DEWATERING OF THE CLAYTON FORMATION DURING CONSTRUCTION OF THE WALTER F. GEORGE LOCK AND DAM, FORT GAINES, CLAY COUNTY, GEORGIA

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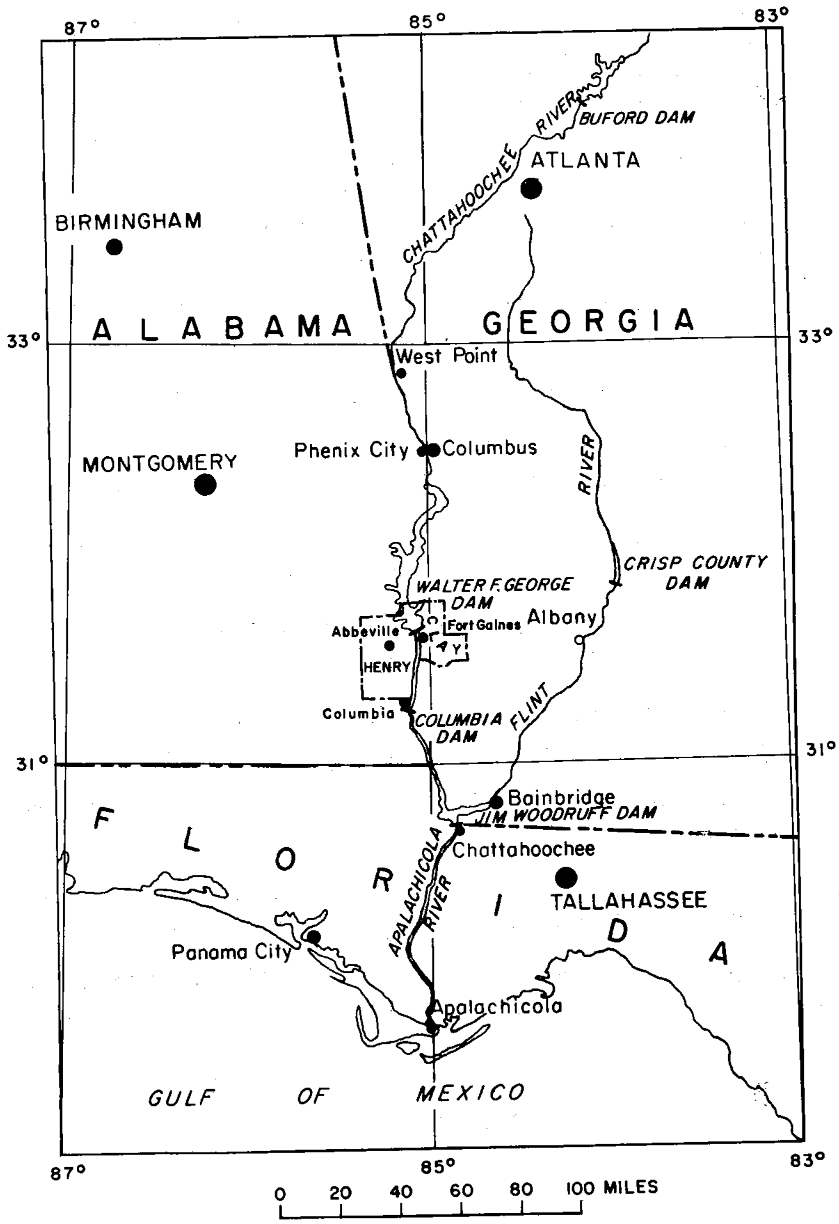

Figure 1. -- Index map of Walter F. George Lock and Dam

DEWATERING OF THE CLAYTON FORMATION DURING CONSTRUCTION OF THE WALTER F. GEORGE LOCK AND DAM, FORT GAINES, CLAY COUNTY, GEORGIA

By J. W. Stewart

ABSTRACT

Walter F. George Lock and Dam, the largest manmade structure in the South, extends over 2½ miles across the flood plain of the Chattahoochee River at Fort Gaines, Clay County, in southwest Georgia and in Henry County, in southeast Alabama. The multipurpose dam consists of two rolled-filled earth dikes, a concrete spillway, a single-stage lock with an 88-foot lift, and a 130,000 kilowatt capacity powerhouse.

The foundation of the dam at the river is constructed in the Clayton Formation, and the earth dikes are constructed on river terraces at about 150 feet above msl (mean sea level). At the damsite, the top of the Clayton Formation consists of an "earthy" limestone, which is about 35 feet thick except in the river channel, where it is 12 to 15 feet thick; a "shell" limestone, which averages about 40 feet thick; and a basal "sandy" limestone, which averages about 35 feet thick. The Providence Sand underlies the "sandy" limestone and its thickness is about 175 feet at the damsite. These formations contain water under artesian conditions.

The "shell" unit of the Clayton was the principal water-bearing formation pumped during construction of the lock and dam. The large yields of the wells from concentrated areas over extended periods of time indicate that in the vicinity of the Chattahoochee River, the Clayton Formation is a productive aquifer with transmissivity ranging from 48,000 to 77,000 gpd per ft. (gallons per day per foot) and storage coefficient ranging from 2.5×10^{-3} to 2.8×10^{-5}. At the spillway site, pumpage ranged from an average of 1,700 to 8,400 gpm (gallons per minute) during the period April 1957 to July 1959; at the powerhouse site, pumpage ranged from 1,600 to 5,000 gpm during the period October 1957 to September 1961; and at the lock site, pumpage ranged from 4,000 to 5,000 gpm during the period July 1960 through December 1961. The large yields represent a source of large quantities of ground water available for industrial and other uses in an area readily accessible by barge from the Gulf of Mexico to Columbus, Ga.

During dewatering, the potentiometric surface was lowered from a pre-pumping altitude of about 115 to 120 feet above msl to a minimum altitude of about 40 feet above msl, or near the bottom of the "shell" limestone. The stage of the Chattahoochee River ranged from about 20 to 60 feet above the potentiometric surface at the dewatering sites.

The Chattahoochee River seemingly is recharging the Clayton Formation near the damsite, possibly through large solution cavities such as were observed during construction of the spillway site at the river. Furthermore, a "honeycombed" network of large solution holes caused the collapse of a section of "earthy" limestone near the powerhouse site. Some underground leakage is expected to occur at the damsite because of the cavernous condition of the limestone, particularly on the Alabama side of the river.

INTRODUCTION

Location of Area

Walter F. George Lock and Dam is in southwest Georgia, on the Chattahoochee River, about a mile north of Fort Gaines, Clay County, and about 15 miles east of Abbeville, Henry County, in southeast Alabama (fig. 1). The western bank of the Chattahoochee River is the boundary between the two States, from West Point, Ga. to the southeast corner of Alabama, a total distance of about 175 river miles. The powerhouse and the western embankment of the dam are in Alabama and the spillway, lock, and eastern embankment are in Georgia.

History of the Lock and Dam

Walter F. George Lock and Dam is one of four dams planned by the U.S. Corps of Engineers in the initial development of the Apalachicola, Flint, and Chattahoochee Rivers as a part of the comprehensive basin development in the River and Harbor Acts of 1945 and 1946. Two dams, Jim Woodruff on the Apalachicola River near Chattahoochee, Fla., and Buford on the upper Chattahoochee River about 35 miles northeast of Atlanta, were completed in 1957.

Work on Walter F. George Lock and Dam began in 1955 and was completed in 1963. Columbia Lock and Dam, about 25 miles downstream from Walter F. George Dam, was started in 1959 and was also completed in 1963.

Walter F. George Lock and Dam consists of two rolled-fill earth dikes, a concrete spillway, a lock with a lift of 88 feet, and a powerhouse of 130,000-kw (kilowatt) capacity. The completed lock and dam constitute the largest manmade structure in the South, extending over 2½ miles across the Chattahoochee River and its flood plain.

The reservoir extends about 85 miles up the Chattahoochee River to Columbus, Ga. and Phenix City, Ala., and covers an area of about 45,000 acres. The total shoreline is estimated to be 500 miles long.

Dewatering of the artesian aquifer in preparation for construction of the gated spillway began April 1957 and continued through July 1959. Upon completion of the apron for the spillway in 1959, construction of the powerhouse and turbines on the west (Alabama) side of the river was started, and in October 1959 dewatering of the aquifer began for this phase of construction. Dewatering of the formation for construction of the lock on the east (Georgia) side of the river began July 1, 1961, and continued through 1963.

Purpose of the Report

The purpose of this report is to present the available information regarding the relation between the rate of ground-water withdrawal and the rate of decline of artesian pressure in a 40-foot "shell" limestone aquifer that was dewatered during construction of Walter F. George Lock and Dam. The need for basic hydrologic data concerning the yield of the aquifer along the Chattahoochee River has been apparent for some time. The report indicates a potential source of a large supply of ground water available for industrial and other uses in an area readily accessible by barge transportation from the Gulf of Mexico to Columbus, Ga.

Acknowledgments

The writer is grateful to the many people who cooperated and assisted in the collection of field data used in this report. The U.S. Corps of Engineers, Mobile District, made available well-location maps, logs of test holes, permeability and pumping-test data, and other valuable information. Acknowledgment is due Messrs. Herbert Fields and Fremon Estep, geologists, U.S. Corps of Engineers, for their cooperation and assistance at the site, and for furnishing water-level measurements, pumpage records, and geologic information. The writer also gratefully acknowledges the cooperation and assistance of Mr. R. L. Wait, hydrologist, and Mr. H. E. Blanchard, hydrologic engineering technician, U. S. Geological Survey.

GEOLOGY

At Walter F. George Lock and Dam, unconsolidated sediments overlie a limestone which is earthy at the top, shelly in the middle, and sandy at the base. Two river-terrace deposits in the valley of the Chattahoochee River near Fort Gaines were described by Wait (1960, p. 96). The lower one is below an altitude of 150 feet and overlies the Clayton Formation in the vicinity of the lock and dam. It consists of 30 to 40 feet of unconsolidated, crossbedded silty sand, silt, and gravel. Terrace gravel may become an important source of ground water in the area now that the dam is completed and the terrace is partly flooded.

The limestone of the Clayton Formation at the dam site was divided into three units by geologists of the U.S. Corps of Engineers (1956). The upper unit, or "earthy" limestone, is a soft, chalky to earthy, white to cream, porous limestone made up of very fine-grained calcite crystals and small fragments of poorly cemented fossils. It is nonwaterbearing. The middle unit, or "shell" limestone, is a fairly dense to porous cream limestone containing numerous oysters and poorly cemented casts and molds of other fossils, chiefly gastropods. This is the principal water-yielding bed of the Clayton at the dam site. The lower unit is a "sandy" limestone, which is also water bearing.

The Providence Sand of Late Cretaceous Age, which underlies the Clayton Formation, was penetrated by several test holes drilled by the Corps of Engineers at the dam site. Table 1 shows the materials logged from test hole 303, drilled by the Corps of Engineers about 220 feet west of the Chattahoochee River and about 450 feet south of the dam. (See also fig. 2A.)

Table 1. -- Selected test hole log[1]

Test hole 303. About 220 feet west of Chattahoochee River and 450 feet south of lock and dam. (Altitudes are feet above mean sea level; depths are from land-surface to base of beds.)

Material	Thickness (feet)	Depth (feet)	Altitude (feet)
Clay, brown, sandy	3.0	3.0	149.1
Clay, red	7.0	10.0	142.1
Sand, tan, fine to medium	7.0	17.0	135.1
Sand and gravel	12.0	29.0	123.1
Limestone, white, earthy, soft	6.0	35.0	117.1
Limestone, white, earthy; contains shell fragments	8.0	43.0	109.1
Limestone, gray, earthy, firm	10.0	53.0	99.1
Limestone, earthy, with yellow stains	3.5	56.5	95.6
Limestone, gray, earthy, firm	20.5	77.0	75.1
Limestone, earthy, shelly	3.0	80.0	72.1
Limestone, shell, hard to firm; many solution holes	39.3	119.3	32.8
Limestone, shell, sandy	5.0	124.3	27.8
Sand	3.2	127.5	24.6
Limestone, shell, sandy, hard	3.4	130.9	21.2
Sand, with shell fragments	3.4	134.3	17.8
Limestone, earthy, dark	5.6	139.9	12.2
Sandstone, firm to hard, with some solution holes	8.1	148.0	4.1
Sand, with shell fragments	1.3	149.3	2.8
Limestone, shell, hard	5.8	155.1	[2]-3.0
Sand, silty, and black clay	4.4	159.5	7.4
Clay, black, waxy, micaceous; silty and sandy	15.0	174.5	22.4

[1] Log of test holes furnished by U. S. Corps of Engineers.

[2] Minus sign denotes below mean sea level.

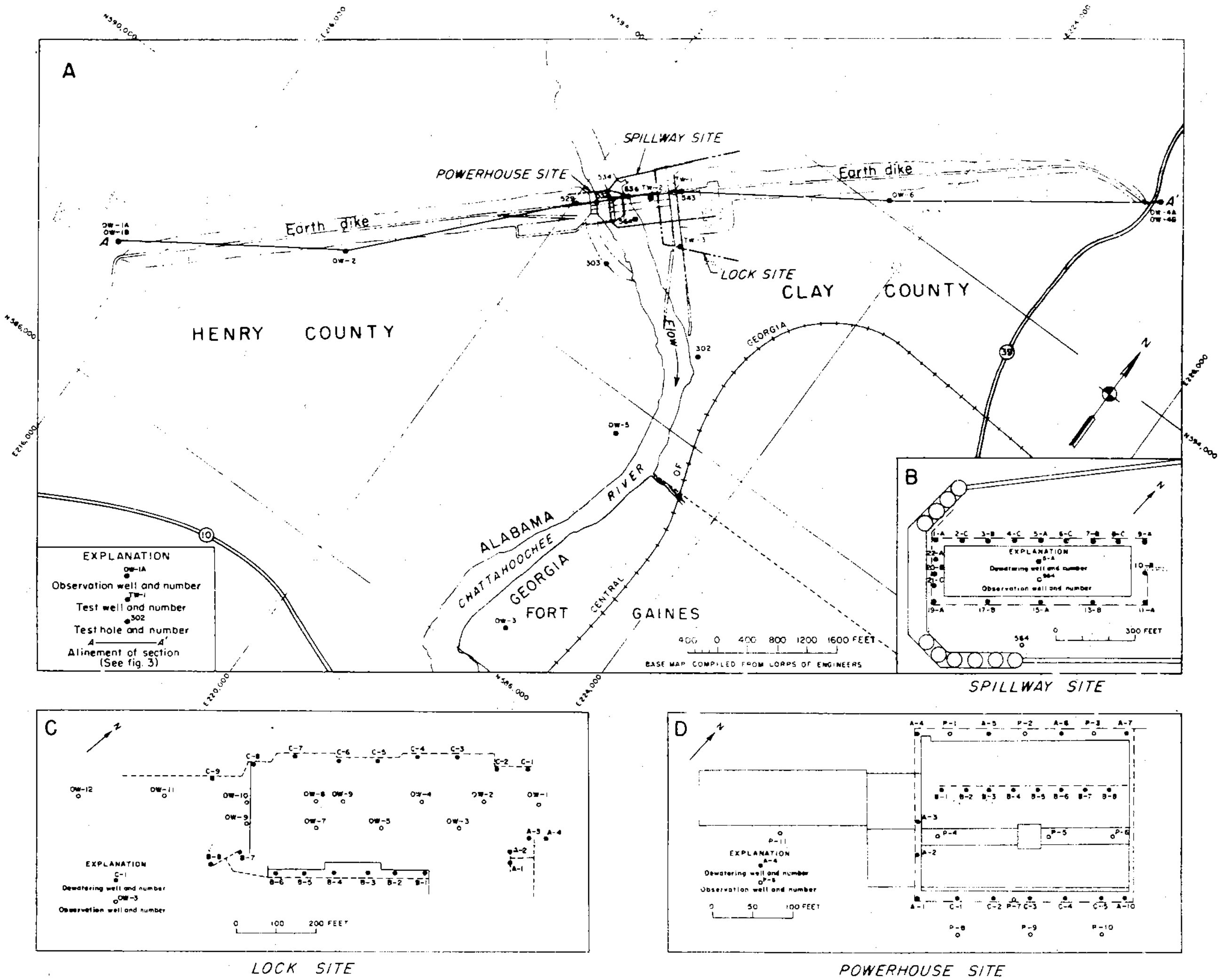

Figure 2. – Location of dewatering wells, observation wells, and test holes at Walter F. George Lock and Dam.

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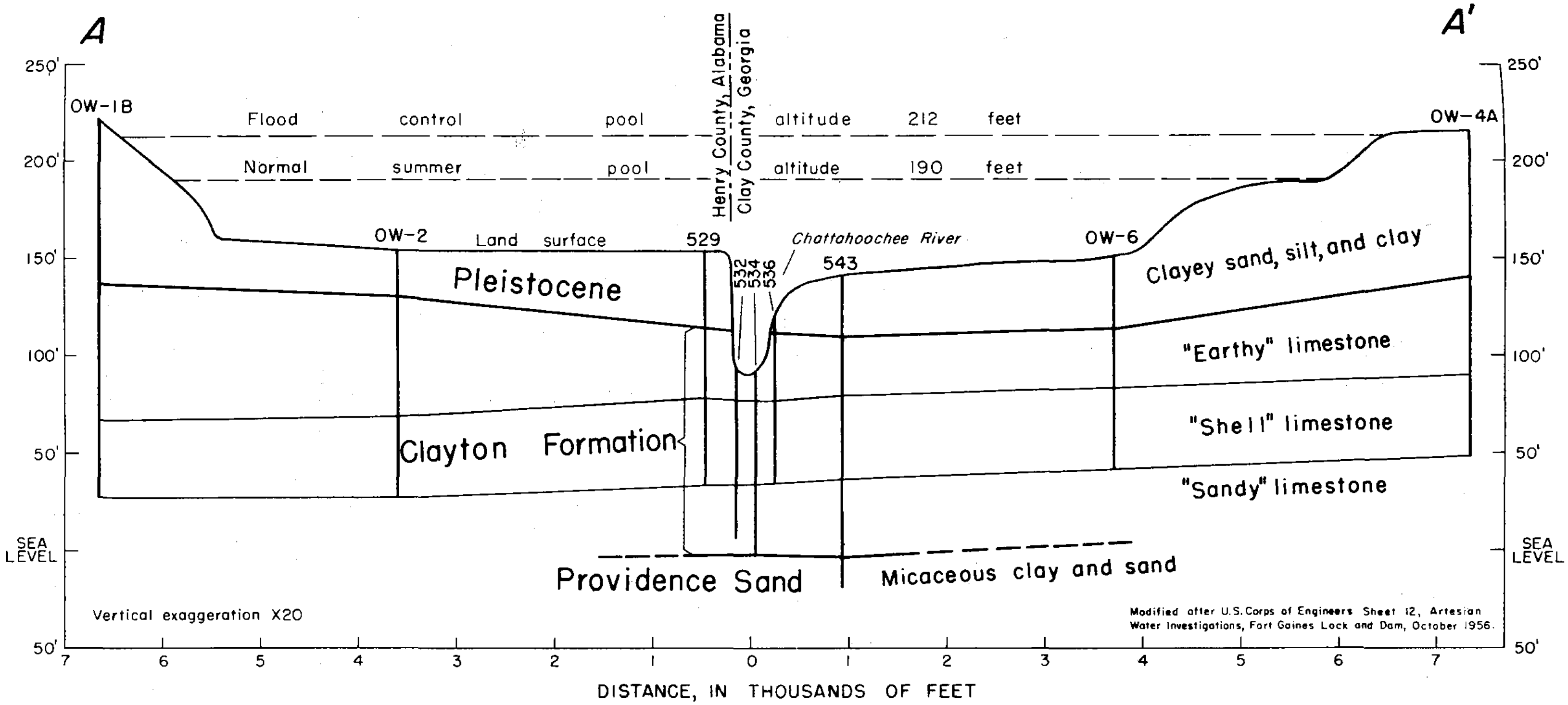

Figure 3. – Geologic section along axis of Walter F. George Dam.

A geologic section (A-A′) drawn along the axis of the dam from the termination of the earth embankment on the east and west sides of the river is shown in figure 3. The location of the section is shown in figure 2.

At the dam site, the top of the upper bed of "earthy" limestone has been eroded by the Chattahoochee River. In the river bed at the spillway site it is about 12 feet thick, and along both sides of the river near the dam it is about 35 feet thick. The "shell" limestone is about 40 feet thick at the spillway site and along the earth embankment on both sides of the spillway. The altitude of the top of the "shell" limestone along the axis of the dam ranges from about 70 feet above msl on the west side of the river (Well OW-1B, fig. 2A) to about 90 feet above msl on the east side of the river (Well OW-4A, fig. 2A).

The bottom of the limestone ranges from 30 to 50 feet above msl. A structure-contour map prepared by geologists of the Corps of Engineers indicates that the "shell" limestone in the area dips south at about 20 feet per mile and that the surface is somewhat irregular. Figure 4 shows the configuration and altitude of the top of the "shell" limestone at the lock and dam, based on geologic data furnished by the Corps of Engineers.

Solution pits are fairly common in exposures of limestone along both banks of the Chattahoochee River upstream and downstream from the dam. Toulmin and Winters (1954, p. 77-78) described filled solution pits, 10 to 30 feet in diameter and 10 to 18 feet in depth, occurring in the top of the Clayton Formation on the Alabama side of the river near Fort Gaines. Similar pits on the Georgia side of the river were also described, but were not as well exposed as those in Alabama.

During preparation of the switchyard area southwest of the powerhouse site (fig. 2A) on the Alabama side of the river, numerous large solution cavities were exposed in the "earthy" unit when a large section of it collapsed under the weight of a tractor. Subsequent investigation revealed that the caved-in limestone was riddled with solution cavities ranging in size from a few inches to as much as 2 feet in diameter and from 4 to 6 feet in depth. (See fig. 5.) The upper part of the limestone was removed in the area of the collapsed section, and the cavities and excavation filled with concrete. Thereafter, an intensive test-drilling program was conducted along the top of the earth embankment on both sides of the river in order to determine if additional cavities existed beneath the earth embankment. Test holes were first drilled into the "earthy" limestone on 20-foot centers, followed by holes placed on 10- and 5-foot centers. Upon completion, each test hole was grouted under pressure in order to fill completely any cavities intersected during drilling. Several test holes on the Alabama side were reported to have taken unusually large amounts of grout, indicating the presence of a fairly large cavity, or cavities, in the "earthy" limestone.

Some underground leakage has occurred at the dam site since impoundment of the river to about normal operating lake level. This leakage was due to the cavernous condition of the limestone in and along both sides of the Chattahoochee River and in the excavations for the various sites. The amount of leakage and the specific areas of occurrence are not known because of the erratic nature, distribution, and occurrences of solution cavities in the limestones and the lack of geologic control along the earth embankments and the area downstream from the dam site. However, underground leakage at the dam depends largely upon the depth, size, extent, and degree of interconnection of solution cavities in the limestone. The presence of a "honeycombed" network of solution cavities beneath the dam or the earth embankments, like those near the powerhouse site, could conceivably result in channeling of the "earthy" limestone and cause an increase in ground-water outflow under the dam foundation and the earth embankments.

Several sinkholes occur on the Alabama side of the river, about 1,600 to 3,000 feet south of the lock and dam and 800 to 1,600 feet west of the river. Most of these sinks contained water at depths of about 5 to 8 feet below land surface (135 to 138 feet above msl) in 1956. The potentiometric surface during January-April 1956 was about the same altitude as the river (less than 110 feet above msl), and was about 25 to 30 feet below the level of the shallow water table in the area.

In addition, the head of water in the artesian aquifers increased after the lake was formed, and in some low areas downstream from the lock and dam, the increase in artesian head has been sufficient to cause the water to rise in a number of drain sinks. Such conditions are most likely to occur where solution cavities in the "earthy" limestone are indirectly connected with the "shell"

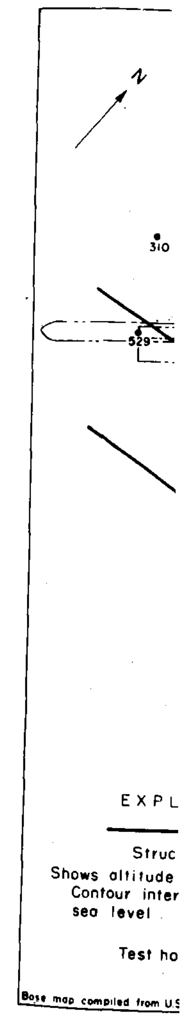

Figure 4. -- St

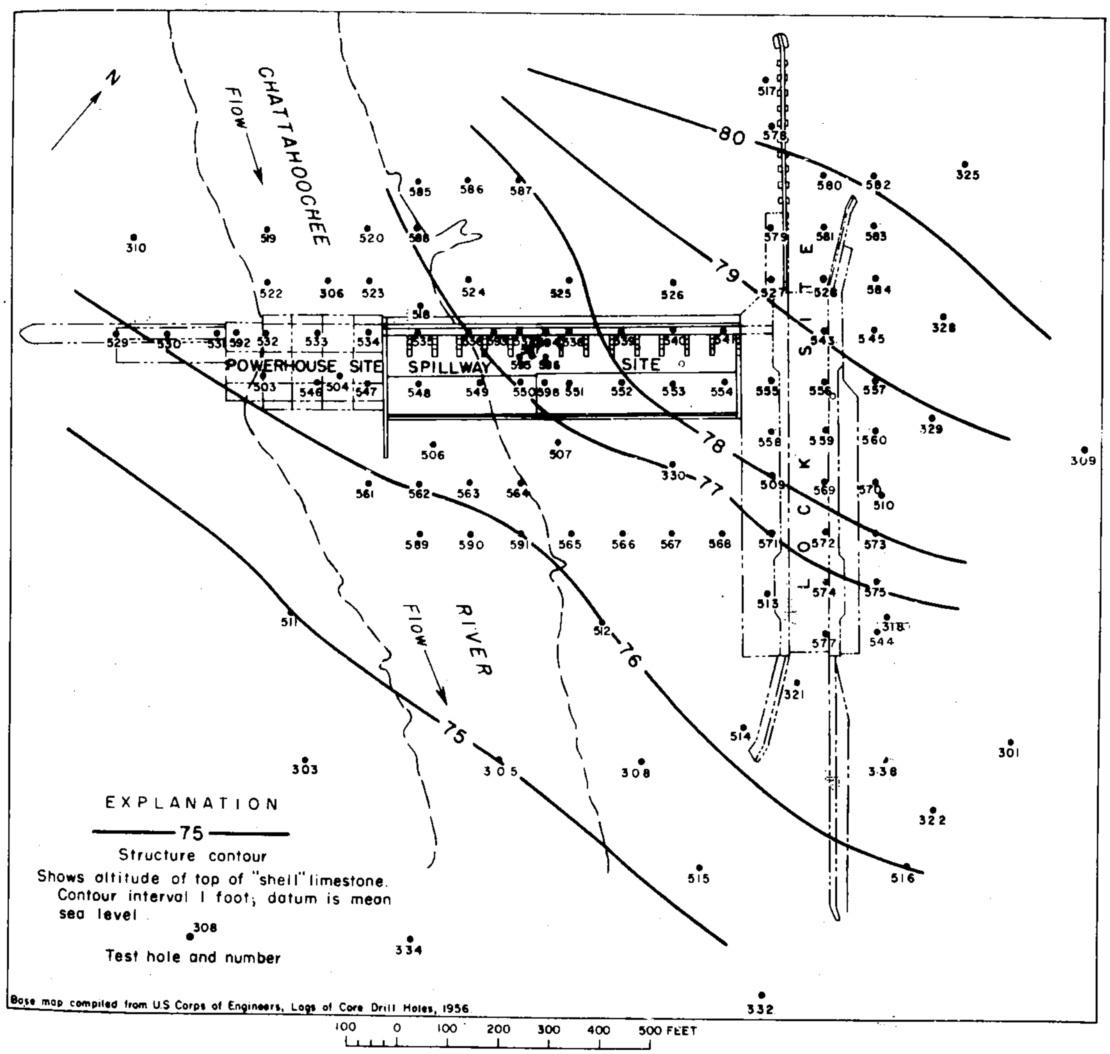

Figure 4. – Structure-contour map of top of "shell" limestone of Clayton Formation.

limestone, and the increased pressure may cause the water to move upward into the sand and gravel.

HYDROLOGIC PROPERTIES FROM FIELD TESTS

In January and February 1956, the Corps of Engineers conducted two aquifer tests utilizing well TW-1 in the first stage cofferdam, about 600 feet north of the Chattahoochee River. (See fig. 2A.) During the January test, the well was pumped at 690 gpm for about 4 hours, and in February the well was pumped at 901 gpm for about 2½ hours. The computed transmissivity for the first test was about 60,600 gpd per ft and the storage coefficient was 2.0×10^{-4}; for the second test, the transmissivity was 76,600 gpd per ft and the storage coefficient was 2.8×10^{-5}.

A test of a second well (TW-2), also in the first stage cofferdam but only 300 feet north of the river, was made by pumping the well at 857 gpm for about 5 hours. Computations based on data obtained from the test gave a transmissivity of about 49,100 gpd per ft and a storage coefficient of 6.1×10^{-4}. The transmissivity was slightly less than that computed from the tests of TW-1.

An estimate of the transmissivity of the "shell" limestone also was computed from drawdown and pumping data obtained during dewatering for the gated spillway in the first stage cofferdam. A daily recording gage was installed on observation well 564, about 160 feet south of the southern line of dewatering wells in the cofferdam. (See fig. 2A.) Several periods of pumpage and shutdown were recorded for four wells during the dewatering process, and the records were computed to determine the transmissivity and storage coefficient. The former ranged from 48,300 to 56,300 gpd per ft and the latter ranged from 2.5×10^{-3} to 5.8×10^{-3}.

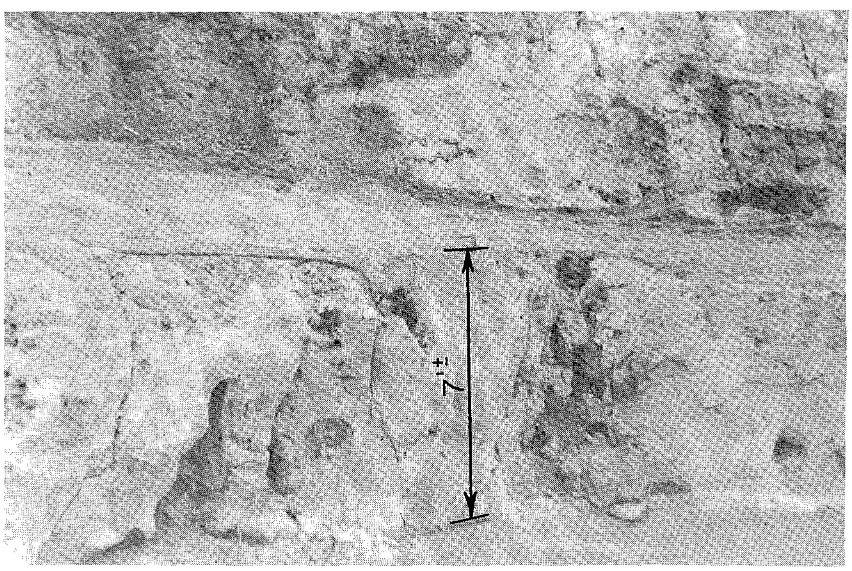

Figure 5. -- Solution cavities in "earthy" limestone of Clayton Formation near powerhouse site

POTENTIOMETRIC SURFACE

Before construction began, the altitude of land surface near the dam was about 150 feet above msl. The bed of the river at the spillway is about 90 feet above msl, or 10 to 15 feet above the top of the "shell" limestone. The 10 to 15 feet of "earthy" limestone at the dam site confined ground water in the "shell" limestone and the "sandy" limestone, the middle and lower units of the Clayton Formation.

The potentiometric surface of an artesian aquifer is an imaginary surface to which water will rise in tightly cased wells that penetrate the aquifer. Where the potentiometric surface is above land surface, artesian wells will flow. In several test holes drilled in the bed of the Chattahoochee River in 1955-56, the artesian pressure was sufficient to cause the water to rise above the tops of the well casings. However, the tops of the casings were 100 to 105 feet above msl, or 45 to 50 feet below the land surface of the dam.

During the latter part of 1955, the earliest date for which water-level records were available, the potentiometric surface in the area was 115 to 120 feet above msl; in February 1956, it was about 120 feet above msl. Figure 6 shows the configuration of the potentiometric surface in the spillway site during late 1955 and early 1956. The direction of ground-water movement was to the south toward the Chattahoochee River, and the hydraulic gradient was about 1 foot in 100 feet. The potentiometric surface was estimated to be 115 to 120 feet above msl shortly before the start of large-scale pumping at the dam in April 1957.

DEWATERING AT CONSTRUCTION SITES

Gated Spillway Site

Pumping at the gated spillway began in April 1957 and ended in July 1959, and ranged from less than 2,000 gpm (3mgd [million gallons per day]) in 1959 to about 8,800 gpm (12.6 mgd) in 1957. Twenty 18-inch dewatering wells and nine 6-inch observation wells were drilled in a rectangular area of about 250 by 800 feet in the spillway site. (See fig. 2B.) The bottom of the spillway was 60 feet above msl and extended about 16 feet into the upper part of the "shell" limestone. The dewatering wells were completed with blank casing from land surface to a depth of 78 feet above msl (near bottom of "earthy" limestone, and slotted casing from 78 to 35 feet above msl (bottom of "shell" limestone). The observation wells were cased with 6-inch blank casing to about the same depth as the dewatering wells and were completed as open-hole wells at a depth of 35 feet above msl. The wells were pumped with diesel-driven deep-well turbine pumps discharging into 20- to 26-inch headers, and the flow was metered prior to being discharged into the river.

Dewatering for the gated spillway began April 10, 1957, and pumpage from two wells averaged 3,500 gpm at the end of the month. The earliest water-level measurements available for dewatering wells at the spillway were made shortly after the start of pumping on April 10. The potentiometric surface ranged from 70 to 75 feet above msl in the pumped wells and from 90 to 105 feet above msl in observation wells. The stage of the Chattahoochee River was about 115 feet above msl.

Figure 7 shows the altitude of the potentiometric surface at the spillway site during the 4 months of heaviest pumping in 1957. At the beginning of June, the pumping rate averaged 6,200 gpm (fig. 7A) and during the latter part of June and all of July the average discharge from seven to 14 wells was about 8,400 gpm, the highest monthly rate during construction of the spillway. However, for short periods of pumping the discharge rate averaged 8,600 gpm at the beginning of July (fig. 7B) and 8,900 gpm during mid-July. At the end of July, the potentiometric surface of the pumping level was 40 to 53 feet above msl and that for the nonpumping level was 45 to 70 feet above msl (fig. 7C). The stage of the Chattahoochee River averaged about 100 feet above msl during the latter part of July 1957, or 50 to 60 feet above the potentiometric surface of the pumping level.

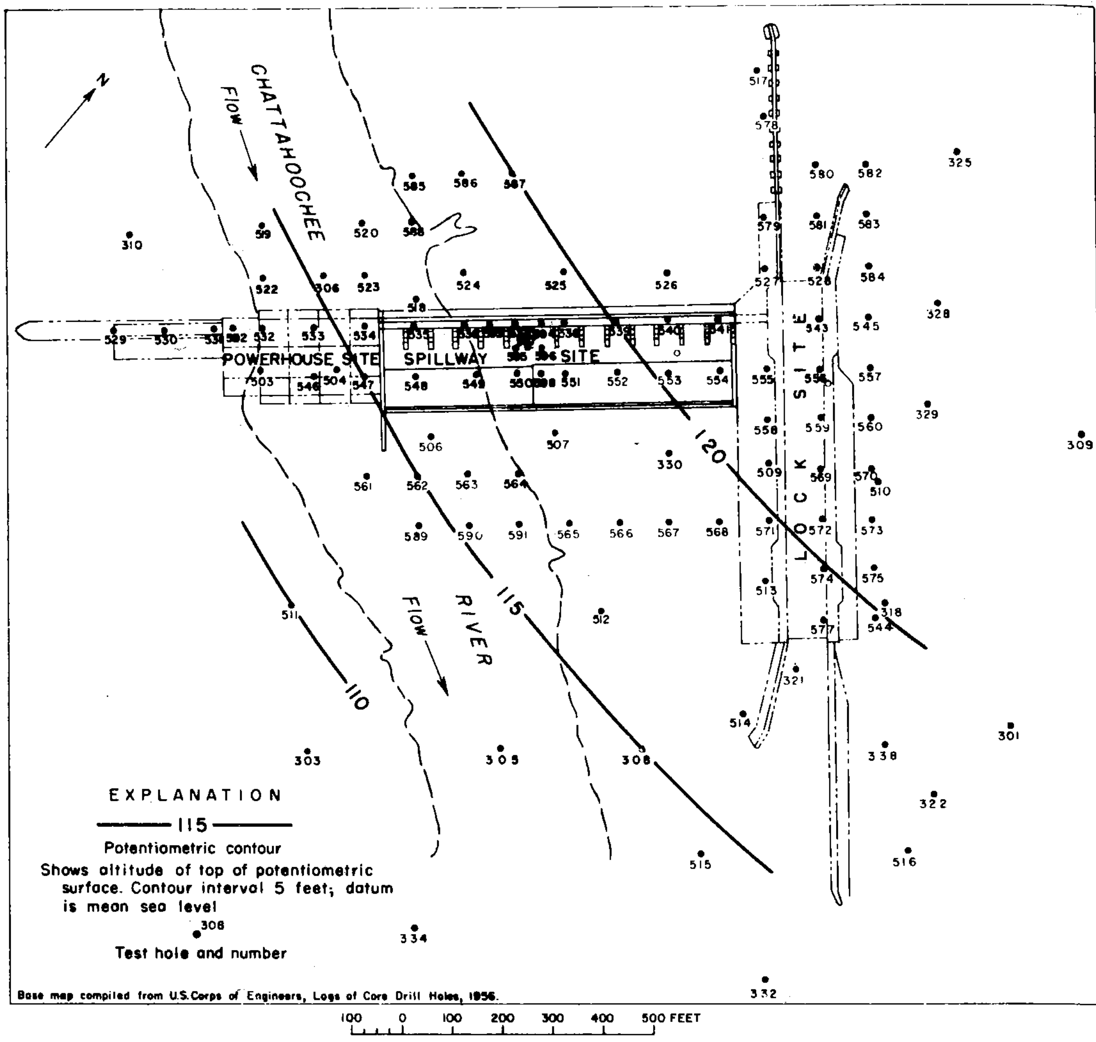

Figure 6. -- Potentiometric map of Clayton Formation, November 1955-March 1956.

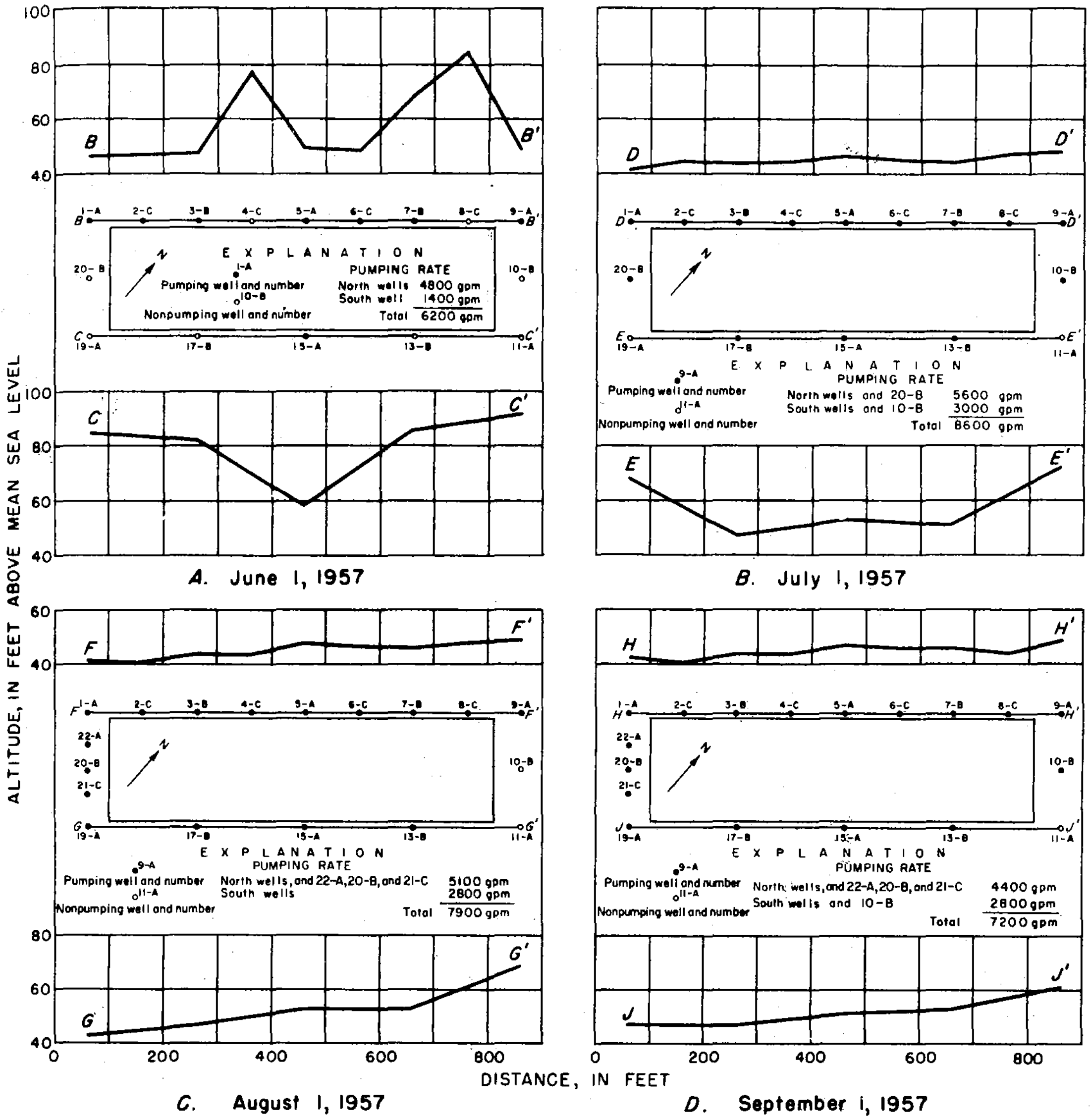

Figure 7. -- Profiles of potentiometric surface on north and south sides of spillway site during dewatering operations, June-September 1957.

Pumpage declined progressively during the latter part of 1957, decreasing from 7,200 gpm at the beginning of September (16 to 17 wells pumped) to 6,000 gpm in December (7 to 8 wells pumped). At the end of August 1957 (fig. 7D), the potentiometric surface in the construction site ranged from 40 to 60 feet above msl, and in December 1967 it averaged 45 to 80 feet above msl. The river stage ranged from 100 to 113 feet above msl during August-December 1957.

Figure 8 shows the water-level fluctuations in one dewatering and one observation well at the spillway site for 1957-59. (See location in figs. 2B and 8.) After the initial drawdowns in most spillway wells in July and August 1957, pumping levels remained fairly steady during the last half of the year, although pumpage decreased to about 6,000 gpm by the end of December 1957.

During all of 1958 and early 1959, water levels in wells fluctuated over a wide range in response to the large changes in pumping rates. Pumping at the site was terminated in July 1959, and, by mid-September, water levels in most wells had recovered to an altitude of 100 feet, or about 20 feet less than the potentiometric surface observed in the area in 1957. Water-level records were not available for the wells after September 1959; however, the recovery of water-levels probably was not complete because the powerhouse dewatering wells in Alabama (opposite spillway site) were placed in operation in the latter part of October 1959, and pumping may have affected the water levels in the spillway site.

Powerhouse Site

Pumping at the powerhouse site began in October 1959 and ended in December 1961; it ranged from less than 2,000 gpm (3mgd) in 1961 to 5,000 gpm (7.2 mgd) in 1959.

The foundation of the powerhouse site is at altitude 48 feet above msl, although a small area was excavated to 37 feet above msl, or about a foot above the bottom of the "shell" limestone.

Twenty-four dewatering wells were drilled into the "shell" limestone in the powerhouse site to dewater the formation. The wells were drilled on centers ranging from 45 to 93 feet within an area of about 200 by 275 feet. (See fig. 2.) The wells were completed with 14-inch screens and bottomed at a depth of about 36 feet above msl. The wells were pumped with 3-stage turbine pumps, discharging into 12-inch headers, and metered as was done at the gated spillway. Eleven 3-inch observation wells were drilled into the "shell" limestone and bottomed at the same depth as the dewatering wells.

Dewatering for the powerhouse site began October 30, 1959, by pumping several "A" wells (fig. 2D). The altitude of the water surface in the area prior to pumping was about 107 feet above msl, or about 3 feet below the level of the river and about 15 feet below the prepumping level at the dam site. At the end of November 1959, 10 wells were pumped at an average rate of about 5,000 gpm, and, at the end of December 1959, 19 wells were pumped for an average discharge rate of 5,000 gpm. The water surface in selected observation wells at the end of December 1959 ranged from 50 to 67 feet above msl, which represented a decline of 35 to 40 feet for the two months since the start of pumping (fig. 9). The altitude of the river level during this period was about 110 feet above msl.

Water levels began to rise in January 1960, owing to a reduction in pumping at the powerhouse site. Water levels continued to rise until July 1960, at which time pumping began at the lock site and water levels commenced to decline. At the end of July 1960, the combined pumpage at both sites averaged about 7,000 gpm (2,400 gpm at powerhouse site and 4,600 gpm at lock site). Water levels at the powerhouse site declined 5 to 7 feet, indicating that the additional pumping at the lock site may have affected the water levels in wells at the powerhouse site. The combined pumping at both sites resulted in considerably less drawdowns in the powerhouse wells than that obtained during pumping of the powerhouse wells at 5,000 gpm prior to the time of pumping the lock wells. During August 1960, the combined pumping at both sites increased to 9,300 gpm (3,800 gpm at powerhouse site and 5,500 gpm at lock site), and water levels in the wells declined an additional 3 to 7 feet. Water levels remained fairly steady during the early part of 1961, but rose 5 to 20 feet the latter part of the year when pumping increased to less than 2,000 gpm at the powerhouse site. The potentiometric surface ranged from 60 to 80 feet above msl in 1961, or 25

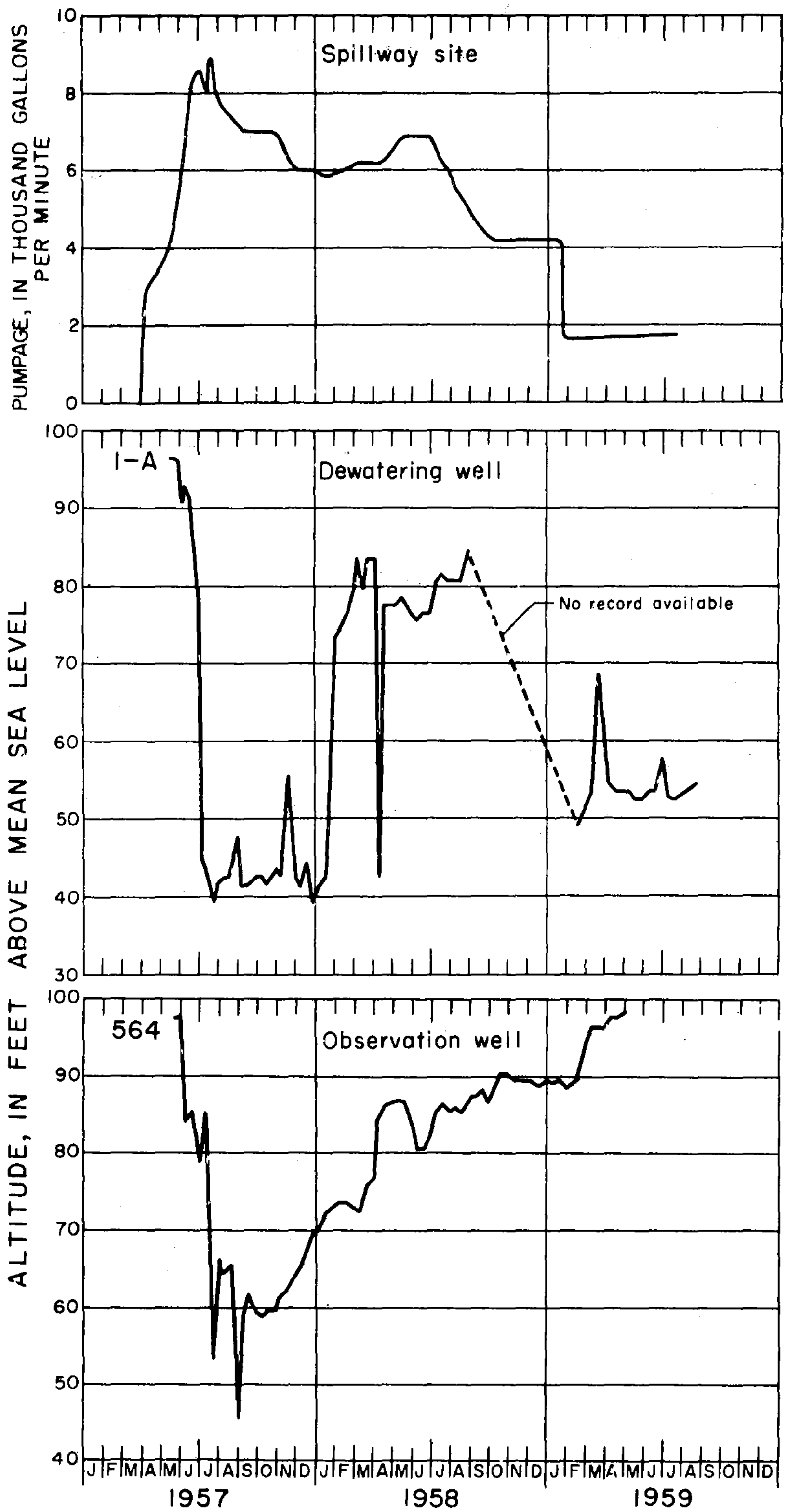

Figure 8. -- Water level in an observation well and a dewatering well and pumpage at spillway site.

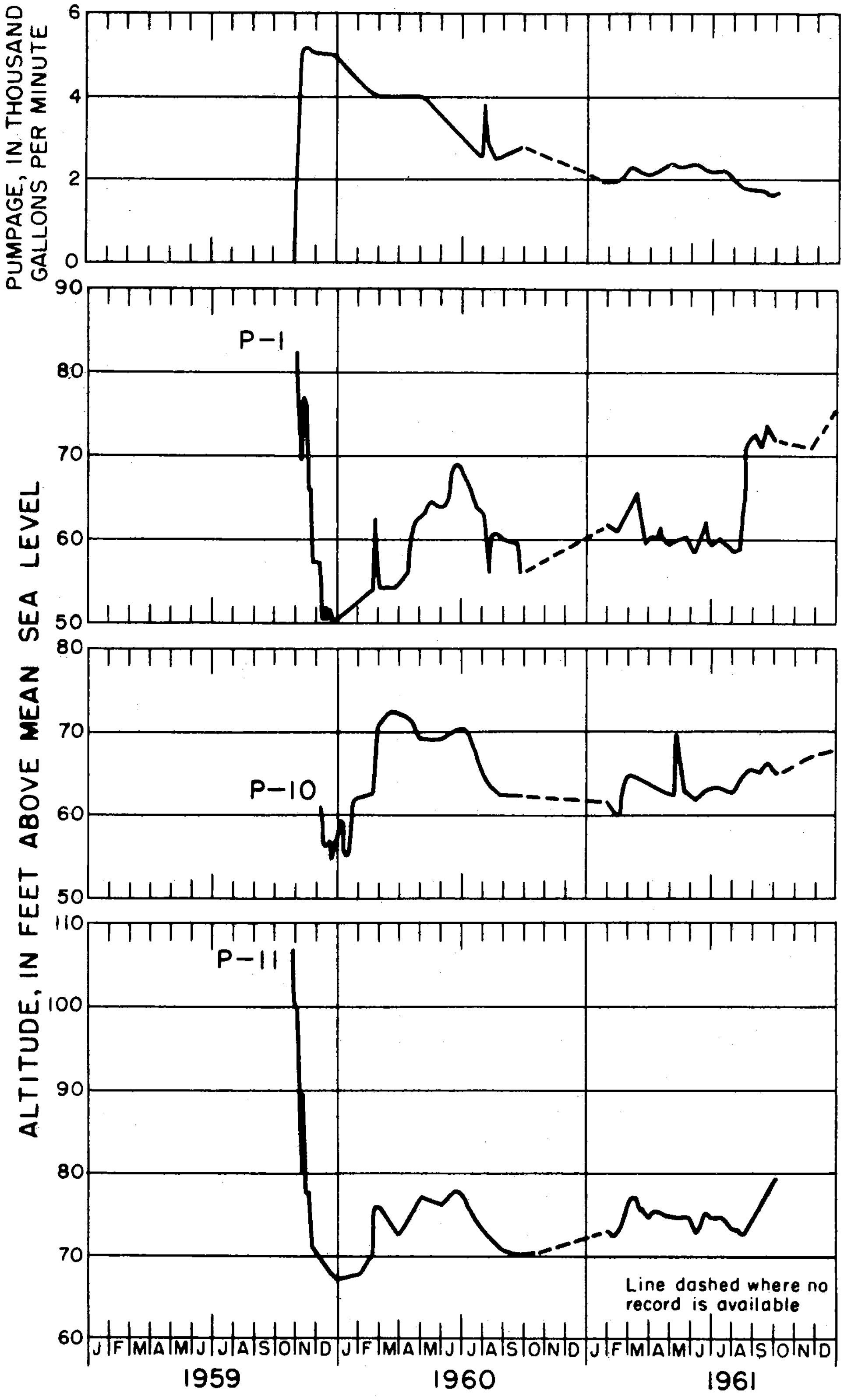

Figure 9. – Water level in three dewatering wells and pumpage at powerhouse site.

to 50 feet lower than the levels observed October 1959, and 20 to 40 feet lower than the river levels at the site during the latter part of 1961.

Lock Site

The lock site is on the east side of the Chattahoochee River in Georgia. (See fig. 2.) A photograph of the partly completed lock viewed upstream is shown in figure 10. The floor of the lock is 88 feet above msl, or about 3 feet above the top of the "shell" limestone. Pumping at the lock site began July 1960 and continued through 1961, and averaged about 4,000 gpm (5.8 mgd) in 1961 and about 5,000 gpm (7.2 mgd) in 1960.

Twenty-one dewatering wells and 12 observation wells were drilled in a rectangular area of about 300 by 1,200 feet at the lock site. (See fig. 2.) Two rows of dewatering wells were drilled on centers ranging from 75 to 100 feet, and two rows on centers of 35 to 50 feet. The latter wells were concentrated in a small area on the upstream side of the lock. The observation wells were placed in two rows along both sides of the center line of the lock and were spaced on 60- to 200-foot centers. The dewatering wells were cased with 12-inch steel casing to a depth of about 95 feet above msl, and were completed as 12-inch open-hole wells to a depth of about 35 feet above msl. The observation wells were cased with 6-inch casing to about the same depth as the dewatering wells and were completed as 6-inch open-hole wells to a depth of about 38 feet above msl. Turbine pumps similar to those installed at the spillway and powerhouse sites were used to lower the water levels at the lock site.

Dewatering at the site prior to excavation began July 1, 1960, by pumping the line of "C" wells. (See fig. 2C.) The altitude of the prepumping water level was 100 to 107 feet above msl. Pumpage averaged about 4,900 gpm from July to December 1960. At the end of December, the discharge rate averaged 4,000 gpm, and the altitude of the water surface was about 55 to 64 feet above msl (fig. 11). During 1961 pumpage averaged slightly more than 4,000 gpm. The altitude of the water surface at the end of December 1961 was 62 to 66 feet above msl, or about the same level as that observed during most of 1961. The level of the river was about 110 feet above msl, or 45 to 50 feet above the potentiometric surface at the end of December 1961. The termination of pumping at the powerhouse site in December 1961 did not appear to affect the water levels at the lock site.

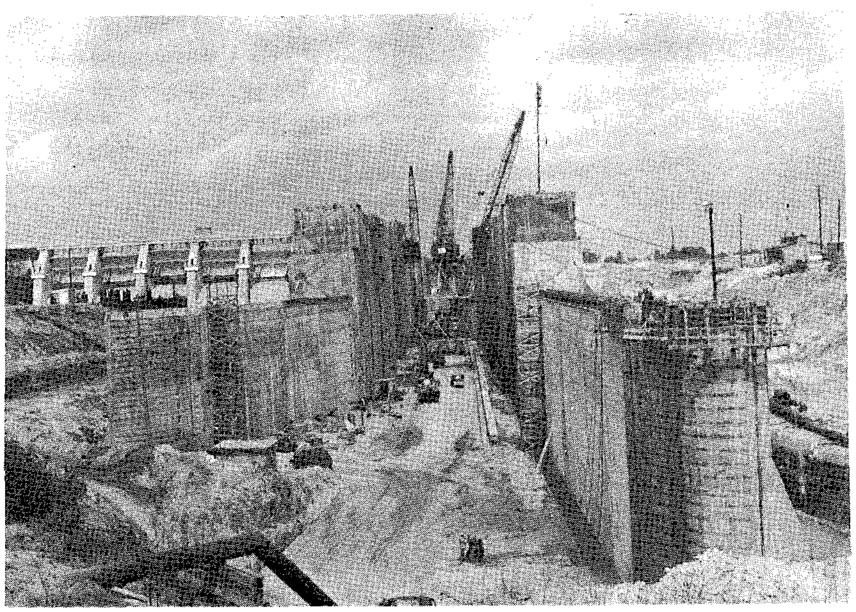

Figure 10. – Construction of Walter F. George Lock, April 5, 1962

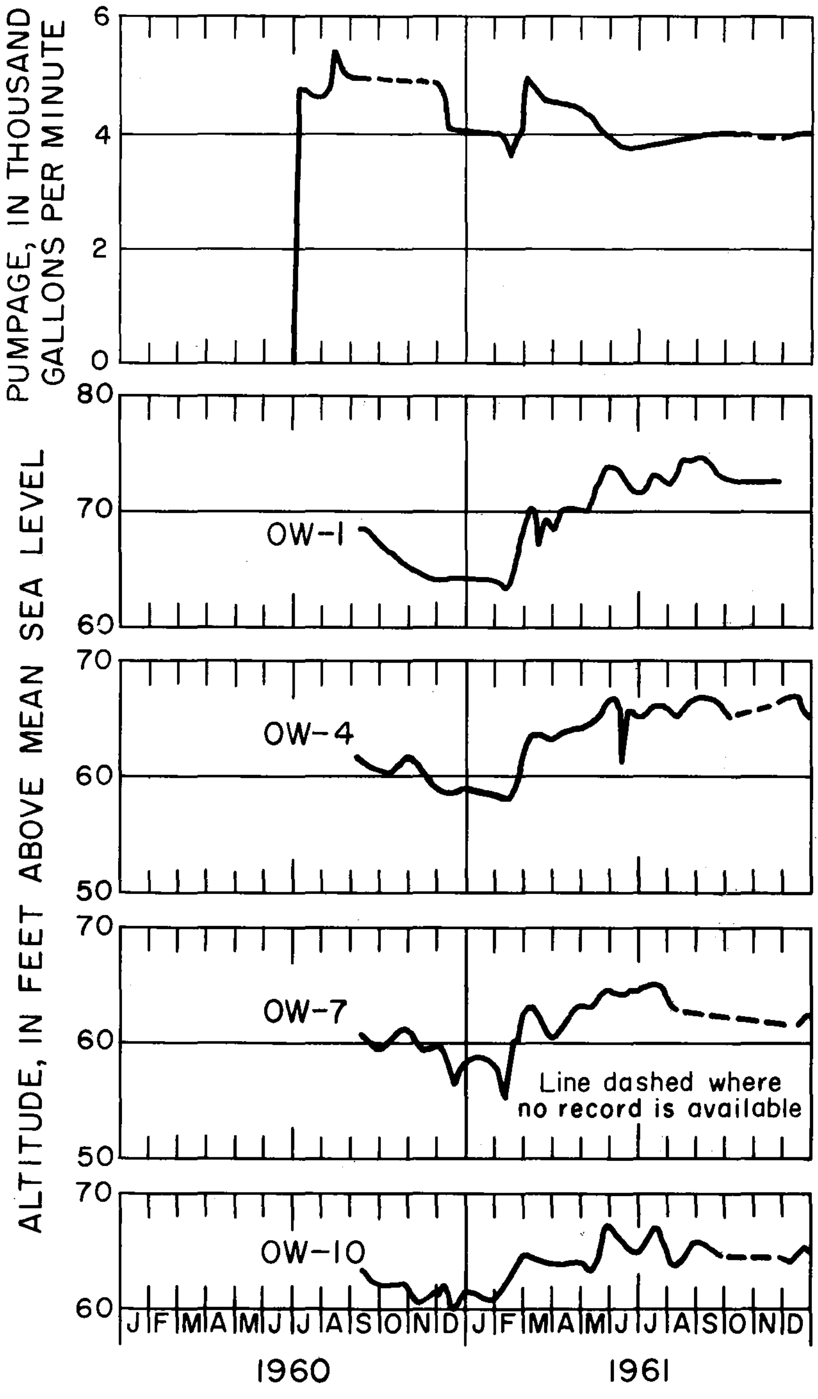

Figure 11. – Water level in four dewatering wells and pumpage at lock site

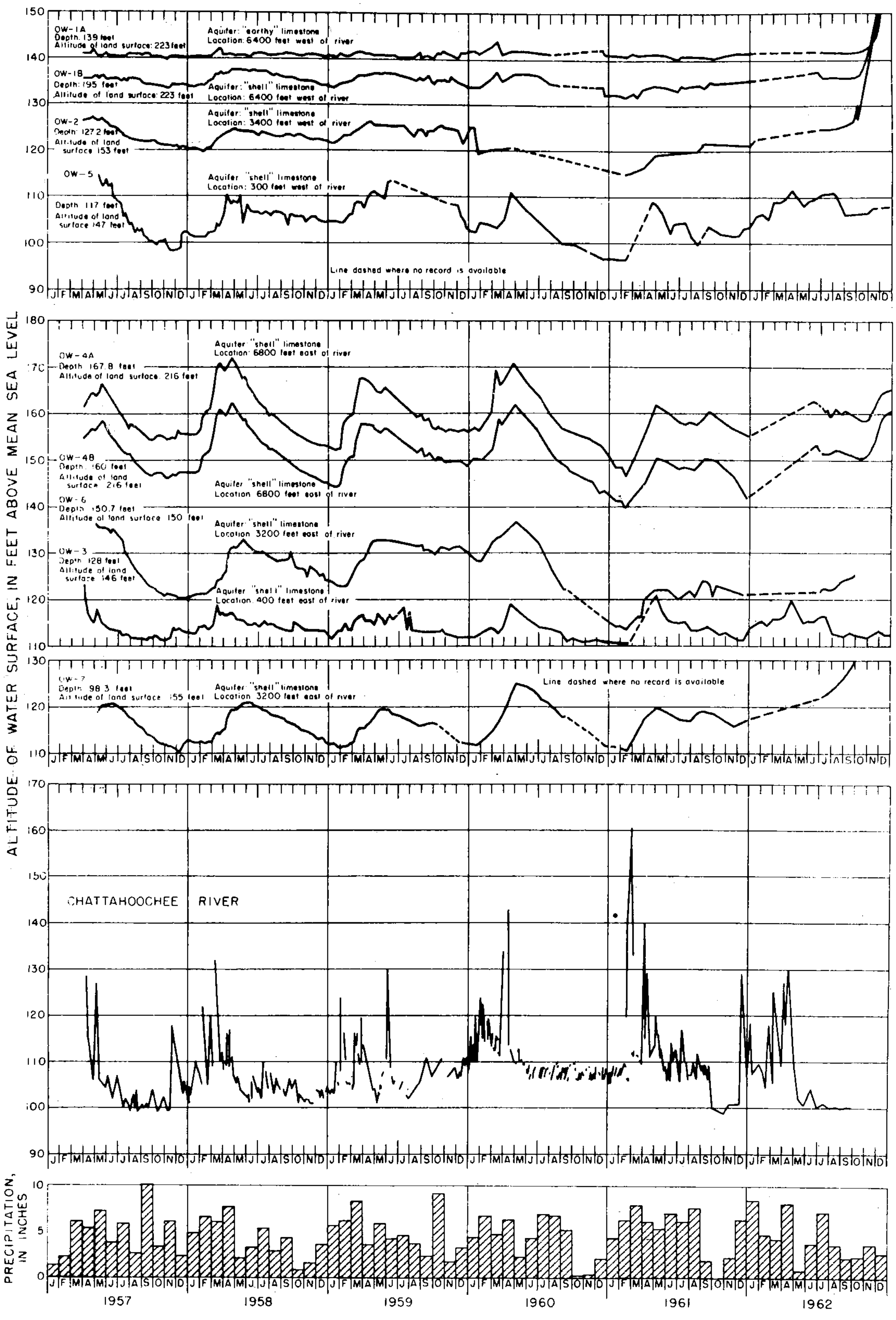

Figure 12. – Water level in observation wells, stage of Chattahoochee River, and precipitation at Fort Gaines.

EFFECTS OF PUMPAGE ON WATER LEVELS IN OUTLYING WELLS

Figure 12 shows hydrographs of nine wells outside the area of pumpage at the lock and dam, stages of the Chattahoochee River at Fort Gaines, and precipitation for 1956-62. (See fig. 2.) Three wells in Alabama (OW-1A, -1B, and -2) were 3,400 to 6,400 feet west of the Chattahoochee River and one well (OW-5) was 3,000 feet south of the dam and 300 feet west of the river; three wells in Georgia (OW-4A, -4B, and -6) were 3,200 to 6,800 feet east of the river; well OW-3 was 5,500 feet south of the dam and 400 feet east of the river; and well OW-7 (not shown on map) was 4,700 feet north of the dam and 3,200 feet east of the river. All wells penetrated the "shell" limestone with the exception of well 1A, which was drilled into the overlying "earthy" limestone. The remaining wells were cased to a depth of about 78 feet above msl and completed as open-hole wells in the "shell" limestone.

The annual range in water-level fluctuations in observation wells about 3,400 feet east of the Chattahoochee River generally was 2 to 4 times greater than that for wells about the same distance west of the river. The difference in water-level fluctuations is due largely to the fact that the area northeast of the lock and dam is probably the principal recharge area for the Clayton Formation.

Two wells (OW-3 and -5) were affected by change in the stage of the Chattahoochee River. Stages of the Chattahoochee River, about 2 miles south of the dam, for 1957-62 are shown in figure 12. The record is incomplete and several peak stages during flood conditions are not shown on the graph. However. during high river stage the water levels in the wells showed pronounced rises, indicating both a loading of the aquifer and a hydraulic connection between the river and the aquifer.

Either the water levels in outlying wells were not influenced by pumping at the dam, or the effects of the pumping were so small that the fluctuations were masked by precipitation and changes in atmospheric pressure. The lowest water levels occurred during winter following periods of minimum precipitation in the fall, and the highest water levels occurred in the spring following periods of maximum precipitation in winter and early spring. The only significant change in water levels occurred in late 1960 and early 1961 when the lowest water levels were recorded for the 5-year period. The decline in water levels was probably due to the below-average precipitation (less than 1 inch) during October and November 1960. Water levels remained fairly high during April-August 1961, because of above average rainfall.

Figure 13 shows profiles of the potentiometric surface in the "shell" limestone along the axis of the lock and dam prior to and during three dewatering periods at the different sites. The test holes shown near the river were destroyed during construction of the sites; however, two test holes (532 and 536) are used to show the potentiometric surface at the spillway and powerhouse because the location of the holes represents the approximate center of pumping at the two sites. The center of pumping at the lock site was approximately 400 feet east of the river.

At the spillway site, the lowest potentiometric surface was 40 feet above msl, or about 5 feet above the base of the "shell" limestone as a result of pumping about 8,000 gpm for less than 2 months; at the powerhouse site the lowest potentiometric surface was 48 feet above msl for a pumping rate of about 5,000 gpm for 2 months; and at the lock site the potentiometric surface was 60 feet above msl for a pumping rate of about 5,000 gpm for about 2 months.

The lowest water levels in wells at the spillway and powerhouse sites occurred shortly after peak pumpage (fig. 9), but at the lock site the lowest water levels occurred about 6 months after peak pumpage (fig. 11).

The only period available for comparison of water levels during simultaneous pumping at both sides of the river is that shown for the powerhouse and lock sites on February 15, 1961. Pumpage at the powerhouse site averaged 2,600 gpm, and the water surface was 60 feet above msl; at the lock site pumpage averaged 4,000 gpm, and the water surface was 55 feet above msl. The yield per foot of drawdown in wells at the spillway site was considerably greater than that obtained for wells at the powerhouse site.

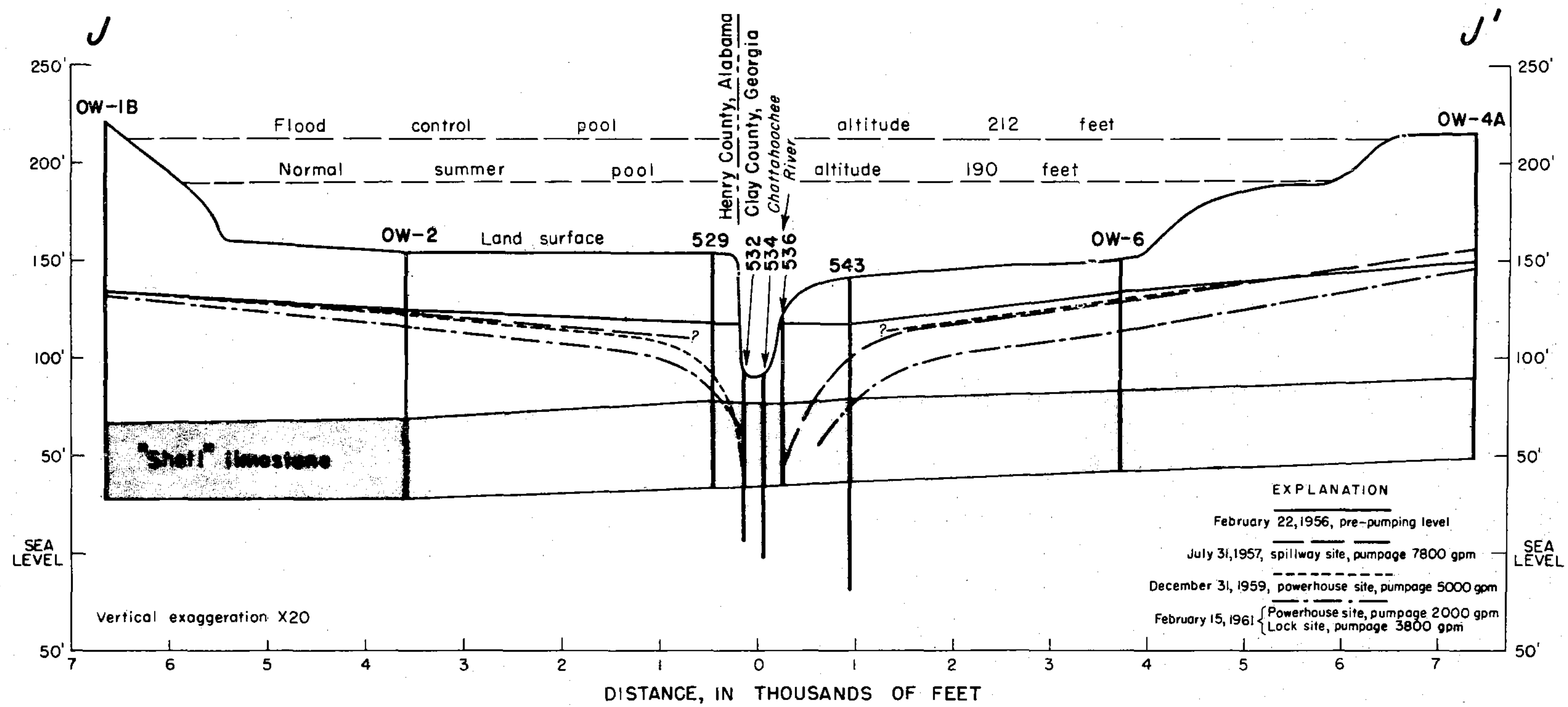

Figure 13. – Four profiles of potentiometric surface in "shell" limestone along axis of dam.

RIVER INFILTRATION

The bed of the Chattahoochee River at the dam site is 90 feet above msl, where the river has cut a 20-foot channel into the upper part of the "earthy" limestone. The top of the "shell" limestone is 12 to 15 feet below the river bottom.

During construction of the spillway, several large solution holes were observed in the "earthy" limestone in the original bed of the river and along the banks of the river on the Alabama side, opposite the spillway. The water in the solution holes fluctuated in response to changes in stages of the river, indicating a hydraulic connection between the river and the water in the Clayton Formation. In addition, the occurrence of large solution cavities in the overlying "earthy" limestone near the powerhouse site on the east side of the river (fig. 5) also illustrates the cavernous conditions that might be expected in the limestone at the lock and dam site.

Based on a sustained pumping rate of 5,000 gpm for one year, an average transmissivity of 52,000 gpd per ft for the "shell" limestone, and a storage coefficient of 4×10^{-3}, a drawdown on the order of 50 feet would occur in a well 4,000 feet from the center of pumping, assuming that no recharge or discharge boundaries were intercepted by the cone of depression. No noticeable drawdown was observed in well OW-2, about 4,000 feet west of the center of pumping, after several months of continuous pumping in excess of 7 mgd; likewise, no drawdown was observed in well OW-6, about 3,200 feet east of the river.

The large individual yields of the spillway wells, ranging from 1,500 to 1,800 gpm, as well as the total combined pumpage from a battery of 18 wells ranging from 6,900 to 8,800 gpm for over a year, indicate a very productive aquifer. During pumping of the wells, the temperature of the water from wells near the river was reported to be several degrees warmer than the normal temperature of the ground water in the area, indicating that river water was probably recharging the "shell" limestone. During pumping at an average rate of 8,400 gpm for about a month, the water surface ranged from about 40 to 55 feet above msl, or about 5 to 20 feet above the bottom of the "shell" limestone. On the basis of the permeability of the "shell" limestone, the hydraulic gradient between the river and the spillway, and a section of the aquifer parallel to the river, it is considered highly improbable that the aquifer would yield a sustained pumpage of such large quantities of water without depleting the water in the formation at the dam site if the river were not recharging the aquifer.

For example, based on an average permeability of 1,500 gpd per sq ft for the "shell" limestone (as determined from aquifer tests) at the spillway site, gradient from the river to the wells of 75 feet in 100 feet, and an aquifer section parallel to the river 200 feet long by 400 feet thick, then the quantity of water moving into the spillway area is about 9 mgd, or about the same quantity that is pumped daily at a rate of 6,400 gpm.

Further evidence that recharge is occurring by induced infiltration for the river is that the nearby observation wells along the earth embankment on both sides of the river, and the wells north and south of the dam, did not show a decline in water levels as a result of the heavy withdrawals at the dewatering sites. Hydrographs of wells for the pumping at the spillway, powerhouse, and lock sites did not show any significant changes in water levels other than the normal seasonal fluctuations, indicating that the cone of depression did not extend any appreciable distance from the center of pumping. It appears, therefore, that the river is recharging the Clayton Formation at the dam site. Also, recharge probably occurs along stretches of the river upstream, particularly where the limestone is exposed in the river bed, and possibly along stretches downstream from the dam.

SUMMARY

The potentiometric surface of the Clayton Formation at the Walter F. George Lock and Dam was 115 to 120 feet above msl shortly before dewatering operations began in April 1957. During dewatering at the spillway site, pumpage from two to eight wells ranged from less than 2,000 gpm (3 mgd) in 1959 to a peak of about 8,800 gpm (12.6 mgd) in 1957. The potentiometric surface during heaviest pumpage in 1957 was 40 to 53 feet above msl in pumping wells and 45 to 70 feet above msl in nonpumping wells. The level of the Chattahoochee River was about 110 feet above msl, or 50 to 60 feet above the potentiometric surface of the pumping level in the area.

Water levels in wells at the spillway site recovered rapidly upon termination of pumping in July 1959 and shortly thereafter rose to about 100 feet above msl, or about 20 feet below the levels observed in the area shortly before the start of dewatering operations in April 1957. Recovery of water levels at the site was not complete because the dewatering wells at the powerhouse site were placed in operation shortly thereafter.

At the powerhouse site, pumpage from 2 to 21 wells ranged from slightly more than 5,000 gpm (7.2 mgd) in 1959 to less than 2,000 gpm (3 mgd) in 1961. The potentiometric surface was 45 to 65 feet above msl for a pumping rate of 2,000 gpm during early 1961, and the river level was about 110 feet above msl. At the end of 1961, pumpage was reduced to less than 2,000 gpm, and the potentiometric surface ranged from 60 to 80 feet above msl, or about 25 to 50 feet lower than in 1959, and 20 to 40 feet lower than the river level observed during the latter part of 1961.

At the lock site, 21 dewatering wells were installed, and pumping from two to 14 wells ranged from about 2,000 to 5,000 gpm (3 to 7.2 mgd) during July 1960 through December 1961. The potentiometric surface at the site was 100 to 107 feet above msl prior to pumping, and, by the end of 1961, it was 63 to 80 feet above msl. The level of the river was about 110 feet above msl at the end of 1961, or 30 to 50 feet higher than the potentiometric surface at the site.

The transmissivity of the "shell" limestone ranged from 49,000 to 76,000 gpd per ft, and the storage coefficient ranged from 2.0×10^{-4} to 2.8×10^{-5}, based on the results of aquifer tests conducted by the Corps of Engineers. An analysis of data, based on several periods of drawdown and recovery of water levels in 1 to 4 wells for periods of 8 to 12 hours during dewatering operations, gave a transmissivity of 48,000 to 56,000 gpd per ft and an average storage coefficient of 4×10^{-3}.

The large yields of individual wells in the area ranging from 1,500 to 1,800 gpm, and a total combined pumpage of 5,000 to 8,000 gpm (7.2 to 11.5 mgd) from five to 18 wells for 1 to 2 years, indicates that the Clayton Formation is a productive aquifer at the lock and dam site.

Water levels in observation wells at a distance of about 3,000 feet east and west of the Chattahoochee River were not affected during the dewatering operations. Hydrographs of selected observation wells throughout the area did not show any noticeable decline in water levels during dewatering, indicating that the cone of influence did not extend any appreciable distance from the river. On the basis of the hydrologic properties computed for the "shell" limestone in the area and a pumping rate of 5,000 gpm for a year, the drawdown in observation wells 4,000 feet from the river should be on the order of 50 feet. Thus, it appears that the "shell" limestone is being recharged by induced infiltration in the area.

During construction of the spillway, large solution holes were observed in the "earthy" limestone, and the water in the holes fluctuated in response to changes in river levels, indicating a hydraulic connection between the river and water in the Clayton Formation. In addition, the occurrence of large solution cavities near the powerhouse site, which were exposed when a large section of limestone collapsed, showed the cavernous conditions that might be expected along the river and in other parts of the lock and dam sites.

Some underground leakage has occurred at the damsite since impoundment of the river. The amount of leakage and specific areas of leakage are not known because of the irregular occurrence and distribution of cavities in the limestone. However, these will depend upon the depth, size, extent, and degree of interconnection of the solution cavities in the limestones. The occurrence of a large number of cavities in a small area, such as were found near the powerhouse site, could conceivably cause channeling of the "earthy" limestone and result in increased outflow under the dam foundation and the earth embankments.

Closing of the dam will increase the head of water behind the dam and inundate a large area, and recharge to the Clayton Formation will probably increase. Therefore, the possibility exists that for some low areas downstream from the dam, the increase in artesian head may be sufficient to cause a rise in water at or above land surface where solution cavities indirectly connect the "earthy" and "shell" limestones.

Large individual yields of the wells and large withdrawals at each of the dewatering sites during extended periods of time indicate that the Clayton Formation is a highly productive aquifer in the vicinity of the Chattahoochee River. Thus, the Clayton Formation is a potential source of large quantities of ground water for both industrial and municipal uses in an area readily accessible by barge transportation from Columbus, Ga., to the Gulf of Mexico.

REFERENCES

Herrick, S. M., 1961, Well logs of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 70, 462 p.

Toulmin, L. D., and Winters, S. S., 1954, Pre-Eocene solution features in southeast Alabama and southwest Georgia: Florida State Univ. Studies No. 13, Contributions to Science, no. 2, p. 72-82.

U. S. Army, Corps of Engineers, 1956, Artesian water investigations, Fort Gaines Lock and Dam, sheet 12, South Atlantic Division.

____1958, Artesian aquifer is held down in spillway cut: Eng. News-Record, v. 160, no. 9, p. 42-44, Feb.

____1959, Water resources development by the U. S. Army, Corps of Engineers in Georgia, South Atlantic Division.

——1959, Walter F. George Lock and Dam Information Pamphlet, South Atlantic Division.

Wait, R. L., 1960, Summary of the geology and ground-water resources of Clay County, Georgia: Georgia Geol. Survey Mineral Newsletter, v. 13, no. 2, p. 93-101.

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