MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph.D.

Director

BULLETIN 72

GROUND WATER INVESTIGATIONS ALONG BOGUE PHALIA BETWEEN SYMONDS AND MALVINA, BOLIVAR COUNTY

By

TRACY WALLACE LUSK, M.S.

UNIVERSITY, MISSISSIPPI

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COMMISSION

STAFF

LETTER OF TRANSMITTAL

Office of the State Geological Survey
University, Mississippi
July 3, 1951

To His Excellency,
Governor Fielding Lewis Wright, Chairman, and
Members of the Geological Commission

Gentlemen:

Herewith is Bulletin 72, Ground Water investigations along Bogue Phalia between Symonds and Malvina, Bolivar County.

It is a report on the investigation of a request most unusual to the State Geological Survey; namely, how much water could safely be pumped from the Bogue by the rice farmers of that area. Not only so, but the Bogue in itself is a most unusual stream (bayou)· It has its source, its entire course, and its end wholly within the level, almost flat, alluvial plain of the Mississippi River. Consequently, only a bit of surface water flows into its channel. Of necessity, therefore, it has to be supplied by ground water. And, as the excellent young geologist, Tracy Wallace Lusk, writes, the water has to come from the upper 25 or 30 feet of the alluvial fill, for that is the total depth to which the Bogue has sunk its channel.

Another feature of the difficult problem is the fact that at low water the flow of the Bogue is scarcely sufficient to be recorded on the flow meters. Despite all these difficulties the author has presented estimates worthy of a geologist of much longer experience.

The State Geologist sees the possibility of even a more abundant supply of water from wells sunk to depths greater than the Bogue channel. Should such development penetrate an old buried meander channel of the Mississippi River filled with sand and gravel, conceivably such a channel extending back underneath the Levee and the River channel might even draw its water from the River itself.

This investigation has opened up a vast new field of exploration.

Very sincerely yours,

William Clifford Morse
Director and State Geologist

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GROUND WATER INVESTIGATIONS ALONG BOGUE PHALIA BETWEEN SYMONDS AND MALVINA, BOLIVAR COUNTY

TRACY WALLACE LUSK, M. S.

INTRODUCTION

The area included in the present investigation is located between Symonds and Malvina in Bolivar County, Mississippi (Sections 10, 11, 14, 15, T. 23 N., R. 7 W.).

On November 10, 1950, Mr. A. Wilson, of the Surface Water Division of the U. S. Geological Survey and of the Mississippi State Geological Survey, and the writer visited the area and measured the discharge of Bogue Phalia at Symonds and Malvina. The measurements were made by means of a velocity meter which proved to be very inaccurate because of the sluggish nature of the stream. However, a very good idea of the quantity of water being fed the stream by the ground water within such a limited area could be clearly seen by these measurements.

Irrigation of rice fields is fast becoming the immediate problem of many delta farmers. For the simple reason the farmer is the body and soul of the State of Mississippi, it becomes the duty of the Mississippi State Geological Survey to do all within its power to aid him in any way possible. With this in mind, it is the purpose of this investigation to determine to what extent water can be pumped from Bogue Phalia for irrigation. The writer fully realizes that an investigation of this kind can only conclude to a rough approximation of the prevailing conditions. It is hoped that this report will serve its purpose and that more accurate work can be done during the period of heavy pumping. At that time the draw-down on the stream and the draw-down on the water table should be observed.

GEOGRAPHY

The rainfall is that of a humid region, averaging about 54.67 inches for 1949. Rosedale being about six miles west and Cleveland being about twelve miles southeast were the two stations from which the average was calculated. The maximum, as normal, was reached during the first four months of the year and a second maximum was reached in October. A minimum of rain fell from May through September. In November it was again exceedingly low being less than half an inch. During a normal year there are 10,675 acre-feet of rainfall in the four square miles of area under investigation.

The temperature is generally warm, July being the warmest month and January being the coldest month. The winters are short leaving the growing season about 220 days between the last killing frost of spring and the first killing frost of fall.

The area on both sides of Bogue Phalia is very definitely level having a maximum relief of five feet. Bogue Phalia has cut a channel approximately twenty-five to thirty feet deep.

Bogue Phalia in this particular locality drains an area of approximately one mile back from both banks. There are relatively few drainage ditches into the stream.

As would be expected of this area of Mississippi, the principal crop is cotton. However, the growing of rice is progressing at a very rapid rate. Corn, oats, and hay crops are also grown to feed the livestock.

STRATIGRAPHY AND HYDROLOGY

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RIVER ALLUVIUM

Since the scope of this work lies entirely within the river alluvium, the author finds it necessary to describe this part of the geology only. In order to obtain a complete picture of the river alluvium, well logs of Bolivar County, found in Mississippi State Geological Survey Bulletin 65[1] were studied.

The alluvium in this area ranges in thickness from 130 to 150 feet and is composed chiefly of loam, clay, sand, and gravel. The loam in many places is sandy and contains small, usable amounts of water. The tenant farm houses located near the banks of Bogue Phalia are each supplied with water by a shallow well driven to depths of 25 to 40 feet. The water is brought to the surface by ordinary pitcher pumps. Water at this depth was confirmed by a series of auger holes. Near the top of the water table the saturated zone is composed of a sandy clay and grades down into a fine grain sand.

The sand is yellow to dark blue, micaceous, and highly glauconitic.

The Bogue Phalia has a general flow from north to south; however, for about one mile of the section under investigation it flows from west to east. The stream has cut a channel deep enough to penetrate the water table. Therefore, water flowing into the channel through seeps and springs is a major factor in the size and continuous life of the stream. The discharge measurements of November 1950, at Malvina and Symonds proved the significance of the ground water. The discharge at Symonds was twice the discharge at Malvina. Observations showed no surface drainage into the stream at the time the measurements were made and proved the additional water comes from ground water.

The writer is of the opinion that the ground water found in the alluvium here is replenished by the Mississippi River. With the ground water having an adequate source, the only question is whether or not the sand is sufficiently permeable to release the water at a fast enough rate to replenish Bogue Phalia as fast as it is pumped.

RECOVERY METHOD

COMPUTATION OF COEFFICIENT OF PERMEABILITY

According to Theis,[2] the recovery formula is used to compute the coefficient of transmissibility (T) and thus the field coefficient of permeability (P_f). The coefficient of transmissibility is expressed in terms of gallons per day per foot of aquifer. The field coefficient of permeability is defined as the number of gallons of water a day that percolates under prevailing conditions through each mile of water-bearing bed for each foot of thickness of the bed and for each foot per mile of hydraulic gradient. By multiplying the field coefficient of permeability by the temperature correction (C_t) it is converted to Meinzer's[3] coefficient of permeability (P_m) which is defined as the rate of flow of water, in gallons a day, through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 per cent at a temperature of 60°F.

$$T = \frac{264\ Q\ \operatorname{Log}_{10} t}{st'}$$

T = Coefficient of Transmissibility
t = Time (min.) that well has been pumped
t′ = Time (min.) from shutdown
Q = Discharge (Gal./min.)
s = Residual draw-down

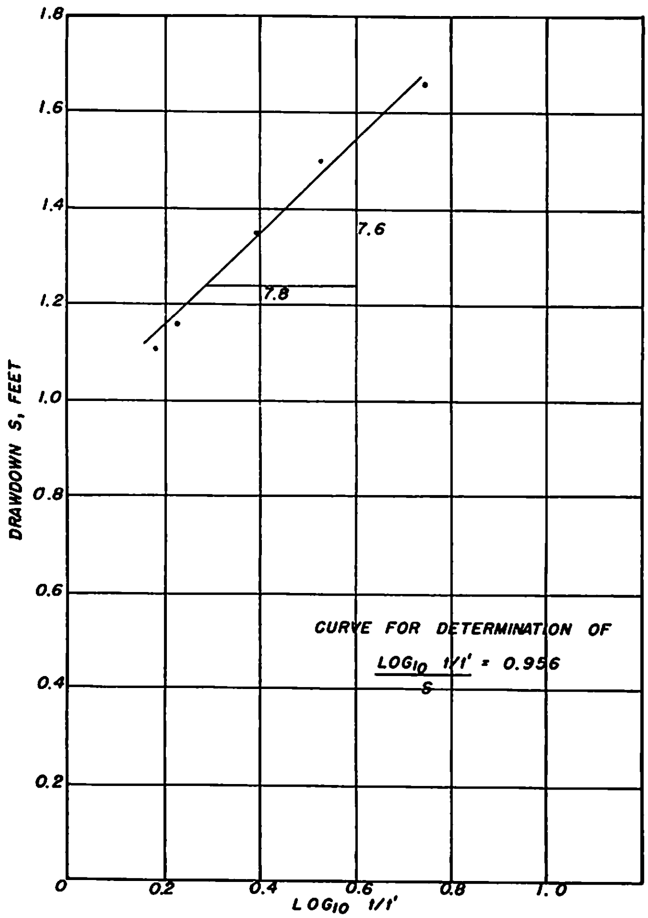

Plate 1.—Curve for determination of $\frac{\text{Log}_{10}t/t'}{s}$

$\text{Log}_{10}t/t'$ was plotted against s to produce a straight line, the slope of which is taken as the value of $\frac{\text{Log}_{10}t/t'}{s}$ and substituted in the equation.

$$\frac{\text{Log}_{10}t/t'}{s} = 0.956 \text{ (Table 1 and Plate 1)}$$

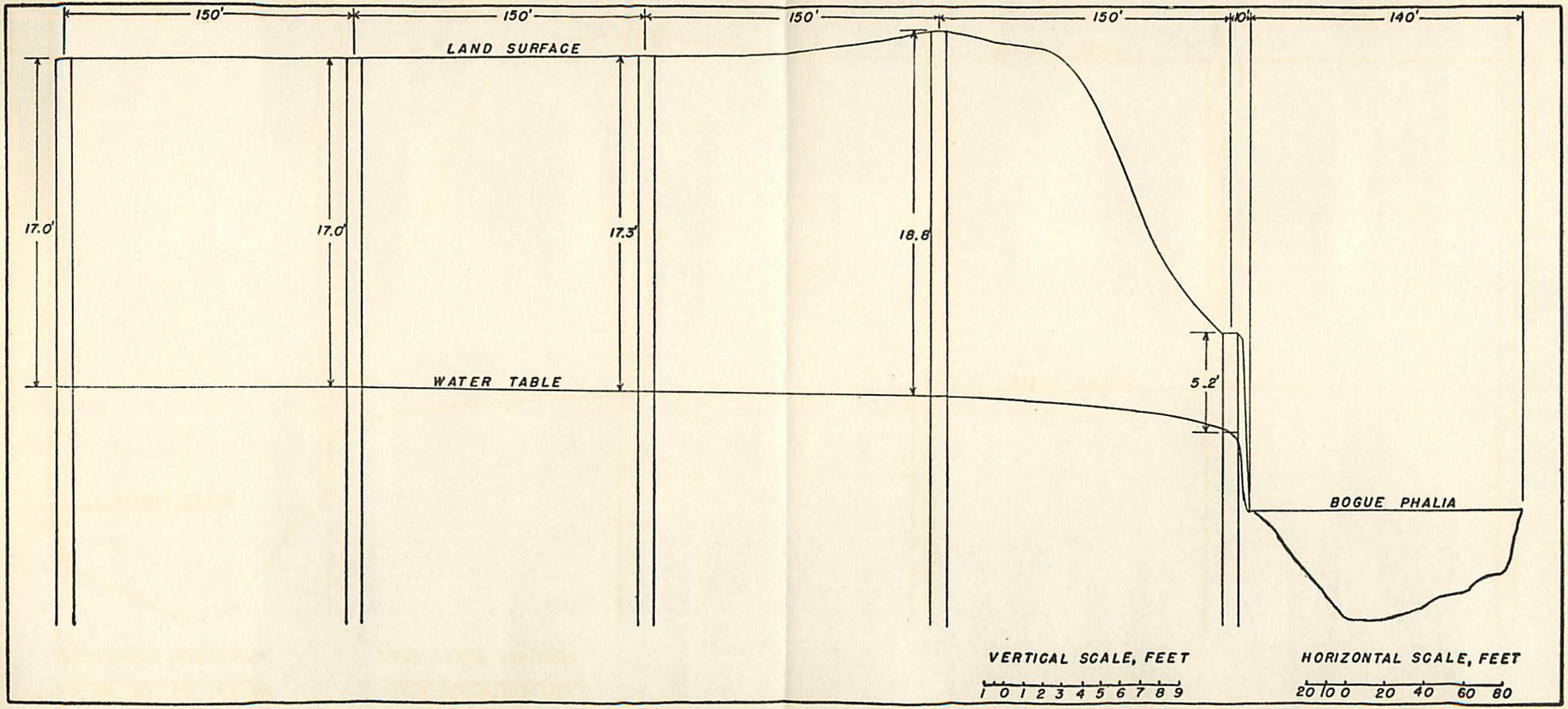

Plate 2.—Cross-section of Bogue Phalia and test holes at right angle to Bogue Phalia.

$$T = 264 \times 3 \times 0.956$$
$$= 757.1 \text{ gal./day/ft. of aquifer}$$

$$P_f = \frac{757.1}{25} = 30.3$$

or

$$P_m = P_f C_t{}^*$$
$$P_m = 30.3 \times 0.89$$
$$= 27 \text{ gal./day/ft.}^2$$

COMPUTATION OF GROUND WATER SUPPLY

Between Malvina and Symonds Bogue Phalia flows over about a 2.5 mile course. The average width of the stream bed is about 100 feet. The hydraulic gradient of the ground water flowing into the stream was determined graphically (Plate 2).

$Q = AiP_m$
Q = Discharge (Gal./day)
A = Area (sq. ft.)
i = Hydraulic gradient
P_m = Coefficient of Permeability (Gal./day/ft.^{2})
$Q = 1{,}320{,}000 \times 0.4 \times 27$
$Q = 14{,}250{,}000$ gal./day

For every foot of drawdown in the stream there would be an increase of 3,550,000 gal./day flowing into it from ground water. In other words, if the stream were pumped down one foot the hydraulic gradient (i) would change to 0.5; thus the discharge (Q) would be 17,800,000 gal./day.

FLOW NET METHOD**

COMPUTATION OF COEFFICIENT OF PERMEABILITY

The flow net method is here used to compute the coefficient of permeability (k), and the discharge (Q) into the stream.

The flow lines were obtained by means of a model, simulating field conditions. By introducing dye into the sand of the model, the flow lines could be traced. The path of these flow lines was used as a basis for drawing the flow net of the well (Plate 3).

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*Wenzel, L. K., and Fishel, V. C., Method for determining permeability of water-bearing materials: U. S. Geol. Survey Water Supply Paper 887, p. 7, 1942.

**Kellogg, F. H., Personal communication.

The flow net method computes the coefficient of permeability (k) in feet per minute.

$$Q = kh \frac{n_a \pi r_e}{n_l}$$

Solving for k

$$k = \frac{Q}{h \pi r_e} \; \frac{n_l}{n_a}$$

k = Coefficient of permeability
Q = Discharge (cu.ft./min.)
h = Residual drawdown
n_a = Number of area squares
n_l = Number of squares along drawdown curve

r_e = Radius of drawdown

$$k = \frac{0.401}{2.26 \times \pi \times 6.5} \times \frac{2}{14}$$

$k = 0.00124$ ft./min.

COMPUTATION OF GROUND WATER SUPPLY

The same procedure and formula are used to compute the discharge (Q) into the stream from ground water as were used to compute the coefficient of permeability (k) except here k is known and Q is the unknown quantity.

$$Q = kh \frac{n_a}{n_l} L$$

Q = Discharge (cu. ft./min.)
k = Coefficient of permeability (ft./min.)
h = Head drop (ft.) (Plate 2)
L = Length of stream bed (ft.)
n_a = Number of area squares (Plate 4,
n_l = Number of squares along drawdown curve (Plate 4)

$$Q = 0.00124 \times 5 \times \frac{17}{3} \times 13.200$$

$Q = 464$ cu.ft./min.
Converting cu.ft./min. to gal./day,
$Q = 464 \times 7.48 \times 1440$
$Q = 5,000,000$ gal./day

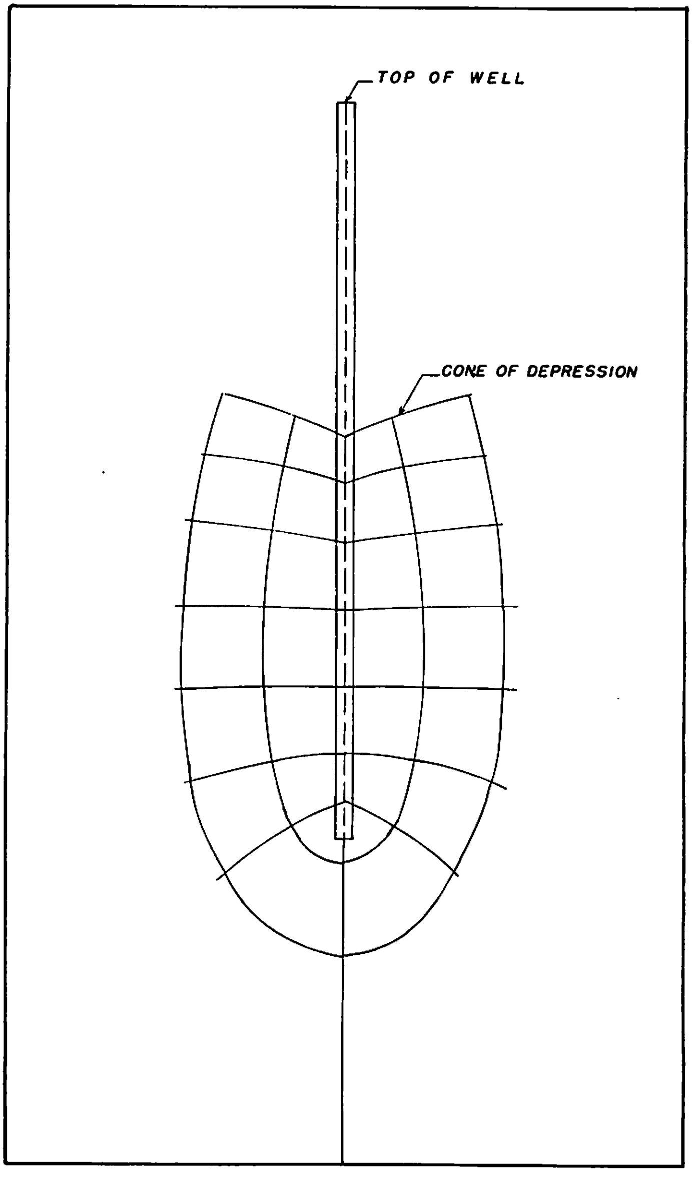

Plate 3.—Flow net of test well.

For every foot of drawdown in the stream there would be an increase of 1,000,000 gal./day flowing into it from ground water. If the stream level dropped one foot lower below the water table, the head (h) would change to six feet; thus the discharge (Q) would be 6,000,000 gal./day.

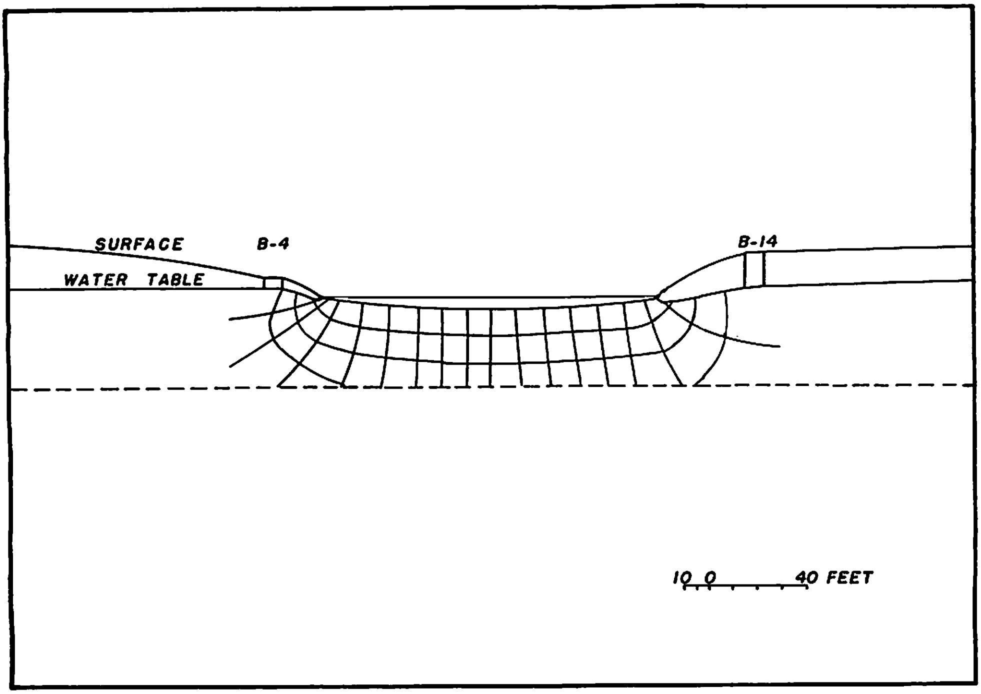

Plate 4.—Flow net of Bogue Phalia.

CONCLUSIONS

RECOVERY METHOD

The Recovery Test was used to calculate the coefficient of permeability of the sand bed of the alluvium deposits that is supplying most of the water to Bogue Phalia. Only the upper 25 feet of this sand bed was tested, because it is this sand that is feeding the stream. The sand further down is much coarser and is considered to be much more permeable. Therefore, by making the computations on the basis of the upper sand, a much truer estimate could be made of the amount of water that could safely be pumped from the stream.

Because of the highly impermeable character of the soil and subsoil of the alluvium, it is the belief of the writer that the recovery formula, which is used for artesian conditions, can be used under the present water table conditions. Practically everywhere a test hole was drilled, a slight rise in the water level was evident. Also the model proved that the flow pattern was essentially the same as the flow of an artesian aquifer.

Correction for partial penetration was considered, but was not included in the report because it would only increase the coefficient of permeability. Until further study is made of this problem, it is considered wise to stay on the conservative side of a pumping estimate.

FLOW NET METHOD

The Flow Net Method was used as a check on the Recovery Method and also as an interesting comparison. The Flow Net Method can be applied to water table conditions as well as to artesian conditions. The only difficult problem is to determine the proper flow pattern. For this problem, a model was set up simulating field conditions. The model provided the basic flow lines from which the flow net was drawn.

While the writer feels that the above calculations are conservative, the wise farmer will take due precaution by keeping a constant check on the draw-down of the stream throughout the entire period of pumping. Such information will be of the utmost value in determining any future increase in acreage.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the cooperation and interest of the citizens in the area covered by this report. He also wishes to thank Mr. A. Wilson for giving his time and knowledge in making the discharge measurements of Bogue Phalia.

Through the personal counsel and guidance of Dr. W. C. Morse and Dr. F. H. Kellogg the writer was able to achieve the undertaking.

Special acknowledgement is due James S. Attaya, James Turner, and E. E. Chapple for their sincere and diligent effort in making possible the completion of the field work involved in this investigation. The writer feels fortunate to have had such capable men to assist him and to them he is deeply indebted.

DATA FOR RECOVERY TEST (TABLE 1)

t	t′	t/t′	$Log_{10}t/t'$	s
250	0		∞	2.26
251	1	251	2.399	1.91
255	5	51	1.707	1.87
262	12	21.83	1.339	1.84
265	15	17.66	1.247	1.83
267	17	15.71	1.196	1.82
270	20	13.50	1.130	1.81
275	25	11.00	1.041	1.79
280	30	9.33	.969	1.75
285	35	8.14	.910	1.74
290	40	7.25	.860	1.71
295	45	6.56	.816	1.69
300	50	6.00	.778	1.68
305	55	5.54	.743	1.66
310	60	5.17	.713	1.63
325	75	4.33	.636	1.58
340	90	3.78	.577	1.54
355	105	3.38	.528	1.50
370	120	3.08	.488	1.46
400	150	2.67	.426	1.40
430	180	2.50	.397	1.35
490	240	2.04	.309	1.27
550	300	1.83	.262	1.23
617	367	1.68	.225	1.16
670	420	1.59	.201	1.13
730	480	1.52	.181	1.11

CLIMATOLOGICAL DATA 1950 (TABLE 2)

MONTHLY TEMPERATURE

Station		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
Cleveland	Max.	62.9	61.1	63.1	71.5	84.1	89.1	89.6	88.0	80.2	80.6	62.1	50.2	73.5
	Min.	45.6	41.2	41.6	50.4	64.2	69.5	68.1	67.8	63.3	54.9	36.7	31.2	52.9
Rosedale	Max.	63.5	62.1	62.0	72.5	83.9	88.6	88.8	87.9	80.8	80.9	62.9	51.1	73.7
	Min.	44.1	40.7	40.0	48.4	63.5	69.6	68.9	67.5	64.4	54.4	34.8	30.4	52.2

MONTHLY PRECIPITATION

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Cleveland	9.76	6.69	11.59	3.30	3.59	2.48	4.93	5.22	4.13	1.04	2.02	4.93	59.68
Rosedale	12.23	7.42	8.08	3.20	2.52	2.49	6.32	2.69	4.64	1.05	1.85	5.60	58.09

LOGS OF TEST HOLES (TABLE 3)

Test Hole B-1

Location: SW. ¼, SW. ¼, Sec. 10, T. 23 N., R. 7 W.
Drilled: December 19, 1950. Elevation 135 feet.

Depth	Thickness	Description
		Alluvium
14	14	Soil and sub-soil, loam, dark, heavy
18	4	Sand, fine, yellow (iron stained), glauconitic, water bearing

Test Hole B-4

Location: SW. ¼, SW. ¼, Sec. 14, T. 23 N., R. 7 W.
Drilled: December 20, 1950. Elevation: 125 feet.

Depth	Thickness	Description
		Alluvium
6	6	Soil and sub-soil, brown loam
8	2	Sand, silty, yellow, water bearing
10	2	Clay, sandy, streaks of black carbonaceous material

Test Hole B-9

Location: NE. ¼, SE. ¼, Sec. 14, T. 23 N., R. 7 W.
Drilled: January 25, 1951. Elevation: 140 feet.

Depth	Thickness	Description
		Alluvium
10	10	Soil, black gumbo
14	4	Sand, yellow brown, fine, glauconitic
16	2	Sand, same as above, water bearing

Test Hole B-11

Location: Center Sec. 10, T. 23 N., R. 7 W.
Drilled: January 25, 1951. Elevation: 140 feet.

Depth	Thickness	Description
		Alluvium
16	16	Soil and sub-soil, black gumbo grading into yellow brown sandy loam
17	1	Sand, yellow brown, fine silty, glauconitic, water bearing

Test Hole B-12

Location: SW. ¼, NW. ¼, Sec. 15, T. 23 N., R. 7 W.
Drilled: January 26, 1951. Elevation: 145 feet.

Depth	Thickness	Description
		Alluvium
15	15	Soil and sub-soil, dark gumbo grading into brown clay
21	6	Clay, sandy, yellow brown, grading into sand, yellow brown, fine to medium, water bearing

Test Hole B-13

Location: NE. ¼, SE. ¼, Sec. 15, T. 23 N., R. 7 W.
Drilled: January 26, 1951. Elevation: 142 feet

Depth	Thickness	Description
		Alluvium
16	16	Soil and sub-soil, gumbo and loam
19	3	Sand, dark blue, fine, silty, clay near top, water bearing.

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2. Theis, C. V., Formula as used by Wenzel, L. K., Fishel, V. C., Methods for determining permeability of water-bearing materials: U. S. Geol. Survey Water-Supply Paper 887, pp. 95-96, 1942.

3. Meinzer, As used by Stearns, N. D., Laboratory tests on physical properties of water-bearing materials; U. S. Geol. Survey Water-Supply Paper 596, p. 148, 1928.