to drain by pumping water from the lower strata.

6. Results from a pipe drain constructed indicate that such drains will lower the water table and improve soil conditions.

7. To improve conditions the following recommendations are made:

1) lining of many canals
2) investigation of possible change in methods of application of water
3) proper maintenance of open drains
4) install closed drains wherever possible
5) further investigations as to the advisability of shallow wells and/or deep drains and further testing of permeability and distance of influence.
BIBLIOGRAPHY


FIGURES
Map of Lewiston Area
1948

Scale:
1 inch = 1 mile
Fig. 1
**PROFILE "A"**

Ground Surface

Distance in feet

**PROFILE "B"**

Ground Surface
Fig. 4 Canal Bed Above Ground Surface. The canals are elevated so that the bottom of the canal is above the ground surface. Eldon G. Hanson in picture.

Fig. 5 Canal Bed Above Ground Surface. The canals are elevated so that the bottom of the canal is above the ground surface.
Fig. 6 Canal Bed Above Ground Surface. The canals are elevated so that the bottom of the canal is above the ground surface.

Fig. 7 Sub-Irrigation. Water from the center ditch percolates to the ground water table and then laterally a distance of approximately 200 feet to irrigate lands on either side.
Fig. 8 Open Drain Only Five Months After Construction. A new open drain shows sloughing of banks and large area used.

Fig. 9 Old Open Drain. This open drain, constructed years ago, has been cleaned occasionally and become four or five times as wide as originally.
Fig. 10 **Old Open Drain with Spoil Bank.** This drain shows much the same condition as the drain in figure 9. Large spoil banks grow many weeds on land that could be under cultivation if the banks were leveled.

Fig. 11 **Cattails in Open Drain.** Cattails grow very well in the bottom of drains. Many open drains, filled like this, cause reduction of velocity of flow of water in the drain and also from the soil to the drain.
Fig. 12 Tumble Weeds in Open Drain. In the fall when winds blow tumble weeds, open drains in many cases are the final resting place for the weeds.

Fig. 13 Trash and Willows in Open Drains. Open drains are low and trash accumulates in them readily. The moist soil of the drains supports the growth of willows.
Fig. 15 Eleven-foot Depth Well. Used for preliminary tests in Lewiston Area, Utah, July, 1947.
Fig. 16  Pumping From Surface Stratum

\[ Q = \pi k \frac{H^2 - h^2}{\log\frac{R}{r}} \]

- **\( Q \)** = Rate of extraction in cubic feet per day
- **\( k \)** = Permeability in feet per day
- **\( r \)** = Radius of well in feet
- **\( R \)** = Radius of circle of influence in feet
- **\( h \)** = Distance from well bottom to draw down curve in feet
- **\( H \)** = Distance from well bottom to original water table in feet
Fig. 17 Robert Johnson Drilling Equipment. Jet equipment used to drill test wells in Lewiston Area, Utah.
Depth in feet

0

20

40

60

80

100

120

140

160

180

200

Soil-Water table at 3'

Sand

Water in well

Blue Clay

Blue Clay - Little Sand

Sand

Blue Clay - Little Sand

Clay and Gravel

Gravel - 80 GPM

Clay and Sand

Clay and Gravel

Clay

Sand and Gravel

Clay and Sand (White)

Sand (Mixture) Clay

Gravel

Clay
Fig. 19 Test Well No. 1. Drilled on Amalgamated Sugar Company farm, Lewiston. Air compressor in background used for testing well.
Fig. 20  AIR LIFT

Level of water in well

3/4" pipe

1/4" pipe

Perforations (Source of water in well)

AIR LIFT NOZZLE
Fig. 21 "Pumping Test Well No. 1. Air compressor method used to pump 80 g.p.m. from Test Well No.1. Photo by O. W. Israelsen."
Depth in feet

Soil - Water table at 3'
Sand and Clay

Blue Clay

Sand

Blue Clay

Project 285
TEST WELL-2
Lewiston area, Utah
Oct. 1947
Scale 1"=30'
Fig 22
Fig. 23 Test Well No. 2. Drilled on L. D. Bodily farm, Lewiston.
Soil
Water table at 6'
Sand and Clay

(Clay started brown changed to blue)

Blue Clay
Fig. 25 Test Well No. 3. Drilled on Lorain Karren farm, Lewiston.
Amalgamated Sugar Co.

Lewiston, Utah

Sand Box
Utah Agricultural Exp. Sta. Proj. 285
18 Nov. 1947

Top View

Cover - 4'4" x 4'4"
2" plank laid both directions - solid.
Sand Box
Utah Agricultural Exp. Sta. Proj. 285
18 Nov., 1947

Fig. 27
Sheet 2

Side View

Steel
$rac{3}{4}$" $\phi$
6" Ctr. to Ctr.

$rac{1}{4}$" $\phi$
12" Ctr. to Ctr.

If no steel
make wall
9" thick.

6" Tile West

6" Tile East

6" Tile North

6" Tile

To Clay or put in 1' of gravel and rock.
Fig. 28  **Trenching and Pipe Laying Machine.** Owned by Sumner G. Margetts Co., Salt Lake City, Utah. Digs trench, lays pipe and places gravel, all in one operation.

Fig. 29  **Trenching Machine.** Another view.
Fig. 30  **Pipe Layer Compartment and Gravel Chute.** The fellow at the left is looking into the compartment where the pipe layer works. The hands of the worker at the right are on the gravel chute.

Fig. 31  **Extreme Rear of Machine.** Pipe layer's compartment and gravel chute.
Fig. 32 **Pipe and Gravel.**
The machine (in the background) uses the pipe and gravel as it proceeds along the track. A target to keep the machine of the grade is shown in front of the machine.

Fig. 33 **Easy Digging.**
Material contains no water and it is easy to construct trench.
Fig. 34 Muck. Material is soft and runny and has been lifted out of the trench many times.

Fig. 35 Caving Trench. The material underneath flows into the trench and leaves no support for surface material.
Amalgamated Sugar Co.
Farm
Lewiston, Utah

Profile of Pipe Drain
South from Sta. 13+60
Utah Agricultural Experiment Sta. Pro. 285
Scale: Vert 1 in = 5 ft
Horiz 1 in = 200 ft

Date: 12-10-47
Fig. 37
Fig. 39 Outlet. Water flowing from constructed drain. D.E. Smith, Manager of Amalgamated Sugar Company in Lewiston.

Fig. 40 Outlet After Completion of Receiving Box. Water is piped on down the steep hill to prevent erosion.
Fig. 41 Receiving Box. Incoming water from drain. Outgoing water in steel pipe to Cub River.
Amalgamated Sugar Co.

Lewiston, Utah

Ground Water Profile at
Stn. 10+00 W
Fig. 42
Amalgamated Sugar Co.

Lewiston, Utah

Ground Water Profile at

5th Apr. 50 S

Exp. Sta. Pro. 285 - '47
Fig. 50  **Pipe Drain After Completion.** Land is again level and ready for farming.

Fig. 51  **Pipe Drain After Completion.** Another level spot to produce crops.