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W. H. Dickerson

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PUMPING TESTS

On The Ohio Valley Substation Irrigation Well

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THE AUTHOR

W. H. Dickerson is Professor of Agricultural Engineering in the College of Agriculture, Forestry, and Home Economics, and Agricultural Engineer in the Agricultural Experiment Station.

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WEST VIRGINIA UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
COLLEGE OF AGRICULTURE, FORESTRY, AND HOME ECONOMICS
A. H. VANLANDINGHAM, DIRECTOR
MORGANTOWN

Pumping Tests on the Ohio Valley Substation Irrigation Well

W. H. DICKERSON

Introduction

GROUND-water resources are of considerable importance to the Ohio River Valley, being used to a considerable extent for rural, and to a much greater extent for industrial and municipal purposes. According to the United States Geological Survey (2) the use of this water by cities and towns along the river in West Virginia amounted to 9 million gallons per day and the use by industry to 41 million gallons per day in 1954. Ground-water supplies in the area are tapped by wells, and radial collectors are also used by industries and municipalities where very large volumes of water are required.

The future development and intensification of agriculture on productive lands adjacent to the Ohio River may result in even greater withdrawal of ground-water. One potentially large use is for irrigation of high value crops, a practice that is beginning to receive some attention in this area. The economical development and handling of ground-water supplies for rural interests may become a problem of transcending importance, as it already is for industry and municipal users.

A study of the performance of existing wells is one method which might lead to increasing the potential value and usefulness of ground-water supplies. The exploration of the relationships between discharge, drawdown, and recovery for the aquifer penetrated by a well can furnish information on how the well should be pumped, and provide invaluable data on the construction of new wells under similar conditions. The United States Geological Survey has collected much valuable information of this type (2).

The measurement of the efficiency of a well as a hydraulic structure can also reveal information that should be considered in the design and development of wells. For rural use, water may be required at locations where differences in pumping head may be considerable due to the drawdown affected by the hydraulic efficiency of the well. Under such circumstances, poor hydraulic efficiency may appreciably increase pumping costs.

Well Tests

Pumping a well with concurrent measurement of discharge and drawdown in the well and in piezometers within the radius of influence can provide detailed information on the well performance and the hydrologic characteristics of the aquifer. Information on the extent of the radius of influence, the slope of the drawdown curve, the direction of movement of water, and the permeability and coefficient of storage of the aquifer can be secured (1). Such data are a prerequisite to an understanding of ground-water supplies and their attendant development and use. Tests involving only the measurement of discharge and the drawdown, or depth to water in a well, can reveal certain performance characteristics of the well. Lacking the sophisticated instrumentation necessary for a study of all of the factors enumerated, a pumping test with measurement of discharge and drawdown was made on the irrigation well on the Ohio Valley Substation of the West Virginia University Agricultural Experiment Station.

The procedure followed is known as the step-drawdown test. The theoretical basis for this test has been described by Jacob (3) and Rorabaugh (6). Originally, the test was devised for artesian conditions. Later, a method of correcting the drawdown to permit the procedure to be used for the analysis of water table wells was suggested by Jacob (4). Also, it can be shown that when the drawdown is small in relation to the saturated thickness of the aquifer, the correction for water table conditions becomes small and can be omitted without appreciable loss of accuracy or alteration of the general conclusions that would be reached.

Purpose of the Step-Drawdown Test

The total drawdown in a screened well, see Figure 1, is made up of two losses. These are: (1) the loss due to friction by water moving through the aquifer, and (2) the losses due to friction in the aquifer in the immediate proximity of the well screen, by the passage of water through the well screen, and losses involved in the movement of water into the pump. The latter of Group 2 is ordinarily a small component of the total losses involved.

The step-drawdown test can be used to secure a measure of the second category, that is, it provides a basis for determining the efficiency of the well as a hydraulic structure. The test procedure does not require piezometers or observation wells around the main well, being based solely on measurement of drawdown and discharge from the well under test. An analysis of the data will indicate the adequacy of the

*Schematic Drawing
Ohio Valley Sub-station Irrigation Well*

Figure 1

well screen, and whether or not the well was properly developed. Development, in well-drilling terminology, refers to the removal of fines from the formation, or aquifer, adjacent to the screen. This enlargement of the pore space serves the purposes of increasing the volumetric rate of flow into the well by increasing the effective radius of the well, and serves to prevent the movement of small particles of sand through the well screen. Sand in the water causes rapid wear of pump parts.

Location and Description of Well Tested

The well on which the test was made is on the Ohio Valley Substation Farm near Point Pleasant, West Virginia. It was drilled into the Pleistocene Epoch alluvial formations of the terrace along the Ohio River, some 3,000 feet east of the river. This stretch of the river valley, known as Point Pleasant bottom, has been described by Carlston and Graeff (2). The well is 12 inches in diameter and 74 feet deep, with a 12-foot screen on the bottom of 62 feet of casing. The driller's log showed in descending order, 10 feet of sandy clay, 51 feet of sand, and 13 feet of sand and gravel. These deposits rest on firm sandstone and shale bedrock. The pumping unit consists of a 15-H.P. electric motor coupled to a deep-well turbine. The well is also equipped with a 3-inch water meter. The well is used as a source of water for irrigation research and for other purposes on the Substation Farm.

The driller conducted pumping tests on the well immediately after its completion in the Spring of 1956 to determine its yield and drawdown over a continuous period of 48 hours. These tests were for the purpose of determining whether or not the performance was acceptable under the terms of the drilling contract and also served as a basis for the selection of the pumping unit.

Step-Drawdown Test Procedure

Prior to the step-drawdown test, made September 9, 1958, a preliminary run was made on the well to determine the pressure settings required on the pump to obtain the desired rates of discharge. The rates selected were 75, 150, 225, and 300 g.p.m. In the test the pump was operated to approximate these rates as closely as possible. Beginning at the lowest rate, the discharge was increased to the next higher rate at the end of 3 hours of pumping. It was not possible to achieve the predetermined rates exactly, but this was not essential for the purpose of the test. The drawdown was recorded every 5 minutes for the first 30 minutes of each step and thereafter at 10-minute intervals. The drawdown measurements were made with an electric sounder, using the base

of the pump as a reference elevation. Volume of discharge was determined from the water meter for the same intervals of time, and from these data the average rate of discharge for each step was calculated. The test procedure was based on methods outlined in the *Johnson National Drillers' Journal* (5).

Test Results

The results of the test are shown graphically in Figure 2 and are summarized in Tables 1 and 2. The average pumping rate for the initial step was 80.4 g.p.m. The drawdown after 100 minutes of pumping was 4.8 feet below the initial water level. After 3 hours of pumping the rate was increased to the second step for which the rate was calculated to be 160.1 g.p.m. The drawdown increased by 4.8 feet for a total of 9.6 feet. The increment of drawdown for step 2 was measured 100 minutes after the beginning of step 2, the measurement being made between the projected line for step 1 and the line of step 2 at 280 minutes after the beginning of the test. This cancels the effect of time of pumping on drawdown, a procedure made necessary by the fact that the drawdown normally tends to increase with time of pumping even though the rate

TABLE 1. DISCHARGE-DRAWDOWN RELATIONSHIPS

STEP	MINUTES AFTER START OF PUMPING	DISCHARGE GPM	TOTAL* DRAWDOWN, FT.	SPECIFIC CAPACITY GPM/FT.
1	0 — 180	80.4	4.8	16.8
2	180 — 360	160.1	9.6	16.7
3	360 — 540	231.9	14.1	16.4
4	540 — 640	304.0	18.7	16.3

*Drawdown after 100 minutes of pumping at the rate for each step, see Figure 2.

TABLE 2. SPECIFIC CAPACITY IN RELATION TO INCREMENTS OF DRAWDOWN

STEP	DISCHARGE GPM	INCREASE GPM	DRAWDOWN BY INCREASE, FT.	SPECIFIC CAPACITY EACH STEP, GPM/FT.
1	80.4	80.4	4.8	16.8
2	160.1	79.7	4.8	16.6
3	231.9	71.8	4.5	16.0
4	304.0	72.1	4.6	15.7

of discharge is constant. Following this procedure the data on Figure 2 for step 3 and step 4 were secured. The pump was stopped 640 minutes (10 hours, 40 minutes) after the start of the test.

Table 1 shows that the specific capacity, defined as g.p.m. per foot of drawdown, decreased slightly with each successive step of the pumping rate. The difference between the specific capacity figures gives the loss due to the increased rate of discharge. The small change in specific capacity indicates that the hydraulic efficiency of the well is very good and that the well is capable of yielding water at rates considerably higher than those used in the test. A large change would indicate poor hydraulic efficiency due to poor development, improper selection of well screen, excessive friction losses in the pump intake, or a combination of these.

The data in Table 2 were secured by calculating the specific capacity for each step in order to make a comparison between steps. Specific capacity is obtained by dividing the increase in pumping rate for each step by the corresponding increase in drawdown. The specific capacity for the last step, an increase of 72.1 g.p.m., was 15.7 g.p.m. per foot of drawdown. This compared to 80.4 g.p.m. and 16.8 g.p.m. per foot for the initial step is a decrease of about 6.5 per cent in specific capacity. A change of this small magnitude is proof of a highly efficient well.

Summary

Ground-water resources are of importance to rural, industrial, and municipal users in the Ohio River Valley.

One method of increasing the potential usefulness of ground-water supplies is through a study of the performance of existing wells. Such studies can determine the capabilities of existing facilities and also provide data to be used in the design and construction of new wells.

The step-drawdown test conducted on the Ohio Valley Substation irrigation well is a procedure for determining the efficiency of a well as a hydraulic structure. The test showed the well to be highly efficient as a hydraulic structure for handling the rates of discharge measured. The small change in specific capacity with increased discharge indicates that the well is capable of producing at rates considerably higher than the maximum employed in the test. The favorable results secured are a reflection of proper development of the aquifer and a good selection of well screen. Periodic tests could be used to indicate the degree to which this efficiency is maintained over the years, and show when the well is in need of treatment or repair.

Care in making test measurements, a knowledge of the log of the well and its construction features, as well as information on the local geology are required for the proper interpretation of such tests.

References

1. Brown, Russell H., "Selected Procedures for Analyzing Aquifer Test Data." *Journal American Water Works Association*, Vol. 45, No. 8, 1953.
 2. Carlston, Charles W., and Graeff, George D. Jr., "Ground-Water Resources of the Ohio River Valley in West Virginia." *West Virginia Geological Survey*, Vol. XXII, Part III, 1956.
 3. Jacob, C. E., "Drawdown Test to Determine Effective Radius of Artesian Well." *Proceedings A.S.C.E.*, Vol. 72, No. 5, 1946.
 4. ———— "Notes on Determining Permeability Under Water Table Conditions." Unpublished Manuscript. 1944.
 5. *Johnson National Drillers' Journal*. "Testing Wells by Step-Drawdown Method." Vol. 29, No. 4, 1957.
 6. Rorabaugh, M. I., "Graphical and Theoretical Analysis of Step-Drawdown Test." *Proceedings A.S.C.E.*, Separate No. 362, Vol. 79, 1953.
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