UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
Soil and Water Conservation Branch
Irrigation and Drainage Investigations

PROGRESS REPORT ON DRAINAGE INVESTIGATIONS

EMMETT VALLEY
GEM COUNTY, IDAHO

By

George B. Bradshaw
Drainage Engineer

(A report based on data gathered under cooperative agreement with the Soil Conservation Service, the Idaho Agricultural Experiment Station Gem County Board of Commissioners, Gem County Production and Marketing Administration, U. S. Bureau of Reclamation, and the U. S. Geological Survey, during 1951 to 1954)

Boise, Idaho
May 1954

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FOREWORD

This second progress report on the drainage investigation in Emmett Valley, Gem County, Idaho contains a detailed account of the methods used and data obtained since January 1, 1953 to date.

After consultation with personnel of cooperating agencies and other recognized authorities in the drainage field on the obtained data, the author has suggested an overall plan for the drainage and reclamation of the problem area.

It is hoped that these recommendations will soon be put into effect so that the problem area can be restored to full agricultural production.

Claude H. Pair

Project Supervisor

ORGANIZATION

The Gem County Drainage Investigation is being conducted under a memorandum of understanding between the Idaho Department of Reclamation, the Idaho Agricultural Experiment Station, the Bureau of Plant Industry, Soils, and Agricultural Engineering, the U. S. Regional Salinity Laboratory, Agricultural Research Administration, the Soil Conservation Service, U. S. Department of Agriculture and the Bureau of Reclamation, U. S. Department of Interior.

A joint working plan entitled "Payette Valley Drainage Investigations, Gem County, Idaho," describing the procedures to be used, was signed by the following cooperating agencies.

1. U. S. Department of Agriculture, Soil Conservation Service.
   (a) Division of Irrigation Engineering and Water Conservation. 1/
   (b) Operations Division.
2. Idaho Agricultural Experiment Station.
3. Gem County Board of Commissioners.
4. U. S. Bureau of Reclamation.
5. Gem County Production and Marketing Administration.

Members of the Emmett Valley Drainage Committee are:

Wayne D. Criddle, Chairman	Work Project Leader, Agricultural Research Serv.
R. N. Irving	Soil Conservation Service, State Conservationist.
Edwin J. Core	Soil Conservation Service, Unit Office
Lester V. Benjamin	Soil Conservation Service, Area Conservationist.
Victor Myers	University of Idaho.
Keith Anderson	Bureau of Reclamation.
Mark Kulp	State Commissioner of Reclamation.
R. L. Nace	U. S. Geological Survey.
John Hereth	P.M.A., Gem County.
Roy Knox	Gem County Board of Commissioners.
Charles Pritzl	Canyon County Drainage District No. 1

1/ Since January 1, 1954, this work has been under the Soil and Water Conservation Research Branch, Agricultural Research Service.

Members of the Emmett Valley Drainage Committee, (Continued)

Davis Stoher- - - - - - - - - - - - - - - - - - - -	Canyon County Drainage District No. 2.
Irl Bishop- -	Gem County Drainage District No. 1.

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil and Water Conservation Research Branch
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Dr. Robert M. Salter- - - - - - - - - - - - - - -	Chief, Soil and Water Conservation Branch, Agricultural Research Service.
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Wayne D. Criddle- - - - - - - - - - - - - - - - -	Work Project Leader.
Claude H. Pair- - - - - - - - - - - - - - - - - -	Project Supervisor.
George B. Bradshaw- - - - - - - - - - - - - - - -	Project Leader.

Soil Conservation Service

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Lester Holmquist- - - - - - - - - - - - - - - - -	Engineering Aid

SUMMARY

The present Emmett Valley Drainage Investigation was started in August of 1951 as the result of recommendations made in May of 1951 by representatives of the Soil Conservation Service of the Department of Agriculture, Idaho Agricultural Experiment Station, Gem County Board of Commissioners, U. S. Bureau of Reclamation, U. S. Geological Survey and the Gem County Production and Marketing Administration.

The objectives of the drainage investigation have been:

1. To obtain basic physical data necessary to design drainage systems and reclaim water-logged and alkali-saline lands in the Emmett Valley.

2. To develop methods and techniques that might be applied to the solution of drainage and salt problems on lands in the inter-mountain and northwestern states.

The purpose of this report is to present a fairly detailed account of the significant work done to date and the results obtained since inception of the investigation.

The Emmett Valley, located in southwestern Idaho, has an area of about 80 square miles of which about 50 are farmed under irrigation. (See Figure 1 for location)

The climate of Emmett Valley is characterized by fairly low annual rainfall, light snowfall and moderate winter temperatures.

The problem area is characterized by barren spots, native alkali or salt tolerant plants. Native plants found in the water-logged alkali area include salt grass, salt brush, alkali weed, greasewood, poverty weed and foxtail. Stunted growth and off color plants can be observed in most of the affected area.

The problem soils of the Emmett Valley are generally characterized by high water table conditions, low salinity, high pH, high soluble and exchangeable sodium percentages and low rates of infiltration and permeability.

<u>Causes of the water-logged condition</u>

A survey of water-logged lands in the Emmett Valley indicates that 50% of the land is affected to severely water-logged. The causes of the severe water-logged condition in the valley cannot be attributed to any one factor. The problem water in the valley has its source from a combination of the following:

1. Over-irrigation on the valley floor.

2. Irrigation and canal seepage from the Emmett Bench and the South Slope.

3. Ground water flowing down the valley.

4. Artesian water raising from below.

5. Seepage of precipitation from adjacent hills.

6. Seepage from local sloughs, stagnant drains, ditches and ponds.

Correlation between the artesian well locations and the water-logged area indicate that the artesian aquifer is directly associated with the valley-wide water-logged condition. Water from the above sources, with the exception of item 4, moves down slope into a mammoth soil change. This soil change consists of the alluvial fan or fans that form the artesian aquifer. Artesian water moving up valley in the aquifer forms an impermeable wall or dam in excess of 600 feet deep. This buried fan retards the ground water movement down the valley and is the primary cause of the water-logging.

Drainage plan

The over-all valley drainage plan should employ a combination of open drains, tile drains and drainage wells. The most feasible and economical plan will be to install drainage wells where the aquifer, economics and other conditions permits and open or tile drains where they will give the maximum benefit for the least cost.

Alkali reclamation

Reclamation of the alkali soils following drainage should be put on a pay as you go basis. On lighter textured alkali soils an application of two or three tons per acre of gypsum or other soil amendments can be applied initially to start the reclamation process. For heavier textured soils each application may have to be increased to 5 tons per acre. When this gypsum is used up or the beneficial effect is worn off another application should be applied. This procedure will spread the soil amendment cost over a period of years and still allow the farmer to realize a return from the land.

Irrigation recommendations

A strong effort should be made to prevent applications of excess irrigation water. An irrigation study should be made in the Emmett Valley to determine the best unit irrigation stream for border irrigation and to delineate the sahllow soil areas that should be sprinkler irrigated.

Border, basin or sprinkler irrigation should be used on the alkali soils. As much of the soil as possible should be under water during the irrigation. This maintains the smallest area for salts and alkali to "wick up" and accumulate in.

Cropping practices

Alkali tolerant crops should be planted on the problem soils during the reclamation period. Crops that grow well under border basin or sprinkler irrigation should be selected.

ACKNOWLEDGEMENTS

Credit is given to the following persons and agencies for their assistance and cooperation in initiating and evaluating the Emmett Valley Drainage Investigation.

Mrs. Edith Florence, Agricultural Stabilization and Conservation secretary, local office staff and the County Committeemen for their assistance in making farmer contacts, assisting with field surveying, conducting farmer questionaires and making office space and field personnel available in Emmett.

Mr. Lester Holmquist, soil conservation Service, for his assistance with more than 20,000 field measurements and observations that have been made since the investigation was initiated.

The following persons for their assistance in evaluating the data collected and the recommendations made.

Mr. Keith Anderson - - - - - - - -	U. S. Bureau of Reclamation.
Mr. R. L. Nace - - - - - - - - - -	U. S. Geological Survey.
Mr. Wallace Hart - - - - - - - - -	Construction Contractor.
Mr. Paul Durand- - - - - - - - - -	A. A. Durand and Sons, Well Drilling and Development Contractors.
Mr. Dell Shockley- - - - - - - - -	Soil Conservation Service.
Mr. W. W. Donnan - - - - - - - - -	Agricultural Research Service.
Dr. Milton Fireman - - - - - - - -	U. S. Salinity Laboratory.
Mr. R. C. Reeve- - - - - - - - - -	U. S. Salinity Laboratory.
Mr. Ross K. Petersen - - - - - - -	Johnson Well Screen Company.
Dr. Vaughn E. Hansen - - - - - - -	Agricultural Research Service.
Mr. W. D. Criddle- - - - - - - - -	Agricultural Research Service.
Mr. Claude Pair- - - - - - - - - -	Agricultural Research Service.

Mr. Morlan W. Nelson, Soil Conservation Service for his assistance with both the general alkali problem and initiation of the alkali investigation.

Messrs. Sterling Davis, from the Agricultural Research Service and Dick Harpt, and John Rinard, Soil Conservation Service, for their assistance in making topographic and piezometric line and elevation surveys.

Mr. John Hull, former Area Conservationist, Soil Conservation Service, for his assistance in initiating the drainage investigation.

ACKNOWLEDGEMENTS
(Continued)

Mr. John Turner, Armco Drainage and Metal Products, and the Pioneer Irrigation District for their assistance in assembling information on the 30 irrigation and drainage wells in the Pioneer Irrigation District.

The U. S. Bureau of Reclamation for making their ground water data adjacent to the Black Canyon Canal available, and for assistance on soil and water analysis, and other technical advice.

The University of Idaho for making the alkali and soil survey of the Emmett Valley available prior to publication and for assisting on water analysis, and other technical advice.

The Gem County Commissioners and shop foreman for making funds, automotive storage space and shop facilities available at Emmett.

Mrs. Alice Hanley and Mrs. Ann Hicks for typing, editing and stenciling the report.

PROGRESS REPORT ON DRAINAGE INVESTIGATIONS
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EMMETT VALLEY, GEM COUNTY IDAHO
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INTRODUCTION

The present Emmett Valley Drainage Investigation was started in August 1951 as the result of recommendations made in May 1951 by representatives of the Soil Conservation Service of the Department of Agriculture, Idaho Agricultural Experiment Station, Gem County Board of Commissioners, U. S. Bureau of Reclamation, U. S. Geological Survey and the Gem County Production and Marketing Administration. The investigation has been conducted by the Agricultural Research Service under the guidance of the Emmett Valley Drainage Committee, representing the above-named agencies. The general methods and techniques used in the investigation were described in U. S. D. A. Technical Bulletin 1065, "Drainage Investigation Methods for Irrigated Areas in Western United States." (4) 1/

The objectives of the drainage study in the Emmett Valley were set forth in the Joint Working Plan for the Payette Valley Drainage Investigations:

1. To obtain basic physical data necessary to design drainage systems and reclaim water-logged and saline-alkali lands in the Emmett Valley.

2. To develop methods and techniques that might be applied to the solution of drainage and salt problems on lands in the intermountain and northwestern states.

It is the purpose of this report to present a fairly detailed account of the work done and the results obtained since inception of the investigation.

Description of the Area

The Emmett Valley, located in southwestern Idaho, has an area of about 80 square miles, of which about 50 square miles are farmed under irrigation. (See figure 1.) The valley is approximately 14 miles long and varies from 5 to 6 miles in width. The valley is fairly flat south of the river and slopes gently upward for about three miles to a low range of steep hills. The major part of this land lies a few feet above the level of the Payette river and is poorly drained. There is a narrow strip of bottom land between the river and the bench escarpment. This narrow strip is poorly drained and varies from slightly to

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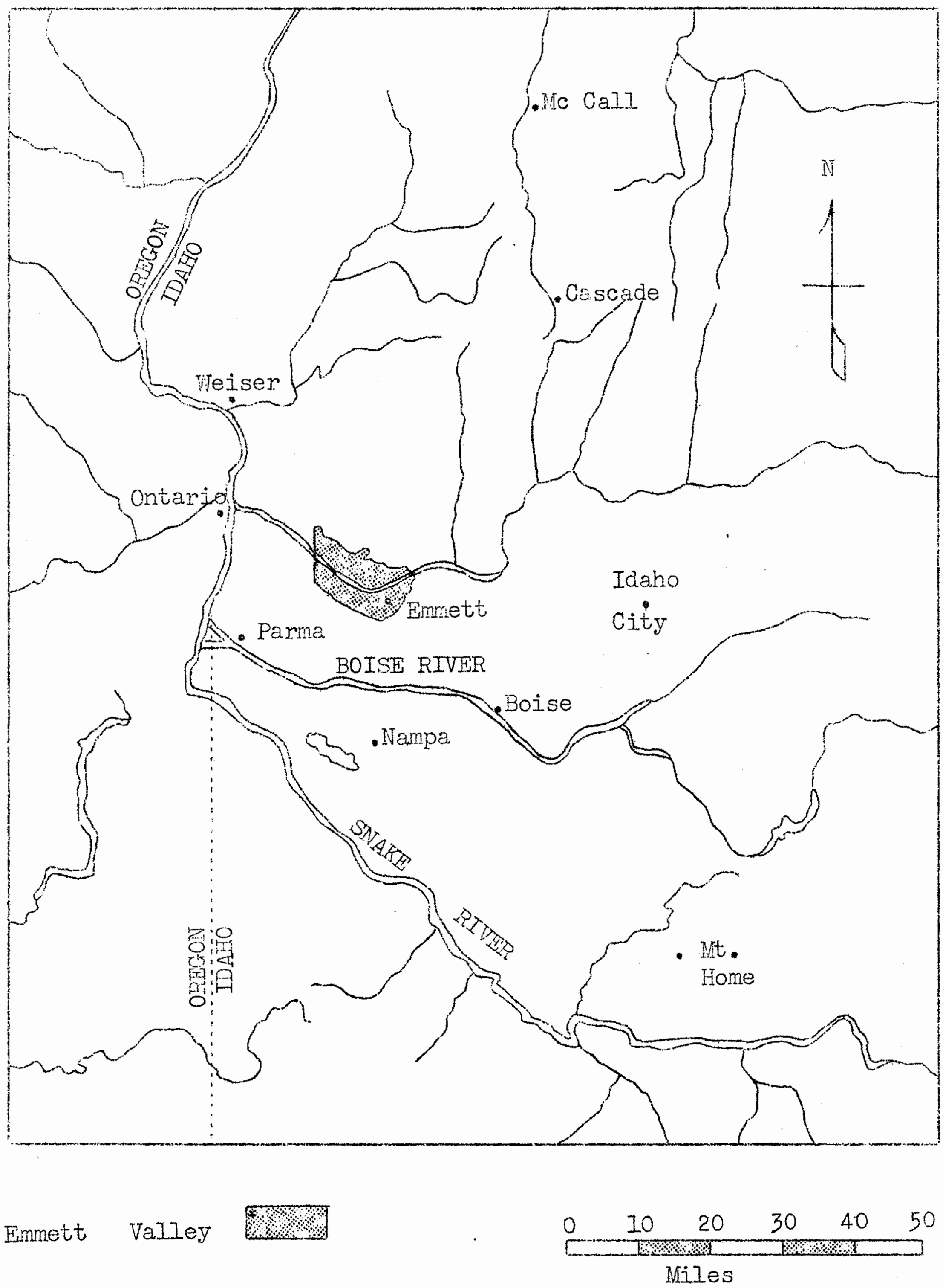
1/ Figures in parentheses refer to literature cited.

FIGURE 1

EMMETT VALLEY
LOCATION MAP

GEM COUNTY, IDAHO



severely water-logged. The steep escarpment is about 60 to 100 feet high. This escarpment is the southern boundary of the two to three miles of sloping river terraces.

Precipitation and Temperature

The climate of Emmett Valley is characterized by fairly low annual rainfall, light snowfall and moderate winter temperatures. The temperature, rainfall and frost-free periods of the Weather Bureau Stations at Emmett, Caldwell, and Parma are presented in tables 1 and 2.

Table 1. Temperatures, frost-free periods, and frost dates from Weather Bureau Stations in and near the Emmett Valley.

	Caldwell, Idaho		Emmett, Idaho		Parma, Idaho	
	48-year period	1953	46-year period	1953	30-year period	1953
Jan. avg. temp. °F.	28.3	42.1	29.1	41.9	27.8	41.4
July avg. temp. °F.	73.5	73.3	75.0	72.2	74.1	73.5
Maximum temp. °F.	107.0	104.0	109.0	105.0	111.0	100.0
Minimum temp. °F.	-34	9	-35	8	-27	6
Date of last spring killing frost (lower than 32°)	5/7	5/1	4/30	5/10	4/24	4/29
Date of first fall killing frost (lower than 32°)	10/3	10/3	9/26	10/3	10/9	10/3
Length of growing season in days	149	156	149	146	168	158

The average temperature for January 1953 was about 13 degrees warmer than the long time normal for the three stations. The average temperature for July 1953 was slightly below the normal.

The precipitation records (Table 2) shows the annual precipitation (October 1, 1952 and October 1, 1953) at Caldwell to be 24.3 percent above normal, at Emmett to be 53.4 percent above normal, and at Parma 23.8 percent above normal.

Crops of the Emmett Valley

Practically all the farms in the Emmett Valley are under irrigation. The principal crops are fruit, hay, grain, corn and sugar beets. Most of the hay and corn is grown on the valley benches; the major

Table 2. Monthly precipitation at three locations in and near the Emmett Valley.

	Caldwell, Idaho		Emmett, Idaho		Parma, Idaho	
	1952-53	Length of record average	1952-53	Length of record average	1952-53	Length of record average
	inches	inches	inches	inches	inches	inches
October	Trace	0.78	0.00	0.90	0.00	0.77
November	0.71	1.14	1.03	1.31	0.54	0.98
December	1.17	1.14	1.93	1.39	0.91	1.00
January	2.78	1.26	3.95	1.38	1.52	1.13
February	1.86	1.14	2.25	1.20	1.92	0.89
March	0.53	1.04	0.73	1.20	0.64	0.74
April	1.04	0.94	2.24	1.04	0.78	0.83
May	2.90	0.98	3.41	1.02	2.85	0.69
June	1.37	0.77	1.90	0.94	1.39	0.79
July	0.00	0.33	0.00	0.28	0.00	0.13
August	0.33	0.22	0.10	0.21	0.09	0.23
September	Trace	0.47	0.00	0.58	Trace	0.44
Annual	12.69	10.21	17.54	11.45	10.64	8.62

portion of the fruit is grown on the alluvial fans south of the river. The poorly drained land south and southwest of Emmett is used primarily as native pasture. Some of the water-logged areas have been reclaimed and are presently producing fairly good crops.

A summary of the acreage planted and the production per acre or per tree from 1919 to 1949, in Gem County was presented in table 3 of the June 1953 progress report. This table was summarized from the U. S. Department of Commerce, Bureau of the Census Reports. The increases in yields for the various crops do not necessarily indicate an increase in soil productivity. Better crop breeding and more resistant types of plants contribute greatly to the increase in yields.

In the early 1870's James Wardwell built a sawmill on the Payette River at the head of the lower valley, where the Umatilla stageline crossed the river. A postoffice called Emmettsville was built a few miles below the sawmill. A village grew up around the sawmill and in a few years the postoffice and name were transferred to the new settlement. Eventually, the settlement became a trading point for the lumbermen and stock raisers of the Payette Valley. The surrounding hills of unoccupied public lands made stock raising one of the natural industries of the early settlers. The fertile lands, the abundance of water, and the easy methods of irrigation soon made farming an industrial companion to stock raising. The soils, climate, and other factors were very favorable for the growing of prunes and other fruit. More fruit was shipped from Emmett during 1919 and 1920 than from any other point in Idaho. Nearly 15,000 acres of land in the vicinity of Emmett was planted to orchards. When Gem County was created on March 19, 1915, Emmett was made the County seat.

The first record indicating a drainage and alkali problem was obtained from "The Emmett Indix," published on December 31, 1903.

"The Block House Swamps" 1/. "Almost anyone in the Payette Valley can tell you where the Block House swamps are located, but very few can tell you where the name, which is a peculiar one, originated.

"The swamps, which lie about three miles southwest of Emmett have been in existence ever since the first settlers came to this valley. The reason of their being so well known, is that the swampy nature of the ground afforded great pasture for horses and cattle. It is said that the Indians would come down from the mountains in the winter and camp along the river. They would then turn their horses loose in the swamps and have no fear of not finding them in the spring, as they would not stray away, the country surrounding the swamps being extremely barren, devoid of all vegetation except sagebrush.

"In the early 60's four bachelors, George Andrews, Mose Rice, Tom Anderson and Jack Howard, took up a thousand acres of the swamp land and fenced it in for grazing purposes. They lived in a large house, which resembled an old time block house. It was located near the present road to Falk's store, about a half mile below the McNish sawmill. These old bachelors lived there a number of years. Because of the odd appearance of the house and their owning most of the swamp, someone started calling the swamps the "Block House" and it has been kept up ever since.

"There is only one drawback to the swamps as an ideal pasture land. It is full of pot holes, which are alkali gatherings, reminding one of a boil, being of the same shape. The center is full of very soft alkali mud in which a person or animal would sink from sight in a very short space of time if not rescued. Cattle have got into them and sunk. Some of the holes are as much as forty or fifty feet in circumference.

1/ The Emmett Index - December 31, 1903

"Attempts have been made to drain the swamps to convert them into farming land, but it is probable that they will be there for years, a great place for mallards, but no good for agricultural purposes."

The Problem

The problem areas of the Emmett Valley are generally characterized by high water table conditions and the soils have low salinity, high pH, high soluble and exchangeable sodium percentages and low rates of infiltration and permeability. (5)

Water-logging and alkali conditions have reduced the value and production of the soils of a large portion of the Emmett Valley. Water-logging has damaged approximately 35 square miles of land in the valley. This ranges from barely visible damage to bogs, swamps and complete abandonment. Water-logging in the valley is probably due to an aggregation of the following water sources.

1. Artesian water raising from below the surface soil.
2. Over-irrigation
3. Seepage from canals and ditches
4. Seepage from adjacent hills

A fairly large water-logged acreage is also attributed to soil changes. Soil changes occur where a horizontal soil stratum changes from a more to a less permeable one. These soil changes may be very slight from a sandy loam to a silt loam, or they may be very great and change from a coarse sand or gravel to a very slowly permeable clay. Ground water moving down from higher elevations is retarded by these soil changes. The ground water table is built up and water-logging occurs.

Alkali elements have damaged approximately 25 square miles in the valley. The part damaged is very extensive and is characterized by areas of poor germination or stunted plant growth, or by areas entirely barren. These unproductive areas are principally on the following soils:

1. Letha clay loams to sandy loams.
2. Reed silty clays to loams.
3. Cannon clays to gravelly clay loams.

Alkali and saline soils are usually formed as a result of a high water table or water-logged conditions. The ground water which contains dissolved salts rise to the surface by capillary action and evaporates, leaving soluble salts in the surface soil. The low rates of infiltration and permeability are possibly due to the alkali condition. The soil colloids tend to become saturated with sodium which generally results in poor soil structure and impaired permeability.

Native Vegetation of the Problem Area

The problem area is characterized by barren spots and native alkali or salt tolerant plants. Native plants found in the water-logged alkali area include salt grass, salt brush, alkali weed, greasewood, poverty weed and foxtail. Stunted growth and off color plants can be observed in most of the affected area.

Previous Investigations

At various times since 1915 Federal, County, and private agencies have made investigations in the Emmett Valley. Much progress has been made towards solving the drainage and reclamation problems. Some of these studies and investigations are listed below.

1. An investigation was started in 1915 on the Canyon County Drainage District No. 1 by Mr. E. O. Larson. Test wells were installed and readings made.

2. During 1918 crop survey maps were prepared for the Canyon County, District No. 1.

3. An investigation was made in the Canyon County Drainage District No. 2 with 75 test wells and 6 measuring stations for drainage flow.

4. An investigation was made in the Canyon County Drainage District No. 1 with 23 wells.

5. In 1936 the Bureau of Reclamation began an extensive study of the water tables around the southern edge of the valley adjacent to and below its Black Canyon Canal.

6. In 1940 an alkali and soil survey was initiated by the Idaho Agricultural Experiment Station and the Division of Soil Survey, B.P.I.S. and A.E.

7. In 1947 the Idaho Agricultural Experiment Station, the Division of Soil Surveys and the U. S. Regional Salinity Laboratory, B.P.I.S., and A. E. initiated an investigation to study characteristics of the saline and alkali soils and other soil problems of the area.

Glossary of Terms

Aggregates: Fragments or clods the soil forms during the drying and cracking process.

Alkali soil: Soils which have an excessive degree of saturation of exchangeable sodium in the base exchange complex. The exchangeable sodium percentage is greater than 15 and the conductivity of the saturation extract is less than 4 millimhos per cm - pH values 8.5 to 10.

Artesian aquifer: A confined water-bearing strata in the soil. The water is generally confined by a layer of slowly permeable clay or shale over the aquifer.

Color indicators: A complex dye which changes color with slight changes of pH values. Used in classifying soils with respect to acidity or alkalinity.

Electrical conductivity: The reciprocal of the electrical resistance in ohms of a conductor which is 1 cm. long and has a cross-sectional area of 1 sq. cm. A quantitative method of determining the degree of salinity in soil or water samples.

Evaporation ring: A twelve-inch length of well casing with a bottom welded on. Used in measuring the water lost to evaporation.

Exchangeable sodium percentage: The degree of saturation of the soil base exchange complex with sodium.

$$\text{e.s.p.} = \frac{\text{Exchangeable sodium}}{\text{Cation exchange capacity}} \times 100$$

Geochemical chart: A graphical method of analyzing ionic analysis data.

Ground water table: The upper boundary for ground water. It is the point at which the pressure in the water is equal to the atmospheric pressure.

Hydraulic gradient: The decrease in hydraulic head per unit distance in the direction of flow in the soil.

Infiltration rate: The rate of movement of water into the soil per unit of time.

Infiltration ring: A twelve-inch length of pipe or well casing to be used in measuring the infiltration rate of the soil.

Ionic analysis: The quantitative determination of the major cations and anions in the soil or water. Usually includes the following cations Ca, Na, K, Mg; anions Cl, SO_4, HCO_3 and CO_3.

Irrigation efficiency: The percentage of irrigation water delivered to the farm or field that is available in the soil for consumptive use by the crops.

Length of run: The distance water must travel in furrows or over the surface of the field from the head ditch to the end of the field.

Observation well: Hole in the ground used to determine the depth to water or hydrostatic pressure of the entire underground soil profile to the depth of the well. The well indicates the level of the surrounding ground water table.

pH: An expression of acidity or alkalinity. pH of 7 is neutral. Values grading below 7 become more acid and values ranging above, indicate stronger alkalinity.

Permeability: The volume of water crossing unit area in unit time with unit hydraulic gradient and at a standard temperature of $68^{o}F$. Expressed in inches per hour or centimeters per hour.

Piezometer: A pipe driven into the soil so that there is no leakage down the outside of the pipe and all entrance of water into the pipe is from the bottom. The piezometer indicates pressure at the point of entrance rather than the level of the ground water table.

Proctor Needle: Equipment for measuring the bearing load, in pounds per square inch, on a soil surface before the needle penetrates the soil.

Residual drawdown: Is the difference in feet between the initial water level in a well and the water level at the time of measurement.

Saline soil: Conductivity of the saturation extract is greater than 4 millimhos per cm. (at $25^{o}c$) and the exchangeable-sodium percent is greater than 15. The pH is generally above 8.5.

Soil change: A point where a soil stratigraphy changes from a more to a less permeable profile. This change may interfere with the movement of water through the soil.

Soluble sodium-percentage: This term is used in connection with irrigation waters and soil extracts to indicate the proportion of sodium ions in solution in relation to the total cation concentration.

Soil amendments: The most general soil amendments are gypsum, sulphur, limestone and sulfuric acid. They are applied to an alkali soil to reduce the exchangeable-sodium-percentage to a good crop-growing level.

Transmissibility: An aquifer permeability figure expressed in gallons per day per foot width of aquifer.

METHODS OF OBTAINING DATA

The methods of securing the basic data on the various studies were generally adapted from research in other areas. Additional needed techniques were developed as the investigation progressed. These techniques and methods have been modified and simplified to aid in deriving maximum production with limited personnel and equipment.

The following methods and techniques were used in obtaining the various sections of the report.

1. All available records were checked for information and data pertaining to the problem area. The more valuable data was assembled and included in this report.

2. An artesian well location survey was made on the portion of the valley south of the river.

3. Piezometers and wells were used to obtain the hydraulic gradient of the ground water table and to detect artesian pressures on the various farms studied.

4. Crop increases were obtained from individual farmers for the various farms studied.

5. Chemical analysis on various soil and water samples were made by the Bureau of Reclamation.

6. Water samples were analyzed with a conductance bridge during the alkali reclamation studies.

7. Infiltrometer rings were used to measure the effect of gypsum and various reclamation waters on the alkali soils.

8. Aggregates were recorded during the alkali reclamation studies on the Ranch I plot.

9. The structure, workability and amount of visible gypsum was recorded after each leaching period.

10. Proctor Needle readings were made in each ring after each leaching period to determine surface hardness.

11. The intake rate was measured in the rings with a standard evaporation hook gage.

12. The soil and water temperature was recorded for each infiltration period. These temperature readings were used to convert the intake rate to a standard temperature.

13. pH readings were made at each infiltration run to aid in analyzing the results in each ring.

14. A water-logged survey was made for the Emmett Valley. The land was catalogued under the following degrees of water-logging.

    a. Severely water-logged
    b. Moderately water-logged
    c. Effected
    d. Not effected

50 foot escarpment on its north side. This escarpment leads up to a gently sloping terrace or bench. This terrace is 1 to 3 miles wide and comprises the greater part of the valley on the north side of the river.

Soil Survey

A soil survey of the Emmett Valley area was initiated August 26, 1939 under a survey work plan for Gem County, Idaho in which the entire county outside of the National Forest was to be included. This area amounted to about 422 square miles. The Bureau of Plant Industry, Idaho Agricultural Experiment Station and Soil Conservation Service were listed as cooperating agencies.

In 1940 the survey was continued under a cooperative agreement between the Idaho Agricultural Experiment Station and the Division of Soil Survey, Bureau of Plant Industry Soils and Agricultural Engineering.

The terraces above the river probably were formed of river transported material mixed with material from the adjoining uplands of the Payette and Idaho formations, whereas, the river bottom lands and the soils south of the river are derived from more recent, mixed transported soil materials. The alluvial material deposited by the Payette river had its origin principally from acid to somewhat sub-basic igneous rocks, such as quartz, monzonite, granodirite, quartz diorite, and granite, which predominate in the drainage basin of the river above Emmett. A minor proportion probably was derived from basalt, which underlies a small part of the drainage basin, particularly Squaw Butte and the adjoining area north of Black Canyon. It is likely that a considerable admixture of quartz and other acid igneous material has been derived from the Payette and Idaho formations. A description of each soil series was given in the June 1953 progress report.

The general location and extent of the various soils series are shown in figure 2. The severely water-logged and problem area occurs primarily in areas of Letha, Reed, Canon and Muck soils. The Reed and some Muck soils do not lend themselves favorably to open or tile drains because of their thickness and low permeabilities.

Alkali Survey

An alkali survey, including alkali and saline conditions of the Emmett Valley area, was initiated in 1941 by the same personnel that made the soil survey. The alkali survey was conducted in conjunction with the soil survey. The various classes or degree of salinity and alkali were based mainly on obvious conditions of alkali and salinity as evidenced by salt accumulation, natural vegetation, crop growth and the morphology of the soils. These field observations were checked by conductivity and pH tests.

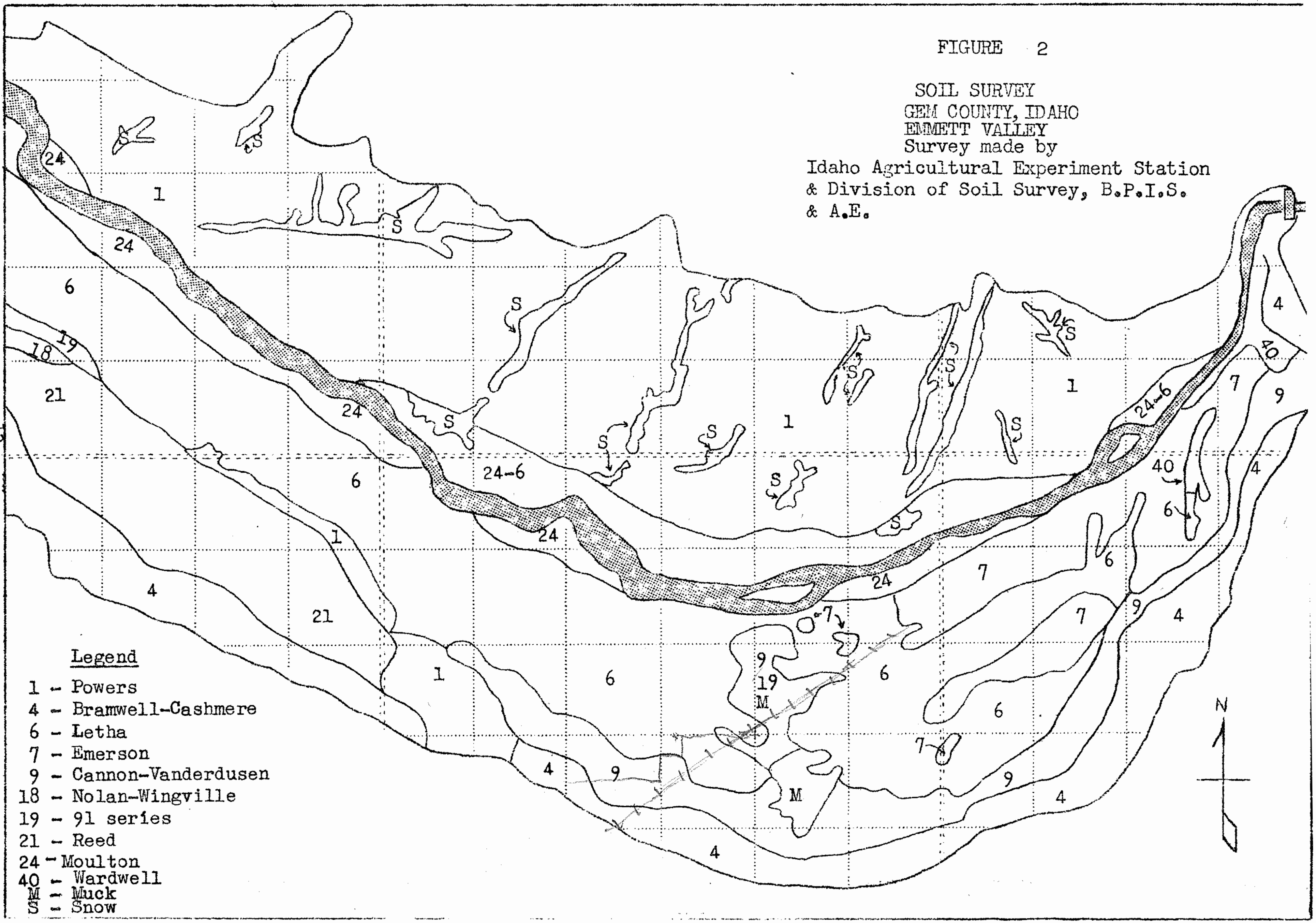


FIGURE 2

SOIL SURVEY
GEM COUNTY, IDAHO
EMMETT VALLEY
Survey made by
Idaho Agricultural Experiment Station
& Division of Soil Survey, B.P.I.S.
& A.E.

The general location and extent of the various classes are shown in figure 3. The alkali area generally occurs on the Letha, Reed and Cannon soil series. The Letha soils are generally moderately permeable and should reclaim fairly rapidly following drainage. The Cannon soils will be slightly more difficult to reclaim due to a slower permeability in the surface soil. However, open or tile drainage is very feasible on the Cannon soils due to the permeable substrata. The Reed soils will be the most difficult to reclaim due to the slow permeability and thickness of the strata. The 15 feet or more of slowly permeable soil makes the efficiency of open or tile drains very low. This requires a very close spacing of drains and coupled with the gypsum required for reclamation on heavy alkali soils makes reclamation relatively costly.

During 1950 the U. S. Regional Salinity and Rubidoux Laboratories, Division of Soil Surveys and the Idaho Agricultural Experiment Station published a bulletin entitled "Characteristics of Saline and Alkali Soils in the Emmett Valley area, Idaho." (5)

The chemical and physical characteristics of 35 selected soil samples were given in the appendix of the above mentioned publication. The location of the soil samples were shown in figure 5 of the June 1953 report. A major part of the soil samples are located in the acute problem area. The chemical and physical characteristics of the soils sampled were also given in appendix tables 1, 2, 3, and 4 of last year's report.

Ground Water Survey

During 1936 the U. S. Bureau of Reclamation initiated a ground water investigation in the area bordering the Black Canyon Canal on the southern edge of the Emmett Valley. A total of 91 observation wells were installed and monthly readings were made from 1936 to 1945. The observations were discontinued from 1946 to 1950. The observations were resumed in 1950 and have been continued to date.

The well locations were shown on figure 7 of the June 1953 progress report. The observation wells are located an eighth of a mile up to two miles below the Black Canyon Canal.

A table of the high and low water table elevations, by years, were given in appendix table 5 of the June 1953 report. The ground water fluctuation varies with the well location. In some areas the fluctuation may be 10 to 14 feet between the low and high ground water cycle.

Water-logged Survey

During 1953 a survey was made by Lester Holmquist of the Soil Conservation Service to determine the extent of the water-logged land in the Emmett Valley. The land was classified under the following catagories:

a. Severely water-logged
b. Moderately water-logged
c. Effected
d. Not effected

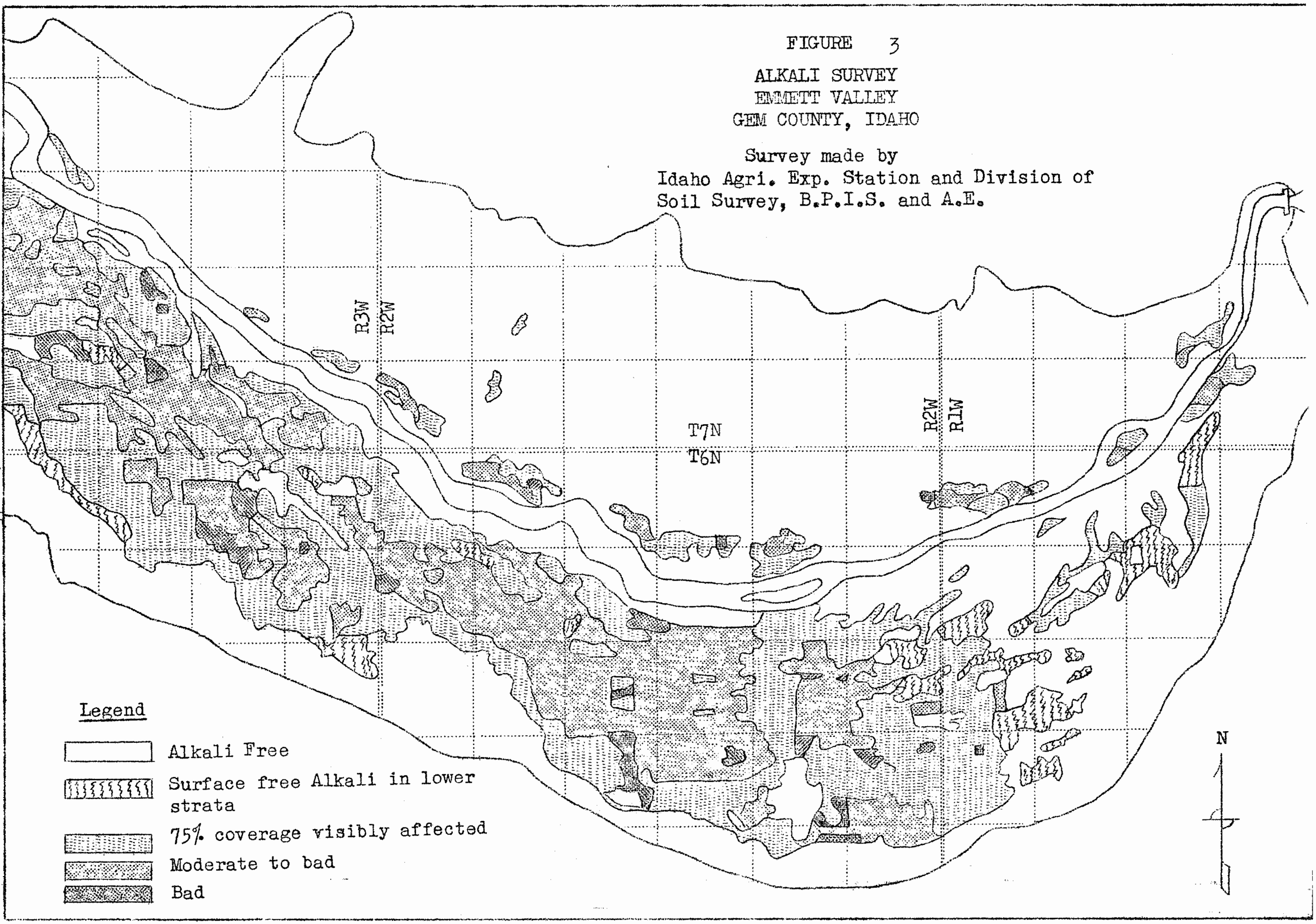


FIGURE 3
ALKALI SURVEY
EMMETT VALLEY
GEM COUNTY, IDAHO
Survey made by
Idaho Agri. Exp. Station and Division of
Soil Survey, B.P.I.S. and A.E.
R3W
R2W
T7N
T6N
R2W
R1W
N
Legend
Alkali Free
Surface free Alkali in lower strata
75% coverage visibly affected
Moderate to bad
Bad

The location and extent of the various classes are shown on figure 4. The percentage of the valley land in each catagory are given in the following tabulation. (This includes the area shown on figure 4)

Catagory	Acres	Percent of land
Severely water-logged	2560	8
Moderately water-logged	6720	21
Effected	6720	21
Not effected	16000	50

The survey indicates that 50 percent of the farm land in the valley is effected by high water table and 29 percent of the valley lands are moderately to severely water-logged.

Artesian Aquifer Investigation

An artesian well location survey of the Emmett Valley was initiated during 1952. On April 7th a card questionnaire was mailed out to farm owners in the problem area south of the Payette river. A 65 percent return was obtained on the questionnaire.

Artesian well locations

The results of this survey were used as a guide in locating the existing artesian wells in the valley. Ninety-one wells were located in the valley floor south of the bench; their locations are shown in Figure 5.

Correlation of the artesian well locations and the water-logged area.

The artesian well locations correlate very well with the water-logged survey. The superimposed well location map on the lands classified as moderately to severely water-logged is shown in figure 6. There is considerable acreage water-logged east of the last known artesian well. This could be attributed to ground water moving down slope against the artesian aquifer and also the possibility that the artesian aquifer extends some distance east of the last known well.

The correlation between the artesian well locations and the water-logged area indicates that the artesian aquifer in some way is associated with the water-logged alkali area in the Emmett Valley. With this in mind, it was decided to pursue this possibility and to determine the following characteristics of the artesian aquifer:

a. Extent of the artesian aquifer with respect to both geographic location and depth.
b. Source of the artesian water
c. Quality of the artesian water
d. Transmissibility of the artesian aquifer

The above items are not reported in sequence as they are closely associated and portions of each study tie together.

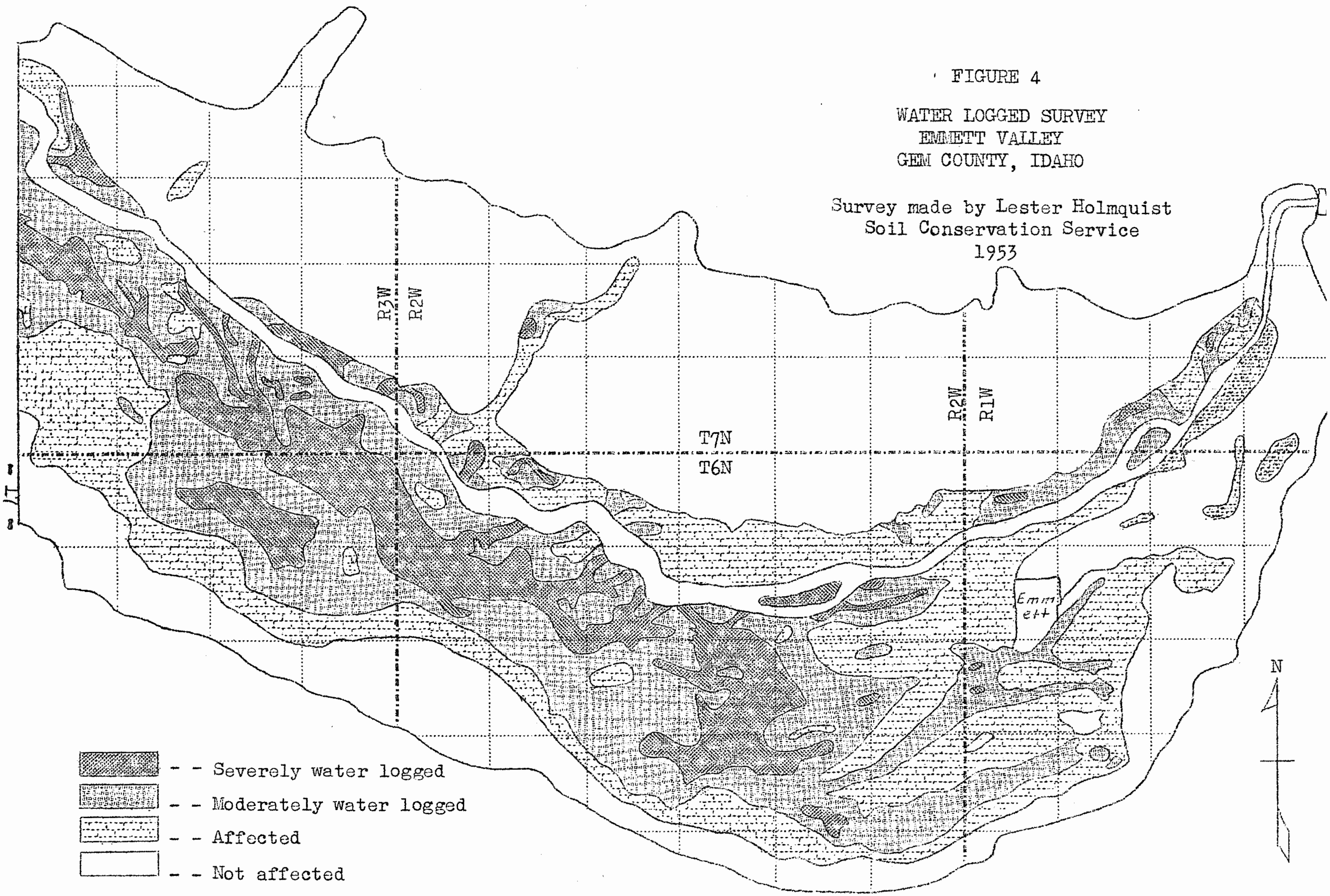


FIGURE 4

WATER LOGGED SURVEY
EMMETT VALLEY
GEM COUNTY, IDAHO

Survey made by Lester Holmquist
Soil Conservation Service
1953

Table 3. - Artesian well logs from the Emmett Valley, Gem County, Idaho

Gus Zigler		Well No. 64		Well No. 55-A		Well No. 49-A		Well No. 26-A		E. C. Herman		Well No. 11-A		Well No. 4-A	
Depth ft.	Log tex.	Depth ft.	Log tex.	Depth ft.	Log tex.	Depth ft.	Log tex.	Depth ft.	Log tex.	Depth ft.	Log tex.	Depth ft.	Log tex.	Depth ft.	Log tex.
0-33	g	0-40	g	1-30	g	0-28	g	0-6	soil	0-6	soil	0-5	soil	0-28	g
33-37	sa	40-53	c	30-37	sa	28-36	bc	6-26	g	6-18	g	5-30	g	28-32	c
37-40	bc	53-75	sa	37-75	bc	36-49	sa	26-46	sa	18-21	bc	30-35	sa	32-90	sa
40-45	si	75-85	c	75-87	sa	49-60	bc	46-127	si-sa	21-25	si	35-40	bc	90-92	c
45-47	bc	85-118	sa	87-91	bc	60-68	sa-c	127-133	c	25-27	sa	40-46	sa	92-140	sa
47-60	si	118-140	c	91-92	sa	68-71	c	133-138	c	27-43	bc	46-60	bc	140-171	sa-c
60-83	sa	140-	sa	92-99	bc	71-85	sa	138-148	sa	43-	sa	60-62	sa	171-183	sa
83-85	bc			99-101	sa	85-109	bc	148-166	c			62-65	bc	183-188	sa-c
85-95	sa			101-104	bc	109-110	sa-c	166-195	sa-c			65-67	s	188-326	sa
95-100	bc			104-108	sa	110-112	sa-m	195-210	c			67-75	bc		
												75-103	sa		
100-112	sa			108-110	bc	112-136	c	210-	sa			103-106	bc		
112-120	bc			110-111	sa	136-146	sa					106-116	sa		
120-147	sa			111-127	bc	146-149	c					116-117	bc		
147-150	bc			127-	sa	149-150	sa					117-130	sa		
150-	sa					150-154	c					130-140	c		
						154-155	sa					140-145	fi-sa		
						155-156	c					145-146	bc		
						156-160	sa-c					146-156	sa-si		
						160-164	c					156-176	si		
						164-166	sa-si					177-180	c		
						166-170	c					180-	sa		
						170-171	sa								
						171-172	sa-c								
						172-180	c								
						180-	sa								

Legend

g - - - - - - - gravel
sa- - - - - - - sand
fi-sa - - - - fine sand
si- - - - - - - silt
m - - - - - - - muck
c - - - - - - - clay
bc- - - - - - - blue clay

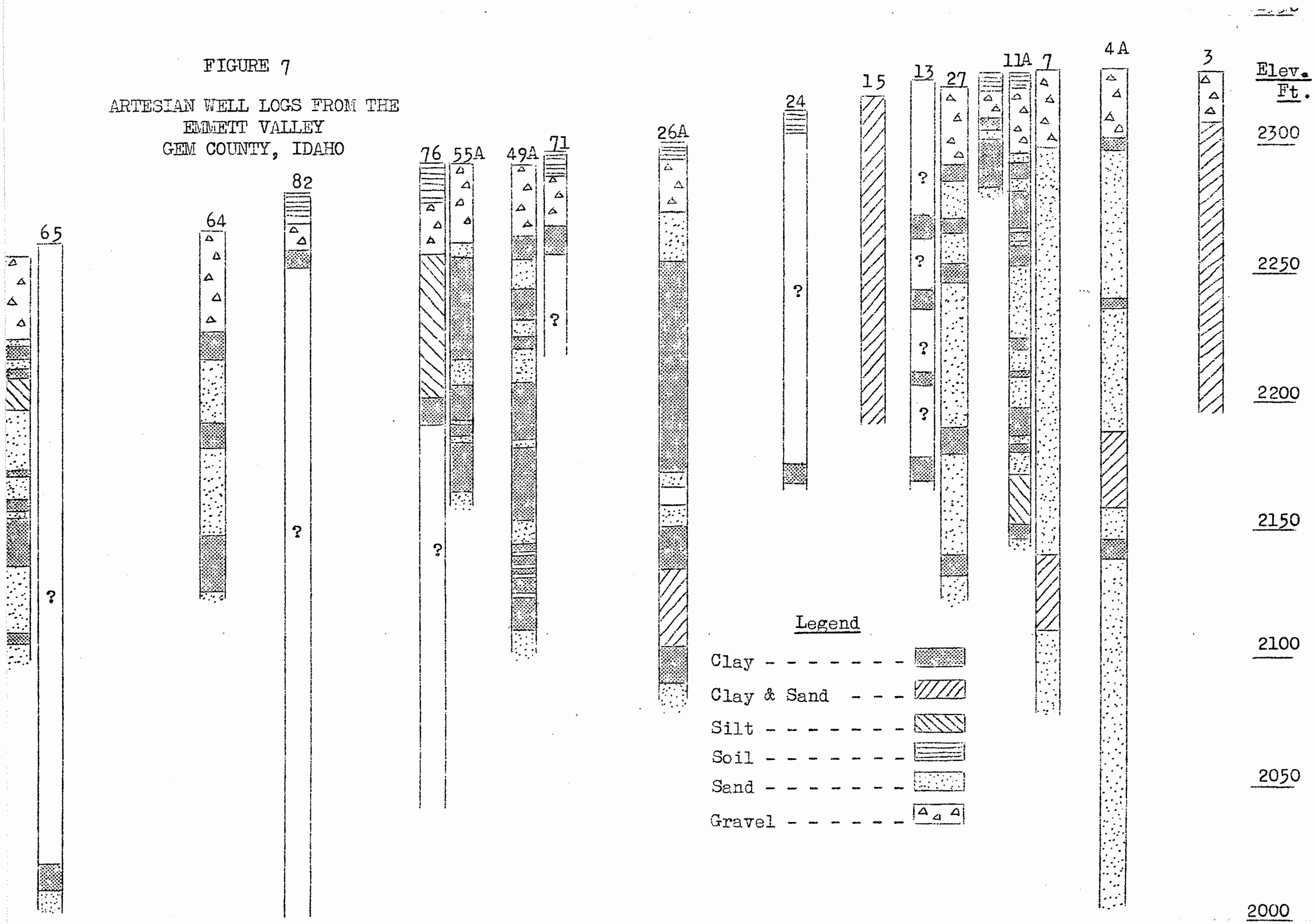


FIGURE 7
ARTESIAN WELL LOGS FROM THE
EMMETT VALLEY
GEM COUNTY, IDAHO
65
64
82
76
55A
49A
71
26A
24
15
13
27
11A
7
4A
3
Elev.
Ft.
2300
2250
2200
2150
2100
2050
2000
Legend
Clay
Clay & Sand
Silt
Soil
Sand
Gravel

Table 4. - Physical survey of the artesian wells in the Emmett Valley, Gem County, Idaho

No.	Location	Well installed: date	Dia. in	Depth ft.	Surveyed date	T^{o} F.	pH	Cond. $k \times 10^{5}$ @25°C	Water pressure at ground surface ft.	lb.
1	6-2-26 NW$\frac{1}{4}$ NE$\frac{1}{4}$		4	70	3/13/53	73	8.2	30.3	-	-
2	6-2-23 SW$\frac{1}{4}$ SW$\frac{1}{4}$		8 & 6	375	3/13/53	65	8.2	27.2	-	-
3	6-2-22 NW$\frac{1}{4}$ SW$\frac{1}{4}$	Dec. 1951	4	134	3/13/53	68	8.5	23.0	13.0	5.65
4	6-2-22 NW$\frac{1}{4}$ NW$\frac{1}{4}$		4	140	3/13/53	62	8.4	23.6	11.4	4.94
4-A	6-2-15 NW$\frac{1}{4}$ NW$\frac{1}{4}$	May 1953	4	326	5/20/53				0.8	0.35
5	6-2-23 NW$\frac{1}{4}$ SE$\frac{1}{4}$	1950	4	300	3/13/53		9.3	23.9	0.3	0.14
6	6-2-22 NE$\frac{1}{4}$ SE$\frac{1}{4}$		4		3/17/53	60	8.2	27.8	6.8	2.97
7	6-2-9 NE$\frac{1}{4}$ SE$\frac{1}{4}$	1953	4	250	3/23/53	62	8.6	22.1	3.4	1.49
8	6-2-9 Ctr. NW$\frac{1}{4}$		4	100	3/23/53	55	8.5	30.4	7.8	3.38
9	6-2-9 SW$\frac{1}{4}$ NW$\frac{1}{4}$		4	180	3/23/53	64	8.6	24.1	33.4	14.45
10	6-2-17 SE$\frac{1}{4}$ NE$\frac{1}{4}$		4		3/23/53	66	8.6	23.6	8.5	3.68
11	6-2-16 NW$\frac{1}{4}$ NW$\frac{1}{4}$		4	135	3/23/53	62	8.5	23.7	20.5	8.86
11-A	6-2-16 NE$\frac{1}{4}$ NW$\frac{1}{4}$	Aug. 1953	4	180	8/24/53	62	8.3	23.8	25.4	10.99
12	6-2-17 NE$\frac{1}{4}$ NE$\frac{1}{4}$		4	240	3/23/53	68	8.7	22.1	8.3	3.62
13	6-2-18 NE$\frac{1}{4}$ SE$\frac{1}{4}$	1937	4	156	3/24/53	59	8.6	24.3	22.2	9.59
14	6-2-8 SE$\frac{1}{4}$ NE$\frac{1}{4}$		4	200	3/25/53	62	8.5	25.7	30.5	13.22
15	6-2-8 NW$\frac{1}{4}$ NE$\frac{1}{4}$	Oct. 1949	4	125	3/25/53	59	8.5	24.5	25.9	11.22
16	6-2-6 SE$\frac{1}{4}$ SE$\frac{1}{4}$	1937	4	200	3/25/53	60	8.5	24.1	34.2	14.86
17	6-2-6 SE$\frac{1}{4}$ NW$\frac{1}{4}$		4		3/25/53	57	8.4	24.4	42.3	18.33
18	6-2-6 NW$\frac{1}{4}$ SW$\frac{1}{4}$		4	140	3/25/53	59	8.4	19.9	18.6	8.07
19	6-2-8 NW$\frac{1}{4}$ SE$\frac{1}{4}$		4	154	3/25/53	68	8.4	24.8	13.8	5.96
20	6-2-8 NE$\frac{1}{4}$ NW$\frac{1}{4}$	1950	4	240	3/25/53	71	8.5	25.3	37.0	16.09
21	6-2-8 NE$\frac{1}{4}$ SW$\frac{1}{4}$		4	240	4/29/53	67	8.2	25.6	38.2	16.56
22	6-2-8 NE$\frac{1}{4}$ SW$\frac{1}{4}$		4		4/29/53	55	8.2	27.6	6.1	2.66
23	6-2-8 NW$\frac{1}{4}$ SW$\frac{1}{4}$		4	58	4/29/53	61	8.2	22.7	6.9	2.98

Table 4 (Cont.) - Physical survey of the artesian wells in the Emmett Valley, Gem County, Idaho

No.	Location	Well installed date	Dia. in	Depth ft.	Surveyed date	T° F.	pH	Cond. k x 10^5 @25°C	Water pressure at ground surfae ft.	lb.
	7 K Sec									
24	6-2-7 NE¼ NE¼		4	144	4/29/53	66	8.5	22.8	23.7	10.26
25										
26	6-2-7 NW¼ NW¼	1933	4	167	4/29/53	63	8.2	30.9	31.6	13.68
26-A	6-3-12 NE¼ NE¼	Feb. 1954	4	165	2/12/54	65			27.5	11.9
26-A	6-3-12 NE¼ NE¼	Mar. 1954	4	215	3/19/54	68			49.3	21.4
27	6-2-4 SE¼ SW¼	1933	4	199	5/5/53	64	8.0	28.0	11.3	4.88
28	6-2-5 SE¼ NE¼	1941	4	300	5/4/53	67	8.0	51.8	5.5	2.40
29	6-2-6 SE¼ NE¼	1951	4	176	5/4/53	62	8.4	24.1	39.2	17.00
30	6-2-31 SE¼ SE¼	1950	4	228	5/4/53	68	8.1	25.6	39.5	17.10
30			6	94	5/4/53	66	8.1	44.6	-	-
31	7-2-31 NE¼ SW¼		4	139	5/6/53	62	8.0	24.3	35.8	15.50
32			4	150	5/6/53	60	8.1	24.6	11.3	4.90
33	7-3-36 NE¼ NE¼		4	165	3/25/53	61	8.2	45.8	38.0	16.48
34	6-3-1 NW¼ NE¼	1940	3	176	5/6/53	60	8.3	24.0	34.3	14.87
34-A	6-3-1 NW¼ NE¼	1913	4	93	5/6/53	60	8.3	21.7		
35	6-3-1 NW¼ NE¼		4		5/6/53	50	8.3	22.8	33.8	14.65
36	7-3-36 SW¼ SE¼ L Gurney		4	150	5/6/53	58	8.3	23.9	16.9	7.32
37	7-3-36 NE¼ SW¼		4	185	5/6/53	58	8.3	24.4	24.6	10.65
38	7-3-36 SE¼ SW¼	1952	4	140	5/6/53	60	8.3	22.7	34.3	14.88
39	7-3-36 SE¼ SW¼		3	99	5/6/53	60	8.3	24.4	23.3	10.10
40	6-3-1 NE¼ NW¼	1947	4	151	5/7/53	59	8.2	21.5	38.2	16.58
41	7-3-36 SE¼ SW¼	1947	4	154	5/7/53	61	8.3	21.4	39.3	17.01
42	7-3-36 SE¼ SW¼	1940	4	145	5/7/53	60	8.3	23.9	35.2	15.27
43	7-3-36 SE¼ SW¼		4		5/7/53	57	8.3	22.3	28.3	12.27
44	7-3-36 SW¼ SW¼		4		5/7/53	59	8.2	25.6	4.4	1.93

Table 4 (Cont.) - Physical survey of the artesian wells in the Emmett Valley, Gem County, Idaho

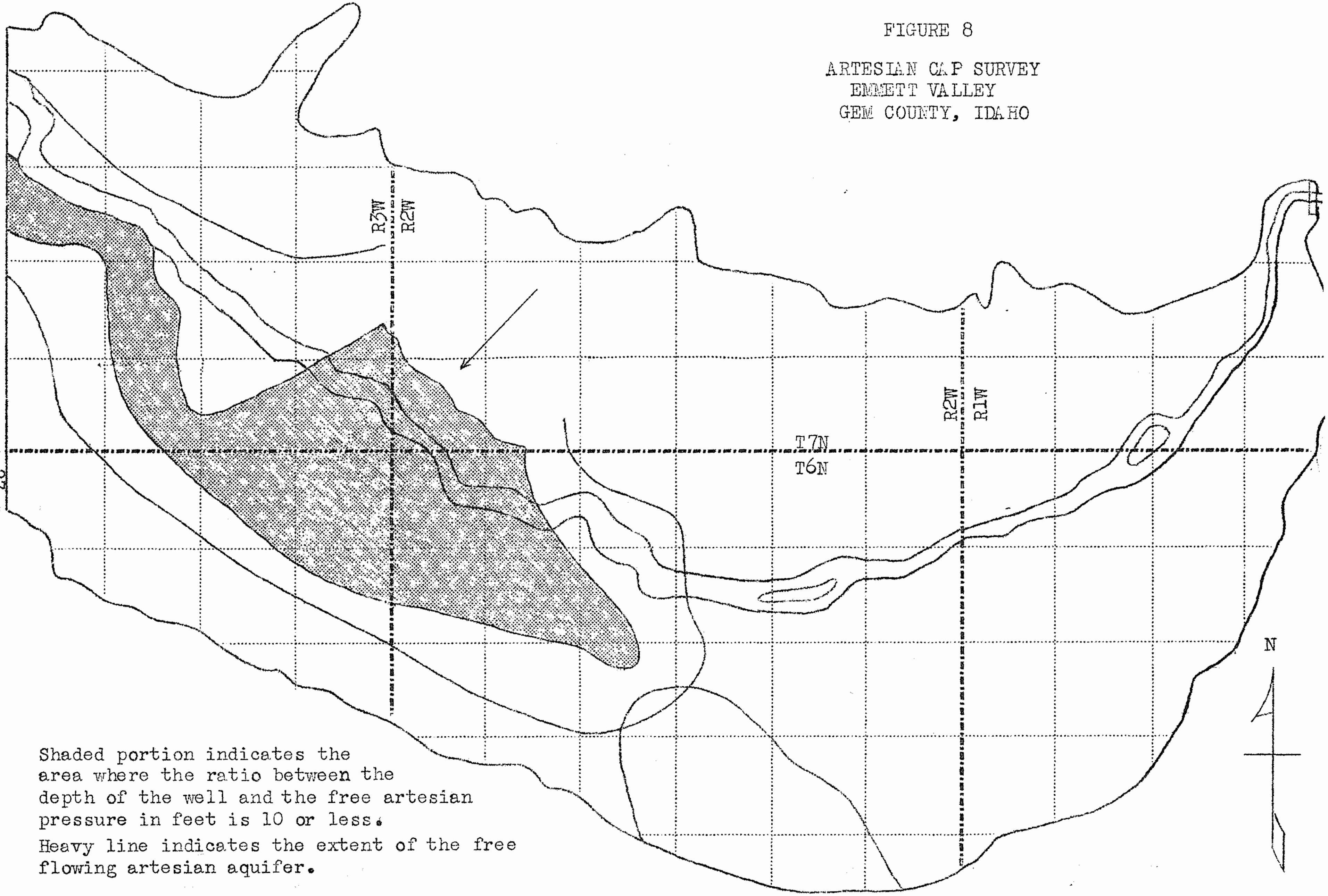
No.	Location	Well installed date	Dia. in.	Depth ft.	Surveyed date	T° F.	pH	Cond. k x 10^5 @25°C	Water pressure at ground surface ft.	lb.
45	7-3-36 SW¼ SW¼		4		5/7/53	60	8.4	22.2	37.5	16.22
46	7-3-36 NW¼ SW¼		4		5/7/53	50	8.3	27.6	26.7	11.57
47	7-3-36 SW¼ SW¼		4	90	5/7/53	56	8.4	24.5	16.4	7.11
48	7-3-36 SW¼ SW¼	1947	3½	127	5/7/53	60	8.3	24.7	27.4	11.87
49	7-3-36 SW¼ SW¼	1933	4	140	5/7/53	60	8.4	23.0	42.4	18.35
49-A	7-3-36 SW¼ SW¼	5/29/53	4	180	6/11/53	58	8.3	23.5	48.3	20.91
50	7-3-36 SW¼ SW¼	1938	4	161	5/7/53	62	8.4	24.1	41.5	17.97
51	7-3-36 SW¼ SW¼		4	140	5/7/53	63	8.3	25.7	9.4	4.09
52	7-3-36 SW¼ SW¼	1944	4	132	5/7/53	58	8.4	26.1	29.7	12.87
53	7-3-36 SW¼ SW¼		4	104	5/7/53	59	8.5	23.1	24.8	10.77
54	7-3-35 SE¼ SE¼		4	178	5/21/53	60	8.2	23.7	46.5	20.14
55	7-3-35 SE¼ NE¼		4		5/21/53	57	8.3	26.3	20.0	8.66
55-A	7-3-35 SW¼ NE¼	2/2/54	4	127	2/6/54	59	8.3	38.0	19.4	8.24
56	6-3-1 NW¼ NW¼		4		5/21/53	62	8.3	22.3	33.2	14.40
57	7-3-35 NE¼ SW¼		4		5/21/53	60	8.2	25.7	24.1	10.44
58	6-3-1 SW¼ SE¼		4	91	5/21/53	58	8.3	19.9	12.2	5.29
58-A	6-3-1 NE¼ SW¼		4	92	6/11/53	55	8.3	21.2	Very low	
59	7-3-35 SW¼ NW¼	1950	4	110	5/21/53	54	8.4	23.1	4.9	2.14
60	7-3-27 SW¼ NE¼		4	165	5/21/53	56	8.1	22.5	20.1	8.68
61	7-3-27 SE¼ NW¼		4	69	5/21/53		8.3	25.4	1.5	0.65
62	7-3-27 SW¼ NW¼		4	138	5/21/53	54	8.3	24.5	6.9	2.99
63	7-3-27 SW¼ SE¼		4		5/22/53	–	8.4	25.7	Pressure system	
64	7-3-22 SE¼ SW¼		4	140	5/22/53	59	8.2	23.2	37.9	16.44
65		1950	4	275	5/22/53	65	8.3	25.6	36.8	15.97
66	7-3-21 NW¼ SW¼	1942	4	225	5/22/53	58	8.4	21.3	17.4	7.52

Table 4 (Cont.) - Physical survey of the artesian wells in the Emmett Valley, Gem County, Idaho

No.	Location	Well installed date	Dia. in.	Depth ft.	Surveyed date	T° F.	pH	Cond. $k \times 10^5$ @25°C	Water pressure at ground surface ft.	lb.
67	7-3-21 NW¼ SE¼		4		5/22/53	59	8.4	21.5	Pressure system	
68	7-3-21 SW¼ SE¼		4	100	6/11/53	59	8.3	22.4	5.6	2.41
69	6-3-2 NE¼ NW¼		4		6/24/53	66	8.0	20	-	-
70	7-3-11 NE¼ NW¼		4	200	6/24/53	64	8.0	16.7	2.0	0.87
71	6-3-2 SW¼ NE¼	1928	5	620	6/25/53	68	8.1	22.6	50	21.82
72	6-3-2 NW¼ NE¼		4	200	7/24/53	59	8.0	23.9	24.6	10.67
73	7-3-35 SE¼ SW¼		4		7/24/53	60	8.1	25.5	32.4	14.08
74	7-3-35 SW¼ SW¼		4		7/27/53	59	8.2	27.3	20.8	8.99
75	6-3-2 NW¼ NW¼	1940	14	800	7/27/53	73	8.3	23.4	6.0	2.61
76			4-3	250	7/27/53	65	8.4	25.9	17.6	7.63
77	7-3-34 SE¼ SE¼		4	150	7/17/53	61	8.3	27.3	6.8	2.93
78	7-3-27 SW¼ SW¼	1939	4	304	7/27/53	62	8.2	23.0	51.0	22.11
79	7-3-34 NW¼ NW¼	1950	4	281	7/27/53	65	8.3	25.3	41.6	19.76
80	6-3-3 NW¼ NW¼		4	90	7/27/53	-	8.1	21.6	± A few inches	
81										
82	7-3-33 NE¼ SE¼	1944	3-4	387	7/27/53	70	8.3	25.3	19.9	8.64
83	7-3-28 NE¼ SE¼		4	225	7/27/53	60	8.3	23.6	9.8	4.26

FIGURE 8

ARTESIAN CAP SURVEY
EMMETT VALLEY
GEM COUNTY, IDAHO



Shaded portion indicates the area where the ratio between the depth of the well and the free artesian pressure in feet is 10 or less.

Heavy line indicates the extent of the free flowing artesian aquifer.

The hydraulic gradients between artesian wells were computed and the points at chich they intersected the ground surface is shown by a heavy line on figure 8. The plotting of this line also indicates that the artesian water is entering the valley from the northeast. The hydraulic gradients also indicate that wells 1 to 6 are on a separate aquifer and that the water enters the valley from the south or southeast. Well No. 4-A was drilled in the general area where the two aquifers intersect. Prior to drilling of the well the expected free artesian pressure was computed by the hydraulic gradients to be about one foot. The well was finally terminated at 326 feet and had 0.8 feet of free artesian pressure. The wells on either side of well 4-A have a fairly good pressure which also indicate two separate aquifers.

Correlation of the Block House Swamp and the Artesian Aquifers

A correlation of the Block House swamp and the artesian aquifers shown on figure 8 is very interesting. This correlation is presented in figure 8-A. The swamp and bog holes occur in the area immediately up valley from the artesian aquifers. Several of the bog holes were reportedly measured to a depth of more than 30 or 40 feet. The existance of this swamp and soil change is apparently due to the artesian aquifers. During the period the valley was being built up, the fans from either side formed a dam across the valley floor and formed a swamp immediately up valley. As the valley was built up the fans raised with the valley. The fans, which now form the artesian aquifers, are at least 600 feet deep. If this theory on the creation of the Block House swamp is right, the bog holes may extend 600 feet or more in depth. This causes a difficult drainage problem in the swamp area. as the problem water is apparently coming from a deep depth. This is partially substantiated by the warm sulphur water raising in the bog areas.

Profile of artesian water pressure levels

A profile showing the artesian water pressure levels, the ground surface elevations and the well depths are shown in figure 9. The high water pressure level existing in the general vicinity of well No. 30 and the blunt slope on the water pressure level at the eastern end of the aquifer indicate that the water is probably coming into the valley in the general vicinity of well No. 30 and fanning out under the valley floor. The abrupt face and hydraulic gradient of the water pressure level indicates that the artesian water is moving up valley. The hydraulic pressure gradient is in the opposite direction to the slope of the land surface.

Ratio of well depth to free artesian pressure

A chart showing the ratio of artesian well depths to free artesian pressures are illustrated in figure 10. The chart supplements the previous figures and tables. It indicates that the water may be entering the valley in the general vicinity of well No. 30. It also suggests that there may be additional fans feeding into the artesian aquifer from both east and west of the main fan. The drop in ratio of depth to pressure in the vicinity of well No. 65 would tend to in-

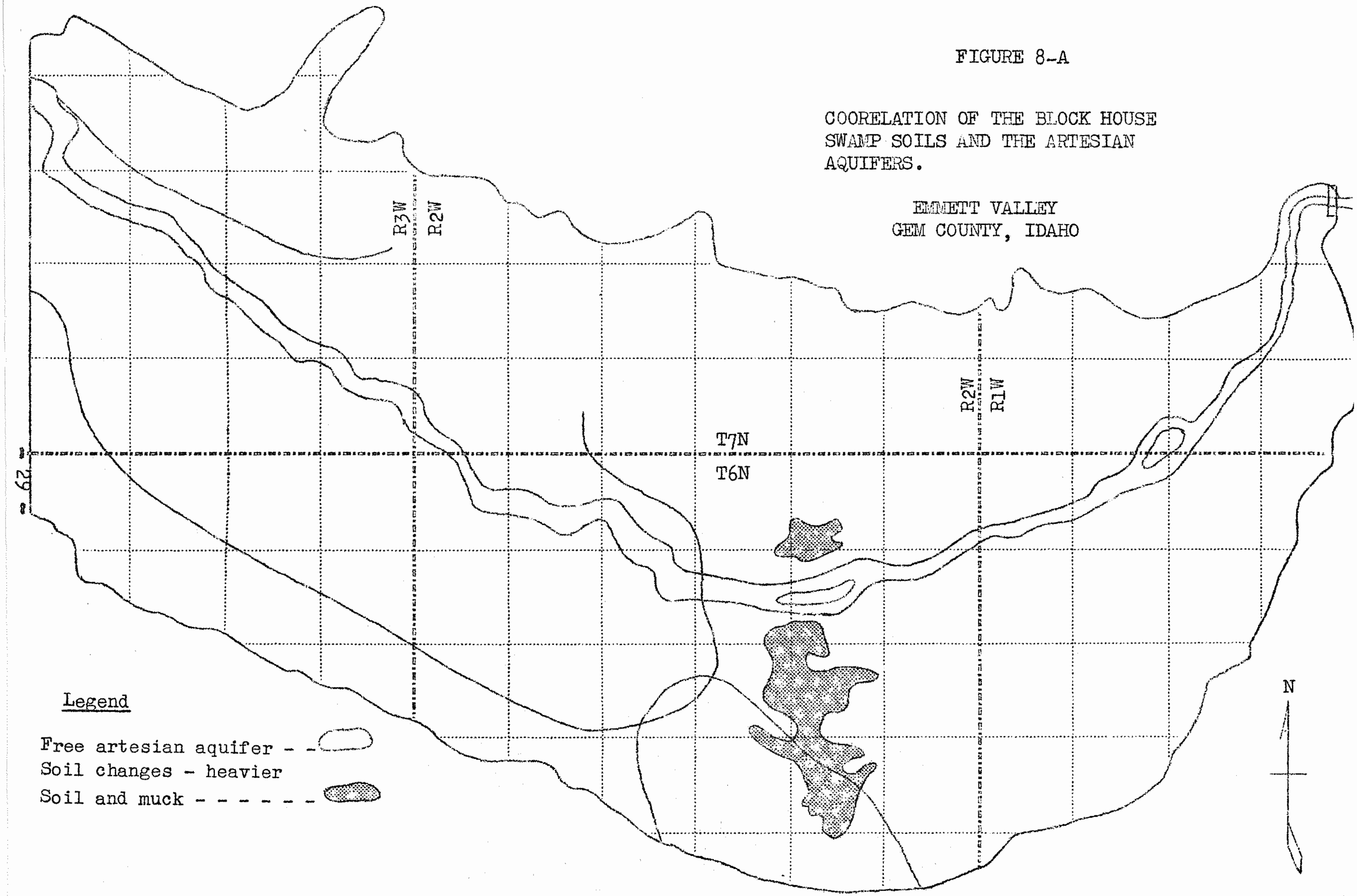


FIGURE 8-A

COORELATION OF THE BLOCK HOUSE SWAMP SOILS AND THE ARTESIAN AQUIFERS.

EMMETT VALLEY
GEM COUNTY, IDAHO

FIGURE 9

PROFILE OF ARTESIAN WATER PRESSURE LEVELS, GROUND SURFACE ELEVATIONS AND WELL DEPTHS.

EMMETT VALLEY
GEM COUNTY, IDAHO

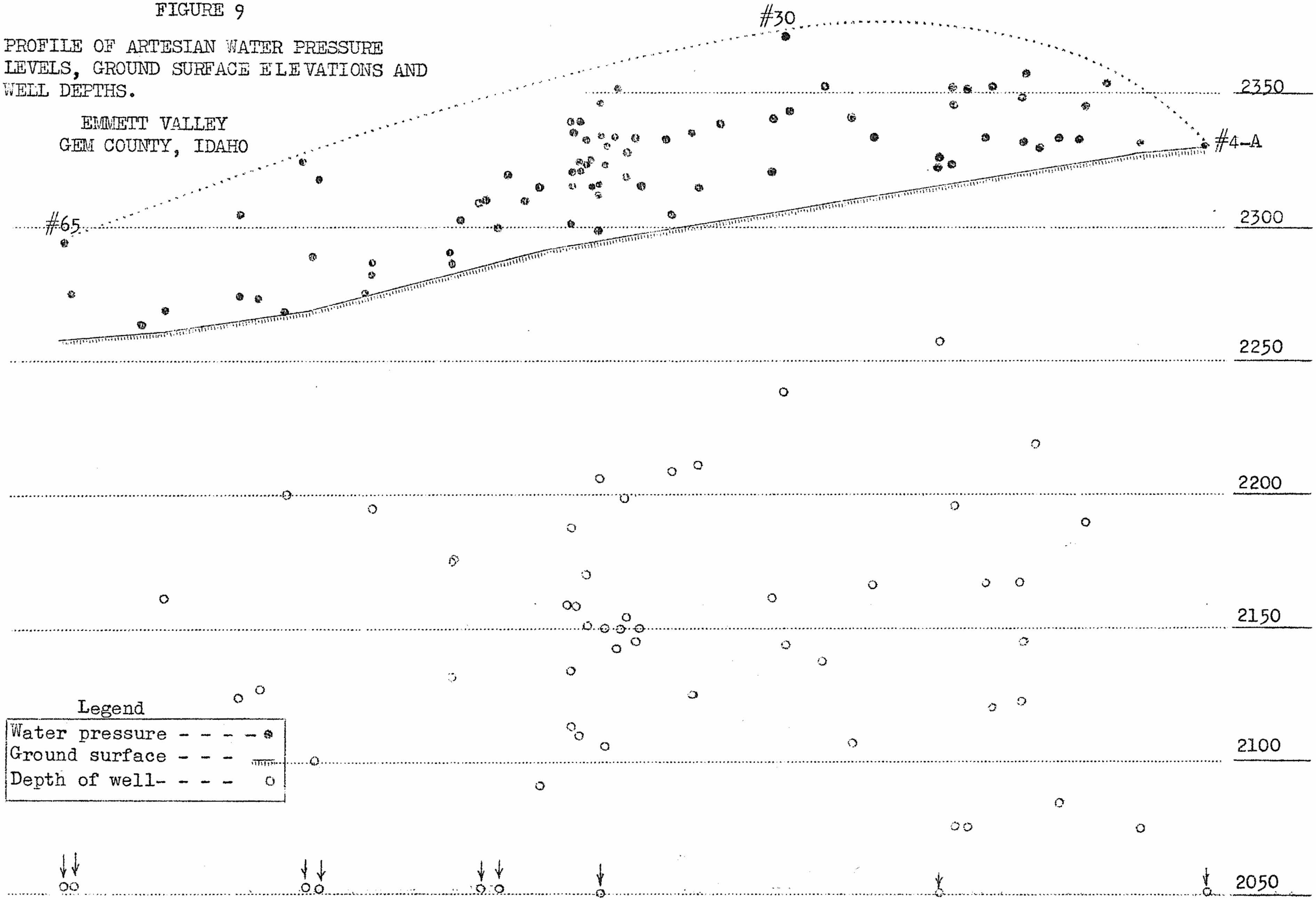
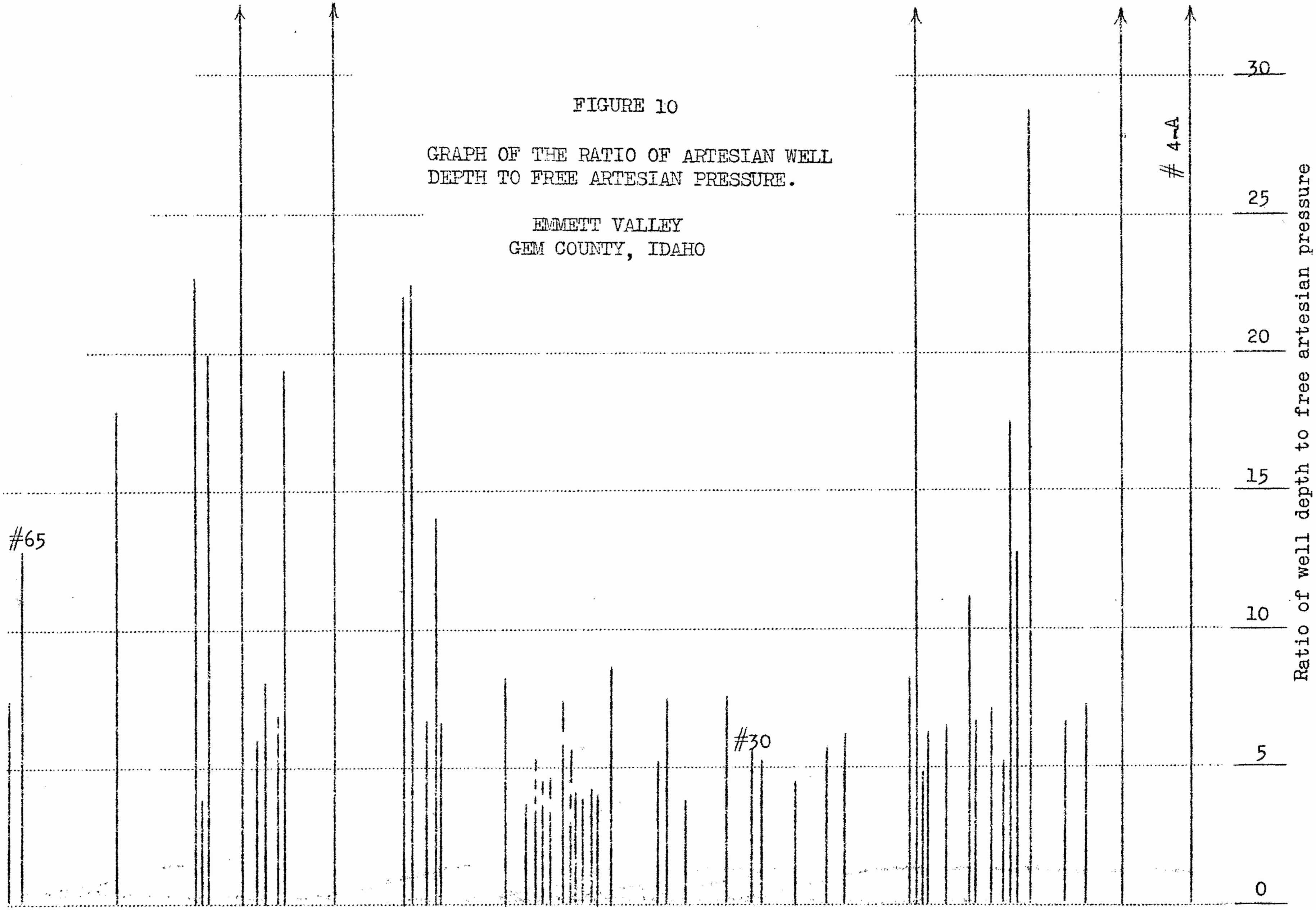


FIGURE 10

GRAPH OF THE RATIO OF ARTESIAN WELL DEPTH TO FREE ARTESIAN PRESSURE.

EMMETT VALLEY
GEM COUNTY, IDAHO



dicate the presence of a fan in that area.

Artesian pressure changes with respect to well depth

A study was made on wells No. 49-A and 26-A to determine the water pressure increases as the penetration into the artesian aquifer increases. Observations were made during drilling and were not complete due to time element connected with making the measurements. A summary of the observations obtained on well No. 49-A are presented in table No. 5.

Table No. 5. Pressure changes with respect to well depth, Emmett Valley, Gem County Idaho

Depth of well ft.	Heighth of well casing in.	Discharge gpm	Water pressure ft.	Temperature Fahrenheit
5				56
36				57
72				58.5
136	38	50	7.6	60
138	18	65	19.9	60
149	22	50	20.4	59
170	60	25	-	58
180	24	65	27.5	58
180 after develop	24	180	48.2	58

The discharges in table 5 are somewhat erratic and are possibly due to various degrees of cleaning and development. This is not as apparent in the water pressure readings except for the long time development that was done to finish the well.

A similar study was made on well No. 26-A. The well was drilled to 165 feet and developed, then a month later the well was deepened to 215 feet and developed. This gives a fairly good comparison as both aquifers were developed. The following tabulation gives the discharge, pressure and temperature changes with an increase of 50 feet in depth.

Discharge, pressure and temperature changes in well No. 26-A with increase in depth.

Depth of well ft.	Discharge gpm	Water pressure ft.	Temperature Fahrenheit
165	11.2	27.5	65
215	65.6	49.3	68

The discharge, water pressures and temperature all increased with depth.

During 1940 a 14-inch hole (oil well) was drilled a mile south-west of Letha. At 600 feet a high pressure artesian aquifer was tapped which eventually stopped the drilling at about 800 feet. There are numerous stories told in the area of how the well shot a column of water from 20 to 40 feet high and splashed it in the top of the drill rig. A man that worked on the well reported that people were mistaken on the heighth of the water column. He said the 14-inch pipe stood 20 feet high above the ground and that a "measured" head of water stood 4 feet above the pipe outlet. This 4-foot head on a 14-inch pipe gives a computed discharge of 7470 gpm or 15 cfs. This figure is for a discharge point 20 feet above the ground.

Geochemical analysis of artesian well water

Artesian water samples were collected at various geographic locations and well depths in the valley. An effort was made to obtain information on area trends as well as depth trends. A summary of the geochemical analysis is presented in table 6. The salinity laboratory rating for the water indicates that it is class one water with the exception of 9 samples. These are class two because of the salinity hazard. This additional salt will be of considerable value in reclaiming the alkali soil.

Geochemical Chart of artesian water ionic analysis

The artesian water ionic analysis is plotted on a geochemical classification chart and presented in figure 11. The chart indicates a general trend in water quality. Overall, the water quality is better close to the suspected artesian source and gradually gets worse as you get further from the source. This may be due to calcium being absorbed by the soil and the artesian water picking up sodium. There are 9 water samples from well No. 49-A shown on the chart. The depths of each sample are given in the legend block. These samples indicate a definite lowering of quality with an increase in depth.

Artesian water pH values

The pH values presented in table 4 were plotted with respect to location and are shown in figure 12. There is a definite trend of pH values. They range from 8.0 at the suspected source to 8.6 or 8.7 at the eastern end of the artesian aquifer. There may be some mixing of artesian waters and ground waters from the south slope bench. It may be that water is going under the toe of the fan or there may be a few small fans from the south slope dovetailing into the large fans from the north. The pH values are 3 to 5 points higher on the eastern end of the aquifer than they are on the west end. This may be attributed to the slow water movement on the east end. The water has to move up valley and would tend to be stagnant and have a better chance to pick up sodium from the aquifer or lose calcium to the aquifer. The western end of the aquifer would have some natural drainage downslope and tend to be lower.

Table 6. – Artesian well water analysis from the Emmett Valley, Gem County, Idaho *

Well No.	Depth	Date	Cond. $ECx10^6$ at 25°C	Boron	Anions CO_3	HCO_3	Cl	SO_4	Cations Ca	Mg.	Na	K	Resid. Na_2CO_3	Na	Ca	pH	SAR	Salinity lab. Rating
	Feet			p.p.m.	m.e./l.	m.e./l.	m.e./l.	m.e./l.	m.e./l.	m.e./l.	m.e./l.	m.e./l.	m.e./l.	%	%			
38	165	4/24/52	440	0.25	0.00	2.97	0.44	1.17	2.73	0.17	1.47	0.04	0.07	33.3	61.9	7.97	1.26	C2-S1
49-A	2	6/4/53	497	0.10	0.39	4.55	0.08	0.21	1.11	0.26	4.02	0.09	3.57	73.4	20.3	8.54	4.99	C2-S1
49-A	36		316	0.05	0.39	2.78	0.01	-	0.66	0.02	2.40	0.03	2.49	77.0	21.2	8.76	4.17	C2-S1
49-A	72		284	0.05	0.00	2.95	0.01	-	0.53	0.06	1.97	0.05	2.36	75.5	20.3	8.46	3.76	C2-S1
49-A	136		222	0.07	0.00	2.19	0.01	0.07	0.34	Tr.	1.82	0.04	1.85	82.7	15.5	8.46	4.52	C1-S1
49-A	149		232	0.06	2.27		0.01	-	0.35	"	1.90	0.02	1.92	83.7	15.4	8.80	4.66	C1-S1
49-A	154		227	0.05	0.23	2.07	0.01	0.06	0.30	0.02	1.96	0.02	1.98	85.2	13.0	8.64	4.95	C1-S1
49-A	170		232	0.07	2.42		0.01	-	0.53	0.06	1.78	0.05	1.83	73.6	21.9	9.24	3.35	C1-S1
49-A	180		232	0.06	0.31	1.95	0.01	0.04	0.32	0.01	2.00	0.01	1.93	85.5	13.7	8.70	4.89	C1-S1
49-A	180		227	0.06	0.31	1.93	Tr.	0.03	0.30	0.01	1.98	0.01	1.93	86.1	13.0	8.72	4.97	C1-S1
1	70	12/7/53	300		0.00	2.84	0.27	0.15	0.70	0.20	2.19	0.06	1.94	71.5	22.2	7.80	3.35	C2-S1
2	375	12/7/53	270		0.00	2.65	0.25	0.13	0.66	0.25	2.16	0.09	1.74	71.5	20.9	7.75	3.24	C2-S1
3	134	12/7/53	220		0.03	2.17	0.18	0.21	0.22	0.10	2.19	0.04	1.88	88.2	8.6	8.25	5.57	C1-S1
7	250	12/7/53	200		0.00	2.30	0.14	0.10	0.22	0.10	2.16	0.00	1.98	87.0	8.9	8.10	5.40	C1-S1
8	100	12/7/53	300		0.00	3.00	0.18	0.22	0.38	0.10	2.81	0.00	2.52	85.5	11.5	8.25	5.73	C2-S1
9	180	12/7/53	210		0.00	2.52	0.16	0.06	0.30	0.15	2.35	0.00	2.04	84.0	10.7	8.30	5.00	C2-S1
20	240	12/7/53	250		0.00	2.72	0.19	0.06	0.33	0.15	2.50	0.00	2.24	83.9	11.1	8.15	5.10	C1-S1
23	58	12/7/53	240		0.11	1.89	0.15	0.35	0.30	0.20	2.10	0.00	1.50	80.7	11.5	8.15	4.20	C1-S1

Table 6(Cont.) - Artesian well water analysis from the Emmett Valley, Gem County, Idaho

Well No.	Depth	Date	Cond. $ECx10^6$ at 25°C	Boron	Anions CO_3	Anions HCO_3	Anions Cl	Anions SO_4	Cations Ca	Cations Mg.	Cations Na	Cations K	Resid. Na_2CO_3	Na	Ca	pH	SAR	Salinity lab. Rating
	Feet			p.p.m.	m.e./l	m.e./l	m.e./l	m.e./l	m.e./l	m.e./l	m.e./l	m.e./l	m.e./l	%	%			
30-A	228	12/7/53	250		0.00	2.72	0.20	0.08	0.66	0.20	2.00	0.00	1.86	70.0	23.1	7.50	3.05	C1-S1
30-B	94	14/7/53	350		0.00	3.01	0.54	1.10	2.37	0.10	2.00	0.00	0.54	44.8	53.1	7.55	1.79	C2-S1
34-A	176	12/7/53	250		0.00	2.47	0.18	0.07	0.48	0.10	2.16	0.00	1.89	78.8	17.5	8.15	4.00	C1-S1
34-A	93	12/7/53	230		0.00	2.27	0.16	0.11	0.30	0.10	2.06	0.00	1.87	83.7	12.2	8.05	4.61	C1-S1
47	90	12/7/53	250		0.19	2.25	0.06	0.11	0.37	0.15	2.28	0.00	1.92	81.4	13.2	8.15	4.47	C1-S1
50	161	12/7/53	200		0.00	2.55	0.14	0.09	0.36	0.10	2.21	0.00	2.09	82.8	13.5	8.15	4.60	C1-S1
58	91	12/7/53	200		0.07	1.83	0.14	0.15	0.22	0.10	1.88	0.00	1.58	85.5	10.0	8.25	4.70	C1-S1
64	140	12/7/53	230		0.00	2.33	0.22	0.09	1.04	0.15	1.38	0.00	1.14	53.7	40.5	7.55	1.78	C1-S1
65	275	12/7/53	250		0.00	2.65	0.20	0.03	1.05	0.15	1.75	0.00	1.45	59.4	35.6	7.75	2.26	C1-S1
68	100	12/7/53	240		0.00	2.29	0.12	0.16	0.56	0.10	1.94	0.00	1.63	74.6	21.6	8.30	3.38	C1-S1
70	200	12/7/53	150		0.05	1.52	0.11	0.12	0.44	0.15	1.31	0.00	0.98	69.0	23.2	8.30	2.39	C1-S1
71	620	12/7/53	250		0.00	2.31	0.15	0.12	0.32	0.10	2.16	0.00	1.89	83.7	12.4	8.30	4.72	C1-S1
75	800	12/7/53	250		0.09	2.30	0.15	0.11	0.28	0.20	2.19	0.00	1.91	82.0	10.5	8.45	4.47	C1-S1
78	304	12/7/53	230		0.00	2.34	0.21	0.09	0.72	0.10	1.68	0.00	1.52	67.2	28.8	8.15	2.62	C1-S1
79	281	12/7/53	250		0.00	2.68	0.16	0.14	0.70	0.20	2.00	0.04	1.78	69.4	23.8	8.10	3.04	C1-S1
80	90	12/7/53	220		0.00	1.83	0.26	0.36	0.15	0.35	0.43	0.09	0.33	25.8	56.9	7.75	0.60	C1-S1

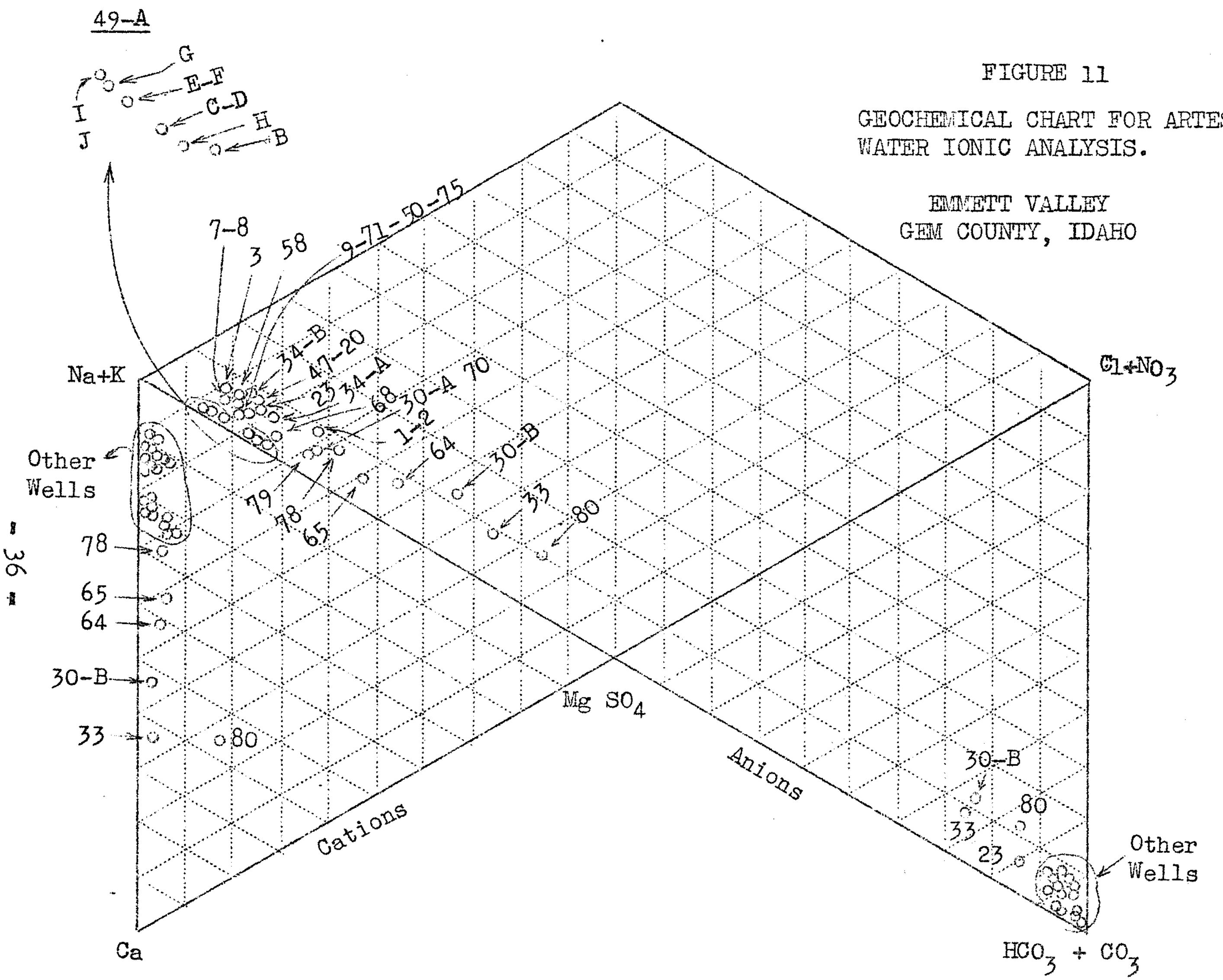
16

* Water analysis was made by the University of Idaho and the U. S. Bureau of Reclamation.

FIGURE 11

GEOCHEMICAL CHART FOR ARTESIAN WATER IONIC ANALYSIS.

EMMETT VALLEY
GEM COUNTY, IDAHO

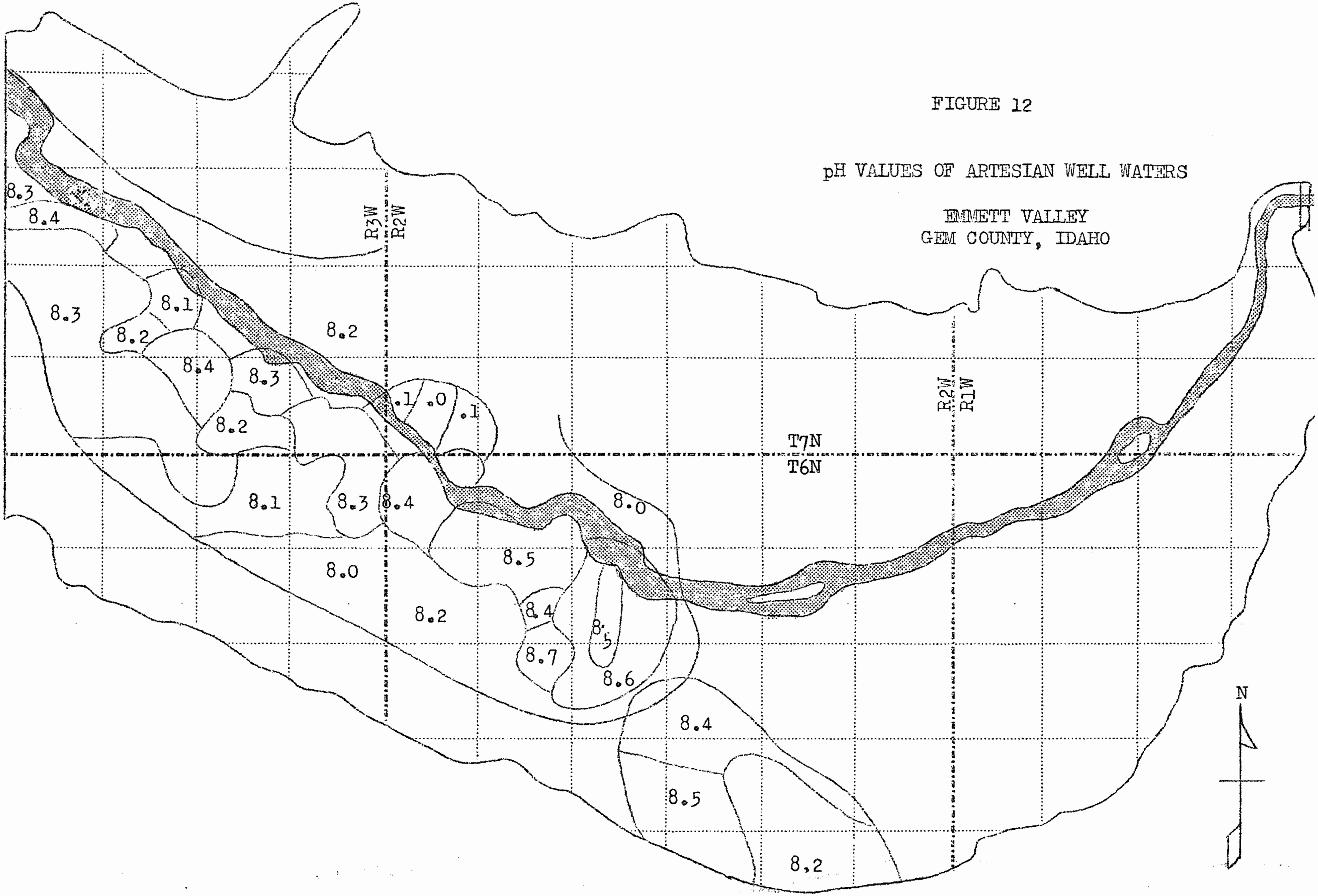


	Legend	Depth-ft.
49-A	B	2
	C	36
	D	72
	E	136
	F	149
	G	154
	H	170
	I	180
	J	180

FIGURE 12

pH VALUES OF ARTESIAN WELL WATERS

EMMETT VALLEY
GEM COUNTY, IDAHO



Sodium adsorption ratio

The sodium adsorption ratios shown in table 6 are illustrated with respect to location in figure 13. The sodium adsorption ratios from the geochemical analysis indicate the same trend that were obtained with the pH values from table 4.

Sodium miliequivalents per liter and percentage trends

The m.e./l. and percentage of sodium shown in table 6 are presented with respect to location in figure 14. The m. e./ l of sodium are surprisingly uniform and show slight, if any, trend. The sodium percentage is higher on the eastern end than on the west while both are higher than the source area. This could be attributed to the artesian water losing calcium to the aquifer. Figure 14 substantiates the findings on figures 7 to 13.

Calcium miliequivalents per liter and percentage trends

The m.e./l and percentages of calcium shown in table 6 are presented with respect to location in figure 15. The m.e./l of calcium show a considerable change. The m.e./l of calcium drops from better than 2 to 0.22 at the eastern end of the aquifer and to about 1 at the western end. The percentage of calcium in the water drops from 50% at the source to 10 % at the eastern end and about 30% on the western end. This substantiates the previous theory that the water moves very slowly on the eastern end and more rapidly on the western end. This would account for the lower calcium in the water as it would have a longer period to be absorbed by the soil.

Artesian aquifer transmissibility investigation (8)

An investigation to determine the transmissibility of the artesian aquifer at various locations in the Emmett valley was initiated during the past year. The method used was employed by Jacob and Lohman near Grand Junction, Colorado to obtain transmissibility data. Jacob and Lohman used a variable discharge and a constant head. The aquifer investigation made in the Emmett valley employed both a variable discharge and a constant discharge. Equipment was designed and constructed to use the constant discharge method as it was reportedly more reliable.

Theory and formulas: When a well that penetrates an extensive confined aquifer is pumped at a constant rate, the drawdown increases roughly as the logarithm of the time. This theory holds true for an effectively infinite and perfectly elastic aquifer of uniform thickness. Due to the variations in caving of the artesian aquifer at the bottom of the well and the difficulty in measuring the effective diameter we decided to use the recharge method rather than the discharge one. To use the discharge method, it is necessary to make an estimate of the well diameter or measure the well with well calipers. The well diameter is not used in the recharge method and is considered to be more reliable.

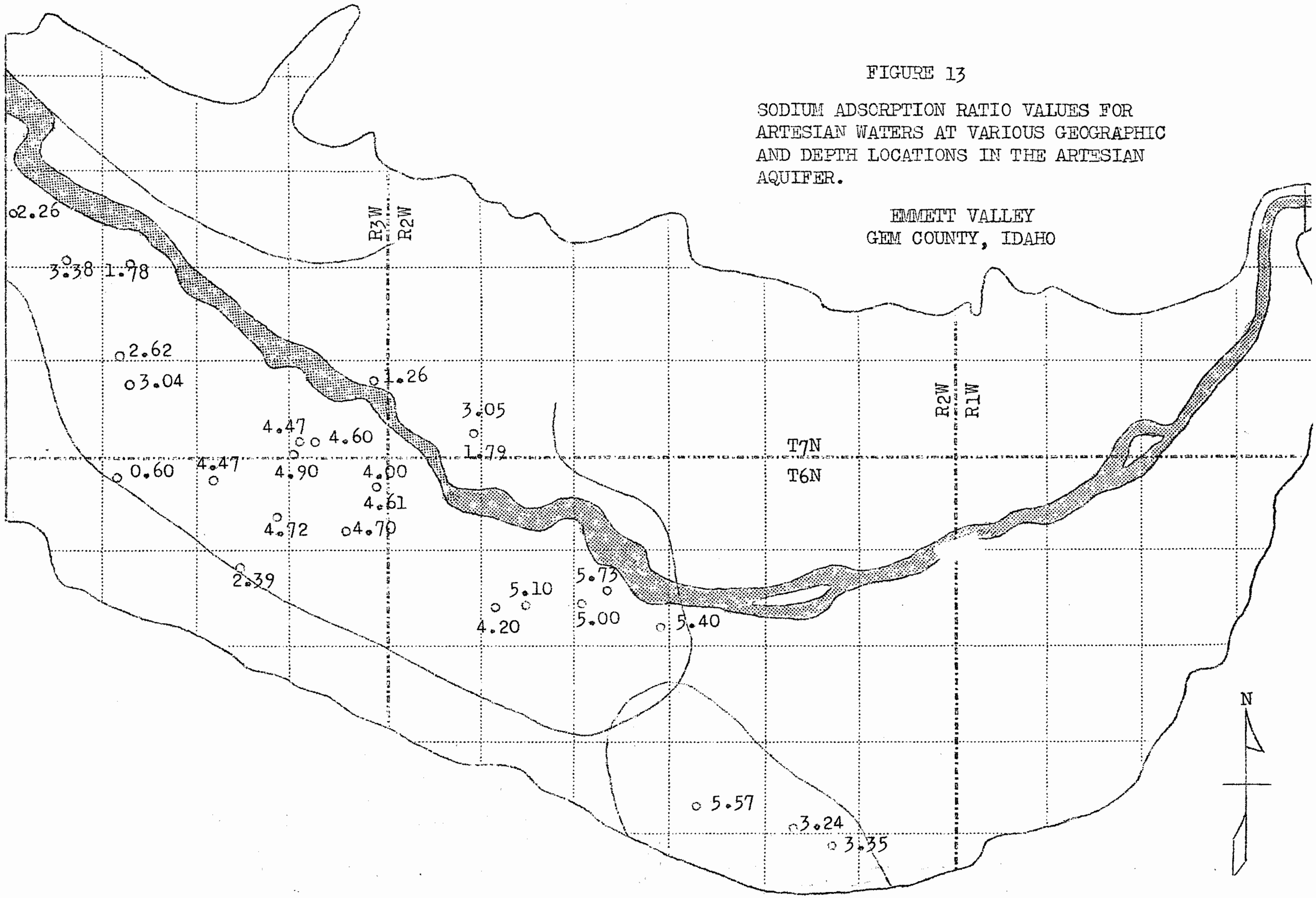


FIGURE 13

SODIUM ADSORPTION RATIO VALUES FOR ARTESIAN WATERS AT VARIOUS GEOGRAPHIC AND DEPTH LOCATIONS IN THE ARTESIAN AQUIFER.

EMMETT VALLEY
GEM COUNTY, IDAHO

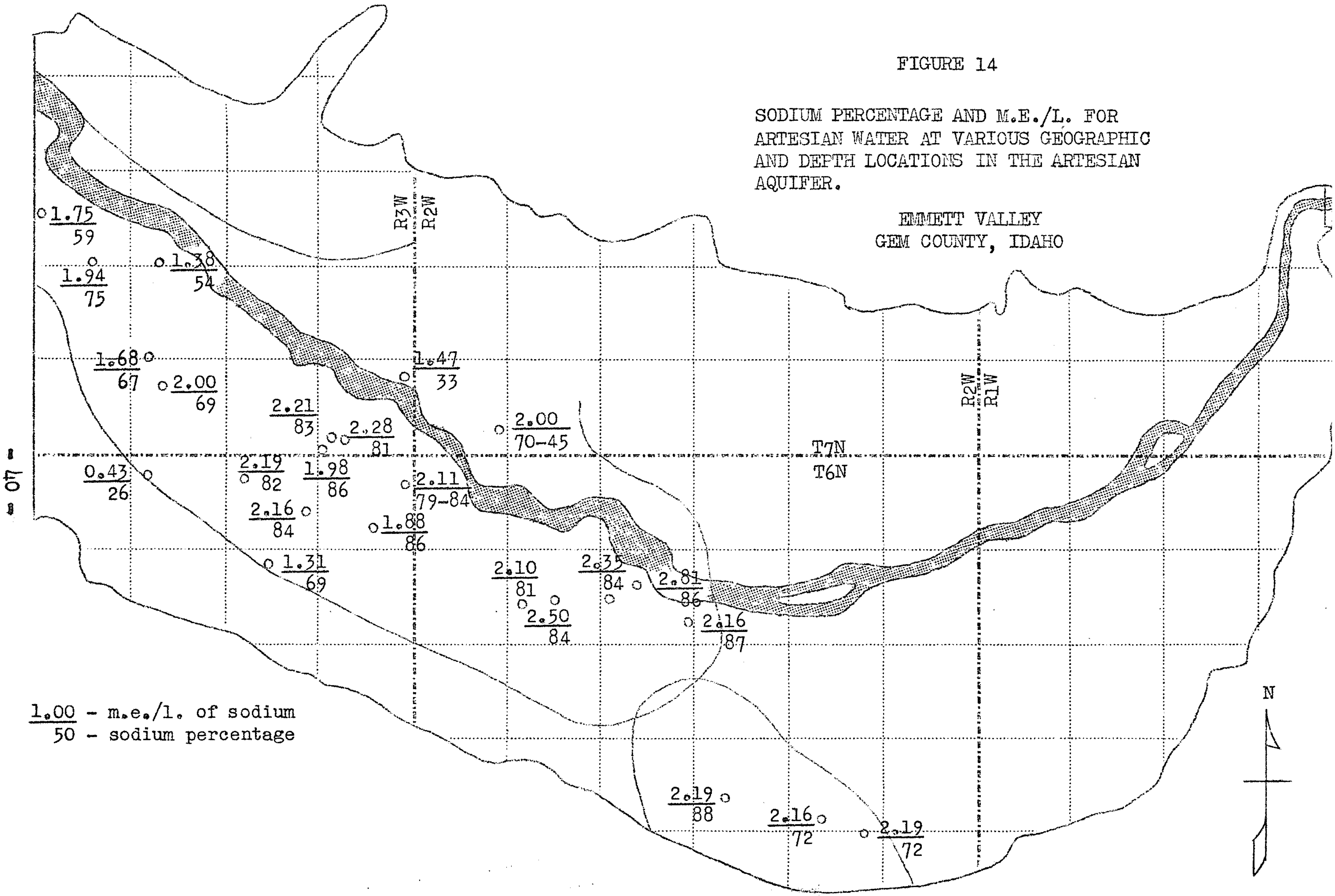


FIGURE 14

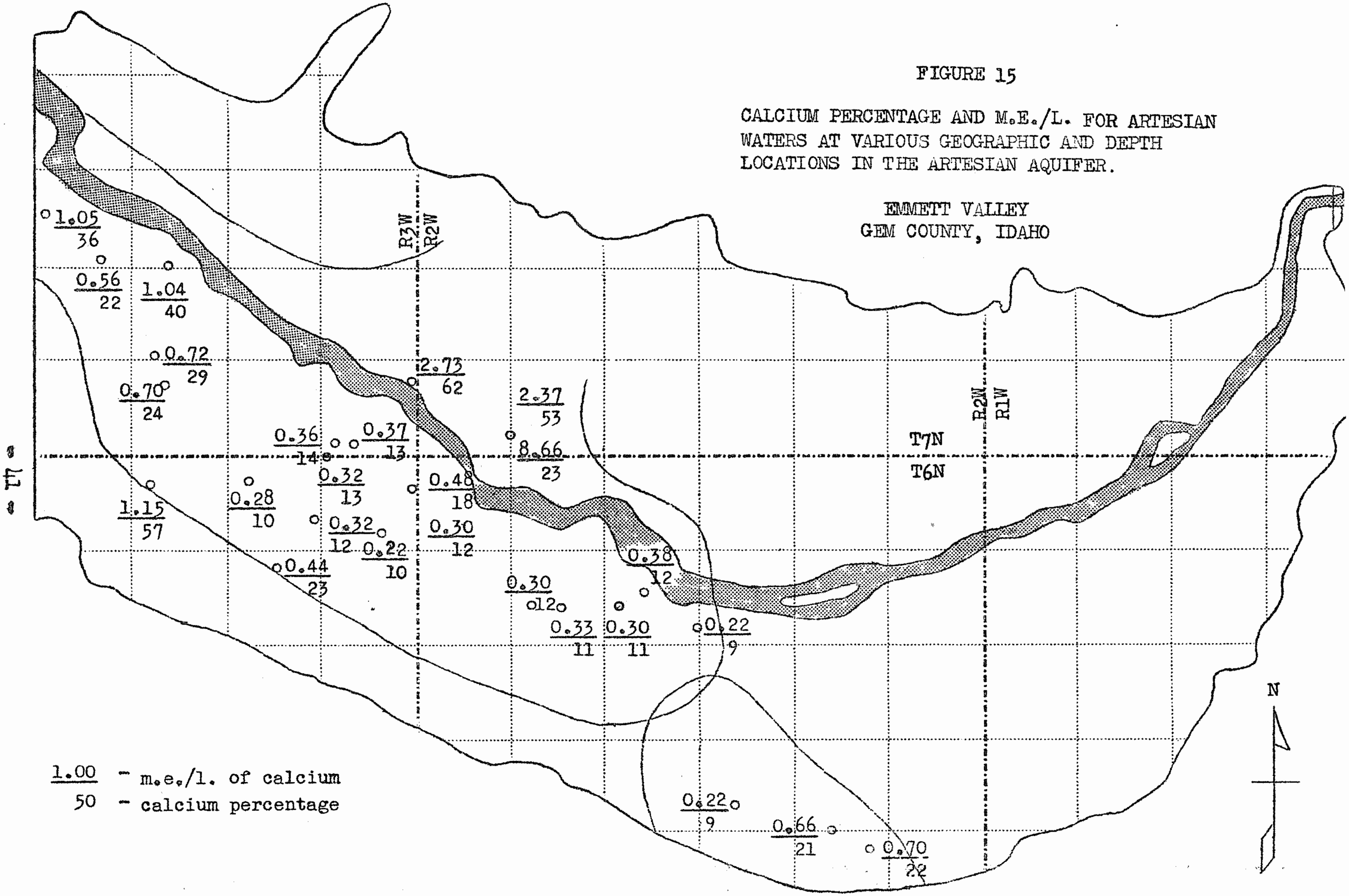
SODIUM PERCENTAGE AND M.E./L. FOR ARTESIAN WATER AT VARIOUS GEOGRAPHIC AND DEPTH LOCATIONS IN THE ARTESIAN AQUIFER.

EMMETT VALLEY
GEM COUNTY, IDAHO

FIGURE 15

CALCIUM PERCENTAGE AND M.E./L. FOR ARTESIAN WATERS AT VARIOUS GEOGRAPHIC AND DEPTH LOCATIONS IN THE ARTESIAN AQUIFER.

EMMETT VALLEY
GEM COUNTY, IDAHO



The two methods and the formulas employed in each are described below.

Discharge method:

The well is discharged at a constant rate during the test. Various discharge rates were used during the study. A rate of 1/3 or 1/2 the discharge capacity of the well was found to give the best results.

The well pressure during discharging is measured at increasing periods of time. The first pressure measurement should be made at about one minute after discharge starts. Readings were then made at the following times; 2 minutes, 4 minutes, 7 minutes, 15 minutes, 30 minutes, 50 minutes, 70 minutes, 90 minutes, 130 minutes, etc. The pressure readings are converted to feet of water pressure for plotting. The following formula was used to determine the transmissibility during discharging.

$$T = \frac{264 \times Q}{\Delta s}$$

T = Transmissibility figure expressed in gallons per day per foot width of artesian aquifer

264 = Constant required to give the transmissibility figure in gallons per day per foot

Q = Discharge in gallons per minute

Δs = The change in water pressure over one log cycle of t/r_W^2. Using semilog paper, values of water pressure are plotted on the linear scale and corresponding values of t/r_W^2 are plotted on the logarithmic scale.

t = time in minutes since the discharge started

r_W = radius of the well in feet. The radius of the wells were assumed as one foot.

Recharge method:

The well is turned off and the pressure increases are measured with similar time intervals. A figure of residual drawdown is used in plotting the readings. For example; - if the well had 50 feet of pressure before the well was discharged and 30 feet of pressure at time t^1 then the residual drawdown would be 20 feet. The same formula is used in the Recharge method.

$$T = \frac{264 \times Q}{\Delta s}$$

T = gallons per day per foot width of aquifer

264 = constant

Q = discharge in gallons per minute

Δs = The change in residual drawdown over one log cycle of t/t^1

Using semilog paper, values of residual drawdown are plotted on the linear scale and corresponding values of t/t^1 are plotted on the logarithmic scale.

t = time since discharge began

t^1= time since discharge stopped

Transmissibility equipment: The design and material list required to construct the transmissibility equipment is presented in figure 16. A 1/4 inch glass manometer tube was used to maintain a constant head on the discharge orifice at the end of the 4-inch pipe. The pressure in the artesian well was measured with a mercury gage and the readings converted to feet of water pressure. The 4-inch gate valve was used to regulate and maintain the pressure on the orifice. The valve would have to be opened as the test progressed due to the falling pressure in the well. A 24-inch wide piece of loosely rolled window screen was used to smooth out the turbulence caused by the valve. An over-all picture of the transmissibility equipment is shown in figure 17. A close up picture of the discharge orifice and manometer tube is shown in figure 18. A close up of the 4-inch control valve is shown in figure 19. The mercury gage used in the study is shown in figure 20. The mercury gage was constructed so that low head wells could be read directly in water pressure rather than in centimeters of mercury.

Transmissibility curves: Discharge and recovery curves along with transmissibility calculations for wells No. 49-A, 29 and 30 are presented in figures 21, 22 and 23. The transmissibility test was made on well No. 49-A as soon as possible following drilling. Well No. 29 was 3 years old and well No. 30 was 4 years old. The older wells have more possibility for caving and leakage. This may have some effect upon the transmissibility figures obtained with the discharge technique. Some of the recharge curves were straight lines, while some of them were either convex or concave. The shape of the curves are due to some physical characteristic of the artesian aquifer. A summary of the transmissibility data collected on 10 artesian wells in the valley are presented in table 7. The table includes information on depth, diameter, initial head or water pressure, discharge and recharge data, transmissibility computations, and aquifer efficiencies. The acquifer efficiency was computed by dividing the final head after discharging and recharging for the same period of time by the initial head. A summary of the transmissibility tests with respect to changes in transmissibility with time is presented in table 8. The transmissibility figures shown under the discharge section would be for the following times since discharge started.

.1-1 = one tenth of a minute to 1 minute

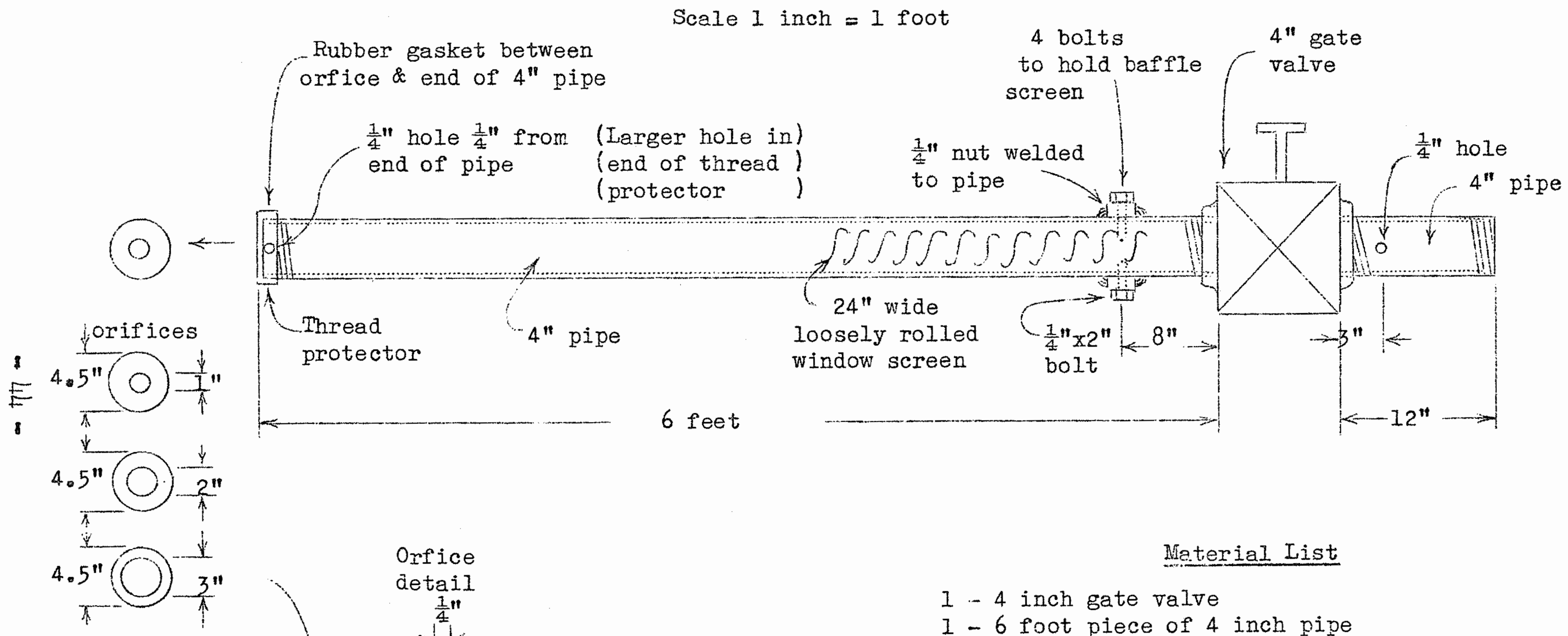
1-10 = one minute to 10 minutes

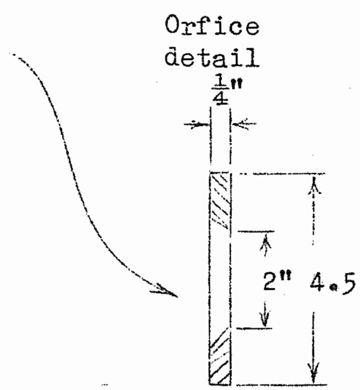
10-100= ten minutes to 100 minutes

100-1000=one hundred minutes to 1000 minutes

FIGURE 16

TRANSMISSIBILITY EQUIPMENT, SPECIFICATIONS AND MATERIAL LIST





Material List

1 - 4 inch gate valve
1 - 6 foot piece of 4 inch pipe
1 - 1 foot piece of 4 inch pipe
3 - Orfices 4.5" O.D. (1,2&3 inch orfices)
4 - 1/4 in. by 2 in. bolts
3 - 4 inch thread protectors
1 - Mercury pressure gage
1 - Water manometer

TRANSMISSIBILITY EQUIPMENT

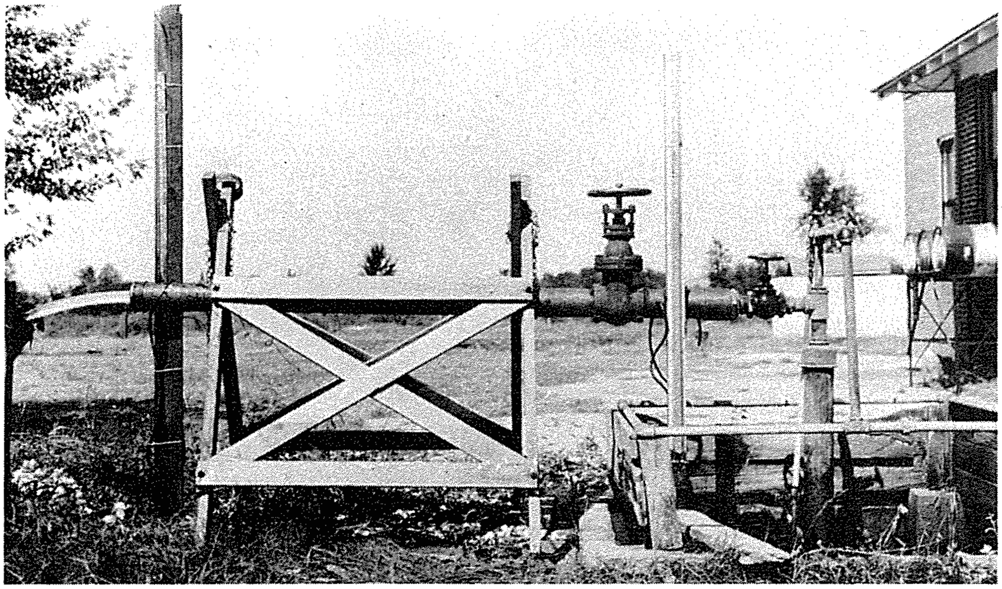


Figure 17 Transmissibility equipment used to determine the characteristics of an artesian aquifer.

Figure 18 Orfice and manometer tube used to measure the discharge from an artesian aquifer.

Figure 19 Four inch gate control valve used to maintain a constant head on the discharge orfice.

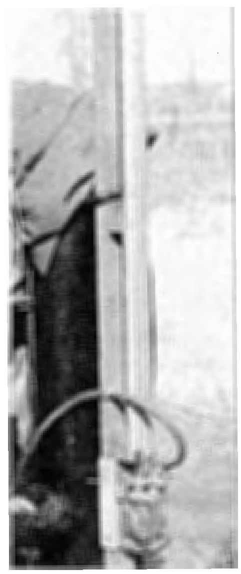


Figure 20 Mercury gage used to measure the pressure changes in an artesian aquifer.

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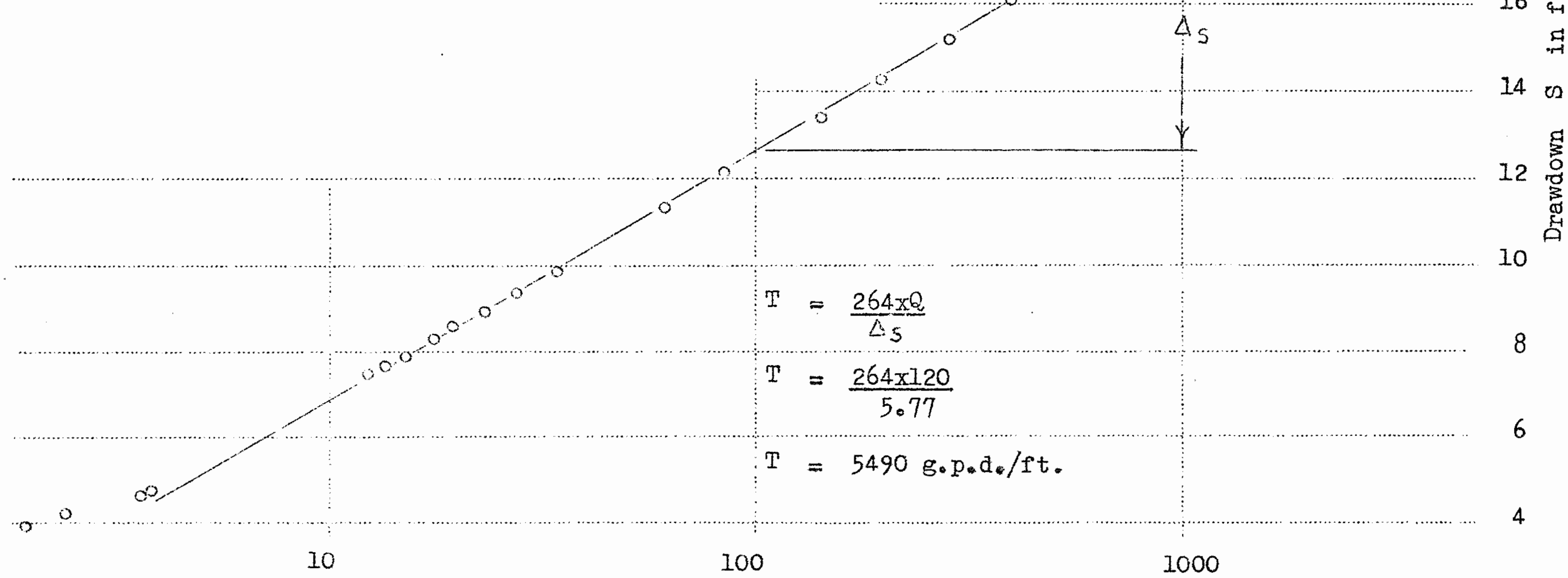
FIGURE 21

RECOVERY CURVE FOR WELL NO. 49-A

May 29 to June 4, 1953

EMMETT VALLEY
GEM COUNTY, IDAHO

(120 g.p.m. discharge)
(Discharged for 2945 minutes)
(Recharged for 4208 minutes)



Time since discharge started ÷ time since discharge stopped t/t^1 in minutes.

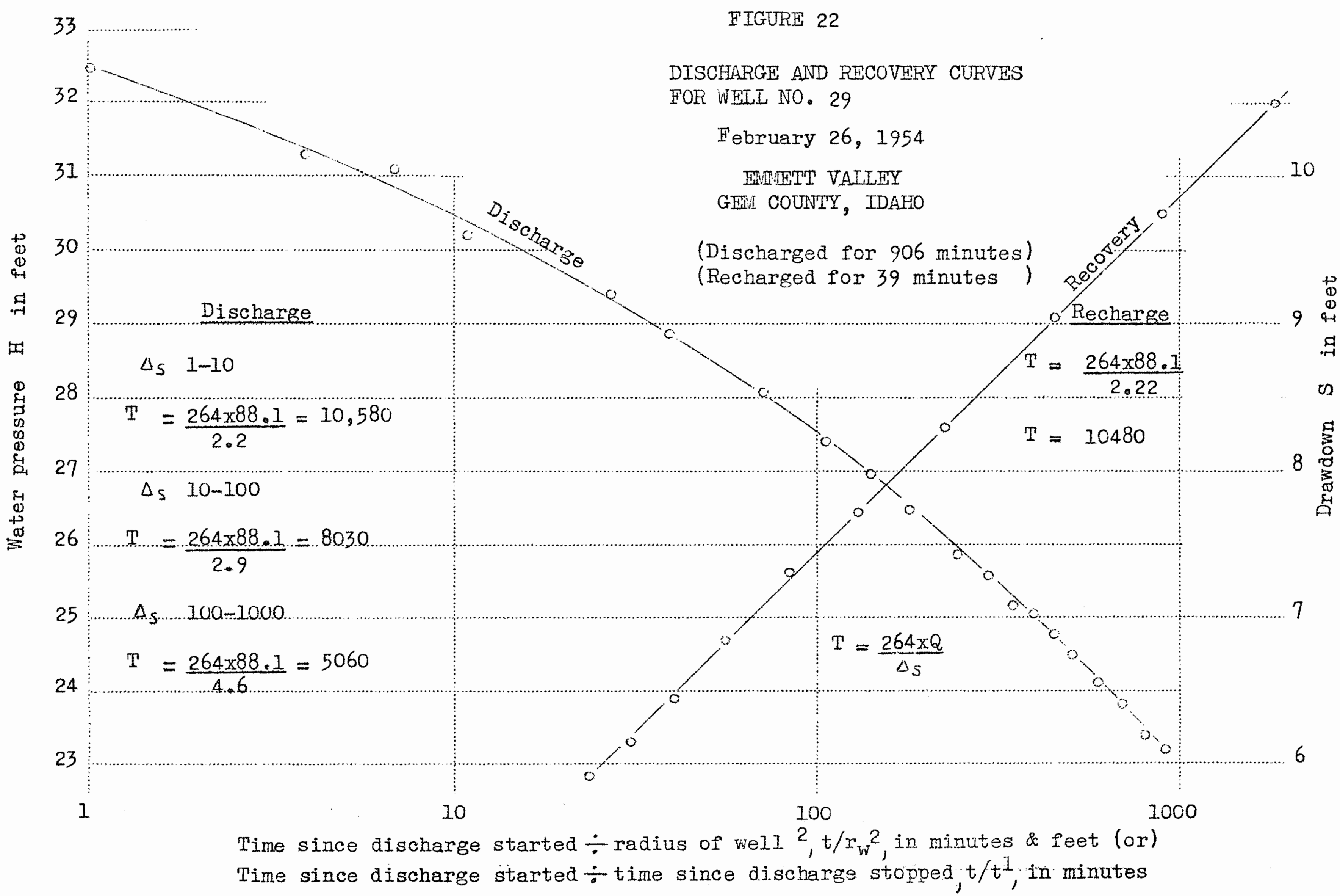


FIGURE 22
DISCHARGE AND RECOVERY CURVES
FOR WELL NO. 29
February 26, 1954
EMMETT VALLEY
GEM COUNTY, IDAHO
(Discharged for 906 minutes)
(Recharged for 39 minutes)
Discharge
Recovery
Discharge
Δs 1-10
T = 264x88.1 / 2.2 = 10,580
Δs 10-100
T = 264x88.1 / 2.9 = 8030
Δs 100-1000
T = 264x88.1 / 4.6 = 5060
Recharge
T = 264x88.1 / 2.22
T = 10480
T = 264xQ / Δs
Water pressure H in feet
Drawdown S in feet
33
32
31
30
29
28
27
26
25
24
23
10
9
8
7
6
1
10
100
1000
Time since discharge started ÷ radius of well 2, t/rw2, in minutes & feet (or)
Time since discharge started ÷ time since discharge stopped, t/t1, in minutes

FIGURE 23

DISCHARGE AND RECOVERY CURVES
FOR WELL NO. 30.

March 3, 1954

EMMETT VALLEY
GEM COUNTY, IDAHO

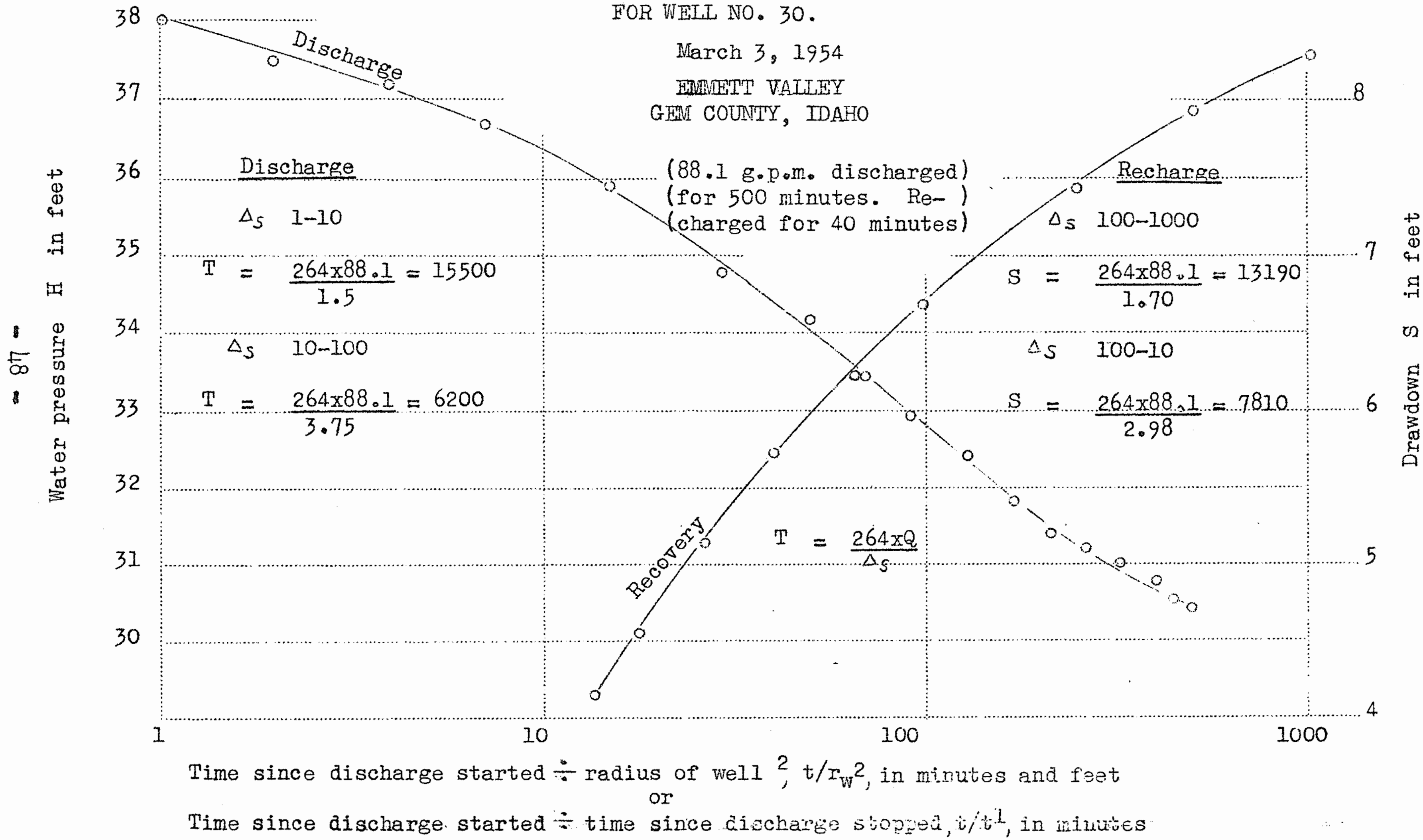


Table 7. - Artesian wells transmissiblity data, Emmett Valley, Gem County, Idaho.

Well No.	Dia in.	Depth ft.	Date Survey	Init. Head ft.	Discharge: Variable: Max. gpm	Min. gpm	Ave gpm	Discharge: Constant: Orifice in.	Head ft.	Q gpm	H max ft.	H min ft.	Time min.	Recharge: S max ft.	S min ft.	Time min.	Transmissib: Dischg gpd/ft	Rechg gpd/ft	Aquif Eff %
9	4	180	4/2/53	33.4				2	3	88.1	12.4	5.5	42	9.7	1.2	42	3640	4652	96
9	4	180	4/2/53	33.4				2	1	51.0	20.2	16.5	53			53	4480		
9	4	180	4/9/53	31.6				2	2	72.2			9	3.4	0.6	9		6450	97
9	4	180	9/1/53	33.8				2	2	72.2	15.8	8.8	377	9.7	2.2	45	3230	3859	
9	4	180	9/2/53	34.1				1	3	20.5	29.8	27.2	520	3.2	0.7	60	4040	3380	
49-A	4	180	5/29/53	45.6	180	115	120						3945	21.9	4.1	2593		5490	
51	4	145	5/27/53	27.1	325	240	265						1477	6.9	0.8	1682		32550	
50	4	161	6/27/53	41.4	250	170	190						61	24.5	1.7	84		3815	81
11-A	4	180	8/24/53	25.4	35	26	29						4105	5.2	2.5	148		7600	
57	4	161	9/3/53	23.8	1.5	1.2	1.2						195	19.6	1.4	195		42	94
57	4	161	9/4/53	23.6				small	6	1.1	4.4	3.6	90	19.6	0.7	25	1140	52	
57	4	161	9/8/53	26.0	1.7	1.4	1.4						120	19.6	0.6	120		54	98
55-A	4	127	2/6/54	19.4	90	68	70						1359	6.8	1.0	216		8550	
26-A	4	151	2/12/54	27.5	-	-	11.2						222	6.4	2.0	48		1350	
26-A	4	215	3/19/54	49.3			65.6						1446	11.4	0.5	231		5580	
29	4	176	2/24/54	39.8				2	2	72	34.3	30.7	120	5.5	0.7	120	9950	10440	98.
29	4	176	2/25/54	40.2				2	3	88.1	34.8	25.8	450	11.4	0.8	30	8770	10340	
29	4	176	2/26/54	39.4				2	3	88.1	32.5	23.2	906	11.3	5.9	39	8030	10480	
30	4	228	3/2/54	41.9				2	3	88.1	37.7	32.5	120	5.6	0.6	120	11800	13850	98.
30	4	228	3/3/54	42.7				2	3	88.1	38.0	30.4	500	8.6	4.1	40	15500	13190	
30	4	228	3/4/54	41.8				1	3	20.5	41.1	39.9	90	1.2	0.1	90	12020	11100	99.

Table 8. Transmissibility changes with respect to time.

Well No.	9	9	49-A	51	50	11-A	9	9	26-A
Date	4/9/53	4/2	5/29	5/27	6/27	8/24	9/1	9/2	3/19/54
t/r_w^2				Discharge					
.1-1									
1-10	6450						3220	7730	
10-100	5410	22500					3220	4040	
100-1000	4470	5620					11900		
Trans. trend with respect to time	↓	↓					↑	↓	
t/t^1				Recharge					
10,000-1000			5587			2620			
1,000-100	5820		5587			7600	7175	7730	5580
100-10			5587	25,000	2920	12700	3845	3610	2890
10-1		4652	8630	12,700	3815			5760	
Trans. trend with respect to time			↑	↓	↑	↑	↓	↕	↓

Table 8 (continued)

Well No.	57	55-A	26-A	29	29	29	30	30	30
Date	9/3/53	2/6/54	2/12	2/24	2/25	2/26	3/2	3/3	3/4/54
t/r_w^2				Discharge					
.1-1									27100
1-10				1460	9700	10580	11800	15500	12020
10-100	3575			9950	8020	8030	7275	6200	9830
100-1000					4560	5060		7270	
Trans. trend with respect to time				↓	↓	↓	↓	↕	↓
t/t^1				Recharge					
1000-100	42.3	7700			12900	10480		13190	
100-10		8550	847	10,440	10340	10480	13850	7810	11,100
10-1			1350	9,050			6200		5,700
Trans. trend with respect to time		↑	↑	↓	↓		↓	↓	↓

The transmissibility figures shown under the recharge section of the table are for the following times: Time in minutes since the discharge started divided by the time in minutes since the discharge stopped. For example; - if the well was discharged for 100 minutes and at the end of 100 minutes of recharging t/t^1 would be:

$$\frac{100 + 100}{100} = \frac{\text{time since discharge started}}{\text{time since discharge stopped}} = 2$$

Transmissibility data with respect to geographic location: A summary of the transmissibility data with respect to geographic location is presented in figure 24. The higher transmissibility figures are located in the suspected source area and the lower figures are farther out in the fan.

This trend in transmissibility fits in very well with the theory that the artesian water is entering the valley from the northeast through a buried fan. This is logical as the physical characteristics of the fan would show the permeability or transmissibility to be higher in the neck and lower farther out in the fan. The coarser material would be deposited farther upstream in the fan and the finer particles would be carried out into the fan. This would tend to cause a general lowering of the transmissibility as the distance from the source increased.

Summary of the artesian aquifer investigations:

Correlation between the artesian well locations and the water-logged area indicates that the artesian aquifer is directly associated with the valley-wide water-logged condition. The well logs, hydraulic gradients, geochemical study, and the transmissibility data indicate that the source of the artesian water is from the north or northeast rather than from the east or southeast as was previously suspected. The artesian water enters the valley from the northeast paralleling Bissell Creek and fans out under the valley floor. There are numerous aquifer levels. The first flows were encountered at less than 50 feet depth and the last ones at a depth greater than 600 feet. The pressure increases with depth and this indicates the presence of a master aquifer that may be leaking towards the ground surface. This pressure trend would indicate leaking acquifer caps.

Surface drainage investigations

An investigation to determine the range of influence and the performance of open drains in five of the major soil series in the Emmett Valley was initiated during the investigation. Piezometers (3) were installed at right angles to the proposed drain locations to determine the ground water level prior to drainage. Observations on the soil profile and the drain's effect upon the ground water table were observed during the drain construction periods. Piezometer observations were continued during the fall and winter to obtain the minimum and maximum ground water level following drainage. The effective range of influence varied from about 100 feet or less in the silty clays to 400 feet or more in the sandy loams underlain with gravel.

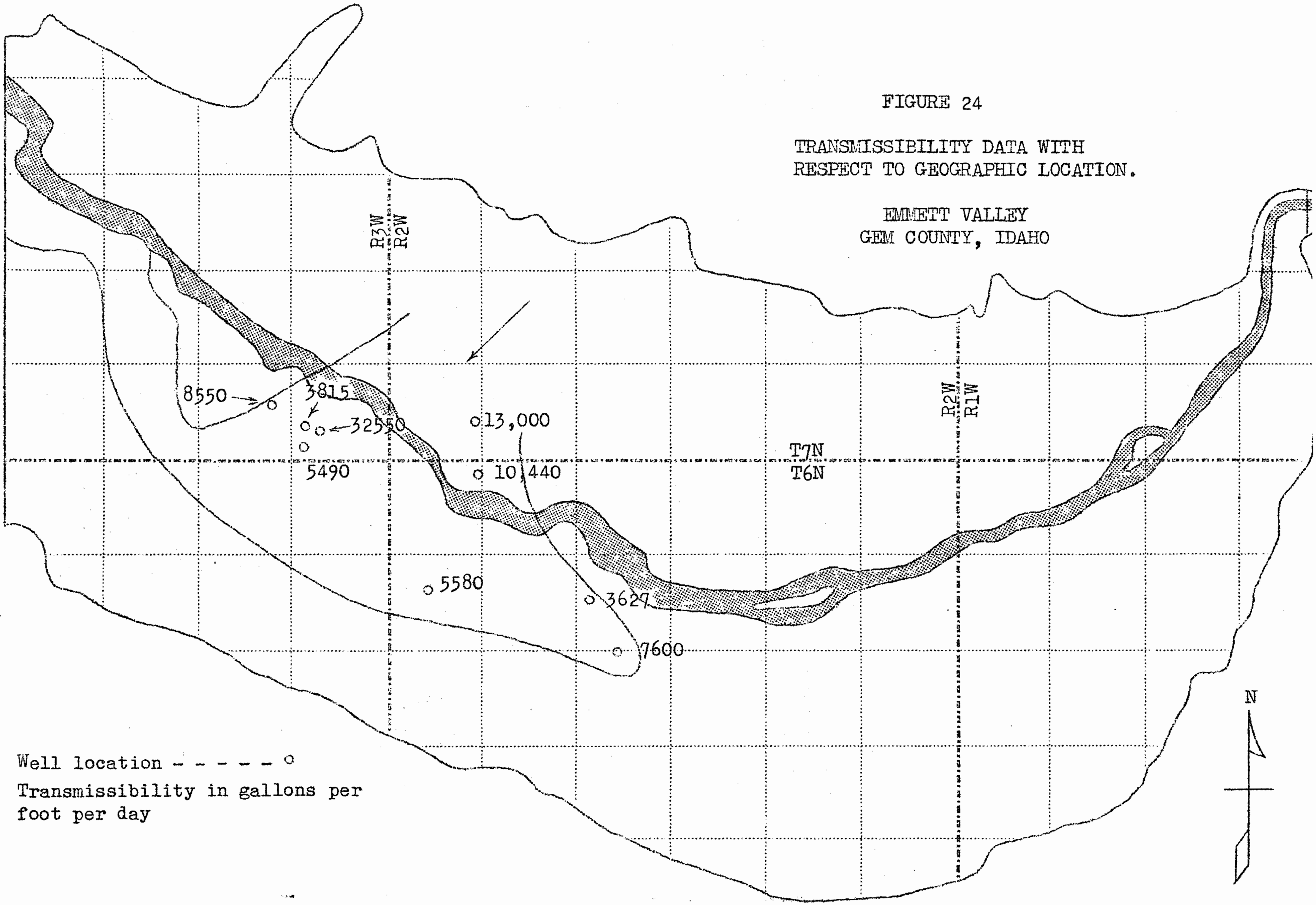


FIGURE 24

TRANSMISSIBILITY DATA WITH RESPECT TO GEOGRAPHIC LOCATION.

EMMETT VALLEY
GEM COUNTY, IDAHO

Well location - - - - - o
Transmissibility in gallons per foot per day

Drainage investigations were set up on seven farms in the valley. They covered the following soil series and textures:

Ranch	Soil Series	Texture
A	Letha	Sandy loam
B	Muck	Silty clays
C	Snow	Clay loam
D	Snow	Clay loam
E	Letha	Clay loams and gravelly fine sandy loams
F	Moulton	Loam to loamy fine sand
G	Reed & Nolan	Silty clay loams

The ranch locations are shown on figure 25. Five of the ranches are located in the general problem area south of the Payette river and the remaining two, Ranches C and D, are located on problem areas north of the river. Ranch D is located at the toe of the bench escarpment, and Ranch C is located at the toe of the escarpment on Bissell Creek.

Summary of the drainage investigations to date

A summary of the water table information collected on the seven ranches investigated is given in table 9. The work done to date is not conclusive due to a lack of irrigation information on one-half of the soils studies and one-third of the farms studied are still to be drained.

The following tentative conclusions have been formed from the investigations to date.

1. The present drainage system is not adequate to completely reclaim any of the ranches investigated. Additional tile, open drains or wells will be required to complete the drainage job.

2. A rather close spacing of tile or open drains will be required to lower and maintain the ground water level at a safe depth of $4\frac{1}{2}$ feet. Drains $6\frac{1}{2}$ feet deep, spaced at 200-foot intervals will be required to adequately drain the slowly permeable soils and artesian areas similar to the muck soils investigated. This spacing of drains will expand to 7 or 8 hundred feet depending upon the depth to and the presence of the permeable gravel substrata.

3. A valley wide study of irrigation efficiencies and lenghth of run for furrows and borders should be initiated. A high irrigation efficiency will keep the amount of water lost to the ground water table at a minimum and aid in the over-all drainage problems.

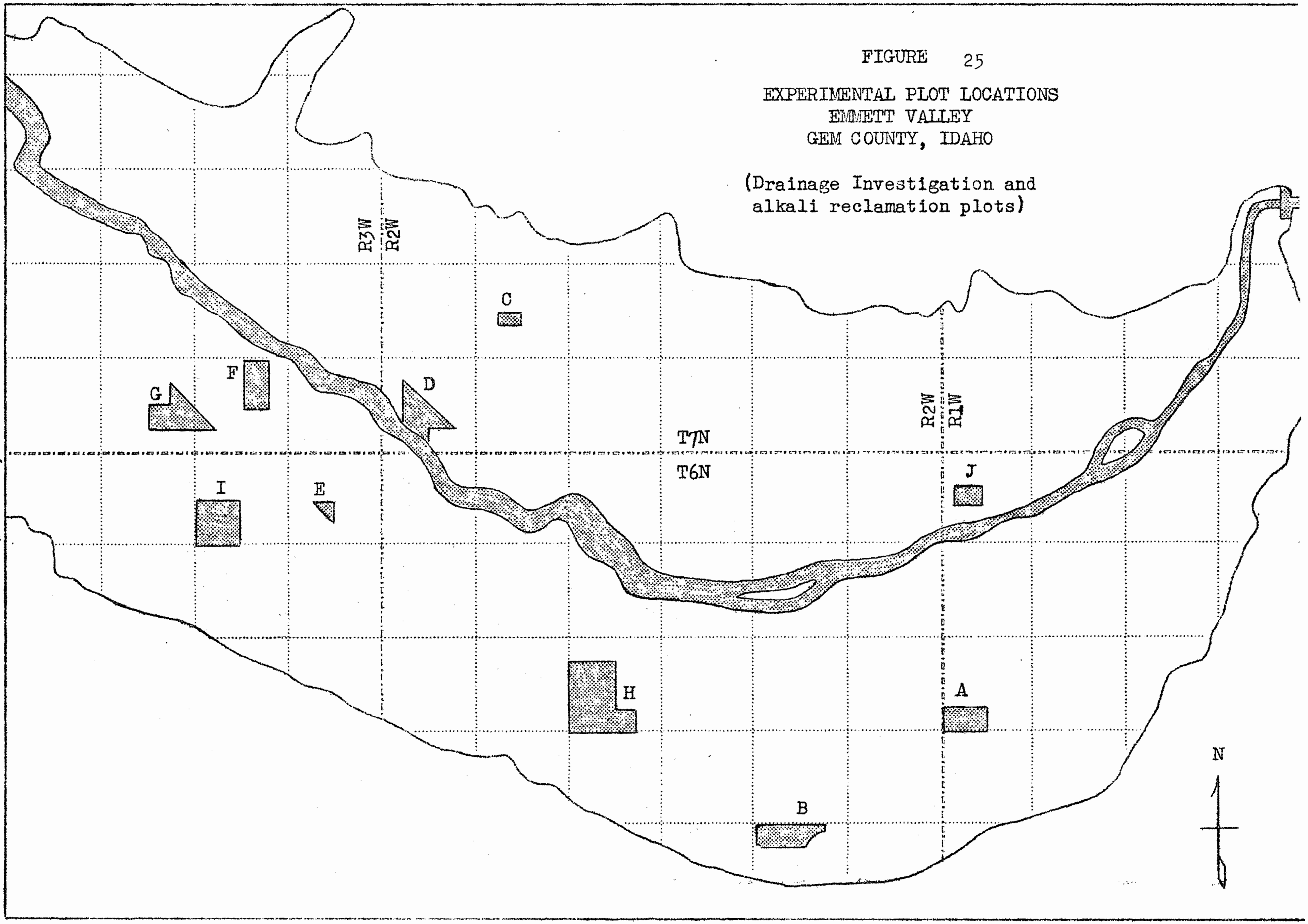


FIGURE 25

EXPERIMENTAL PLOT LOCATIONS
EMMETT VALLEY
GEM COUNTY, IDAHO

(Drainage Investigation and alkali reclamation plots)

Table 9. – Water table elevations for the six ranches investigated in the Emmett Valley, Gem County, Idaho.

Ranch No.	Area	Soil Series	Soil Texture	Depth of drain	Dur. irrig.	Maximum Water Table: Depth to max. water tab.	Maximum Water Table: Distance from drain or slough to a drawdown of 4 ft.	3 ft.	2 ft.	1 ft.	Minimum Water Table: Depth to max. water tab.	Minimum Water Table: Distance from drain or slough to a drawdown of 4 ft.	3 ft.	2 ft.	1 ft.
	ac.			ft.		ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
A	80	6	SL	6.2	No	2	750	850	950	–	3	825	950	–	–
B	105	M	C–M	7.5	No	0.5	–	40	80	200	2	60	120	260	–
C	6	S	CL	–	No	1 Art.					2.5				
D	80	S	Cl–L	6.0	Yes	1	20	60	133	533	4	150	–	–	–
E	20	6	CL–LS–GSL	–	Yes	0.7 Art.					1.4				
F	71	24	L–FSL–LFS	6.0	Yes	0.5		80	410	580	3	80	280		

Soils

Series

6 – Letha
24 – Moulton
M – Muck
S – Snow

Texture

M – Slowly permeable muck
C – Clay
CL – Clay loam
L – Loam
FSL – Fine sandy loam
SL – Sandy loam
LFS – Loamy fine sand
LS – Loamy sand
GSL – Gravelly sandy loam

Drainage installation in the Emmett Valley, Idaho from 1927 to 1954

A summary of the open and tile drains installed in the Emmett valley since 1927 is shown in table 10. During that period 100 miles or more of open drains were installed. Since 1944 drainage systems have been installed on at least 215 farms. There are two tile drains in the valley and no vertical drainage wells.

Table 10. Drainage installations in the Emmett Valley, Idaho from 1927 to 1954.

Year	Individual farm drains	Drainage Installation: Tile drains: Per yr.	Tile drains: Total	Open drains: Per year	Open drains: Total	Vertical drains: Per year	Vertical drains: Total
	number	miles	miles	miles	miles	number	number
1927-28				19.96	19.96		
- -				10.66	30.62		
35-36				3.45	34.07		
38-40				2.46	36.54		
44	8			4.06	40.60		
45	6			2.01	42.61		
46	24			8.24	50.85		
47	54			17.02	67.87		
48	39	0.15	0.15	9.17	77.04		
49	27			10.65	87.69		
50	40			6.72	94.41		
51	12			4.60	99.01		
52	5	0.12	0.27	0.99	100.00		
53				0.00	100.00		
54			0.27		100.00		

Crop increases due to drainage and reclamation

A summary of the crop production figures on the various ranches investigated is presented in table 11. Crop production on land used prior to drainage is also shown. It will be noted that the good crop increases were generally obtained on the alkali free or slightly alkali lands. Some of these lands were very wet and supported bogs or tule patches. All that was needed on the farms that responded rapidly was drainage. Very slight crop increases if any were obtained on the moderately to strongly alkali soils following drainage. Soil amendments will be required on these strongly alkali soils before significant increases in crop production will occur.

Alkali reclamation investigations

An investigation to determine the effect of various leaching waters and various amounts of soil amendments on the alkali soils in the Emmett valley was continued during the past year. Three types of leaching waters were used during the investigation. These types available for large scale use were river water, drainage water and artesian water. Various applications at the rate of 5 and 10 tons of gypsum per acre were used for the soil amendments. Check plots were made on soils where no soil amendments were added.

Table 11. – Crop increases due to drainage and reclamation. Emmett, Valley, Gem County, Idaho

No.	Area	Open Drains	Drainage Cost	Soils Series	Soils Texture	Soils Alkali	Farm Leveled	Farm Leached	1949 Crop	1949 Fert	1950 Crop	1950 Fert	1951 Crop	1951 Fert	1952 Crop	1952 Fert	1953 Crop	1953 Fe
	Ac.	Ft.	Dollars						Lb.ac.	Lb.ac.	Lb.ac.	Lb.ac.	Lb.ac.	Lb.ac.	Lb.ac.	Lb.ac.	Lb.ac.	Lb.a
A	80	7340	3906	6	SL	F-S-M	–	No	P	–	P	–	P ▩	–	P	–	P	–
B	105	1186	1624	M-18-9	C-M	F-S-M	–	No	P	–	P	–	P ▩	–	P	–	P	–
C	6			S	CL	F	No	No	S	–	S	–	S	–	S	–	S	–
D	80	2804		S	CL-L	F	No	No	▩			–	C-8000	–	O-G-2820	M-L	O-1520	M-
E	20			6	CL-LS-GSL	S-M-H	No	No	P	–	P	–	P	–	P	–	P	–
F	12.3	2030	843	24	LFS		slight	No	P		P	–	U-0.67 ▩	–	A-3740	–	C-9688	N-1
F	12.9			24	L		Yes	No			C-1000	N-200	G-3030 ▩	N-150	A-3720	–	A-2000	–
F	6.8			24	FSL		Yes	No	A-8000	–	A-8000	–	A-8000 ▩	–	G-18000	N-150	A-5118	–
F	6.9			24-7	L-FSL-LFS		Yes	No			O-1600	–	G-3030 ▩	–	O-1600	N-150	A-5118	–
F	32.2			24-6	FSL-LFS		No	No					U-0.67 ▩	–	U-0.67	–	U-0.78	–
G	24	1200	444	21-18	SCL	S-M-H	Yes	No	P	–	C-1240	–	A-1660 ▩	–	A-2160	–	A-3330	–
H	280			6	L-SL	M	No	No	P	–	P	–	P	–	P	–	P	–
I	160			21	SC-SCL	H	No	No	P	–	P	–	P	–	P	–	P	–
J	2	800	144	24-39	SL	F	Yes	No	S ▩	–	O-2560	–	A-1000	–	A-10,000	M-L	C-2800	M-
J	5			M-39	SL	F	Yes	No	S ▩	–	O-1600	–	A-1600	–	C-4000	M-L	C-2800	M-
J	7			M-39	SL	F	Yes	No	S ▩		C-10,000	–	A-7428	–	A-12,000	M-L	C-2800	M-
J	16			M-39	SL	F	Yes	No	S ▩	–	O-1600	–	O-1600	–	O-960	M-L	A-14,300	M-

Legend

Series
- 6 – Letha
- 7 – Emerson
- 9 – Cannon
- 18 – Nolan
- 21 – Reed
- 24 – Moulton
- 39-39 Series
- M – Muck
- S – Snow

Texture
- M – Slowly permeable
- C – Clay
- SC – Silty Clay
- SCL – Silty Clay Loam
- CL – Clay Loam
- L – Loam
- FSL – Fine Sandy Loam
- LS – Loamy Sand
- GSL – Gravelly Sandy Loam

Alkali
- F – Alkali free
- S – Slightly alkali
- M – Moderately alkali
- H – Strongly alkali

Crop
- A – Alfalfa
- B – Barley
- C – Sweet corn
- G – Grain
- O – Oats
- P – Pasture
- S– Swamp
- U – Animal Units per acre

Ferterlizer
- M – Manure
- N – Ammonium Nitrate
- L – Light application
- ▩ – Drainage installed

Twelve inch long sections of steel well casing were used to form the check plots. These sections of well casings were driven seven inches into the soil. This left five inches of ring above ground to act as a leaching pond well. Various types of leaching water and amounts of soil amendments were applied to the soil inside these rings.

Eighty-one rings were installed on three of the most typical alkali problem areas. Twenty-seven rings were installed in a slowly permeable strongly alkali soil. Two other sets of 27 rings each were installed in moderately and rapidly permeable soils. Rings with a welded, leak proof, bottom were installed at each set of ring locations for use as evaporation pans and rain gages.

The following observations and records were obtained on the ring studies:

1. Water and soil temperature at a depth of approximately one inch below the soil surface in the rings.

2. Evaporation during the measurements.

3. Intake rates

4. pH readings of the soil surface and leaching water during each leaching period (2)

5. Aggregation of the soil in the rings following leaching periods

6. Soil structure during the investigation

7. Soil workability during the investigation

8. Visible gypsum between leaching periods.

9. Pentrometer or Proctor Needle readings between leaching periods.

<u>Chemical analysis of the river, drain and artesian waters used in the investigation</u>

A chemical analysis of the various reclamation waters used in the rings is presented in table 12. The analysis was made by Dr. V. C. Bushnell of the U. S. Bureau of Reclamation. A summary and several computations made from the analysis in table 12 is shown in table 13. The last column in table 13 indicates that 0.6 of a pound of usable gypsum is applied to the soil in one acre foot of river water. Three hundred ninety-seven pounds of gypsum will be required to counteract the effect of an acre foot of drain water. However, with the application of one acre foot of artesian water, 233 pounds of usable gypsum are applied to the soil. This is a very significant difference and shows up in the field work presented later in the report.

Table 12. - Chemical analysis of the river, drain and artesian waters used in the Alkali Reclamation Investigations. 1/ Emmett Valley, Gem County, Idaho

Sample No.	pH	EC x 10^5 at $25^\circ C$	Boron PPM	Anions, m.e./l.				Cations, m.e./l.				Residual $Na_2 CO_3$ m.e./l.	Percent Sodium		Salinity Lab. Rating
				CO_3	HCO_3	Cl	SO_4	Ca	Mg	Na	K		Found	Possible	
1 2/	7.50	12	0.23	0.00	0.91	0.03	0.78	0.48	0.16	0.45	0.06	0.27	39.1	100	Good
2 3/	7.70	65	0.07	0.00	4.36	0.46	2.00	1.69	0.63	3.84	0.14	2.04	61.9	100	Doubtful
3 4/	7.97	44	0.25	0.00	2.97	0.44	1.17	2.73	0.17	1.47	0.04	0.07	33.3	100	Good

Table 13. - Percentages of various anions, cations and available gypsum in the river, drain and artesian waters used in the Alkali Reclamation Investigations, Emmett Valley, Gem County, Idaho

Sample No.	HCO_3	Cl	SO_4	Ca	Na	Total Ca SO_4	Total Ca SO_4	Ca excess over Na	Effective gypsum in one ac. foot of water
	o/o	o/o	o/o	o/o	o/o	ppm	lb/ac.ft.	ppm	lb/ac.ft.
1 2/	53	2	45	42	39	33	88	0.06	0.6
2 3/	64	7	29	27	61	101	274	-43	-397
3 4/	65	10	26	62	33	186	500	25	233

1/ Analysis by the U. S. Bureau of Reclamation.
2/ Payette River water - Sec. 31, T.7N. R2W., 4/22/52.
3/ Forgy drain water - Sec. 31 T.7N. R2W., 4-22/52.
4/ Soulen artesian water - Sec. 36, T.7N. R3W., 4-22-52.

Ranch "I" alkali reclamation investigation

Ranch "I" is located in the eastern end of the Emmett Valley on one of the old undulating terraces adjacent to the Payette river. (See figure 25 for ranch location) The soils are strongly alkali and silty clay to a depth of 10 to 20 feet. The soils respond very slowly to tile or open drains and require considerable gypsum or other soil amendments to effect a complete reclamation. Reclamation on this ranch has been very costly and has proven unsatisfactory to date.

Infiltrometer ring layout: The rings were installed about 50 feet from a six foot open drain. This drain maintains a sufficiently low water table under the rings to permit reclamation with soil amendments. The rings were also located in an area that was completely devoid of any pasture or native weeds. When water is applied to this barren spot a black "crayon color" or scum forms on the surface or evaporation edges of the wet area. The ranch is used as a part-time pasture during the year. The pasture is very spotty and varies from absolutely barren areas to some small areas that have very poor pasture growth.

The infiltrometer ring layout, the rings using river, drain, and artesian water, and the amount of gypsum applied to each ring was shown in figure 38 of the June 1953 Progress Report. River water was applied to 9 rings, drain water to 9 rings, and artesian water to 9 rings. Applications of none, five and ten tons of gypsum per acre were applied to the rings. This layout of 27 rings gave three replicates for each treatment. The rings were not all the same size and were installed so that there were an equal number of large, intermediate and small rings for each treatment and set of replicates. The evaporation ring consisted of a 12-inch long section of 12-inch diameter well casing with a plate welded in the bottom. The ring was used as a combination evaporation pan and rain gage.

Ranch "I" soils at the plot location: The general valley soil survey shows the Reed soils are very slowly permeable to a depth of fifteen feet or more. A ten foot soil survey at the plot location was presented on a Soil Profile Chart. The soils were found to be silty clay loam and clay to a depth of 10 feet. Two thin hard crumbly fractured clay strata were found at 3.6 and 8.2 feet. Ground water was being carried in the fractured clay strata. The water table was measured at 3.6 feet which indicated the strata was not under pressure at this location in the field.

A pH reading with a color indicator (Thymol Blue) was made at each six-inch interval and soil change for the 10 foot soil log. The pH was found to be very high at the surface, but was below 8.5 at a depth of three feet. The pH was very low for the remainder of the 10 feet. The pH also indicates that the alkali is concentrated in the upper one to two feet of soil.

Soil aggregates formed in the infiltration rings during drying: During drying between leaching periods, it was observed that the soils in the various rings cracked into aggregates or clods. It was also observed that the number of aggregates correlated very closely to the type of water used in the rings and the amount of soil amendment added to each ring. A picture of the aggregates formed following the first leaching period were presented in figure 41 of the June 1953 Progress Report.

A summary of the aggregates following the first, second, third, and fourth leaching periods are given in table 14. The aggregate numbers shown are an average of three replicates for each treatment.

The aggregate totals shown in table 14 indicates that the drain and artesian water have a slightly more beneficial effect upon the structure of the soil than the river water. There has been an overall increase in aggregation since the last observations were made on 10/20/52. The increase of aggregation in the rings having no gypsum applied is very encouraging. It indicates that some slight benefit is being obtained by washing the soil. The final aggregation with respect to water used shows very slight benefit of one type over the other. The number of aggregates in the 27 rings with respect to water type are as follows:

Water type	Total number of aggregates
River	28
Drain	39
Artesian	42

The number of aggregates in the 27 rings with respect to gypsum application are as follows:

Tons of gypsum	Total number of aggregates
0	33
5	35
10	51

Structure, workability and visible gypsum: A summary of structure, workability and visible gypsum following the four leaching periods are presented in table 15. Observations were made in the field, visually and with respect to working the soil in the various rings with a 3/4 inch wood chisel.

Analysis of table 15 indicates that some structure was developed in the slowly permeable soils with applications of five and 10 tons of gypsum per acre. It would appear, however, that the structure degenerated following the third and fourth leaching periods. The soil had a bubbly vesicular structure that appeared to get more pronounced following the third and fourth leaching periods. The application of gypsum has a marked effect upon the workability of the soil. The check rings with no gypsum applied remained hard to work following the four leaching periods. The rings having an application of five tons of gypsum worked up moderate to easy following the first leaching period and worked up moderate to hard following the fourth leaching period. This would also indicate that the five tons per acre of gypsum is nearly used. Only a slight trace of gypsum was found in several of the rings. The rings having an application of 10 tons of gypsum per acre worked up easily following the first three leaching periods. The workability increased considerably following the fourth period. There was only a slight trace of gypsum in the rings. It also appeared that the ten ton per acre application of gypsum was nearly used up. The good soil structure decreased and the workability increased as the gypsum applied to the soil was used up.

Table 14. Summary of aggregates formed in the Ranch "I" infiltration rings, following the first, second, third, and fourth leaching periods. Emmett Valley, Gem County Idaho.

Type water used	Gypsum applied per acre tons	Following the first leaching period 6-22-52 aggregates	Following the second leaching period 7-29-52 aggregates	Following the third leaching period 10-20-52 aggregates	Following the fourth leaching period 4-12-54 aggregates
River	0	1	1	1	3
	5	4	3	1	3
	10	8	7	4	6
	Total	13	11	6	12
Drain	0	1	3	2	3
	5	4	4	2	4
	10	9	7	4	6
	Total	14	14	8	13
Artesian	0	1	4	3	5
	5	10	3	4	5
	10	6	7	4	4
	Total	17	14	11	14

Proctor Needle tests: A series of 10 tests were made in each ring with a Proctor Needle, Pentrometer, following the 2nd, 3rd, and 4th leaching periods to determine the bearing in pounds per square inch for the soils under the various treatments. This makes 30 replicates for each treatment shown. A summary of the pentrometer data is presented in table 16.

Table 15. – Summary of structure, workability and visible gypsum following the four leaching periods on the Ranch "I" Investigation, Emmett Valley, Gem County, Idaho.

Water used	No gypsum applied to soil					5 tons of gypsum per acre					10 tons of gypsum per acre				
	1st	2nd	3rd		4th	1st	2nd	3rd		4th	1st	2nd	3rd		4th
	6/11	7/31	10/20	3/16/54	4/16/54	6/11	7/31	10/20	3/16/54	4/16/54	6/11	7/31	10/20	3/16/54	4/16/54
								Structure							
River	poor	poor	poor	poor	poor	fair	fair	poor	poor	poor	fair	fair	poor	fair	fair
Drain	poor	poor	poor	poor	poor	fair	poor	poor	poor	poor	fair	good	fair	fair	fair
Artesian	poor	poor	poor	poor	poor	fair	good	fair	fair	fair	fair	good	fair	fair	fair
								Workability							
River	hard	hard	hard	mod.	hard	mod.	mod.	mod.	mod.	hard	easy	easy	mod.	mod.	mod.
Drain	mod.	hard	hard	hard	hard	mod.	mod.	mod.	mod.	hard	mod.	easy	easy	mod.	mod.
Artesian	mod.	mod.	hard	mod.	hard	easy	mod.	mod.	mod.	mod.	mod.	easy	easy	easy	mod.
								Visible Gypsum							
River	–	–	–	–	–	mod.	trace	none	none	none	consid.	trace	trace	trace	trace
Drain	–	–	–	–	–	mod.	trace	none	trace	none	consid.	mod.	trace	trace	trace
Artesian	–	–	–	–	–	mod.	trace	trace	trace	trace	consid.	mod.	trace	trace	trace

Table 16. Summary of the Proctor Needle data following the second, third, and fourth leaching periods on the Ranch "I" investigations. Emmett Valley, Gem County Idaho.

Water applied	Gypsum applied	Following the 2nd leaching per. 7/31/52	Following the 3rd leaching per. 10/20/52	Prior to the 4th leaching per. 3/15/54	Following the 4th leaching per. 4/15/54
	tons/ac.	lb./sq.in.	lb./sq.in.	lb./sq.in.	lb./sq.in.
River	0	3047	2185	1868	2580
	5	1911	2164	2178	2584
	10	2222	1853	1359	1984
Drain	0	3409	2317	2053	2497
	5	1911	2056	1974	2300
	10	1704	1881	1583	1892
Artesian	0	3099	2150	1766	2713
	5	1911	2014	1499	2250
	10	1859	1888	1387	2273
Ground surface outside the rings		2051	2604	2300	1727

The three different waters used gave very similar results at the close of the third leaching run. The drain water without gypsum gave slightly higher values than the river or artesian waters. A considerable reduction in bearing load was recorded between the 0, 5, and 10 ton applications of gypsum following the third run. The Proctor Needle data prior to the 4th leaching period showed similar results to the readings made on 10/20/52. The readings taken on 3/15/54 were made after a 17-month lapse of time. They were generally lower than those made following the 3rd leaching period, however, the difference in bearing load between the 0, 5, and 10 tons of gypsum was significent. The soils were worked up prior to the 4th period. The Proctor Needle data following the 4th leaching period substantiates the observations made im table 15. No gypsum was found remaining in the rings having a five ton application. This was also indicated by the Proctor readings. No gypsum was observed and the readings were comparable for the river and drain water between the check rings and the ones having five ton applications. Gypsum was still visible in the rings using artesian water.

Intake rates: A summary of the intake rates for the four leaching periods are presented in table 17. The intake rates have been corrected for evaporation and a viscosity correction has been applied to convert the intake rates to a standard temperature of 60 degrees Fahrenheit.

Table 17. – Summary of the intake rate data for the 1st, 2nd, 3rd and 4th leaching periods on the Ranch "I" investigation,1/ Emmett Valley, Gem County, Idaho.

Water applied	Gypsum applied	First leaching period 1952							Second leaching period 1952				
		4/22	4/24	4/25	4/28	5/2	5/5	5/9	6/11	6/12	6/13	6/17	9/8
	t/ac.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.
River	0	0.04	0.02	0.01	0.00	0.00	0.01	0.01	0.04	0.02	0.01	0.02	0.08
	5	0.07	0.03	0.01	0.02	0.01	0.02	0.01	0.06	0.02	0.01	0.03	0.11
	10	0.06	0.03	0.02	0.01	0.01	0.02	0.01	0.05	0.02	0.02	0.03	0.11
Drain	0	0.06	0.03	0.00	0.00	0.00	0.01	0.00	0.03	0.01	0.02	0.09	0.02
	5	0.10	0.03	0.03	0.02	0.01	0.02	0.01	0.06	0.02	0.02	0.02	0.10
	10	0.10	0.03	0.03	0.03	0.01	0.02	0.01	0.09	0.03	0.03	0.06	0.13
Artesian	0	0.03	0.02	0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.02	0.08
	5	0.10	0.03	0.03	0.02	0.01	0.02	0.01	0.06	0.02	0.01	0.02	0.13
	10	0.07	0.03	0.02	0.02	0.01	0.01	0.01	0.13	0.03	0.02	0.04	0.15

Water applied	Gypsum applied	Third leaching period 1952			Fourth leaching period 1953							
		9/9	9/10	9/11	3/17	3/18	3/19	3/22	3/23	3/24	3/25	3/26
	t/ac.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.
River	0	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.00
	5	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.01
	10	0.04	0.04	0.03	0.14	0.02	0.01	0.01	0.01	0.01	0.02	0.01
Drain	0	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00
	5	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.01	0.00
	10	0.06	0.05	0.03	0.13	0.02	0.01	0.01	0.00	0.01	0.01	0.01
Artesian	0	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00
	5	0.03	0.03	0.02	0.03	0.01	0.00	0.00	0.00	0.01	0.00	0.00
	10	0.07	0.06	0.06	0.13	0.01	0.01	0.00	0.00	0.00	0.00	0.00

1/ Intake rates have been corrected for evaporation and to a standard temperature of 60 degrees Fahrenheit.

Several of the rings were leaking at the start of the fourth leaching period. The rings were all driven about an inch to tighten them in the soil and to stop this leakage. The intake rates dropped to nearly zero in all of the rings following driving. It has since been concluded that the soil was possibly compacted during the driving. The soil adhered very tightly to the sides of the rings and had to be pounded out when the study was concluded. It is possible that the soil was compacted and the permeability reduced in the ring and in the area immediately below.

The intake rates for the zero and five ton applications stayed fairly uniform during the study. The intake rates for the ten ton applications have slowly increased during the study.

The intake rates are still very low and will make reclamation very long and costly.

pH values: A summary of the pH values from April 22, 1952 to April 16, 1954 on the Ranch "I" alkali reclamation plot is presented in table 18. The pH values shown in table 18 are an average of three replicates. The pH values were obtained on the soil surface in the rings during the drying periods and the pH of the leaching water was obtained during leaching periods. The pH values were determined with Thymol Blue. (Color indicator)

The pH values compare very favorably with the amount of gypsum applied to the soil in the rings. The final pH values compare very closely between the rings using river, drain and artesian water. The average pH of the soil in the rings having no gypsum applied is about 9.5, in the rings having 5 tons of gypsum added to the soil, it is about 8.8, and the rings having 10 tons added, the pH is about 8.5. An interesting trend occurred in the series of tests over the period from April 22 to October 20. The pH in the rings using river and drain water and having a 10 ton application of gypsum dropped very slowly during the study. They had a final pH of 8.2 to 8.4. The average pH on the rings using artesian waters and having a 10 ton gypsum application dropped from 9.6+ to 8.1 immediately. The pH average increased to about 8.4 during the second leaching period and then dropped again at the end of the season.

During the drying period following the 4th leaching period, the pH values slowly increased in the rings having no gypsum applied. The following tabulation gives the changes in pH between March 29 and April 12, 1954.

Table 18. - Summary of the pH values for the four leaching periods on the Ranch "I" investigation. Emmett Valley, Gem County, Idaho. 1/

Water applied	Gyp. appl.	Dry	1st period 1952		Dry	2nd period 1952		Dry	3rd period 1952		Dry 1952		Dry 1953		Dry 1954
		4/22	4/25	5/19	6/11	6/12	6/26	7/31	9/8	9/23	9/25	10/20	4/10	5/1	3/16
River	0	9.6+	9.6	9.6	9.6	9.6	9.6	9.4	8.7	9.0	9.2	9.5	9.5	9.4	9.6
	5	9.6+	8.6	8.3	8.5	8.2	8.4	8.4	8.2	8.4	8.5	8.5	8.5	8.4	8.8
	10	9.6+	8.4	8.3	8.5	8.1	8.3	8.1	8.1	8.3	8.4	8.3	8.3	8.3	8.5
Drain	0	9.6+	9.2	9.5	9.6	9.2	9.0	9.3	8.5	8.8	8.9	9.5	9.5	9.6	9.6
	5	9.6+	8.6	8.9	8.6	8.5	8.8	8.4	8.4	8.7	8.7	8.6	8.6	8.5	8.7
	10	9.6+	8.5	8.7	8.4	8.3	8.2	8.2	8.3	8.2	8.4	8.2	8.2	8.2	8.4
Artesian	0	9.6+	9.5	9.6	9.6	9.6	9.6	9.3	8.6	9.2	9.3	9.3	9.4	9.6	9.5
	5	9.6+	8.4	8.5	8.6	8.4	8.4	8.2	8.3	8.4	8.5	8.6	8.4	8.5	8.7
	10	9.6+	8.1	8.4	8.3	8.3	8.4	8.2	8.2	8.2	8.3	8.1	8.3	8.2	8.4

Table 18. -(Continued)

Water applied	Gyp. appl.	4th Leaching period 1954								Dry 1954						
		3/17	3/18	3/19	3/22	3/23	3/24	3/25	3/26	3/29	3/31	4/2	4/5	4/7	4/12	4/16
River	0	8.3	9.0	9.1	9.2	9.1	9.1	9.0	9.1	9.2	9.3	9.5	9.6	9.5	9.4	9.5
	5	8.3	8.5	8.7	9.1	9.0	9.0	9.1	9.2	8.8	9.0	9.2	9.1	9.0	8.8	8.8
	10	8.2	8.3	8.3	8.8	8.9	8.8	8.8	8.8	8.5	8.4	8.4	8.4	8.4	8.5	8.2
Drain	0	8.4	8.4	8.6	8.7	8.9	8.9	8.9	8.9	9.3	9.3	9.5	9.5	9.5	9.5	9.5
	5	8.4	8.4	8.5	8.6	8.9	8.7	8.9	9.0	8.7	8.9	9.0	9.0	8.9	8.6	9.0
	10	8.5	8.4	8.4	8.4	8.5	8.6	8.7	8.7	8.6	8.7	8.7	8.6	8.5	8.5	8.4
Artesian	0	8.9	8.8	9.0	9.1	9.3	9.4	9.3	9.3	9.4	9.4	9.4	9.4	9.4	9.5	9.3
	5	8.2	8.3	8.3	8.2	8.4	8.4	8.6	8.1	8.8	8.7	9.0	8.9	8.9	8.7	8.6
	10	8.2	8.3	8.3	8.3	8.3	8.3	8.4	8.5	8.4	8.5	8.5	8.4	8.5	8.4	8.2

1/ The ph values shown are an average of three replicates.

Water applied	Gypsum applied	pH values 3/29/54	pH values 4/12/54
River	0	9.2	9.4
	5	8.8	8.8
	10	8.5	8.5
Drain	0	9.3	9.5
	5	8.7	8.6
	10	8.6	8.5
Artesian	0	9.4	9.5
	5	8.8	8.7
	10	8.4	8.4

The pH values of the rings having no gypsum applied to the soil ended with 9.5 to 9.6, the soils having a 5 ton gypsum application, ended at 8.7 to 8.8, and the soils having a 10 ton application, ended at 8.4 to 8.5.

This is an average increase in pH of 0.2 for all of the treatments since the drying period at the end of the third leaching period.

Summary of the Ranch "I" alkali reclamation study:

1. The Reed soils are slowly permeable to a depth of 15 feet or more.

2. The soil profile is strongly alkali in the top foot, moderately alkali in the second and third foot and alkali free below three feet.

3. Ground water is moving laterally in a fractured clay strata at a depth of $3\frac{1}{2}$ feet.

4. The drain and artesian water tend to aggregate the soil without the application of gypsum.

5. The aggregation in the soils having gypsum applied decreased with each leaching period. This was evidently due to the gypsum being used in the soil.

6. The structure and workability of the soil was initially improved, but was decreasing at the end of the third leaching period.

7. The application of 5 and 10 tons of gypsum decreased the bearing load of the soil about 6 and 15 percent at the close of the 3rd leaching period. The pentrometer test is a very good indication of workability and structure in the soil.

8. The artesian water with ten tons of gypsum applied to the soil gave the highest intake rate at the close of the 3rd leaching period. It gave about twice the intake rate of the river and drain water. The intake rate increased with each leaching period.

9. The pH observations indicate very beneficial results from the application of gypsum. Five tons of gypsum gave comparable results with 10 ton applications at the close of the third leaching period. The pH values for the 5 ton gypsum application came up about 0.4 for the river water, 0.3 for the drain water and no change in the artesian water between the end of the third and fourth leaching periods. The favorable comparison between the five and ten ton applications of gypsum will be very valuable to the farmer in that the application of gypsum can be put on a pay as you go basis. This will not alter the total amount of gypsum required, but may allow the gypsum to be applied in smaller quantities.

10. Reclamation of the slowly permeable Reed soil will be very slow and expensive and may not be feasible at the present time. The cost of open or tile drains would be very high and the gypsum application required to reclaim the soil may run as high as 30 tons per acre in some areas for complete reclamation.

Ranch "H" Greasewood alkali reclamation investigation

Ranch "H" is located in central part of the Emmett Valley, south of the Payette river on a nearly level low terrace a few feet above the river flood plain. The area has a water table that fluctuates between 20 and 45 inches. The surface is very gently undulating and has a relief of 6 to 24 inches between the broad swells of ridges and the narrow meandering channels of an old flood plain. (See figure 25 for ranch location) The soils are moderately to strongly alkali and rapidly permeable to a depth of 3.5 feet. A coarse sand and gravel bar lies below 3.5 feet. The soils will respond very rapidly to drainage and reclamation.

Infiltrometer ring layout: The infiltrometer ring layout and a general view of the farm were shown in figure 43 of the June 1953 Progress Report. The rings were installed on one of the gently undulating ridges.

It was determined that the water table under the rings would be low enough to permit experimental reclamation with soil amendments. The ranch is in a virgin condition and has a native vegetation cover of greasewood and salt grass. The ranch is used as pasture during the year. The area produces some pasture during the spring, however, the over-all pasture production is very poor.

The infiltrometer ring layout, the rings using river, drain and artesian water, and the amount of gypsum applied to each ring was shown in figure 44 of the June 1953 Progress Report. River water was applied to the right nine rings, drain water to the middle nine rings, and artesian water was applied to the left nine rings. Gypsum in the amounts of 0, 5, and 10 tons per acre were applied to the rings using various water treatments. This layout of 27 rings gave three replicates of each treatment. The rings were all 12 inches in diameter. The evaporation ring consisted of a 12-inch long section of 12-inch diameter well casing with a welded-in bottom. The ring was used as a combination evaporation pan and rain gage.

Ranch "H" Greasewood soils at the plot location: The general valley soil survey shows the Letha soils is medium to very light surface textured with some heavier subsoils. Gravel strata may underlie these soils at depths of 3 to 8 feet. A four foot depth soil survey at the plot location was presented on a soil profile chart in figure 45 of the June 1953 Progress Report. The soils were primarily a loamy fine sand to a depth of $3\frac{1}{2}$ feet and gravel below that. Two thin cemented sand strata were found at depths of $1\frac{1}{2}$ and 3 feet. The water table during January was below the four foot survey.

A pH reading with a color indicator (Thymol Blue) was made in the profile at each six inch depth or soil change. The pH was found to be fairly low right at the surface, high at a depth of six inches (9.2) and generally remained above 8.6 to a depth of $3\frac{1}{2}$ feet. The pH indicates a fairly uniform distribution of alkali in the soil profile.

Structure, workability and visible gypsum: A summary of structure, workability, and visible gypsum prior to and following the two leaching periods is presented in table 19. The observations were made in the field, visually, and with respect to the difficulty of working up the soil in the various rings with a 3/4 inch wood chisel.

Analysis of table 19 indicates that a fair to good structure is being developed in the soils with a 10 ton application of gypsum. The table also indicates that the artesian water without an application of gypsum has a beneficial effect upon the structure of the soil. There was also some gypsum left in the soil at the close of study.

Growth pattern on the Greasewood plot: A summary of the growth pattern in the rings at the greasewood plot prior to the third leaching period is presented in table 20. The plants in the rings included voluntary grasses and weeds. The plant growth indicated the river water treated rings to be best, the artesian water treated rings second, and the ones using drain water was last.

Table 20. Summary of the growth pattern on the Ranch "H" Greasewood plot prior to the third leaching period. Emmett Valley, Gem County, Idaho.

Water applied	Gypsum applied tons/ac.	Growth pattern Plants
River	0	fair
	5	good
	10	good
Drain	0	fair
	5	fair
	10	fair
Artesian	0	fair
	5	good
	10	fair

Table 19. – Summary of structure, workability and visible gypsum prior to and following the three leaching periods on the Ranch "H" Greasewood investigation. Emmett Valley, Gem County, Idaho. [1]

Water used	Prior to leaching	No gypsum applied to soil				5 tons of gypsum per acre				10 tons of gypsum per acre			
		1st	2nd		3rd	1st	2nd		3rd	1st	2nd		3rd
		8/5/52	10/20/52	3/15/54	4/15/54	8/5/52	10/20/52	3/15/54	4/15/54	8/5/52	10/20/52	3/15/54	4/15/54
							Structure						
River	poor	poor	poor	poor	poor	fair	poor	good	fair	fair	fair	good	fair
Drain	poor	poor	poor	poor	fair	mod.	mod.	fair	fair	fair	fair	good	fair
Artesian	poor	mod.	mod.	poor	fair	mod.	fair	fair	good	fair	fair	fair	good
							Workability						
River	mod.	mod.	mod.	mod.	mod.	mod.	mod.	easy	mod.	easy	easy	easy	easy
Drain	mod.	mod.	mod.	mod.	mod.	mod.	mod.	easy	mod.	easy	mod.	easy	mod.
Artesian	mod.	mod.	easy	mod.	mod.	mod.	easy	easy	easy	easy	easy	easy	easy
							Visible Gypsum						
River	–	–	–	–	–	mod.	trace	trace	trace	mod.	mod.	trace	trace
Drain	–	–	–	–	–	trace	trace	trace	trace	mod.	mod.	trace	trace
Artesian	–	–	–	–	–	mod.	trace	trace	trace	mod.	mod.	trace	trace

1/ Values shown are an average of three replicates.

Proctor Needle tests: A series of 10 tests were made in each ring with a Proctor Needle (Pentrometer) following the three leaching periods to determine the bearing in pounds per square inch for the soils under the various treatments. This makes 30 replicates for each treatment shown. A summary of the pentrometer data is presented in table 21.

Table 21. Summary of Proctor Needle data following the first, second and third leaching periods on the Ranch "H" Greasewood investigations, Emmett Valley, Gem County Idaho.

Water applied	Gypsum applied	Following the 1st leaching period 7/31/52	Following the 2nd leaching period 10/20/52	Prior to the 3rd leaching period 3/15/54	Following the 3rd leaching period 4/15/54
	tons/ac.	lb./sq.in.	lb./sq. in.	lb./sq. in.	lb./sq. in.
River	0	1833	1583	892	817
	5	1630	1406	707	744
	10	1446	1406	631	599
Drain	0	1772	1489	896	752
	5	1609	1575	744	678
	10	1487	1550	511	570
Artesian	0	1589	1387	760	654
	5	1222	1279	625	489
	10	1426	1536	629	493
Ground surface outside the rings		1365	1799	988	1084

The Proctor Needle values for the three different waters applied were fairly erratic following the first and second leaching periods; however, a definite trend in penetration values were observed in the readings made immediately before and following the third leaching period. The artesian water showed a lower value on all averages except for the 10-ton gypsum applications. Without the application of gypsum, the artesian water indicated the best effect, the drain water second, and the river water last. The over-all Proctor Needle averages indicated the artesian water to be first on all gypsum treatments, the drain water second, and the river water last. The results are very favorable towards the artesian water.

Dry rings during the third leaching period: A summary of the rings that were dry on the Greasewood plot are presented in table 22. The observations were made on the morning of the day following filling. The average time between filling and the reported observations was about 24 hours. The observations made on March 22 were made 72 hours after filling.

Table 22. Summary of Ranch "H" Greasewood plot rings that were dry on various dates during the third leaching run. Emmett Valley, Gem County Idaho

Comparison		3/17	3/18	3/19	3/22	3/23	3/24	3/25	3/26
		%	%	%	%	%	%	%	% 1/
Gypsum	10	89	22	22	100	33	11	22	33
	5	56	22	22	67	44	22	33	33
	0	33	0	0	44	0	33	0	0
Water	art.	56	22	22	78	33	33	33	33
	drain	56	11	0	67	22	11	11	11
	river	67	22	22	67	22	22	11	22
10 tons gypsum	art.	67	0	33	100	33	33	33	33
	drain	100	33	0	100	33	0	33	33
	river	100	33	33	100	33	0	0	33
5 tons Gypsum	art.	67	33	33	67	67	33	67	67
	drain	33	0	0	67	33	0	0	0
	river	67	33	33	33	33	33	33	33
No gypsum	art.	33	0	0	67	33	33	0	0
	drain	33	0	0	33	0	33	0	0
	river	33	0	0	33	0	33	0	0

1/ Percent of total rings that were dry

The observations indicate an application of 5 or 10 tons of gypsum to be comparable and considerably better than leaching without gypsum. A comparison of waters applied indicate the artesian water to be the most beneficial and the river water slightly better than the drain water. A ten-ton application of gypsum gave comparable results with the three types of water. The artesian water was slightly better, the drain water second, and the river water last. A five-ton application of gypsum indicated the artesian water to be first, the river water second, and the drain water last. A comparison of the various waters used with no application of gypsum shows comparable results. The artesian water may have a slight advantage over the drain or river water.

Intake rates: A summary of the intake rates for the three leaching periods are presented in table 23. The intake rates have been corrected for evaporation and a viscosity correction has been applied to convert the intake rates to a standard temperature of 60 degrees Fahrenheit. Comparison of the final intake rates are shown in the following tabulation:

Table 23. - Summary of the intake rate data for the first, second, and third leaching periods on the Ranch "H" Greasewood investigation. Emmett Valley, Gem County, Idaho. 1/

Water applied	Gypsum applied	First leaching period 1952 6/17	6/18	6/19	6/20	6/23	6/24	Second leaching period 1952 9/8	9/9	9/10	9/11
	t/ac.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.
River	0	0.37	0.08	0.06	0.05	0.01	0.00	0.23	0.09	0.05	0.06
	5	0.53	0.14	0.18	0.07			0.26	0.20	0.12	0.14
	10	0.49	0.21	0.24	-			0.42	0.31	0.16	0.20
Drain	0	0.36	0.06	0.05	0.04	0.01	0.01	0.17	0.07	0.04	0.04
	5	0.49	0.08	0.11	0.08			0.28	0.12	0.08	0.08
	10	0.70	0.15	0.11				0.32	0.20	0.13	0.14
Artesian	0	0.48	0.11	0.08	0.06			0.19	0.08	0.06	0.09
	5	0.57	0.22	0.19				0.30	0.26	0.18	0.20
	10	0.53	0.21	0.19				0.43	0.40	0.33	0.27

Table 23. - (Continued)

Water applied	Gypsum applied	Third leaching period 1954 3/16	3/17	3/18	3/19	3/22	3/23	3/24	3/25	3/26
	t/ac.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.
River	0	0.19	0.10	0.06	0.05	0.08	0.07	0.07	0.05	0.05
	5	0.45	0.23	0.15	0.15	0.16	0.12	0.13	0.14	0.14
	10	0.55	0.93	0.23	0.23	0.23	0.20	0.17	0.18	0.19
Drain	0	0.17	0.12	0.08	0.08	0.08	0.06	0.06	0.09	0.08
	5	0.21	0.18	0.13	0.13	0.13	0.15	0.09	0.10	0.10
	10	0.45	0.33	0.21	0.24	0.24	0.17	0.18	0.19	0.19
Artesian	0	0.18	0.12	0.11	0.12	0.13	0.10	0.09	0.12	0.12
	5	0.35	0.27	0.22	0.22	0.22	0.21	0.21	0.30	0.30
	10	0.42	0.29	0.20	0.22	0.19	0.17	0.17	0.19	0.19

1/ The intake rates have been corrected for evaporation and to a standard temperature of 60 degrees F.

Comparison	Rating
No gypsum	Artesian 1st Drain 2nd River 3rd
5 tons gypsum	Artesian 1st River 2nd Drain 3rd
10 tons gypsum	All comparable

The comparison indicates the artesian water to be the most beneficial, the drain water second, and the river water last. The intake rates increased very favorably with the increase of gyp sum applications.

pH values: A summary of the pH values from June 17, 1952 to April 15, 1954 on the Ranch "H" Greasewood alkali reclamation plot is presented in table 24. The pH values shown in table 24 are an average of three replicates. The pH values were obtained from the surface soil in the rings during the drying periods and the pH of the leaching water was obtained during the leaching periods.

The pH values have been increasing since the end of the second leaching period. A comparison of the pH values between 10/20/52 and 4/15/54 are given in the following tabulation:

Source of water applied	Gypsum applied	10/20/52	4/15/54
	tons	pH	pH
River	0	8.9	9.0
	5	8.8	8.5
	10	8.2	8.5
Drain	0	8.9	9.1
	5	8.4	9.1
	10	8.3	8.6
Artesian	0	8.5	9.0
	5	8.3	8.7
	10	8.2	8.4

The pH values for the rings using artesian and river water are slightly better than those using drain water. The increases in pH between the two dates could be due to a movement of sodium into the rings or the gradual use of the applied gypsum.

Table 24. Summary of pH values for the three leaching periods on the Ranch "H" Greasewood investigation. Emmett Valley, Gem County Idaho. 1/

Water applied	Gypsum applied t/ac.	Dry	1st period 1952		Dry		2nd period 1952		1952		1953		1954
		6/17	6/17	6/20	6/30	9/8	9/8	9/10	9/23	10/20	4/10	5/1	3/15
River	0	9.6	9.6	8.2	8.5	9.1	8.2	8.2	8.4	8.9	8.7	9.2	9.4
	5	9.4	8.8	8.1	8.3	8.5	8.2	8.2	8.4	8.8	8.3	8.4	8.3
	10	9.3	8.8	8.2	8.2	8.3	8.1	8.2	8.2	8.2	8.1	8.1	8.1
Drain	0	9.2	9.0	8.4	8.5	9.3	8.2	8.3	8.6	8.9	8.9	9.1	9.2
	5	9.6	9.1	8.3	8.6	8.6	8.1	8.2	8.4	8.4	8.5	8.4	9.0
	10	9.5	8.7	8.2	8.3	8.2	8.2	8.2	8.3	8.3	8.1	8.1	8.2
Artesian	0	9.6	8.8	8.3	8.7	9.2	8.2	8.2	8.5	8.5	8.7	9.1	9.2
	5	9.6	8.8	8.2	8.3	8.5	8.3	8.3	8.3	8.3	8.3	8.3	8.8
	10	9.6	8.4	8.2	8.3	8.3	8.2	8.1	8.3	8.2	8.0	8.3	8.6

Table 24 (continued)

Water applied	Gyp; appl: t/ac.	3rd period 1954								Dry 1954						
		3/16	3/18	3/19	3/22	3/23	3/24	3/25	3/26	3/29	3/31	4/2	4/5	4/7	4/12	4/15
River	0	8.2	8.2	8.1	8.0	8.0	8.0	8.0	8.0	8.4	8.7	9.0	8.9	9.1	9.0	9.0
	5	8.1	8.1	8.0	8.0	8.0	8.0	8.0	8.0	8.3	8.5	8.6	8.5	8.5	8.6	8.5
	10	8.1	8.1	8.0	8.0	8.0	8.0	8.0	8.0	8.4	8.3	8.4	8.4	8.4	8.2	8.5
Drain	0	8.3	8.4	8.4	8.5	8.5	8.5	8.5	8.5	8.6	8.8	9.1	9.0	9.1	9.2	9.1
	5	8.3	8.4	8.4	8.4	8.4	8.4	8.5	8.5	8.7	8.8	8.9	8.8	9.2	9.1	9.1
	10	8.3	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.6	8.5	8.6	8.5	8.7	8.5	8.6
Artesian	0	8.3	8.3	8.2	8.3	8.3	8.3	8.3	8.3	8.5	8.5	8.7	8.7	8.8	8.7	9.0
	5	8.2	8.3	8.2	8.3	8.3	8.3	8.3	8.3	8.6	8.5	8.6	8.6	8.6	8.7	8.7
	10	8.2	8.3	8.2	8.3	8.3	8.3	8.3	8.3	8.4	8.3	8.4	8.4	8.4	8.4	8.4

1/ The pH values shown are an average of three replicates

Summary of the Ranch "H" Greasewood alkali reclamation study:

1. The soils are rapidly permeable and should reclaim very rapidly following drainage.

2. The soils are moderately alkali to a depth of $3\frac{1}{2}$ feet. A very permeable gravel bar lies below $3\frac{1}{2}$ feet.

3. A fair structure is being developed in the soils with the application of gypsum. The artesian water alone is developing some structure in the soil.

4. The growth pattern indicates the river water treated rings to be best, the artesian water second, and the drain water last.

5. The over-all Proctor Needle values indicates the artesian water to be first, the drain water second, and the river water last.

6. A comparison of the dry rings indicates the intake rate of the artesian water to be the best and the river water slightly better than the drain water.

7. The rings using artesian water had the best intake rate, the drain water second, and the river water last.

8. The pH values for the rings using artesian and river water slightly better than those using drain water.

Ranch "H" Salt Grass alkali reclamation investigation

The salt grass plot is located about 150 feet southeast from the greasewood plot. The general description of the area and soils are identical to the greasewood plot. The soils are moderately alkali to a depth of 6 feet. A coarse sand and gravel bar lies below 6 feet. The soils will respond rapidly to drainage and reclamation.

Infiltrometer ring layout: The infiltrometer ring layout and a general view of the farm are shown in figure 46 of the June 1953 Progress Report. The rings were installed in one of the gently undulating valleys on the terrace. The water table is sufficiently low to permit reclamation during the study. The soil is in its native condition and has a cover of salt grass. The area is used as pasture. River water, drain water, and artesian water was applied to nine rings each. The rings using the various leaching waters had applications of gypsum of 0, 5 and 10 tons per acre. This layout of 27 rings gave three replicates for each treatment. The rings were cut 12 inches long from 12-inch well casing. The evaporation ring results from the Greasewood plot were applied to the Salt Grass plot data.

Ranch "H" Salt Grass soils at the plot location: A soil survey to a depth of seven feet at the plot location was presented on a Soil Profile Chart, figure 48 of the June 1953 Progress Report. The soils were primarily sandy loam to a depth of six feet with stratas of silt loam and sand in the profile. A coarse sand and gravel bar lies at a depth of six feet. A pH reading was obtained at each six inch interval or soil change. The pH was found to be fairly low at the surface, high at a depth of 0.3 feet (9.0) and generally remained above 8.6 to a depth of six feet. The pH indicates a fairly uniform distribution of alkali in the soil profile.

Structure, workability and visible gypsum: A summary of structure, workability and visible gypsum prior to and following the two leaching periods are presented in table 25. The observations were made identical to those on the Ranch "I" and Ranch "H" Greasewood investigations.

Analysis of table 25 indicates that a fair to good structure is being developed in the soils. The structure without an application of gypsum ranged from good with artesian water, fair with drain water to poor with river water. The rings using artesian and drain water appeared to have a better structure than the river water for all treatments. The workability compared favorably for all treatments.

A trace of the five ton application and a moderate amount of the ten ton application of gypsum was visible in the soil when the rings were removed.

Growth pattern on the Salt Grass plot: A summary of the growth pattern in the rings at the Salt Grass plot prior to the second leaching period is presented in table 26. The plants in the rings included grasses and voluntary weeds. The plant growth indicated the river and drain water to be slightly better than the artesian water.

Table 26. Summary of the growth pattern on the Ranch "H" Salt Grass plot prior to the second leaching period. Emmett Valley, Gem County Idaho.

Water applied	Gypsum applied tons/ac.	Growth pattern plants
River	0	good
	5	excellent
	10	excellent
Drain	0	good
	5	excellent
	10	excellent
Artesian	0	good
	5	excellent
	10	good

Proctor Needle tests: A series of 10 penetration tests were made in each ring with a Proctor Needle (Pentrometer) prior to and following the two leaching periods. A summary of the data is presented in table 27.

Table 25. Summary of structure, workability and visible gypsum prior to and following the two leaching periods on the Ranch "H" Salt Grass investigations, Emmett Valley, Gem County Idaho.

Type water used	Prior to leaching	No gypsum applied to the soil			5 tons of gypsum per acre			10 tons of gypsum per acre		
	8/5/52	10/20/52	3/15/54	4/15/54	10/20/52	3/15/54	4/15/54	10/20/52	3/15/54	4/15/54
					Structure					
River	poor	fair	mod.	poor	fair	good	fair	fair	good	fair
Drain	poor	fair	fair	fair	fair	good	good	fair	good	good
Artesian	poor	poor	fair	good	fair	good	good	fair	good	good
					Workability					
River	hard	easy	mod.	mod.	easy	easy	mod.	easy	easy	easy
Drain	hard	easy	mod.	mod.	easy	easy	easy	easy	easy	easy
Artesian	mod.	mod.	mod.	mod.	easy	easy	easy	easy	easy	easy
					Visible gypsum					
River	-	-	-	-	mod.	trace	trace	consid.	mod	mod.
Drain	-	-	-	-	mod.	trace	trace	consid.	mod.	mod.
Artesian	-	-	-	-	mod.	trace	trace	consid.	mod.	mod.

Table 27. Summary of the Proctor Needle data prior to and following the first and second leaching periods on the Ranch "H" Salt Grass investigations. Emmett Valley, Gem County Idaho.

Water applied	Gypsum applied tons/ac.	Prior to the 1st leaching period 7/5/52 lb/sq.in.	Following the 1st leaching period 10/20/52 lb/sq. in.	Prior to the 2nd leaching period 3/15/54 lb/sq.in	Following the 2nd leaching period 4/15/54 lb/sq.in.
River	0	1817	1471	725	998
	5	2249	1361	570	917
	10	2139	1300	528	860
Drain	0	2051	1493	587	760
	5	2178	1577	536	707
	10	2330	1554	566	815
Artesian	0	1921	1204	407	625
	5	1518	1049	350	576
	10	2063	1265	385	593
Ground surface outside the rings			2100	534	949

A definite trend in penetration values were observed in the readings made following the two leaching periods. The over-all values indicates the artesian water to be the most beneficial, the drain water to be second, and the river water to be the poorest.

Dry rings during the second leaching period: A summary of the rings that were dry on the Salt Grass plot are presented in table 28. The observations were made on the morning of the day following filling the average time between filling and the reported observations was about 24 hours. The observations made on March 22 were made 72 hours after filling.

The observations indicate an application of 5 or 10 tons comparable and better than leaching without gypsum. A comparison of waters applied indicates the artesian water to be the most beneficial, the drain water second, and the river water last. A comparison for 10 ton gypsum applications rates the artesian and drain water slightly better than the river water. A comparison for 5 ton gypsum application rates the artesian water first, the drain water second, and the river water last. A comparison of the various waters used with no application of gypsum, rates the artesian water better than the river or the drain water. The drain water was slightly better than the river water.

Table 28. Summary of Ranch "H" Salt Grass plot rings that were dry on various dates during the second leaching run. Emmett Valley, Gem County Idaho. 1/

Comparison		1954							
		3/17	3/18	3/19	3/22	3/23	3/24	3/25	3/26
		%	%	%	%	%	%	%	%
Gypsum	10	100	56	44	78	22	22	22	22
	5	89	33	33	56	33	66	33	33
	0	33	11	0	33	11	11	11	11
Water	art.	89	67	56	78	44	44	44	44
	drain	78	33	22	56	22	22	22	22
	river	56	0	0	33	0	0	0	0
10-tons gypsum	art.	100	100	33	100	33	33	33	33
	drain	100	67	33	67	33	33	33	33
	river	100	0	0	67	0	0	0	0
5-tons gypsum	art.	100	67	67	67	67	66	67	22
	drain	67	33	33	67	33	33	33	11
	river	67	0	0	33	0	0	0	0
No gypsum	art.	67	33	0	67	33	33	33	11
	drain	33	0	0	33	0	0	0	0
	river	0	0	0	0	0	0	0	0

1/ Percent of total rings that were dry

Intake rates: A summary of the intake rates for the two leaching periods are presented in table 29. The intake rates have been corrected for evaporation and a viscosity correction has been applied to convert the intake rates to a standard temperature of 60 degrees Fahrenheit.

Comparison of the final intake rates are shown in the following tabulation:

Comparison	Rating	
No gypsum	artesian	1st
	drain	2nd
	river	3rd
5-tons gypsum	artesian	1st
	drain	2nd
	river	3rd
10-tons gypsum	artesian	1st
	drain	2nd
	river	3rd

Table 29. Summary of intake rate data for the 1st and 2nd leaching periods on the Ranch "H" Salt Grass investigation, Emmett Valley, Gem County Idaho. 1/

Water applied	Gyp. appl.	First leaching period 1952				Second leaching period 1954								
		9/8	9/9	9/10	9/11	3/16	3/17	3/18	3/19	3/22	3/23	3/24	3/25	3/26
	tons/ac.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.	in.hr.
River	0	0.08	0.03	0.03	0.01	0.14	0.07	0.02	0.08	0.05	0.00	0.01	0.01	0.01
	5	0.12	0.04	0.04	0.03	0.83	0.17	0.10	0.08	0.08	0.06	0.07	0.07	0.11
	10	0.09	0.03	0.03	0.02	1.39	0.27	0.14	0.12	0.10	0.07	0.08	0.08	0.11
Drain	0	0.10	0.05	0.03	0.02	0.45	0.19	0.10	0.07	0.05	0.05	0.02	0.02	0.05
	5	0.13	0.04	0.03	0.02	1.20	0.43	0.30	0.21	0.40	0.15	0.13	0.09	0.12
	10	0.13	0.04	0.04	0.02	1.62	0.54	0.28	0.26	0.58	0.20	0.19	0.13	0.15
Artesian	0	0.14	0.08	0.05	0.03	0.76	9.28	0.15	0.14	0.19	0.11	0.11	0.10	0.12
	5	0.14	0.16	0.11	0.08	1.89	0.49	0.26	0.26	0.28	0.25	0.23	0.20	0.15
	10	0.22	0.11	0.07	0.04	1.55	0.41	0.40	0.36	0.25	0.27	0.23	0.21	0.23

1/ The intake rates have been corrected for evaporation and to a standard temperature of 60 degrees F.

The comparison indicates the artesian water to be the most beneficial, the drain water second, and the river water last.

pH values: A summary of the pH values from September 8 to April 14, 1954 on the Ranch "H" Salt Grass alkali reclamation plot is presented in table 30. The pH values shown in table 30 are an average of three replicates. The pH values were obtained in the same manner as those on the Ranch "I" and Ranch "H" Greasewood investigations.

The pH values dropped down to 8.1 or 8.3 at the start of the second leaching period. The pH values increased slightly towards the end of the leaching period. During the drying period following the second leaching period the pH values stabilized fairly well. The check rings were 0.3 to 0.9 of a pH higher than the rings having 5 or 10 ton applications of gypsum. The artesian water rated best, the drain water second, and the river water last. Comparable results were obtained between the 5 and 10 ton gypsum applications. This would indicate that there was considerable gypsum still available in the soil.

Summary of the Ranch "H" Salt Grass alkali reclamation study:

1. The soils are moderate to rapidly permeable and should reclaim rapidly following drainage and the application of soil amendments.

2. The soils are moderately alkali to a depth of six feet.

3. A good structure is being developed in the soil and the workability is being improved with all treatments.

4. The growth pattern in the rings indicate the river and drain water to be slightly better than the artesian water.

5. The Proctor Needle data indicates the artesian water to be the most beneficial, the drain water second, and the river water last.

6. The dry ring data indicates the artesian water to be the most beneficial, the drain water second, and the river water last.

7. Intake rate data rates the artesian water first in all treatments, the drain water second, and the river water last.

8. The pH values indicated the artesian water to be the most beneficial, the drain water second, and the artesian water last. Comparable results were obtained between the 5 and 10 ton gypsum applications. This would indicate that there was considerable gypsum still available in the soil.

Summary of data on the three alkali reclamation plots

A summary of the observations and data on the three alkali reclamation plots is presented in table 31. A total of 10,000 observations and field measurements were summarized and condensed to form the table. It contains a summary of the aggregates, Proctor Needle readings, intake rates, pH readings and dry ring percentages for the nine leaching periods. Four leaching periods on the Ranch "I", three on the Grease-

Table 30. Summary of pH values for the two leaching periods on the Ramch "H" Salt Grass investigation. Emmett Valley, Gem County Idaho. 1/

Water applied	Gypsum applied t/ac.	Dry	1st leaching period			Drying period									
			1952			1952									1954
		9/8	9/8	9/9	9/10	9/23	9/25	9/29	10/1	10/3	10/14	10/20	4/10	5/1	3/15
River	0	8.8	8.1	8.2	8.2	8.5	9.1	8.9	8.7	8.6	8.6	8.7	8.5	8.3	8.8
	5	8.5	8.1	8.2	8.2	8.1	8.5	8.2	8.3	8.1	8.2	8.2	8.1	8.0	8.1
	10	8.5	8.1	8.2	8.1	8.0	8.2	8.2	8.3	8.4	8.4	8.2	8.0	8.0	8.1
Drain	0	8.5	8.2	8.2	8.2	8.5	8.7	8.7	8.8	8.7	8.7	8.5	8.6	8.4	8.7
	5	8.1	8.2	8.1	8.1	8.1	8.3	8.3	8.3	8.0	8.3	8.1	8.1	8.1	8.3
	10	8.2	8.1	8.2	8.2	8.1	8.1	8.1	8.2	8.0	8.2	8.2	8.0	8.1	8.1
Artesian	0	8.3	8.1	8.2	8.0	8.2	8.4	8.3	8.3	8.2	8.2	8.2	8.4	8.2	8.3
	5	8.6	8.2	8.2	8.1	8.1	8.1	8.1	8.0	8.1	8.1	8.1	8.1	8.1	8.2
	10	8.0	8.1	8.2	8.1	8.1	8.1	8.1	8.0	8.1	8.1	8.1	8.0	8.1	8.1

Table 30 (continued)

Water applied	Gyp. appl. t/ac.	2nd leaching period								Drying period						
		1954								1954						
		3/16	3/18	3/19	3/22	3/23	3/24	3/25	3/26	3/29	3/31	4/2	4/5	4/7	4/12	4/15
River	0	8.1	8.1	8.0	8.0	8.0	8.1	8.1	8.3	8.7	8.7	8.7	9.0	9.1	8.6	9.0
	5	8.1	8.1	8.0	8.0	8.0	8.0	8.0	8.2	8.4	8.2	8.2	8.1	8.1	8.0	8.1
	10	8.1	8.1	8.0	8.0	8.0	8.0	8.0	8.2	8.3	8.1	8.1	8.0	8.0	8.0	8.1
Drain	0	8.3	8.3	8.3	8.2	8.3	8.5	8.4	8.6	8.6	8.8	8.7	8.9	8.7	8.7	8.6
	5	8.3	8.3	8.3	8.2	8.3	8.5	8.4	8.5	8.3	8.5	8.3	8.2	8.3	8.2	8.1
	10	8.3	8.3	8.3	8.2	8.3	8.5	8.4	8.4	8.4	8.3	8.2	8.0	8.1	8.0	8.0
Artesian	0	8.2	8.3	8.2	8.1	8.2	8.3	8.2	8.3	8.4	8.5	8.5	8.4	8.6	8.5	8.3
	5	8.2	8.3	8.2	8.1	8.2	8.3	8.2	8.3	8.1	8.3	8.1	8.1	8.2	8.1	8.1
	10	8.2	8.3	8.2	8.1	8.2	8.3	8.2	8.3	8.2	8.1	8.1	8.0	8.0	8.0	8.1

1/ The pH values shown are an average of three replicates.

Table 31. Summary rating for the aggregates, Proctor Needle, intake rates, and pH values for the Ranch "I", Ranch "H" Greasewood and Ranch "H" Salt Grass alkali Reclamation investigations. Emmett Valley, Gem County Idaho.

Rating	Aggregates final	Proctor Needle readings spring of 1954			Intake rate final readings			pH final readings			Dry ring percentage	
	"I"	"I"	"GW"	"SG"	"I"	"GW"	"SG"	"I"	"GW"	"SG"	"GW"	"SG"
1st	R-10	R-10	D-10	A-5	R-10	A-5	D-5	A-10	R-10	A-10	A-10	A-10
2nd	D-10	A-10	A-5	A-10	A-10	D-10	A-10	R-10	A-10	R-10	D-10	A-5
3rd	A-0	A-5	A-10	A-0	D-10	A-10	A-5	D-10	D-10	D-10	R-10	D-10
4th	A-5	D-10	R-10	R-10	A-5	R-10	D-10	A-5	R-5	R-5	A-5	D-5
5th	A-10	A-0	R-5	D-5	D-5	R-5	A-0	D-5	A-5	A-5	A-0	A-0
6th	D-5	R-0	D-5	D-10	R-5	A-0	R-10	R-5	A-0	D-5	D-5	R-10
7th	R-0	D-5	A-0	R-5	D-0	D-5	R-5	A-0	R-0	A-0	R-5	R-5
8th	R-5	D-0	R-0	D-0	A-0	D-0	D-0	R-0	D-5	D-0	D-0	D-0
9th	D-0	R-5	D-0	R-0	R-0	R-0	R-0	D-0	D-0	R-0	R-0	R-0

Legend:

"I"	Ranch "I" Alkali reclamation plot
SG	Ranch "H" Salt Grass alkali reclamation plot
GW	Ranch "H" Greasewood alkali reclamation plot
R-0	River water - No gypsum applied to soil
R-5	River water - 5 tons of gypsum applied to soil
R-10	River water - 10 " of gypsum applied to soil
D-0	Drain water - No gypsum applied to soil
D-5	Drain water - 5 tons of gypsum applied to soil
D-10	Drain water - 10 tons of gypsum applied to soil
A-0	Artesian water - No gypsum applied to soil
A-5	Artesian water - 5 tons of gypsum applied to soil
A-10	Artesian water - 10 tons of gypsum applied to soil

wood, and two on the Salt Grass plot were made. The averages of the results from each set of three replicates were classified as first, second, third, etc., according to the number of aggregates, softness from the Proctor Needle tests, rapidity of the intake rate, alkali improvement indicated by the pH values and dry ring percentages. The spread of the rings using artesian water is blocked in with a solid line. The blocked-in area indicates that the artesian water is in the upper portion of the table and shows a trend that indicates an over-all advantage in using the artesian water to reclaim the alkali land in the valley. By assigning a figure of 9 to a rating of first, 8 to second, 7 to third, etc., and adding up the totals of the river, drain and artesian waters, a figure was obtained showing the over-all desirability of water for use in reclamation of alkali areas. The totals obtained were:

Artesian water - - - - - - - - - - - -	230 points
Drain water- - - - - - - - - - - - - -	159 points
River water- - - - - - - - - - - - - -	149 points

This tabulation indicates that the artesian water gives considerably better results and that the over-all difference between river and drain water is rather slight.

Vertical Drainage Investigations

During the course of the investigation, it was concluded that the use of pumped wells could have an important place in the over-all drainage plan for the Emmett Valley. As a forerunner to making a vertical drainage investigation in the valley, it was decided that some initial costs, maintenance and operation figures and radius of influence data be obtained on existing wells in the Emmett Valley. It was found that there were no drainage wells in operation in the valley and that these cost estimates would have to be obtained from other areas which were similar in nature and had a similar drainage problem.

The Pioneer Irrigation District with office at Caldwell, Idaho was selected as a comparison area. The Pioneer Irrigation District has thirty wells ranging in depth from 60 to 165 feet. These wells are used jointly as drainage and irrigation wells. Mr. John Turner, former president of the Pioneer Irrigation District board stated, "During the low ground water table years when drainage was not a problem, the wells had been pumped to supplement the short supply of irrigation water. During years of adequate irrigation water supply, the wells had been primarily used for drainage; and that the wells had paid for themselves either as irrigation or drainage wells."

A summary of the installation costs and operational costs were obtained from the Pioneer Irrigation District office in Caldwell. The initial costs for the 30 wells, installed from 1936 to 1950 were presented in Appendix Table 6 of the June 1953 Progress Report. Well numbers 29 and 30 gave the best cost estimates as they were installed during 1949 and 50. Well No. 29 is 143 feet deep and cost a total of $5464; well No. 30 is 98 feet deep, and cost $4395.75. The wells both have 20-inch casings.

A summary of the available operating costs during 1950, 51, 52 and 53 are presented in table 32.

Table 32. - Operating costs of drainage and irrigation wells in the Pioneer Irrigation District of Caldwell, Idaho

Well No.	Motor HP	1950 Power KWH	1950 Cost Dollars	1951 Power KWH	1951 Cost Dollars	1952 Power KWH	1952 Cost Dollars	1953 Power KWH	1953 Cost Dollars
1	7½	12850	113.18	1300	23.50	7340	61.80	8930	92.55
2	20	-	-	42000	268.05	21520	156.50	23890	208.35
3	10	14510	145.45	14880	165.35	10910	133.45	14470	166.60
4	15	28200	243.45	22520	239.20	20040	252.05	18090	203.40
5	15	42690	290.50	21990	233.60	28100	257.20	29570	276.15
6	20	37010	237.85	29850	257.90	32670	286.65	15360	195.50
7	10	17430	174.49	16970	168.15	12030	161.40	12610	142.65
8	40	32840	307.83	24520	252.75	8450	80.60	5490	72.35
9	25	36520	275.69	43350	309.10	44220	299.80	38220	317.40
10	15	29280	299.06	30050	260.65	29360	253.25	18440	230.25
11	15	50810	319.35	51800	304.90	50170	300.70	47640	342.65
12	40	63290	400.65	61300	385.50	77270	447.50	76190	515.60
13	30	57420	366.34	80200	467.70	67020	391.65	67450	477.70
14	40	74890	527.20	69360	462.90	51760	442.00	73320	515.20
15	15	27160	243.02	20830	207.45	24480	223.80	21220	227.75
16	15	30140	248.33	38960	285.65	24840	229.00	36840	281.80
17	40	47110	377.75	35130	325.60	31080	279.70	37590	351.65
18	15	19930	219.84	9290	122.60	-	-	-	-
19	30	-	-	15810	215.85	21160	176.35	16090	132.00
20	40	95040	565.73	88480	533.95	101380	553.45	97100	635.30
21	40	51430	383.55	47920	337.40	56640	377.65	49760	360.45
22	25	63210	388.30	75220	422.45	-	-	74620	545.55
23	15	25320	224.85	41950	281.95	41660	294.10	35080	296.20
24	10	26690	201.40	25750	202.40	24100	185.55	18720	190.75
25	10	24460	192.40	22580	189.45	25370	192.95	24020	212.15
26	15	17490	202.75	29300	254.90	43340	287.65	42240	329.55
27	25	-	-	-	-	28430	196.95	24020	212.15
28	2	5950	54.93	6680	53.75	6480	49.90	7450	80.25
29	25	76310	509.85	60240	433.60	50740	383.75	56070	443.25
30	20	-	-	24880	204.45	63720	369.75	62730	450.80
Other wells		133160	1178.75	109220	1120.10	168960	1524.50	106650	1266.15
Total		1,141,140	8692.49	1,162,330	8990.80	1,173,240	8849.60	1,159,870	9772.10

Estimated well costs

This spring a drainage well cost estimate was obtained from a large reliable well drilling company. The costs were developed for a 140 foot well 18 inches in diameter capable of discharging 2000 gallons per minute. A detailed breakdown of the well cost is presented in table No. 33.

Table 33. Estimated cost for a 140 foot deep, 18-inch diameter, 2000 gpm drainage well.

Item	Unit quantity	Price per unit	Item cost
Drilling	140 ft.	$18.00	$2520
Casing 18 inch O.D.	110 ft.	10.00	1100
Screen "Everdure"	30 ft.	112.50	4375
Screen fittings			346
Developing work			600
Yield and drawdown test			500
Pump	1		
Motor	1-70 HP		3000
Electrical equipment			
Outlet structures			50
Pump House	1	400	400
Total cost			$12,891

The following appendix tables on vertical drainage were included in the June 1953 Progress Report.

Appendix
Table No.

6. Initial costs of drainage and irrigation wells in the Pioneer Irrigation District at Caldwell, Idaho.

7. Operating costs of drainage and irrigation wells in the Pioneer Irrigation District at Caldwell, Idaho

8. Summary of the water pumped from 10 wells in the Pioneer Irrigation District during the period of 1926 to 1934.

9. Detailed information concerning the Franklin Road Well, No. 12 for the year 1934.

SUGGESTED DRAINAGE AND RECLAMATION PLANS

The following conclusions and valley wide drainage plans are suggested from the results of previous work done in the Emmett Valley and the observations and investigations made under the present investigation which was initiated in August of 1951.

Causes of Water-logging

The causes of the severe water-logged condition in the Emmett Valley cannot be attributed to any one factor. It is caused by a combination of soil changes and ground water from numerous sources. The problem water in the valley has its source from a combination of the following:

1. Over-irrigation of the soils on the valley floor: Some of the shallow soils overlying the permeable gravel bars in the Emmett Valley have very high intake rates and contribute considerable water to the ground water table.

2. Irrigation and canal seepage from the Emmett Bench and the South Slope: The Bench and the Slope have fairly high intake rates and contribute considerable water to the ground water table.

3. Ground water flowing down the valley: Two years ago when the Black Canyon Dam was repaired, the water level in the wells in the upper end of the valley dropped considerably. A 70 foot hole below the Dam was pumped out, which acted as a sump, also the reservoir was drained as low as possible. During this repair period, a number of shallow wells near Emmett went dry and had to be deepened.

4. Artesian water from below: Artesian water is leaking through the retaining artesian caps and is contributing to the drainage problem. The current investigation indicates that artesian water is entering the water-logged area from the following sources:

   A. The artesian aquifers were formed under braiding stream conditions and are built up in a "leaf structure." Water apparently enters the valley in a large number of permeable aquifers connected with soils of slower permeabilities.

   B. Analysis of the artesian wells as piezometers indicate that pressures increase with depth. There is apparently a large master aquifer at a depth of approximately 600 feet. Water leaking through the braiding stream structure towards the surface is also indicated by a number of artesian wells in the valley whose discharge and pressure dropped when an adjacent well tapped a deeper aquifer.

Artesian water also flows out from under the buried fans, around the edges of the fan, and contribute to the ground water table. This is indicated by the number of warm sulphur smelling springs around the edges of the buried fan. (See figure 8 for fan location)

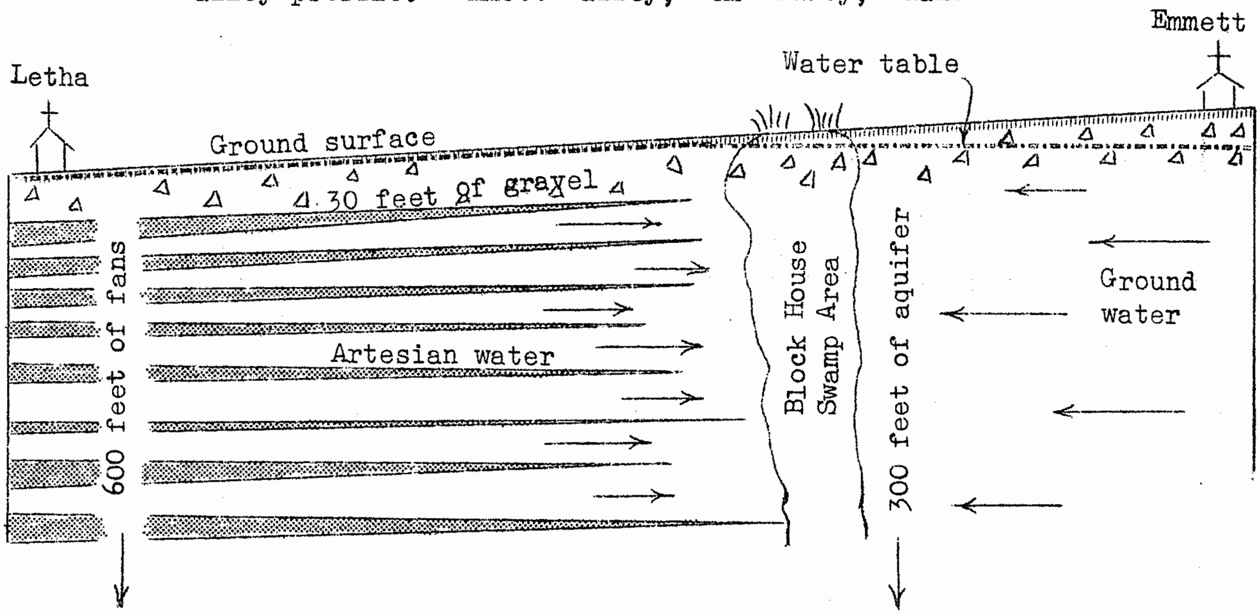
5. Seepage of precipitation from adjacent hills

6. Seepage from local sloughs, stagnant drains, ditches and ponds.

Water from the above sources, with the exception of item 4 moves down-slope into a mammoth soil change. This soil change consists of the alluvial fan or fans that are shown in figure 8. The soil profile or aquifer is more than 326 feet thick at well No. 4-A (See figure 7) to about 30 feet thick at well 11-A. Artesian water moving up valley in the aquifer forms an impermeable wall or dam in excess of 600 feet deep. A profile of this "underground dam" is shown in figure 26. This buried fan retards the ground water movement down the valley and is the primary cause of the water-logging.

FIGURE 26

Valley profile. Emmett Valley, Gem County, Idaho



Drainage Plans

The over-all valley drainage plan should employ a combination of open drains, tile drains and drainage wells. The most feasible and economical plan will be to install drainage wells where the aquifer, economics, and other conditions permits, and open or tile drains where they will give the maximum benefit for the least cost.

It is recommended that the following drainage devices and locations be used in the over-all valley drainage plan: (A general location of the following items are located on Figure 27.)

1. Three gravel pits were excavated in Section 14, T 6N R2W by the State Highway Department. The pit locations are shown on Figure 27 by item No. 1. The south pit covers 14 to 16 acres and is reportedly about 12 to 14 feet deep. The gravel pits are immediately up valley from the Block House swamp and soil change shown on Figure 2. The pits can be used as drainage sumps by connectin them to deep open drains or the installation of sump pumps. The pumps would give more drainage relief as the water in the pits could be maintained at a lower level. A dragline or bulldozer can be used to slope the bottom to one end and deepen the pits. The south pit could be deepened to about 30 or 40 feet on one side. It is felt that converting these gravel pits to drainage sumps will give a large amount of drainage relief at a minimum cost.

2. A line of vertical drainage wells or a deep open drain should be located east of the Block House swamp and soil change. (See item 2 on Figure 27 for location) This line of interception wells or drain would eliminate the water-logged condition on the east of the mammoth soil change caused by the artesian aquifer and the Block House swamp. The drain would lower the water table up valley from the fan and bog and would establish a drainage outlet for the water-logged area east of the artesian aquifer and bog.

3. Deep open or tile drains located west of the Block House swamp. The drains should run in a north-south direction (See item 3 on Figure 27 for location) They should be ended next to the Payette river and the drainage water pumped out of the drains and into the river. Sump pumps may be required as there is not sufficient fall for gravity outlets. The drains will be used to remove excess irrigation water and artesian water that "weeps" through the artesian caps. The first drain should be installed west of the Block House swamp at a point where the ground water table is again too close to the surface. The spacing of drains down the artesian fan will depend for a large part upon seepage from over-irrigation and waste of irrigation water. The installation of drains should progress down valley as they are required.

4. Deep 6 to 12 foot open or tile drains located below the South Slope and the Emmett Bench. These drains would be used to pick up seepage water from canals, ditches, and over-irrigation on the permeable South Slope and the Emmett Bench. The seepage water would be removed before it enters the slowly permeable soils in the valley floor (See Figure 2 for location of the slower permeable Reed, Cannon, and Vanderdusen soils) Some sections of the drains can have a gravity flow outlet; however, some will have to be pumped into the river to maintain them at proper depth. (See item 4 on Figure 27 for drain locations).

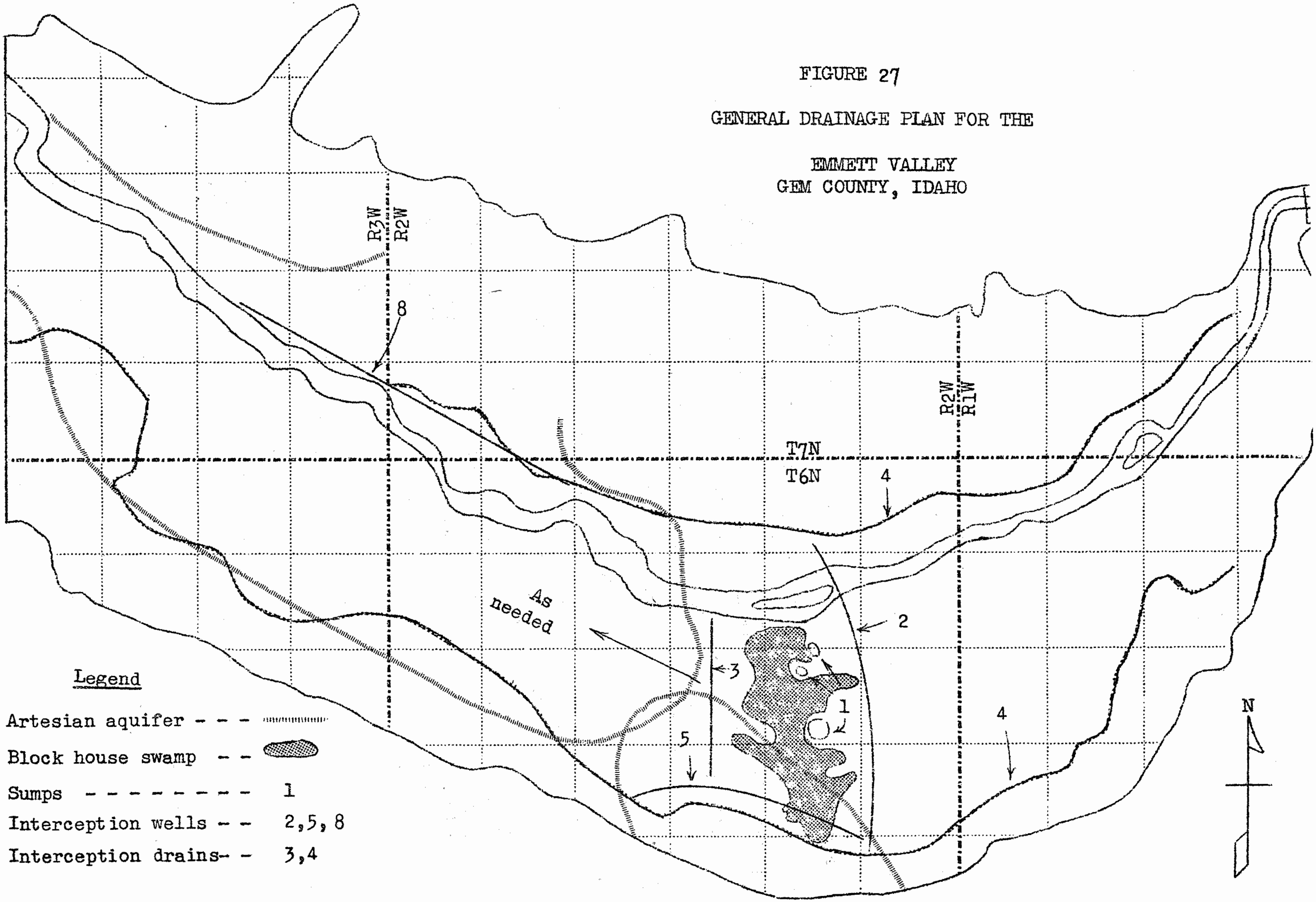


FIGURE 27

GENERAL DRAINAGE PLAN FOR THE

EMMETT VALLEY
GEM COUNTY, IDAHO

5. A series of vertical drains may be required in the South Slope artesian aquifer to remove the artesian pressure from below (See item 5 on Figure 27 for drain location) The problem in this area is attributed to a separate artesian aquifer and draining it with wells should have no effect upon the artesian wells in the main artesian belt around Letha. The Block House swamp is closely associated with this artesian aquifer. The drainage wells recommended in item 5 will materially reduce the hydrostatic pressure in the south end of the Block House swamp and facilitate drainage of the bog and pot holes.

   Drainage of bog holes similar to the ones in the Block House swamp is being attempted in several areas of the west. In small bogs the muck is cleaned out with a clamshell or orange peel bucket and the hole backfilled with gravel. Tile drains are laid to the bogs and used to drain off the artesian water. In the larger bogs a large diameter, 20 to 30 foot long section of pipe is being sunk in the bog with an orange peel and used as a sump. The water is being outletted into tile drains. A cap is placed over the pipe or gravel fill and the bog area backfilled and leveled so that it can be farmed.

6. There are numerous minor soil changes around the edges of the valley floor. These water-logged areas can be reclaimed with interceptor open or tile drains immediately up-slope from the soil changes.

7. Additional open and tile drains will, undoubtedly, be required in some local areas to fully reclaim the remaining water-logged areas. These areas will persist due to local soil changes and topographic conditions.

At one time it was thought that a line of vertical drainage wells across the artesian aquifer throat would reduce the artesian water pressure under the valley floor and would materially assist with natural drainage in the valley. (See item 8, Figure 27 for location). Subsequent investigations have indicated that the leaf-like soil structure in the fans, caused by braiding streams, and the existance of a 600 foot deep high pressure artesian aquifer practically eliminate this as a feasible drainage plan. The cost of an adequate line of interceptor wells would be exceptionally high and the legal aspects practically prohibitive. Public sentiment is generally in favor of the existing artesian artesian wells and some of the farmers have filed water rights on the water for domestic and irrigation use. It is felt that any effort to change the hydrostatic pressure in the main artesian aquifer would meet with disfavor and legal troubles.

Alkali Reclamation Recommendations

Reclamation of the alkali soils following drainage should be put on a pay as you go basis. On the lighter textured alkali soils an application of two or three tons per acre of gypsum or other soil amendment can be applied initially to start the reclamation process. When this gypsum is used up or the beneficial effect has worn off, another application should be applied. For heavier textured soils, each application may have to be increased to 5 tons per acre. This procedure will spread the soil amendment cost over a period of years and still allow the farmer to realize a return from the land.

From 1 to 6 applications may be required depending upon the severity of the alkali problem. The reclamation progress and the time requirements for additional amendments should be checked with pH color indicators and laboratory analysis.

It may be possible to deep plow the soil in some areas where the alkali is concentrated in the surface 6 inches or first foot, and the soil mantle is sufficiently thick. This would spread the alkali in the soil profile and also place relatively alkali free soil on the surface.

Irrigation Recommendations

A strong effort should be made to prevent applications of excess irrigation water, beyond that required for leaching, because of danger of adding to the ground water table. An irrigation study should be conducted in the Emmett Valley to determine the best unit irrigation stream for border irrigation and to delineate the shallow soil areas that should be sprinkler irrigated to prevent excess additions to the water table.

General irrigation recommendations would be to use border, basin or sprinkler irrigation on the alkali soils. As much of the soil as possible should be under water during the irrigation. This maintains the smallest area for salts and alkali to "wick up" and accumulate in. Border and furrow ridges or crown offer excellent opportunity for salt accumulation and would become highly saline and or alkali in the problem soils.

Cropping Practices

Alkali tolerant crops should be planted on the problem soils during the reclamation period. Crops that grow well under border, basin and sprinkler irrigation should be selected. A list of somewhat alkali tolerant field and forage crops are listed in the following tabulation. They read from a higher to a lower alkali tolerance in general, but also take into account their affect on intake rate, ease of handling and other factors which facilitate the reclamation process.

Field Crops	Forage Crops
Wheat	Tall wheat grass
Rye	Pubescent wheat grass
Barley	Alfalfa
Rape	White and yellow sw. clover
Oats	Birds foot trefoil
	Strawberry clover
	Rescue grass
	Rhodes grass

Sugar beets are relatively alkali tolerant, however, very little success has been had in the Emmett Valley when they were border irrigated. They may be worked into the crop rotation plan as the reclamation progresses.

LIST OF REFERENCES

(1) Bradshaw, G. B.
1953 Soil Changes As They Affect Water-logging and Drainage (Mimeographed)

(2) ______________ and Nelson, M. W.
1952 Field Methods for Evaluating Some Factors Relating to Soil Reclamation and Recommendations Pertaining to Drainage (Mimeographed)

(3) Donnan, W. W. and Bradshaw, G. B.
1950 Methods of Determining Ground Water Levels and Movements (Lithographed)

(4) ______________ and Bradshaw, G. B.
1952 Drainage Investigations Methods for Irrigated Areas in Western United States (U.S.D.A. Technical Bulletin No. 1065)

(5) Fireman, M., Mogen, C. A. and Baker, G. O.
1950 Characteristics of Saline and Alkali Soils in the Emmett Valley Area, Idaho. (Idaho Agricultural Experiment Station Research Bulletin No. 17)

(6) French, H. T.
1914 History of Idaho, Vol. 1.

(7) Hawley, J. H.
1920 History of Idaho

(8) Jacob, C. E. and Lohman S. W.
1952 Nonsteady Flow to a Well of Constant Drawdown in an Extensive Aquifer. American Geophysical Union, Volume 33, No. 4.