1927

Annual report of the Department of Irrigation, fiscal year 1926-27

George Hardman

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United States. Department of Irrigation

ANNUAL REPORT OF THE DEPARTMENT OF IRRIGATION FOR THE FISCAL YEAR 1926-27.

Project #29, Purnell, at Las Vegas, Nevada. Based on cooperative agreement between the Nevada Agricultural Experiment Station and the Irrigation Division of the United States Bureau of Public Roads.

by

F. L. Bixby, Senior Irrigation Engineer,
Project Leader,
and
W. L. Stockwell, Jr. Junior Irrigation Engineer
for the Irrigation Division,
and

George Hardman, Assistant Research Prof. of Irrig.
for the Experiment Station.

The three major studies now being carried out under the above agreement together with their various subtopics are as follows:

1. Development of Underground Waters.
    a. The measurement of the wells and springs of the Las Vegas Valley and correlation studies of the precipitation on the surrounding mountains.
    b. The determination of the capacities of non-flowing and small flow artesian wells of southern Nevada by pumping.
    c. Development of springs.
2. Drainage of Irrigated Lands.
    a. Drainage investigations in the Moapa Valley.
    b. Mapping and classifying of lands in the Moapa Valley to determine feasibility of proposed flood control and water storage project.
3. Soil Fertility and Crop Adaptation.
    a. Fertilizer experiments with soil in pots.
    b. Cooperative Field Fertilizer Trials.
    c. Experimental Farm.

Measuring Airways Well
spring - 1927.
flow - 1.72 cfs.

Union Pacific Well
summer - 1927.
flow - 3.67 cfs.

For the purpose of this report the engineering features of the work will be discussed under two general heads, namely:

1. Development of Underground Waters.
   a. The measurement of the wells and springs of the Las Vegas Valley and correlation studies of the precipitation on the surrounding mountains.
   b. The determination of the capacities of non-flowing and small flow artesian wells of southern Nevada by pumping.
   c. Development of springs.
2. Drainage of Irrigated Lands.
   a. Drainage investigations in the Moapa Valley.
   b. Mapping and classifying of lands in the Moapa Valley to determine feasibility of proposed flood control and water storage project.

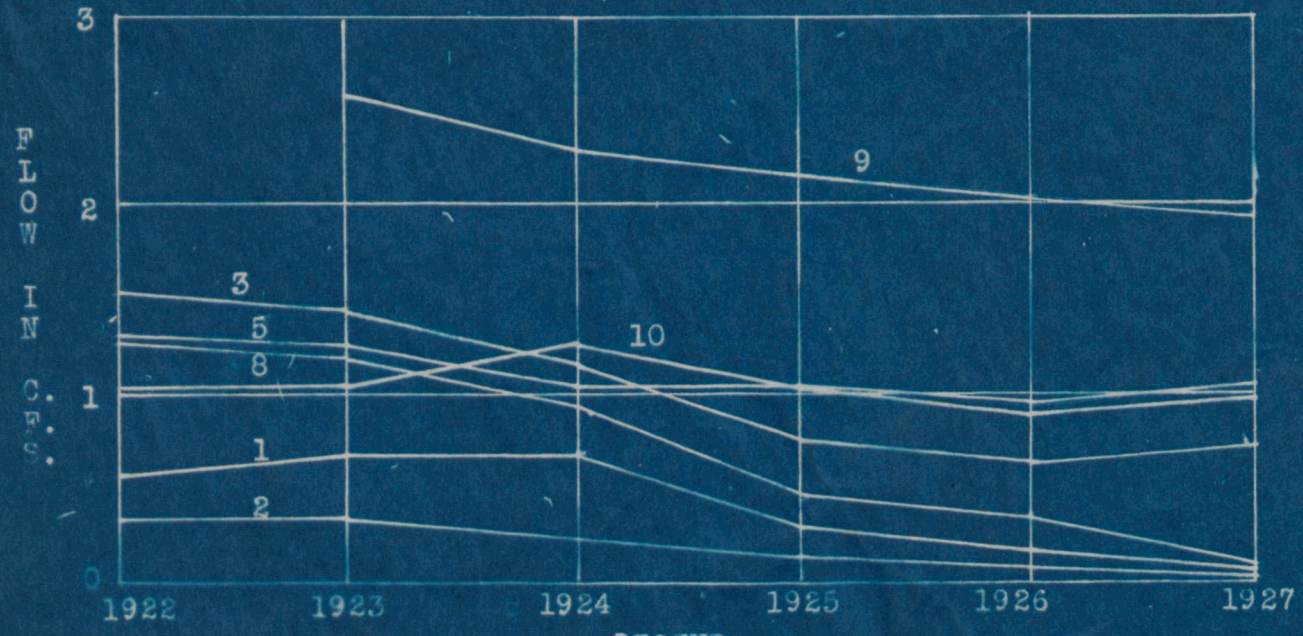
1. The Development of Underground Waters.

a. The measurement of artesian wells. There are several new wells in the Las Vegas Valley which are reported this year bringing the number measured to 55. There are possibly 150 to 175 wells in the Valley but the wells measured are those that are easily accessable and are considered as representative of this artesian belt.

For convenience the wells and springs have been grouped in four divisions, the first three being in the Las Vegas

GROUP I
REPRESENTATIVE WELLS

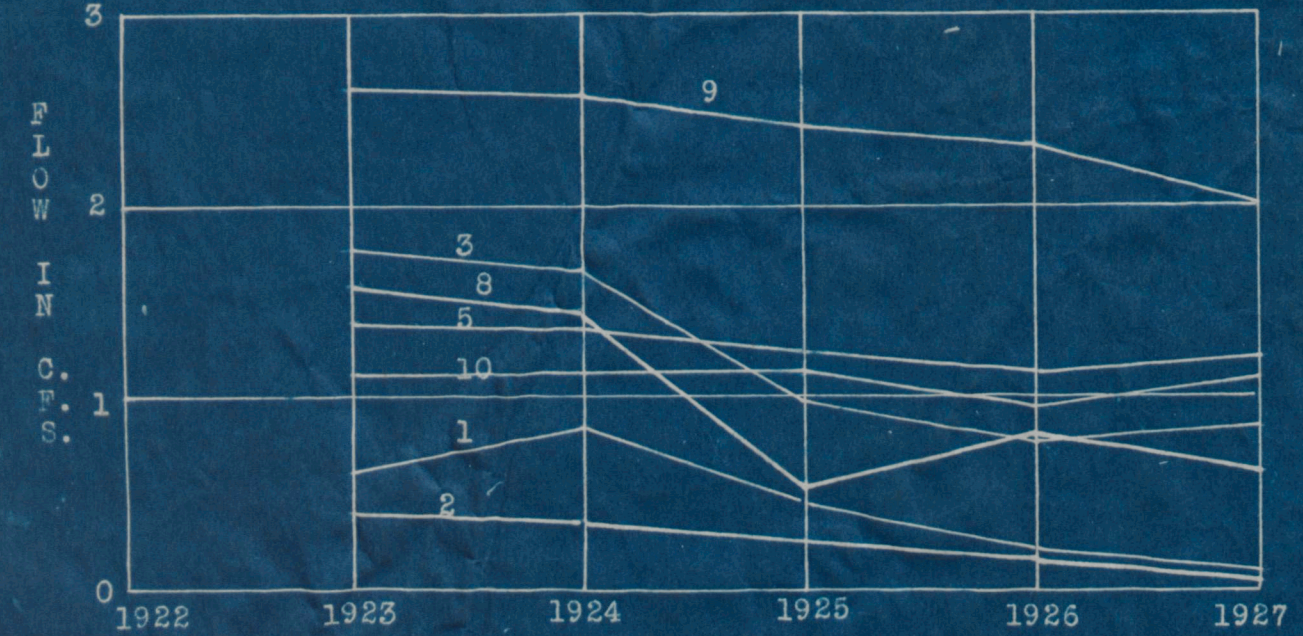
SUMMER FLOWS



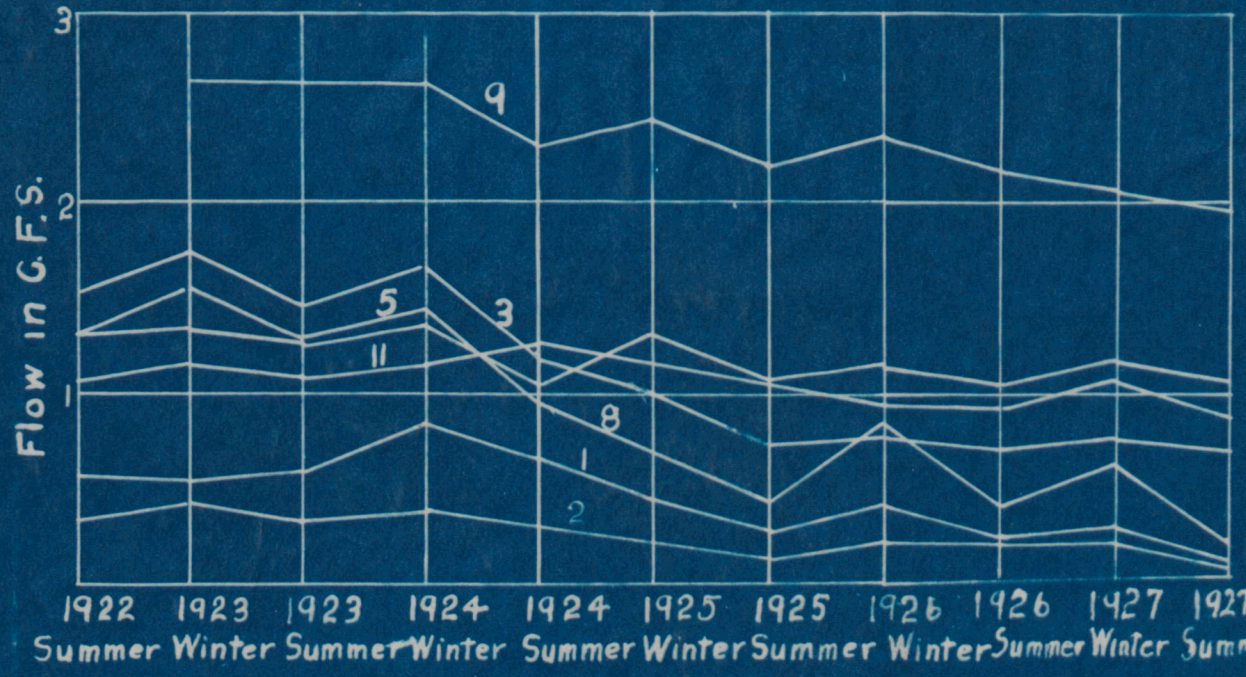
LEGEND

1	SMOKE	8	TAYLOR
2	EGGLINGTON	9	LINDSAY
3	SYNDICATE I	10	SUND
5	SYNDICATE 3		

WINTER FLOWS



Group I
Representative Wells



Legend
1 Smoke
2 Eglington
3 Syndicate 1
5 Syndicate 3
8 Taylor
9 Lindsay
11 Sund

Valley and the fourth the wells and springs of the Pahrump Valley.

I. The upper Mesa Group.

II. The wells in and about Las Vegas.

III. The wells in the southern end of the Las Vegas Valley.

IV. The Wells and springs of the Pahrump Valley.

Table of Records. Group I

~~Group 1. Wells of the Upper Mesa area.~~

Summer Measurement in C. F. S.

	Name	Year 1922	1923	1924	1925	1926	1927
1	Smoke	0.59	0.67	0.68	0.28	0.19	0.08
2	Eglington	0.34	0.36		0.14	0.072	0.052
3	Syndicate 1	1.53	1.44	1.15	0.74	0.68	0.74
4	Syndicate 2	1.53	1.57	1.38	1.04	0.94	1.04
5	Syndicate 3	1.31	1.28	1.04	1.04	0.99	1.04
6	Syndicate 4	0.75	1.04	0.94	0.74	0.69	0.74
7	Syndicate 5	0.45	0.50	0.45	0.45	0.35	0.28
8	Taylor	1.31	1.29	0.92	0.45	0.37	0.125
9	Lindsay		2.65	2.30	2.18	2.02	1.94
10	Sund	1.06	1.09	1.28	1.04	0.89	0.94
11	U. P.			8.12		3.95	3.67
12	Jefferson				0.24	0.24	0.21
13	Tule Springs		1.07	1.08	1.18	1.04	1.04
14	Wickmans					1.57	1.34
15	Air Ways						1.61

Winter Measurements in C. F. S.

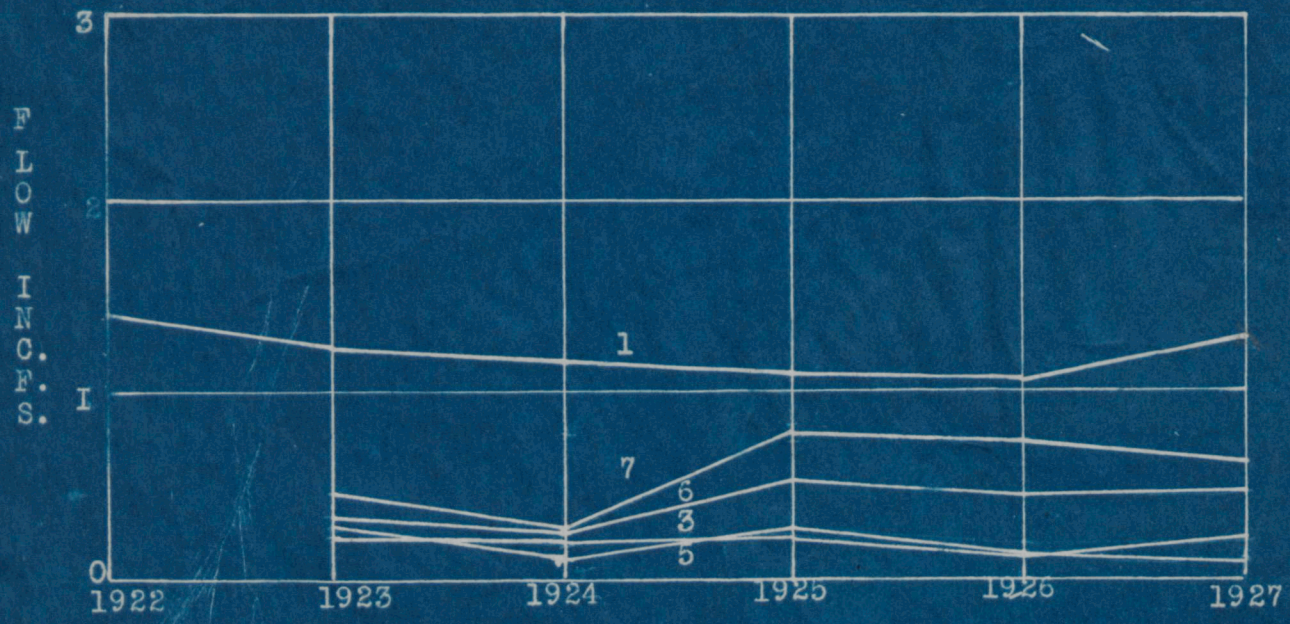
		1922	1923	1924	1925	1926	1927	1928
1	Smoke		0.63	0.85	0.42	0.26	0.106	0.072
2	Eglington		0.42	0.38		0.21	0.08	0.080
3	Syndicate 1		1.79	1.69	0.99	0.78	0.84	[illegible] 0.74
4	Syndicate 2		1.96	1.76	1.57	1.04	1.04	0.84
5	Syndicate 3		1.37	1.38	1.21	1.15	1.38	0.94
6	Syndicate 4		1.04	1.10	0.84	0.74	0.79	~~0.26~~ 0.74
7	Syndicate 5		0.56	0.60	0.48	0.37	0.35	0.26
8	Taylor		1.58	1.44	0.69	0.83	0.61	0.28
9	Lindsay		2.65	2.62	2.43	2.34	2.07	2.37
10	Sund		1.14	1.15	1.15	0.94	1.12	1.10
11	U. P.				5.86	4.24	4.18	4.72
12	Jefferson				0.24	0.24	0.24	0.24
13	Tule Springs			1.10	0.98	1.21	1.04	1.04
14	Wickmans					1.57	1.34	1.58
15	Air Ways						1.72	1.69

The wells of the upper Mesa Group as a whole have shown a decrease which may be attributed to a light rainfall in the Spring Mountains, and to the further fact that wells 14 and 15 were drilled and brought in with good flows.

Although these two new wells do not seem to affect one another they have a considerable affect on other wells in the vicinity. The Wickman well when open reduces the flow of the Eglington and the Smoke Wells to a point where the water does rise over the top of the casing and the flow of syndicate numbers 1, 2, and 3 drop from 0.74cfs to 0.60cfs for no. 1, 0.94 to 0.78cfs for no. 2 and 1.08 to 0.84cfs for no.3. The air field well does not weem to have as quite as great an affect on the series but has reduced the flow of some wells south and east of it. Among these wells are the Jefferson well and the old Boul wells where the water surface drops to 3 feet below the top of the casing when this well is opened to its full capacity. The measurements on the Union Pacific well show that it has fallen off in flow to some extent. The most recent reading show that this well has a flow at this time of 3.95cfs against a flow of 5.86cfs. in March of 1925. This well's decrease may be due to sanding up and fact that the joints in the casing have become closed cutting off the flows of the upper strata that might have been seeping in before.

GROUP II
REPRESENTATIVE WELLS

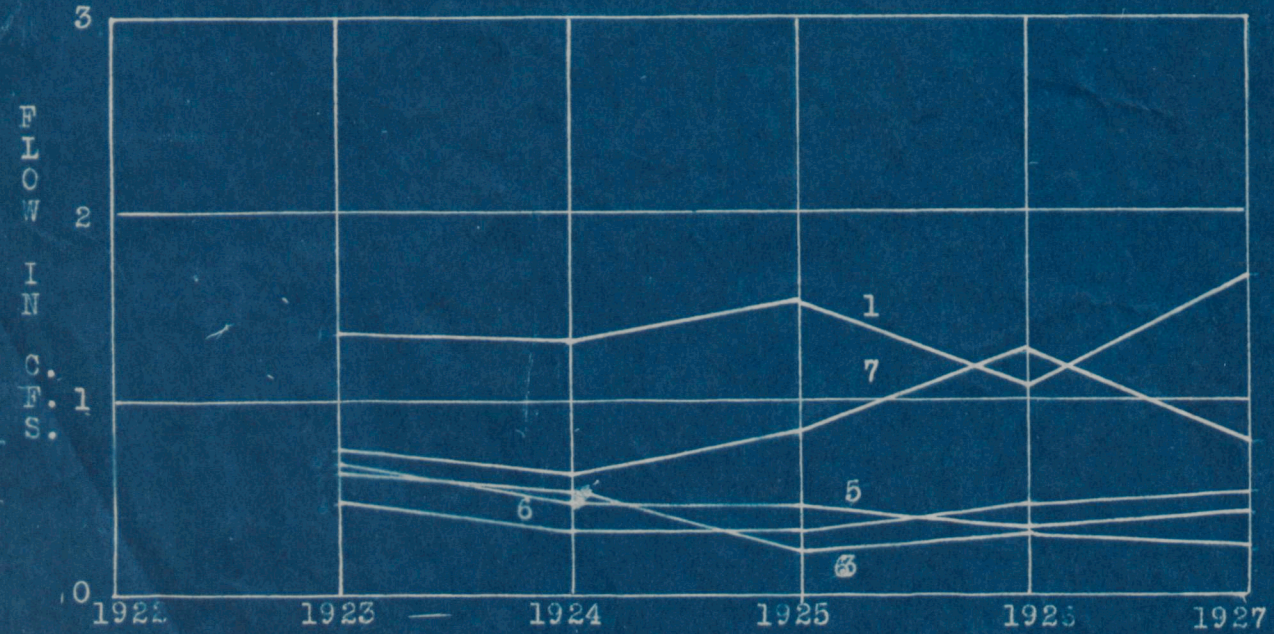
SUMMER FLOWS



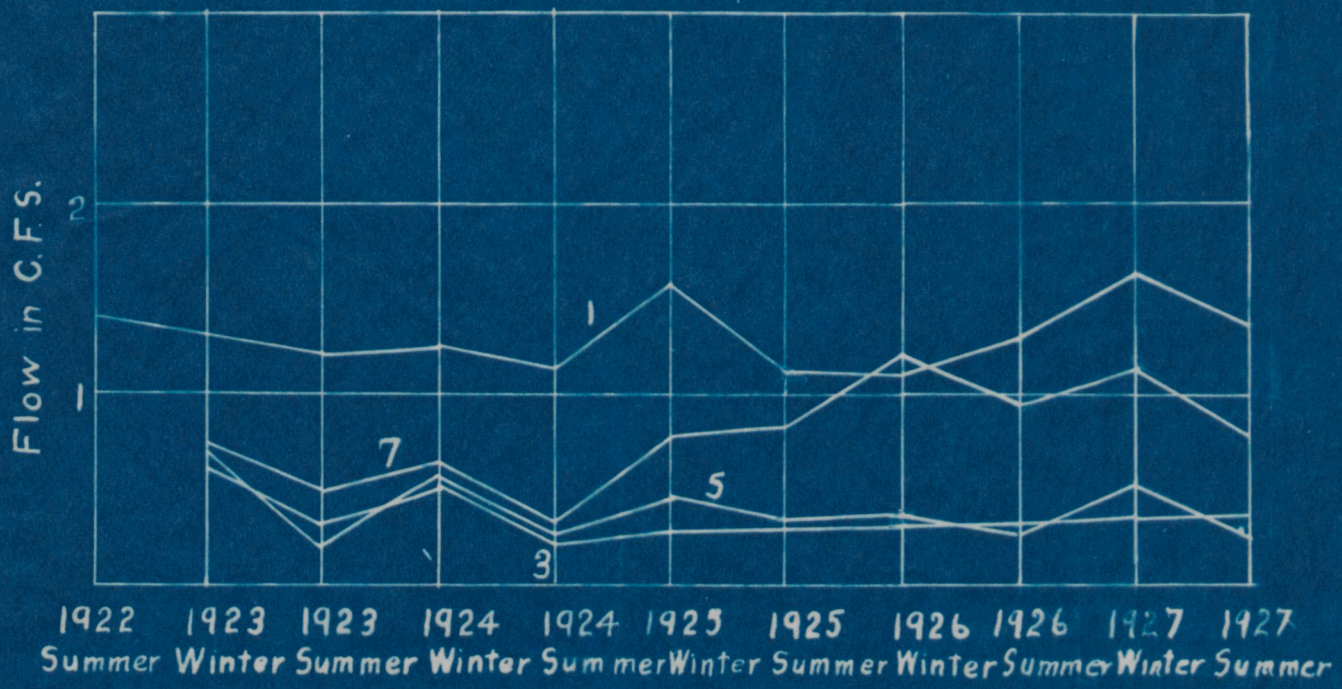
LEGEND

I	RUSSELL	6	HAGGARD
3	TATE	7	ANDERSON
5	ULLOM		

WINTER FLOWS



Group II
Representative Wells



Legend
1 Russell
3 Tate
5 Ullom
7 Anderson

Group 11 Wells in and about the Town of Las Vegas

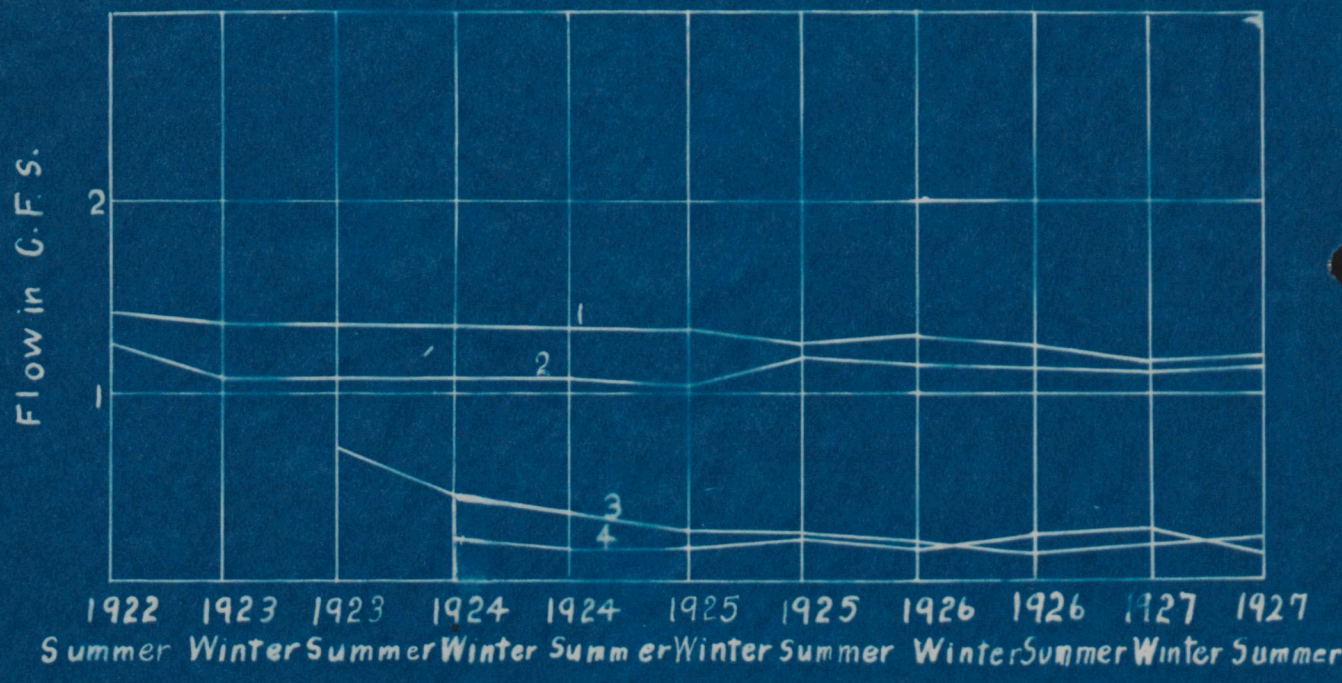
Summer Flows in C. F. S.

	Name	1922	1923	1924	1925	1926	1927
1	Russell	1.41	1.21	1.13	1.10	1.04	1.30
2	Dinsmore		0.24	0.24	0.08	0.08	0.08
3	Tate		0.29	0.18	0.28	0.18	0.22
4	Filbey		0.25	0.18	0.18	0.20	0.36
5	Ullom		0.24	0.21	0.32	0.18	0.13
6	Haggard		0.32	0.25	0.52	0.44	0.48
7	Anderson		0.48	0.25	0.84	0.75	0.62
8	Brown			0.21	0.56	0.44	0.37
9	Dutton			0.35	0.28	0.28	0.24
10	Syndicate 7		0.67	0.26	0.28	0.21	0.26
11	Syndicate 8		0.21	0.14	0.10	0.24	0.34
12	Parks				0.36	0.28	0.42
13	Oppedyke				0.03	0.05	0.00
14	Hunt						0.58

Winter Flows in C. F. S.

	Name	1922	1923	1924	1925	1926	1927	1928
1	Russell		1.37	1.37	1.57	1.10	1.69	1.44
2	Dinsmore		0.55			0.32	0.17	0.14
3	Tate		0.63	0.55	0.28	0.32	0.24	0.28
4	Filbey		0.52	0.45	0.32	0.21	0.45	0.47
5	Ullom		0.67	0.52	0.47	0.39	0.42	0.40
6	Haggard		0.48	0.39	0.35	0.57	0.54	0.545
7	Anderson		0.74	0.63	0.84	1.27	0.79	0.74
8	Brown			0.55	0.91	0.89	0.84	0.84
9	Dutton			0.35	0.30	0.30	0.30	
10	Syndicate 7		0.67	0.63	0.67	0.68	0.79	0.45
11	Syndicate 8		0.43	0.38		0.10	0.30	0.32
12	Parks					0.40	0.38	0.34
13	Oppedyke					0.07	0.10	0.105
14	Hunt						0.63	0.47

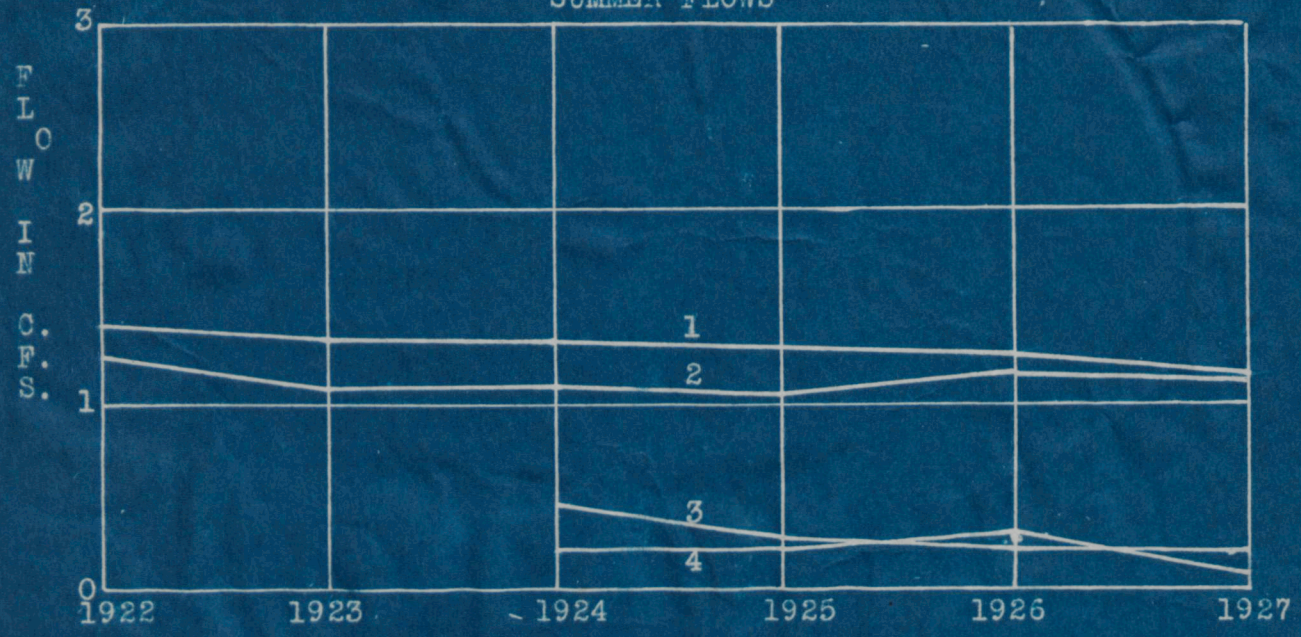
Group III
Representative Wells



Legend
1 McGriffs
2 Pasno
3 Blakes
4 Cannon

GROUP III
REPRESENTATTIVE WELLS

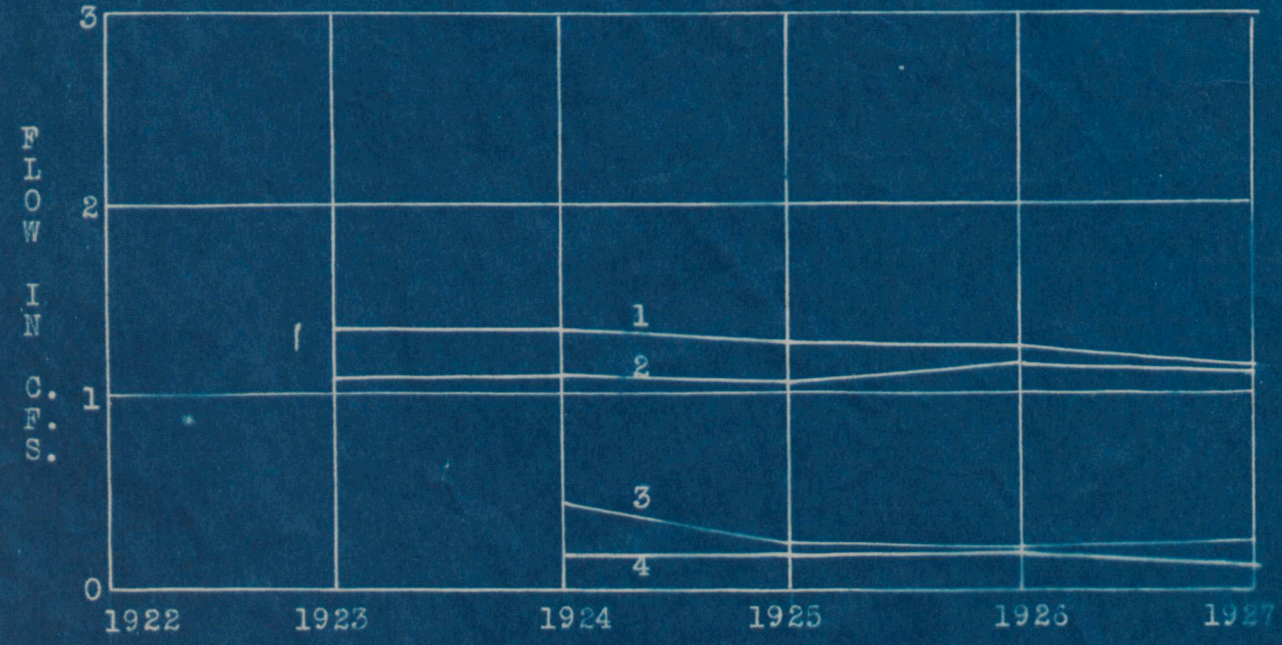
SUMMER FLOWS



LEGEND

1	MCGRIFFS	4	CANNON
2	PASNO	3	BLAKES

WINTER FLOWS



Group 111 Wells in the southern end of the Valley

Summer Flows in C. F. S.

Name	1922	1923	1924	1925	1926	1927
1 McGriff	1.41	1.36	1.36	1.32	1.28	1.15
2 Pasno	1.28	1.10	1.09	1.04	1.18	1.15
3 Bleak			0.46	0.24	0.21	0.18
4 Cannon			0.22	0.21	0.21	0.125
5 Houseman				0.70	0.64	0.61
6 Miller					0.32	0.24
7 Wendgert				0.70	0.56	0.48
8 Campbell						0.36
9 Campbell						0.39
10 Beckley					0.125	0.16

Winter Flows in C. F. S.

Name	1922	1923	1924	1925	1926	1927	1928
1 McGriff		1.36	1.35	1.37	1.28	1.15	1.10
2 Pasno		1.09	1.09	1.04	1.18	1.12	0.99
3 Bleak			0.46	0.24	0.21	0.24	0.136
4 Cannon			0.22	0.21	0.21	0.16	0.125
5 Houseman				0.94	0.72	0.61	0.61
6 Miller				0.38	0.48	0.46	0.45
7 Wendgert					0.64	0.56	0.56
8 Campbell 1						0.32	0.37
9 Campbell 2						0.39	0.39
10 Beckley					0.14	0.18	0.14

The wells in this group in many cases have shown decided decreases but in the main these are evidently nothing more than the usual seasonal variations. A number of new wells have been drilled in this territory but they have mostly tried for the deep water strata. Two of these wells are noted here for the reason that they were drilled along the lower edge of the artesian belt, and encountered two different formations and neither well found a great deal of water below the six hundred foot level.

The Hunt well is now the deepest well in the Valley being 1150 feet deep and having a flow of 0.50cfs. Of this about 0.30 is from the upper flows of 300 and 600 feet, the rest from below the 600 feet depth.

The formations in this well were alternate strata of limerock, conglomerate and clay, which is the general stratification found in nearly all of the wells in this vicinity.

The Garhieme well was drilled earlier in the year and was put down to a depth of 950 feet. This well, after the first 300 feet, was in a clay formation all the way down, the water being found in narrow veins of sand in the clay. This formation is not often found in the Valley and would seem to indicate that there may be a clay dike on the eastern edge of the Valley whcih is holding up the water and giving the Valley its artesian flows.

The walls of the third group are located in the southern end of the Valley. Although in general it is a stable group some of these wells have shown a tendency to fall off in

flow this year to a considerable extent. One new well was drilled in this section in the last year and the formation encountered was so entirely different that it is mentioned and a log of the well given. It will noted that this well struck basalt at a very shallow depth. In other places in the Valley this formation is found below 1000 feet. This well was drilled within a thousand feet of the McCriff well and near two wells that flow about 0.30cfs apiece. The water in this well rose to within 18 feet, of the top of the hole but never flowed. The elevation is about 30 feet higher than the McCriff well.

Log of Hunt-McCriff Well No. I

0-40	Clay
40-340	Lime conglomerate
340-351	Red Clay and boulders water rose to 100 ft.
351-685	Basalt ic conglomerata
685-690	Gravel, Water 18 ft. below top of casing
690-715	Basalt ic conglomerata
715-717	Water very brackish

This last stratum was stopped off by filling in to a depth of 700 ft.

The following graphs show in general thehvariations in the flow of the artesian wells in the Las Vegas Valley since 1922.

Some measurements are given here of the wells and springs in the Pahrump Valley which lies on the western side of the Spring Mountain Range and receives the drainage from that side of the mountains. The artesian belt in this territory is not as well developed as the Las Vegas Valley due to the sparsely settled condition of the Valley and the great distance from the Railroad.

Group 4 Wells Measured in the Pahrump Valley.

In 1927

Date	Name	Flow in CFS.	1916
Mar. 14, 1937	Annse Spring	2.30	
20	Intermittent Spring	0.42	4.73
21	Pahrump Spring	2.59	
22	Pahrump Ranch Well 2	0.89	
	Pahrump Ranch Well 5	0.64	
	Raycraft Well 2 & 3	0.74	
	" " 1	0.356	
	" " 4	0.30	
	" " 5	0.50	
	" Spring	0.634	
20	Three mile Spring	0.046	
	Six mile Spring	0.072	
24	Manse Ranch Supply	2.14	3.23
15	Williams Spring	0.382	
22	Boul Well 1	0.200	
	" " 2	0.14	
	" " 3	0.10	

Of these the Annse, Intermittent and Williams Springs are located in the Charleston Mountains and are fed from the melting snows and local showers on the slopes immediately above them. They have an intermittent discharge varying from a maxium in April and May to a minium in late summer. The three mile and six mile springs are near the north edge of the Valley and apparently associated with the spur of the Charleston Mountains which here forms the north boundary of the Valley. The others are in the main artesian district.

Tests on Loss of Water in Open Ditches.

Three interesting tests were made on the loss of water in open ditches in different parts of this territory.

The first one was made on the Gilcrease ditch 12 miles north west of Las Vegas. The measurements were made in July and August of 1926 to determine the losses that might be expected in a ditch that w as run through a fairly loose

soil.

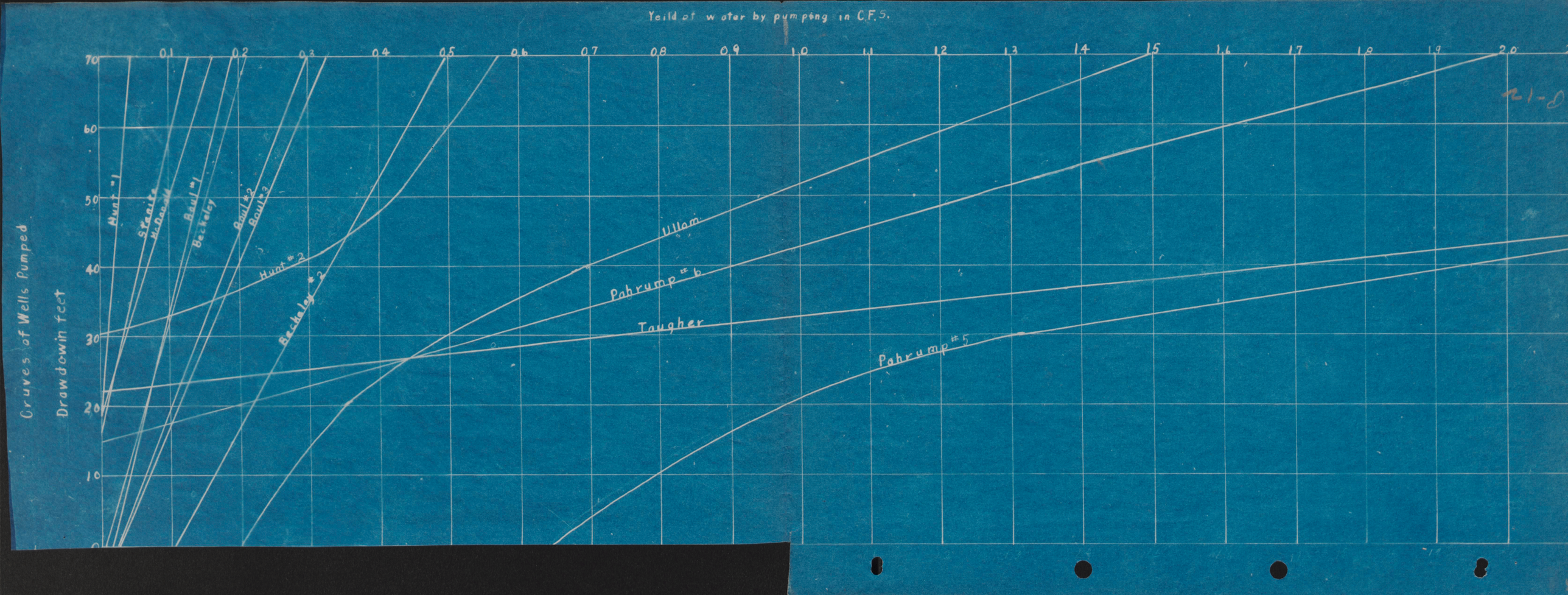
This ditch is one and three fourths miles long, with weirs set 9000 feet apart. The total fall in the length of the ditch betwenn the weirs was 45 feet or the grade of the ditch was on half of one percent/ The measurements on the ditch are as follows:

Tests of Loss of Head in Gilcrease Ditch.

Date	Upper Weirs CFS.	Lower Weirs CFS.	Differences CFS.
7/2/26	1.04	o.72	0.32
7/6/26	1.10	0.72	0.34
7/10/26	1.08	0.72	0.36
7/14/26	1.08	0.74	0.34
7/17/26	1.04	0.74	0.30
7/22/26	1.08	0.74	0.34
7/31/26	1.08	0.72	0.36
8/5/26	1.08	0.72	0.36
8/10/26	1.08	0.72	0.36
8/15/26	1.08	0.74	0.34
8/20/26	1.08	0.76	0.32
8/25/26	1.04	0.76	0.32
8/30/26	1.04	0.78	0.30
9/23/26	1.12	0.81	0.31
12/28/26	1.12	0.82	0.30
2/12/26	1.12	0.82	0.30
7/7/27	1.04	0.70	0.34

This ditch showed an average loss of 0.33 cfs. over the period of the measurements or about one third of the total flow. At the time of the measurement the ditch had been in operation for a period of two years. Such leaks as gopher holes and breaks in the ditch were watched for and repaired as soon as found.

The next test was carried on a ditch at the Pahrump Ranch in the Pahrump Valley. This ditch was 4363 feet between the weirs, with a fall of 22 feet. Readings on the ditch are as follows:


Yeild of water by pumping in C.F.S.
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
70
60
50
40
30
20
10
Curves of Wells Pumped
Drawdown in feet
Hunt #1
Stanley
McDonald
Bowl #1
Beckley
Bowl #2
Bowl #3
Hunt #2
Beckley #2
Ullom
Pahrump #6
Taugher
Pahrump #5

Tests of Loss of Head in Pahrump Ranch Ditch.

Date	Upper Weir CFS.	Lower Weir CFS.	Difference CFS
2/13/27	2.60	2.12	0.48
3/16/27	2.59	2.08	0.51
3/20/27	2.59	2.06	0.53
3/24/27	2.59	2.06	0.53
3/28/27	2.59	2.06	0.53
4/2/27	2.59	2.09	0.50
4/6/27	2.59	2.10	0.49
4/8/27	2.59	2.09	0.50

The water in this ditch was used for running a Pelton Wheel for ~~the~~ an ice machine and further measurements could not be made as it was shut off. The average loss of 0.51 cfs constitutes about a fifth of the flow and considering that this test was run in the coolest part of the year when there was very little loss due to evaporation and transpiration it seems high. The ditch itself has been used for a number of years and runs through a very heavy clay soil that was apparently nearly impervious to water and did not cut a great deal.

The tests on the third ditch are still in progress, the measurements given below being taken during the month of June. The ditch, a new one used to bring water from a well of the upper mesa group to the Taylor Ranch, is 15,492 feet in length with a fall of 102 feet in this distance.

Test of Loss of Head in Taylor Ranch Ditch.

Date	Upper Weir CFS	Lower Weir CFS	Difference CFS
6/8/27	1.69	0.50	1.19
6/11/27	1.66	0.55	1.11
6/15/27	1.66	0.60	1.06
6/20/27	1.69	0.65	1.04
6/24/27	1.69	0.65	1.04
6/28/27	1.66	0.67	0.99
7/1/27	1.66	0.67	0.99

These measurements would indicate that it is not practicable to carry water over such a long stretch of country in an open ditch as the losses are too great.

The pump tests in this Valley have been nearly completed. The tests have shown that the natural flow of many of these wells may be increased to some extent and that pumping will produce considerable water if it has to be resorted to.

Beckley Well #1

The first well pumped this year was the Beckley Well #1. This well had a flow of 0.019cfs. at the start of the test. It was pumped with the Kimball deep well turbine. The test is as follows:

Pump Test of Beckley Well #1.

Date	Draw down	R. P. M.	Weir	Reading	CFS.
7/28/[illegible]	69	1013	V. N.	0.365	0.304
	45	750	"	0.305	0.131
	30	610	"	0.268	0.093
	15	330	"	0.18	0.038

and The flow at the end of the test was 0.038 so a slight increase was afforded by pumping. However the small amount of water developed by pumping would not justify the expense of installing an outfit. The small wells in this particular section of the country do not seem to develop any great amount of water by pumping.

Hunt-McGriff Well #2

This was a shallow surface well and was pumped to determine whether the surface strata in this section would produce sufficient water for domestic use. The deep well Kimball Turbine was used in this test.

* insert after first paragraph

Pump Test of Hunt-McGriff Well # 2.

Date	Draw down	R. P. M.	Weir	Readings	CFS
8/4/27	60	1230	V.N.	0.520	0.429
	45	940		0.46	0.382
	36	830		0.32	0.147

The water surface in this well stood at 32 feet below the surface of the ground and the pump test was run for eight hours at 60 feet to determine whether the inflow to the well would be affected by continued pumping. * insert here.

Hunt-McGriff Well #1

This well was dug on the extreme south end of the Valley on the edge of the Las Vegas Wash ~~and was intended to be used as a supply for developing clay deposits and for making cement brick. The well~~ and is interesting in that the log of it shows an entirely different formation from any other well in the Valley. This formation outcrops in the lower foothills of the southern part of the Spring Mountain Range. The water level stood at 14 ft. below surface when drilling was stopped at 715 ft. in a very hard lime stratum.

The well was pumped with an airlift outfit, the compressor supplying 90 cu. ft. of air a minute, with a submersion of 85ft. The well pumped 0.042 cfs at this depth and held up to this for four hours. ~~This test was made on the 26 of August 1926.~~

Pump Test of Hunt Well # 1.

Date	Draw down feet	Quantity CFS	Length of Run hours
8/26/26	85	0.042	4

Beckley Well #2

The next test to be made was on a well of Mr. Beckley's known as # 2. This well which had been recently deepened to 815 ft., had a flow of 0.125 cfs at the start of the test. This well was pumped with the No. 7 deep well Kimball turbine.

Pump Test of Beckley Well # 2

Date	Drawn down	R.p. m.	Weir	Reading	C. F. S.
9/13/26	70	1260	1 Cipp	0.28	0.50
	65	1140	" "	0.26	0.45
	52	1020	" "	0.24	0.39
	45	910	" "	0.225	0.36
	35	829	" "	0.21	0.32
	25	726	" "	0.18	0.24
	15	645	V N	0.36	0.197
	7	500	V N	0.31	0.136

The flow at the end of the test was 0.126 cfs showing no improvement from pumping. This was expected since very little sand was pumped.

Taughan well.

This well is located in the south eastern part of the Las Vegas Valley. It is east of the Las Vegas Wash and a little out of the artesian belt. No flows were encountered though water of good quality was struck at 140 ft. that rose to about 18 ft. from the surface. Several cavities or heavy veins were found at from 300 to 370 ft. These water veins were more like underground lakes than anything, the drill dropping 20 ft. at a time with no resistance. The water immediately arose to within 32 ft. of the surface and gave evidence of a sufficient supply to insure a pumping well. A test was made in the latter part of September with the following results.

Pumping the Taugher Well
yield - 1.50 cfs, at
15 foot drawdown.

P-15

Pump Test of Taugher Well.

Date	Draw down	R. P. M.	Weir	Reading	C. F. S.
9/29/26	37	1960	2' Cipp	0.37	1.50
	30	1820	" "	0.26	0.89

This well proved to be one of the strongest pumping wells in the Valley but the water is so alkaline as to be almost unfit for use. ~~A log of the well is given the appended log tables.~~

Some pump tests of wells in the Pahrump Valley area shown in the following tables.

~~The next wells to be tested were those in the Pahrump Valley and some results were obtained which were quite gratifying.~~ The wells in this Valley are thought to obtain their supply of water from the eastern slopes of the Spring Mountain Range. They are somewhat higher in elavation than these in the Las Vegas Valley, the elevation of the Las Vegas water bearing area being from 1900 to 2300 ft above sea level while the Pahrump area lies between the 2600 and 2900 ft. levels.

The wells in this Valley are used for irrigation and stock watering. There are only about 2500 acres under cultivation in the artesian belt in this area.

Buol Well #1 This well was first tested with the Kimball deep well turbine and then shot with 30 pounds of 80% dynamite. The results of the test are given in the following table.

Pump Test of Buol Well #1.

Date	Drawdown in ft.	Quantity in C. F.S.	Remarks
7/25/27	00	0.035	natural flow at start
	66	0.115	after 24 hrs. pumping
	00	0.05	flow at end of pumping
	00	0.20	flow after shooting.

Pumping this well for 24 hrs. at 66 feet increased the natural flow, while the use of a small amount of powder in the bottom of the hole caused a further increase. The well is in a hard limestone formation, the water appearing in small openings in the rock. Shooting evidently has a tendency to open the water courses with a resultant increase in flow.

Buol Well #2 This well was first tested by pumping, then shot and retested, and finally given a second shot. No pumping test was made after the second shooting. The results of the test are shown in the following table.

Pump Test of Buol Well #2

Date	Drawndown in ft.	Quantity in C. F. S	Remarks
3/1/27	00	0.033	natural flow
	66	0.289	after pumping 24 hr.
	00	0.08	flow at end of pump test
	66	0.486	yield under pump after shooting with 100# of 40 % dynamite
	00	0.10	flow at end of above test
	00	0.145	flow after shooting with 70# 80% dynamite.

Pumping alone in this case causes the natural flow to increase about 100%, while shooting and pumping combined gave an increase in the flow of over 300%. The first charge of dynamite doubled the yield of the well under pumping, and it may be assumed that a further increase would have resulted from the shooting had the test been carried out.

Buol Well# 3 A single run of 24 hours was made on this well. The yield under the pump and the flow after the test are shown .

Pahrump Valley near the
Mc Donald Well, looking
toward Mt. Charleston.

Freak Wells—in Pahrump Valley,
same depth, same size casing,
eight feet apart.
Raycraft Wells #2 and #3.

Pump Test of Baul Well # 3.

Date	Drawdoun in ft.	Quantity in C. F. S.	Remarks
3/10/27	00	0.03	flow before test
	66	0.32	yield under pump
	00	0.10	flow after test.

While the yield of this well at the drawdown limit of the pump was too small for economical pumping the increase in the natural flow after the test was sufficient to warrant the expense of such a test.

MdDonald Well 3/18/27

This well is also located on the valley floor but is about 3 miles nearer the foot of the mountain slppes than the Stennett well described below. The water level in the w ell stood 18 feet below the ground surface at the time of the test. A single run of 8 hours with the Kimball pump was made, the discharge during this time at a drawdown of 66 feet averaging about 0.16 cfs. The yield was not considered sufficient to justify further testing.

There appears to be considerable water under the central portion of the valley, but the artesian pressure is not sufficient to bring it to the surface and since it is found in thin layers of fine sand that does not yield the water readily the opportunity for successful pumping wells does not appear favorable.

These three wells are located on the northern edge of the artesian belt and appear to be affected to a greater extent seasonal variations in the water supply than other wells in the basin. The owner reports a decrease in flow since other wells in the vicinity have been drilled. It appears

from the results of the above tests that either pumping occasionally or shooting with heavy charges of a high percentage dynamite might pay in increased artesian flows. Which would be the more economical method would depend upon the facilities available, dynamite probably being cheaper at the present time.

Stennentt Well 8/25/27

This well is situated about 6 miles east of the Boul series on a clay flat near the center of the Valley. Although the ~~well~~ hole is over 600 feet it was never a flowing well, the water standing 16 feet from the surface of the ground at the time of the test. The same is true of several other wells in this immediate vicinity. Since the well is cased with 6 inch casing the Kimball pump could not be used. A 2 inch horizontal centrifugal, installed in a 10 feet pit, was made use of in this test. The discharge after a six hour run at a drawdown of about 23 feet below the bottom of the pit was 24 gallons per minute.

Pahrump Well # 5

This well was drilled in 1912 and is on the southern edge of the Pahrump Ranch, a mile south east of the big Pahrump spring that was the original water supply of the Ranch. This well had been pumped with a centrifugal pump some years previous to the present test. with the deep well pump The well flowed 0.64 cfs at the start of the test with quite a heavy pressure head. ~~This test was made with the 6 inch Kimball deep well turbine with results as shown in the following table~~

Pahrump Well #5
flow - 0.64 cfs.

Pump Test of above
Well. Yield at
47 feet, 2.23 cfs.

IRRIGATION

Water Application

The length of time necessary for the water to be on the land to permit the desired depth of penetration should determine the size of head and the width and length of the checks. The factors which affect penetration are slope, texture, and subsoil conditions.

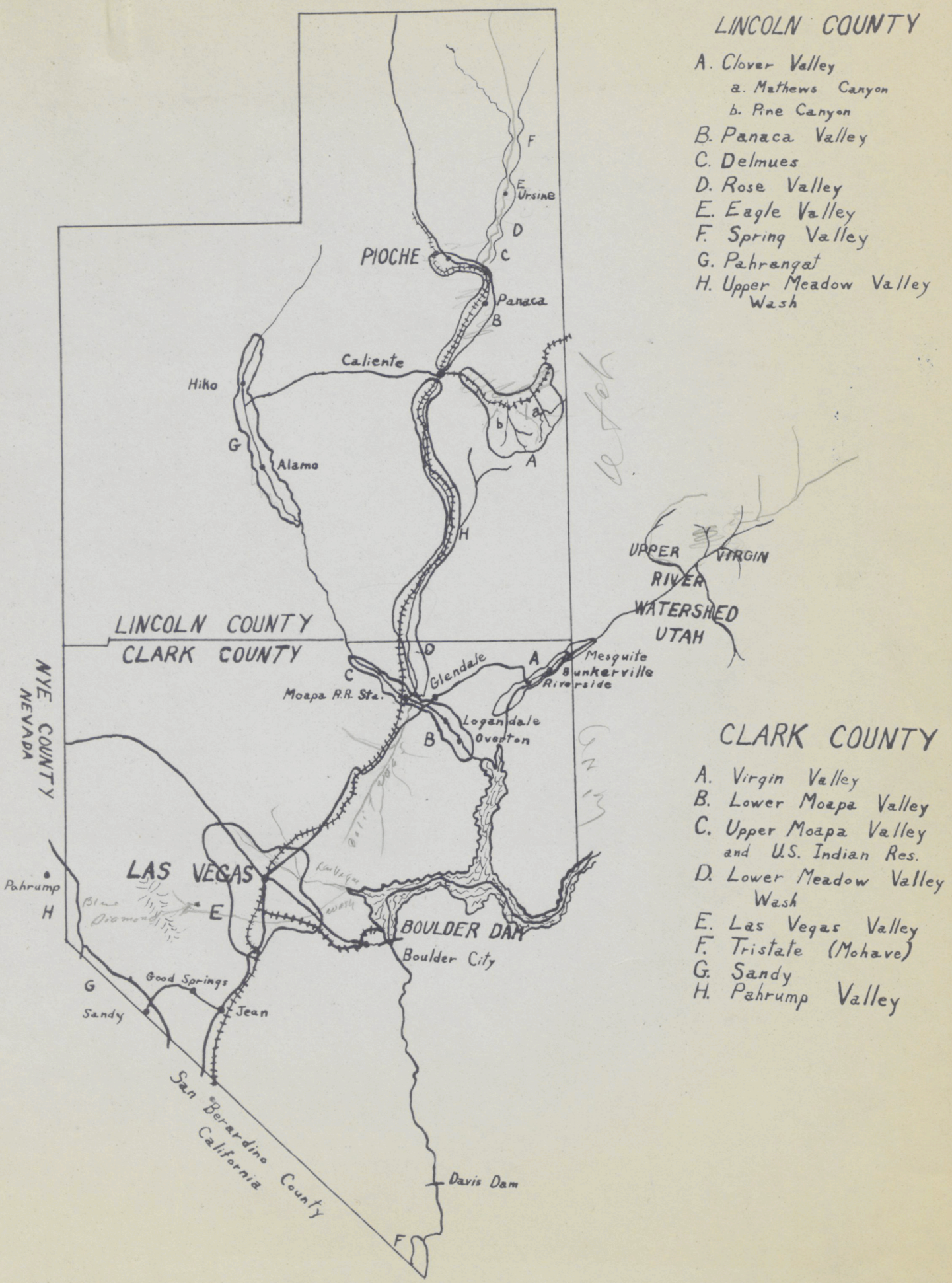
The table below presents the recommended width and length of borders for light, medium, and heavy soils for heads of water from one to five second-feet. The time required to apply specified depth of water is also given.

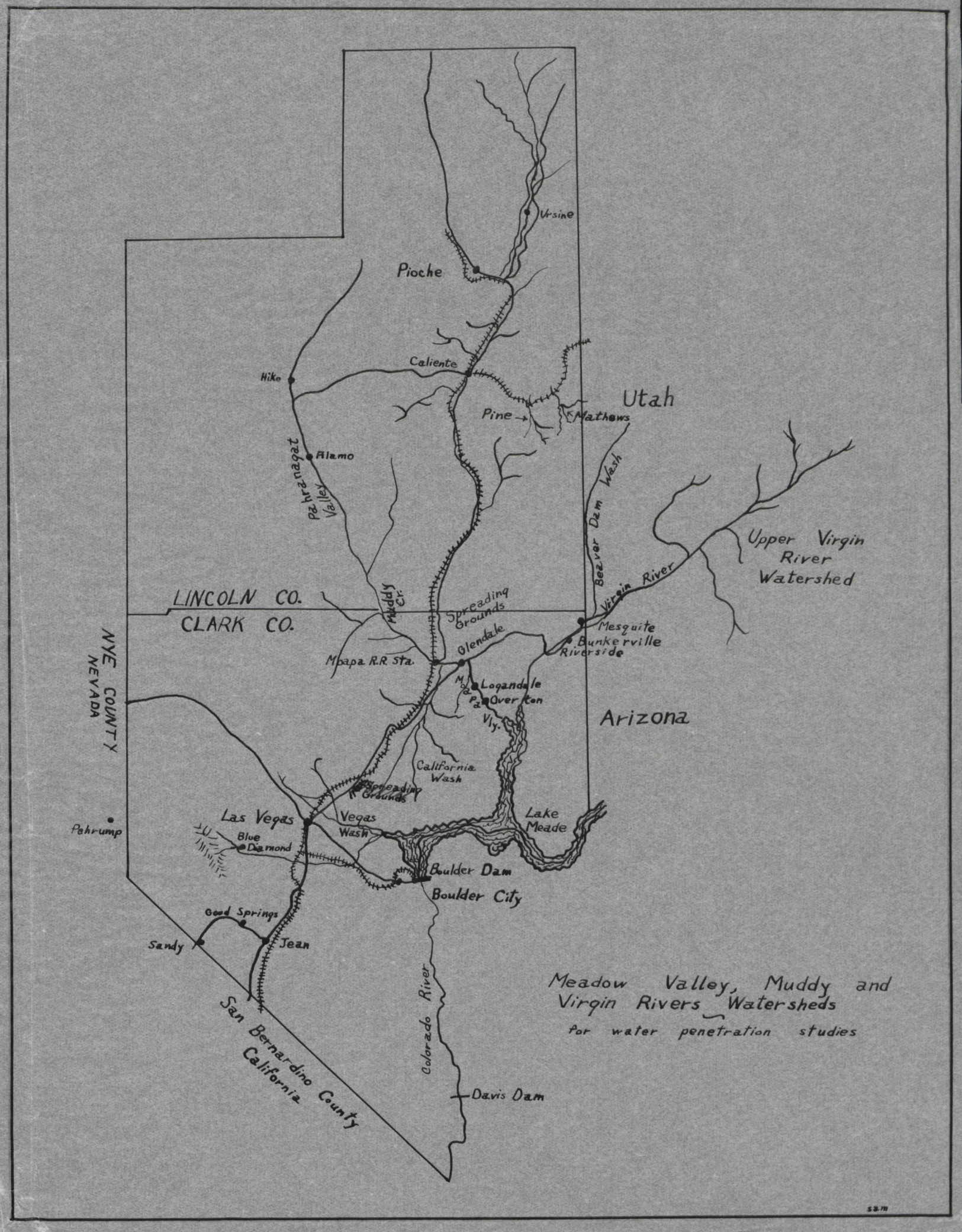
Head of Water for ea. Border	(1) Light Soils OLA OLB				(2) Medium Soils OMA OMB				(2) Heavy Soils OHA OHB			
	Width	Length	Area	Time	Width	Length	Area	Time	Width	Length	Area	Time
(3) c.f.s.	Ft.	Ft.	Acres	Min.	Ft.	Ft.	Acres	Min.	Ft.	Ft.	Acres	Min.
1	15	220	.076	18	20	330	.152	54	30	660	.455	163
2	20	330	.152	18	30	440	.300	54				
3	30	440	.30	24	30	550	.376	45				
4	30	440	.30	18								
5	30	440	.30	15								

(1) Approximate time for 4" application

(2) Approximate time for 6" application

(3) c.f.s. (second foot) equals 40 miners inches


LINCOLN COUNTY
A. Clover Valley
a. Mathews Canyon
b. Pine Canyon
B. Panaca Valley
C. Delmues
D. Rose Valley
E. Eagle Valley
F. Spring Valley
G. Pahranagat
H. Upper Meadow Valley Wash
PIOCHE
Ursine
Panaca
Caliente
Hiko
Alamo
UPPER VIRGIN RIVER WATERSHED UTAH
LINCOLN COUNTY
CLARK COUNTY
NYE COUNTY NEVADA
Glendale
Mesquite
Bunkerville
Riverside
Moapa R.R. Sta.
Logandale
Overton
CLARK COUNTY
A. Virgin Valley
B. Lower Moapa Valley
C. Upper Moapa Valley and U.S. Indian Res.
D. Lower Meadow Valley Wash
E. Las Vegas Valley
F. Tristate (Mohave)
G. Sandy
H. Pahrump Valley
LAS VEGAS
Pahrump
Blue Diamond
BOULDER DAM
Boulder City
Good Springs
Jean
Sandy
San Berardino County California
Davis Dam


Ursine
Pioche
Caliente
Hiko
Utah
Pine
Mathews
Alamo
Pahranagat Valley
Muddy R.
Beaver Dam Wash
Upper Virgin River Watershed
Virgin River
LINCOLN CO.
CLARK CO.
Spreading Grounds
Mesquite
Bunkerville
Riverside
Glendale
Moapa R.R. Sta.
Logandale
Overton
Vly.
Arizona
NYE COUNTY NEVADA
California Wash
Spreading Grounds
Las Vegas
Vegas Wash
Lake Meade
Pahrump
Blue Diamond
Boulder Dam
Boulder City
Good Springs
Sandy
Jean
Colorado River
San Bernardino County California
Davis Dam
Meadow Valley, Muddy and Virgin Rivers Watersheds
for water penetration studies
sam

Pump Test of Pahrump Well # 5

Date	Drawdown	Weir	R.P.M.	Readings	CFS
4/18/27	47	2' Cipp	2256	0.48	2.23
	40	" "	2016	0.44	1.95
	34	" "	1820	0.38	1.57
	30	" "	1738	0.32	1.32
	25	" "	1612	0.28	0.99
	20	" "	1423	0.27	0.89
	12	" "	1100	0.25	0.84
	6	" "	990	0.225	0.72

There was no increase in the flow of the well after the pumping test though some large sized gravel was pumped out. It will be noted that the capacity of the pump was reached at 47 ft. The wells in this vicinity seem to be in the heart of the artesian belt and have the larger flows and the highest pressures.

Pahrump Well # 6

This well was drilled some distance up on the Spring Mountain Range about 2 miles south east of No. 5. The water stood at 17 ft. below the surface of the ground. At one time the owner of the Pahrump Ranch started to tunnel into this well at a point 100 ft. below the top of the casing but this work was never finished due to running into water about 60 ft. from the mouth of the tunnel.

Pump Test of Pahrump Well # 6.

Date	Drawdown	R. P. M.	Weir	Reading	C. F. S
4/28/27	66 ft.	1925	2 Cipp	0.42.5	1.85
	60	1726	" "	0.39	1.63
	54	1628	" "	0.345	1.34
	49	1320	" "	0.32	1.21
	42	1126	" "	0.28	0.99
	36	1005	" "	0.23	0.74
	28	932	" "	0.215	0.66
	23	834	L 2	0.19	0.26

Ullom Well

This well is about 2 miles west of Las Vegas in a district that shows a large summer variation. The wells in this belt are usually about 600 ft. deep and have an average flow of about 0.50 cfs in the winter which drops to 0.20 cfs during the summer.

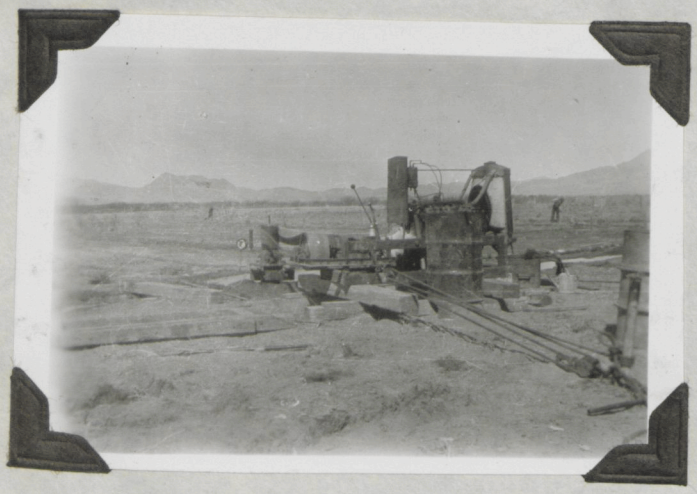
Pump Test of Ullom Well

Date	Drawdown	R. P' M.	Weir	Reading	C. F. S
6/9/27	55	1850	2 Cipp	0.30	1.10
	50	1790	2 Cipp	0.28	0.94
	44	1640	" "	0.25	0.84
	40	1590	" "	0.23	0.69
	33	1540	1 "	0.25	0.42
	30	1460	1 "	0.23	0.35

This well yielded fairly liberally under the pump. However, there was no improvement in the flow after pumping, even though considerable quantities of sand were removed. The discharge of 0.20 cfs before pumping dropped to 0.17 cfs after the test.

Whitney Well

This well was one which had been sunk during the month of June to a depth of 300 ft. The water rising to about 20 ft. of the top of the casing but not flowing. The well was first tested with a ten inch Kimball turbine but did not give enough water to supply the pump. Following this test the well was deepened to about 500 ft. and again tested. Because the ten inch Kimball gave only 40' drawdown our # 7 with 66' of pump and suction pipe was borrowed for the test. At the end of a 5 hour run the pump was discharging about 0.75 second feet at 66 ft. drawdown. This is not sufficient water to justify pumping at this depth hence the test was stopped at this time.



Pumping Outfit at
Boul Well #2.

Shooting Boul Well #2,
result of a 70# charge
of 80% gelatine.

Methods of Increasing Flows in Wells

Several methods of increasing the flows of old wells with some satisfactory results were tried this year. In the Pahrump Valley two wells were increased in flow by the use of powder explosives.

The first on was Boul well #2 where two charges of powder were used. The first charge of 100 lbs. of 40% dynamite increased the flow from 0.080 to 0.10 cfs. The second shot of 70 lbs. of 80% dynamite was exploded in the well and increased the flow from 0.10 to 0.145 cfs, giving a total increase of 0.065 second feet at a cost of about $60.00. This increase should be permanent and was much cheaper than the buying of a windmill which owner of the well had contemplated.

The second well on which this method was tried was another of this series, Boul #1, 30 lbs. of 80% dynamite were exploded in the bottom of the well with a resultant increase in flow from 0.050 to 0.20cfs. Both these wells could be still further increased by the use of larger amounts of explosive. The usual practice in shooting wells is to use 100# of powder for every100 ft. of depth of hole in which it is used. However in this case the powder was not available so a lesser amount was used.

One well in the Las Vegas Valley was increased by the removing of a string of old 8 in. casing which was loose in the hole and putting down a line of four which was cemented off about 150 ft. below the surface.

This forced the water which had evidently come up around the old, loose casing and escaping into the surface

This forced the water which had evidently come up around the old loose casing and escaping into the surface strata to come up inside of the new casing and to the surface. The flow increase in this well was from 0.106 cfs before the old casing was removed to 0.42 cfs after the new casing was installed or a gain of 0.318 cfs by this method.

The Development of Springs

Williams Spring

Two springs were worked on in the Pahrump Valley in March of this year. The first of which, the Williams Spring in the Mountains east of the Pahrump Ranch, was cleaned out by the use of powder, 50 lbs. being exploded in the pool which the spring formed. The increase here was considerable, the flow at the start of the work of 0.065 cfs increasing at the end of the test after the powder had been used to 0.382 cfs or a gain of 0.317 C. F. S in flow by the use of the powder. This spring is situated on a small talus slope about 150 ft. from a rock ledge and more water could probably be gotten if a trench was dug back to this ledge and the aperture through which the water comes enlarged.

Raycraft Spring

The second spring to be developed was one at the Raycraft Ranch. The original flow of this spring was 0.13 cfs. The muck was cleaned out of this spring with a slack line dipper bucket made from a fifty gallon gasoline barrel, and an old hay sling carrier running on a 150 ft lenghh of 5/8 in. drilling cable which hung between two ten ft. 8 x 8 in. uprights. The outfit was run by a Fordson Tractor. About forty five cubic


S3
W1
S4
Reservior
W2
S2
S1
W4
W3
P-2 3/
Taylor Springs

yards of gravel and muck were cleaned out of the spring in the day and a half that it was operated. The outlet ditch was deepened 2½ ft. and the flow of water after the job was finished and the extra head of the pool had run off was 0.34 feet on a 1 ft. rectangular weir or 0.634 cfs. This work was done in March and the flow of the spring had not diminished when it was measured in the last part of May, at which time the work was completed in the Pahrump Valley.

Taylor Ranch Springs

While our department has taken a comparatively small part in the active development of water on this ranch yet we have conducted a number of tests and many measurements and ~~have~~ has had an active interest in the place for a number of years. Further than this the work here is of particular interest because of the fact that the development was apparently carried to completion; that is ~~apparently~~ all the available water ~~is now obtained.~~ has been developed.

This ranch is one of the oldest in the Las Vegas Valley, being first occupied about 1850. The particular inducement here was an area of good soil watered by a series of springs. These springs had a flow estimated at about 12 to 15 miners inches (40 inches per sec. ft.). Little or no effort to increase the flow of the springs was made for many years. Recently a reservoir capable of holding the overnight flow was built, which permitted a larger irrigating head for a shorter time. A small well was drilled some distance back of the springs on higher land and piped to the house for domestic use. This is well # 1 in the accompanying sketch.

In 1924 the ranch was sold to Mr. Taylor who immediately began the development which ended this summer. The first effort was a well about ½ mile west of the springs and at an elevation nearly 50 ft. higher. The flow obtained was small. It was ditched into the reservoir and becomes part of all subsequent measurements of the total flow of the springs. During the summer of 1925 two wells were drilled. These are about 150 feet from the edge of the reservoir and about 26 ft. higher than the level of the water in the reservoir. Neither of the wells gave a strong flow but responded fairly generously when pumped. Syphons leading into the reservoir were installed the following year on these wells and gave a fair increase over the natural flow.

Previous to the drilling of the wells discussed above some development work had been carried out on two of the springs. Of these # 3 on the sketch was a small seep into which a trench was cut and a drain installed. A flow of about 2 inches was developed here, which was not led into the reservoir. No 1 spring had been tested by our department a number of years ago by pumping but had since been neglected and the flow obtained at that time largely lost.

The present work on this spring consisted of running a trench into the spring at a depth of about 10 ft. sinking a wooden casing in the spring to keep the sand and muck out, and laying a pipe line in the trench from the spring to the reservoir. The flow increased following this development from about 2 inches to about 12 inches.

Drillin with hand rig
in old spring at
Taylor Ranch.

Pumping Taylor Well #4,
yield 1.90 cfs, at
23 feet drawdown.

P-25

At the beginning of the year 1927 the following wells and springs were discharging into the reservoir; wells numbers 2 and 3 and springs number 1 and 2 and several small seepages. The total flow as shown in the following table was 0.83 cfs. In addition well # 3, supplying the house, and spring # 3 were flowing. Well #4 was then drilled on the upper bank of the reservoir as near the water as possible to set the drilling rig.

This well came in with a flow of about 0.69 cfs. However, the total flow from the reservoir measured only about 1.04 cubic feet per second, thus showing a gain of 0.21 cfs. only, and indicating clearly that this well was obtaining its supply from water that would otherwise largely have appeared in the previously developed wells and springs. The old spring in the center of the reservoir, # 2, suffered the most severe loss, the spring # 3 and well # 3 showed a reduction in flow. Since these are both north of the new well and on somewhat higher land the conclusion drawn was that the water flow was coming from the southwest and that the new well with its lower outlet was intercepting the flow.

The spring in the reservoir which was once the chief source of supply had now practically ceased to flow. In an effort to restore this flow the driller put down a line of three inch casing directly into the center of the old spring. Many reports of the depths of these mound springs, varying from severalhundred feet to bottomless pits, have been received, but an this case the quicksand s were penetrated at 30 feet. At this point a stiff clay was encountered and from there down

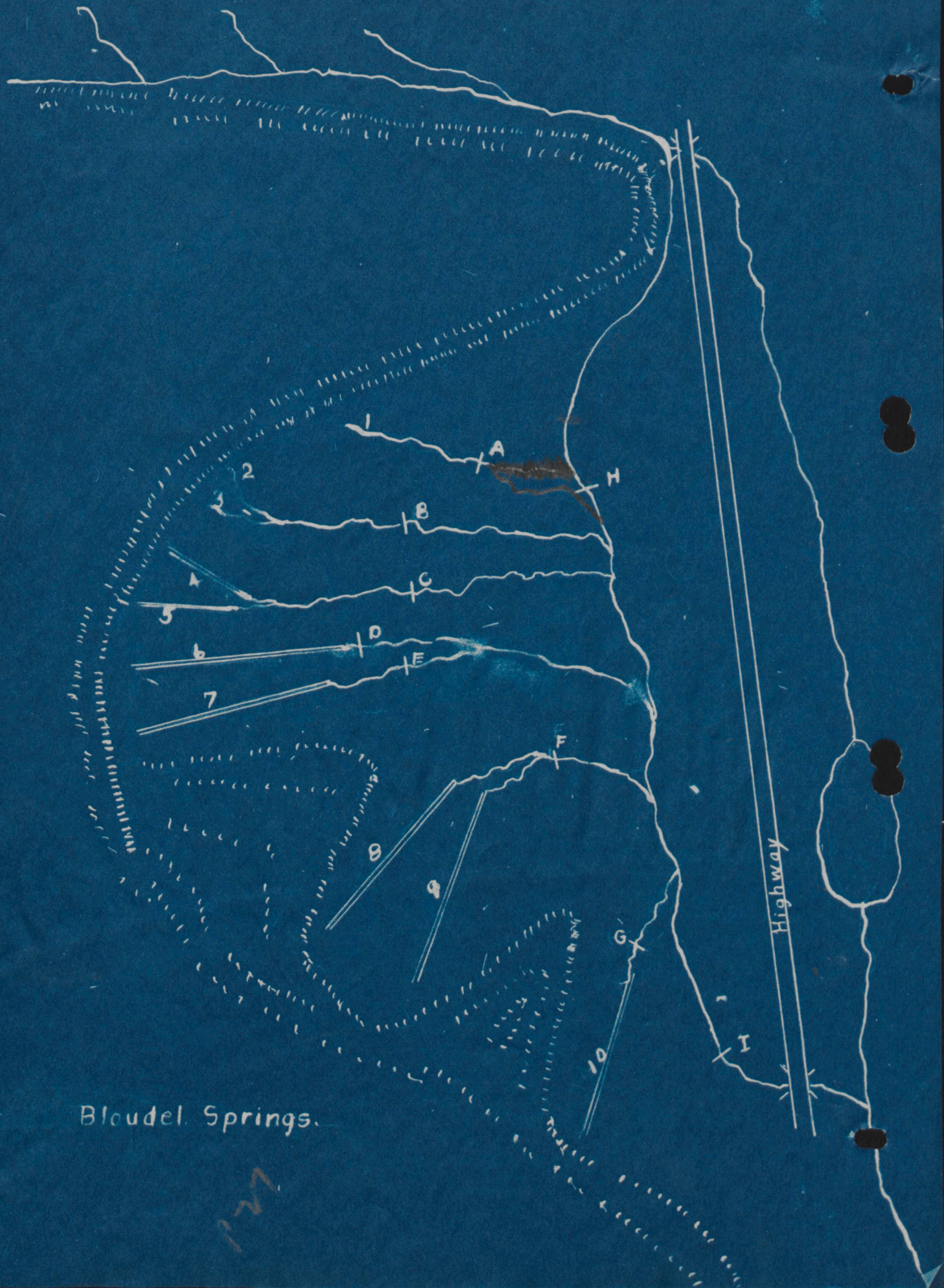
it was necessary to use a jet pump and hand spudding rig. The casing was sunk to about 40 ft. before the spring flow returned, and then to the extent of only a few inches.

It was believed at this time that the limit of the water supply had been reached at this place, but to further test this assumption a pump test was installed and operated at full drawdown capacity of about 33 feet for 72 hours. The discharge of the pump at the beginning of the test was 1.90 second feet dropping to 1.38 second feet at the end of the test.

The interesting part of the experiment, however, was the behavior of the other wells and springs during the test. Spring # 2 in the reservoir stopped flowing immediately. After about 13 hours pumping spring # 3 was dry and the syphon on well # 2 broke. At the end of 24 hours pumping the water dropped sufficiently in well #3 to break the syphon, and spring # 1 decreased about half, but did not cease flowing at any time during the test. Before the end of the test well # 1 leading to the house ceased flowing. Sometime elapsed after the pump was stopped before the total flow returned to the normal. The story of the entire development and pump test is told in the following table.

Table showing Discharge of the Taylor Springs at Various Stages of Development.

Date	Quantity in C. F. S.	Remarks
1925	0.40	Original flow of springs (estimated)
1925	0.59	After developing spring # 1
1925	0.71	After drilling wells # 2 and # 3
1925	1.04	After installing syhons on wells 2 & 3
1927	0.83	Before beginning work on well # 4
1927	1.04	After drilling well # 4



Bloudel Springs.

Table of Results of Final Pump Test at Taylor Ranch.

Date	Quantity in C. F. S.	Remarks
5/26/27	1.90	Beginning of test, spring # 2 ceased flowing.
5/27/27	1.70	After 24 hours pumping spring # 3 and wells # 1 and # 2 ceased flowing.
5/28/27	1.50	After 48 hours pumping, well # 3 ceased flowing, spring # 1 reduced by half.
5/29/27	1.38	End of test 72 hours.

Before ending the test practically all the water from the whole series of springs and wells was coming thru the pump on # 4 well. The flow in spring # 1 has returned somewhat, but spring # 3 remains dry. The house well, # 1, has regaind a part of its flow, but neither of the syphons has yielded enough to keep them primed and they both have been abandoned.

Bloodel

~~The Muddy~~

~~River~~

Springs

The Muddy River occupies the lower extremity of a rather lafge drainage basin, through which at an earlier date the ancient White River flowed. The principal topographic features of the valley, such as the flood plains or present valley floors, the deep, narrow, steep walled canyons and high excarpments that border the valleys are all the work of this old river. Except for a very brief period following exceptionally heavy storms the bed of the old White River is dry for the greater part of its length, the only surface flow occuring where springs appear. The most important of these spring sustems are those in the White River Valley, the Pahranagat Valley and the Moapa Valley.

The springs that feed the Muddy River issue from limestone and conglomerate at the foot of a low limestone hill. Other seepages occur in the bed of the river . The flows from

the larger springs readily find their way to the main stream but many of the smaller springs and seepages fail to reach the stream, the water being lost through evaporation and transpiration. There is also an area of land adjacent to the springs that is somewhat swampy and from which some water appears to be lost by evaporation.

The total flow of the Muddy River, with a drainage area of 1080 square miles, as measured over a weir a short distance below the springs is about 50 second feet, varying rather widely with the seasons and somewhat from year to year. The rainfall over much of the drainage basin is very light and the runoff practically nil. There are, however, several mountains ranges upon which the precipitation is sufficient to permit some runoff and it is from these mountains that the bulk of the supply for the Muddy River Springs comes.

It is not believed that a large supply of water is escaping underground and that this water can be brought to the surface to increase the flow of these springs but rather that the very small flows may be consolidated and the seepages cut off and in this manner all the water conserved.

The present development was carried out on a group of springs known as the Bloedel Springs. These springs issue from the foot of a slope at an elevation of 10 to 15 feet above the valley floor. The work consisted of starting at the lowest feasible point and trenching toward the source of water.

The first work in the development was the drilling of 3 series of holes along the slope of the hill about 50 feet back of the springs. These holes were about 10 feet deep and 5 feet apart, and the holes in each series staggered so as to cover as much of the territory as possible. The rise of the water surface in the holes directly back of the springs showed the fastest rise. The channels were then dug toward the holes showing the greatest rise.

The accompanying sketch illustrates the position of the various springs on which work was done together with the weirs used in measuring the flow increases. The springs are numbered while the corresponding weirs are lettered. Measurements were made of the flow from each individual spring and of the total discharge of the group before any development was started. The flows of the various springs and the group are shown in the following table.

Discharge of Bloedel Springs before Development.

Date	Spring No.	Weir No	Weir Type	Reading	C. F. S.
5/28/27	1	A	V. N.	0.40	0.256
	2 & 3	B	2' rect.	0.42	1.75
	4 & 5	C	V. N.	0.23	0.065
	6	D	V. N.	0.23	0.065
	7	E	V. N.	0.25	0.080
	8 & 9	F	V. N.	0.30	0.135
	10	G	V. N.	0.32	0.058
	~~1 &~~ 11	H	~~3' rect.~~ 1½' rect	~~0.28~~	~~0.~~ 0.720
	12	I	3' rect.	0.49	3.32

The measurement marked # 12 over weir 1 was made in the ditch leading from the springs. This total also includes a small stream from another series of springs, but this does not effect the final results since this stream is included in all the measurements of the total flow.

Springs numbers 1, 2 and 3 were not worked on because of the fact that they had strong flows and showed evidence of having been developed at some previous time.

Springs 4, 5, 6 and 7 were trenched back first, but when the trench of number 6 reached the level of numbers 4 and 5 these ceased to flow, indicating that these were merely seepages of the surface water which filled the ground above the outlets of number 6 and 7. The flows in number 6 and 7 increased materially and finally when a ledge of rock was reached at a depth of 10 feet from the surface and 50 feet back from the starting point a crevice was found which was opened and the work on these two stopped. The increases obtained on these two springs are shown in the following table.

Development of Bloedel Springs # 6 and # 7.

Date	Spring No.	C. F. S.	Remarks
5/28/27	6	0.065	Original flow
	7	0.080	" "
6/14/27	6	0.32	Ledge of rock reached.
	7	0.21	" " " "
6/16/27	6	0.72	Ledge of rock broken.
	7	0.428	" " " "
6/30/27	6	0.72	Last measurement.
	7	0.428	" "

Springs 8 and 9 were next orked on. These were started at the bottom of an old talus slope and carried back by trenching to a vertical ledge of limestone from under which the water seemed to be coming. A section was broken out of this wall and a considerable increase in flow obtained. The table given below shows the increases obtained by development of these springs.

Development of Bloedel Springs # 8 and # 9.

Date	Spring No	C. F. S.	Remarks
5/28/27	8 & 9	0.125	First Reading
6/20/27	8 & 9	0.502	Lime reef appeared
6/21/27	8 & 9	0.745	Lime reef broken
6/23/27	8 & 9	1.40	Trench completed
6/30/27	8 & 9	1.44	Last reading.

Spring number 10 was next developed by trenching. This trench was dry except for a small flow in the bottom of the ditch until a ledge of rock was reached. The trench was deepened along the face of this ledge until a crevice was found at a depth of 9 feet from the ground surface and 65 feet from the starting point. This crevice was enlarged by drilling and breaking out a small piece of rock. The table below gives the story of the development ofthis spring.

Development of Bloedel Spring # 10.

Date	C. F. S.	Remarks
5/28/27	0.058	First reading
6/26/27	0.325	Lime ledge reached
6/27/27	0.924	Lime ledge broken
6/30/27	0.965	Last reading.

The last readings of the year were made on June 30th with the results as shown in the following table.

Discharge of Bloedel Springs following Development.

Date	Spring No.	Weir No.	Weir Type	Reading	C. F. S
6/30/27	1	A	V. N	0.39	0.240
	2 & 3	B	3' rect	0.42	1.75
	4 & 5	C	V. N.	0.00	0.000
	6	D	1' rect	0.37	0.717
	7	E	1' rect	0.25	0.404
	8 & 9	F	1' rect	0.45	1.44
	10	G	1' rect	0.44	0.924
	~~11~~	H	1½' rect	0.38	~~0.965~~ 0.720
	12	I	3' rect	0.76	6.33

Discharge of Bloedel Springs 1 year following Development Table

The total increase obtained from cleaning out these three springs was from 3.32 cfs the total flow of all the springs at the start of the work to 6.33 cfs at the completion of the development. This gain of 3.01 cfs will undoubtedly fall a little as the water bearing area works off the excess head. In order to determine the permanency of the present development it will be necessary to continue the measurements of the flows for at least another year. During this time the trenches will have to be kept free from all debris and in approximately the condition they were when development stopped. The possibility of future extensive development of the whole group of the Muddy River Springs depends at least in some measure upon the records of the present development, hence it is particularily important that accurate records should be obtained over as long a period as possible.

The Muddy Valley Irrigation Company and others interested in the flow of the Muddy River may agree to continue this work after a year complete record of the present development and the flow of the Muddy River has been obtained. To this end a new weir crest and water stage recorder were installed on the 12 foot Home Ranch weir at the head of the Muddy River. This weir is below all the inflows to the Muddy River except the Meadow Valley Wash. The water master for the Muddy River will attend the instrument and change the record sheets weekly when he makes his rounds of the upper river territory.

An increase of 3 second feet in the flow of this river during the hot part of the season might mean one of two things to this valley: the addition of about 200 acres of ,land

to the productive area of the valley with a sufficient amount of water to grow crops, or the shortening of the period between water turns considerably during the season of greatest use. There is undoubtedly more water to be developed in this area by the cleaning out of the other springs that feed the Muddy River, or by the drilling of a number of wells in this area to intercept the flows of these springs. The present development by our department may lead to more extensive efforts at a later date.

2. Flood Control and Drainage.

a. Drainage Investigations in the Moapa Valley.

The drainage work this year has been that of collecting data on the depth of the water table over the Muddy Valley. This information may then be used by the Muddy Valley Irrigation Company in determining the means to take in ridding these lands of alkali and in lowering the water table of the valley to a point where it will not be injurious to crop productions.

The work included the sinking of a number of additional wells in the valley in areas that showed a high water table, and the reading of all the wells by a resident of the valley about three times a month. There are now 64 wells in this area, spaced about one half mile apart and usually located near roads or fence lines for easy accessibility for observations. The average depth of the water table over this area seems to be about 4 feet below the surface during the summer and shows a rise fo nearly 2 feet during the winter months when the lands are not in use. The area covered by the wells should be extended to include lands farther up the

valley which do not at this time show many indications of waterlogging but which may be affected in the near future.

b. The Mapping and Classifying of lands in the Moapa Valley.

The field work of mapping the Moapa Valley lands to assist in the determination of the cost which these lands might stand under the proposed irrigation district plan was well under way by the first of July. The lands to be included in this survey are the lands in the valley already under ditch and those not under ditch that might be brought under cultivation if additional water could be obtained. The information desired includes the total area of land now under ditch, the acreag e of tilled and tillable land, the acreage of land actually cultivated and the acreage of waste land in the area. Similar data on the land proposed to irrigate under the enlarged canal system is likewise desired. The area of land needing drainage should be determined and mapped.

The above information when used in connection with the economic survey recently completed by Mr. Headley of the Experiment Station, the soil survey of the Moapa Valley by the Bureau of Soils and additional studies of the producing power of the various soils which are to be made soon, and the detailed surveys of the proposed flood cntrol and storage reservoirs should be very valuable. Such studies are necessary in arriving at the feasibility of any project.

3. Soil Fertility and Crop Adaptation.

a. Fertilizer experiments with soil in pots. 1926-27.

The corn crop on the pots this past season was almost a total failure. The crop started nicely but the extreme heat

Experiments with soils in Pots - 1927.

Cannon Series
sour clover

Houseman Series
sour clover

Kaolin Series
sour clover

Jefferson Series
sour clover

Las Vegas Series
sour clover

Jefferson Series
sweet clover

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in July and August caused the crop to wither and it made practically no growth. It was very difficult to cultivate the small surface area in the pots and the soil takes on a very hard, unfavorable texture from the frequent irrigations.

A winter crop of clover was seeded in September, sour clover being used again on all the pots except numbers 1 to 6 and 13 to 18 of the Jefferson series which were seeded to Hubam clover. The growth on all the pots was satisfactory, though as in previous years phosphorus was the only element giving a marked stimulation. The story of the growth of the clover is told very clearly in the following series of pictures.

b. Cooperative field fertilizer trials. 1926-27.

The cooperative field trials with fertilizers were started in 1925 in an effort to secure some data on the effect of the various mineral fertilizer elements upon several different soils and crops in the Las Vegas and Moapa Valleys. Under this cooperation the Experiment Station furnishes the fertilizer materials and supervises their application. The farmer is expected to apply the fertilizers according to the plan furnished and keep a complete record of the growth and production of the various plats.

1	2	3	4	5	6	7	8	9	10	11
Check	Nitrogen	Phosphorus	Potash	Nitrogen Phosphorus Potash	Check	Nitrogen	Phosphorus	Potash	Nitrogen Phosphorus	Check
No treatment	200# $(NH_4)_2SO_4$	300# superphosphate	200# K_2SO_4	Total of 700# as NO. 2, 3 and 4	No treatment	(Duplicate of Nos 2, 3 4 and 5)				NO treatment

The cooperative trials for this year are ~~three~~ 5 in number, two 4 in the Moapa Valley and one in the Kas Vegas Valley. The work has been successful and the relations between the Experiment Station and the cooperators cordial.

The general plan for the application of the fertilizers as worked out with the help of Dean Stewart of the College of Agriculture is given below.

PLAN FOR FERTILIZER APPLICATIONS IN FIELD TRIALS.

E. G. McGriff Orchard.

In the Las Vegas Valley two plats of peaches and one of grapes were originally selected on the farm of Mr. E. G. McGriff. Out of the original selection one plat onlu of peaches is now retained. This is a plat of early Albertas, mwhich was kept because of the marked effect of the fertilizers upon the trees and the convenient location of the plat.

The applications of fertilizers have been made according to the general plan, except that the fertilized rows were not duplicated and the amount of material given each tree has been varied somewhat from year to year. In regard to the duplication of treatments it was felt that in effect each tree could be considered an individual unit and that there would be no practical benefit obtained from further duplication.

1924-25

The first applications of minerals was made in April, 1925 at the following rates, ammonium sulfate 2 pounds, acid phosphate 2½ pounds, potassium sulfate 2 pounds and the complete gertilizer 6½ pounds per tree. Late frosts almost completely destroyed the fruit crop so there was mean of estimating the effect of the ferillizers upon the fruitt crop. However the effect of the ammonium sulfate, both alone and in combination, upon the vegetative growth was fast and startling. Within the first two weeks after the application of the fertilizers the growth on the trees receiving this treatment was greater than the average growth of the orchard for the season, and this rate of growth continued until the new wood on these trees averaged at least four times greater than on the unfertilized trees.

There was little visible effect from the use of the other two elements. The rate of application of the ammonium sulfate appeared to be a little too large, especially when used in combination with the phosphorus and potash, and caused tooogreat a stimulation of the trees. However there was no winter killing and the trees appeared in good condition the following spring.

1925-26

The second application of fertilizers to the peach trees was made in February, 1925. It consisted of about one pound to each tree of ammonium sulfate and potassium sulfate, and one and three fourths pounds of acid phosphate, and three and three fourths pounds of the complete fertilizer. Believing the results of the test the past season sufficiently conclusive Mr. McGriff gave all the trees in the orchard, except the trees in the experimental plat, a light application of ammpnium sulfate. For this reason the trees in the experiment did not stand out from the rest of the orchard as they did the past season.

This year an excellent crop of peaches gave an opportunity to observe the effect of the various fertilizer elements upon the fruit crop. In this connection it was noted that the phosphorus and potash appeared to hasten ripening while the ammonium sulfate seemed to retard. It was the opinion of the owner that this latter would be a most favorable factor toward producing a good quality of fruit as it tended to allow a more natural ripening. The more abundant foliage on these trees protected the fruit from the hot sun in June and reduced the percentage of sun scald.

1926-27 The application of fertilizers were again made in February, and at about the same rates as in the proceeding season. Due to an error ammonium sulfate was applied to the check row and since all the remaining trees in the orchard received a small application of this material there is really no check left in the orchard. The two rows receiving phosphorus and potassium given such negative results the two previous seasons that Mr. McGriff figured a small amount of ammonium sulfate might do no harm and gave them all a light application of this material.

The experience of this season confirms the conclusions of the two preceeding years. The set of fruit on the trees receiving the ammonium sulfate was excellent and the June drop lighter than usual. The effect of the denser foliage in protecting the fruit from the direct raysof the sun and in this manner allowing a more natural ripening was again demonstrated. The direct effect of the nitrogen may also be in this direction. According to Mr. McGriff this is a desirable tendency, the fruit from the fertilized trees having a better flavor and keeping qualities. The picking season is also extended somewhat which is a favorable effect when the fruit is consumed locally.

The exact increase in the yield of fruit from the use of ammonium sulfate was not determined but from observations on the growth of the trees, the number of fruit spurs and the apparent amount of fruit per tree it is estimated that the use of this material has easily doubled the yield of peaches on this orchard. Mr. McGriff has estimated that the use of ammonium sulfate to the value of about $250 has given him an increased

Asparagus, Wells Bros.
spring - 1927.

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return in fruit to the value of about $2500. In addition to the direct return the use of this material has given new vigor to the trees and promises to greatly prolong the useful life of the orchard.

1927-28 It is our intention during the coming season to have Mr. McGriff discontinue the application of ammonium sulfate to the check, phosphorus and potash rows and restore the experiment to its original basis. Some idea of the lasting effect of the application of ammonium sulfate may be gained from a study of the behavior of the trees in the check row.

Wells Brothers Asparagus

The field of asparagus on the farm of the Wells Brothers now being used for the fertilizer work is one of the oldest in the Moapa Valley. It has been fertilized several times in the past with barnyard manure andis now in a fair state of fertility, tho at the time the experiments were started the yield had fallen somewhat from the peak production. It was selected because the soil is uniform, the stand well established and the field small enough to handle as a unit. The soil on which this experiment is being conducted is a heavy, dark loam, underlain with a dark peaty material. It is a very good asparagus soil. The fertilizers are applied according to the general plan as given above.

1924-25

The initial application of fertilizers was made in April, 1925. The first cutting of the asparagus having been started by this time it was of course too late for any benefit to the current crop. Moreover, the harvested part of the asparagus crop depends largely upon stored up food in the roots,

which in turn depends upon the previous season's growth. Hence an application of fertilizers at this season was expected to benefit the growth after the cutting season and this benefit should be reflected in increased yields the following year. Mr. Wells kept a record of the yield of each plat for comparison with the production of succeeding seasons.

Observations were made on the growth of the plants at intervals during the summer, and while it is extremely difficult to rate the differences in growth of such a crop as asparagus from visual observations the growth appeared stronger and continued longer on the plats which received an application of potash or phosphorus. That is, plats 3, 4, 5, 8, 9 and 10 appeared a little better than the checks.

1925-26

The second application of the fertilizers to the asparagus was made in February, 1926, at the same rate as previously. The record of the production of each plat is shown in the table given below.

Mr. Edwin Wells reports that for some unknown cause a portion of this field including plats 6 to 10 appeared to suffer from drouth to a greater extent than the balance of the field tho every effort was made to give each plat the same amount of water.

1926-27

The fertilizers were applied in February this season. It had been hoped that a small fertilizer drill would be available for spreading the materials but could not be obtained so the fertilizers were again spread by hand.

The yield this season was slightly less than in the immediately preceding years. This decline may possibly have been due to the late cool spring, tho more likely to the lighter growth

of the preceding summer. The blame for this light growth may be laid in part to the extremely hot, dry summer with its a accompanying scarcity of irrigationwater and in part to the attacks of rust. Asparagus rust had never been known in the Moapa Valley before this season, and in normal years the danger from this disease is probably negligable. The summer of 1925 witnessed an unusually severe attack of rust on grains, grasses and native vegetation, and the asparagus did not entirely escape.

The yield in pounds of each plat of the experimental field for the years 1925, 1926 and 1927 is shown in the table below.

Table Yields - Wells Bros. Asparagus.

	pounds per plat			increase over 1925	
Plat	1925	1926	1927	1926	1927
1. ck	270.9	349.1	200.0	78.2	-70.9
2. N	194.4	269.4	225.6	75.0	31.2
3. P	250.6	373.3	265.1	138.7	14.5
4. K	273.0	394.0	225.1	121.0	-47.9
5. NPK	283.5	412.7	215.4	139.2	-68.1
6.cck	278.9	349.0	230.3	70.1	-48.6
7. N	231.7	291.6	200.9	59.9	-30.8
8. P	199.5	256.6	189.1	57.1	-10.4
9. K	220.5	261.0	166.7	40.5	-53.8
10. NPK	232.9	264.7	165.7	31.8	-67.2
11. ck	217.9	293.8	187.0	75.9	-50.9
	Averages				
1-6-11 ck	255.9	330.6	205.8	74.5	-50.1
2-7 N	213.05	285.5	213.25	72.45	0.2
3-8 P	225.05	317.9	227.1	92.9	2.05
4-9 K	246.75	327.5	195.9	80.75	-50.85
5-10NPK	258.2	338.7	190.55	80.5	-67.65

note -- minus sign denotes decrease.

It is not possible to draw any conolusions from the data gathered to date on this experiment. All the plats with the exceptions of numbers two and three, show decrease in yields when compared to the 1925 production. The average decrease of the three

check plats is 50.1 pounds per plat as compared with the average increase of the two plats receiving nitrogen alone of 0.2 pounds and of phosphorus alone of 3.05 pounds. Potash alone gave about the same production as the check plats while the yields on the plats receiving the complete fetilizer were lower than the checks.

Jess Whipple, Asparagus, 1926-27.

Since the asparagus experiment on the Wells ranch is being conducted on a dark, heavy, peaty loam with a very light coating of river flood silt it was felt that another field on a lighter type of soil might be valuable. Moreover considerable attention should be paid to this crop in the Moapa Valley because it is undoubtedly destined to attain a rank of first importance in the agriculture of the valley. The location chosen for the new trial is in a field of two year old asparagus. The soil is a river flood silt underlain at a depth of about three feet with the dark peaty material common to this section of the valley. The stand of asparagus is excellent and the growth of the tops very strong. A very light cutting was taken from the field this season but the experiment was laid out too late to obtain figures on the yield from the various plats.

Each plat in this field is made up of three rows, each six feet apart and 242 feet long, and contains exactly one tenth of an acre. The fertilizers were applied by hand in the furrows on each side of the center row. In this way the center rows receive double the application given the outside rows, but there seems no way to avoid this and yet retain the fertilizers on the desired area when applyong the materials by hand.

The plan followed in making the applications was the same as the general plan given above except that two extra plats were added. These two receive manure at the rate of 20 tons per acre and are to be known as the manmee checks. The plan is identical with that used on the experimental farm at Las Vegas. The first cuttings for record will be made next spring.

Bert Mills,
Cantaloupes.

This experiment, started in April, 1925, was intended to test the effect of commercial fertilizers upon hte cantaloupe crop. The soil is a river drift with a base of peaty clay. The fertility appears about average for the upper valley. Cantaloupes with an occasional green manure crop have been grown on the land for several seasons.

The experiment followed the regular order determined upon for all the cooperatuve field trials, namely one tenth acre plats of nitrogen, phosphorus, potassium and complete fertilizer with duplicate plats for additional checking. In this field the plats are made up of two rows the full length of the field, except that the check plats are of one row only.

1924-25

The first application of fertilizers was made in April, 1925. The stand of melons at this time was excellent and the growth throughout the season very good. Close observation failed to show any apparent differences in the growth of the vines on the various plats that could be attributed to the effect of the fertilizers. The melons from each plat were picked separately and counted. The summary of the count failed to show any significant differences between the variously treated plats or between the treated and the check plats.

1925-26 The experiment was repeated in 1926. This was a very bad season for melons, the extremely hot weather in July bringing on a sort of blight that had many of the appearances of the melon wilt such as is common in the Imperial Valley. The experimental field was so badly effected that the yield was reduced to practically nothing. No Count was made of the number of melons picked, but careful observations throughout the season failed to show any marked differences between the plats.

The field was seeded to Hubam clover in October, but the stand was too poor to permit of any check being made of the residual effect of the fertilizer upon the clover crop. The crop of Hubam was plowed under in February.

1926-27 The season of 1927 started very inauspiciously. The stand of melons at the time therfertilizers were applied in March was ragged and uneven. The spring was cold and late but the warm weather came on gradually, there was a notable abscence of insects and the melons made a strong normal growth. The yield was excellent. Observations were made both by Mr. Mills and myself throughout the growing and picking seasons. No differences in the color or growth of vines or in yield of melons could be detected. Count was not kept of the number of melons harvested.

3. c. Experimental Farm. The need for a small tract of land upon which certain experiments could be carried out under the complete control of the Station has been felt ever since work was started in the Las Vegas Valley. But it was not until after the passage of the Purnell Act that sufficient funds were available for that purpose. The Union Pacific Railroad was approached through

Experimental Farm
view of head ditch,
roadway and buildings.

Experimental Farm
buildings.

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Mr. J. H. Burtner, Agricultural Agent, and Mr. Walter Bracken, Manager of the Las Vegas Water Company, regarding the loan of a tract of land and water. The reqyest was regarded favorably and a ten acre tract onthe old Las Vegas Ranch selected.

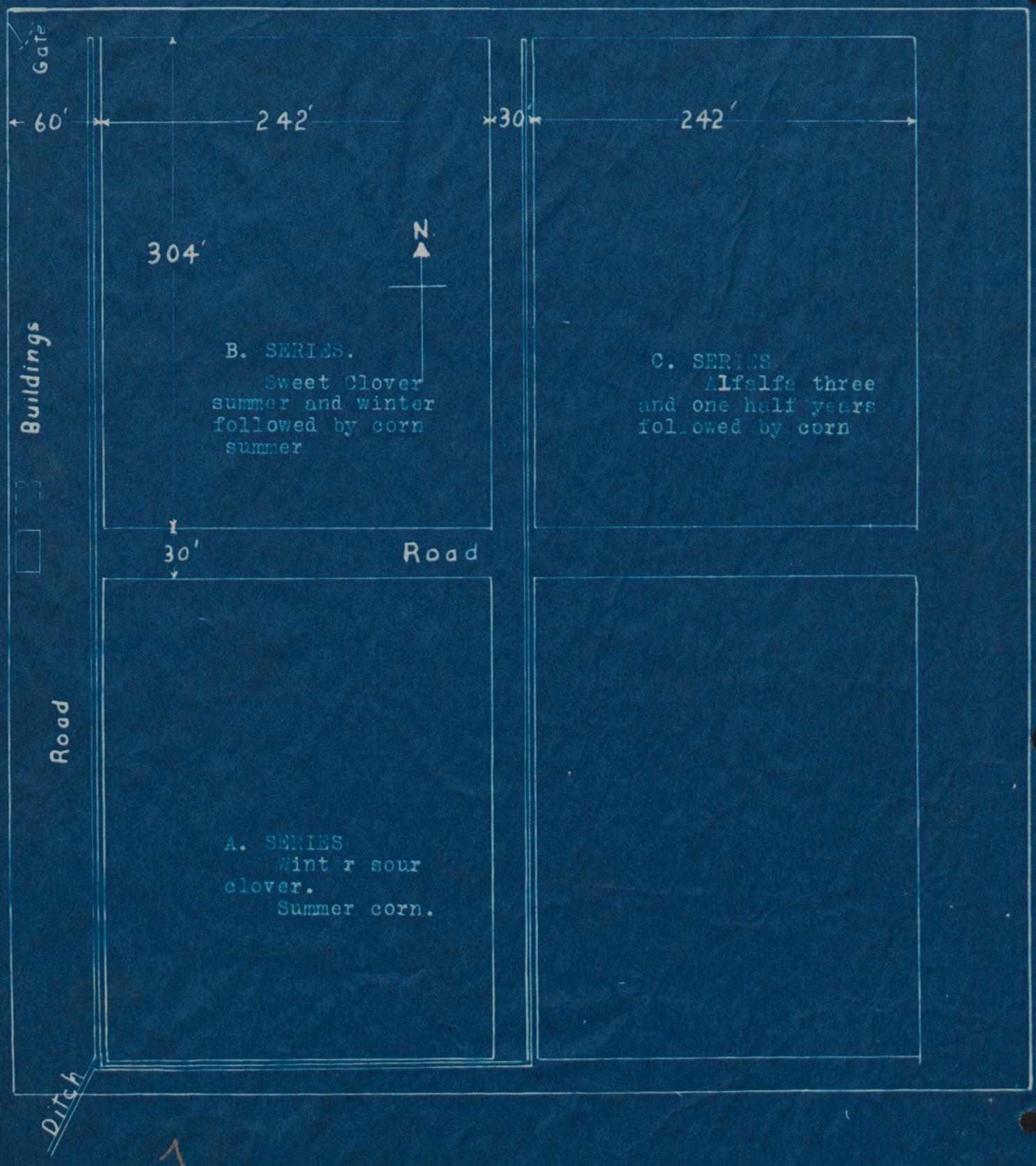
This tract of virgin land was partly in mesquite, but mostly covered with a heavy growth of shad scale and other desert plants. The soil is a clay loam of fair depth, 5 to 6 feet to hardpan, and in general is fairly typical of the better class of virgin lands in the Las Vegas Valley. It is better than the poorest soils, inhich are hardly worthy of consideration for agricultural purposes, but scarcely as good as the better ones. It was felt that this soil was poor enough to show the effect of the fertilizers and other treatments and yet with sufficient depth and body to hold moisture and be capable of improvement.

This soil is classified by the Bureau of Soils as a Spring clay loam. A typical analysis of this type of soilsis given in the following table:

Mechanical analyses of Spring clay loam
(Copy from p.232 of soils survey of Las Vegas area)

Number	Description	Fine Gravel	Course Gravel	Medium Sand	Fine Sand	Very fine Sand	Silt	Clay
		per cent	per cent	per cent	per cent	per cent	per cent	per cent
530270	Surface crust 0 to 1/5 inch	0.1	0.1	0.0	7.2	46.4	18.8	27.2
530271	Mulch 1/5 to 2½ inches	.2	.1	.0	9.2	40.2	20.3	30.0
530272	Subsurface 2½ to 8 inch	.3	.2	.1	7.4	42.5	20.9	28.5
530273	Subsoil, 8 to 26 inch	.0	.1	.2	8.8	37.2	23.4	30.4
530274	Subsoil 26 to 54inch	.0	.1	.3	4.8	32.6	27.8	34.6
530275	Subsoil 54 to 72 inch	.2	.7	.6	7.3	35.9	23.6	41.5

Experimental Plot
University of Nevada Experiment Station
Las Vegas Nev



8-1

The alkali content of this soil is fairly high, one analysis of assample taken about 600 feet from the Experimental tractshowing 0.53% total alkali. The distribution, however, is very uneven, giving rise to a spotty condition in the soil.

1926-27 The work of putting the farm into condition was continued this season. An office and garage building of concrete was begun in July and finished in August. Later a machine shed was added. This building serves as headquarters for the work in this territory. It also permits the keeping of such supplies as gasoline, oils and fertilizers in a safe, dry place. Tools and equipment can be housed under lock. The office is comparatively cool and comfortable on the hottest days of summer.

Such farming equipment as our funds permitted were obtained and the work of laying out and putting into production the various plats carried on. The Hubam clover that was seeded in the preceeding February was plowed under in July. The growth was quite heavy in places, making it necessary to disk it down before plowing. After plowing the field was disked, floated and furrowed for irrigating. The land was then given a good soaking and allowed to remain undisturbed about two months. When the field was then disked up preparatory to the final leveling the material turned under was found to be quite thoroughly decomposed.

The final layout of the fields and plats was determined upon and the leveling of the fields cokpleted to fit thefinished

Experimental Farm
plowing under Hubam
Clover, July 1927.

Experimental Farm
sour clover on
series A, 1927.

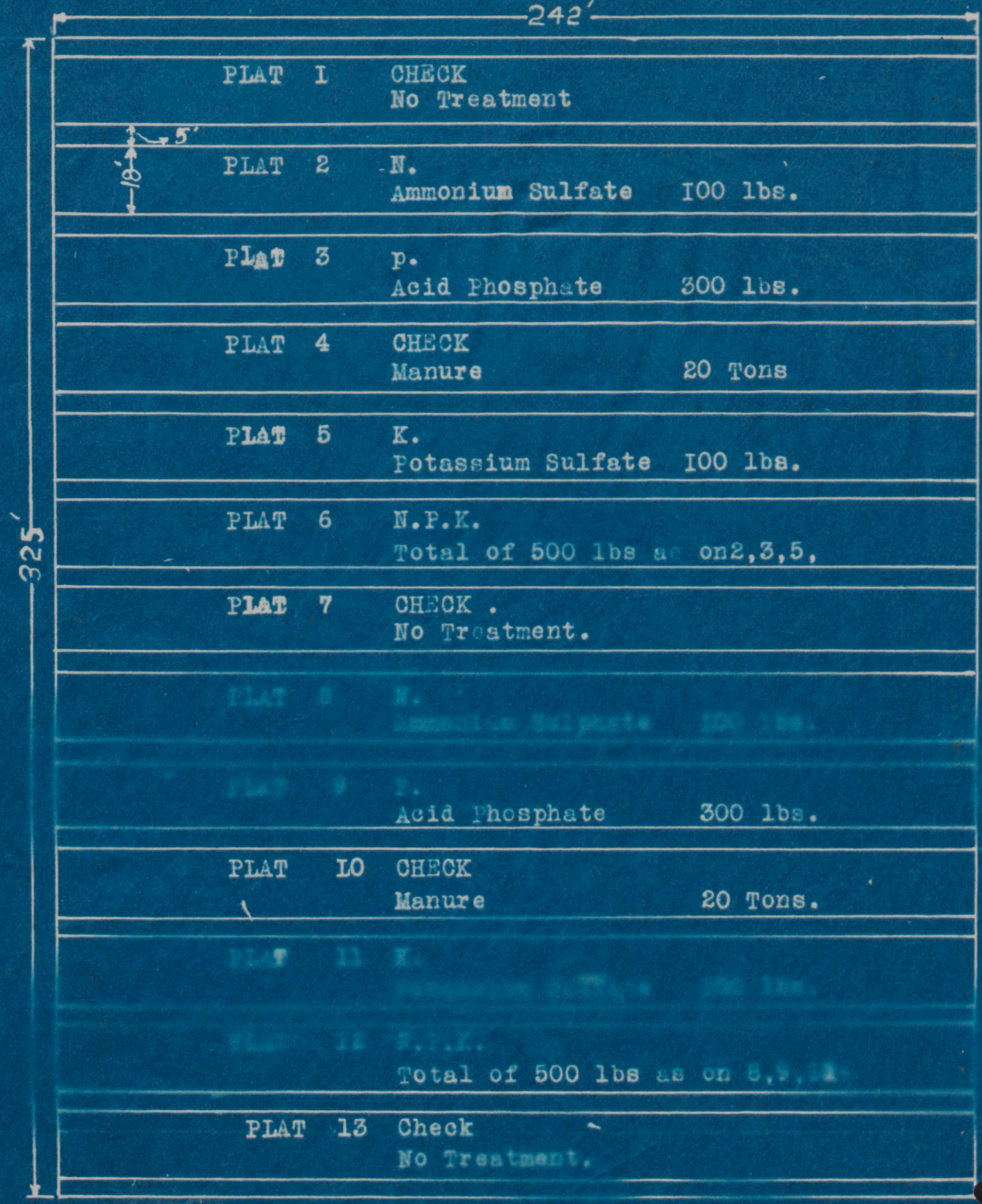
scheme. The appended drawings show the layout of the fields and plats, together with the treatments.

Series A. One series of plats was ready to receive the first crop and was planted to Scur Clover in November. The weather was colder than usual for the time of year which retarded germination and several spots in the field showed a tendency to cement up and refuse to take the irrigation water. Both of these factors tended to cause an irregular stand of clover. However, by the latter part of April when the crop was turned under there was a fair crop on all the plats.

After plowing under the clover the plats were re-levelled and prepared for the corn crop to follow. By the time it was necessary to plow for the corn the green manure crop was found to be welll decomposed. The field was prepared and the fertilizers applied about June 18th.

Following the application of the fertilizers the ground was laid off for planting to the corn. In laying off the furrows were laid open rather deeply with one disk of the tractor plow, and then a stream of water turned interthe furrow. This was allowed to run until the bottoms of the furrows were thoroughly wet, but was turned off while there was considerably dry soil on the surface of the ground. Then as soon as the bottoms of the furrows had dried until fairly firm the corn was dropped by hand into the wet soil. Covering was accomplished by harrowing lengthwise of the furrows until the seed was covered lightly and then cross-wise until the furrows were well filled. A second harrowing several days later served to check the weed growth and loosen the surface soil. Practically a perfect stand of corn was obtained. It is

LAYOUT OF PLATS ON EXPERIMENTAL FARM.



expected by frequent cultivations to carry the crop nearly to tasseling time without further irrigation.

Series B ~~and C~~

The fields for ~~these two~~ this area series were prepared, the fertilizer applied and the seed sown in March. A good stand of Sweet Clover (Melolotis alba) was obtained ~~on the B series, but a bad soil condition combined with a spell of hot weather resulted in a rather spotty stand of alfalfa on the C series.~~

The growth of the sweet clover has been satisfactory though some weeds and grassesamade their appearance. Frequent clipping to prevent the grasses going to seed, and the stronger growth of the clover should remedy this condition. ~~The behavior of the alfalfa plats has not been quite so satisfactory, and it is possible that the spotted condition of the stand may necessitate plowing up and reseeding.~~ See under B + C.

Irrigation and Soil Moisture

Experience indicates that the depth of water used on new raw desert soils rarely if ever gives a true measure of the duty of water for the same lands after they have been under cultivation for several years and have become thoroughly subdued. However, the amount of water used, especially when coupled with careful studies of the moisture retained in the soil after irrigations, should be of value as an indicator of the improvement of the soil condition under the several crop rotation systems and various fertilizer treatments.

With these considerations in mind plans were made to measure the quantity of water applied to each plat, and to check the amount retained in the soil through moisture samples taken before and after each irrigation. Measurement is accomplished

Experimental Farm
head weir

Experiental Farm
division weir.

by running the water ove a weir at the head of the plats. This weir is fitted with a water stage register which gives a permanent and cnntinuous record of the flos. The division of the main stream to the various plats is accomplished by small division weirs set in the bank of the head ditches. By setting these small weirs with their crests on an exact level a very fair division of the stream between the various plats can be made. It is not contemplated that each plat should receive exactly the same amount of water as all the others because slight soil and crop differences make necessary some slight variations in the amount of water given. Rather the plan is to irrigate each plat in a normal manner, giving the amount of water that good practice dictates.

Moisture samples are taken immediately before and as soon after irrigations as the moisture in the soil has become thoroughly dissiminated. With normal applications this is usually about 48 hours after irrigating. The moisture equivalents, which were determined for each foot of each plat by the Irrigation Division of the Bureau of Public Roads, are helpful in determining when the moisture in the soil has reached a stage of equilibrum. With known volume weights it is simple matter to convert the moisture percentages into inches of water and thus to determine the exact amounts retained in the soil from each irrigation.

The moisture sampling is one with an especially designed tool, somewhat on the order of a miners spoon. This tool takes a small sample, leaves only a small hole in the ground and reduces the amount of labor necessaryiin taking the samples. Three borings are made for each sample, the whole amount of soil from the three

METHOD OF TAKING SOIL SAMPLES

FOR MECHANICAL AND CHEMICAL ANALYSES AND ORIGINAL SOIL

Samples for Chemical Analyses

Five borings made to each plot. Depth four feet by one foot sections,

Locat e Holes

Measure three fe t from center pegs to North and West end of p end of plats, to South and East end of plats. Take distances shown in sketch.

For Soil Moisture Determinations

Take three borings to a depth depth of four feet by one foot sections. Measure as above but from opposite corners place holes at forty feet from end lines and at center

holes thrown together, thoroughly mixed, and the sample for the moisture determination taken from this composite. A regular order in taking the samples is followed so that successive borings are made within a very small space. The following diagram illustrates the order in which the samples are taken. An electric oven, heated to about 105 degrees, is used in drying the samples.

Before starting the moisture work moisture equivalent determinations were made for each foot to a depth of 4 feet on each plat. The samples for these determinations were made with a special sample which cut a hole about 2 inches in diameter. Five borings were made to each plat as shown in the appended diagram.

After the small amount of soil needed for the moisture equivalent determinations had been taken out the remainder of the sample was placed in a labelled canvas bag and stored for future chemical studies. The chemical studies should be started as soon as proper facilities are available.

The volume weight determinations have proven difficult to conduct. Owing to the sticky, elastic nature of the soil the ordinary volume weight soil tube is hard to operate and the samples secured show a very wide variation in weight. With the coming of winter more time will be devoted to this feature and it is hoped that a workable method of taking the necessary samples may be developed.