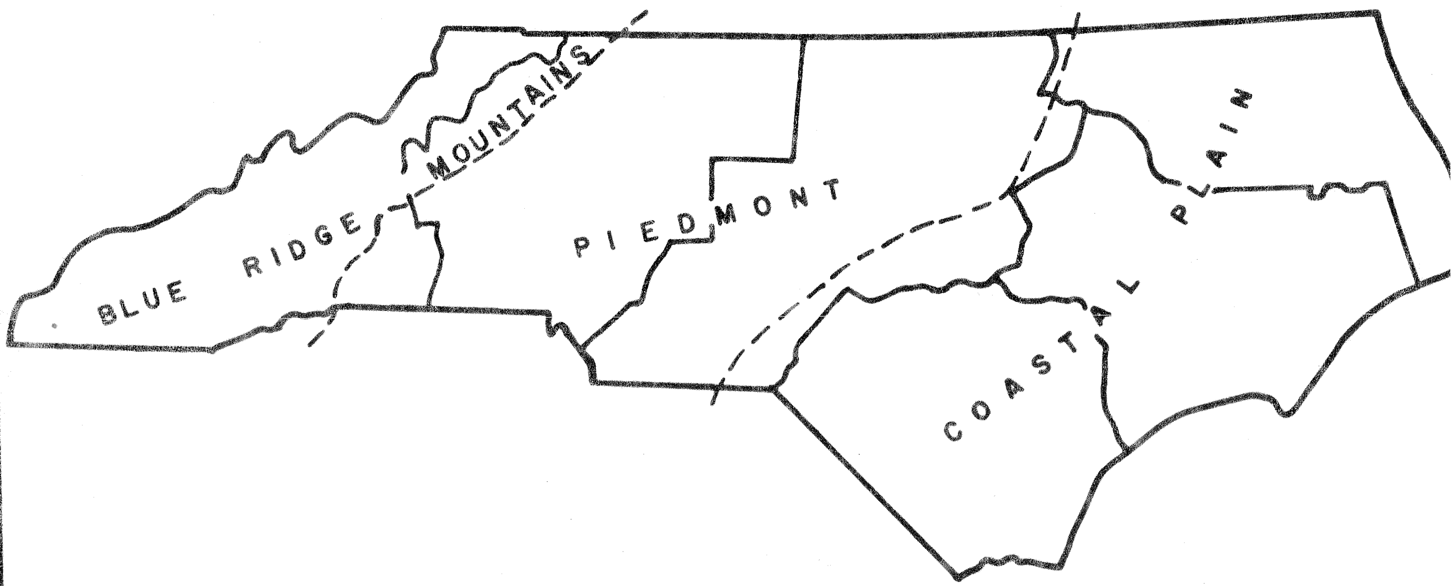
GROUND-WATER CONDITIONS AT TANGLEWOOD PARK, CLEMMONS, N.C.

GROUND-WATER CIRCULAR NO. 4



DIVISION OF GROUND WATER

NORTH CAROLINA

DEPARTMENT OF WATER RESOURCES

1964

NORTH CAROLINA
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GEOLOGY AND GROUND-WATER RESOURCES AT TANGLEWOOD PARK, CLEMMONS, NORTH CAROLINA

By Richard R. Peace, Jr.

ABSTRACT

Tanglewood Park lies in the southwest part of Forsyth County and has an area of about 1,114 acres. It is underlain by mica gneiss of Precambrian (?) age. The gneiss contains veins of secondary quartz at only a few locations in the park.

Most of the park's water supply is obtained from 21 wells. A total of 30 wells have been drilled in the park and the yields have ranged from 0 to 40 gallons per minute. A total of about 300 gallons per minute of good quality water is available for present use.

As a part of the study, 14 sites for future wells were selected, and the drilling of a series of auger holes was recommended to evaluate the ground-water potential of the Yadkin River flood plain.

INTRODUCTION

Since its beginning in the summer of 1954, Tanglewood Park has had a large annual increase of people using the facilities in the park. This yearly increase and the addition of new facilities has created a progressively greater demand for water. Ground-water is the source of the water supply for Tanglewood Park except that taken from Mallard Lake to supply the recently installed irrigation system on the golf course. In June 1964, Mr. Gardner Gidley, Park Superintendent, requested that an investigation be made to determine future ground-water development at Tanglewood Park. This report gives the results of the investigation.

LOCATION OF AREA

Tanglewood Park, in the southwest part of Forsyth County, has an area of about 1,114 acres. The park lies between north latitude 35°59' and 36°01', and west longitude 80°23' and 80°26' (fig. 1). It is bounded on the north by U. S. Highway 158, on the east by the Craver and Hanes Farms, on the south by Armfield Farm and on the west by the Yadkin River (fig. 5). It was formerly the William Neal Reynolds farm and was willed to the citizens of this area to be used as a park.

PURPOSE AND SCOPE

The purpose of this investigation was to collect data on the ground-water resources in and around Tanglewood Park and to relate these data to the geology of the area and potential ground-water development. The principal objectives of the investigation were to:

1. Inventory existing wells in Tanglewood Park.
2. Study well logs from the surrounding area in regard to depths and yields.
3. Determine the chemical quality of the ground water.
4. Make a geologic map of the area.

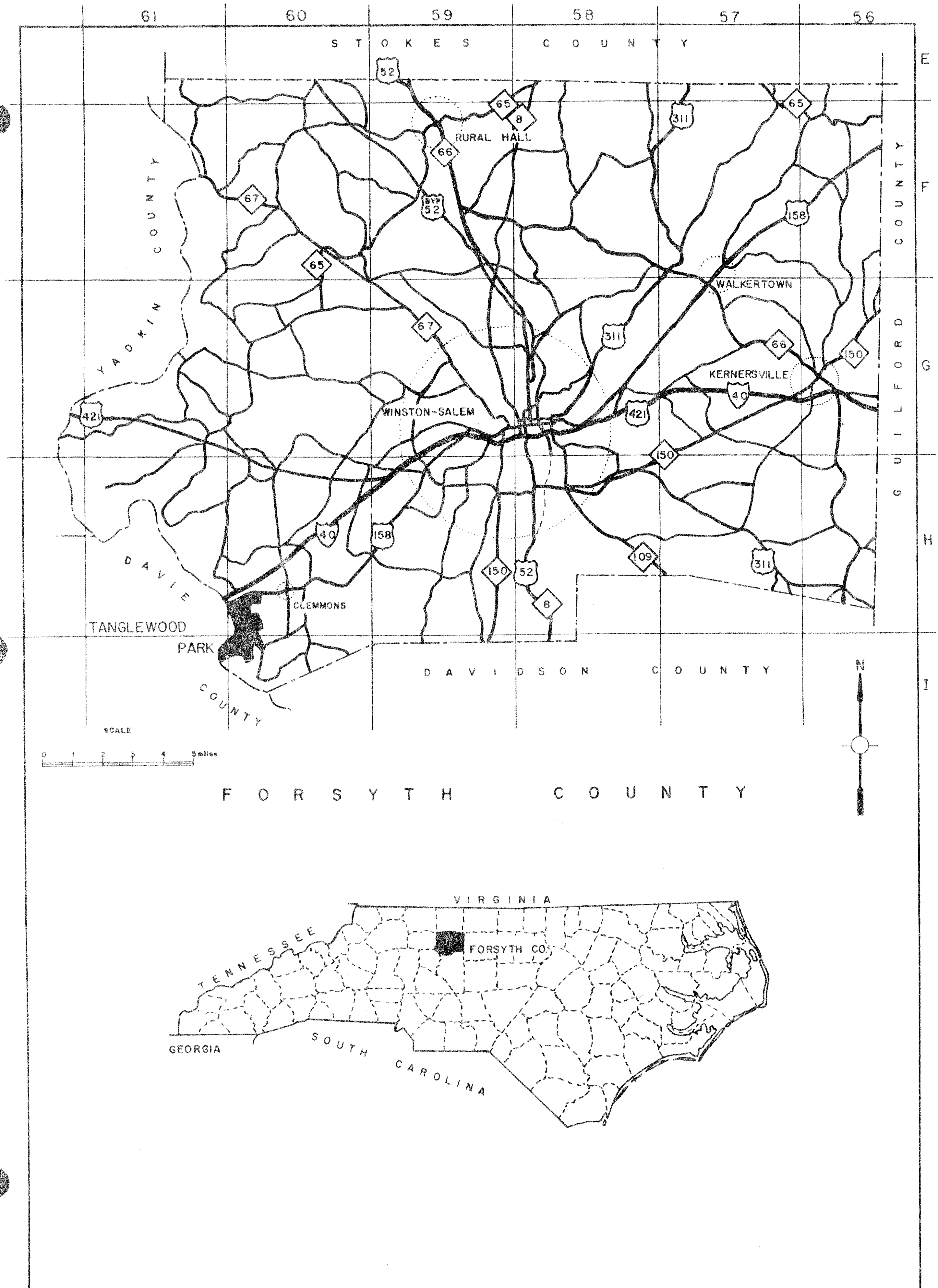
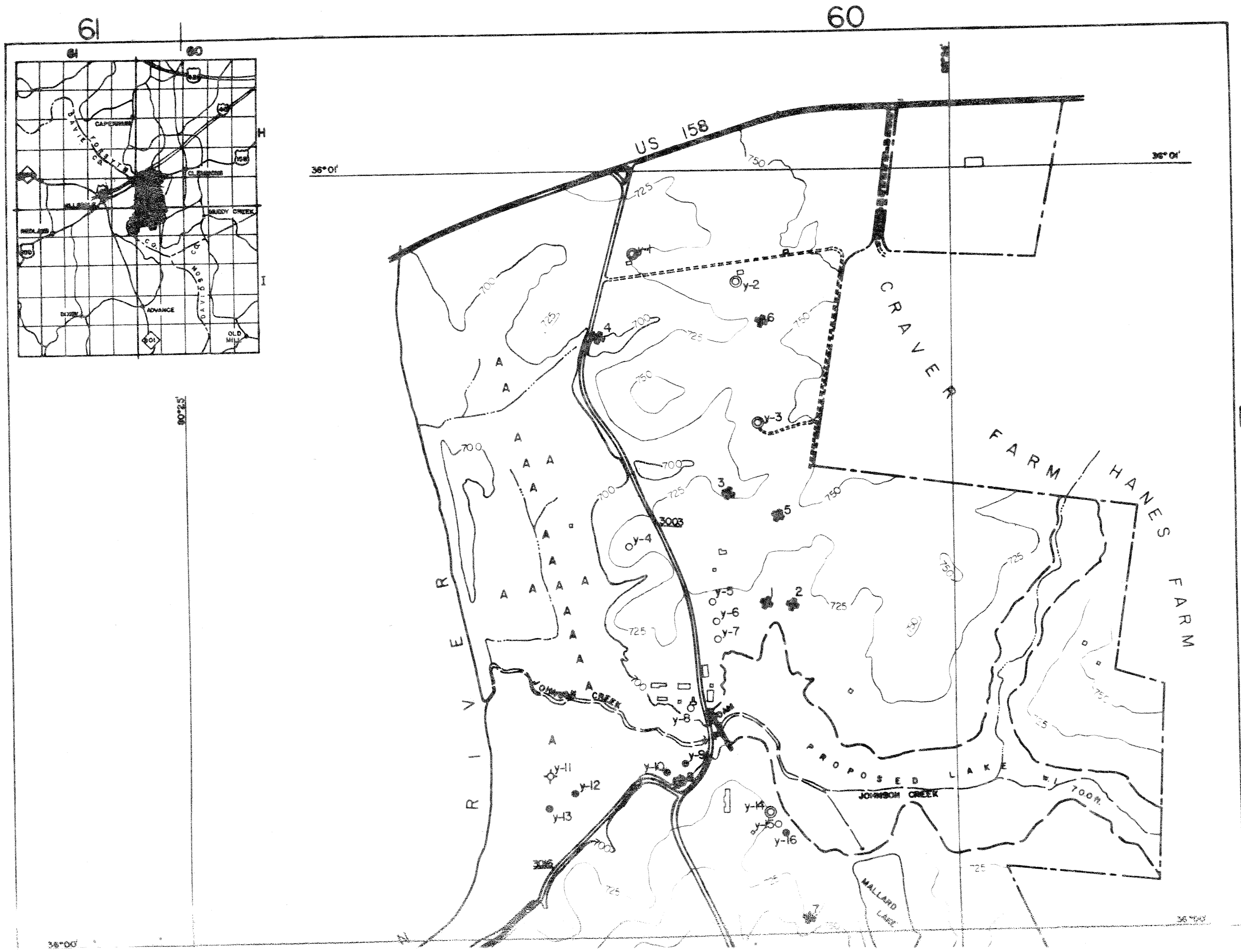
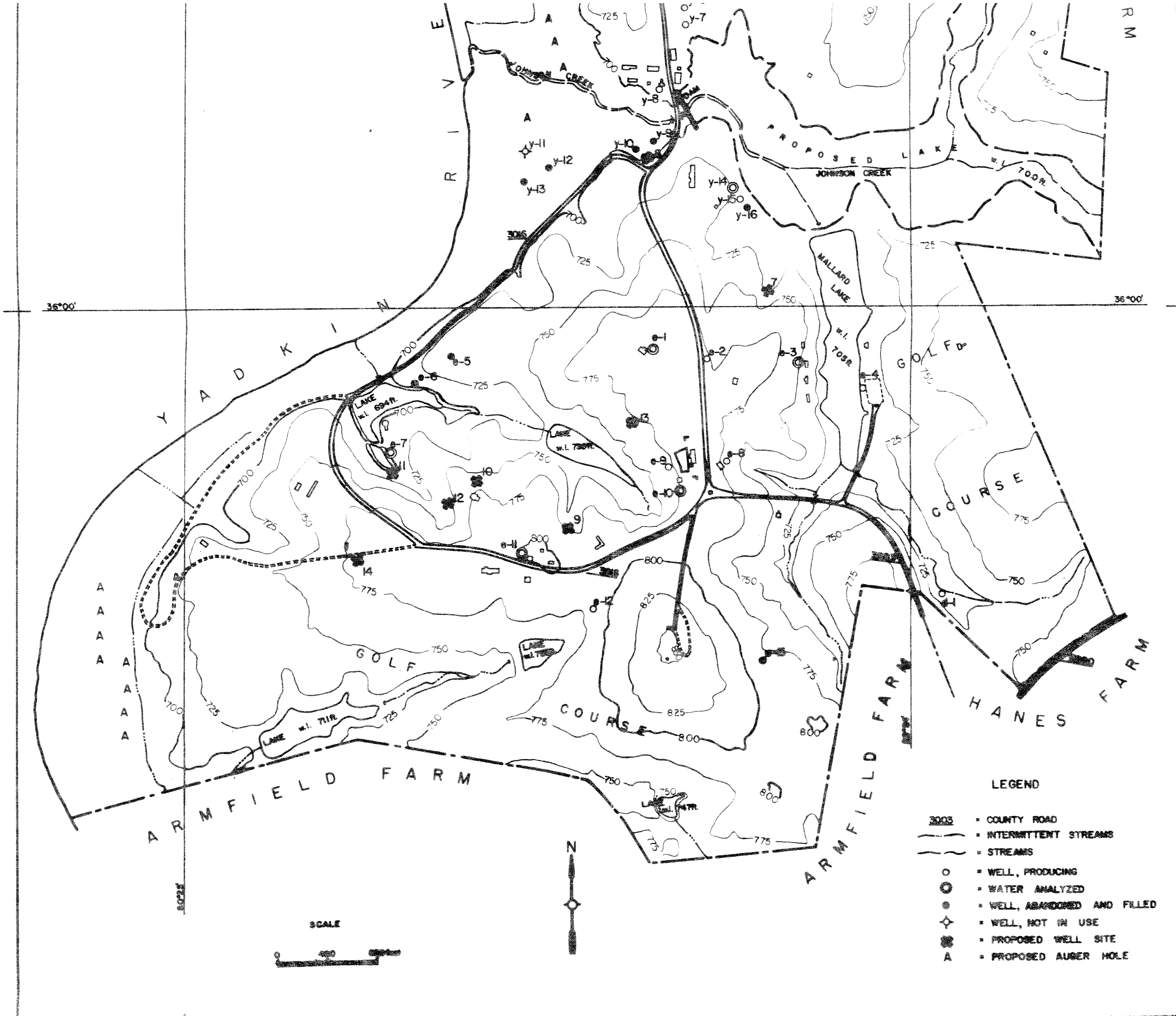


FIGURE 1. — SHOWING LOCATION OF AREA STUDIED.


61
60
H
I
US 158
36°01'
80°25'
36°00'
RIVER
CRAVER FARM
HANES FARM
PROPOSED LAKE
JOHNSON CREEK
MALLARD LAKE
3003
3016
700
725
750
y-1
y-2
y-3
y-4
y-5
y-6
y-7
y-8
y-9
y-10
y-11
y-12
y-13
y-14
y-15
y-16
ADVANCE
OLD MILL
MUDDY CREEK
CLEMMONS
DAVIE CO.
FORSYTH CO.
DAVIDSON CO.



[illegible] LOCATION OF WELLS IN TANGLEWOOD PARK CLEMMONS, N.C.

5. Evaluate water-level data from wells in the vicinity of Tanglewood Park that are completed in the same goelogic unit that underlies the park and determine the general range of fluctuation in the park area.

6. Select drilling sites for potential supply wells.

The investigation was made under the general supervision of H. M. Peek, Chief of the Ground-Water Division, North Carolina Department of Water Resources.

PREVIOUS INVESTIGATIONS

Information on the geology and ground water from the Piedmont section of North Carolina was first published by former State Geologist, Dr. J. L. Stuckey (1929), in a report in which he recorded data on 592 wells. In 1948 a report by M. J. Mundorff, "Geology and Ground Water in the Greensboro Area, N. C.", was published by the N. C. Department of Conservation and Development. In this report he describes the geology in the Tanglewood Park area and has data on 12 wells southwest of Clemmons, N. C. including three wells located on the Tanglewood Farm. Any other investigations have been of a local nature.

TOPOGRAPHY AND DRAINAGE

Tanglewood Park lies within the upland section of the Piedmont Province which, in the park area, is a dissected peneplane. The Yadkin River flood plain lies along the western boundary of Tanglewood Park and ranges from 150 to 1,200 feet in width. The park area is drained principally by the Yadkin River and Johnson Creek, a tributary of the Yadkin. Several small, unnamed intermittent streams are tributaries of Johnson Creek, and some flow directly into the Yadkin River.

CLIMATE

The climate at Tanglewood Park is mild, and the temperature and precipitation moderate. Based on 69 years of records of the U. S. Weather Bureau for Winston-Salem, N. C., the average annual precipitation is 44.45 inches, consisting mostly of rainfall. The average maximum monthly rainfall (4.83 inches) occurs in July, and the average minimum monthly rainfall (2.60 inches) occurs in November. Medium snowfall occurs about four times a year. Based on 13 years of record, the average annual temperature is 58.8°F. The average maximum temperature (77.2°F) is in July and the average minimum temperature (40.5°F) is in December.

WELL-NUMBERING SYSTEM

The numbering of wells in this report is based on a state-wide grid system of longitude and latitude.

The state is divided into quadrangles of five-minutes of latitude, identified by upper case letters and five-minutes of longitude, identified by numbers. Each five-minute quadrangle is divided into 25 one-minute quadrangles, identified by lower case letters. The wells in each one-minute quadrangle are numbered serially. Thus, a well numbered "H-60, y-12" would be well number 12 in the one-minute quadrangle "y" of the five-minute quadrangle H-60 (fig. 2).

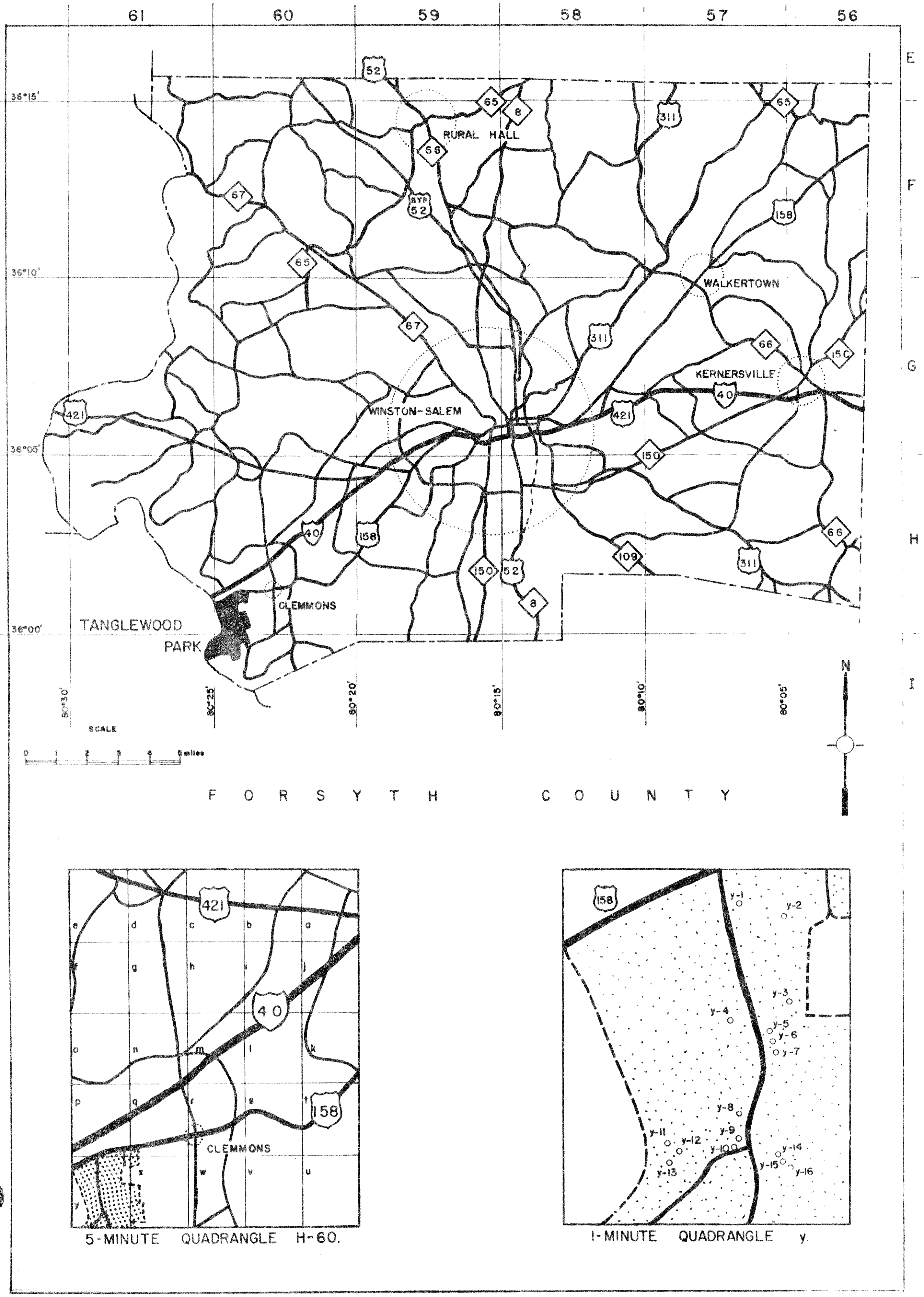


FIGURE 2. — MAP SHOWING WELL NUMBERING SYSTEM.

ACKNOWLEDGMENTS

Acknowledgment is made to the employees of Tanglewood Park for furnishing information on the Park's water supply. Special acknowledgment is made to Mr. Gardner Gidley and Mr. Roger Warren for the time spent with the author in the gathering of data for this report. To G. W. Clayton Drilling Company and Bainbridge and Dance Drilling Company for supplying geologic information, acknowledgment is also given.

GEOLOGY

Tanglewood Park is underlain by massive mica gneiss of Precambrian (?) age. The gneiss consists chiefly of plagioclase feldspar, amphibole (hornblend) and biotite. It has a fine-grained texture (¼ to ½ m m) and is dark gray to grayish-black in color. The gneiss crops out in a few places in the park and large boulders can be seen around a lake on road 3016 where the Yadkin River flood plain is narrow. In the southern part of the area on the golf course, no rocks are exposed. A large amount of quartz float was mapped at only one place; however, reports from park employees (oral communication) told of two other locations where the quartz was exposed but removed when the golf course was built. On the geologic map (fig. 3) the known quartz area is indicated by a solid line and the reported areas by a dashed line.

The electric log of well I-60, d-1, shown in figure 4, indicates that below a depth of 110 feet the formation becomes somewhat more dense and that there are few if any fractures in the rock. Oral communication from the driller (Sam Bainbridge, 1964) reported that less than 4 gallons of water per minute was obtained below a depth of 42 feet.

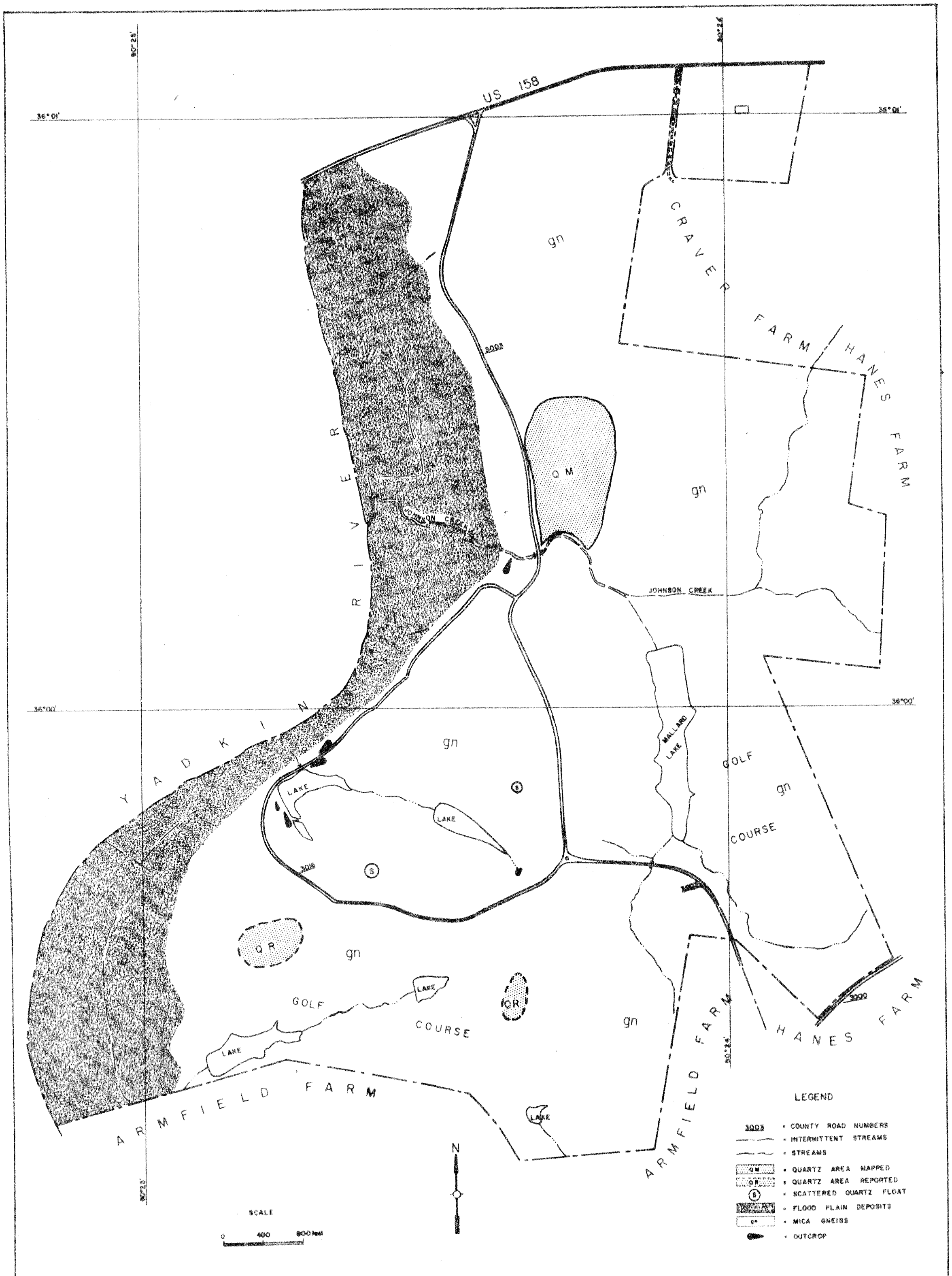


FIGURE 3 - GEOLOGIC MAP OF TANGLEWOOD PARK, CLEMMONS, N.C.

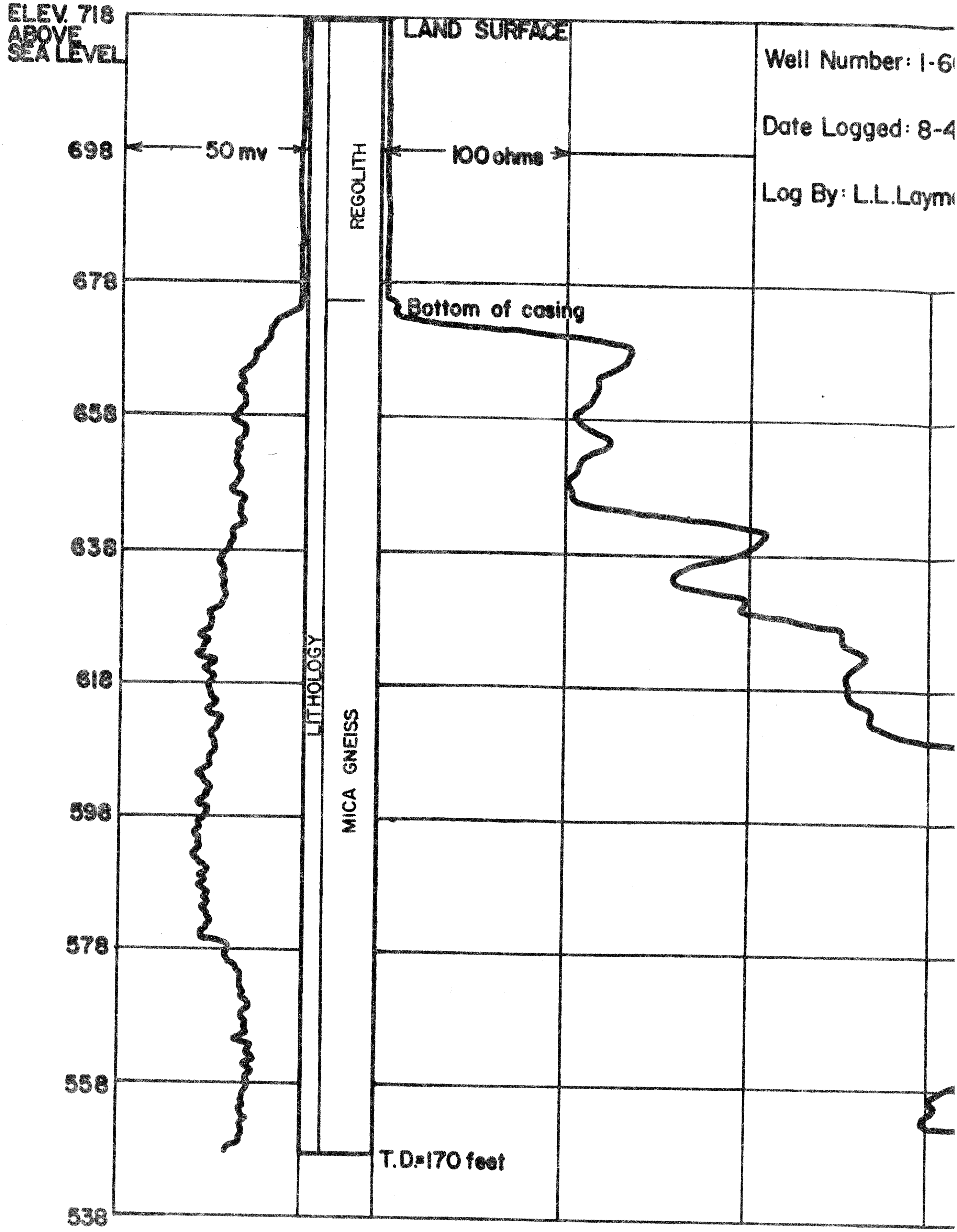
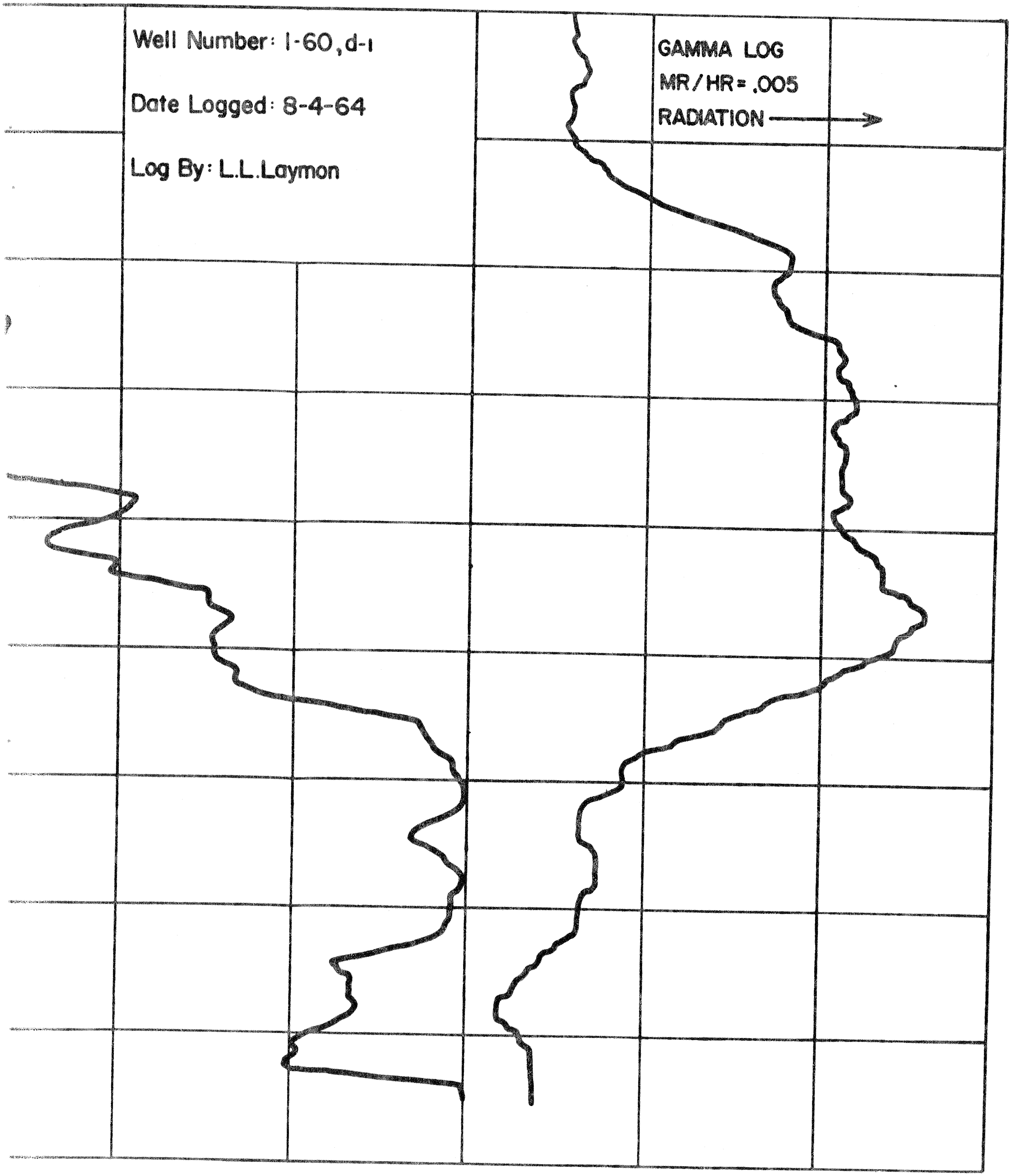


FIGURE 4 - GAMMA AND ELECTRIC LOG OF WELL NUMBER I



F WELL NUMBER 1-60, d-1

The large change in radiation at a depth of about 120 feet, as shown by the gamma log, could be interpreted as a formation contact, however, without the aid of well cuttings this cannot be verified.

Residual and alluvial deposits mantle most of the area. The thickness of this regolith ranges from 0 to about 90 feet. The area of thickest regolith is at wells H-60, y-9 and H-60, y-10. Because of difficulties with boulders and weathered material, the wells were abandoned at the depth of about 90 feet (oral communication, Gardner Gidley, 1964).

The Yadkin River flood plain deposits consist of rounded, "pea" gravel, rounded, fine-to coarse-grained quartz sand, silt, and clay. The thickness of the alluvial deposits is known only at well H-60, y-11 where it is 17 feet.

GROUND WATER

Ground water is water below the land surface that flows from or is pumped from springs and wells. In the Tanglewood Park area ground water is derived from local precipitation, chiefly in the form of rain and occasionally in the form of snow. A part of the precipitation flows into streams and lakes as direct runoff, a part returns to the atmosphere through evaporation and transpiration, and a part seeps downward through the soil and rocks to become ground water. This report contains data on ground-water use and recovery from 30 drilled wells (Table 1, fig. 5). These wells were constructed by cable-tool and rotary drills using 6- or 8-inch -diameter bits.

TABLE I. -- Record of wells in Tanglewood Park, Clemmons, N. C.

Well no.: Numbers correspond to those in figure 5 and table 2. Asterisk indicates chemical analyses given table 2.
All wells are drilled 6- or 8- inch diameter.
Water-bearing unit for all wells is mica gneiss.
All yields are reported.

Depth of well and water level: R, reported; M, measured.
Method of lift: S, submersible; J, jet (deep well); T, turbine.
Use of water: D, domestic; PS public supply.
Use of well: A, abandoned; F, filled.

Quadrangle and Well No.	Date Drilled	Depth of Well	Depth of Casing	Altitude of land surface (feet)	Yield	Method of Lift	Use of Water	Measuring Point		Water Level		Remarks
								Description	Height above or below land surface (feet)	Below land surface	Date measured	
H-60,y-1*	....	100	....	722	5	T	D	....	....	.....	....	
H-60,y-2*	....	150	....	745	5	T	D	....	....	.....	....	
H-60,y-3*	....	150	....	742	35	S	PS	....	....	.....	....	
H-60,y-4	....	100	....	742	5	....	D	....	....	.....	....	
H-60,y-5	1961	140	20	720	40	S	PS	....	....	.....	....	
H-60,y-6	....	125	....	712	35	S	PS	....	....	.....	....	
H-60,y-7	1961	90	27.1	706	25	S	PS	....	....	.....	....	
H-60,y-8	....	180	....	706	8	T	D	....	....	.....	....	
H-60,y-9	....	....	....	690	....	....	A & F	....	....	.....	....	Depth to bedrock 90'
H-60,y-10	....	....	....	686	....	....	A & F	....	....	.....	....	...do....
H-60,y-11	1961	240	17	686	10	....	....	....	....	.....	....	Not in use
H-60,y-12	....	....	....	687	....	....	A & F	....	....	.....	....	
H-60,y-13	1961	97	....	685	12	....	A & F	....	....	.....	....	
H-60,y-14*	....	190	....	734	8	T	PS	....	....	.....	....	
H-60,y-15	....	....	....	704	....	S	PS	Top of csg.	-1.0	16.7	8-6-64	
H-60,y-16	....	....	....	695	....	....	A & F	....	....	.....	....	
I-60,d-1	1964	170.0	42	718	4	....	PS	Top of csg.	0.5	3.12	8-6-64	See p.10
I-60,e-1*	....	140	....	796	10	S	PS	...do......	-8.0	44.1	7-10-64	
I-60,e-2	....	160	....	782	5	S	PS	....	....	.....	....	
I-60,e-3*	....	180	....	750	8	J	PS	Top of csg.	-8.0	54.8	7-11-64	
I-60,e-4	....	160	....	708	35	T	PS	....	....	.....	....	
I-60,e-5	....	....	....	748	....	....	A & F	....	....	.....	....	Well dry
I-60,e-6	....	....	....	705	....	....	A & F	....	....	.....	....	...do....
I-60,e-7*	....	45	....	704	35	T	PS	Top of csg.	0.7	6.3	7-10-64	
I-60,e-8	....	200	....	770	6	S	D	....	....	.....	....	
I-60,e-9	....	160	....	772	6	J	PS	....	....	.....	....	
I-60,e-10*	....	160	....	779	3	T	PS	Top of csg.	0.5	32.5	7-10-64	
I-60,e-11*	....	150	....	801	6	T	D	....	....	.....	....	
I-60,e-12	....	160	....	785	4	S	PS	....	....	.....	....	
I-60,e-13	....	150	....	783	....	....	A & F	....	....	.....	....	

Occurrence, Movement and Storage

Ground water occupies interstices or open spaces in the soil and rocks of the earth's crust. According to their origin these interstices can be divided into original and secondary. Original interstices are created as a result of the process by which the rock was formed, and secondary interstices are created by processes that affect the rock after it is formed. The size, shape, and arrangement of these voids affect the storage and movement of ground water.

The porosity of a rock is its property of containing interstices and can be expressed as a ratio, usually as a percentage, of the open space in a rock to its total volume. The permeability of a rock is defined as its capacity for transmitting water under pressure and is measured by the rate at which water is transmitted through a unit section under a unit hydraulic gradient. For large quantities of ground water to be obtained from wells and springs, the permeability must be high enough to permit water to move freely.

A study of the records of the wells in Tanglewood Park indicates that there are few interstices or open spaces in the underlying mica gneiss. In some areas where the veins of secondary quartz cut the gneiss, yields of up to 40 gpm (gallons per minute) can be developed from individual wells. However, available data indicates that, in most of the area, the porosity and permeability of the gneiss is low and, thus large yields would generally not be expected.

Water-Table and Artesian Conditions

A water table is the upper surface of a zone of saturation except where the surface is formed by an impermeable body such as shale, clay, or other material that confines the water under pressure. The zone of saturation is defined as a zone in which all the interstices or openings are filled with water. Artesian water is ground water that is confined under pressure by relatively impermeable overlying and underlying rocks. It occurs where rainfall and runoff have seeped into interstices of the consolidated rock or into an aquifer that passes between beds of clay or other relatively impermeable material.

In Tanglewood Park, ground water in the crystalline rocks may occur under water-table conditions; however, it most probably occurs under semi-artesian or artesian conditions in most of the area. Water in the regolith generally occurs under water table conditions.

Water-Level Fluctuations and Their Significance

Water-level fluctuations are caused by ground-water recharge, natural discharge, evaporation, transpiration, withdrawals by pumping, variations in the atmospheric pressure, and other minor factors.

In the Tanglewood Park area precipitation or lack of precipitation is the principal cause of water-level fluctuation. Water levels should be highest in the spring when rainfall is abundant and the evaporation rate is low. They should be lowest in the fall and early winter when rainfall is least abundant and the ground-water storage has been depleted because of evapotranspiration during late summer and early fall.

The ideal time to evaluate the productivity of a well is during periods of water-level lows. Tests made at such times accurately indicate the dependability of a well and permits determination of the most efficient pumping rate and maximum yield.

Use

Ground water in Tanglewood Park is used for domestic, stock and public supplies. The water system at the park is constructed so that wells H-60, y-5; H-60, y-6; and H-60, y-7 supply most of the water used in the Manor House and the swimming pool area. The three wells supply about 90 gpm during the peak times of water use. Several of the wells that lie between the three wells listed above and the pool area can be pumped directly into the main system; however, the yield from these additional wells probably does not exceed 35 gpm. Well I-60, e-4, yielding 35 gpm, furnishes an adequate supply to the pavilion on Mallard Lake. Well I-60, e-3, yielding 8 gpm, is the source of supply for four cottages on Mallard Lake. Well I-60, e-7, yielding 35 gpm, furnishes water for a large pavilion in the southwest part of the park.

QUALITY OF WATER

The quality of ground water depends upon the amount and kind of dissolved matter in the water and varies from place to place. The amount and type of dissolved mineral matter in a specific sample of ground water depends primarily upon the type of soil through which the water has moved, the type of rock through which the water has passed, the time the water has been in contact with the soil and rock, and the temperature of the water. The most common chemical constituents found in ground water are calcium, magnesium, iron, sodium, bicarbonate, sulfate, nitrate, chloride, and fluoride.

The chemical quality of water may limit its use for domestic, municipal, industrial, or irrigation supplies. Standards for drinking water established by the U. S. Public Health Service (1962) to control the quality of water supplied by common carriers generally are quoted as desirable for drinking water. According to these standards, supplies should not contain more than 0.3 ppm (parts per million) of iron, 250 ppm of chloride, 250 ppm of sulfate, 0.8 to 1.7 ppm of flouride (depending on the annual average of maximum daily air temperatures), 45 ppm of nitrate, and 500 ppm of total dissolved solids. The carbonate and bicarbonate content is not particularly significant in drinking or culinary water; sodium content is significant for those persons having an abnormal sodium metabolism. Calcium and magnesium are the principal constituents contributing to the hardness of water, and where present in excessive amounts, they are undesirable because of their scale-forming and soap-consuming properties.

Chemical analyses were made on nine selected samples of ground water from Tanglewood Park (Table 2). All constituents were within the limits of the U. S. Public Health Service's recommendations. The water is of good to excellent quality as it contains only small amounts of dissolved matter. The small amount of nitrate nitrogen analyzed in 6 of the 9 samples is probably due to some extent to the large and extensive use of fertilizer on the Tanglewood property. The pH, a measure of the acidic or basic property of the water, ranged from 6.2 to 6.6. Using a numerical

TABLE II. -- Chemical analyses of water from selected wells in Tanglewood Park, Clemmons, N. C.
(Analyses by N. C. Division of Ground Water)

Well Number		H-60,y-1	H-60,y-2	H-60,y-3	H-60,y-14	I-60,e-1	I-60,e-3	I-60,e-7	I-60,e-10	I-60,e-11
		Parts per million								
Iron (Fe)		.02	.02	.02	.00	.00	.01	.00	.02	.02
Bicarbonate (HCO_3)		100	60	94	104	52	66	78	72	78
Carbonates (CO_3)		0	0	0	0	0	0	0	0	0
Chloride (Cl)		6.0	9.0	10	0.0	0.0	0.0	1.0	1.0	2.0
Sulfate (SO_4)		8.0	9.0	27	11	9.0	9.0	7.0	8.0	7.0
Fluoride (F)		.07	0.4	0.5	0.6	0.6	0.6	0.7	0.6	0.7
Hydrogen sulfide (H_2S)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrate (NO_3)		0.0	1.2	2.8	0.7	0.0	0.0	1.2	1.4	2.4
Ammonium nitrogen (as N)		.11	.13	.16	.11	.58	.10	.14	.12	.05
Dissolved solids		74	59	99	112	55	68	93	93	112
Hardness	as $CaCO_3$	51	---	---	51	17	34	34	34	51
	Total	68	68	85	85	51	51	68	68	85
Alkalinity as $CaCO_3$		82	49	77	85	43	54	64	59	64
Specific conductance (micromhos at 25° C)		120	95	180	180	90	110	150	150	180
pH		6.3	6.3	6.2	6.6	6.3	6.3	6.5	6.4	6.3
Color (apparent)		0	0	0	0	0	0	0	0	0
Turbidity, Jackson units		0	0	0	0	0	0	0	0	0
Temperature (°F)		60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5
Date and appearance when collected		8-6-64 Clear	8-6-64 Clear	8-6-64 Clear	7-11-64 Clear	7-10-64 Clear	7-11-64 Clear	7-10-64 Clear	7-10-64 Clear	7-10-64 Clear
Date and appearance when analyzed		8-12-64 Clear	8-12-64 Clear	8-12-64 Clear	7-28-64 Clear	7-28-64 Clear	7-28-64 Clear	7-28-64 Clear	7-28-64 Clear	7-28-64 Clear

letter of 7 as neutral water, this classifies the water in the park as slightly acidic.

The hardness of ground water from Tanglewood Park ranges from soft to medium hard. This classification is according to Lamar's (1942, p. 25-26) and is as follows:

Hardness

Parts per million	Description
1 - 60	Soft
61 - 120	Moderately Hard
121 - 200	Hard
201 - and more	Very Hard

CONCLUSIONS AND RECOMMENDATIONS

The results of the investigation of the geology and ground-water resources of Tanglewood Park, Clemmons, N. C. are as follows:

1. The park is underlain by massive mica gneiss that has not been subjected to a great degree of fracturing, and the porosity and permeability is quite low. A regolith ranging from 0 to about 90 feet in thickness mantles most of the area. Flood plain deposits of gravel, sand, silt, and clay lie along the western boundary of the property.

2. The yields of wells drilled in the mica gneiss ranges from 0 to about 40 gpm.

3. Thirty wells have been drilled in the part. Of this total, 21 are producing wells; 15 for public service, and 6 for domestic use.

4. About 300 gpm of ground water is available from existing wells for recovery in Tanglewood Park at the present time.

5. The water is of good to excellent quality as it contains only small amounts of dissolved matter.

The selection of future drilling sites was one of the principal objectives of this investigation. The most favorable locations for wells in a consolidated rock area such as underlies Tanglewood Park are:

1. Quartz veins or other fractured zones in draws.
2. Quartz veins or other fractured zones regardless of topography.
3. In the head of draws.

The selected future drilling sites are shown in figure 5 and are described as to location, topography, and geology below:

1. 400 feet east of well H-60, y-5; quartz float on slope of draw.
2. 600 feet east of well H-60, y-5; quartz float on slope of draw.
3. 500 feet southwest of well H-60, y-3; in draw at elevation of about 715 feet.
4. 1,400 feet south of U. S. Highway 158, on east side of road 3003; on north slope of draw.
5. 800 feet south of well H-60, y-3; in saddle (between two hills).
6. 300 feet southeast of well H-60, y-2; in draw at elevation of about 730 feet.
7. 500 feet southwest of the western end of Mallard Lake dam; quartz float on south slope of draw.
8. 200 feet south of disposal (septic) unit in the same area of well H-60, y-9; in valley.
9. 250 feet east northeast of well I-60, e-11; in head of draw.
10. 725 feet northwest of well I-60, e-11 (200 feet north of Murray Lybrook cabins); in head of draw.

11. 75 feet north of well I-60, e-7; in draw.

12. 300 feet southwest of recommended site number 10--(along bridle trail 50 feet south of power line); quartz float east slope of draw.

13. 600 feet south southwest of I-60, e-1--(beside deer lot); quartz float on north side of draw.

14. 900 feet south southwest of well I-60, e-7--(in edge of field road in front of park employee's house); quartz float reported in this area.

It should be noted that the quartz float found or reported at recommended sites number 12, 13 and 14 occurs in a straight line, indicating a continuous quartz vein cutting the mica gneiss and probably a major fracture zone in this area.

It is further recommended that a row of auger holes on approximately 200 foot centers be drilled in the flood plain area on the western boundary of the property. This will probably require a total of not more than 25 holes. The purpose is to get a profile of the rock that underlies the flood plain and if this profile indicates any depression in the underlying rock unit, a well should be placed in that location.

Areas excluded from recommended future drilling sites were the golf-course proper and the area to be flooded by a proposed lake on Johnson Creek.

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