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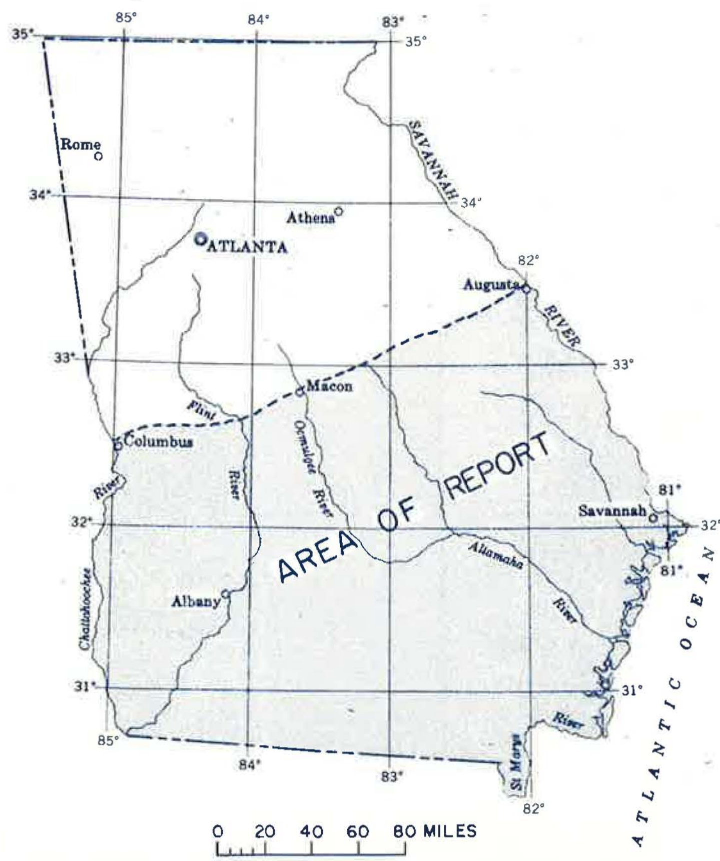
ATLANTA
1980

THE GEOHYDROLOGY OF THE CRETACEOUS AQUIFER SYSTEM IN GEORGIA

by

LIN D. POLLARD and ROBERT C. VORHIS



HYDROLOGIC ATLAS 3

INTRODUCTION

The Cretaceous formations in Georgia are exposed along the inner margin of the Coastal Plain. Lithologic descriptions of these exposures have been given by Veatch and Stephenson (1911), Cooke (1943), LaMoreaux (1946), Eargle (1955), LeGrand (1956 and 1962), Patterson and Buie (1974), and Marsalis and Friddell (1975). The formations dip beneath younger sediments toward the southeast and have been described in the subsurface by Applin and Applin (1947, 1964, and 1967), and Herrick (1961).

The purpose of this report is to delineate the operational water-bearing units (aquifers) and confining units in the Cretaceous aquifer system and to describe the availability and quality of water from each major aquifer. These aquifer characteristics can be used to plan the future development of the second most important aquifer system in the Coastal Plain of Georgia.

This investigation was made by the U.S. Geological Survey in cooperation with the Georgia Department of Natural Resources, Georgia Geologic Survey.

ACKNOWLEDGMENTS

Phillip M. Brown, U.S. Geological Survey, provided the chronostratigraphic unit correlations and geophysical well log stratigraphic interpretations used in this report. Norman F. Sohl, U.S. Geological Survey, provided lithologic descriptions for the Cretaceous formations along the Chattahoochee River. Juergen Reinhardt and Charles C. Smith, U.S. Geological Survey, helped with the correlation of Cretaceous formations with their respective European and Provincial stages.

GEOLOGIC AND STRATIGRAPHIC SIGNIFICANCE

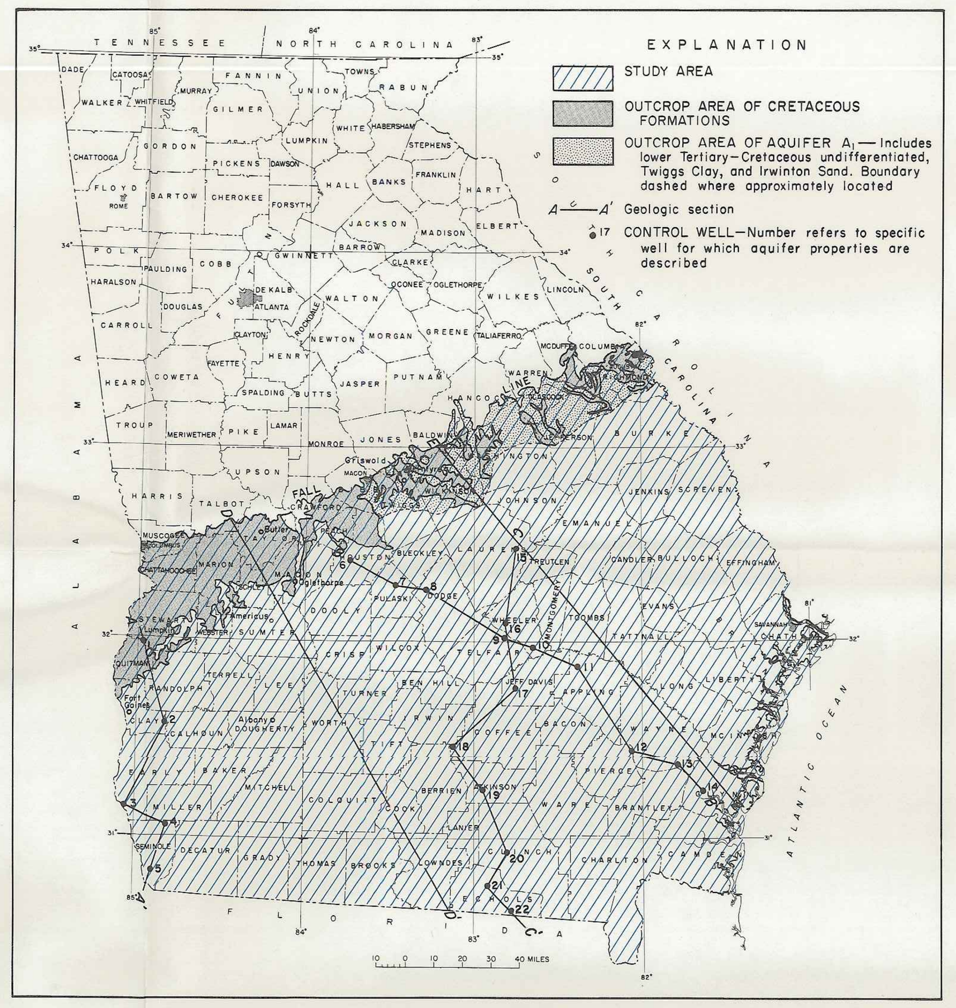
The Coastal Plain province is bounded on the north by the Fall Line, where sediments of Cretaceous and Tertiary age overlap crystalline rocks of the Piedmont province. West of the Ocmulgee River the oldest exposed sediments south of the Fall Line correlate with the Tuscaloosa Formation exposed along the Chattahoochee River. These Cretaceous sediments consist of interbedded sand, gravel, and clay--lithologies indicative of erosion products transported from uplifted rocks to the northwest. After transportation the sediments were deposited in a deltaic environment where shifting river channels, lakes, and swamps prevailed. East of the Ocmulgee River the terrestrial environment lasted for a much longer period of time--Cretaceous through early Tertiary--and thick sequences of nonmarine sand and clay accumulated.

Along the Chattahoochee River the Providence Sand, Ripley Formation, Cusseta Sand, Blufftown Formation, and Eutaw Formation are marine in origin. These sediments consist of fossiliferous sand and calcareous silty clay, which grade into nonmarine sediments toward the Ocmulgee River.

The Cretaceous sediments become more representative of deposition in an offshore marine environment as they dip southeastward beneath younger formations. In general, the clay content increases downdip but in southeast Georgia carbonates predominate.

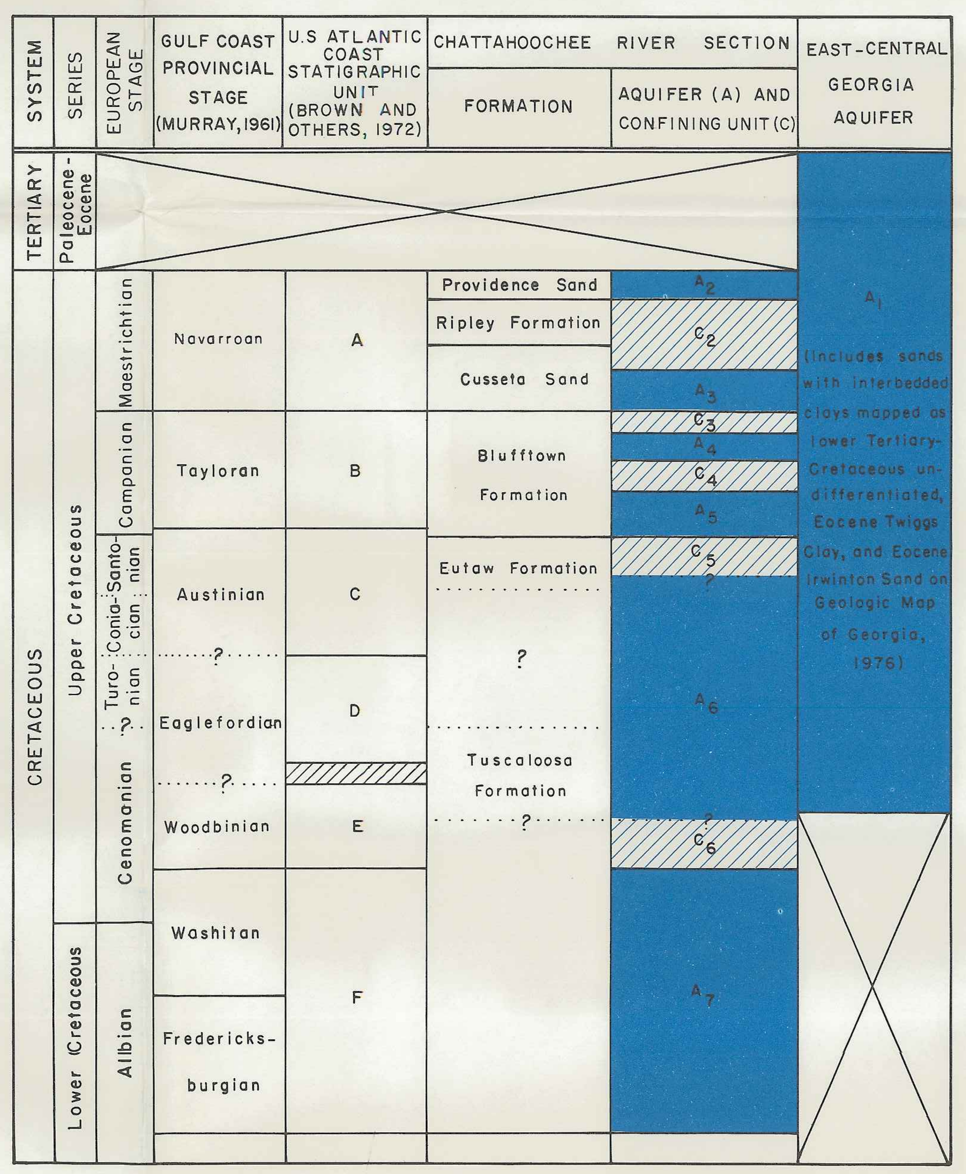
The correlation chart shows the relationship of the Cretaceous aquifers (A_1, A_2, A_3, A_4, A_5, A_6, and A_7) and the intervening confining units (C_2, C_3, C_4, C_5, and C_6) to the stratigraphic units of the Atlantic Coastal Plain (Brown and others, 1972) and to the formations of Cretaceous age along the Chattahoochee River as described by N. F. Sohl (written commun., 1976). Subsurface aquifers and confining units were traced within this stratigraphic framework using the chronostratigraphic units established in Georgia by Brown and others (1979). Their interpretations were based upon faunal control, lithology, and borehole geophysical logs. The operational units used in this study were defined by water-bearing properties obtained from well data and by lithology described from surface exposures, cuttings and cores from wells, and borehole geophysical logs. These units were then superimposed upon the chronostratigraphic units. The two generalized northwest-southeast sections show the relationship between aquifers and confining units.

The complete list of wells used in preparing this report is on file at the office of the U.S. Geological Survey, Water Resources Division, Georgia District, 6481 Peachtree Industrial Boulevard, Doraville, GA 30360.



LOCATION OF STUDY AREA IN THE GEORGIA COASTAL PLAIN PROVINCE, OUTCROP OF CRETACEOUS FORMATIONS, AND GEOLOGIC SECTIONS.

Cretaceous aquifers in Georgia and their stratigraphic equivalents



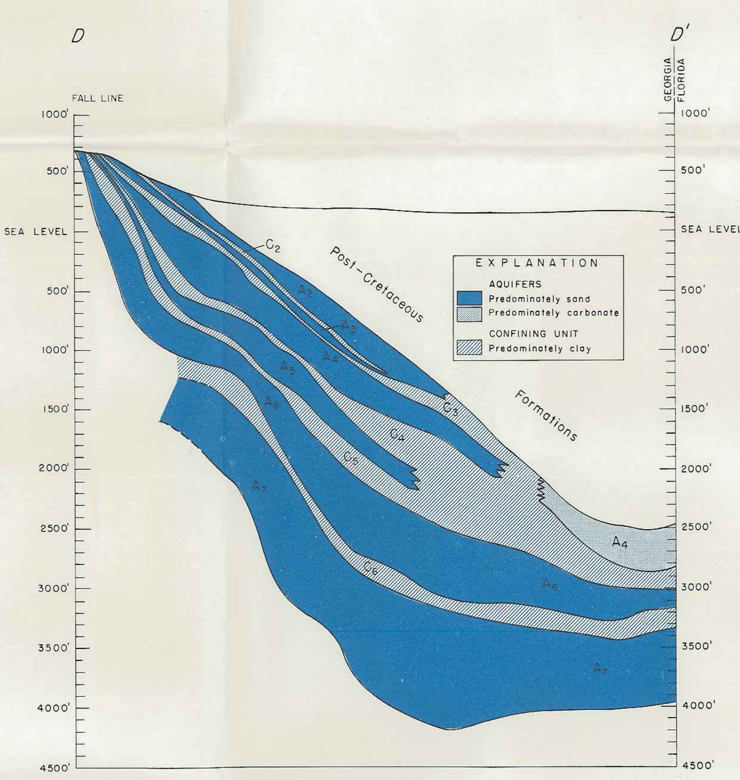
FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

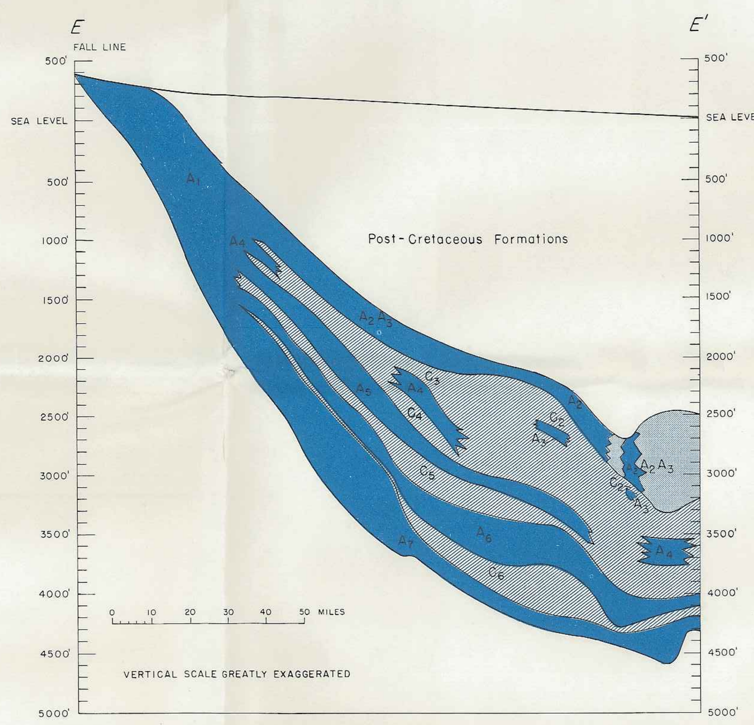
Multiply inch-pound units	By	To obtain SI units
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
gallon (gal)	3.785	liter (L)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	43.81	liters per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)

Properties of aquifers A_2, A_3, A_4, A_5, A_6, and A_7 for the selected wells shown in cross sections

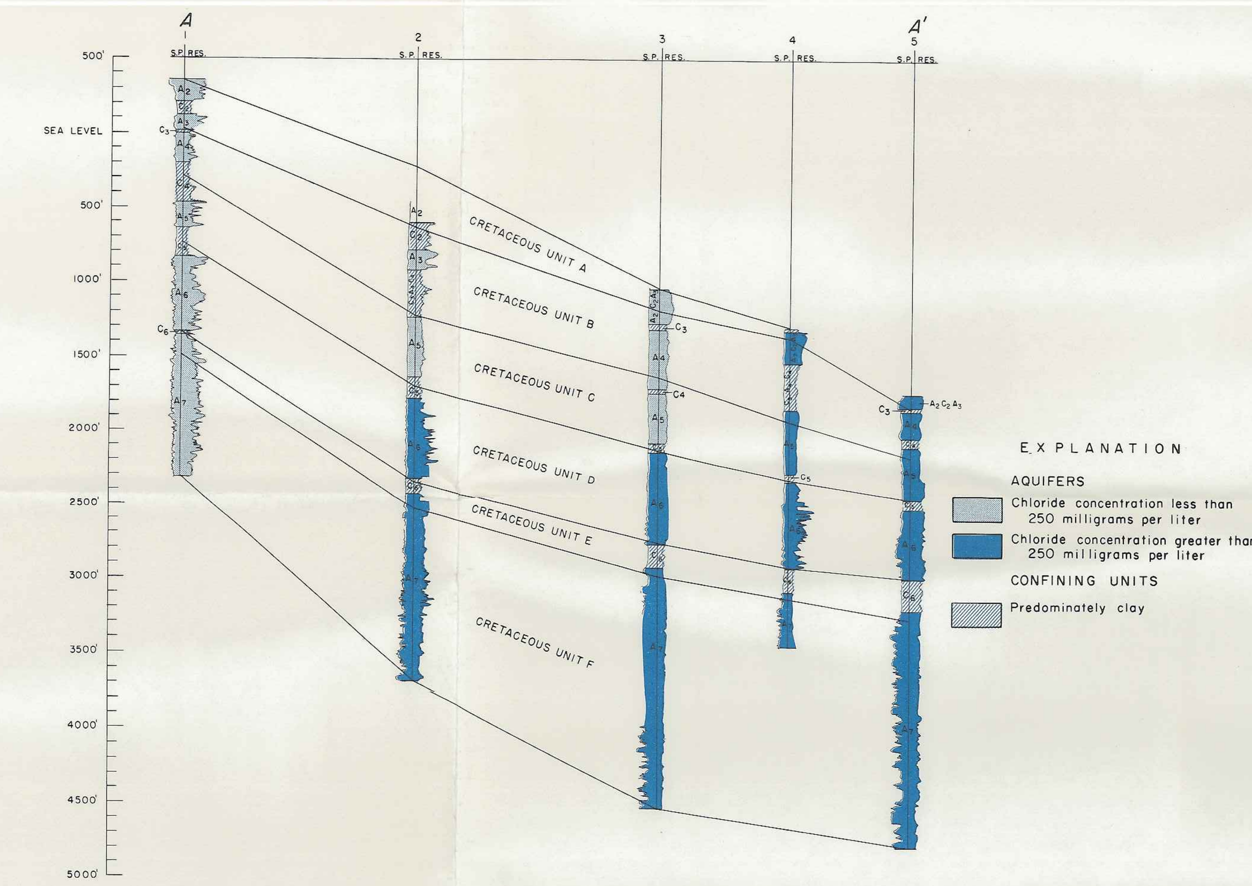
[>, greater than; <, less than]

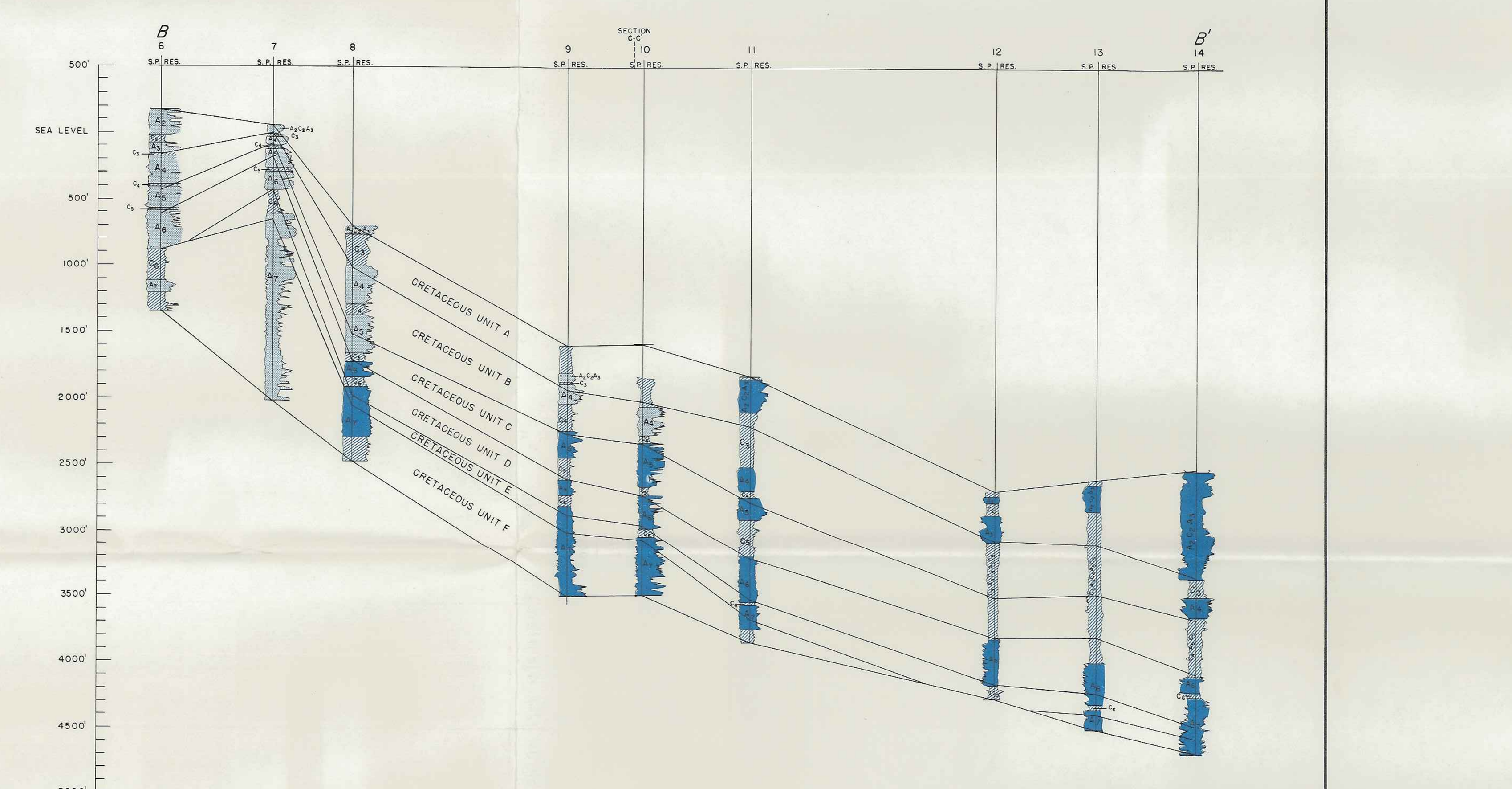
Well number	Well name and county	Coordinate location: Latitude	Coordinate location: Longitude	Altitude of measuring point (ft)	Aquifer	Altitude of top based on mean sea level (ft)	Thickness (ft)	Total sand thickness (ft/percent)	Sand/shale ratio	Number of sand units over 5 ft thick	Number of sand units over 20 ft thick	Thickness of overlying confining unit (ft)	Thickness of underlying confining unit (ft)	Comments
1	W.C. Bradley Co.,1	31°59'33"	84°59'10"	548	A_2	+360	145	115/77	3.8	4	1	No log	97	
	Stewart County				A_3	+118	90	70/78	3.5	4	2	97	5	Good aquifer.
					A_4	+23	223	166/74	2.9	8	0	5	280	
					A_5	-480	165	102/62	1.6	6	1	280	192	
					A_6	-837	492	332/67	2.1	18	5	192	20	Good aquifer.
					A_7	-1,349	953	615/65	1.8	31	5	20	>62	Good aquifer.
2	J.W. West,1	31°33'55"	84°48'15"	345	A_2	-215	390	No log	-	-	-	-	173	Casing to 792 ft.
	Calhoun County				A_3	-778	130	94/72	2.6	3	1	173	317	
					A_4	-	-	-	-	-	-	-	-	Confining.
					A_5	-1,225	397	227/57	1.3	6	0	317	138	Fine sand, silt predominate.
					A_6	-1,760	585	399/76	3.2	12	4	138	119	
					A_7	-2,404	1,267	877/69	2.2	41	5	119	51 into unit underlying F	
3	A.C. Chandler,1	31°10'18"	85°04'40"	187	A_2A_3	-1,015	228	178/78	3.6	2	0	39	60	Fine sand, silt predominate.
	Early County				A_4	-1,303	400	310/77	3.4	0	0	60	34	Do.
					A_5	-1,737	326	251/77	3.3	0	0	34	45	Do.
					A_6	-2,108	629	459/73	2.7	15	1	45	161	Top 125 ft fine sand, silt.
					A_7	-2,898	1,618	1,012/63	1.7	37	5	161	Into unit underlying F.	Unit has lower sand/shale ratio.
4	Emily Harlow,1	31°03'13"	84°48'42"	147	A_2A_3	-1,313	215	165/77	3.3	2	0	50	305	Fine sand, silt predominate.
	Seminole County				A_4	-	-	-	-	-	-	-	-	Confining.
					A_5	-1,833	440	245/56	1.3	0	0	305	60	Fine sand, silt predominate.
					A_6	-2,333	570	297/52	1.1	10	0	60	160	Chloride 250 to >500 mg/L.
					A_7	-3,063	>362	197/54	1.2	10	2	160	-	High chloride concentration. Well ends in A_7.
5	Saunders Co. Inc.,1	30°51'41"	84°53'10"	110	A_2A_3	-1,735	85	47/55	1.2	0	0	265	20	Fine sand, silt predominate.
	Seminole County				A_4	-1,840	164	89/54	1.2	0	0	20	76	Do.
					A_5	-2,080	472	326/69	2.2	0	0	76	78	Do.
					A_6	-2,520	450	280/62	1.6	6	2	78	212	Chloride 250 to >1,000 mg/L.
					A_7	-3,182	1,578	1,063/67	2.1	40	10	212	20 into unit underlying F	High chloride concentration.
6	H. B. Gilbert,1	32°24'07"	83°43'57"	371	A_2	+176	191	152/80	3.9	5	2	10	58	Good aquifer.
	Houston County				A_3	-73	86	68/79	3.8	2	1	58	17	A_3, A_4, and A_5 probably behave as one aquifer.
					A_4	-176	209	193/92	12.0	4	2	17	15	
					A_5	-400	179	156/87	6.8	3	3	15	10	Good aquifer.
					A_6	-589	273	216/79	3.8	6	3	10	237	Do.
					A_7	-1,099	86	66/77	3.3	4	0	237	142	
7	Dana,1	32°18'08"	83°28'58"	341	A_2A_3	+70	79	71/90	8.9	1	1	41	24	Good aquifer.
	Pulaski County				A_4	-33	52	47/91	9.4	1	1	24	30	Do.
					A_5	-115	144	120/83	5.0	4	2	30	20	A_5 and A_6 one aquifer.
					A_6	-279	150	110/73	2.8	5	3	20	180	Do.
					A_7	-609	1,396	1,005/72	2.6	18	6	180	122 into unit underlying F	Good aquifer - top half.
8	B & L Farms,1	38°15'30"	83°17'25"	310	A_2A_3	-685	59	48/81	4.4	2	1	10	251	Good aquifer.
	Dodge County				A_4	-995	280	210/75	3.0	7	3	251	88	Do.
					A_5	-1,363	277	188/68	2.1	11	1	88	68	Do.
					A_6	-1,708	112	80/71	2.5	3	2	68	88	Do.
					A_7	-1,908	367	297/81	4.2	11	1	88	185 into unit underlying F	Do.
9	Henry Spurlin,1	32°01'45"	82°48'35"	242	A_2A_3	-1,798	60	46/77	3.3	2	0	210	23	A_2, A_3, and A_4 one aquifer.
	Telfair County				A_4	-1,881	137	100/73	2.7	5	0	23	220	Do.
					A_5	-2,238	190	146/77	3.3	7	2	220	167	Good aquifer.
					A_6	-2,595	113	70/62	1.6	2	0	167	85	Chloride 500 to >1,000 mg/L.
					A_7	-2,793	557	364/65	1.9	17	1	85	60 in F	Chloride <250 to >250 mg/L.
10	Jordan Heirs,1	31°58'47"	82°38'48"	195	A_2A_3	-	-	-	-	-	-	-	-	No log.
	Wheeler County				A_4	-2,055	227	149/66	1.9	5	1	-	58	
					A_5	-2,340	345	233/68	2.1	10	3	58	71	Good aquifer.
					A_6	-2,756	212	111/52	1.1	6	0	71	32	Chloride to >1,000 mg/L.
					A_7	-3,000	509	337/66	2.0	17	2	32	Into unit underlying F.	Chloride to >250 mg/L.
11	Mrs. W.E. Bradley,1	31°52'55"	82°23'00"	231	A_2A_3	-1,849	225	180/71	2.4	6	0	52	397	
	Appling County				A_4	-2,501	168	126/75	2.4	4	0	397	50	Chloride >500 mg/L.
					A_5	-2,719	167	109/65	1.9	6	0	50	299	Do.
					A_6	-3,185	358	252/70	2.4	6	0	299	19	Chloride >1,000 mg/L.
					A_7	-3,562	173	122/71	2.4	9	0	19	132 in F/underlying unit	A_6 and A_7 are one aquifer.
12	Clark-McCaskill,2	31°26'30"	82°03'40"	75	A_2	-2,710	50	27/54	1.2	2	0	40	87	Chloride >1,000 mg/L.
	Pierce County				A_3	-2,857	213	126/59	1.4	0	0	87	745	Do.
					A_4	-	-	-	-	-	-	-	-	Confining.
					A_5	-	-	-	-	-	-	-	-	Do.
					A_6	-3,815	350	242/69	2.2	7	0	745	105	Chloride >1,000 mg/L.
13	Brunswick-Peninsula Corp.,1	31°23'30"	81°48'31"	73	A_2A_3	-2,627	198	136/69	2.2	4	0	40	1,172	Chloride >1,000 mg/L.
					A_4	-	-	-	-	-	-	-	-	Confining.
					A_5	-	-	-	-	-	-	-	-	Do.
	Wayne County				A_6	-3,997	327	225/69	2.2	11	0	1,172	13	
					A_7	-4,337	167	103/62	1.6	5	1	13	Into unit underlying F.	High chloride concentration.
14	W.C. McDonald,ST1	31°14'42"	81°38'01"	25	A_2A_3	-2,499	846	-	-	-	-	18	146	Carbonate predominates.
	Glynn County				A_4	-3,491	147	89/61	1.5	2	0	146	445	Chloride >1,000 mg/L.
					A_5	-	-	-	-	-	-	-	-	Confining.
					A_6	-4,083	113	87/77	3.3	5	1	445	47	High chloride concentration.
					A_7	-4,243	430	309/72	2.6	13	3	47	Into unit underlying F.	Do.
15	Grace McCain,1	32°28'40"	82°45'33"	287	A_2A_3	-596	367	291/79	3.8	11	3	12	86	Includes lower Tertiary sand.
	Laurens County				A_4	-1,049	84	69/82	4.6	4	0	86	30	
					A_5	-1,163	118	83/70	2.4	3	2	30	12	A_5 and A_6 are one aquifer.
					A_6	-1,293	272	185/68	2.1	8	3	12	166	Do.
					A_7	-1,731	502	340/68	2.1	18	2	166	Into unit underlying F.	Good aquifer.
16	Clyde E. Hinson,1	32°05'40"	82°48'40"	206	A_2A_3	-1,662	100	66/66	1.9	5	0	144	39	Good aquifer.
	Wheeler County				A_4	-1,802	286	198/69	2.3	7	1	39	31	Do.
					A_5	-2,119	203	141/69	2.3	9	0	31	167	Do.
					A_6	-2,489	274	186/68	2.1	5	0	167	28	Chloride 250 to >1,000 mg/L.
					A_7	-2,791	422	297/70	2.4	17	0	28	Into unit underlying F.	Chloride 250 mg/L.
17	J.L. Sinclair,1	31°46'08"	82°44'53"	287	A_2A_3	-1,525	314	231/74	2.8	2	0	12	229	Chloride 250 to >500 mg/L.
	Jeff Davis County				A_4	-2,068	209	149/71	2.5	2	0	229	56	Chloride >250 mg/L.
					A_5	-2,333	190	150/79	3.8	3	0	56	325	
					A_6	-2,848	507	429/85	5.5	15	0	325	62	Chloride 250 to >500 mg/L.
					A_7	-3,417	332	258/78	3.5	5	0	62	Into unit underlying F.	Chloride >1,000 mg/L at top; lower toward bottom.
18	Oveda Fussell,1	31°27'05"	83°08'06"	295	A_2A_3	-1,651	146	120/82	4.6	8	0	146	966	
	Coffee County				A_4	-	-	-	-	-	-	-	-	Confining.
					A_5	-	-	-	-	-	-	-	-	Do.
					A_6	-2,763	517	387/75	3.0	25	1	966	87	Chloride <250 at top to 5,000 mg/L at bottom.
					A_7	-3,367	488	333/68	2.1	20	2	87	154 in F.	High chloride.
19	Doster & Ladson,1	31°16'00"	82°57'00"	223	A_2A_3	-	-	-	-	-	-	-	-	Confining.
	Atkinson County				A_4	-	-	-	-	-	-	-	-	Do.
					A_5	-	-	-	-	-	-	-	-	Do.
					A_6	-3,035	460	316/69	2.2	13	0	1,455	114	Chloride 250 to >1,000 mg/L.
					A_7	-3,609	388	260/67	2.0	7	1	114	Into unit underlying F.	Chloride high.
20	W.J. Barlow,1	30°55'42"	82°47'53"	177	A_2A_3	-	-	-	-	-	-	-	-	Absent.
	Clinch County				A_4	-2,685	87	-	-	-	-	156	413	Carbonate predominates.
					A_5	-	-	-	-	-	-	-	-	Confining.
					A_6	-3,185	265	174/66	1.9	10	0	413	87	Chloride 1,000 to 5,000 mg/L.
					A_7	-3,537	141	100/71	2.4	5	0	87	Into unit underlying F.	High chloride.
21	Bennett & Langsdale,1	30°45'29"	82°54'36"	181	A_2A_3	-	-	-	-	-	-	-	-	Absent.
					A_4	-2,629	92	-	-	-	-	-	292	Carbonate predominates.
					A_5	-	-	-	-	-	-	-	-	Confining.
	Echols County				A_6	-3,164	225	140/62	1.6	10	0	151	131	Chloride 1,000 to 5,000 mg/L.
					A_7	-3,520	393	297/76	3.1	17	3	131	Into unit underlying F.	High chloride.
22	Superior Pine Products,3	30°36'58"	82°46'58"	144	A_2A_3	-2,450	75	-	-	-	-	17	2	Carbonate predominates; A_2, A_3, and A_4 are one aquifer.
					A_4	-2,527	153	-	-	-	-	2	447	
					A_5	-	-	-	-	-	-	-	-	Confining.
	Echols County				A_6	-3,127	76	44/58	1.4	0	0	447	120	Chloride high.
					A_7	-3,323	188	124/66	1.9	11	0	120	Into unit underlying F.	Do.

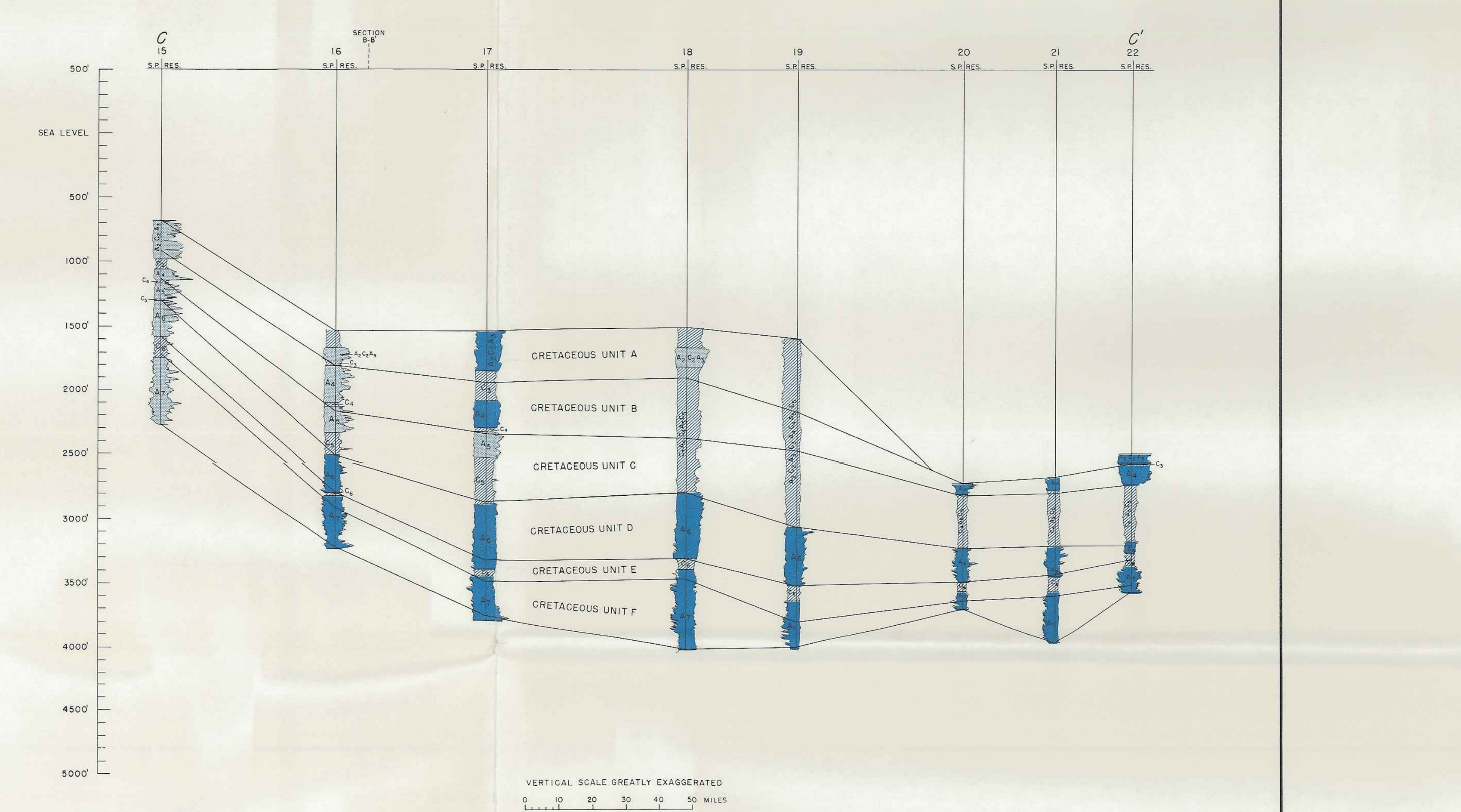




GENERALIZED SECTIONS OF CRETACEOUS AQUIFERS AND CONFINING UNITS.



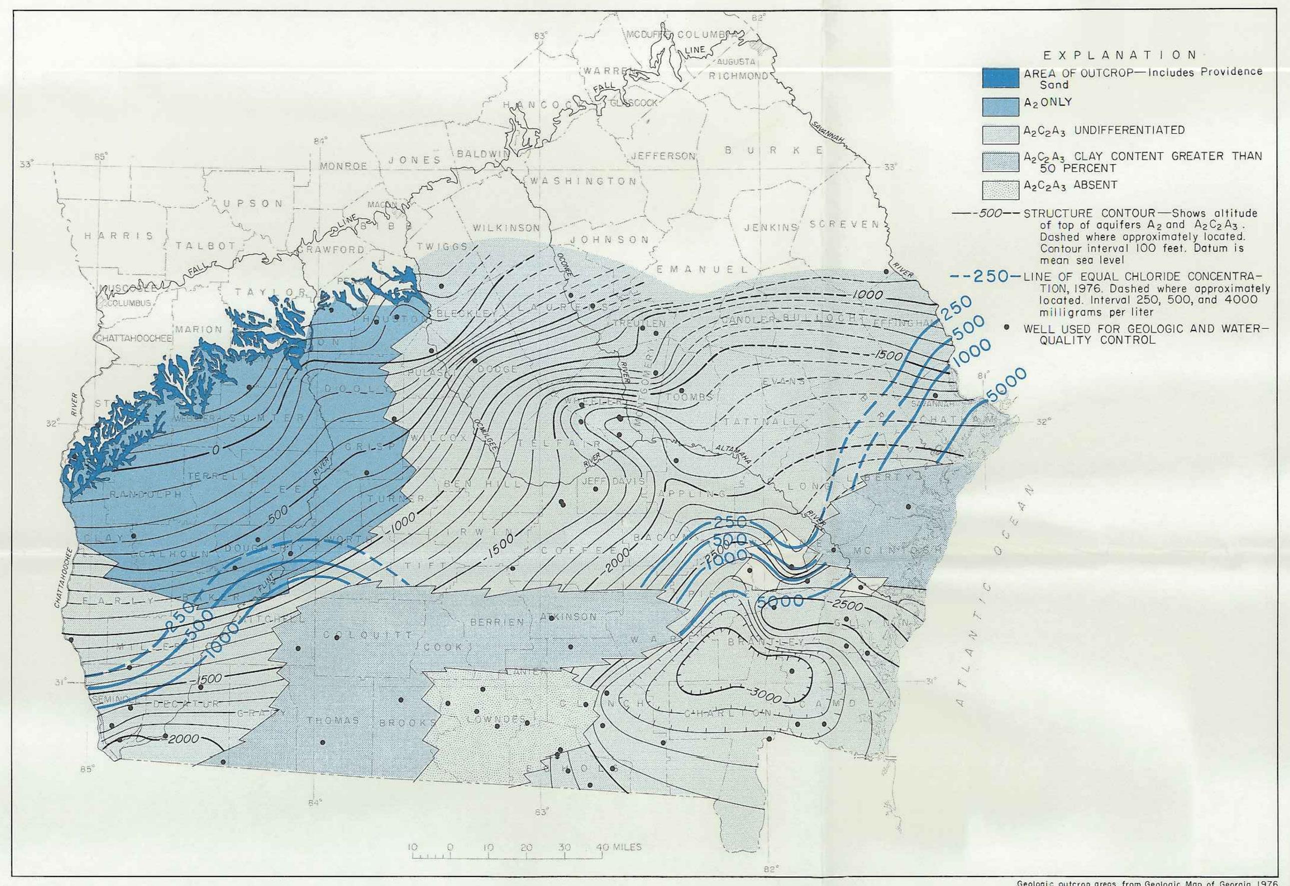




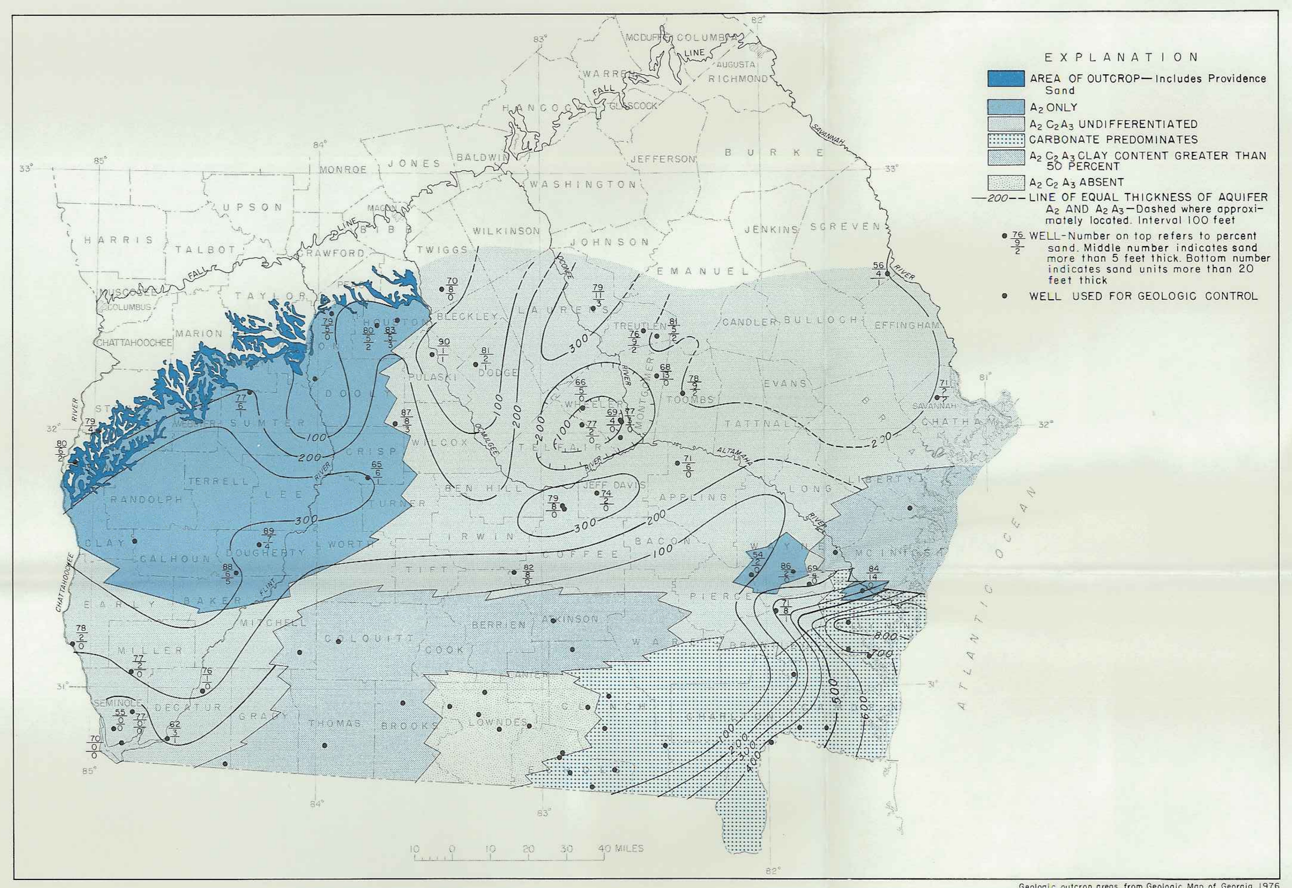
CRETACEOUS AQUIFERS A_2, A_3, A_4, A_5, A_6, AND A_7 RELATED TO THE CHRONOSTRATIGRAPHIC UNITS OF BROWN AND OTHERS, 1972. (THESE SECTIONS ARE MODIFIED FROM BROWN AND OTHERS, 1979.)

Cartography by W.G.Hester and P.N.Grocoff

AQUIFERS A_2, A_3, AND $A_2C_2A_3$



ALTITUDE OF TOP OF AQUIFERS A_2 AND $A_2C_2A_3$ UNDIFFERENTIATED AND CHLORIDE DISTRIBUTION IN WATER FROM THESE AQUIFERS.



DISTRIBUTION, THICKNESS, AND GENERALIZED LITHOLOGY OF AQUIFERS A_2 AND $A_2C_2A_3$ UNDIFFERENTIATED.

Aquifers A_2 and A_3 are distinct water-bearing units in the northwestern part of the Coastal Plain. These two units become less distinct in the remainder of the Coastal Plain, where only one aquifer ($A_2C_2A_3$) can be identified.

Aquifer A_2 correlates with the Providence Sand along the Chattahoochee River and is exposed at the surface in a band that extends from Quitman County eastward into Houston County. Along the Chattahoochee River, A_2 is a medium to coarse quartzose sand that locally can be argillaceous, calcareous, carbonaceous, and crossbedded. Aquifer A_3 correlates with the Cusseta Sand along the Chattahoochee River and is exposed at the surface in a band that extends from Stewart County eastward into Bibb County. Along the Chattahoochee River, A_3 is a medium to very coarse, crossbedded, quartzose sand. A_3 thins toward the south and east and is not separated from A_2 by confining unit C_2, except for two small areas in Wayne, Pierce, and Glynn Counties in southeast Georgia. In these areas more than 50 percent of the aquifer may be carbonate. (The confining units are semipermeable layers that have a clay content greater than 50 percent.)

The combined aquifer $A_2C_2A_3$ dips in the subsurface toward the southeast. In general, the clay content in $A_2C_2A_3$ increases from the northwest to the southeast. In the southeast corner of Georgia, $A_2C_2A_3$ is within a carbonate unit. Sediments of the age represented by $A_2C_2A_3$ are absent in Lowndes County, the western part of Echols and Clinch Counties, and the southern part of Lanier County.

Major recharge to aquifers A_2 and A_3 occurs in the area of outcrop between the Chattahoochee and Ocmulgee Rivers and in the updip sands of aquifer A_1 that are hydraulically connected with the sands of A_2 and A_3. The water moves downdip toward the southeast. Small amounts of water discharge into streams crossing the outcrop area. The potentiometric contours imply that water from aquifers A_2 and A_3 may also be leaking through overlying units and be discharging into streams.

Observed transmissivities for A_2, estimated from specific capacities of wells, average about 550 ft^2/d in Schley County, 900 ft^2/d in Clay County, and more than 2,000 ft^2/d in Stewart County. East of the Ocmulgee River in Laurens County the observed transmissivity is 20,000 ft^2/d and artesian pressure is sufficient to allow wells tapping A_2 to flow. Reported yields range from 100 gal/min in Stewart County and 200 gal/min in Schley County to more than 1,000 gal/min in Laurens County.

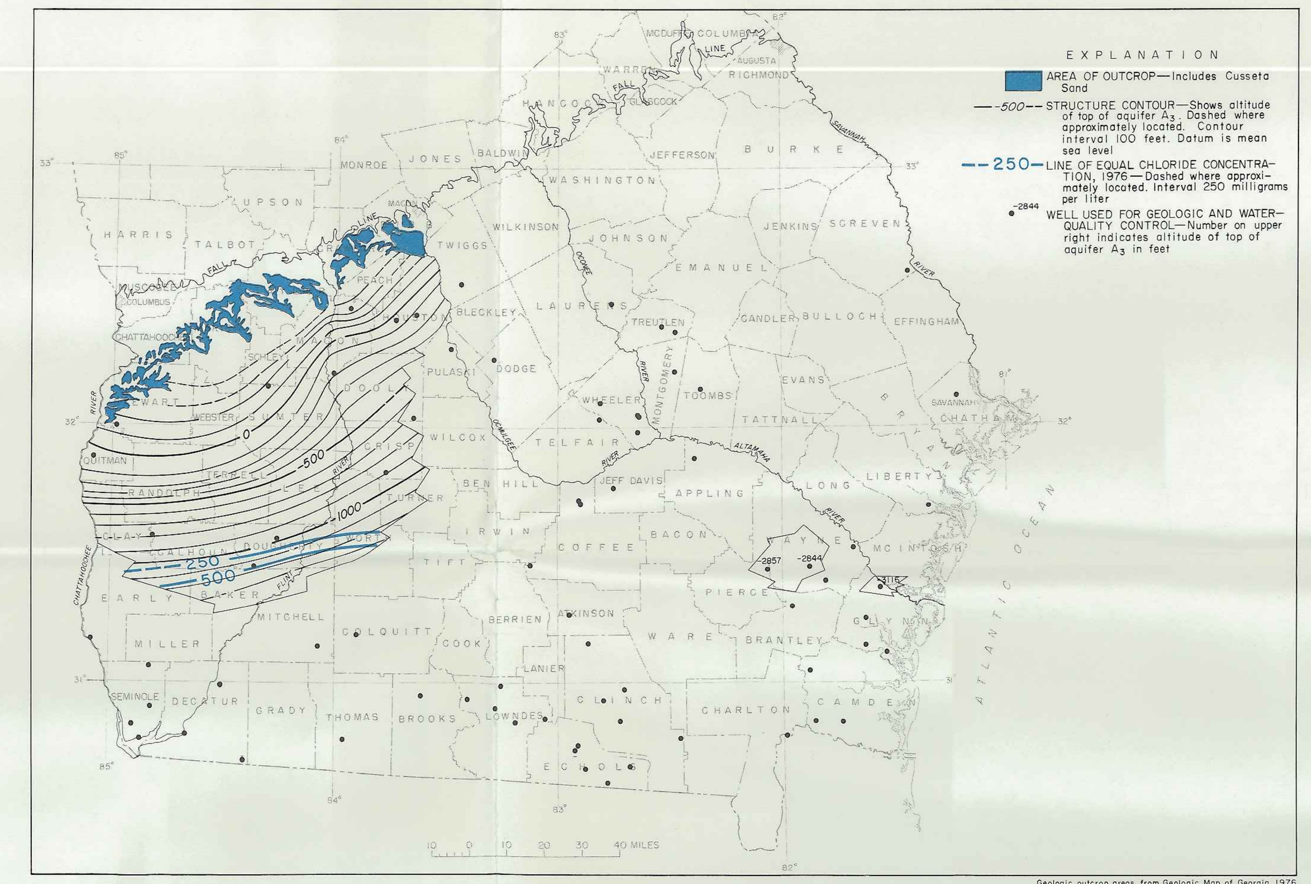
Observed transmissivities for aquifer A_3, estimated from specific capacities, are 650 ft^2/d in Stewart County, 2,000 ft^2/d in Schley County, 3,500 ft^2/d in Macon and Marion Counties, and 14,000 ft^2/d in Houston County. Artesian pressure is sufficient to allow wells in Macon, Houston, and Dougherty Counties to flow. Reported yields are less than 50 gal/min in Stewart County and average about 400 gal/min in Schley County, 500 gal/min in Marion County, and more than 1,000 gal/min in Macon and Houston Counties.

Where larger yields are required, A_2 and A_3 are used together or in combination with other aquifers. In Americus, Sumter County, wells produce water from sediments of early Tertiary age as well as from A_2 and A_3. The estimated transmissivity for the combined early Tertiary--A_2-A_3 aquifer averages 2,000 ft^2/d, but can be as large as 5,000 ft^2/d.

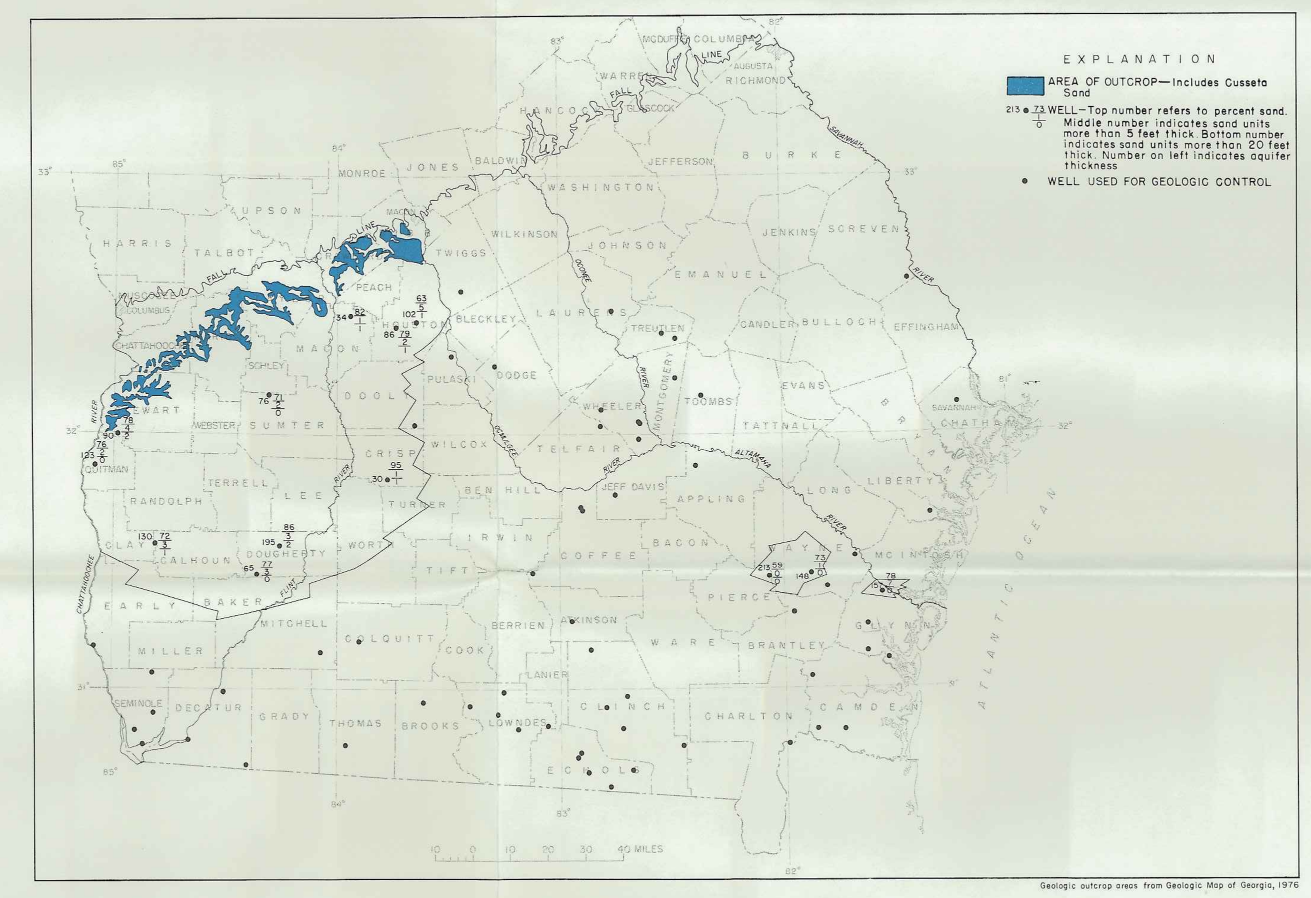
Near the recharge area in Macon County, ground water from aquifers A_2 and A_3 contains less than 50 mg/L dissolved solids and has a pH of about 5. South from the outcrop area the concentration of dissolved constituents in the water becomes increasingly higher. Sodium becomes the dominant cation and bicarbonate the dominant anion. Southwest of Albany, Dougherty County, the chloride concentration is greater than 400 mg/L. Where A_2 and A_3 are locally calcareous, the calcium concentration increases slightly and in southeast Georgia, where A_2 and A_3 are mainly carbonate rock, the water is believed to be very high in dissolved solids, calcium, bicarbonate, and chloride. East of the Ocmulgee River in Laurens County, water from $A_2C_2A_3$ combined has an average dissolved-solids concentration of 100 mg/L and is a calcium bicarbonate type. This water tends to have a high dissolved-iron concentration (6.7 mg/L) and a pH of about 6.7. Geophysical logs indicate that the water from A_2 and A_3 is fresh (less than 250 mg/L chloride) to depths that range from about 1,000 ft to more than 2,300 ft below mean sea level.

Municipalities are the major users of water from aquifers A_2 and A_3. Municipal wells in and just south of the area of outcrop yield 100 to 400 gal/min. In Sumter County over 2 Mgal/d is obtained from the combined early Tertiary--A_2-A_3 aquifer. Since major pumping began in Americus, Sumter County, in the 1950's, the water level has declined an average of 35 ft. Municipal wells in Albany, Dougherty County, are screened in more than one aquifer and only a part of the water is produced from A_2. Based on data from four test wells in the Albany area, A_2 yields 0 to 29 percent of the water in the multiaquifer wells (R. E. Krause, oral commun., 1976). Since major pumping began in Albany in the late 1950's, water levels have declined in some aquifers, but the amount of decline, if any, that has taken place in A_2 is unknown at this time (1978).

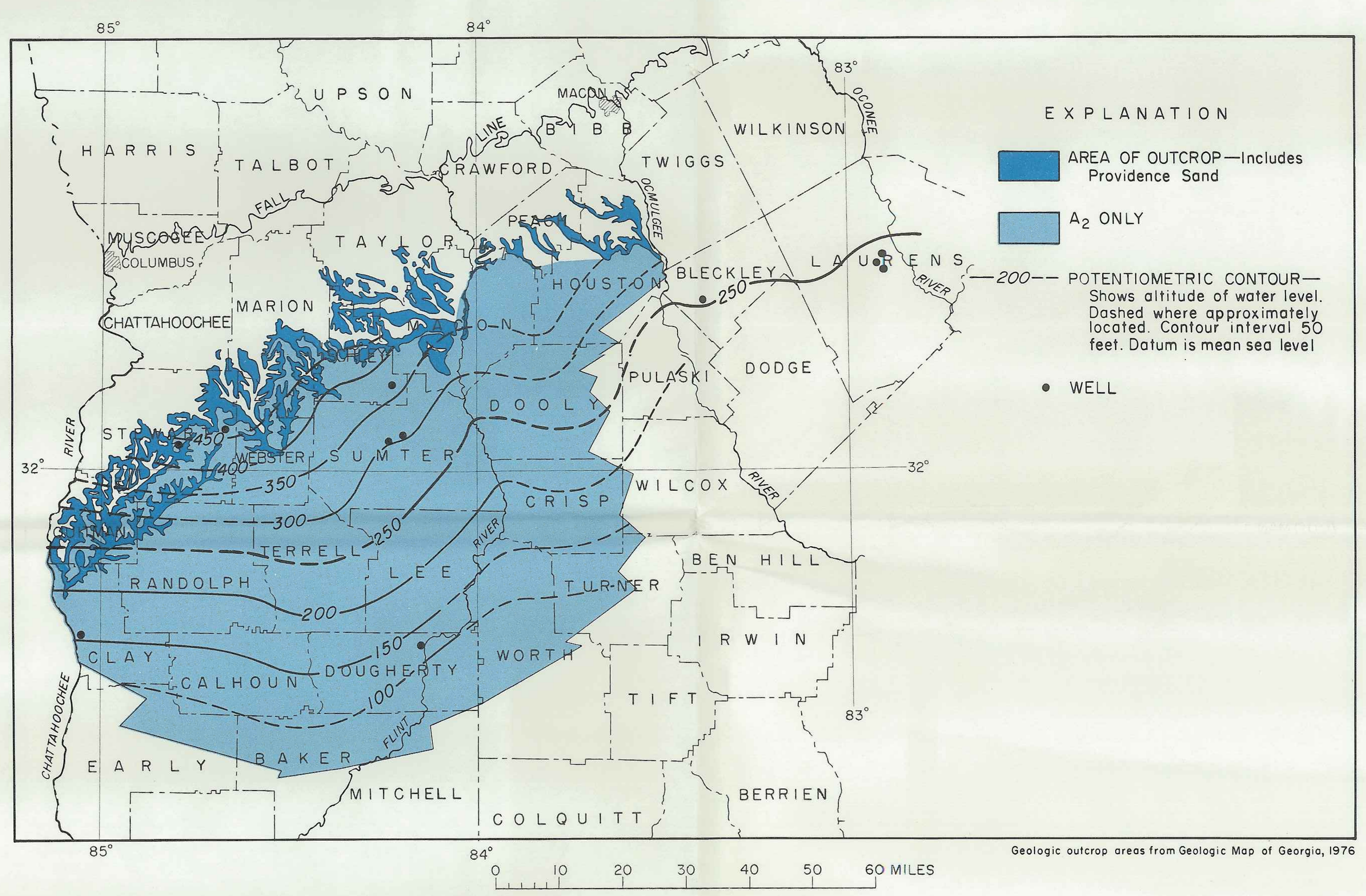
Aquifer A_2 has the greatest potential for development in the northwest Coastal Plain where the sand content is over 80 percent and the thickness is 200 to more than 300 ft. Aquifer A_3 apparently has the greatest potential for development in the southern half of Houston and Macon Counties and the northern part of Sumter County, where the sands are thickest. Aquifer $A_2C_2A_3$ has the greatest potential for future development in the north-central Coastal Plain, where it is composed of more than 75 percent sand, is over 200 ft thick, and contains at least one sand unit more than 20 ft thick. Although the development potential is good in Laurens County, the consequence of low pH and high iron concentration should be considered.



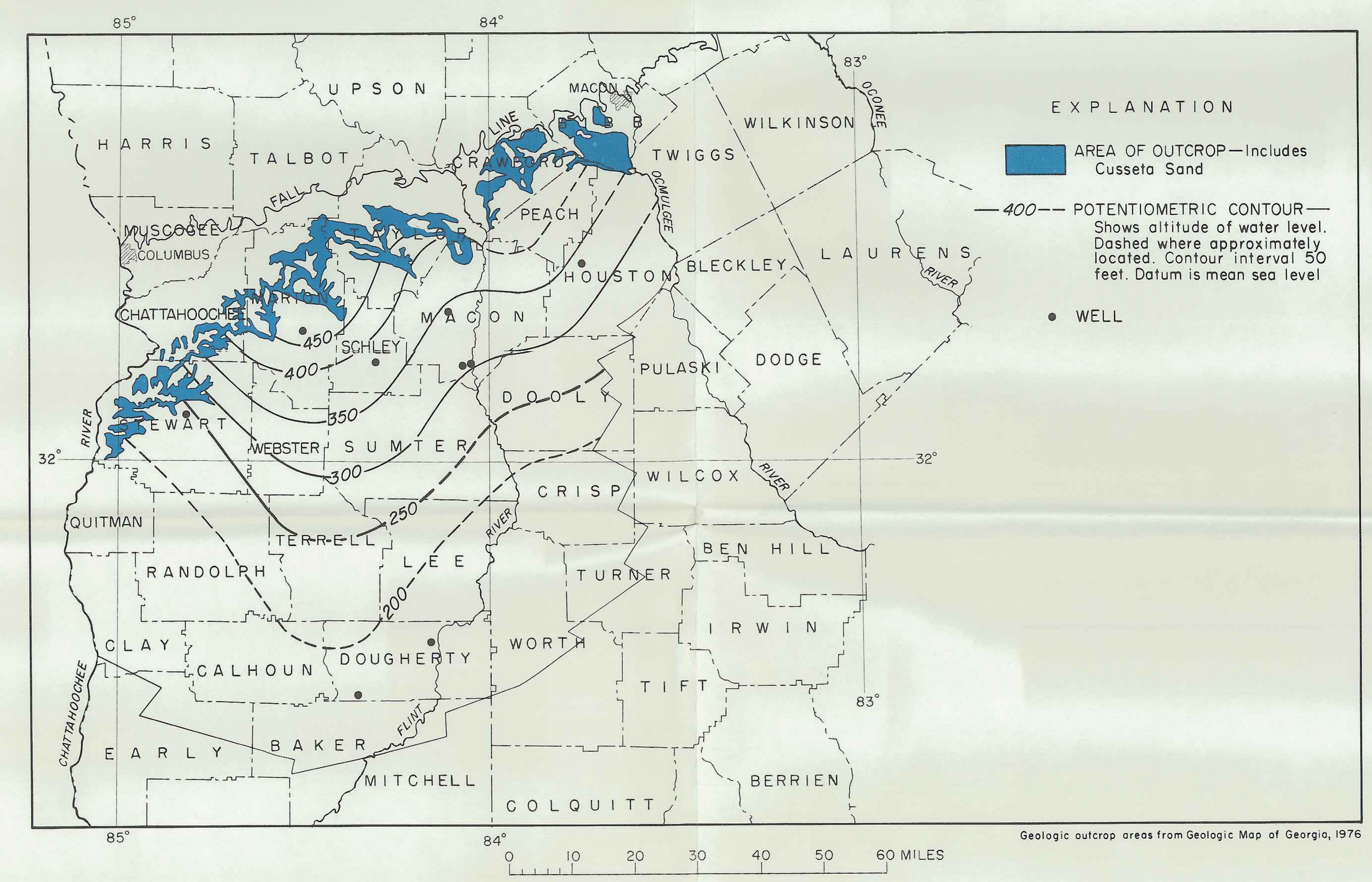
ALTITUDE OF TOP OF AQUIFER A_3 AND CHLORIDE DISTRIBUTION IN WATER FROM THIS AQUIFER.



DISTRIBUTION, THICKNESS, AND GENERALIZED LITHOLOGY OF AQUIFER A_3.



GENERALIZED POTENTIOMETRIC SURFACE OF AQUIFERS A_2 AND $A_2C_2A_3$ UNDIFFERENTIATED, SEPTEMBER 1976.



GENERALIZED POTENTIOMETRIC SURFACE OF AQUIFER A_3, SEPTEMBER 1976.

Cartography by W. G. Hester and P. N. Grocoff

GEOHYDROLOGIC BACKGROUND

Summary of the lithology and water-bearing properties of the Cretaceous aquifer system

Aquifer	Lithology	Water-bearing properties
A_1	Sand, medium to coarse, micaceous; averages 65 percent of A_1; interbedded with clay in layers and lenses.	Yields to more than 2,000 gal/min. Greatest potential for development--where sand units are more than 20 ft thick and where there are no large quantities of water already being pumped from A_1.
A_2	Sand, medium to coarse, along Chattahoochee River; separate unit in northwestern Coastal Plain and is combined with A_3 in remainder of Coastal Plain. Clay; content increases toward southeast. Carbonate; in southeast Georgia where A_2A_3 is over 800 ft thick. Absent in central-south Georgia.	Yields from 200 gal/min in Schley County to more than 1,000 gal/min in Laurens County. Greatest potential for development--northwest Coastal Plain where sand content is more than 20 percent and A_2 is over 200 ft thick.
A_3	Sand, medium to very coarse, crossbedded; average thickness, 80 ft; separate unit in northwestern Coastal Plain and is combined with A_2 in remainder of Coastal Plain. Clay; content increases toward southeast. Carbonate; in southeast Georgia where A_2A_3 is more than 800 ft thick. Absent in central-south Georgia.	Yields range from 50 gal/min in Stewart County to more than 1,000 gal/min in Houston County. Water flows from wells producing from A_2A_3 combined. A_3 is developed with overlying or underlying aquifers.
A_4	Sand, medium to coarse, locally carbonaceous, along Chattahoochee River. Silt, clay; content increases to south and east. Carbonate; in southeast Georgia.	Yields from A_4 not large enough for most municipalities and industries. A_4 combined with overlying and underlying aquifers in production wells.
A_5	Sand, coarse, crossbedded, along Chattahoochee River. Silt, clay, carbonate; content increases toward southeast and forms southern limit to A_5.	Yields from combined aquifers A_4, A_5, and A_6 in Macon, Peach, Houston, and Taylor Counties can be more than 1,000 gal/min. Greatest potential for development--Laurens, Wheeler, Dodge, and Telfair Counties; however, depth to A_5 (500 to 2,000 ft) is a consideration.
A_6	Sand, coarse, along Chattahoochee River. Silt, clay, carbonate; content increases to south and east; distinct carbonate layers present in A_6 in southeast Georgia.	Yields range from about 100 gal/min in Stewart County to more than 600 gal/min in Bibb County. A_6 combined with overlying aquifers in Taylor, Houston, Peach, Marion, and Macon Counties yields from 300 gal/min to more than 1,600 gal/min. Greatest potential for development--northern one-third of Coastal Plain. A_6 is one of the most productive Cretaceous aquifers.

The major source of recharge to the Cretaceous aquifer system is rainfall where the aquifers comprising this system intersect land surface south of the Fall Line. Rainwater infiltrates the surface sediments and moves downgradient through the aquifer system toward points of natural discharge. Some water moves vertically through confining layers between aquifers containing water under different hydrostatic pressures.

Natural discharge from the Cretaceous aquifers in the outcrop area is into streams and rivers. Pumping from the Cretaceous aquifers in these areas can reduce the amount of water normally contributed to streamflow.

The ability of a sand aquifer to store and transmit water depends on: (1) the percentage of sand in the aquifer, (2) the size of the sand grains, (3) the thickness of the individual sand layers, and (4) the effectiveness of the units above and below the aquifer to confine the water. The total thickness and the percentage of sand in each operational water-bearing unit or aquifer and the number of sand units in each aquifer thicker than 5 ft and 20 ft were determined from geophysical logs, lithologic descriptions, and driller's logs. These aquifer characteristics are used to evaluate the potential of the aquifers to yield water for major users in a particular area.

Aquifer transmissivities are used as indicators in a particular area of an aquifer's potential to yield water to wells. The transmissivity of an aquifer is generally defined as the rate at which water is transmitted through the aquifer under a unit hydraulic gradient and is reported in units of feet squared per day (ft^2/d). Transmissivity can be determined from an aquifer test in which one or more wells are pumped and the effect on the water level in adjacent wells tapping the same aquifer is observed. The transmissivity of an aquifer can also be estimated from the specific capacity (gallons per minute of water produced per foot of drawdown) of single wells. Estimated transmissivities for the Cretaceous sand aquifers range from less than 100 ft^2/d near the Fall Line west of the Ocmulgee River to more than 37,000 ft^2/d in aquifer A_1 east of the Ocmulgee River. A more detailed discussion of ground-water hydraulics can be found in Lohman (1972).

WATER QUALITY

Chemical analyses of water from Cretaceous aquifers at selected localities

[Analyses by U.S. Geological Survey]

Well location	Aquifer	Chemical analyses																Depth of water below land surface (ft)
		Silica (mg/L)	Iron (ug/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)	Dissolved solids (mg/L)	Hardness as calcium carbonate: Calcium, magnesium (mg/L)	Hardness as calcium carbonate: Noncarbonate (mg/L)	Specific conductance (micromhos at 25°C)	pH	
Griswold, Jones County	A_1	8.1	0	1.1	0.2	1.3	0.1	4	0.1	2.2	0	0.3	19	4	0	22	5.4	35-75
McIntrye, Wilkinson County		16	1,100	2.3	.3	3.5	3.7	9	7.1	3.2	0.1	0	51	7	0	54	5.6	328-348
Lumpkin, Stewart County	A_2	7.8	0	1.3	.6	3.5	.8	3	1.5	4.7	0	6.6	31	6	3	28	4.6	125-155
Fort Gaines, Clay County		14	-	4.4	1.0	87.0	1.4	218	9.9	13	.8	0	245	15	0	395	8.4	310-370
North of Oglethorpe, Macon County	A_3	18	1,800	6.0	.7	.9	1.8	17	8.7	1.6	.4	0	38	18	4	57	5.8	229-277
Albany, Dougherty County		15	-	5.2	2.3	586	5.6	820	0	435	2.6	7.6	1,500	22	0	2,490	8.4	1,200
Butler, Taylor County	A_5	8.8	10	2.3	.1	.3	.1	1	3.3	1.9	.3	.27	16	6	5	14	4.5	196-216
Northwest of Savannah, Chatham County		17	2,600	41	2.8	1,600	14	854	98	1,900	.8	.1	4,140	120	0	7,300	7.7	2,570-2,580
South of Macon, Bibb County	A_6	10	80	2.5	.2	2.4	.7	0	1.1	2.4	0	4.9	37	7	7	36	5.3	100-243
Northwest of Savannah, Chatham County		21	140	4.0	.5	560	3.9	995	120	210	11	0	1,430	12	0	2,300	7.4	3,216-3,226

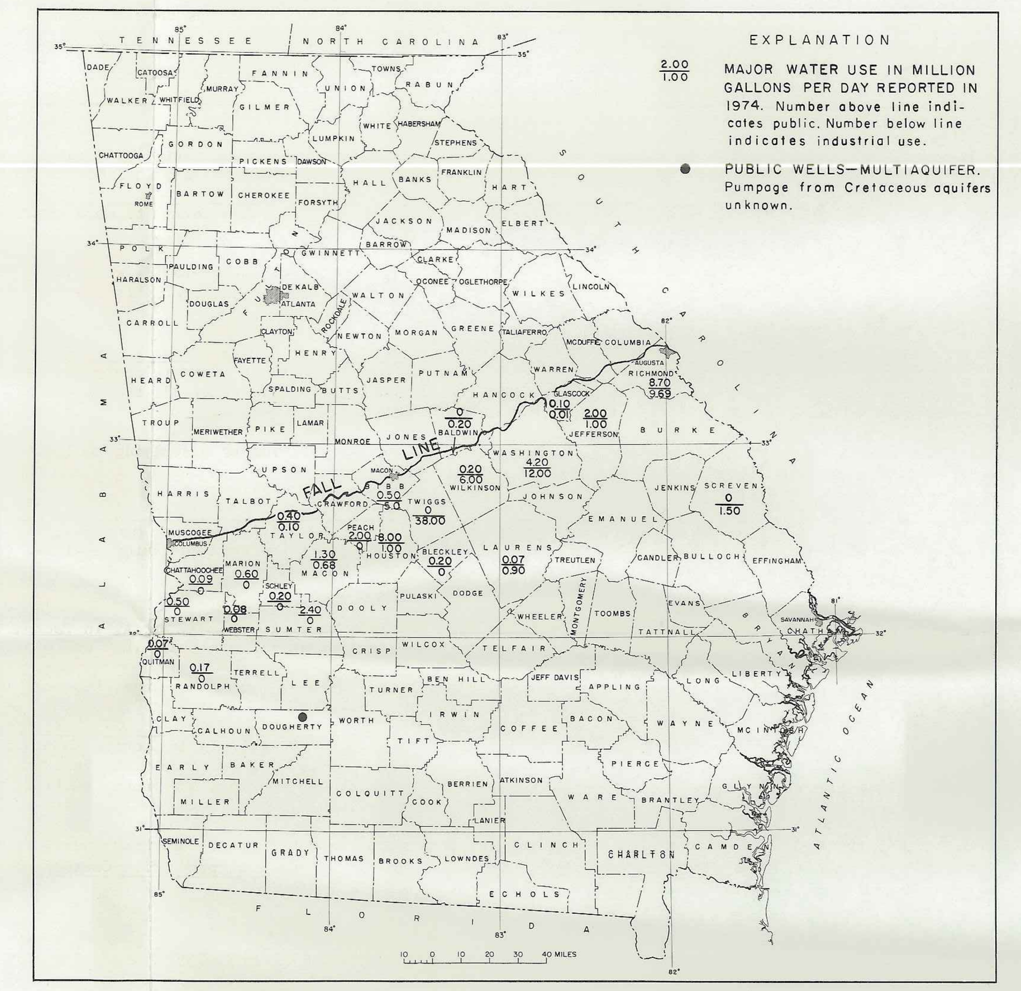
The quality of ground water depends upon the original composition of the water, the composition and texture of the material through which the water has moved, and the length of time the water has reacted with that material. Water near the surface in the outcrop area (aquifer A_1 near Griswold, Jones County, and aquifer A_2 in Lumpkin, Stewart County, shown in above table) is typically low in most dissolved constituents and is slightly acidic. As the water moves downgradient through the aquifer, the dissolved-solids concentration, the pH, and the sodium and bicarbonate concentrations increase.

The above table gives two chemical analyses for water from each aquifer, except A_4 and A_7 for which complete analyses are not available. The first analysis for each aquifer is representative of ground water collected near the aquifer's outcrop area, and the second analysis is representative of water sampled downgradient in the same aquifer. An increase in dissolved constituents with increasing depth and distance downdip is demonstrated for each aquifer. In general, water from the Cretaceous aquifers contains higher concentrations of sodium and chloride ions with increasing depth. One exception is water from aquifer A_6 beneath A_5 in Chatham County, which is a sodium bicarbonate type water rather than a sodium chloride type.

The amount of "saltiness" for each aquifer is represented by distribution maps of chloride concentrations. Estimates of chloride concentrations made from geophysical logs based on techniques described by Alger (1966) and Brown (1971) indicate that freshwater is present in aquifers of Cretaceous age to depths that vary from 1,000 to 2,300 ft below mean sea level at distances as great as 100 mi southeast of the Fall Line.

Iron dissolved in ground water occurs in objectionable concentrations in some wells tapping Cretaceous sand aquifers. Iron is dissolved from material through which the water passes and is carried in solution in water having a low pH and dissolved-oxygen concentration. When air mixes with the water, the iron precipitates as an oxide, causing discoloration of the water and encrustation of pipes.

WATER USE



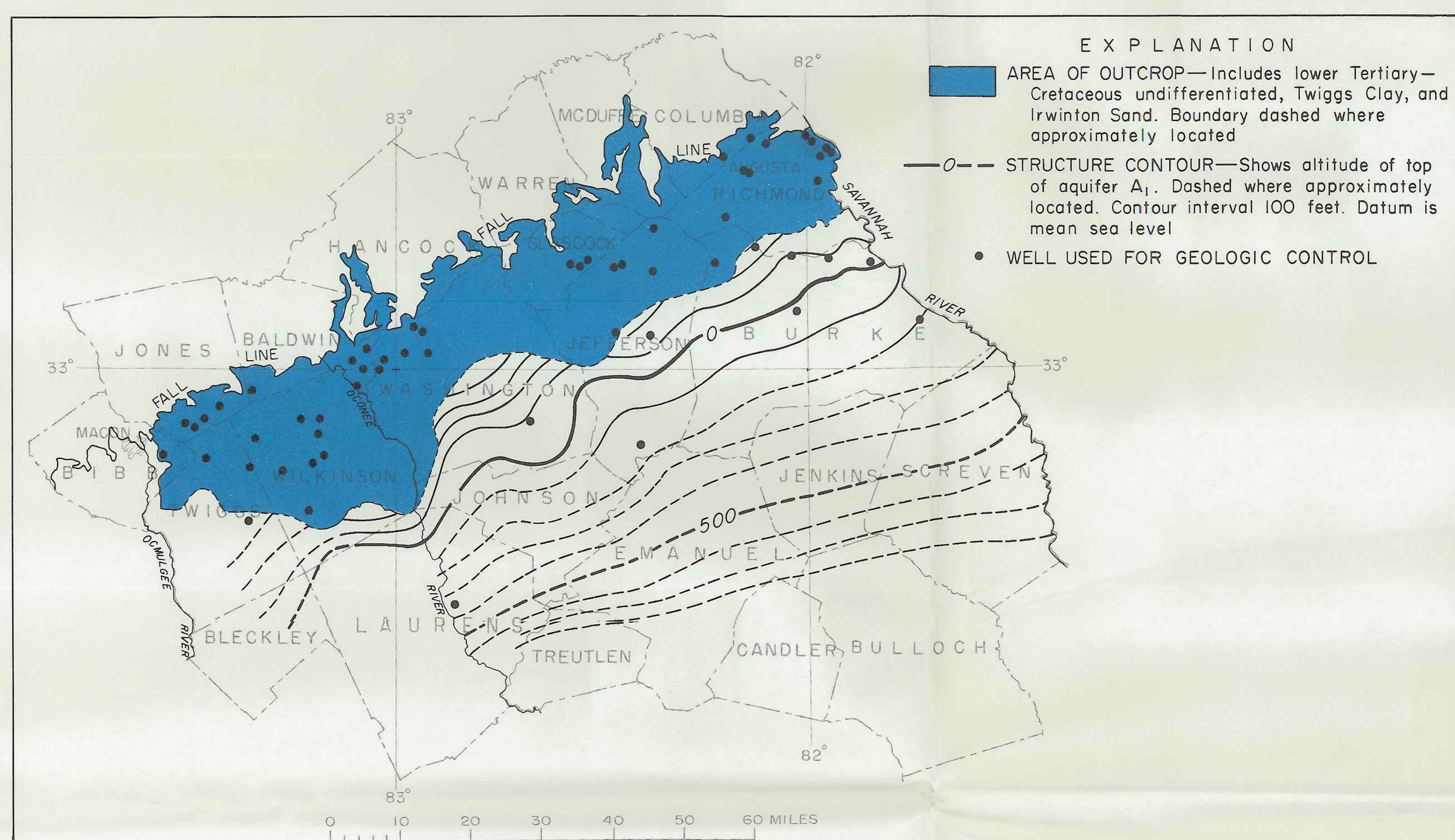
MAJOR GROUND-WATER USE BY COUNTY FROM AQUIFERS A_1, A_2, A_3, A_4, A_5, AND A_6 IN 1976.

Approximately 108 Mgal/d of water was pumped from aquifers A_1-A_6 for public and industrial uses in 1976. The average amount of water pumped per day for each county in which the Cretaceous aquifers are the major contributors is summarized in the above figure.

Public use of ground water from aquifer A_1 in 1976 (14.9 Mgal/d) was greatest in Washington, Jefferson, and Richmond Counties. Industrial use was greatest in Twiggs, Wilkinson, Washington, and Richmond Counties, where over 65 Mgal/d was pumped in 1976 for clay-mine dewatering and clay processing. Total pumpage east of the Ocmulgee River was approximately 85 Mgal/d in 1976.

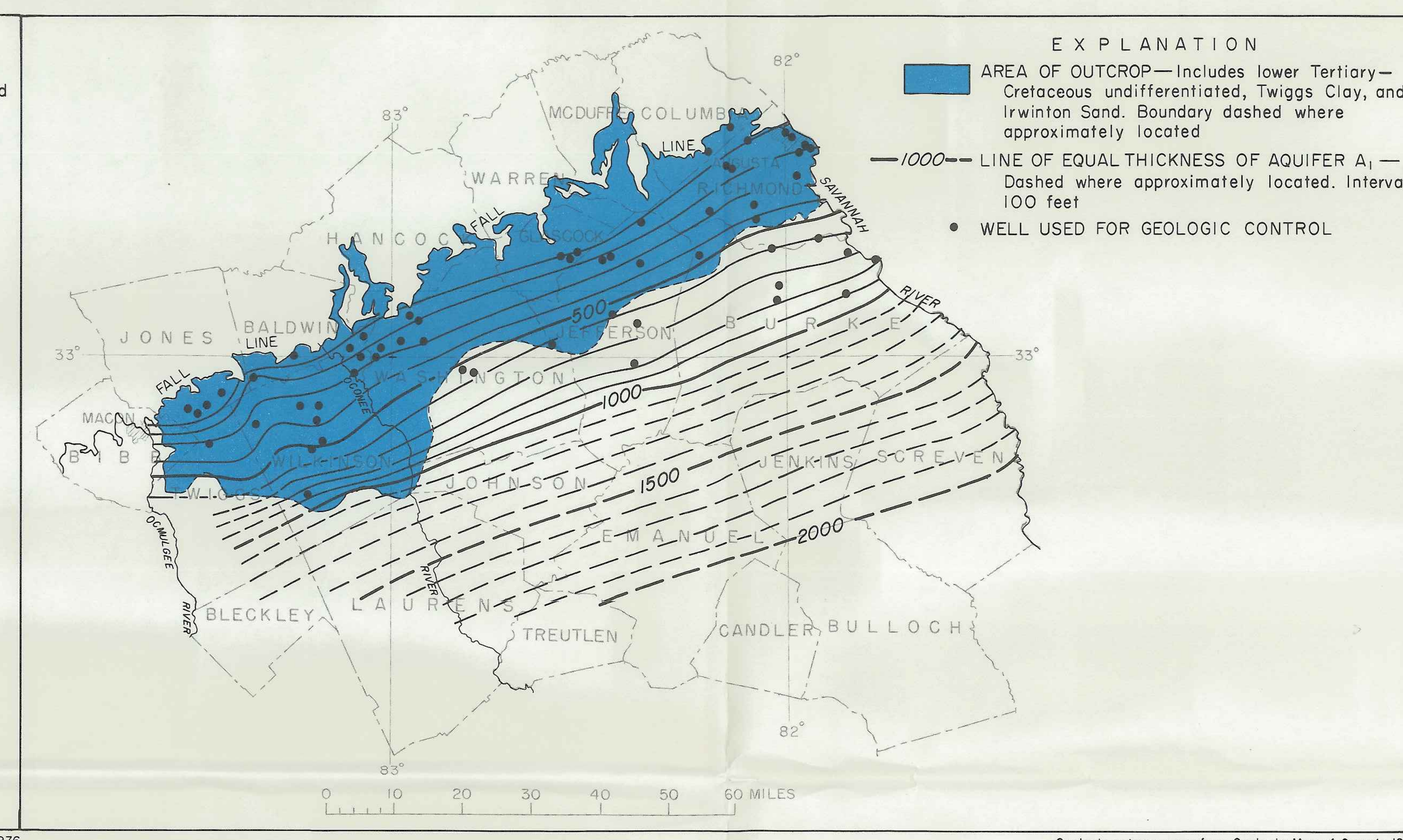
Aquifers A_2, A_3, A_4, A_5, and A_6 west of the Ocmulgee River yielded approximately 16 Mgal/d of water for public supplies in 1976. The major users were in Houston, Sumter, Peach, and Macon Counties. The major industrial users of water, averaging 7 Mgal/d from aquifers A_3, A_4, A_5, and A_6, were in Bibb, Houston, and Macon Counties. Total pumpage for Bibb, Houston, Macon, Peach, and Sumter Counties was greater than 20 Mgal/d in 1976. Wells in Albany, Dougherty County, are multiaquifer wells that withdraw water from A_2 and overlying aquifers. A_2 contributed approximately 1 Mgal/d to total water pumped in the Albany area in 1976.

AQUIFER A_1



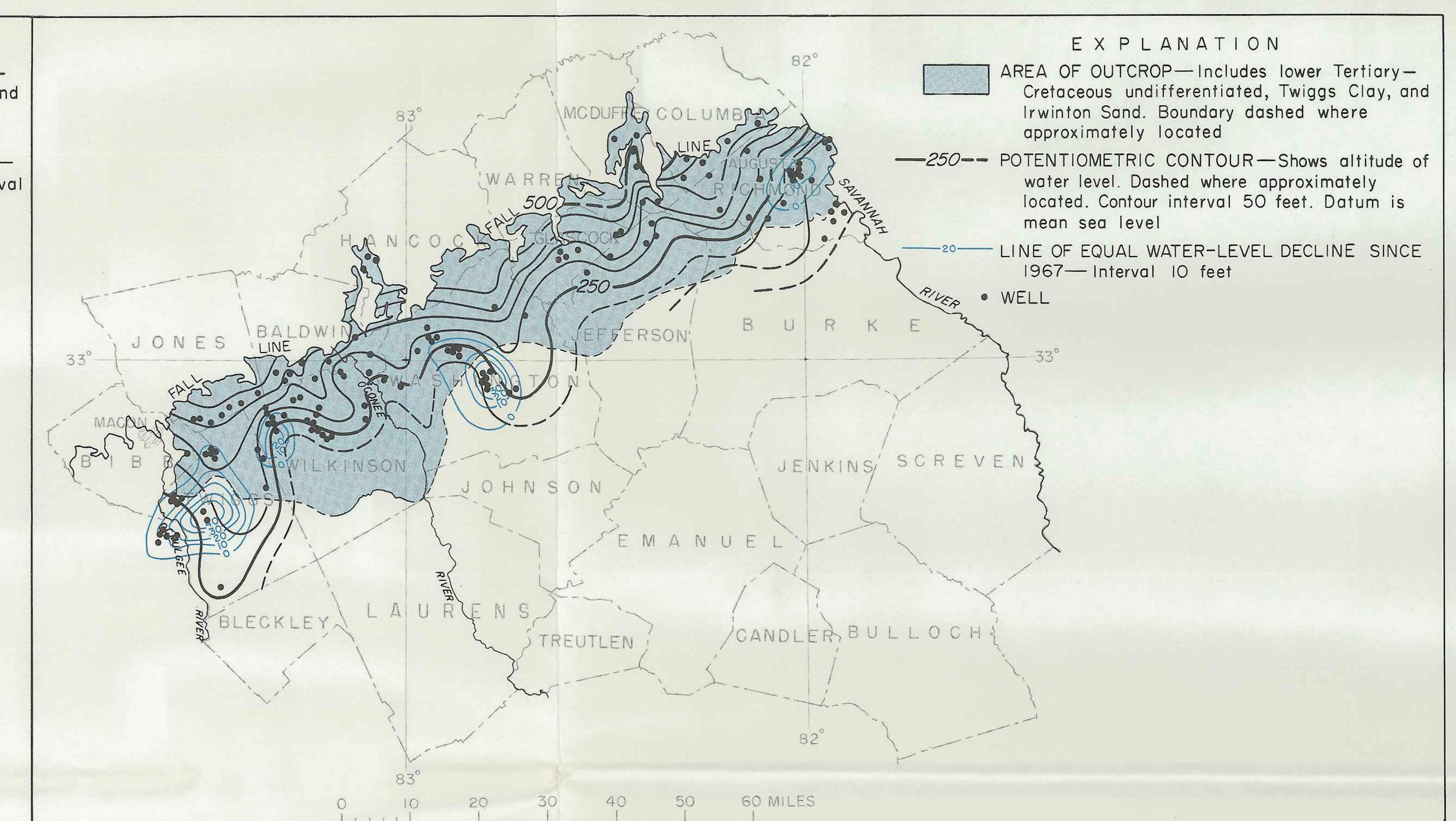
Geologic outcrop areas from Geologic Map of Georgia, 1976

ALTITUDE OF TOP OF AQUIFER A_1.



Geologic outcrop areas from Geologic Map of Georgia, 1976

DISTRIBUTION AND THICKNESS OF AQUIFER A_1.



Geologic outcrop areas from Geologic Map of Georgia, 1976

GENERALIZED POTENTIOMETRIC SURFACE OF AQUIFER A_1, SEPTEMBER 1976.

Aquifer A_1 is exposed from the Ocmulgee River in Bibb County eastward to the Savannah River in Richmond County. A_1 is composed of interbedded sand and clay of Cretaceous age and locally includes sand and clay of early Tertiary age; for the purposes of this report, aquifer A_1 is considered Cretaceous age. The clay is primarily kaolin, which is mined extensively in Twiggs, Wilkinson, Washington, and Jefferson Counties and to a lesser extent in Baldwin, Glascock, and Richmond Counties. A_1 thickens to the south and has an irregular upper surface that is overlain throughout part of the area by a good confining unit called the Twiggs Clay. The subsurface boundary between the area containing A_1, and the area where aquifers A_2, A_3, A_4, A_5, and A_6 can be separately identified, is gradational.

Recharge to aquifer A_1 occurs just south of the Fall Line between the Ocmulgee and Savannah Rivers. Water entering the aquifer moves downdip in a southeasterly direction. Recharge enters the permeable sand and moves around the lenses of kaolin in the aquifer. Because of the discontinuous nature of these lenses, the series of sand and clay acts regionally as one aquifer. Natural discharge from A_1 is into the Oconee, Savannah, and Ocmulgee Rivers and smaller streams in the outcrop area.

Transmissivities between 2,000 and 40,000 ft^2/d have been estimated for A_1 from specific capacities. The maximum reported yield of a well tapping aquifer A_1 is more than 2,000 gal/min.

The large quantity of water being pumped by industry in Twiggs County has caused a water-level decline over the past 10 years, resulting in a marked change in the original water-level surface. Smaller declines have taken place in Wilkinson, Washington, and Richmond Counties. Locally, clay lenses in the aquifer act as confining units, causing water levels to be higher than the regional trend.

Near the recharge area water from aquifer A_1 is low in dissolved-solids concentration (less than 50 mg/L), low in pH (4.0 to 6.7), and is a sodium bicarbonate type. Where the sand in A_1 is overlain by post-Cretaceous carbonate deposits not separated by an effective confining unit, the calcium bicarbonate and dissolved-solids concentrations of the water increase. The iron concentration locally is greater than 1 mg/L. The pH and the sodium bicarbonate and dissolved-solids concentrations increase with distance from the recharge area.

Industry pumps more than 68 Mgal/d from aquifer A_1; 57 Mgal/d of this is for clay mining and processing in Twiggs, Wilkinson, Washington, and Jefferson Counties. Almost half of the water that industry pumps from A_1 is for mine dewatering. Counties having industrial pumpage exceeding 1 Mgal/d are Twiggs, Wilkinson, Washington, Jefferson, Richmond, and Screven. Municipal and county wells produce about 15 Mgal/d from A_1.

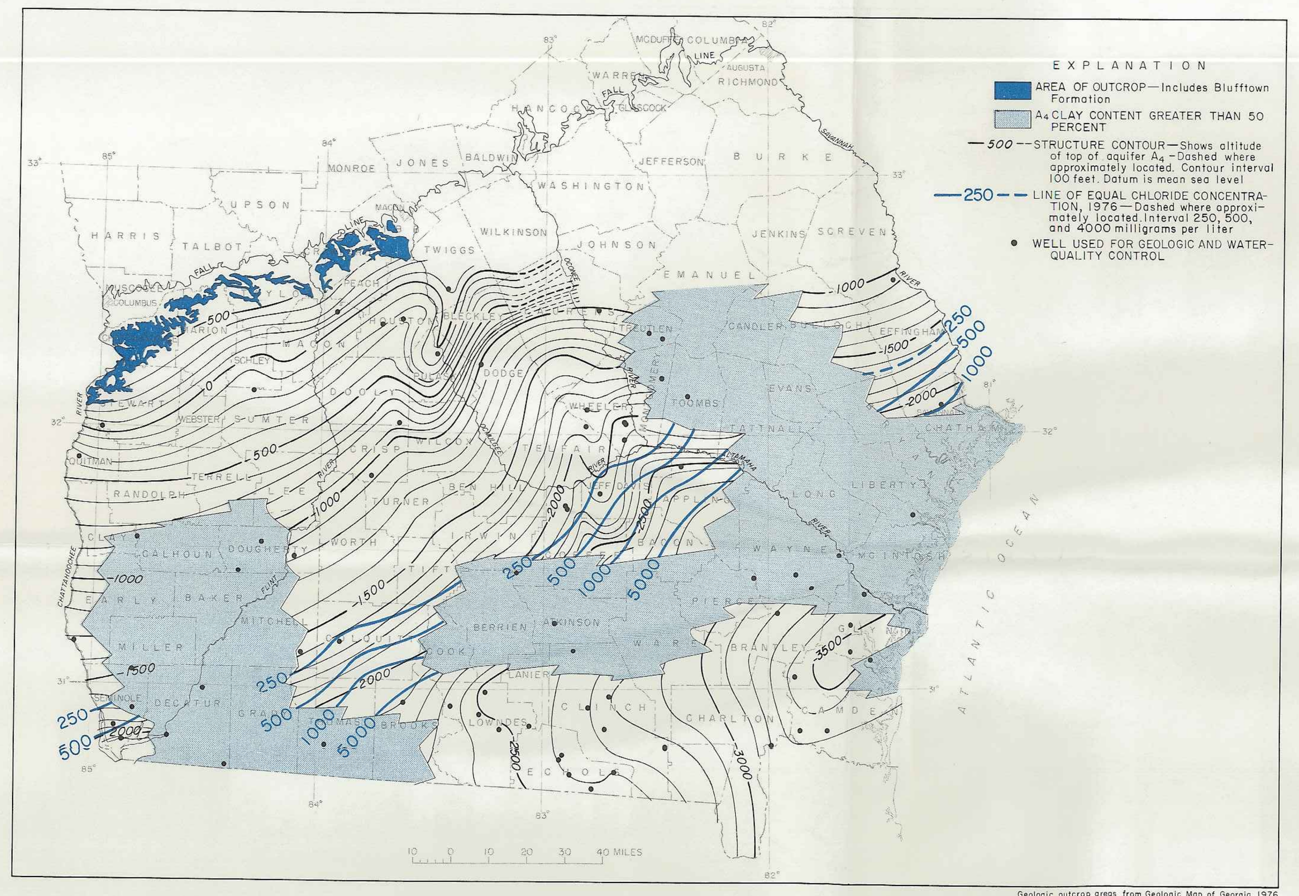
South of the Fall Line, locally thick sand units that have high transmissivities make A_1 a very productive aquifer.

Cartography by W.G. Hester and P.N. Grocoff

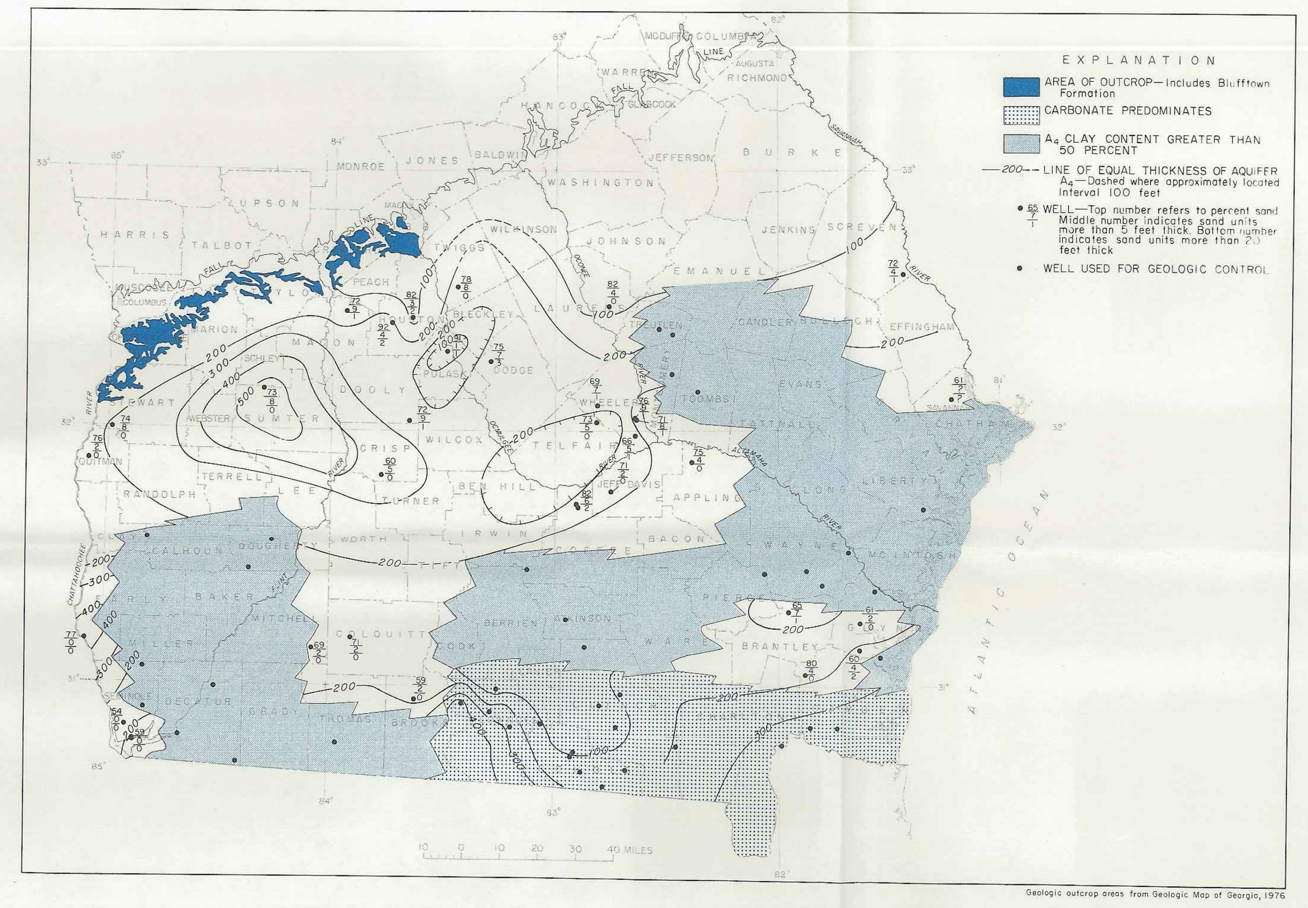
GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

Prepared in cooperation with the
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

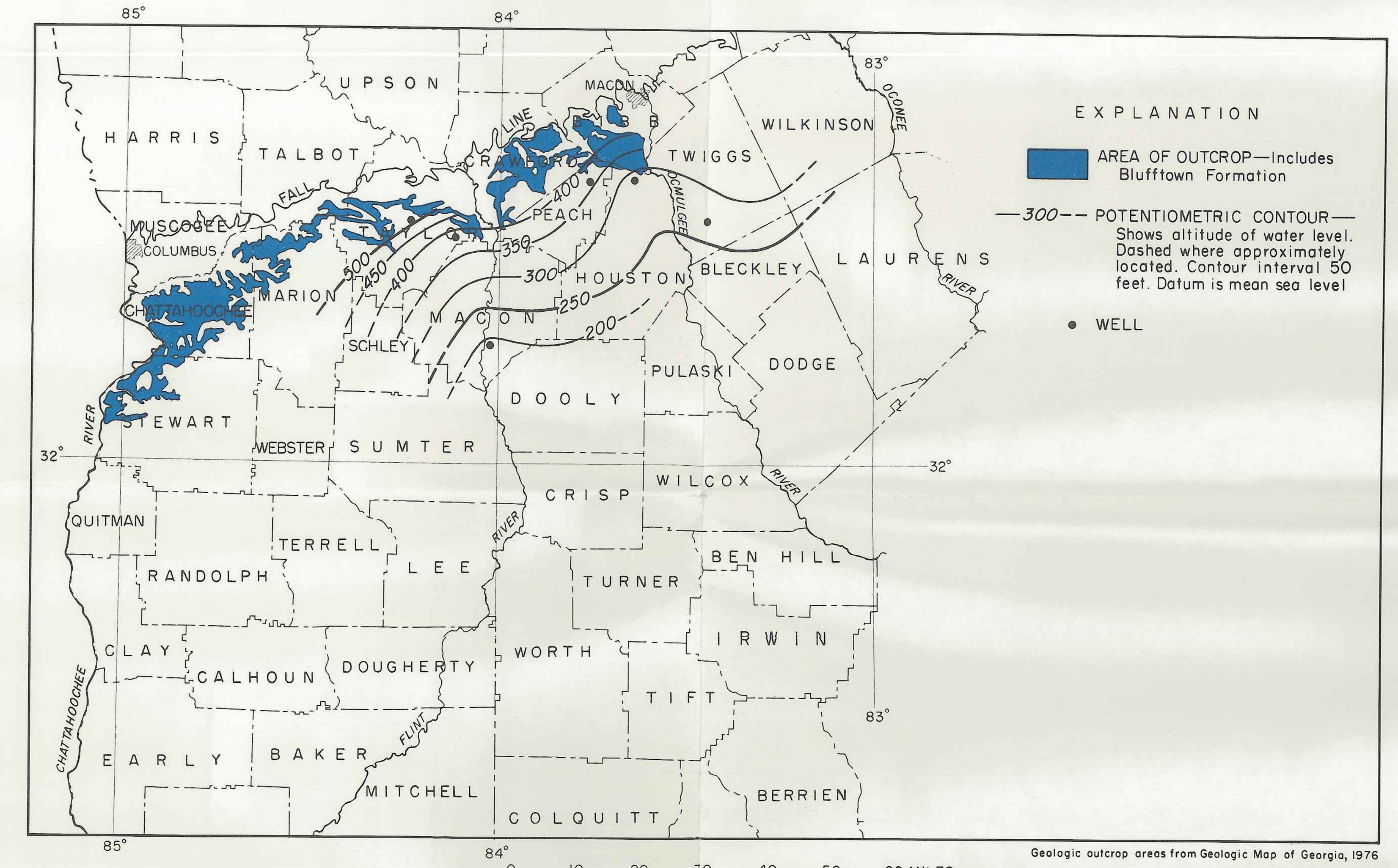
AQUIFER A_4



ALTITUDE OF TOP OF AQUIFER A_4 AND CHLORIDE DISTRIBUTION IN WATER FROM THIS AQUIFER.



DISTRIBUTION, THICKNESS, AND GENERALIZED LITHOLOGY OF AQUIFER A_4.



GENERALIZED POTENTIOMETRIC SURFACE OF AQUIFER A_4, SEPTEMBER 1976.

Aquifer A_4 is exposed at the surface in a band extending from northwest Stewart and Chattahoochee Counties into Bibb County and dips beneath the surface toward the southeast. A_4 correlates with the upper part of the Blufftown Formation along the Chattahoochee River and consists of medium to coarse quartzose sand that is locally carbonaceous. In the downdip direction A_4 contains increasing quantities of silt and clay. A_4 is predominantly a carbonate in southeast Georgia. The thickest sand sequence comprising A_4 is centered in Sumter County, and the aquifer thins outward from this area.

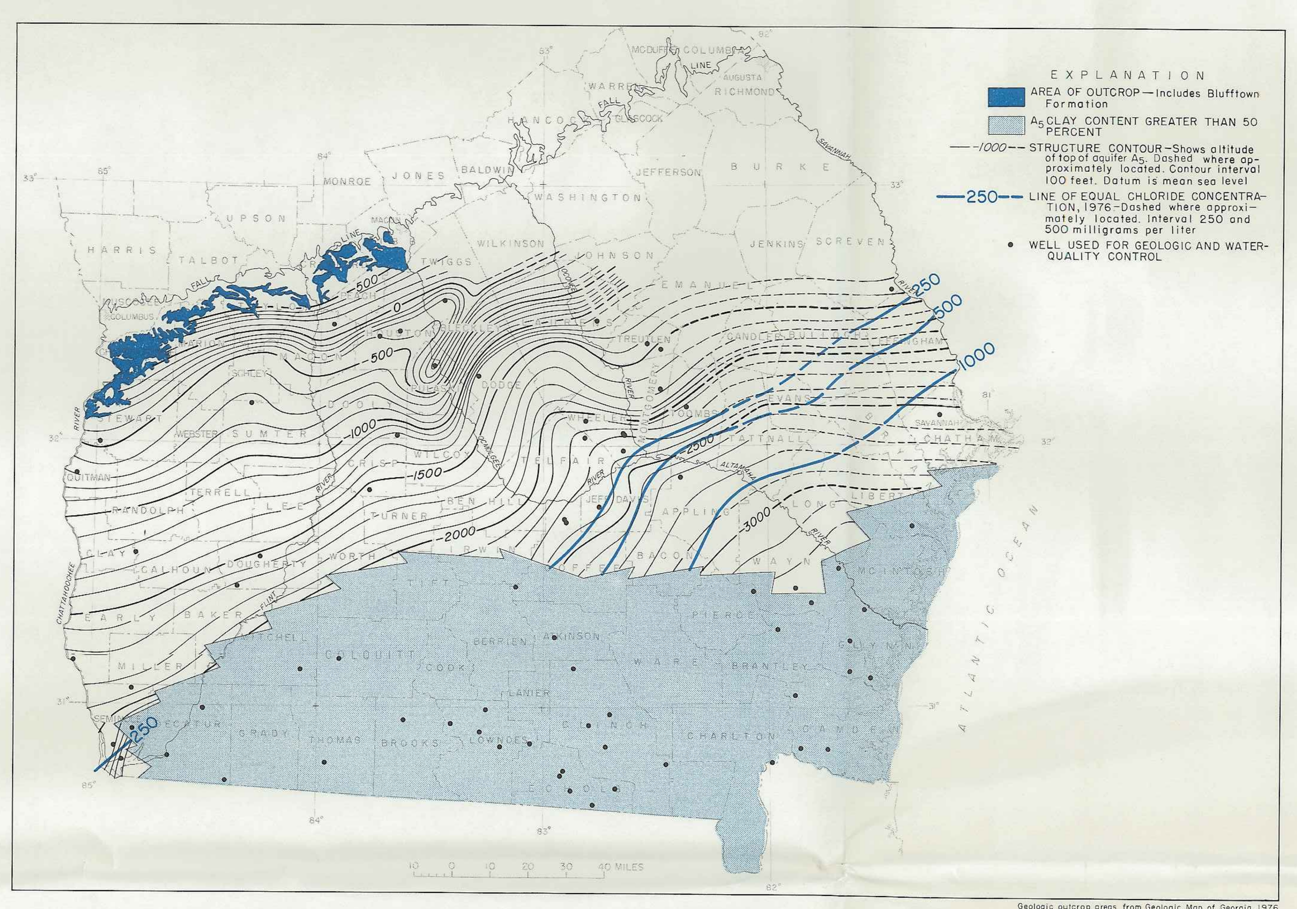
Major recharge to aquifer A_4 takes place in the outcrop area west of the Ocmulgee River and in the interfingering sands at the surface in A_1 east of the Ocmulgee River. The water moves downgradient, and natural discharge for A_4 is into the Ocmulgee and Flint Rivers.

Few values of transmissivity and pumpage are available for A_4 alone, because most wells tapping sands in A_4 also tap sands in overlying and underlying aquifers. Aquifer A_4 combined with A_5 and A_6 produces water in Taylor, Peach, and northern Macon Counties and combined with A_3, A_5, and A_6 produces water in Macon and Houston Counties. The observed transmissivities for A_4, A_5, and A_6 combined, estimated from specific capacities, are 5,200 ft^2/d in Taylor County, 3,900 ft^2/d in Peach County, and 6,800 ft^2/d in the northern part of Macon County. The highest observed values of transmissivity (19,000 ft^2/d) are in combined aquifers A_3, A_4, A_5, and A_6 in Houston County, where yields are greater than 1,000 gal/min for each well.

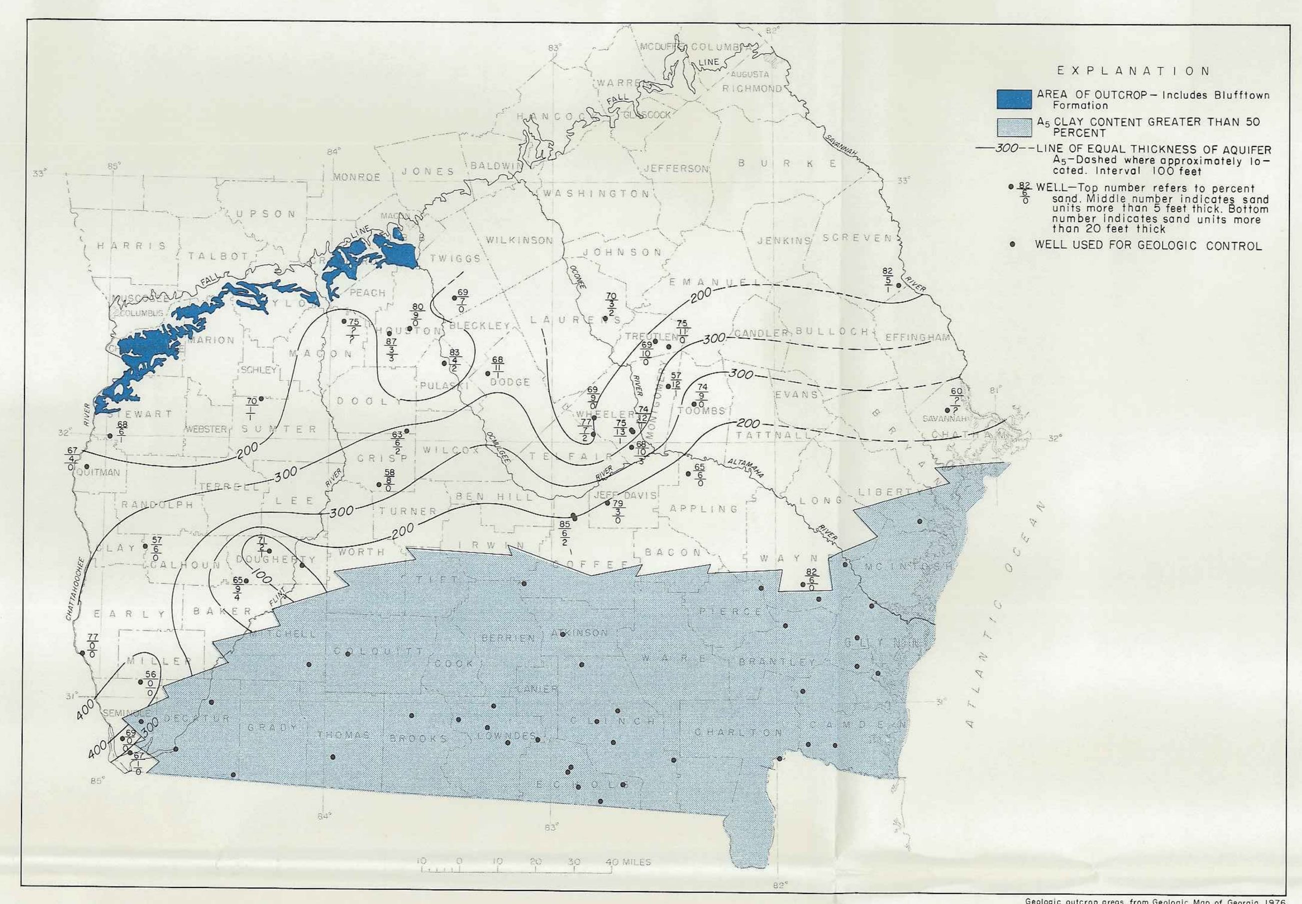
There are no analyses of water exclusively from aquifer A_4. Presumably, the water would have a composition characteristic of the mixed water from combined aquifers and show an increase in the dissolved-solids, sodium, and bicarbonate concentrations in the downdip direction. Geophysical log interpretations indicate that freshwater can be produced from A_4 to depths as great as 2,000 ft below mean sea level.

Few wells derive water solely from aquifer A_4. Near the outcrop area aquifers A_3, A_4, A_5, and A_6 are generally used together. Aquifer A_4 by itself has no great potential for development. Even though A_4 is more than 500 ft thick in the northwest part of the Coastal Plain, the overall fine sand and silt content and a lack of coarse sand units makes well development in this aquifer alone impractical.

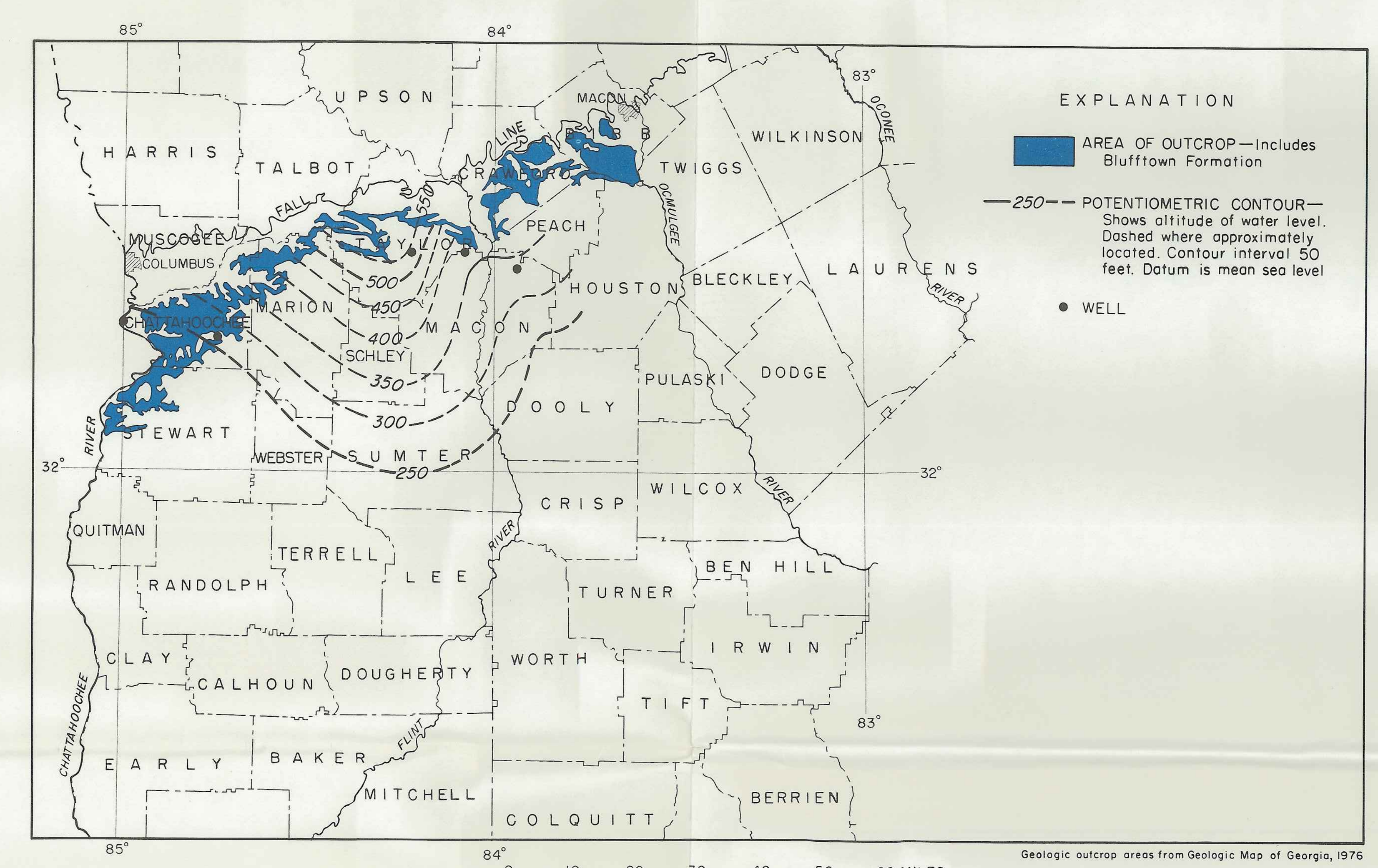
AQUIFER A_5



ALTITUDE OF TOP OF AQUIFER A_5 AND CHLORIDE DISTRIBUTION IN WATER FROM THIS AQUIFER.



DISTRIBUTION, THICKNESS, AND GENERALIZED LITHOLOGY OF AQUIFER A_5.



GENERALIZED POTENTIOMETRIC SURFACE OF AQUIFER A_5, SEPTEMBER 1976.

Aquifer A_5 correlates with the basal part of the Blufftown Formation along the Chattahoochee River where this formation is a coarse, crossbedded, quartzose sand. The outcrop area of the Blufftown Formation extends from Stewart and Chattahoochee Counties along the Chattahoochee River eastward into Bibb County. Because of the increasing clay and carbonate content in the downdip direction, A_5 can be considered an aquifer only in the northern two-thirds of the Coastal Plain.

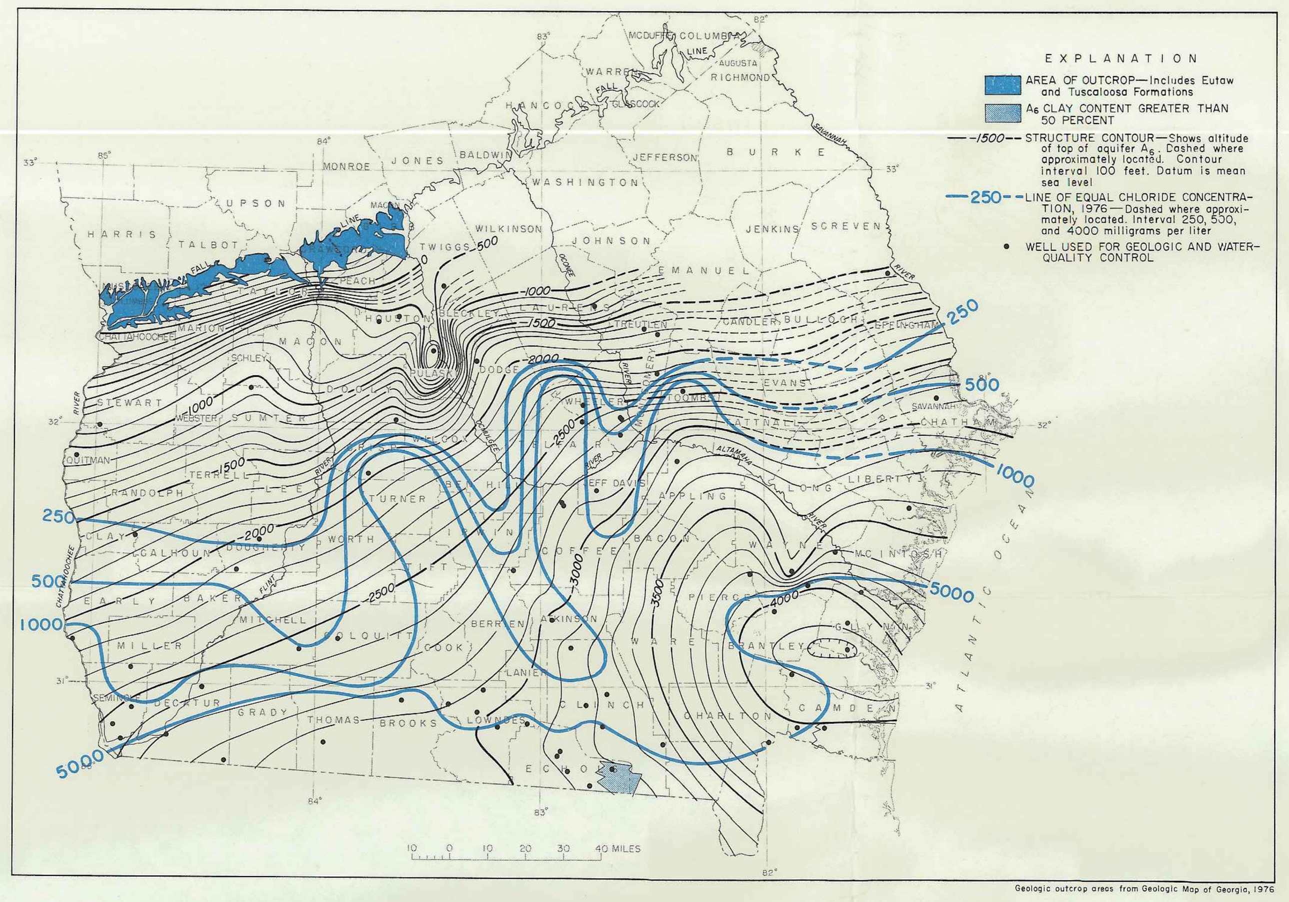
Recharge to aquifer A_5 occurs in the outcrop area west of the Ocmulgee River and in interfingering sands at the surface in A_1 east of the Ocmulgee River. The water in A_5 flows downdip to the southeast. Natural discharge from A_5 is probably into the Flint and Ocmulgee Rivers.

Near the outcrop area, aquifer A_5 is used with other aquifers, usually A_3, A_4, and A_6, to obtain the desired quantity of water. In Macon, Peach, Taylor, and Houston Counties, where A_5 is tapped in combination with A_3, A_4, and A_6, the observed transmissivities range from 1,000 to 19,000 ft^2/d and reported yields from 250 to more than 1,000 gal/min. In Chatham County the artesian pressure in A_5 is sufficient for wells to flow.

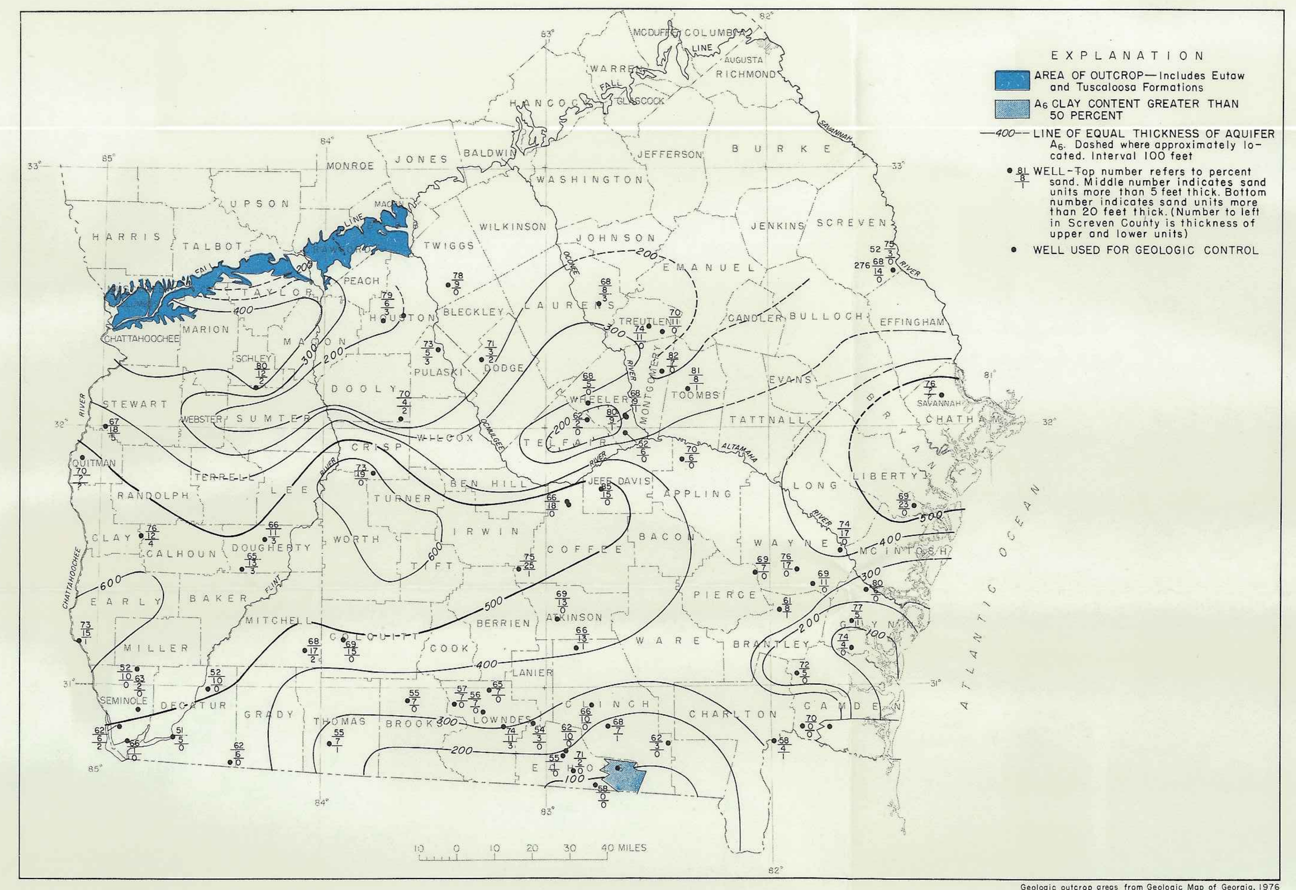
In Taylor County near the outcrop area, water from A_5 is low in dissolved solids (16 mg/L) and has a pH of 4.5. Downdip in Chatham County water from a well northwest of Savannah has a dissolved-solids concentration of 4,140 mg/L, a chloride concentration of 1,900 mg/L, and high concentrations of sodium and bicarbonate.

A_5 is primarily used with the more productive aquifers A_3 and/or A_6. Except for the depth of drilling, A_5 seems to have good potential for development in the central Coastal Plain (Laurens, Wheeler, Telfair, and Dodge Counties).

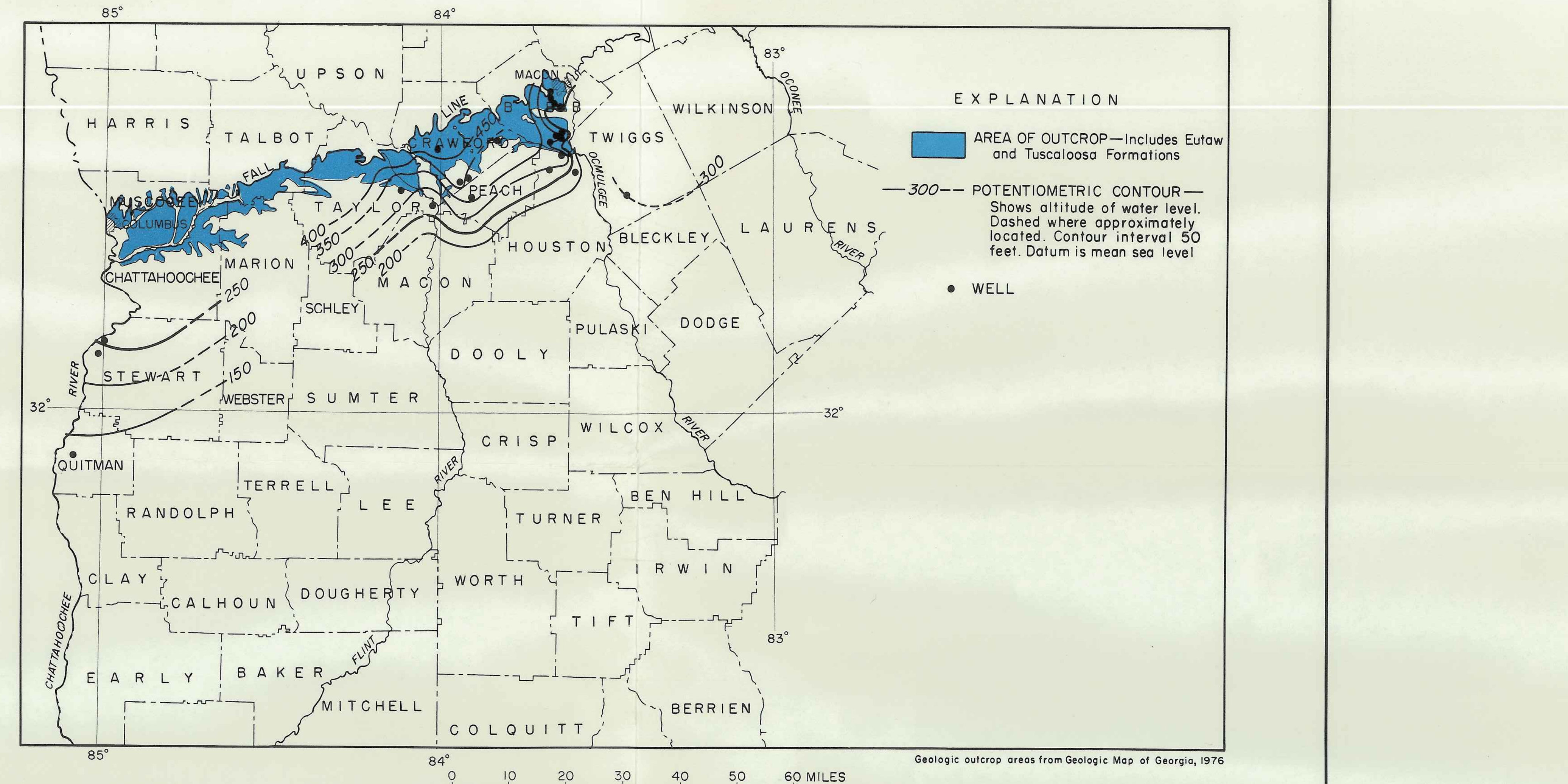
AQUIFER A_6



ALTITUDE OF TOP OF AQUIFER A_6 AND CHLORIDE DISTRIBUTION IN WATER FROM THIS AQUIFER.



DISTRIBUTION, THICKNESS, AND GENERALIZED LITHOLOGY OF AQUIFER A_6.



GENERALIZED POTENTIOMETRIC SURFACE OF AQUIFER A_6, SEPTEMBER 1976.

Aquifer A_6 is exposed at the surface in a band extending from the Chattahoochee River in Muscogee County to the Ocmulgee River in Bibb County. A_6 dips beneath the surface to the south and southeast, where A_6 is more than 4,000 ft below mean sea level. A_6 correlates with the basal Eutaw Formation and the underlying Tuscaloosa Formation along the Chattahoochee River, where both consist of coarse quartzose sand. The Tuscaloosa Formation is also gravelly, micaceous, arkosic, and locally crossbedded. Downdip to the southeast A_6 consists of interbedded thin sand and clay layers. In Screven County aquifer A_6 is divided into two distinct units by an intervening confining unit. In southeast Georgia varying amounts of carbonate are interbedded with the sand and clay layers.

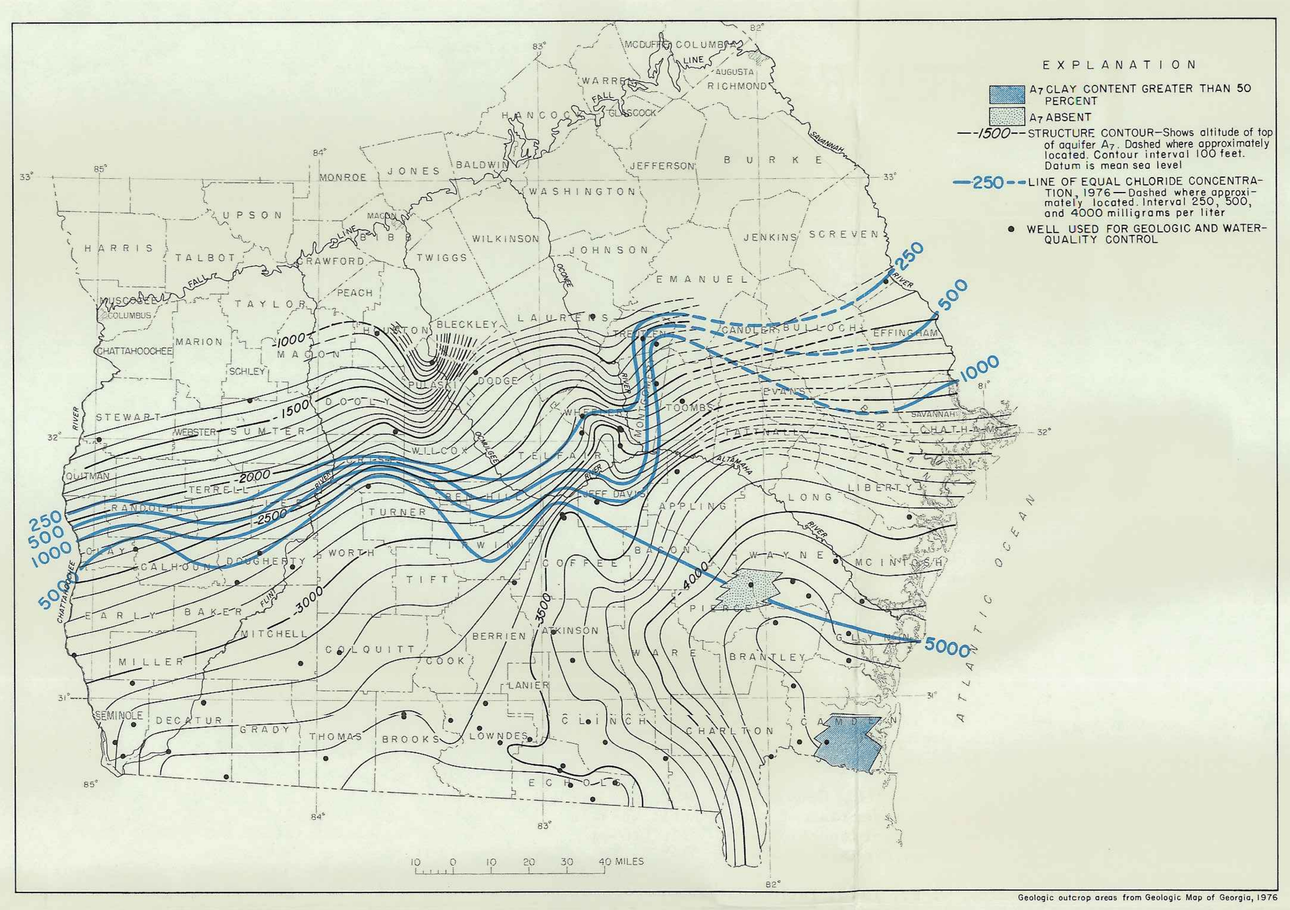
Recharge to aquifer A_6 occurs in the outcrop area west of the Ocmulgee River and in interfingering sands at the surface in A_1 east of the Ocmulgee River. The water in A_6 flows downdip to the southeast. Natural discharge from A_6 is into the Flint and Ocmulgee Rivers and into smaller streams crossing the outcrop area.

The maximum transmissivity, estimated from specific capacities for A_6, is 5,000 ft^2/d in Bibb County where reported yields range from about 250 to more than 600 gal/min. Combined aquifers A_4, A_5, and A_6 have observed transmissivities as high as 5,200 ft^2/d in Taylor County, where the maximum reported yield is 350 gal/min, and as great as 11,000 ft^2/d in Peach County where the maximum reported yield is 760 gal/min. Combined aquifers A_3, A_4, A_5, and A_6 have transmissivities as high as 19,000 ft^2/d in Houston County where the maximum reported yield is more than 1,600 gal/min.

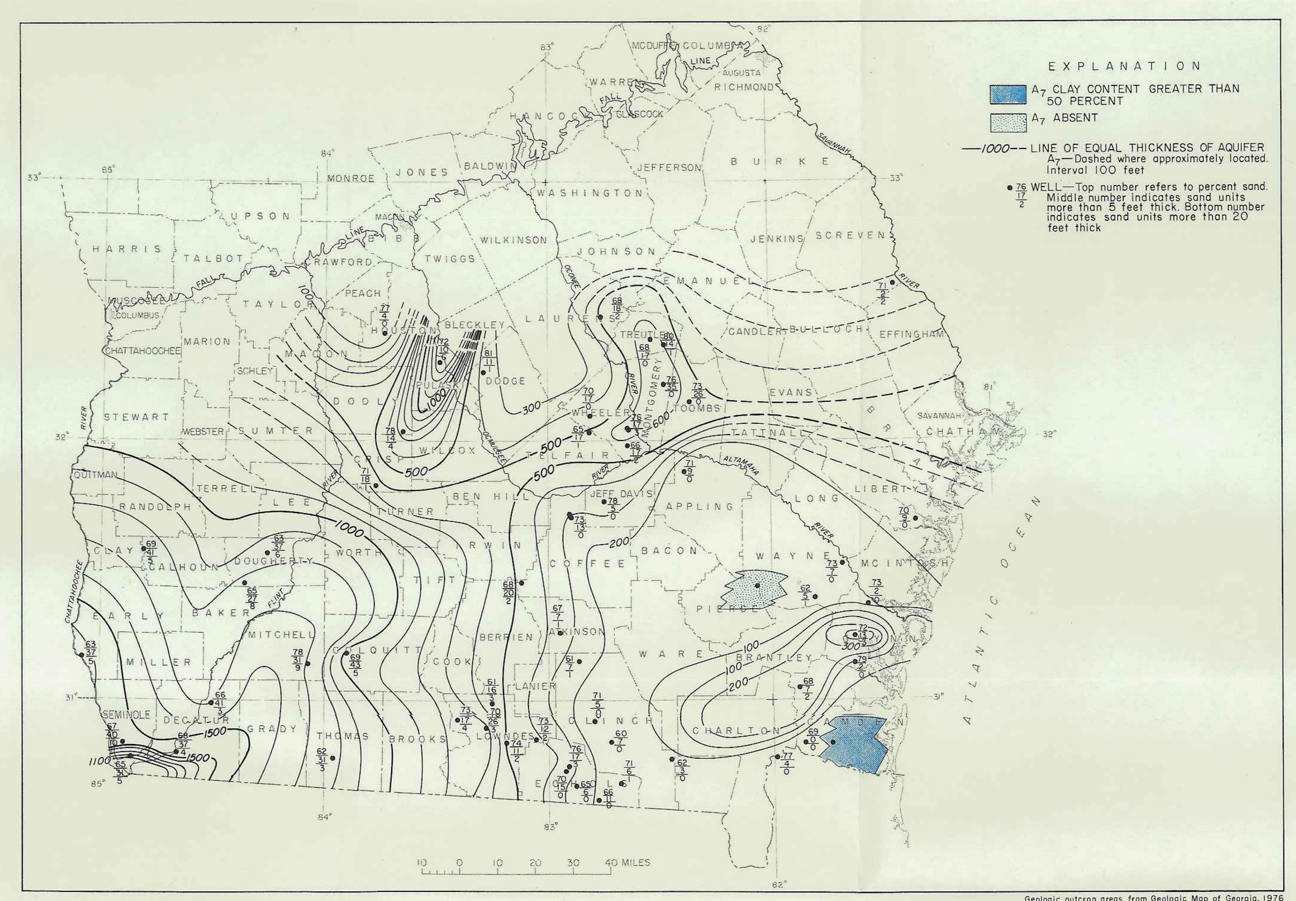
In Bibb County water from A_6 is low in dissolved-solids concentration (less than 50 mg/L), low in pH (4.8 to 6.3), and is a sodium bicarbonate type. Downdip at depths greater than 3,000 ft below mean sea level the dissolved-solids concentration increases to more than 1,400 mg/L, the sulfate concentration is more than 100 mg/L, and the pH is greater than 7.0. The water generally remains fresh as deep as 1,600 to 2,500 ft below mean sea level.

Aquifer A_6 is the most widespread aquifer in the Cretaceous aquifer system. Near the Fall Line in Bibb County, industrial wells are pumping about 5 Mgal/d from A_6, and there is the potential for producing large quantities of water south of Bibb County. Total pumpage from the combined aquifers A_3-A_6 in Houston County is about 9 Mgal/d.

AQUIFER A_7



ALTITUDE OF TOP OF AQUIFER A_7 AND CHLORIDE DISTRIBUTION IN WATER FROM THIS AQUIFER.



DISTRIBUTION, THICKNESS, AND GENERALIZED LITHOLOGY OF AQUIFER A_7.

Aquifer A_7 is the deepest (oldest) aquifer in the Cretaceous aquifer system. A_7 has not been identified at the surface in Georgia and no wells are known to use water from this aquifer.

A_7 is composed of thin interlayered sequences of sand and clay that range from about 500 ft below mean sea level south of the Fall Line to more than 4,400 ft below mean sea level in the southeast corner of Georgia. A_7 is thickest in the southwest corner of Georgia and thins toward the southeast corner.

Most of the recharge to aquifer A_7 takes place along the Fall Line where the oldest identified Cretaceous sediments (Tuscaloosa Formation) lie directly upon the crystalline rock of the Piedmont province. Water moving along this contact enters the sediment of A_7 and travels downdip to the southeast through permeable sands. There is little recharge to A_7 and the water southeast of the 1,000-mg/L line of equal chloride concentration is probably residual water.

Some freshwater could be obtained from the uppermost part of aquifer A_7 in a band extending from Quitman eastward to Laurens County. However, most of the water in A_7 is not fresh and the sand units, occurring at relatively great depth, are many, but thin.

SUMMARY AND CONCLUSIONS

Large quantities of freshwater are available from the Cretaceous aquifers in the Georgia Coastal Plain. Fresh ground water can be obtained to depths of 1,000 to 2,500 ft below mean sea level, as far as 100 mi southeast from the Fall Line. The aquifers having the greatest potential for future development are A_1 between the Ocmulgee and Savannah Rivers and A_6 between the Chattahoochee and Ocmulgee Rivers. Individual well yields are highest (more than 2,000 gal/min) in aquifer A_1. Pumping from the Cretaceous aquifers has caused a decline in the original (prepumping) water level in only a few areas--Americus in Sumter County (aquifers A_2 and A_3) and in Twiggs, northwest Wilkinson, central Washington, and Richmond Counties (aquifer A_1).

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