NORTH CAROLINA
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
GEORGE R. ROSS, DIRECTOR

DIVISION OF MINERAL RESOURCES
JASPER L. STUCKEY, STATE GEOLOGIST

BULLETIN NUMBER 59

Flood-Plain Deposits of North Carolina Piedmont and Mountain Streams as a Possible Source of Ground-Water Supply

PRELIMINARY REPORT

BY
M. J. MUNDORFF

RALEIGH
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LETTER OF TRANSMITTAL

Raleigh, North Carolina

March 9, 1950

To His Excellency, HON. W. KERR SCOTT,
Governor of North Carolina.

SIR:

I have the honor to submit as Bulletin No. 59 another in the series of reports being prepared on the ground-water resources of the State of North Carolina. The present report deals with ground-water supply from flood-plain deposits along streams in the Piedmont and mountain provinces of the State. The report should be of interest to users of ground water in that it describes a new source of supply which promises to be of considerable importance.

Respectfully submitted,

GEORGE R. ROSS,
Director

MEMBERS OF THE BOARD OF CONSERVATION AND DEVELOPMENT

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Flood-Plain Deposits of North Carolina Piedmont and Mountain Streams as a Possible Source of Ground-Water Supply

PRELIMINARY REPORT BY M. J. MUNDORFF

ABSTRACT

In some parts of the Piedmont and mountain sections of North Carolina, ground-water supplies obtained from the underlying crystalline rocks have been inadequate for desired industrial and municipal development. One possible source of ground-water supply that has been generally overlooked is the deposits of sand and gravel adjacent to many of the Piedmont and mountain streams. One such deposit was developed at Camp Mackall in Richmond County, in 1942. A supply of 3,000,000 gallons of water a day was obtained from shallow wells drilled parallel to Drowning Creek, recharge to the aquifer being from the creek.

In 1947, 21 test holes were bored in the flood plains along certain streams. In addition, a reconnaissance was made of many other streams to determine the occurrence and extent of their flood plains and the character of the underlying alluvial material. Information obtained from the test borings and from the reconnaissance indicates that many of the flood plains are underlain by a sufficient thickness of permeable sands and gravels to furnish important supplies of water.

INTRODUCTION

In 1941 a systematic investigation of the ground-water resources of North Carolina was begun as a cooperative project between the Mineral Resources Division of the State Department of Conservation and Development and the Geological Survey, United States Department of the Interior. Field investigations for the basic descriptive reports have been completed in 18 counties and a great deal of information has been obtained for other areas. Some of the results of this work are contained in the following reports published by the North Carolina Department of Conservation and Development:

Information Circular No. 3, "Selected well logs in the Coastal Plain of North Carolina";
Bulletin 47, "Progress report on ground water in North Carolina";
"Hydrologic data on the Neuse River Basin, 1866-1945";
Bulletin 51, "Geology and ground-water resources of the Halifax area, North Carolina";
Information Circular No. 6, "A possible source of ground-water supply in the Elizabeth City area, North Carolina";
"Hydrologic data on the Cape Fear River Basin, 1820-1945";
"Hydrologic data on the Yadkin-Pee Dee River Basin, 1866-1945";
Bulletin 55, "Geology and ground water in the Greensboro area, North Carolina."

The investigations in North Carolina have made increasingly clear the importance of ground water in the State. In the Coastal Plain very large quantities of ground water are available, but in the Piedmont and mountain sections the quantities obtained at some places have not been sufficient to supply the needs of some industries and municipalities.

IMPORTANCE OF GROUND WATER IN THE PIEDMONT AND MOUNTAIN SECTIONS

The most thickly populated areas in the State are in the Piedmont section and about 80 per cent of the industry is in that area. A large part of the remainder is in the mountain section. Hundreds of industrial establishments depend partly or entirely upon ground water as their source of water supply. Approximately 100 municipalities in the Piedmont and mountain sections depend on ground water as a source of supply.

Ground water occurs in the joints and other fractures and openings in the rocks of the Piedmont and mountain sections. Because these openings are generally small and at many places only poorly interconnected, the yield of most wells is not large. The average yield of industrial and municipal drilled wells in the Piedmont and mountain sections is about 35 gallons a minute. Many industries and municipalities have spent considerable sums of money in attempts to obtain larger supplies, drilling as deep as 1,200 feet.

FLOOD-PLAIN DEPOSITS AS A SOURCE OF SUPPLY

One possible source of ground-water supply that has generally been overlooked is the deposits of sand and gravel adjacent to many of the Piedmont and mountain streams.

The first and, to the present time, only attempt made to obtain a large quantity of ground water from flood-plain deposits in North Carolina was for Camp Mackall in Richmond County. At that place about 3,000,000 gallons of water a day was pumped from 48 wells drilled in the sands and gravels along Drowning Creek. The source of most of the water pumped was recharged to the sands from the stream.

At Camp Mackall, two well fields were constructed in 1942, on the southwest side of Drowning Creek. The wells were drilled near the edge of a terrace bounding the swamp that at most places borders the creek. At a few places the stream has swung in against the terrace. The terrace is generally 5 to 6 feet higher than the swamp. In the north well field 20 wells were spaced at intervals of 50 feet along a nearly straight line near the edge of the terrace. In the south well field, 28 wells spaced 50 to 75 feet apart were drilled along a curving line following the edge of the terrace. At the upstream end of both well fields the channel of Drowning Creek is immediately adjacent to the terrace but the stream and terrace diverge considerably downstream and the stream is at least 500 feet from the downstream end of the north well field and probably 600 or 800 feet from the downstream end of the south well field. The wells were 6 inches in diameter and slotted casing served as screens, around which a small amount of gravel was placed. In the north well field the water-bearing sands averaged 12 feet in thickness, the base of the aquifer being an average of 17 feet below the terrace surface (10 feet below normal low water level of Drowning Creek). The deposits in the south well field averaged 10 feet in thickness and their bottom had an average elevation of 7 feet below normal low water level in Drowning Creek. Field coefficients of permeability determined in the laboratory for a number of sand samples ranged from 100 to 3,000 and averaged 1,620.[1] Permeabilities calculated from data obtained during three pumping tests ranged from 5,680 to 7,850. The wells in each field were connected by an 8-inch header and pumped by vacuum at pumping stations at the center of each line of wells.

Approximately 1,500,000 gallons per day was obtained from each field, but after pumping several months the yield declined considerably. The reason for the decline was found to be the excessive distance of many of the wells from the stream. To compensate for this, canals were dug parallel to both lines of wells, the banks of the canals being only a few feet from the wells. As digging of the canals progressed, the yield began to increase, and after completion of the canals the original yield was restored. However, the water was slightly turbid for a time because of agitation of the water and sediments during construction of the canals. It is probable that the canals were so close to the wells that the natural filtration was incomplete.

Many streams in North Carolina flow through flood plains similar to that of Drowning Creek, and although the need of large ground-water supplies is great in many parts of the State, no other attempt has yet been made to develop this source of supply. Therefore, in the spring of 1947, it was decided that a preliminary investigation should be made to determine the location, extent, and thickness of some of the flood-plain deposits that might form potentially important sources of ground-water supply.

FIELD STUDIES

The field work was done chiefly with the aid of a $600 research allotment from the Ground Water Branch, U. S. Geological Survey, but was also supported, in part, by the funds of the regular cooperative program mentioned before.

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[1]Gallons a day through 1 square foot of material under unit hydraulic gradient (1 foot per foot) at the prevailing temperature; or, gallons a day through section 1 foot thick and 1 mile wide under a hydraulic gradient of 1 foot per mile.

The writer was assisted in the field work by G. E. Siple, geologist, U. S. Geological Survey. Field work consisted in part of boring 21 test holes, which gave information on the character and thickness of the deposits underlying the flood plains of 19 streams in 10 counties. In addition, reconnaissance was made of other parts of the State, noting the streams that had flood plains of consequence, the length and width of the flood plains, and the character of the underlying material as exposed in stream banks.

The test holes were bored partly by a 3-inch post-hole auger and partly by a jetting apparatus. All the holes were started with the auger but, because of caving of the hole below the water level, it was necessary to complete most of them by jetting. The jetting apparatus was simple. It consisted chiefly of a small portable centrifugal pump and direct-connected gasoline engine, about 40 feet of 3/4-inch black iron pipe (jetting pipe), 42 feet of 2-inch galvanized pipe (casing) with couplings, and a tee and a 10-foot length of hose with couplings. The pipe was cut in lengths not exceeding 5.3 feet. Accessory equipment included the necessary fittings for connecting the hose to the pump and jetting pipe, a valve for shutting off the water at the pump, and a variety of wrenches and other tools. A very effective jetting bit was made by sawing a longitudinal slot about 1½ inches long in the end of a 3-foot length of the 3/4-inch jetting pipe, and hammering the two halves out (sideways) in opposite directions.

At most places a hole was bored about 4 feet deep with the hand auger, a 5-foot length of casing was inserted, and the hole was completed by jetting. Casing was necessary in most of the holes to prevent caving and, in a number of holes, to prevent loss of water to the permeable sands and gravels penetrated.

The coefficients of permeability were determined for 12 samples of sand and gravel. The coefficients ranged from 550 to 4,750. They are given with the records of the holes in the following table and in the descriptions of the individual holes.

TABLE SHOWING RESULTS OF TEST BORING, MAY-JUNE 1947

County	Well No.	Stream	Stage of Stream	Nature of stream bottom	Elevation of top of aquifer above (+) or below (–) stream level (feet)	Thickness of aquifer (feet)	Character of material	Coefficient of permeability [1]
Burke	T_1	Catawba R.	Low	Sand			Sand and boulders	
Cabarrus	T_1	Coldwater Cr.	Very low	do	+0.7	10.7	Coarse sand	1,750
Do	T_2	Coddle Cr.	do	do	+2.15	11.9	Medium to coarse sand	2,700
Caldwell	T_1	Lower Cr.	Low	do	+6.65	29.0	Fine to coarse sand and gravel	600–1,000
Catawba	T_1	Clark Cr.	do	do	+6.80	18.5	Medium to coarse sand	2,700
Davidson	T_1	Yadkin R.	Very low	do	+0.5	[2]	Sand, gravel, boulders	
Do	T_2	Swearing Cr.	do	do	–2.0	3.5	Sand, fine to medium	
Do	T_3	Rich Fork Cr.	do	do	+2.0	11.6	Sand and gravel	850
Durham	T_1	Northeast Cr.	Low	Silt	–3.1	12.0	Fine sand	
Do	T_2	New Hope R.	do	Silty	–2.95	0.7	Fine to medium sand	
Do	T_3	do	do	do	–7.35	1.0	Fine sand and gravel	
Guilford	T_1	So. Buffalo Cr.	do	Sand	–6.45	9.4	Sand and gravel	900
Randolph	T_1	Carraway Cr.	Very low	Sand and gravel	–3.3	2.0	do	
Rowan	T_1	Second Cr.	do	Sand	+0.85	13.5	do	620
Do	T_2	Grants Cr.	Very low	Sand	+1.6	12.5	Sand	1,400
Do	T_3	Third Cr.	do	do	+1.0	12.8	Sand and gravel	550
Wake	T_1	Crabtree Cr.	Low	do	+4.55	13.0[2]	do	
Do	T_2	Neuse R.	do	do	–4.0	6.5	do	
Do	T_3	Walnut Cr.	do	do	–3.0	0.5[2]	Gravel	
Do	T_4	Crabtree Cr.	do	do	+2.0	2.5[2]	Sand and gravel	
Do	T_5	White Oak Cr.	do	do	+2.5	12.0	do	4,700

[1] Permeability of single samples determined in laboratory; actual permeability determined by pumping tests might be greatly different (see, for example data for Camp Mackall on p. 2).

[2] Unable to penetrate to rock because of boulders or coarse gravel encountered.

RECORDS OF TEST HOLES

More detailed information on the 21 test holes is given below, by counties.

BURKE COUNTY:

T_1

Date—June 26, 1947.

Location—Morganton, about 3½ miles west of, on north bank of Catawba River.

Width of flood plain—½ to 1 mile.

Elevation of hole—About 7 feet above water level in river.

Log of hole:	Thickness (feet)	Depth (feet)
Sand	10	10
Boulders, unable to get any deeper	—	10+

CABARRUS COUNTY:

T_1

Date—June 9, 1947.

Location—Concord, 1.5 miles northeast of, 50 feet north of State Highway 73, 10 feet west of Coldwater Creek.

Width of flood plain—About ¼ mile.

Elevation of hole—9.7 feet above water level at 6:45 p. m.

Log of hole:	Thickness (feet)	Depth (feet)
Sand, dark-brown, fine-grained	1.5	1.5
Clay, dark-brown, rather hard, sandy	4.7	6.2
Sand, dark-gray to blue-gray, very fine, clayey ("salt and pepper" appearance)	2.8	9.0
Sand, light-gray to white, coarse, quartz (Permeability (P)—1,750)	10.7	19.7
Granite, disintegrated	1.5	21.2

Total depth—21.2 feet, cased to 20 feet to prevent loss of circulation in sand between 9.0 and 19.7 feet.

T_2

Date—June 10, 1947.

Location—Concord, 5.5 miles northwest of, 100 yards north of State Highway 73, 10 feet east of Coddle Creek.

Width of flood plain—About ¼ mile.

Elevation of hole—4.95 feet above water level at 5:25 p. m.

Log of hole:	Thickness (feet)	Depth (feet)
Clay, reddish-brown, very micaceous, silty	2.8	2.8
Sand, reddish-brown, medium-grained	1.5	4.3
Sand, coarse, gray, green, and black, and gravel (P-2,700)	8.7	13.0
Sand, light-gray, fine-grained; contains wood	1.7	14.7
Silt and clay, dark-blue and black	.9	15.6
Schist; very fine sandy micaceous material, very hard	.4	16.0

Total depth—16.0 feet, cased to 13.0 feet to prevent loss of circulation.

CALDWELL COUNTY:

T_1

Date—June 26, 1947.

Location—Lenoir, 1 mile south of, 150 yards south of right turn in U. S. Highway 321, 100 feet west of S. Sycamore Street extended, 15 feet south of Lower Creek.

Width of flood plain—About 100 yards on north side, 200 yards on south side of creek.

Elevation of hole—9.65 feet above water level at 12:00 noon.

Log of hole:

	Depth (feet)
Sand, medium-grained, brown, micaceous	0 — 1.0
Clay, chocolate-brown, silty, micaceous	1.0— 3.0
Sand, brown, fine- to medium-grained, micaceous	3.0—13.0
Sand, medium- to dark-gray, fine to coarse, with a few very thin layers of blue-black and chocolate-brown slightly silty plastic clay. (Sample 1, upper part of interval, P-600; Sample 2, lower part of interval, P-1,000)	13.0—30.7
Gravel	30.7—32.0
Gneissic rock (gneiss or schist)	32.0—33.25

Total depth—33.25 feet, cased to 32 feet to prevent loss of circulation.

CATAWBA COUNTY:

T_1

Date—June 27, 1947.

Location—Newton, about 1 mile west of, 100 yards north of State Highway 10, 10 feet east of Clark Creek.

Width of flood plain—150 to 300 yards.

Elevation of hole—6.80 feet above water level at 12:30 p. m.

Log of hole:

	Depth (feet)
Sand, grayish-brown to dark-brown, medium-grained	0 —11.0
Sand, gray, coarse-grained (P-2,700)	11.0—18.3
Rock, very hard (gneiss)	18.3—18.5

Total depth—18.5 feet, cased to 18.5 feet to prevent loss of circulation.

DAVIDSON COUNTY:

T_1

Date—June 2, 1947.

Location—Yadkin College, about 1.5 miles south of, 50 feet north of U. S. Highway 64, 10 feet east of Yadkin River.

Width of flood plain—About ½ mile.

Elevation of hole—7.00 feet above water level at 5:05 p. m. (general surface of flood plain 10 to 15 feet higher than test hole).

Log of hole 1a: (hole 1 abandoned at 10 feet)

	Depth (feet)
Sand, brown, medium- to fine-grained, micaceous, clayey	0 — 6.5
Sand, gray to white, coarse, quartz with some mica and grains of ferromagnesian minerals	6.5— 8.6
Boulders and gravel (?) (could not penetrate farther, lost about half of circulation)	8.6—10.5

DAVIDSON COUNTY—CONTINUED:

T_2

Date—June 13, 1947.

Location—Lexington, 4 miles west of, 200 feet north of old Salisbury highway, 8 feet west of tributary to Swearing Creek (about 150 feet upstream from junction of tributary and creek).

Width of flood plain—About 1/4 mile.

Elevation of hole—3.8 feet above water level.

Log of hole:	Depth (feet)
Clay, red-gray and brown, mottled, plastic	0 — 5.8
Sand, gray, medium-grained	5.8— 7.9
Sand, fine-grained, gray, becoming darker toward base of interval	7.9— 9.3
Rock, very hard	9.3—

Total depth—9.3 feet.

Date—June 24, 1947.

Location—Lexington, 4 miles northeast of, about 1 mile south of U. S. Highway 29, 75 yards southwest of Southern Railroad, 200 feet southwest of dirt road from U. S. Highway 29 to Holly Grove, and 15 feet west of Rich Fork Creek.

Width of flood plain—200 to 300 yards.

Elevation of hole: 6.0 feet above water level at 1:10 p. m.

Log of hole:	Depth (feet)
Sand and silt, cinnamon-colored	0 — 1.5
Silt, brown, with some fine sand	1.5— 4.0
Sand, coarse, and gravel (P=850)	4.0—12.8
Sand, fine, black and white, alternating with coarser sand and water-worn disintegrated rock	12.8—15.6
Disintegrated to hard rock	15.6—16.6

Total depth—16.6 feet, cased to 15 feet (lost circulation between 4.0 and 15.0 feet).

DURHAM COUNTY:

T_1

Date—May 26, 1947.

Location—Lowes Grove, about 1 1/4 miles southwest of (about 8 miles south of Durham), 50 feet south of county road, and 15 feet east of Northeast Creek.

Width of flood plain—1/3 mile.

Elevation of hole—4.4 feet above creek level at 4:15 p. m.

Log of hole:	Depth (feet)
Clay, dark reddish brown, very silty	0 — 7.5
Sand, medium- to coarse-grained, dark-brown, clayey	7.5—13.0
Sand, tan to gray, fine-grained	13.0—19.5
Clay, reddish-brown, silty, very plastic	19.5—20.5
Shale, dark- to reddish-brown, silty to sandy, micaceous, arkosic (Triassic, Newark group)	20.5—21.8

Total depth—21.8 feet.

DURHAM COUNTY—CONTINUED:

T_2

Date—May 27, 1947.

Location—Durham, about 7 miles south of, about 400 feet north of State Highway 54, 6 feet east of New Hope River.

Width of flood plain—½ mile (river at that point is very near east side of flood plain).

Elevation of hole—3.65 feet above water level in river at 3:30 p. m.

Log of hole:

	Depth (feet)
Clay, light-brown, very plastic, silty	0 — 1.5
Clay, gray, yellow, orange, and white, sandy, micaceous	1.5— 6.6
Sand, medium- to fine-grained, gray, quartz	6.6— 7.3
Shale, dark reddish brown, micaceous, sandy (Triassic, Newark group)	7.3— 9.9

Total depth—9.9 feet.

T_3

Date—May 28, 1947.

Location—Durham, about 10 miles south of, 2½ miles south of State Highway 54, 0.6 mile west of State Highway 55, about 200 feet west of bridge over New Hope River, 50 feet north of county road, 10 feet south of New Hope River.

Width of flood plain—0.6 mile (hole nearly in center).

Elevation of hole—3.15 feet above water level in river at 5:55 p. m.

Log of hole:

	Depth (feet)
Clay, dark-brown, orange, gray, blue-gray, very tough, silty; becomes lighter-colored with depth	0 — 7.0
Clay, light-gray to white, plastic, silty to sandy	7.0—10.5
Sand, light-gray to white, fine-grained quartz	10.5—11.0
Sand, white, coarse, and gravel	11.0—11.5
Clay, bluish-gray, silty, with some dark to orange-brown and red sandy clay (coarse sand layer, 13.55-13.85)	11.5—15.0
Shale, red silty to sandy, interbedded with thin layers of medium-grained quartz sand (Triassic, Newark group?)	15.0—16.3

Total depth—16.3 feet.

GUILFORD COUNTY:

T_1

Date—June 23, 1947.

Location—Greensboro, about 3 miles south of, 100 yards east of dirt road (South Elm Street extended) and 10 feet south of South Buffalo Creek.

Width of flood plain—About ¼ mile.

Elevation of hole—4.85 feet above water level in creek at 5:30 p. m.

GUILFORD COUNTY—CONTINUED:

Log of hole:

	Depth (feet)
Clay, dark-brown, sandy	0 — 3.5
Clay, reddish-brown and gray, sandy	3.5—11.3
Sand, gray to blue-gray, fine, becoming progressively coarser with depth	11.3—15.4
Sand, red and brown, coarse (P=900)	15.4—15.8
Gravel, coarse	15.8—16.5
Sand, gray to black, fine	16.5—20.7
Hard rock	20.7—

Total depth—20.7 feet.

RANDOLPH COUNTY:

T_1

Date—June 24, 1947.

Location—Asheboro, about 8 miles west of, ¼ mile south of U. S. Highway 64, 10 feet east of Carraway Creek.

Width of flood plain—300 to 400 yards.

Elevation of hole—7.9 feet above water level in creek at 5:30 p. m.

Log of hole:

	Depth (feet)
Clay, brown and gray, sandy	0 —11.2
Sand, coarse, steel-gray, contains much wood, gravel at base	11.2—13.2
Rock, hard (slate)	13.2—13.35

Total depth—13.35 feet.

ROWAN COUNTY:

T_1

Date—June 11, 1947.

Location—Salisbury, 9 miles west of, 25 feet north of U. S. Highway 70, 3 feet east of Second Creek.

Width of flood plain—200 to 300 yards.

Elevation of hole—0.85 feet above water level in creek at 4:30 p. m. (general surface of flood plain 7 to 9 feet higher than hole).

Log of hole:

	Depth (feet)
Sand, fine-grained, chocolate-brown, micaceous	0 — 1.0
Sand, medium-grained, gray, quartz and feldspar (P=620)	1.0— 9.0
Sand, white, coarse, and gravel	9.0—11.0
Sand, fine, dark-gray, micaceous	11.0—13.5
Disintegrated granitic rock (?)	3.5—14.2
Rock, schistose, black and brown, fine particles, silty and micaceous, mixed with angular quartz and feldspar fragments, both coarse and fine	14.2—19.8

Total depth—19.8 feet, cased to 15 feet.

T_2

Date—June 12, 1947.

Location—Salisbury, about 2 miles west of, 100 yards south of U. S. Highway 70, 6 feet east of Grants Creek.

Width of flood plain—300 to 400 yards.

Elevation of hole—10.0 feet above water level of creek (1.0 foot below surface of flood plain).

ROWAN COUNTY—CONTINUED:

Log of hole:

	Depth (feet)
Sand, brown, fine- to medium-grained, clayey	0 — 8.4
Sand gray to dark-brown, fine- to medium-grained, micaceous, angular to subrounded quartz, feldspar, and grains of ferromagnesian minerals	8.4—14.6
Sand, as above but dark green to black in color (P=1,400)	14.6—20.9
Rock, soft, consisting of hornblende augite, biotite olivine, feldspar, and quartz	20.9—21.2

Total depth—21.2 feet.

T_3

Date—June 25, 1947.

Location—Cleveland, 1½ miles west of, ¼ mile north of U. S. Highway 70, 100 yards south of the Southern Railroad, about 10 feet east of Third Creek.

Width of flood plain—100 yards on east bank, 150 yards on west bank.

Elevation of hole—9.3 feet above water level in creek at 1:15 p. m.

Log of hole:

	Depth (feet)
Sand, brown, fine- to medium-grained, micaceous	0 — 7.9
Clay, brown, tough	7.9— 8.3
Sand, medium- to coarse-grained	8.3—10.6
Clay	10.6—11.0
Sand, coarse, gray	11.0—18.0
Sand, coarse, and gravel	18.0—20.0
Sand, black, and gravel	20.0—21.5
Rock, hard	21.5—

Total depth—21.5 feet.

WAKE COUNTY:

T_1

Date—May 21, 1947.

Location—Raleigh, about 3 miles north of, 400 feet east of U. S. Highway 1 (through Millbrook), 15 feet south of Crabtree Creek.

Width of flood plain—½ mile.

Elevation of hole—12.55 feet above water level in creek at 4:00 p. m.

Log of hole:

	Depth (feet)
Sand, very fine, dark-brown, micaceous	0 — 8
Sand, gray, fine- to medium-grained, micaceous; becomes coarser with depth	8 —19
Gravel, coarse, quartz (unable to penetrate below 21 feet)	19 —21

Total depth—21 feet.

T_2

Date—May 22, 1947.

Location—Raleigh, 11 miles northeast of, 0.85 mile due east of bridge over U. S. Highway 1, 10 feet north of Neuse River.

Width of flood plain—½ to ¾ mile.

Elevation of hole—6.5 feet above water level at 12:15 p. m.

WAKE COUNTY—CONTINUED:

Log of hole:

	Depth (feet)
Sand, medium- to dark-brown, very fine grained, micaceous, slightly clayey	0 —10.5
Sand, light- to medium-gray, fine- to medium-grained, micaceous	10.5—13.0
Gravel (?)	13.0—15.0
Sand, (same as 10.5—13.0)	15.0—17.0
Clay, light-gray	17.0—19.7

Total depth—19.7 feet.

T_3

Date—May 22, 1947.
Location—Raleigh, 2 miles southwest of, 40 feet northwest of Rhamkatte road, 8 feet north of Walnut Creek.
Width of flood plain—¼ mile.
Elevation of hole—2 or 3 feet above creek level.

Log of hole:

	Depth (feet)
Sand, tan and gray, slightly clayey	0 — 5.5
Gravel, coarse (unable to drill or bore deeper)	5.5— 6.0

Total depth—6.0 feet.

T_4

Date—May 23, 1947.
Location—Cary, 3½ miles northwest of (½ mile southeast of Morrisville), 100 yards east of U. S. Highway 70, 50 feet south of Crabtree Creek.
Width of flood plain—½ mile.
Elevation of hole—About 10 feet above creek level.

Log of hole:

	Depth (feet)
Sand and silt	0 — 1.5
Clay, compact, red, becoming sandy with depth	1.5— 8.0
Sand, red to gray, coarse, and gravel (becomes more gravelly with depth, unable to bore beyond 10.5 feet, hand auger used, jetting not attempted)	8.0—10.5

T_5

Date—June 5, 1947.
Location—Cary, 8.2 miles south 76° west of, about 2 miles north of U. S. Highway 64 (1¾ miles southwest of Green Level), 100 feet southwest of dirt road, 5 feet northwest of White Oak Creek.
Width of flood plain—⅓ mile.
Elevation of hole—About 3 feet above creek level.

Log of hole:

	Depth (feet)
Sand, light-brown to tan, medium-grained	0 — 2.5
Clay, gray (wet)	2.5— 4.5
Sand, gray to white, coarse (P=4,750)	4.5— 6.5
Sand, gray, coarse, slightly clayey	6.5—12.0
Sandstone, dense, white, arkosic, and shale (Triassic)	12.0—12.8

Total depth—12.8 feet.

OCCURRENCE OF GROUND WATER IN FLOOD-PLAIN DEPOSITS

CHARACTER OF DEPOSITS

Study of the logs of the test holes bored indicates that permeable water-bearing sands generally occur 5 to 12 feet below the surface of the flood plain. Usually the top of these sands is at about the same elevation as the low-water stage in the stream. The materials overlying the water-bearing sands include fine sands, silts, and clays. The water-bearing sands range in size from medium-grained sand to fine gravel.

SOURCE OF WATER

Although the materials overlying the permeable aquifers in the flood plains generally are not very permeable, the permeability in most places is sufficient to permit a considerable part of the precipitation to percolate slowly downward through them to recharge the underlying sands. At most times the water table slopes towards the streams, and ground water is discharged into them. However, during periods of flood when the river level rises above the water table, the situation is reversed and stream water recharges the flood-plain deposits. After the flood subsides this water returns slowly to the stream. It is apparent, therefore, that where the stream flows on or against permeable sand or gravel, recharge from the stream can be induced by lowering the adjacent water table by pumping from wells constructed near the stream.

RECHARGE FROM PRECIPITATION

The quantity of water recharged to the flood-plain deposits from precipitation probably is not more than a quarter to a third of the total precipitation. The average annual precipitation throughout the State is about 48 inches, so that the yearly recharge from rainfall might be roughly 12 to 15 inches of water. It is improbable that much recharge is added by runoff from slopes adjacent to the flood plain, as most of this runoff is concentrated in regular channels by the time it reaches the flood plain and is discharged directly into the stream. A rate of recharge of 12 inches per year over the area of a flood plain is equivalent to 0.62 gallon a minute per acre of flood plain. Assuming a flood plain 500 feet wide and 2,000 feet long, the area of 1,000,000 square feet or 22.9 acres would be recharged at the rate of 14.2 gallons a minute.

If no recharge were available from the stream, the maximum rate at which water could be withdrawn continuously from a flood plain of the above dimensions would be 14.2 gallons a minute, and to obtain this amount would require a large number of wells scattered over the flood plain. Because of removal of water from storage in the sands, the rate of withdrawal of course would be greater at first than it would be later.

The quantity of water available from storage in a saturated sand 10 feet thick, having an effective porosity or specific yield of 20 per cent and occupying an area of 22.9 acres, is about 15,000,000 gallons. Probably not more than half this amount could be withdrawn even from numerous closely spaced wells, or an amount equivalent to about 14 gallons a minute for a year.

It is obvious from the above that, if any large quantity of water were required, recharge from rainfall would be inadequate.

RECHARGE FROM STREAMS

In nearly all the streams examined, the permeable saturated sands and gravels found under many of the flood plains either cropped out in the stream or were covered only by fine sands that would permit easy entrance of stream water into the aquifer.

Calculations have been made, using the formulas devised by Theis,[1] in order to arrive at an estimate of the amount of water that could be pumped from a line of wells in a flood plain parallel to a stream under certain assumed conditions. The conditions assumed for the primary calculations are as follows:

Basic conditions:

1. The stream follows essentially a straight course.
2. The impermeable valley wall bounding the flood plain is parallel to the stream.

[1] Theis, C. V., The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., 1935, pp. 519–524.

3. The flood plain on only one side of the stream is considered.
4. The sand or gravel comprising the aquifer is homogeneous.
5. The aquifer lies below impermeable materials, except where it is in contact with the stream, so that confined (artesian) conditions exist.

Assumed numerical values:

1. Width of flood plain—500 feet.
2. Distance from stream to line of wells—200 feet.
3. Distance from valley wall to line of wells—300 feet.
4. Thickness of aquifer—10 feet.
5. Depth to base of aquifer, below water level in stream—20 feet.
6. Maximum drawdown—10 feet.
7. Permeability of aquifer—2,500.

With these conditions and values, a line of 20 wells parallel to the stream and spaced 100 feet apart theoretically would yield about 1,500 gallons a minute. Doubling the spacing of the wells and reducing the number to 10, so that the same length of flood plain would be occupied, would decrease the yield by about 25 per cent. An increase in spacing to 400 feet, so that only 5 wells would be used, would reduce the yield to slightly less than half the yield of the 20 wells.

For water-table (nonartesian) conditions, using the same factors assumed above except that the base of the aquifer is 10 feet below the water level in the stream (giving a saturated thickness at the stream of 10 feet), the quantities that could be pumped would be about half the quantities for artesian conditions.

TEMPERATURE OF GROUND WATER IN FLOOD-PLAIN DEPOSITS

The temperature of shallow ground water in the Piedmont and mountain sections of North Carolina ranges from about 58° F. in the western part of the State to about 62° F. in the southeastern Piedmont. This range in ground-water temperature is determined by the range in mean annual air temperature, the temperature of the shallow ground water generally being 2 or 3 degrees higher than the mean annual air temperature. (Deeper ground waters are warmer, the temperature increasing about 1° F. for every 50 to 100 feet of depth.) The average temperature of ground water measured in 11 wells in Guilford County was 61° F., whereas the average annual air temperature is 59° F.

The temperature of ground water obtained from flood-plain deposits, when pumping commenced, therefore, would range from about 58° to 62° F., depending upon the location. As pumping continued, more and more water would be recharged to the aquifer from the stream. Pumping at the rate of one to several millions of gallons a day eventually would mean that probably 80 per cent or more of the recharge would be from the stream and the temperature of the water would vary between the normal ground-water temperature and the temperature of the stream water. Under the conditions that were assumed in calculating the quantity of water that could be obtained from flood-plain deposits—that is, a distance of 200 feet from the stream, a permeability of 2,500, and a thickness of 10 feet below the stream level—calculations indicate that a part of the water would travel to the wells in about 5 to 10 days. Stream temperatures generally are about the same as the average monthly air temperature, although for shorter periods they may be considerably higher. At Asheville the average monthly air temperature ranges from 38.1° F. in January to 72.2° F. in July and at Raleigh from 41.7° F. in January to 78.3° F. in July.

Water flowing from a stream to the well enters the sand at many places and travels by many paths. Water traveling by one path may take several times as long as water traveling by a shorter path. Also, part of the water pumped will be water withdrawn from storage and water recharged by rainfall. Furthermore, the temperature of the earth itself will affect the temperature of the water entering the sand from the stream, cooling the water in the summer and warming it in the winter. Thus, in the summer the water reaching the well will be somewhat warmer than the normal ground water but cooler than the stream water, and in the winter it will be cooler than the normal ground water but warmer than the stream water.

At the Indiana Ordnance Works, near Louisville, Kentucky, water is pumped from seven horizontal collectors within 100 feet of the river's edge at normal pool stage. Pumpage from the entire collector field generally ranges from 30 to 50 million gallons a day. According to Kazmann[1] the temperature of the water pumped ranged from 49° F. to 70° F., although the temperature of the river water ranged from 33° F. to 86° F.

At Parkersburg, West Virginia, 16 of the 18 municipal wells are located 100 to 150 feet from the low-water line of the Ohio River. A large proportion of the water pumped is undoubtedly recharged to the aquifer from the river. Daily pumpage generally ranges from 3,500,000 to 4,000,000 gallons. According to Jeffords[2] the average monthly temperature of the water discharged ranges from about 52°-54° F. in April to 63°-66° F. in September or October, although the temperature of the Ohio River ranged from about 32° F. to 80° F.

It is probable that water pumped from wells recharged by streams in North Carolina would have no greater variation in temperature range than that along the Ohio—perhaps 10° F. higher in the summer and 10° F. lower in the winter than the usual ground-water temperature.

SANITARY QUALITY OF WATER

Not a great deal of information is available regarding the sanitary quality of water to be expected when an aquifer is recharged by a stream. Kazmann[1] states, "The bacteriological quality of the water discharged by the collectors at the Indiana Ordnance Works was extremely good. Gas forming organisms were rarely found in the water, and it is believed that the gas formers as well as the few coliform organisms which were found by bacteriological tests were the results of careless sampling technique, despite the heavy pollution of the Ohio River. Tastes and odors were apparently absent from the water discharged by the collectors, although no systematic attempt was made to detect them."

According to Jeffords[2] the contaminated river water at Parkersburg, West Virginia, undergoes "sufficient natural filtration or other changes to lose its objectionable pathologic properties before reaching the wells."

Probably no sizable stream in North Carolina is as greatly polluted as the Ohio River. No doubt a well just a few feet from a polluted stream would yield polluted water, but it also is quite probable that wells 100 or 200 feet from such a stream would yield pure water. Just how far water needs to travel through sand and gravel in order to be purified is not known; but it is certain that the distance necessary would be affected by various factors such as the type and grain size of sand or gravel, the gradient between the stream and the wells, and possibly also the temperature and chemical character of the water. No doubt the kind of pollution, whether industrial waste or sewage, would have considerable effect also.

GROUND WATER IN FLOOD-PLAIN DEPOSITS, BY RIVER BASINS

Most of the streams along which extensive flood-plain deposits occur are listed, by stream basins and counties, in the following pages. Most of these flood-plain deposits are also shown on the map, plate 1.

A great number of smaller flood plains are not listed or shown, although many of these probably could furnish moderate supplies of ground water.

The flood plains along most of the streams are rarely continuous for more than a few miles. They have developed by erosion and subsequent deposition in stretches of relatively nonresistant rocks, and these stretches are interrupted by stretches of resistant rocks in which flood-plain sediments are not important.

DAN-ROANOKE BASIN

The Dan-Roanoke basin includes parts of Stokes, Forsyth, Rockingham, Caswell, Person, Granville, Vance, Warren, and Halifax Counties. A small part of the basin, mostly along the northern boundary of the State, is included on the Stuart, Critz, Martinsville, Draper, Danville, Roxboro, Oxford, White Plains, and Emporia topographic quadrangle maps.

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[1] Kazmann, R. G., River infiltration as a source of ground-water supply: Am. Soc. Civil Eng. Proc., vol. 73, no. 6, pt. 1, June 1947.
[2] Jeffords, Russell M., Ground-water conditions along the Ohio Valley at Parkersburg, West Va.: West Virginia Geol. Survey Bull. 10, 1945.
[1] Op. cit.
[2] Op. cit.

No test holes were bored in this basin. Topographic maps, soil maps, and field observations indicate that flood-plain deposits occur along some parts of Dan River, Roanoke River, and many smaller streams. Listed by counties the streams with important flood-plain deposits are:

Stokes County: Dan River, Town Fork Creek.
Rockingham County: Wolf Island Creek.
Caswell County: Hogan Creek, Moore Creek, Country Line Creek, Hyco Creek.
Person County: Story Creek, Marlowe Creek, Maho Creek, Hyco Creek.
Granville County: Johnsons Creek, Grass Creek, Little Island Creek.
Vance County: Island Creek, Little Island Creek, Nutbush Creek.
Warren County: Smith Creek, Hawtree Creek, Stonehouse Creek.

The flood plains along most of these streams are interrupted at numerous places by narrower stretches where the rock apparently is more resistant to erosion, preventing the development of the flood plain. It is probable that at many places the flood-plain deposits are thick enough and permeable enough to yield large amounts of ground water, but test drilling will be necessary to prove this and to determine the extent and thickness of the deposits.

TAR RIVER BASIN

The Tar River Basin includes parts of Person, Granville, Vance, Warren, Franklin, Halifax, and Nash Counties. A part of the basin is included on the Roxboro, Oxford, Creedmoor, Spring Hope, and Rocky Mount quadrangle maps.

No test holes were bored in this basin. The available maps, supplemented by field observations, indicate that there are numerous flood plains of sufficient length and width to yield large supplies of ground water, provided that the deposits contain permeable material extending 10 or 15 feet below the low-water level in the streams. The similarity of the flood plains in this basin to those in other basins where more information is available suggests that at many places the flood-plain deposits are capable of furnishing considerable quantities of water.

Streams along which flood-plain deposits of considerable extent occur are listed below by counties.

Granville County: Tar River (for a short distance, near Tar River station).
Vance County: Ruin Creek.
Warren County: Fishing, Little Fishing Creek, Reedy Creek, Shocco Creek, Little Shocco Creek.
Franklin County: Tar River, Cedar Creek, Crooked Creek, Cypress Creek, Sandy Creek.
Halifax County: Fishing Creek (at some places), Little Fishing Creek, Reedy Creek.
Nash County: Fishing Creek (at a few places), Swift Creek (below Gold Rock), Stony Creek and Basket Creek (near Nashville), Sapony Creek, Little Sapony Creek, Peachtree Creek, Little Peachtree Creek, Tar River (at a few places).

NEUSE RIVER BASIN

The Neuse River Basin includes parts of Person, Orange, Durham, Granville, Wake, Nash, Wilson, and Johnston Counties. A considerable part is included on the Chapel Hill, Durham North, Durham South, Creedmoor, Raleigh, Spring Hope, Rocky Mount, Kenly, and Wilson quadrangle maps.

Four test holes, Wake County T_1, T_2, T_3, and T_4, were bored in the stream deposits of this basin. Two of the holes were not completed because the material was coarse gravel that could not be penetrated with the available equipment.

Granite, gneiss, schist, and slate underlie a large part of the basin and, although the flood plains developed on these rocks are not continuous, the deposits where present appear to be thick enough and extensive enough to yield large amounts of water. The material is generally quite permeable. The flood plains appear to be particularly well developed in areas underlain by granite or gneiss, and the deposits in these areas generally are quite coarse. Three test holes, Wake County T_1, T_2, and T_3, were bored in flood plains developed on these rocks in the Neuse River Basin, of which two were satisfactorily completed. In T_1

there was 8.5 feet of permeable sand and gravel below the water level in Crabtree Creek. In T_2, 10.5 feet of permeable sand and gravel was found below the water level of the Neuse River. T_3, in the flood plain of Walnut Creek, could not be completed because of the coarseness of the material encountered. T_4 was bored in the flood plain of Crabtree Creek, near Morrisville, where the stream is underlain by Triassic rocks. The hole could not be completed because of the gravel encountered. Evidence from this hole is inconclusive, but test holes bored in flood plains developed on Triassic rocks in the Cape Fear Basin suggest that generally the flood-plain deposits in areas underlain by Triassic rocks are rather thin and consist mostly of fine sands and clays. Moderate supplies of ground water probably can be developed at many places, but large supplies may not be available except at a few places.

Streams along which flood-plain deposits occur, by counties, are:

Person County: Deep Creek.
Durham County: Flat River, Eno River, Neuse River, Ellerbee Creek, Lick Creek, Little Lick Creek (all these in Triassic rocks).
Granville County: Knap of Reeds Creek, Ledge Creek, and Beaverdam Creek (all in Triassic).
Wake County: Neuse River, Crabtree Creek (part in Triassic, part in granite and gneiss), Brier Creek, Stirrup Iron Creek (in Triassic only), Walnut Creek, Swift Creek, Middle Creek (in gneiss and schist).
Nash County: Moccasin Creek, Turkey Creek, Toisnot Swamp.
Wilson County: Toisnot Swamp, Bloomery Swamp, Contentnea Creek.
Johnston County: Little Buffalo Creek, Buffalo Creek, Little River, Neuse River, Swift Creek, Middle Creek, Black Creek.

CAPE FEAR RIVER BASIN

Included in the Cape Fear River Basin are parts of Rockingham, Caswell, Guilford, Alamance, Orange, Durham, Randolph, Chatham, Wake Moore, Lee, Harnett, and Cumberland Counties. A very small part of the area is included on the Chapel Hill, Durham South, and Troy quadrangle maps.

The upper end of the basin, in Rockingham and Guilford Counties, is underlain chiefly by granite and gneiss, and extensive flood plains have developed along several streams. One test hole, Guilford County T_1, was bored in that area. Permeable sands and gravels were penetrated between 11.3 and 20.7 feet, (15.85 feet below the water level in the creek) and the total thickness of these materials was 9.4 feet.

Southeast of this area, including the southeastern part of Guilford County, Alamance, Orange, Randolph, and Chatham Counties, and the northwest part of Moore County, the streams are underlain by slate. In that area flood plains are lacking or are very poorly developed and it is probable that only small supplies of ground water can be developed from the few deposits present.

Southeast of the slate is a belt of sandstones and shales of Triassic age on which wide and extxensive flood plains have developed. Test holes, Durham County T_1, T_2, T_3, and Wake County T_5, were bored in these flood plains. These borings suggest that, although the flood plains are wide and long, the deposits are generally rather thin and contain a large proportion of clays and fine sands. It is probable that moderate supplies of ground water (possibly a few hundred gallons a minute from a number of wells) can be developed at many places, but at only a few places could larger supplies be developed. Southeast of the belt of Triassic rocks are granites, gneisses, and schists on which a considerable number of flood plains have developed. Most of these are moderately wide and some extend for several miles without interruption. No test holes were bored in that section, but the similarity of these flood plains to that of Drowning Creek near Hoffman, where a ground-water supply of about 3,000,000 gallons a day was developed, suggests that large ground-water supplies could be developed at a number of places.

Streams along which flood-plain deposits occur, by counties, are:

Rockingham County: Troublesome Creek, Little Troublesome Creek, Haw River.
Guilford County: Haw River, Reedy Fork, Richland Creek, Horsepen Creek, South Buffalo Creek.
Durham County: New Hope River, Morgan Creek, Northeast Creek.
Chatham County: New Hope River, Whiteoak Creek, Beaver Creek.

Wake County: Whiteoak Creek, Beaver Creek.
Lee County: Deep River, Lick Creek, Upper Little River.
Moore County: Richland Creek, McLennon Creek, Crane Creek, Lower Little River.
Cumberland County: Little River.
Harnett County: Cape Fear River, Upper Little River, Barbecue Swamp, McLeod Creek.

YADKIN RIVER BASIN

Included in the Yadkin River basin are parts or all of Wilkes, Surry, Yadkin, Caldwell, Alexander, Iredell, Davie, Forsyth, Randolph, Davidson, Rowan, Mecklenburg, Cabarrus, Union, Stanly, Montgomery, Anson, Richmond, and Moore Counties. A considerable part of the basin is included on the Cranberry, Morganton, Wilkesboro, Yadkinville, Hickory, Statesville, Charlotte, Monroe, Albemarle, Wadesboro, Troy, and Rockingham quadrangle maps.

In the upper part of the basin most of the streams flow southeastward from the Blue Ridge escarpment. They have steep gradients and have cut down rapidly so that flood plains have not developed. The base level of a few streams has been held up at some places by more resistant rocks, so that flood plains have developed upstream from these places. A few other streams flow parallel to the Blue Ridge front, and along these streams flood plains have developed also.

In the central part of the basin, particularly in Iredell, Cabarrus, Rowan, Davie, and Davidson Counties, the streams flow for relatively long distances before entering the Yadkin River. The rocks are principally granites, gneisses, and schists, and many of the streams have very well developed flood plains.

Nine test holes were drilled in four counties in this area, including Cabarrus County T_1 and T_2, Davidson County T_1, T_2, and T_3, Randolph County T_1, and Rowan County T_1, T_2, and T_3. Of these nine wells, one, Randolph County T_1, was bored on a flood plain developed on slate. In this hole, on the bank of Carraway Creek, only 2 feet of permeable sands was penetrated and slate was entered at 13.35 feet (5.35 feet below the water level in the creek). There are several sections of well-developed flood plain along Carraway Creek and Uharrie River, but most of the other streams on slate have poorly developed or no flood plains. It may be that moderate supplies of ground water could be developed along Carraway Creek or Uharrie River but large supplies probably are not available.

The other eight test holes were on flood plains developed on granite, gneiss, or schist. One test hole, Davidson County T_1, was on the flood plain of the Yadkin River and could not be completed because coarse gravel or boulders was encountered. One test hole, Davidson County T_2, penetrated only 3.5 feet of permeable material, but in the other six holes the thickness ranged from 10.7 to 13.5 feet and the base of the permeable sands ranged from 9.35 to 12.75 feet below the water levels of the streams. The sands and gravels found in all these test holes appeared to be very permeable. Also, as the thickness and depth in all are greater than the thickness and depth of the deposits on Drowning Creek, at Camp Mackall, in Moore County, where a supply of 3,000,000 gallons a day was developed, it is probable that large supplies of ground water could be developed at most of these locations.

Streams along which flood-plain deposits occur, by counties, are:

Caldwell County: Yadkin River.
Watauga County: Elk Creek.
Wilkes County: Yadkin River.
Surry County: Fisher River, Stewart Creek, Level Creek, Ararat River, Mitchell River.
Yadkin County: North Deep Creek, South Deep Creek, Logan Creek, Forbush Creek.
Forsyth County: Muddy Creek, North Fork, Middle Fork, South Fork.
Alexander County: South Yadkin River, Mill Creek.
Iredell County: Hunting Creek, Rocky River, Mud Creek, South Yadkin River, Fifth Creek, Fourth Creek, Third Creek.
Davie County: Dutchman Creek, Cedar Creek, Elisha Creek, Bear Creek, Hunting Creek.
Rowan County: Third Creek, Fourth Creek, Withrow Creek, Back Creek, Sills Creek, Sloans Creek, Second Creek, Grants Creek, Town Creek, Crane Creek, Reedy Creek. .
Davidson County: Muddy Creek, Reedy Creek, Swearing Creek, Abbotts Creek, Rich Creek.

Randolph County: Uharrie River, Carraway Creek.

Cabarrus County: Dutch Buffalo Creek, Coldwater Creek, Little Coldwater Creek, Buffalo Creek, Coddle Creek, Rocky River, Mallard Creek.

Montgomery County: Cheek Creek, Little River (a few miles, near mouth).

Union County: Lanes Creek.

Anson County: Brown Creek, Little Brown Creek, Goulds Fork, Cedar Creek, Savannah Creek.

Richmond County: Hamer Creek, Buffalo Creek, Cartledges Creek.

Moore County: Deep Creek, Drowning Creek.

CATAWBA RIVER BASIN

Included in the Catawba River Basin are parts or all of McDowell, Burke, Caldwell, Avery, Alexander, Iredell, Catawba, Lincoln, Gaston, Cleveland, Mecklenburg, and Union Counties. Almost all of the area is included on the Mount Mitchell, Morganton, Cranberry, Wilkesboro, Hickory, Lincolnton, Gastonia, Kings Mountain, and Charlotte quadrangle maps.

In some parts of the basin, particularly at the upper end, in the vicinity of Marion, Morganton, and Lenoir, the flood plains are wide and extensive. Three test holes were bored in the basin, two of which were completed. The hole in the flood plain of the Catawba River near Morganton was abandoned at 10 feet because of the boulders encountered. Test hole Caldwell County T_1, near Lenoir, showed the thickest section of sand and gravel of all the test holes put down in this study, 29 feet of permeable sands and gravels being found, of which 22.35 feet was below the water level of Lower Creek. It is probable that the flood plains of Warrior Fork, Johns River, Silver Creek, and some of the other streams of that area would show similar sections. Test hole Catawba County T_1, near Newton, was bored on the flood plain of Clark Creek. This hole showed medium- and coarse-grained sand from the surface to 18.3 feet (11.5 feet below water level in the creek).

Streams along which flood-plain deposits occur, by counties, are:

McDowell County: Catawba River, Buck Creek, North Fork, Crooked Creek, North Muddy Creek, South Muddy Creek.

Burke County: Catawba River, Linville River, Johns River, Warrior Fork, Lower Creek, Silver Creek.

Caldwell County: Lower Creek, Johns River, Lower Little River.

Alexander County: Lower Little River, Middle Little River, Upper Little River.

Catawba County: Clark Creek, Lyle Creek, Bell Creek, Mountain Creek.

Iredell County: Buffalo Shoals Creek, Davidson Creek.

Lincoln County: South Fork, Indian Creek, Clark Creek, Leepers Creek, Killiam Creek.

Gaston County: South Fork, Long Creek, Dutchmans Creek, Crowders Creek.

BROAD RIVER BASIN

The Broad River Basin includes large parts or all of Cleveland, Rutherford, and Polk Counties and small areas in Henderson, Buncombe, and McDowell Counties. About half the area is included on the Saluda, Mount Mitchell, Morganton, Lincolnton, Gaffney, and Kings Mountain quadrangle maps.

A number of streams in Polk and Rutherford Counties have rather wide flood plains. Although no test holes were drilled in this basin, the physiography and geology are similar to those in the vicinity of Newton, Catawba County, and Lenoir, Caldwell County (Catawba River Basin), and suggest that permeable sands will be found to depths ranging from 10 to 30 feet below the water levels of the streams.

A number of wells have been drilled for individuals in the valley of the Pacolet River, near Tryon. The flood-plain materials penetrated were reported by the well owners as having a thickness ranging from 20 to 60 feet, and several of the owners reported sand and gravel at the base of the alluvium.

Streams along which flood-plain deposits occur, by counties, are:

Polk County: North Pacolet River, Green River, White Oak Creek, Walnut Creek.

Rutherford County: Second Broad River, Camp Creek, Cane Creek, Catheys Creek, First Broad River, Robinson Creek, Mountain Creek, Maple Creek, Richardson Creek, Floyds Creek.

Cleveland County: Buffalo Creek, Muddy Fork.

FRENCH BROAD RIVER BASIN

The French Broad River Basin includes parts or all of Jackson, Transylvania, Henderson, Haywood, Buncombe, Madison, Yancey, Mitchell, and Avery Counties. The entire area is included on the Cowee, Pisgah, Saluda, Mount Mitchell, Asheville, Mount Guyot, Roan Mountain, and Cranberry 30-minute quadrangle maps, and parts of the area are included on a number of 7½-minute quadrangle maps.

Many of the flood plains are wide and long. The few available records of wells in some of the flood plains indicate that many of the flood-plain deposits range from 30 to 60 feet in thickness. It is probable that this basin is one of the most favorable for the development of large ground-water supplies from the flood-plain deposits. No test holes were bored in this basin. However, logs of 12 wells of the Champion Fibre Company in the valley of the Pigeon River at Canton, Haywood County, show 19 to 77 feet of flood-plain material. The average thickness of flood-plain material shown by the 12 wells is 49 feet, 8 of the 12 showing 55 feet or more and 4 of the wells showing 19 to 25 feet.

Typical logs are as follows:

WELL 2

Depth, 200 feet
Diameter, 6 inches

	Thickness (feet)	*Depth* (feet)
Soil	17	17
Gravel	3	20
Granite	120	140
Soft black rock	16	156
Granite	44	200

WELL 9

Depth, 202 feet
Diameter, 6 inches

	Thickness (feet)	*Depth* (feet)
Dirt	14	14
Boulders and flint	4	18
Quicksand	3	21
Gravel and coarse sand	4	25
Quicksand	2	27
Gravel and coarse sand	50	77
Soft Rock	5	82
Sandstone (?) rock	100	182
Sandstone (?) and granite	20	202

WELL 5

Depth, 169 feet
Diameter, 6 inches

	Thickness (feet)	*Depth* (feet)
Dirt	50	50
Gravel	10	60
Sandstone (?)	30	90
Granite	79	169

Apparently no attempt was made to develop ground-water supplies from the sand and gravel, probably because the drillers in that area are not accustomed to set screens and develop water supplies from unconsolidated deposits.

Streams along which flood-plain deposits occur, by counties, are:

Haywood County: Pigeon River, East Pigeon River, West Pigeon River, Richland Creek, Beaverdam Creek, Crabtree Creek, Jonathan Creek, Cataloochee Creek, Fines Creek, Big Creek.
Transylvania County: French Broad River, Davidson River, Crab Creek.
Henderson County: French Broad River, Cane Creek, Hooper Creek, Mud Creek, Clear Creek, Boylston Creek, Mills River.
Buncombe County: French Broad River, Hominy Creek, South Hominy Creek, Swannanoa River, Reems Creek, Dillinghams Creek, Flat Creek, Turkey Creek, Newfound Creek.
Madison County: Laurel Creek, California Creek, Middle Fork, Paint Fork, Bull Creek, Spring Creek, Meadow Creek.
Yancey County: South Toe River, Crabtree Creek, Little Crabtree Creek, Cane River.
Mitchell County: Rock Creek, Little Rock Creek, Cane Creek.

WATAUGA RIVER BASIN

A small area in northwestern North Carolina, including parts of Avery and Watauga Counties, is in the Watauga River Basin. The area is included on the Cranberry quadrangle map.

Several of the streams have flood plains of considerable extent and width, and, although no test holes were drilled and other information is not available regarding the thickness or character of the material, it is probable that these deposits are similar to those found in the basin of the French Broad River.

Streams along which flood-plain deposits occur, by counties, are:

Avery County: Elk Creek.
Watauga County: Watauga River, Core Creek, Beaverdam Creek.

NEW RIVER BASIN

The northwestern corner of the State, including parts or all of Watauga, Wilkes, Ashe, and Alleghany Counties, is in the New River Basin. The area is included on the Cranberry, Wilkesboro, Abingdon, Wytheville, and Hillsville quadrangle maps.

A number of streams have fairly wide flood plains extending for stretches of several miles at intervals along their courses. No test holes were drilled in this basin, nor is any other information available regarding the thickness or character of the deposits; however, it appears likely that the deposits compare favorably with those in adjoining basins, and that large supplies of ground water could be developed at a number of places.

Streams along which flood-plain deposits occur, by counties, are:

Watauga County: South Fork, New River, Middle Fork, Meat Camp Creek, Flannery Fork.
Ashe County: North Fork New River, Laurel Creek, Roundabout Creek, Beaver Creek, South Fork New River (at a few places).
Alleghany County: Little River, Pine Swamp Creek, Glade Creek, Brush Creek, Crab Creek, Piney Fork.

LITTLE TENNESSEE RIVER BASIN

Included in the Little Tennessee River Basin are most of Macon, Jackson, Graham, and Swain Counties. This area is included on the Pisgah, Cowee, Mount Guyot, Knoxville, and Nantahala 30-minute quadrangle maps, and a considerable number of 7½-minute quadrangle maps are available.

In this basin are some of the widest and most extensive flood plains of the Piedmont and mountain sections. Although no test wells were drilled and no other information is available regarding the thickness and character of the material in the flood-plain deposits, it is probable that they are similar to those in the basin of the French Broad River, where the deposits are as much as 77 feet thick and contain considerable coarse sand and gravel.

Streams along which flood-plain deposits occur, by counties, are:

Graham County: Panther Creek, Stecoah Creek, Sawyer Creek, Tuskegee Creek, Yellow Creek, Sweetwater Creek, Long Creek, Atoak Creek, Tulula Creek, Mountain Creek.

Swain County: Alarka Creek, Tuckasegee River, Deep Creek, Cooper Creek, Forney Creek, Noland Creek, Hazel Creek, Oconaluftee River.

Jackson County: Soco Creek, Shoal Creek, Camp Creek, Tuckasegee River, Savannah Creek, Scott Creek, Cutowhee Creek.

Macon County: Little Tennessee River, Tessentee Creek, Cullasagee River, Ellijoy Creek, Coweeta Creek, Cartoogechaye Creek, Cowee Creek, Burningtown Creek, Nantahala River.

SAVANNAH RIVER BASIN

A small area, including a small part of Macon, Jackson, and Transylvania Counties, is in the Savannah River Basin. It is included on the Cowee and Pisgah 30-minute quadrangle maps.

No test holes were bored in this basin, nor is any other information available regarding the character and thickness of the flood-plain deposits. However, several streams have wide flood plains at some places, which probably would furnish considerable quantities of ground water.

Streams along which flood-plain deposits occur, by counties, are:

Jackson County: Chattooga River, Whitewater River, Horsepasture River.

Transylvania County: Whitewater River, Horsepasture River.

HIAWASSEE RIVER BASIN

Included in the Hiawassee River Basin are most of Cherokee and Clay Counties. The area is covered by the Murphy and Nantahala 30-minute quadrangles and a number of $7\frac{1}{2}$-minute quadrangles.

Many of the streams in this basin have wide and extensive flood plains. Although no information is available as to the character and thickness of the materials in the flood plains, it is probable that the deposits compare favorably with those in the Little Tennessee River Basin and the French Broad River Basin and that large supplies of ground water can be obtained at many places.

Streams along which flood-plain deposits occur, by counties, are:

Cherokee County: Valley River, Tatham Creek, Junaluska Creek, Worm Creek, Peachtree Creek, Slow Creek, Little Brasstown Creek, Owl Creek, Hanging Dog Creek, Grape Creek, Beaverdam Creek, Sular Creek, Cane Creek, Camp Creek, Shoal Creek, Bearpaw Creek, Persimmon Creek, Nottely River, Martin Creek.

Clay County: Hiwassee River, Tusquitee Creek, Drowning Creek, Shooting Creek, Blair Creek, Qualls Creek, Brasstown Creek, Sweetwater Creek.

SUMMARY

The flood-plain deposits along many of the streams in the Piedmont and mountain sections of North Carolina at many places appear to contain deposits of permeable sands and gravels of sufficient thickness and extent to furnish large quantities of water to lines of wells or to galleries parallel to the streams where their perennial flow is adequate. Recharge from the stream would be induced by pumping the wells or galleries and lowering the water table below stream level. At many places one to several million gallons of water a day could be obtained by this method, and at some places, particularly in the western part of the State, where the flood-plain deposits appear to be thicker, substantially larger supplies might possibly be obtained.

Only a small amount of specific information is available at the present time. A great many more borings should be made to show the thickness, extent, and character of the material along the streams. Pumping tests would be desirable in order to arrive at more definite figures for the permeability of the sands. More information is needed on the quality of water recharged from the streams and on the fluctuations in temperature.

PRINCIPAL RIVER BASINS
OF
NORTH CAROLINA