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STRUCTURAL GEOLOGIC FEATURES AND THEIR RELATIONSHIP TO SALT WATER INTRUSION IN WEST VOLUSIA, NORTH SEMINOLE AND NORTHEAST LAKE COUNTIES

by

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ILLUSTRATIONS

ABSTRACT

Salt water intrusion of wells in the St. Johns River valley between Lakes George and Monroe (northeast Lake, North Seminole and west Volusia Counties) continues to cause problems for local farmers and other interests. Past studies in southwest Florida (Sproul, Boggess and Woodard, 1972) have shown faults to be one means by which deeper connate saline water may contaminate shallower fresh water zones. Subsurface stratigraphic correlation utilizing geophysical logs, cores, and lithologic printouts were used to investigate the geologic structure in the study area with special emphasis being placed on location of faults. A fault was found trending perpendicular to the St. Johns River between Altoona (northeast Lake County) and Lake Dias (west Volusia County). Evidence for the existence of other previously suspected faults was not found.

INTRODUCTION, PURPOSE AND SCOPE

In west Volusia County (Figure 1), there exists a well contamination problem caused by salt water intrusion. As the many relatively deep agricultural supply wells are pumped, connate salt water found beneath the fresh water zones moves upward replacing and/or mixing with stratigraphically higher potable water. Geophysical well logs together with water quality samples indicate that the problem appears to increase with decreasing distance from the St. Johns River. This observation apparently supports a long-standing belief that a fault or series of faults extend along the river. This study was initiated to determine if a fault zone is present along the aforementioned section of the river and, if so, what effect it has upon the ground water system between Lakes George and Monroe.

Wells logged in west Volusia, northeast Lake and north Seminole Counties provided the data necessary to derive the geologic structure in the study area (Figure 2). Additional lithologic information was obtained from the Florida Bureau of Geology.

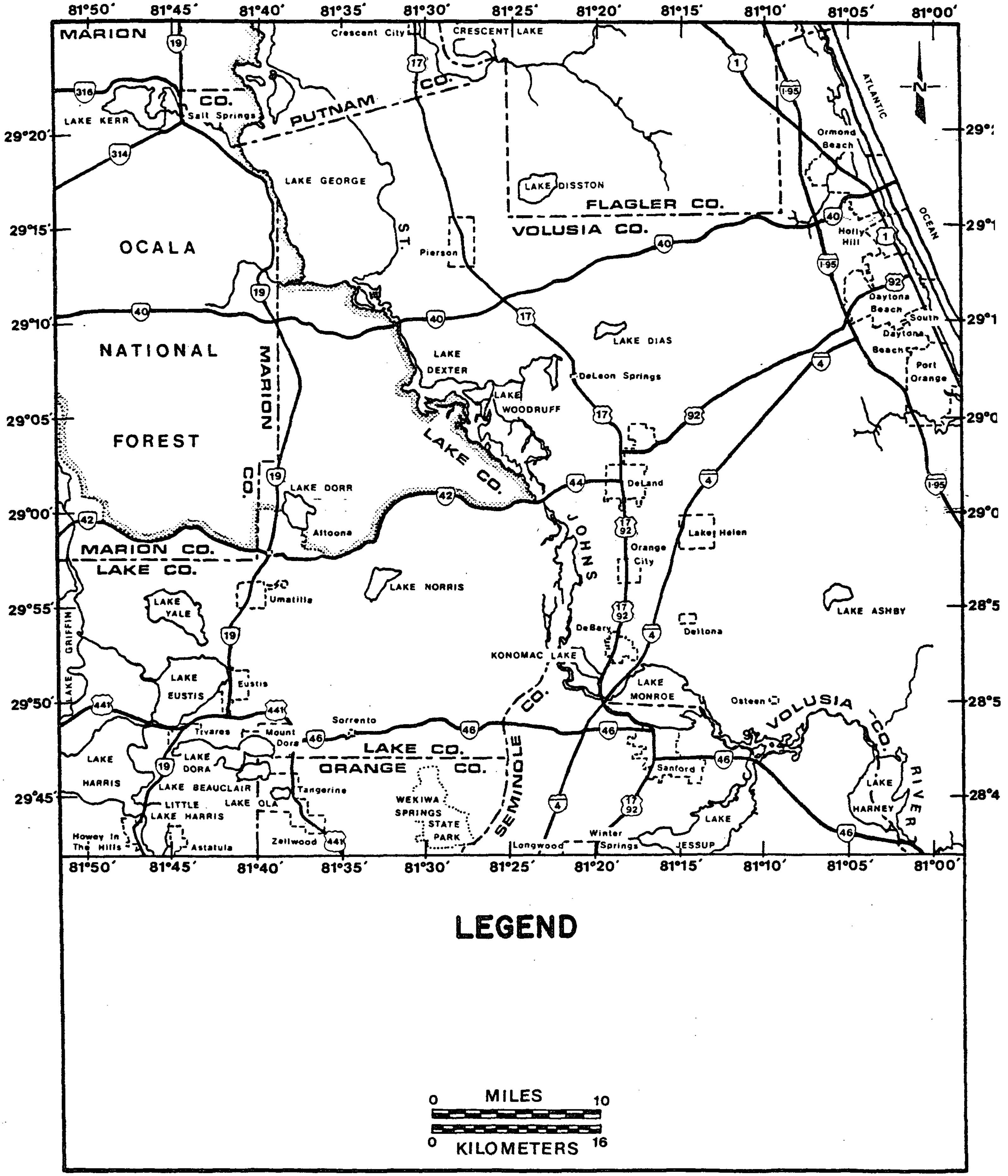


Figure 1. Location of Project Area

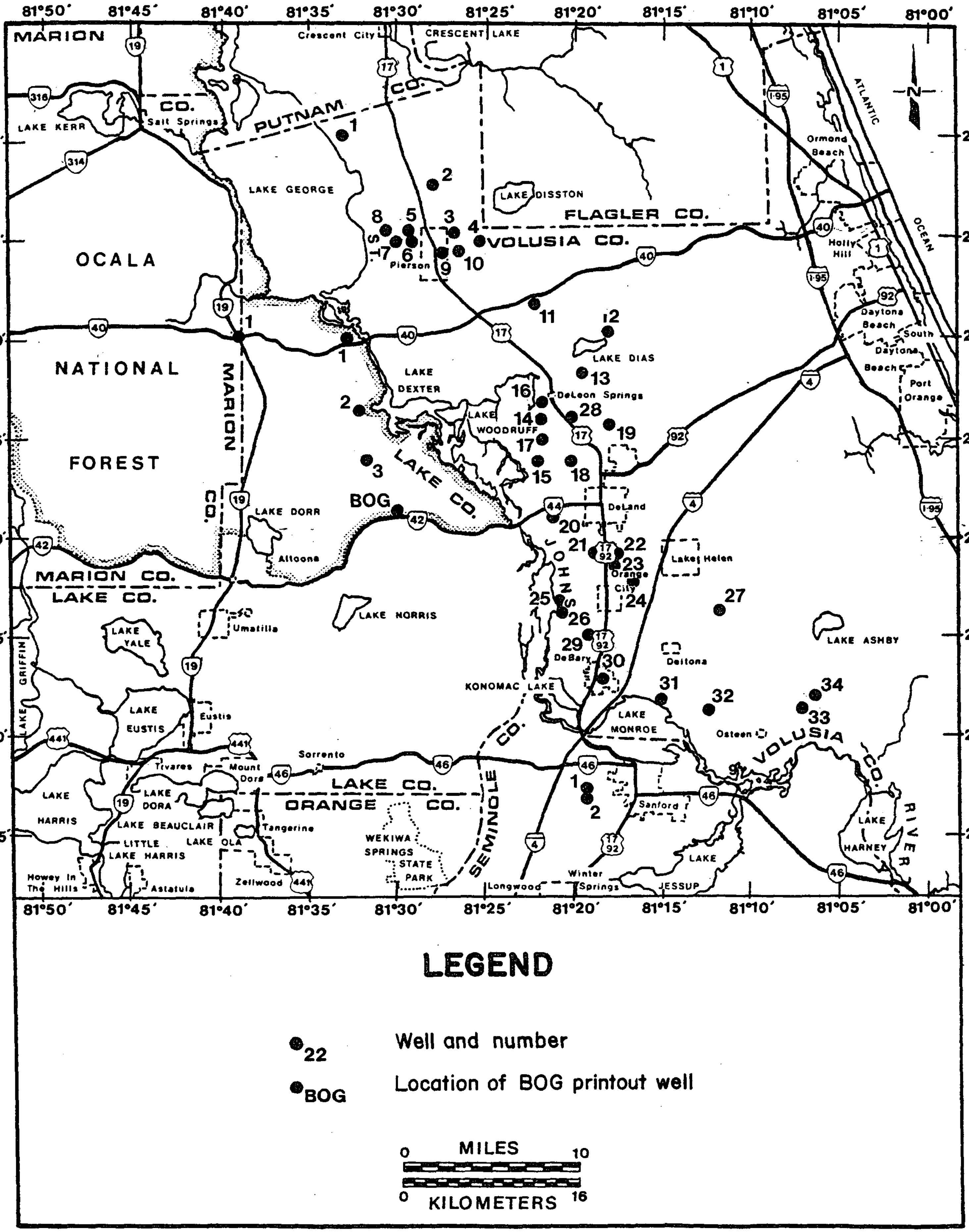


Figure 2. Well Locations and Numbers

METHODS OF INVESTIGATION

Forty wells were geophysically logged: 34 in west Volusia County, 3 in northeast Lake County, 2 in north Seminole County and one well in southeast Marion County. Well construction information and geologic data from each logged well are presented in Appendix A.

Wells were geophysically logged with caliper, gamma ray and electric probes, and bottom hole water samples were obtained from some wells. Geologic correlation was accomplished by means of marker beds recognizable on the gamma ray and/or electric logs.

The gamma ray probe consists of a scintillation detection system with a large sensitive thallium-activated sodium iodide "Lithology" crystal. The gamma ray log measures the intensity of naturally-occuring gamma ray radiation emitted from the rock. Different levels of intensity can be associated with different lithologies.

The electric probe produces two standard resistivity curves: the "long" or 64-inch Normal and the "short" or 16-inch Normal. The resistivity curves measure porosity or percent of void space in rock that contains water. "Normal" refers to the arrangement of electrodes on the probe and the electronic system and circuitry used to produce the curves. This log is obtained only in the uncased section of the borehole.

Bottom hole water samples were obtained using a motorized sampler. Samples were collected from approximately ten feet above total depth logged to minimize contamination of the sample by mud or other opaque material at the bottom of the well. All water samples were analyzed for chloride concentration using the silver nitrate-potassium chromate method.

Five test wells in northwest Volusia County were drilled and logged by the St. Johns River Water Management District (Munch, 1979). Continuous cores of the limestone portion of these wells were used in identifying some of the formation contacts presented in the cross sections and structure contour maps. Descriptions of the core samples are presented in Appendix B.

The Florida Bureau of Geology provided computer printouts of lithologic descriptions of well cuttings. These printouts supplemented logged well data used in the construction of structure contour maps.

Cross sections were constructed utilizing geophysical logs and cores. Formation contacts were determined in both geophysical and printout logs by correlation with previously published lithologic and marker bed information (see Formation Description section).

PREVIOUS INVESTIGATIONS

Previous geologic and hydrologic investigations have postulated the existence of many faults along the St. Johns River but have presented little conclusive evidence to demonstrate their existence. For example, faults are sometimes reported based upon evidence presented in a previous report with no additional data incorporated. In areas where well information is scarce, normal faults are sometimes postulated based on geology deduced from one or two closely spaced wells. However, it is possible that the closely spaced wells are located in a paleokarstic feature such as a sinkhole and do not depict regional trends. In paleokarstic features, the uppermost section of limestone is not present and the top of the limestone section will locally be deeper than in surrounding areas. Even where sufficient well data are available, alternate explanations are often possible, such as the existence of a monocline-like structure where the local formational dip is relatively steep. Due to a lack of sufficient data, there exists relatively few well-documented and widely accepted faults in the state of Florida.

In the study area numerous faults have been postulated by various workers. Vernon (1951) shows several "fractures" in the study area (Figure 3); however his distinction between faults and joints seems somewhat unclear. These fault/joint traces were established first through the use of corehole and surface geology where possible. Vernon shows a major fault along the St. Johns River extending from east of Lake George to west of Lake Monroe. He also shows joints and possible faults trending east-northeast/west-southwest from Lake Disston (southwest Flagler County) to the southwest tip of Lake George, and a second parallel set extending from the Atlantic coast north of Ormond Beach to the Astor area in northeast Lake County. Two additional

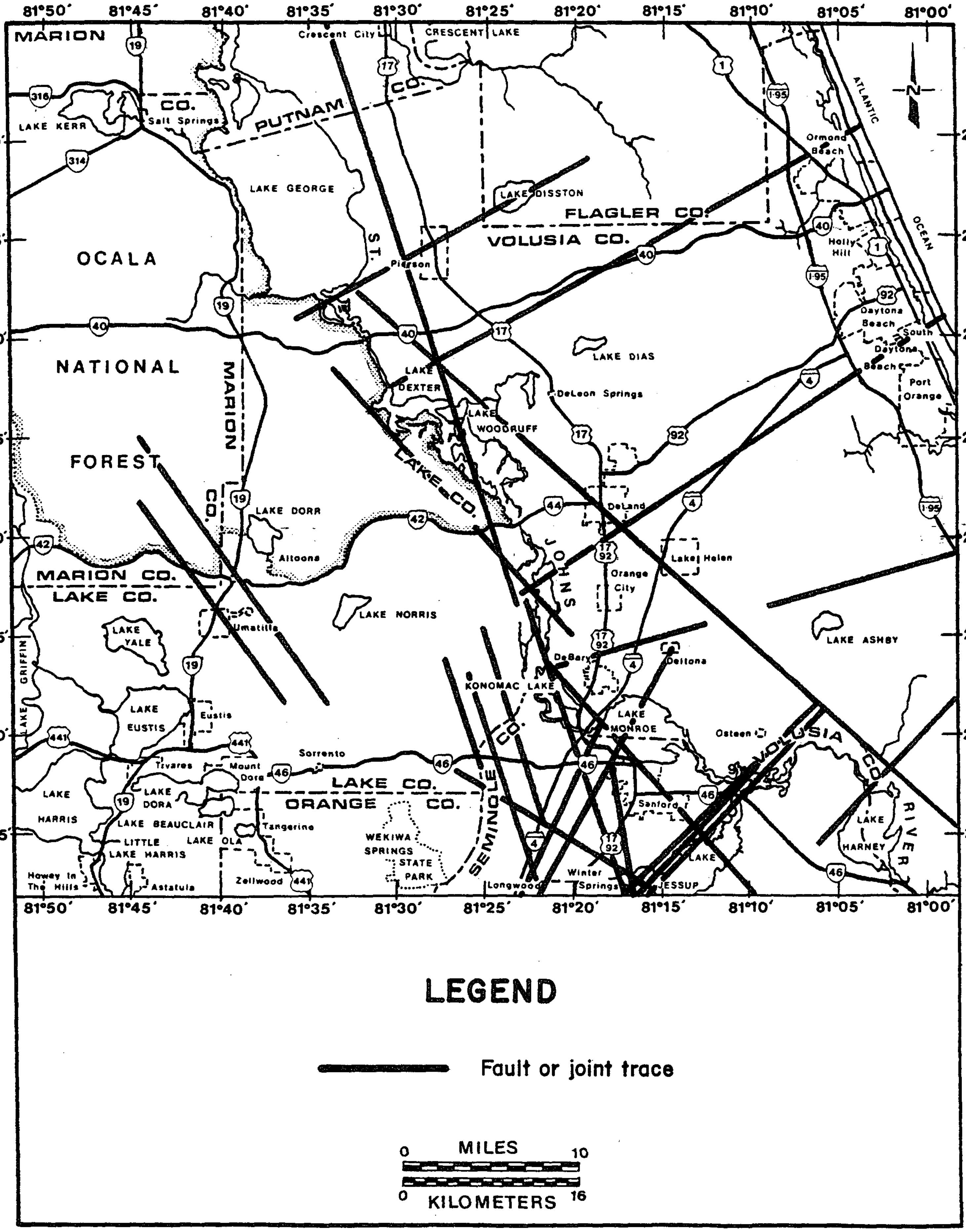


Figure 3. Map Showing Location of Vernon's (1951) Faults and Joints in Project Area

parallel joints trending northwest-southeast pass through the Lake Woodruff-Lake Dexter area.

Wyrick (1960) delineated two faults: one extending from Flagler County through the DeLeon Springs area to a point west of DeLand and then south to the western shore of Lake Monroe in Volusia County, and a second from the north shore of Lake Monroe to the bend in the St. Johns River just north of Lake Harney. The locations of these faults were based on geologic (well) data. These faults are correlative to the two faults described in Knochenmus and Beard (1971) and Barraclough (1962), but the exact locations of the faults differ slightly in each report. Generally the publications dealing with Volusia County tend to show a fault located on the eastern side of the St. Johns River. Publications dealing with Seminole County show the same fault trace located within that county, south of and parallel to the river.

Barraclough (1962) shows a fault along the St. Johns River between north Seminole and southwest Volusia Counties and a possible fault extending north from a point near the intersection of the Lake, Volusia and Seminole County lines. The report infers that the offset of the St. Johns River between Seminole and southwest Volusia Counties is probably controlled by this fault. Again, fault location is based upon well log and contact data.

Brown, D.W., Kenner, W.E., Crooks, J.W. and Foster, J.B. (1962) show a fault along the St. Johns River in west Brevard County that extends into the extreme southwest edge of Volusia County. Its location is based upon previous investigations along with sparce well data.

A fault in the St. Johns River Valley extending between east Orange County and north-central Brevard County is shown in Lichtler, W., Anderson, W. and

Joyner, B. (1968). Evidence for the presence of the fault is the structure contour map of the top of the Avon Park Limestone (which the authors state is less eroded than the top of the Ocala Limestone and hence, the fault is more apparent there). However, location of the fault is based upon limited well data.

In the Ocala National Forest portion of northeast Lake County, Snedaker and Lugo (1972) show several *en echelon* faults trending northwest-southeast and northeast-southwest. One fault is shown extending from the west shore of Lake George southeastward through Astor and slightly into Volusia County. No data are given to substantiate the existence of these faults. Knochenmus and Hughes (1976) also show *en echelon* faults in northeast Lake County; however they are in different locations. One of the faults is shown extending along the St. Johns River from Astor to the DeLand area. Lichtler (1972) shows no faults on his top of the Floridan aquifer map but states this map purposefully does not show locations of probable faults.

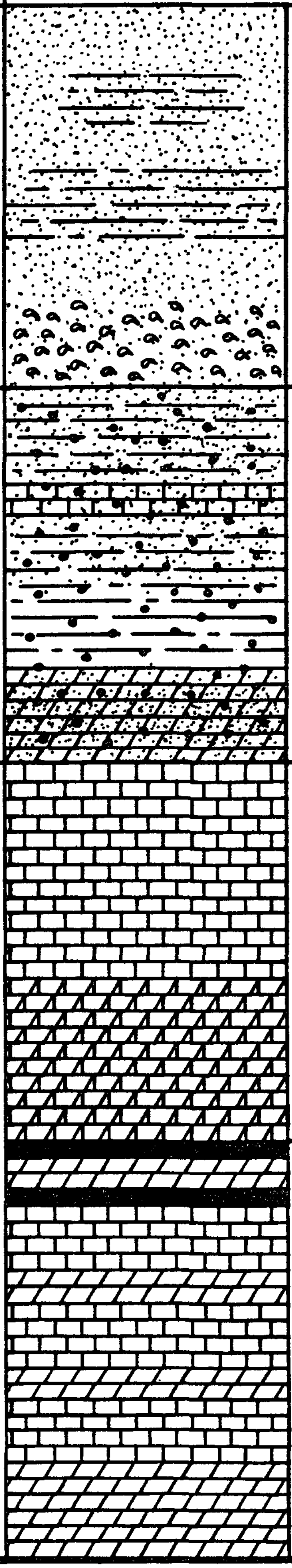
FORMATION DESCRIPTIONS

The stratigraphic column (Figure 4) shows the formations in the study area which are penetrated by water wells. Units range from Eocene through Pleistocene in age and consist, from oldest to youngest, of the Avon Park Limestone, Ocala Limestone, Hawthorn Formation and surficial material. The Lake City Limestone is penetrated by only three deep wells in the study area and therefore is not treated in this report. A discussion of the lithologic and geophysical characteristics of each geologic unit is presented below.

AVON PARK LIMESTONE

The Avon Park Limestone (Eocene) consists of interbedded limestone and dolostone containing peat as discrete beds and as inclusions in the rock. In the study area there are two recognizable and correlatable lithologic zones within the Avon Park Limestone. From bottom to top they are the Avon Park low porosity zone and the upper Avon Park zone. A structure contour map showing the top of the Avon Park Limestone is shown in Figure 5.

The Avon Park low porosity (dolostone) zone consists mainly of hard, thick beds of brown dolostone interbedded with thin, softer beds of limestone. Generally, very low porosity is characteristic of the entire zone; however due to the presence of many fractures and cavities, permeability of the zone can be extremely high. Typically the Avon Park low porosity zone is indicated on gamma ray logs by a uniformly high count rate and occasionally by a few relatively high intensity peaks which correspond to the purest dolostone beds (Figure 6, 235-245 ft.). On electric logs the zone is marked by relatively uniform resistivity or, more commonly by a series of very high resistivity peaks (corresponding to the dolostones) alternating with low resistivity



AGE	FORMATION	THICKNESS	DESCRIPTION
LATE AND POST MIOCENE	SURFICIAL MATERIAL	34 ft. to 139 ft.	Sand, Clay, and Coquina
MIOCENE	HAWTHORN FORMATION	52 ft. to 104 ft.	Sand, Clay, Limestone, and Dolostone, mostly phosphatic
		3 ft. to 32 ft.	Basal Hawthorn: Dolostone, sandy, phosphatic, hard
EOCENE	OCALA LIMESTONE	37 ft. to 75 ft.	Limestone, relatively pure Coquina, bio- and foraminiferal-
		9 ft. to 57 ft.	lower Ocala: Limestone, dolomitic, coquinoid
	AVON PARK LIMESTONE	63 ft. to 162 ft.	Limestone and Dolostone with Peat (disseminated and as beds) or Clay beds
			Avon Park: Dolostone, very hard, low porosity zone

Figure 4. Stratigraphic Column of Project Area.

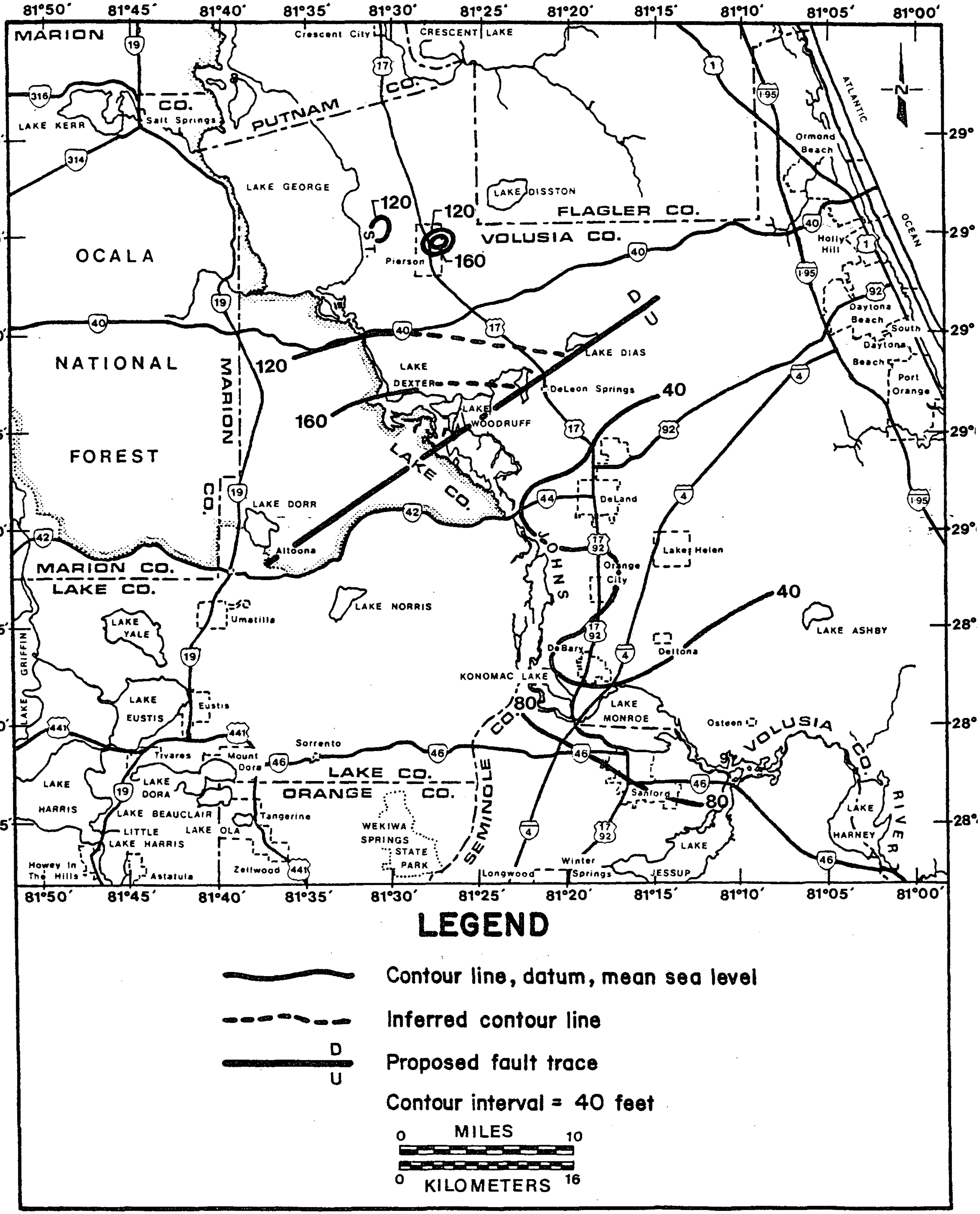


Figure 5. Structure Contour Map of the Top of the Avon Park Limestone

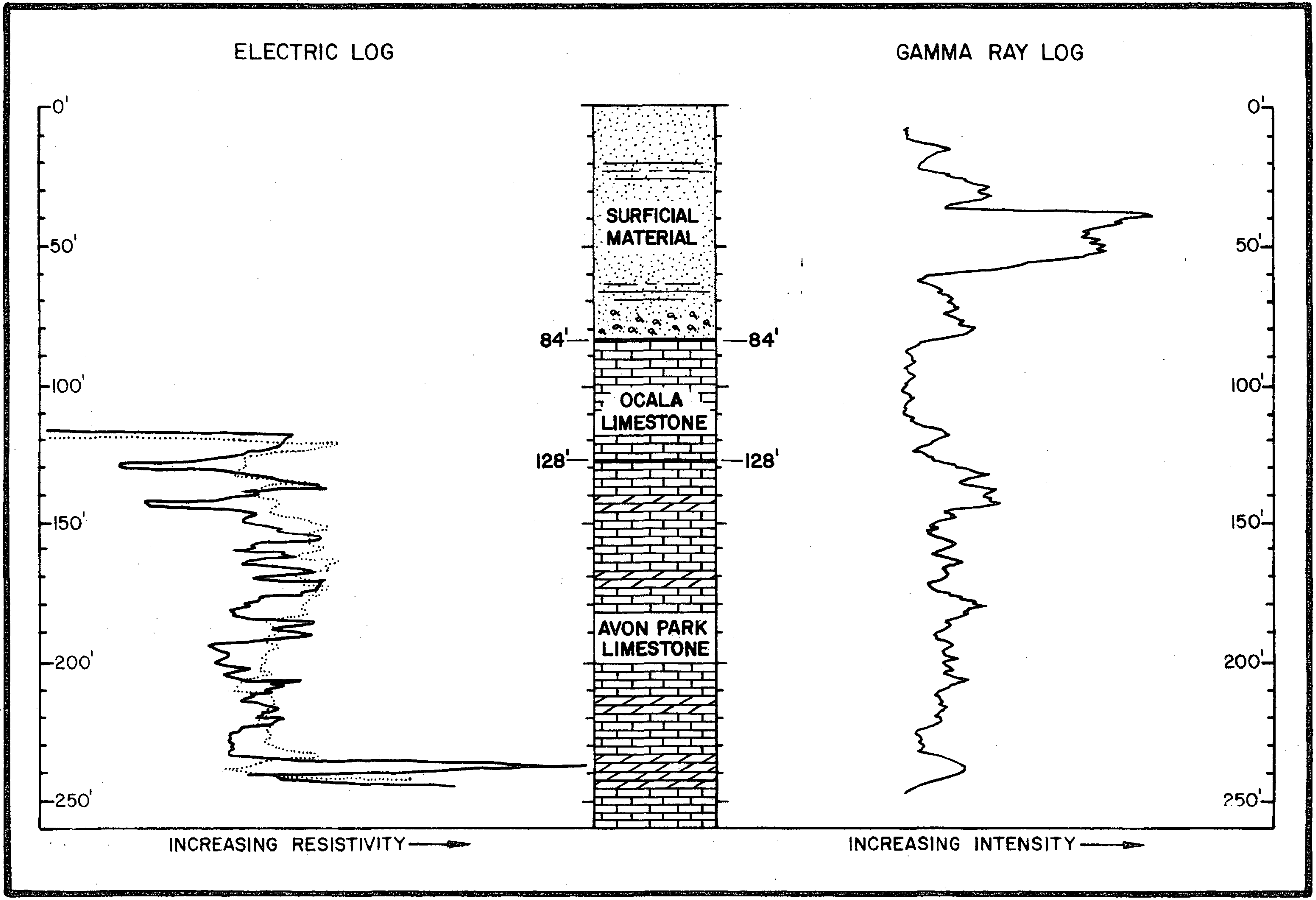


Figure 6. Gamma Ray and Electric (Resistivity) Logs of Well V-15

valleys (corresponding to cavities or thin limestone beds). This pattern is illustrated on Figure 6 in the 235-245 foot interval.

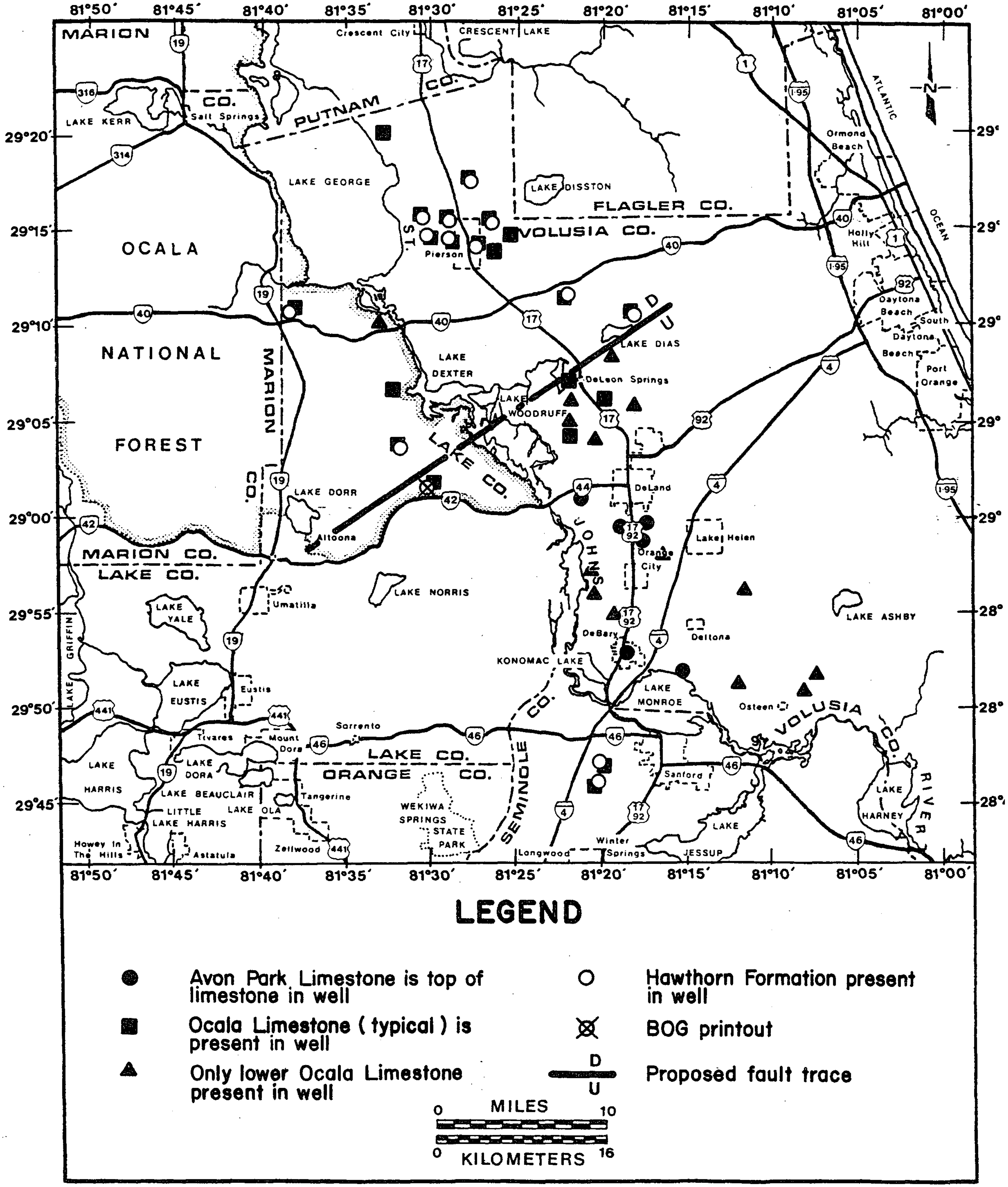
The upper Avon Park zone extends from the top of the low porosity zone to the top of the formation and consists of thin interbedded limestone and dolostone. On gamma ray logs this zone produces a relatively high, but uneven count rate with frequent low peaks (Figure 6, 145-235 ft.). The top of the formation is characterized by a relatively pure bed of hard dolostone surrounded by either peat or clay beds, probably marking an unconformity. This assemblage of lithologies produces a distinctive and sustained increase in counts per second on the gamma ray log as the probe is lowered into the well (Figure 6, 130 ft.). On electric logs this suite of beds produces a central high resistivity peak surrounded on both sides by pronounced decreases in resistivity (Figure 6, 125-145 ft.). The top of the uppermost valley is considered to represent the top of the formation.

The thickness of the upper Avon Park zone ranges from 63 to 162 feet. It is thinnest in the northern portion of the study area and thickens toward the south. However in north Seminole County wells, the zone is approximately equal in thickness to the upper Avon Park zone found in the northeast portion of the study area in northwest Volusia County. The low porosity and upper Avon Park zones can easily be traced into surrounding counties where they correlate very well with the Avon Park zones found in those areas (Johnson, 1979).

OCALA LIMESTONE

The Ocala Limestone (Eocene) consists of white to tan, poorly to well-cemented biohash, primarily composed of foraminiferal tests and fragments. This unit ranges from 37 to 75 feet in thickness. In well-cemented zones, limestone recrystallization and moldic porosity generally dominate. The Ocala appears as an interval of very low intensity on gamma ray logs (Figure 6, 84-128 ft.). Porosity within the formation varies from low to high. In the vicinity of DeBary and in the vicinity of DeLand, the Ocala Limestone is absent. Figure 7 shows the location of wells which penetrate Ocala Limestone. Description of cores from three test wells that penetrated the Ocala Limestone (all located in the northern half of the study area) are given in Appendix B.

In the southern half of the study area, the lower Ocala Limestone appears to be more dolomitic than elsewhere. Here, the entire Ocala Limestone is represented by a thin zone of dolomitic limestone or hard coquinoid limestone located directly above the Avon Park Limestone. This unit is herein referred to as the lower Ocala. Thickness ranges between 9 and 57 feet where the unit is present. In some wells the unit is replaced by more typical, less dolomitic Ocala Limestone. Where this lower Ocala unit is relatively thick, it consists of two characteristic but thin zones: an upper zone showing relatively lower intensity gamma ray radiation (Figure 8, 38-60 ft.) and a lower zone of greater gamma ray intensity. However, the intensity of this zone is less than that of the Avon Park Limestone (Figure 8, 60-97 ft.). On electric logs, the unit produces both low and high resistivity, indicating varying porosity (Figure 8, 52-96 ft.). The unit is found almost exclusively in the southern half of the study area.



LEGEND

●	Avon Park Limestone is top of limestone in well	○	Hawthorn Formation present in well
■	Ocala Limestone (typical) is present in well	⊗	BOG printout
▲	Only lower Ocala Limestone present in well	D/U	Proposed fault trace

Figure 7. Map Showing Formations Present in Wells

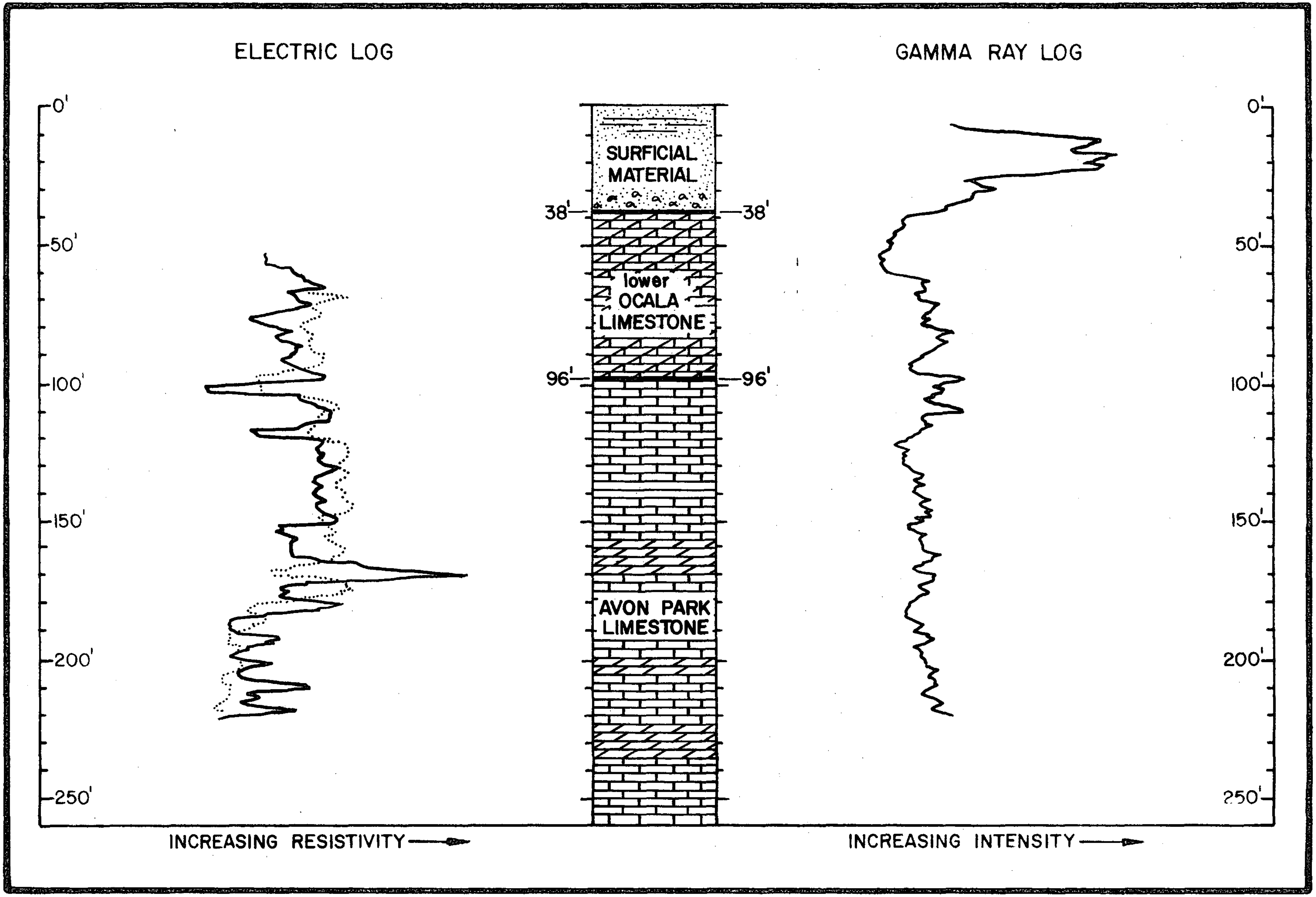


Figure 8. Gamma Ray and Electric (Resistivity) Logs of Well V-14

HAWTHORN FORMATION

The Hawthorn Formation (Miocene) consists of clay, sand, dolostone, limestone and phosphate mixed in varying proportions. Thickness of the Hawthorn in the study area ranges from 3 to 104 feet with an average (arithmetic mean) thickness of 32 feet. Two lithologic zones within the Hawthorn can be distinguished: an upper thick, sand, clay and phosphate zone, and a lower zone consisting of a hard, dark brown and bluish, sandy, phosphatic dolostone bed or series of beds directly overlying the Ocala Limestone (See core description, SJRWMD #8, V-11, Appendix B). Only the lower zone is present in most wells logged in the study area. The Hawthorn is present in thirteen of the forty wells logged. Eleven of these wells are located in the north portion of the study area. In only three of the wells is the thick sand-and-clay upper zone of the formation present (wells L-3, V-3 and V-12, Appendix A).

SURFICIAL MATERIAL

This unit, late Miocene to Recent in age, consists of sand, clay and admixtures of the two with thickness ranging between 34 and 139 feet. On gamma ray logs, the unit is indicated by low to medium intensity (Figure 8, 8-38 ft.). The clay tends to act as an aquitard for the Floridan aquifer where the Hawthorn Formation is absent (Wyrick, 1960).

STRUCTURAL RELATIONSHIPS

A structure contour map of the top of the limestone (which, in the study area is either Ocala Limestone, lower Ocala, or Avon Park Limestone) is shown in Figure 9. Both this map and the structure contour map of the top of the Avon Park Limestone (Figure 5) indicate a probable fault in the area between Altoona and Lake Dorr (northeast Lake County) and south Lake Dias (west Volusia County). The location of the fault mentioned is in the same general area as the fracture trace reported by Vernon (1951) and shown in Figure 3. The fault divides the study area into north and south portions each characterized not only by substantial differences in depth to formation contacts, but also by differences in formations present and small changes in lithology within the same formation.

The north region is characterized by relatively greater depth to formation contacts and a thicker, more complete geologic section. Sixteen wells were logged in this region. The Hawthorn Formation is present in eleven of these wells and typical Ocala Limestone is identified in all but one well.

The south region is characterized by relatively shallower formation contacts and a much less complete geologic section when compared to the north region. Twenty-three wells were logged in this region (Figure 2). Additional data were obtained from one Florida Bureau of Geology lithologic printout of a core hole in the northeast Lake County area. The Ocala Limestone is either absent or very non-typical in composition in most of the wells. The Hawthorn Formation is present in two wells logged in north Seminole County and is very thin there.

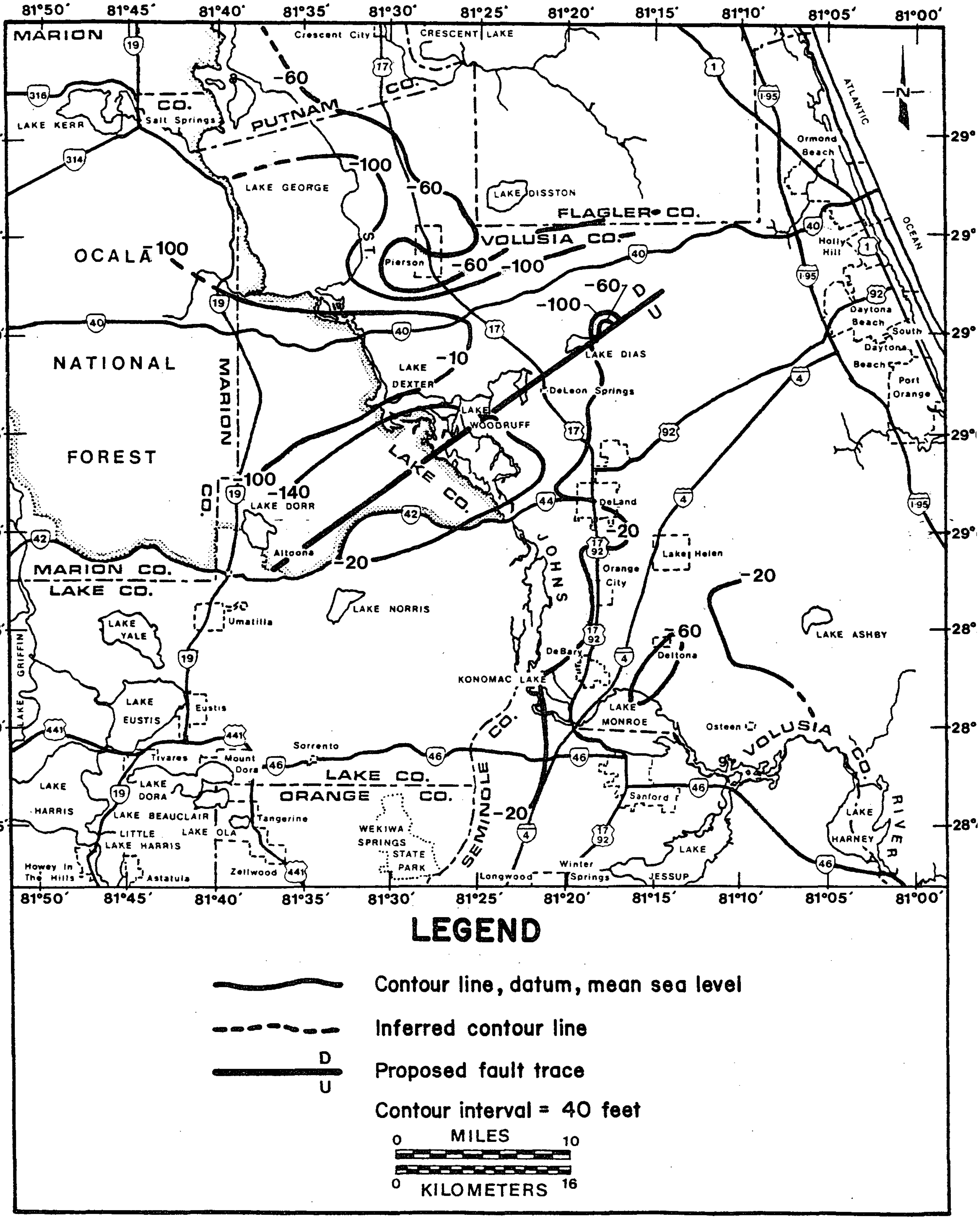


Figure 9. Structure Contour Map of the Top of the Limestone (Floridan Aquifer)

The non-typical, lower Ocala unit is present in most of the wells in the south region with the exception of four wells near the fault (Figure 7) and the two wells logged in Seminole County. In six wells the Ocala is absent and the first limestone penetrated is the Avon Park Limestone.

Figure 10 shows locations of stratigraphic cross sections I through V. These cross sections, Figures 11 through 15 show the fault and an interpretation of stratigraphic relationships across the fault. Cross section locations are shown in Figure 10. Because of the limited number of wells logged on the west side of the St. Johns River, the existence of possible faults directly along the river cannot be confirmed. However, differences in the altitude of formation contacts extending perpendicular to and across the river can all be easily accounted for without recourse to faulting (Figures 11, 12, 13 and 14).

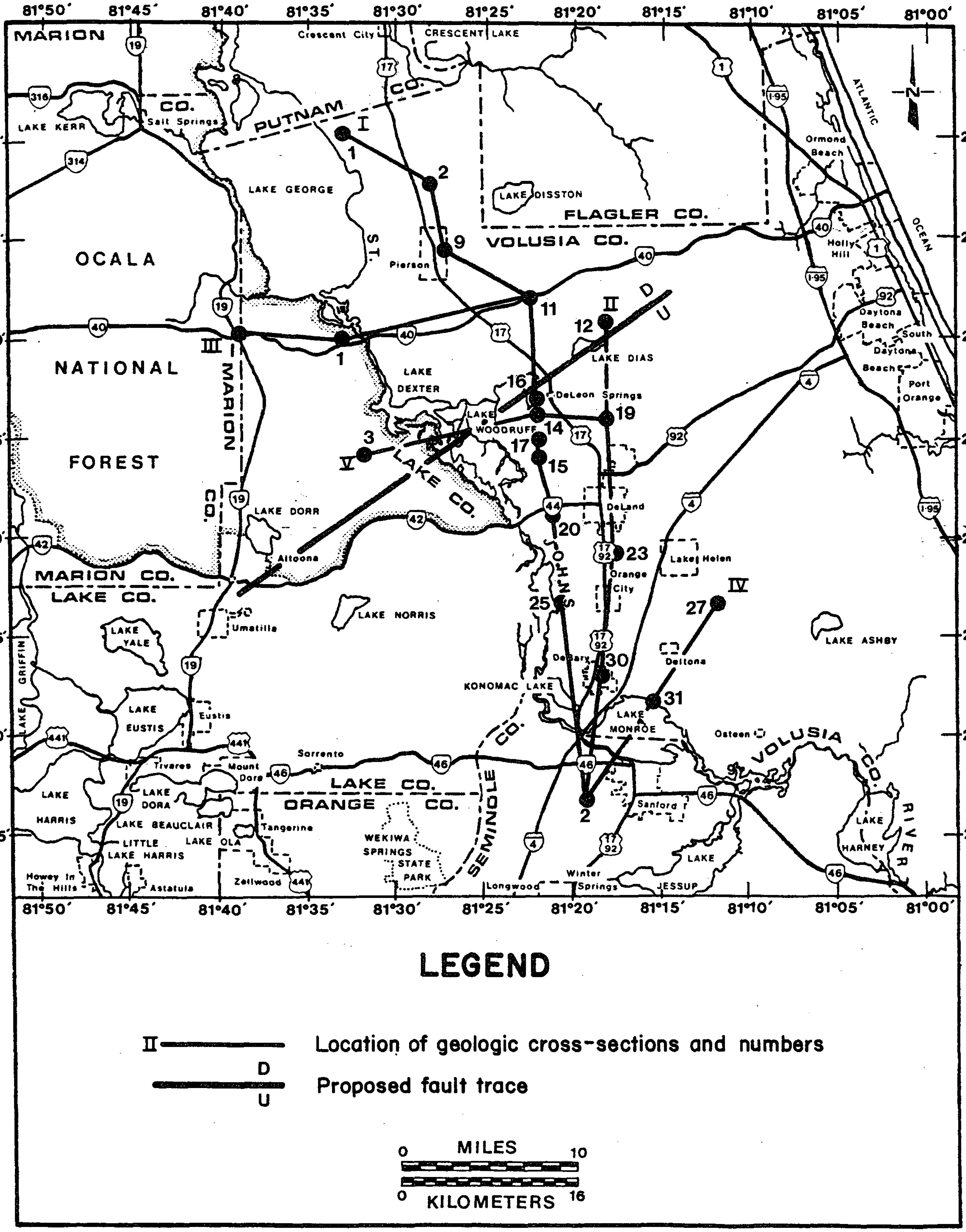


Figure 10. Map Showing Cross Section Locations

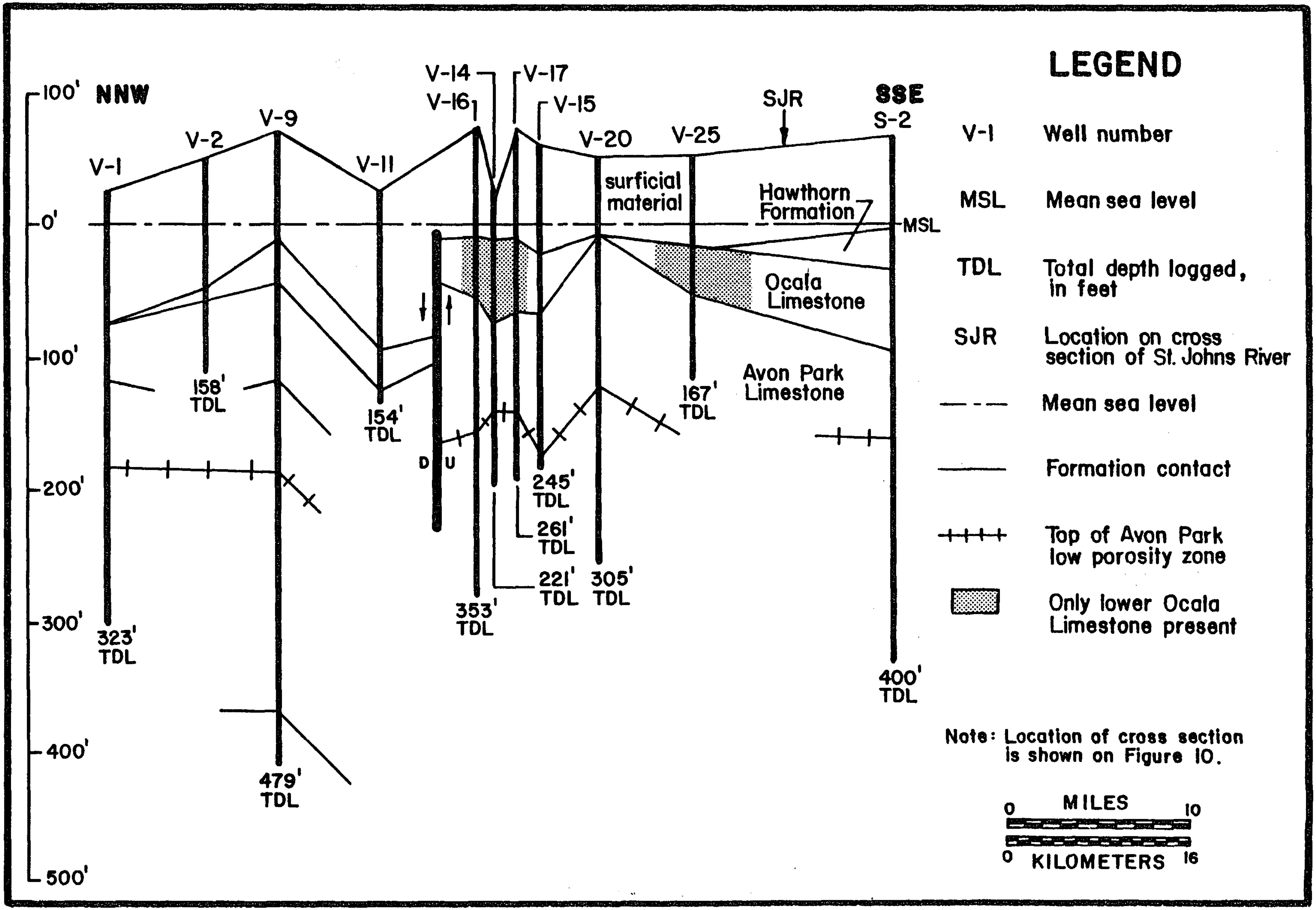


Figure 11. Geologic Cross Section I North-Northwest---South-Southeast in the Project Area

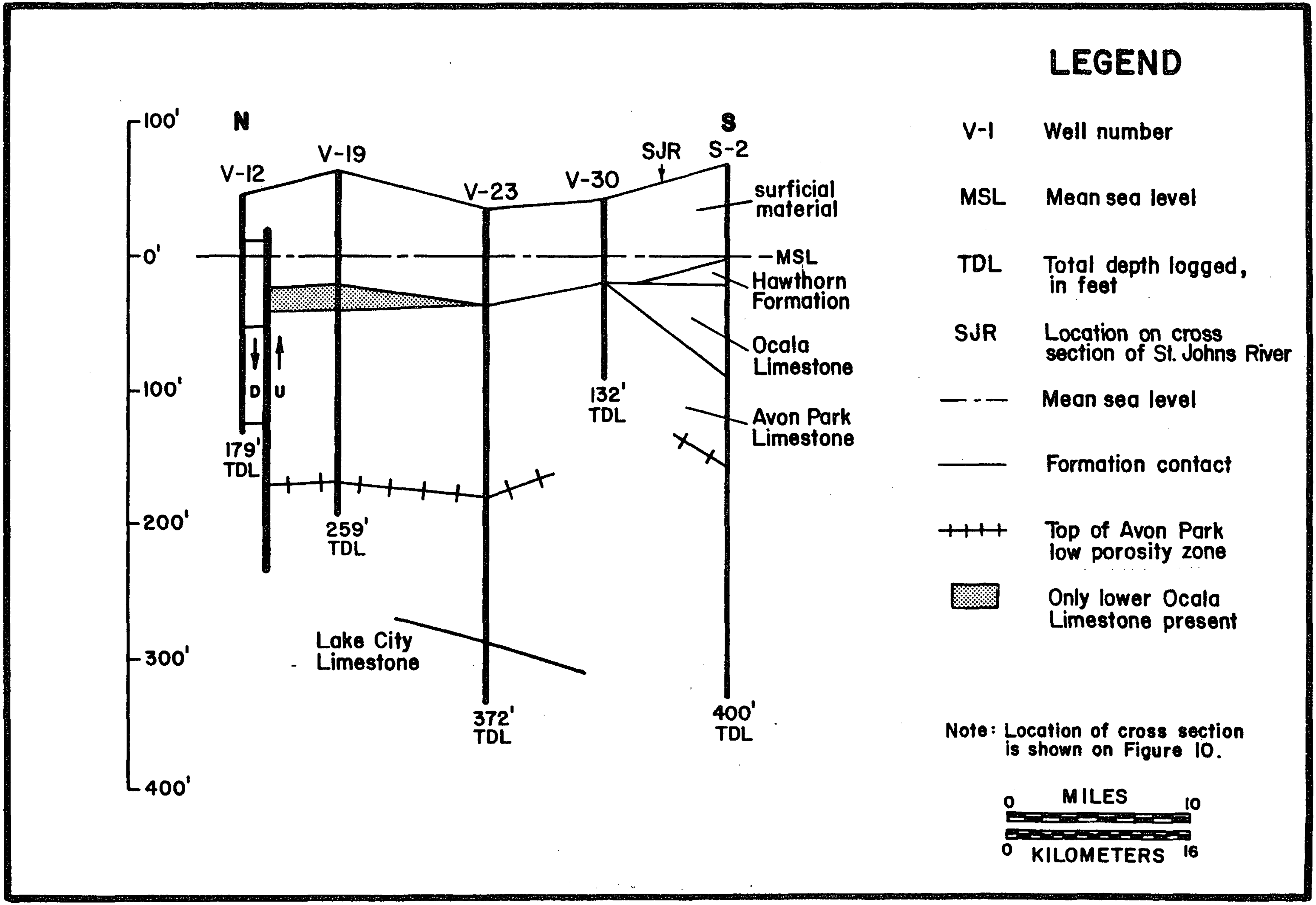


Figure 12. Geologic Cross Section II North-South in the Project Area

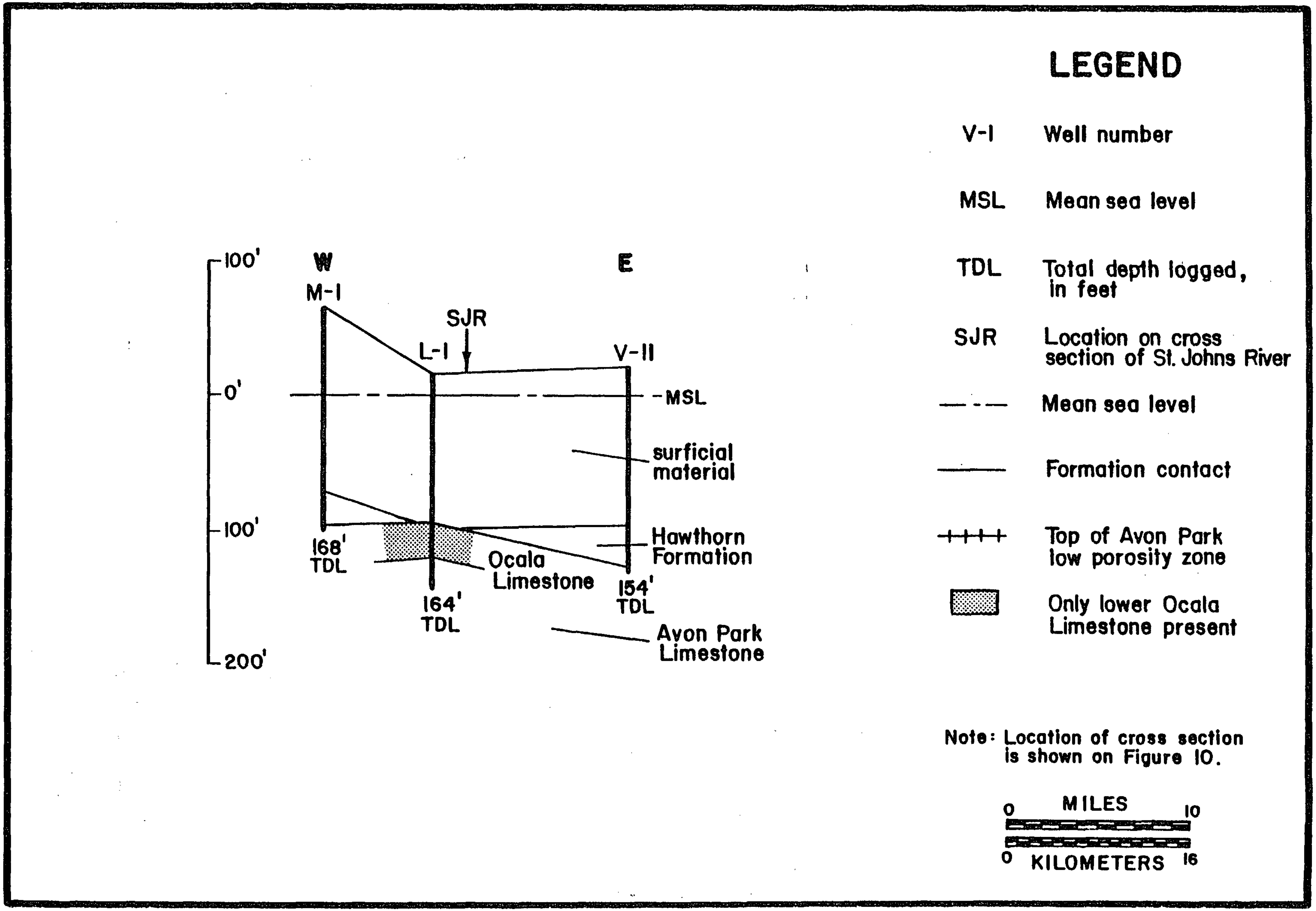


Figure 13. Geologic Cross Section III East-West in the Project Area

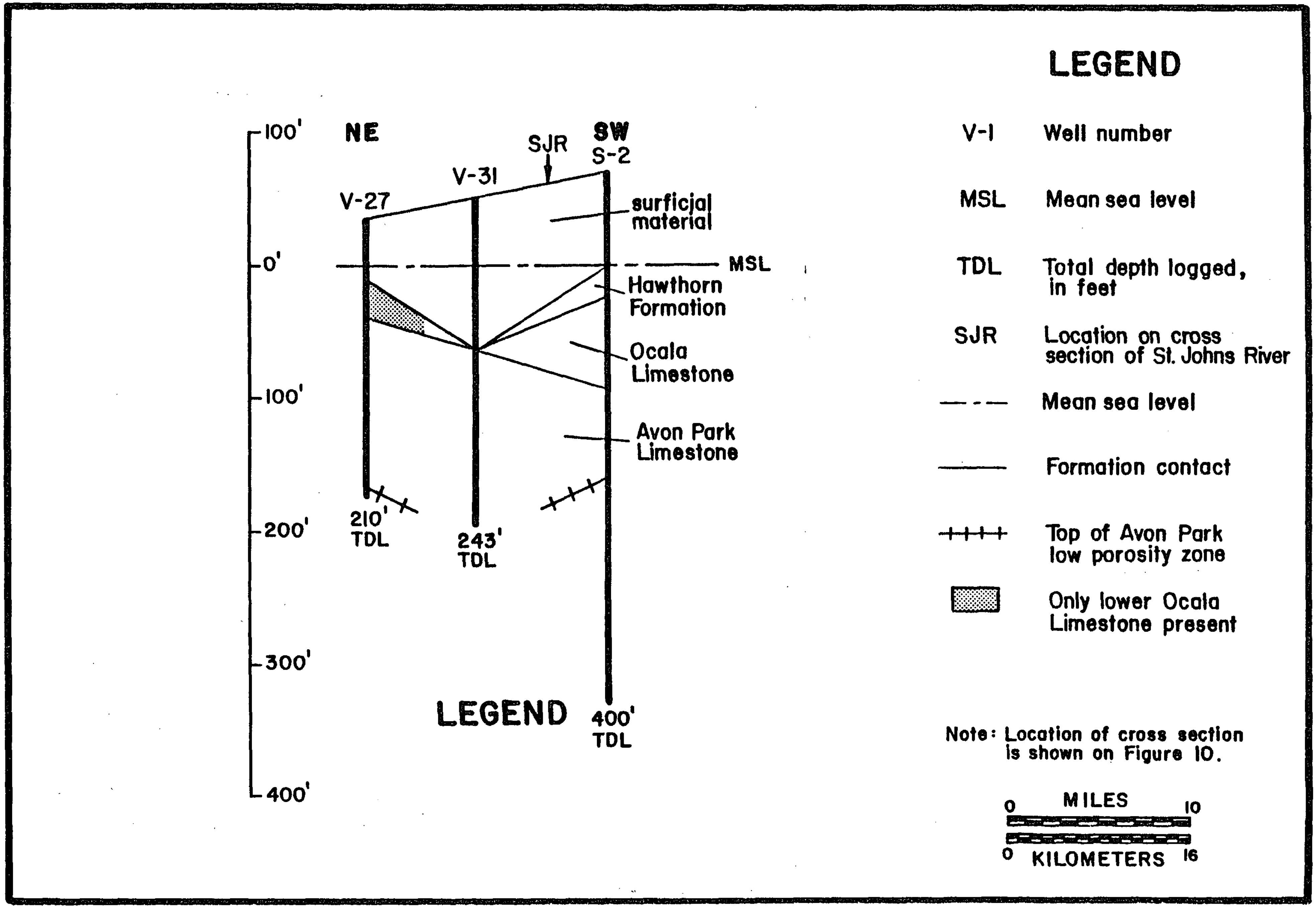


Figure 14. Geologic Cross Section IV Northeast-Southwest in the Project Area

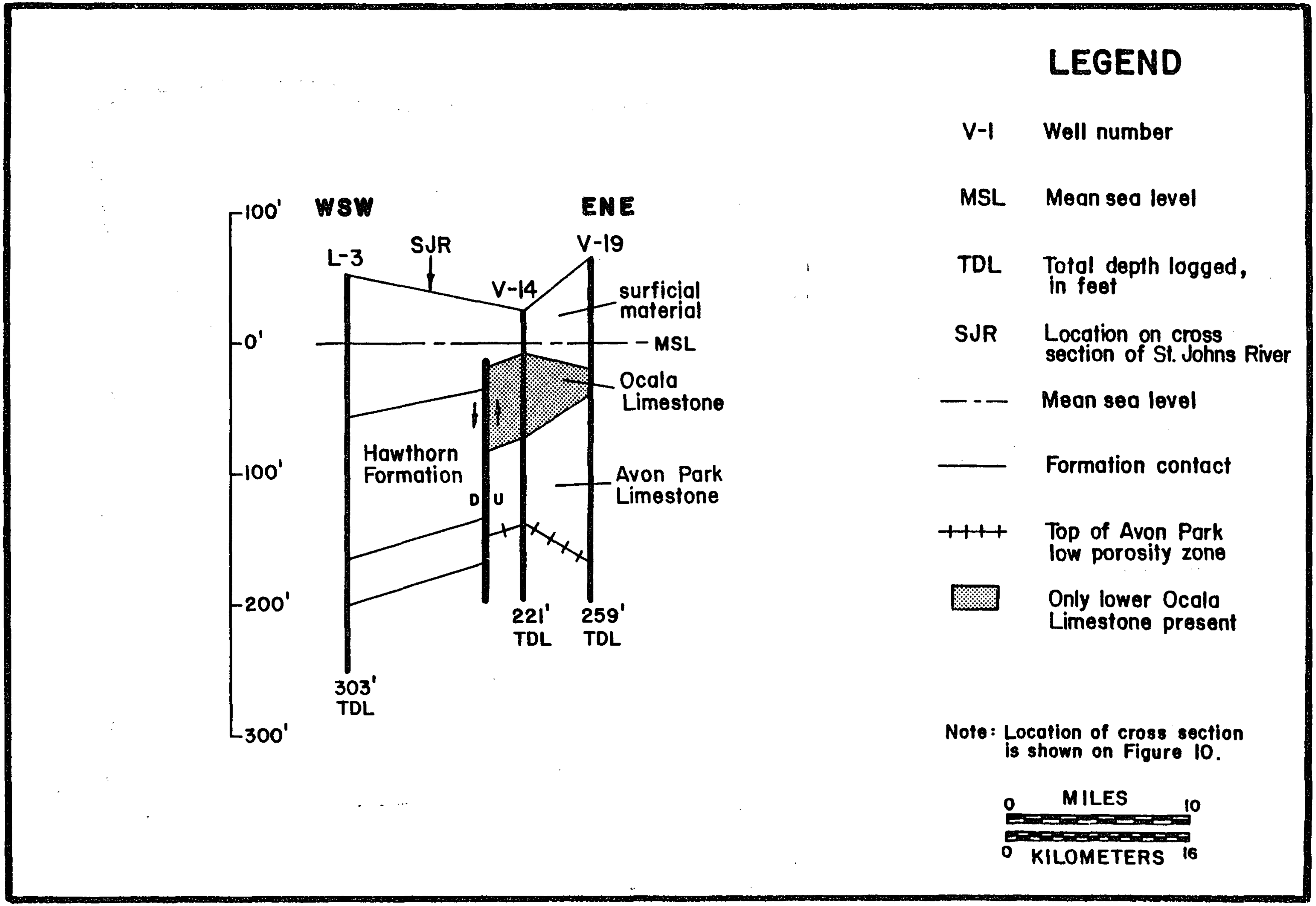


Figure 15. Geologic Cross Section V East-Northeast---West-Southwest in Project Area

STRUCTURE-SALT WATER INTRUSION RELATIONSHIP

Figure 16 shows the locations of wells in the study area determined to be contaminated by salt water intrusion. Because wells both near and relatively far from the proposed fault are contaminated, this fault is probably not the means by which the salt water intrusion has occured. The most probable explanation is that the fresh water-salt water interface seems to be relatively shallow in this area and therefore intrusion probably is related to well depth.

Because the stratigraphic section in the south region is less complete than in the north region, wells drilled in the south region will probably penetrate older geologic formations than wells drilled to an equivalent depth in the north region. Salt water contamination is more probable with increasing well depth and formation penetration.

An estimate for maximum safe depth of new wells in the south region of the study area where most of the contamination occurs is 180 to 200 feet. This estimate is in agreement with an estimate provided by Volusia County, Inspections and Permits, for wells drilled in the DeLeon Springs area (William Hendrix, oral communication, 1978).

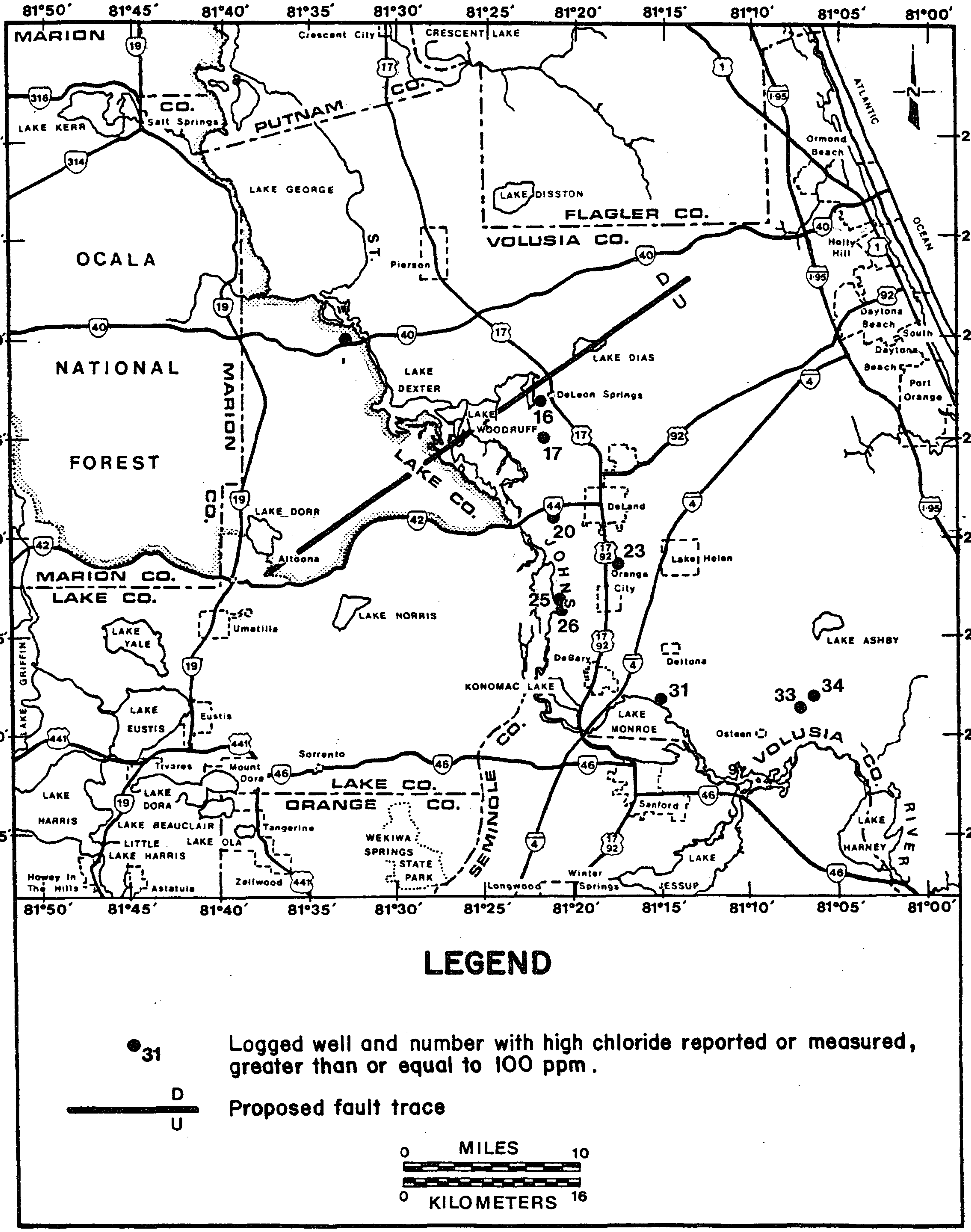


Figure 16. Map Showing Wells Determined to be Contaminated by Salt Water Intrusion

SUMMARY

To determine if a fault is present along or near one section of the St. Johns River, forty wells were geophysically logged in west Volusia, northeast Lake, and north Seminole Counties, and Bureau of Geology lithologic printouts of wells in the area were obtained.

The Avon Park Limestone, Ocala Limestone, Hawthorn Formation and surficial materials were described and the occurance of the Ocala Limestone was tentatively extended to include most of west Volusia County (excluding the immediate vicinities of DeLand and DeBary where the Avon Park Limestone is the first limestone penetrated by wells). In most of the south region, the Ocala Limestone is non-typical and rather thin, probably consisting mainly of dolomitic limestone and dolostone; this lithology is referred to herein as lower Ocala.

Evidence of a fault close to and parallel to the St. Johns River was lacking; however a fault could exist perpendicular to the river between Altoona (northeast Lake County) and south Lake Dias (west Volusia County). This location was determined from structure contour maps and a change in geology across the suspected fault. This location is in the same general area as the location of a fault (or joint) postulated by Vernon (1951). This fault divides the study area into north and south regions with the north region characterized by a more complete geologic section with deeper and thicker formations.

The suspected fault is probably not responsible for the connate salt water contamination, since salty water has intruded wells both near and relatively far from the fault, while some wells close to the fault are uncontaminated. Recommended maximum depth for wells drilled south of the proposed fault is 180 to 200 feet.

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APPENDIX A

LOGGED WELL TABULATION:

WELL CONSTRUCTION AND FORMATION CONTACTS

APPENDIX A

TABLE 1. VOLUSIA COUNTY WELLS -- CONSTRUCTION INFORMATION AND FORMATION CONTACTS

Well No.	Well Depth In feet	Casing Depth/Size feet/inches	Elevation Bottom Casing	Elevation Hawthorn	Ocala	(Top of) Avon Park	LowØ Zone
V-1	323	82/10	-57	*	-74	-115	-178
V-2	158	113/4	-63	-50	-53	*	*
V-3	416	137/8	-85	-33	-85	-142	-211
V-4	345	127/8	-92	*	-90	-161	-239
V-5	361	120/8	-55	-47	-55	-117	-188
V-6	394	105/10	-47	-18	-50	-113	-182
V-7	125	63/4	-43	-37	-43	-99	*
V-8	180	97/4	-86	-74	-87	-140	*
V-9	479	118/10	-46	-8	-42	-115	-185
V-10	123	86/4	-26	*	-16	*	*
V-11	154	131/4	-106	-97	-125	*	*
V-12	179	96/4	-51	+11	-54	-129	*
V-13	161	95/4	-14	*	-13W	-47	*
V-14	221	53/8	-28	*	-10W	-72	-137
V-15	245	115/8	-55	*	-22	-67	-175
V-16	353	92/8	-17	*	-9W	-54	-157
V-17	261	107/8	-32	*	-6W	-63	-137
V-18	191	104/4	-22	*	-16W	-51	*
V-19	259	245/4	-182	*	-22W	-41	-169
V-20	305	252/4	-202	*	*	-7	-122
V-21	150	80/4	-35	*	*	-17	*
V-22	344	106/10	-36	*	*	+5	-151
V-23	372	210/6	-175	*	*	-37	-183
V-24	276	141/8	-71	*	-31W	-40	-160
V-25	167	69/6	-18	*	-16W	-51	*
V-26	149	87/4	-37	*	-14W	-51	*
V-27	210	87/10	-52	*	-7W	-36	-164
V-28	307	146/6	-75	*	-17	-79	-144
V-29	201	81/8	-46	*	-18W	-46	*
V-30	132	105/4	-65	*	*	-23	*
V-31	243	197/6	-147	*	*	-64	*
V-32	205	71/6	-46	*	-36W	-61	*
V-33	258	88/10	-61	*	-36W	-64	-199
V-34	342	65/8	-41	*	-35W	-53	-215

NOTES:

1. Elevation is in feet referenced to mean sea level
2. Low Ø Zone is the low porosity zone of the Avon Park Limestone
3. * An asterisk indicates well did not penetrate formation or formation absent
4. The letter "W" in the Ocala (Elevation) column indicates the presence of the lower Ocala Limestone as defined in this report.

TABLE 2. LAKE COUNTY WELLS -- CONSTRUCTION INFORMATION AND FORMATION CONTACTS

Well No.	Well Depth in feet	Casing Depth/Size feet/inches	Elevation Bottom Casing	Elevation Hawthorn	Ocala	(Top of) Avon Park	Low Ø Zone
L-1	164	120/4	-101	*	-92W	-119	*
L-2	114	106/6	-95	*	-91	*	*
L-3	303	298/6	-248	-59	-163	-200	*
BOG	320	?/?	?	*	-25	-75	-235

TABLE 3. SEMINOLE COUNTY WELLS -- CONSTRUCTION INFORMATION AND FORMATION CONTACTS

Well No.	Well Depth in feet	Casing Depth/Size feet/inches	Elevation Bottom Casing	Elevation Hawthorn	Ocala	Avon Park	Low Ø Zone
S-1	389	130/12	-65	-1	-22	-87	-160
S-2	400	132/12	-63	-1	-22	-92	-160

TABLE 4. MARION COUNTY WELLS -- CONSTRUCTION INFORMATION AND FORMATION CONTACTS

Well No.	Well Depth in feet	Casing Depth/Size feet/inches	Elevation Bottom Casing	Elevation Hawthorn	Ocala	Avon Park	Low Ø Zone
M-1	168	168/6	-101	-72	-96	*	*

NOTES:

1. Elevation is in feet referenced to mean sea level
2. Low Ø Zone is the low porosity zone of the Avon Park Limestone
3. * An asterisk indicates well did not penetrate formation or formation absent
4. The letter "W" in the Ocala (Elevation) column indicates the presence of the lower Ocala Limestone defined in this report.
5. ? Indicates information unavailable

APPENDIX B

DESCRIPTION OF SJRWMD CORES
NORTHWEST VOLUSIA COUNTY

CORE DESCRIPTION

SJRWMD #5

V-7

Location: 29° 14' 31" N; 81° 26' 30" W; Pierson, Turner Rd., Volusia County
Total Depth Logged: 123 ft.
Total Depth Cored: 125 ft.
Casing: 4" PVC to 86 ft.
Measuring Point: Top of casing = Land surface + 1 ft.
Topographic elevation = 60 ft. above mean sea level
Date Logged: 11/10/78

DEPTH BELOW MP	DESCRIPTION
grab samples	
10 ft.	Clay, brown, and sand, fine
20	Clay, light tan, and sand, fine
25	Clay, yellowish gray, and sand, fine; wood splinters; quartzitic sandstone pebbles
30	Clay, dark gray, plastic, blocky; quartzitic sandstone pebbles
40	Shell hash, white, mud, grayish brown, and sand; some sandstone pebbles
50	Shell hash, white; some sandstone pebbles
60	Shell hash, white, black and tan; some very small whole pelecypods
70	Shell hash, gray, black and tan; some very small pelecypods
76	Clay, olive drab; some shell hash
80	Limestone, white, and limestone, gray; some sandstone
cores	
91-94 ft.	Limestone, tan, foram hash, recrystallized; some moldic porosity
94-96	Limestone, tan, foram hash, upper one-third: low moldic porosity; middle one-third: very friable and uncemented; lower one-third: high moldic porosity; also contains small echinoids
96-98	Limestone, tan, foram hash, moderate moldic porosity
98-108	Top one-third: Limestone, tan, foram hash, moderately indurated to friable, moderate moldic porosity Middle one-third: Limestone, tan, foram hash, well indurated and cemented Lower one-third: Limestone, tan, foram hash, friable, very low moldic porosity
108-110	Limestone, tan, foram hash, well-cemented, irregular inclusions of less well-cemented foram hash, moderate moldic porosity
110-113	Limestone, gray to tan, foram hash, well-cemented, moderate to high moldic porosity
113-118	Limestone, gray, foram hash; upper one-half: well-cemented, moderate moldic porosity; lower one-half:

	tan, moderately well-cemented, very high moldic porosity, some original shell material and shells
118-123	Limestone, tan, foram hash, well-cemented, moderate to high moldic porosity
123-125	Limestone, gray, foram hash, well-cemented, moderate to high moldic porosity

CORE DESCRIPTION

SJRWMD #8

V-11

Location: 29° 12' 16" N; 81° 21' 55" W; East of Barberville, on S.R. 40,
Volusia County
Total Depth Logged: 154 ft.
Total Depth Cored: 170 ft.
Casing: 4" id to 131 ft.
Measuring Point: Top of Casing = Land Surface + 1 ft.
Topographic elevation = 25 ft. above mean sea level
Date Logged: 1/10/79

DEPTH BELOW MP	DESCRIPTION
cores	
146-150 ft.	Dolostone, brown to tan, hard, moderate moldic porosity, recrystallized, with included phosphatic grains and pebbles
150-160	Top two feet: Dolomite, brown, hard, sucrosic, low moldic porosity; much sand-sized phosphatic material; Remainder of interval: Limestone, white, foram hash, very poorly cemented to uncemented; slightly harder and recrystalized at top, mostly uncemented near bottom
160-162	Limestone, white, foram hash, hard to very soft and uncemented, fine white lime material in interstices between forams in places
162-164	Limestone, same as 160-162 above; in places, more cemented
164-166	Limestone, same as above
166-168	Limestone, same as above
168-170	Limestone, same as above

CORE DESCRIPTION

SJRWMD #9

V-2

Location: 29° 18' 23" N; 81° 28' 08" W; Seville, Cowart Rd., Volusia County
Total Depth Logged: 158 ft.
Total Depth Cored: 166 ft.
Casing: 4" PVC to 113 ft.
Measuring Point: Top of Casing = Land surface + 2 ft.
Topographic Elevation = 50 ft.
Date Logged: 1/17/79

DEPTH BELOW MP cores	DESCRIPTION
115-117 ft.	Limestone, white, foram hash, moderately well-cemented, low moldic porosity; bottom portion hard and well-cemented
117-127	Limestone, white, foram hash, mainly well-cemented and hard, zones of recrystallization, moderate moldic porosity, some worm tubes with infillings of foram hash
127-129	Limestone, white, foram hash, low moldic porosity, zones of very fine grained foram hash: well-cemented and recrystallized
129-131	Limestone, white, foram hash, low moldic porosity and well-cemented: very fine grained
131-133	Limestone, same as 129-131, but higher proportion of cement
133-135	Limestone, same as 131-133, but slightly more moldic porosity
135-137	Limestone; top one-half: white, foram hash, coarse-grained, poorly cemented; bottom one-half: same as 133-135
137-139	Limestone, white, foram hash, fine grained and less cement and recrystallization, low moldic porosity, fine grained
139-141	Limestone, white, foram hash, zones of (1) coarse grained, large foram limestone, very little cement or recrystallization, (2) fine grained forams with much cement and recrystallization
141-142	Limestone, white, foram hash, uncemented with much limy clay-sized material, fine grained forams, very low moldic porosity
142-144	Limestone, white, foram hash, fine to coarse grained, well- cemented, moderate moldic porosity, moderately recrystallized and cemented; more moldic porosity near bottom
144-146	Limestone, white, foram hash, hard and well-cemented, moderate moldic porosity
146-148	Limestone, white, foram hash, medium to coarse grained, very hard with much recrystallization: gray to tan; bottom portion: gray with high moldic porosity

148-150	Limestone, white, foram hash, very well-cemented, very hard, high moldic porosity, small zones of softer, less well-cemented hash
150-152	Limestone, gray, foram hash, very hard and very well cemented and recrystallized, very high moldic porosity; bottom more coarse and less well-cemented, less moldic porosity, tan
152-154	Limestone, white, foram hash, coarse grained with very little cement, moderate moldic porosity
154-156	Limestone, white, foram hash, finer grained, very little cement, nevertheless moderately hard
156-158	Limestone: top: white, foram hash, poorly cemented and soft; bottom: harder and much more cement, high moldic porosity
158-160	Limestone: top: white, foram hash, fine grained and cemented, high moldic porosity; bottom: white, foram hash, soft, no cement, contains some limy clay-sized material.
160-162	Limestone, white, foram hash; top few inches as bottom 158-160; bottom: very hard and recrystallized, moderate moldic porosity; bottom few inches: dolomitic limestone, tan
162-166	(Partial recovery only: approximately one foot) Dolomitic Limestone, light tan, very fine grained, recrystallized, few forams still recognizable, moderate moldic porosity

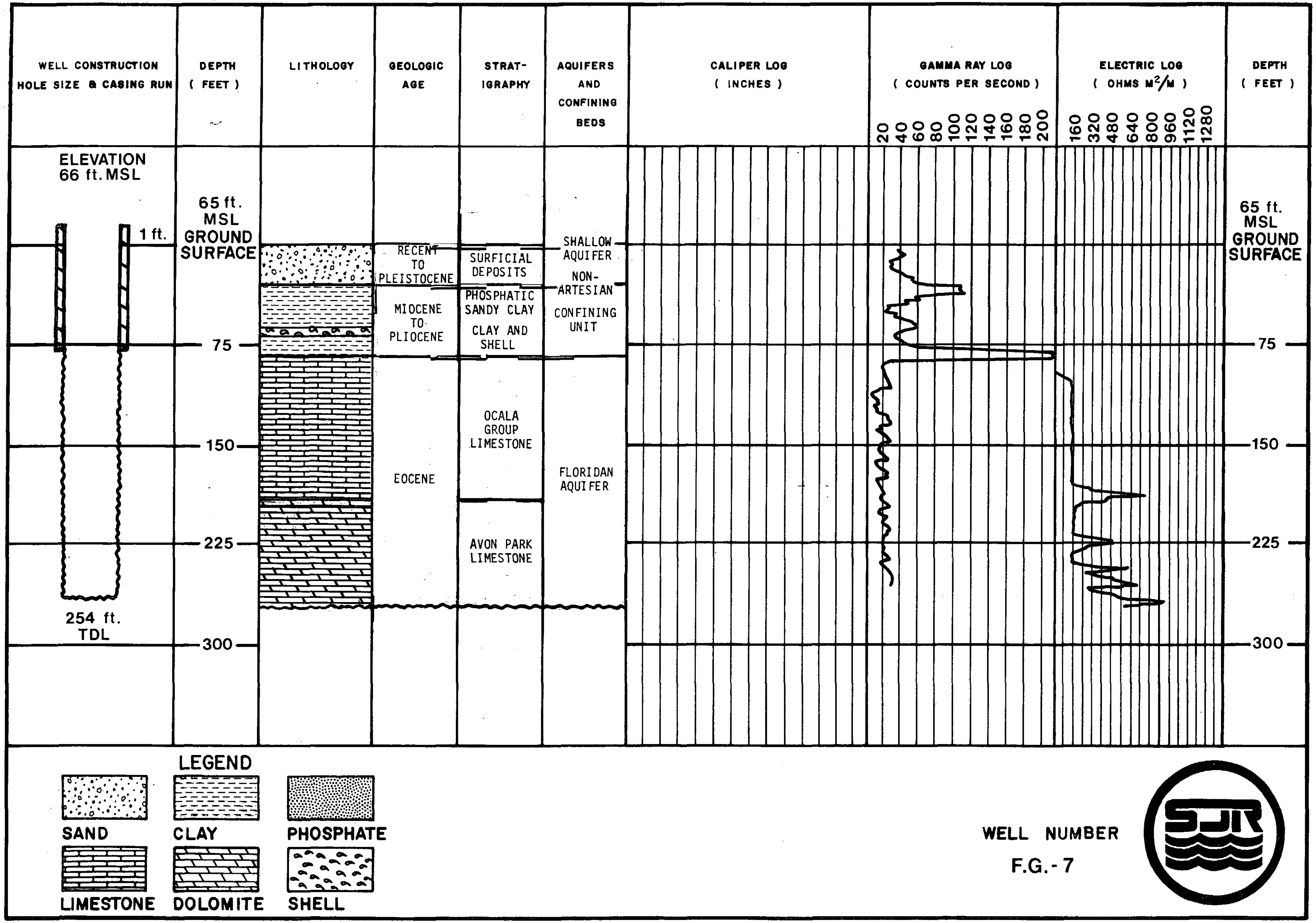

FIGURE A1. -- Hydrogeological and Geophysical Data from Observation Well FG-7

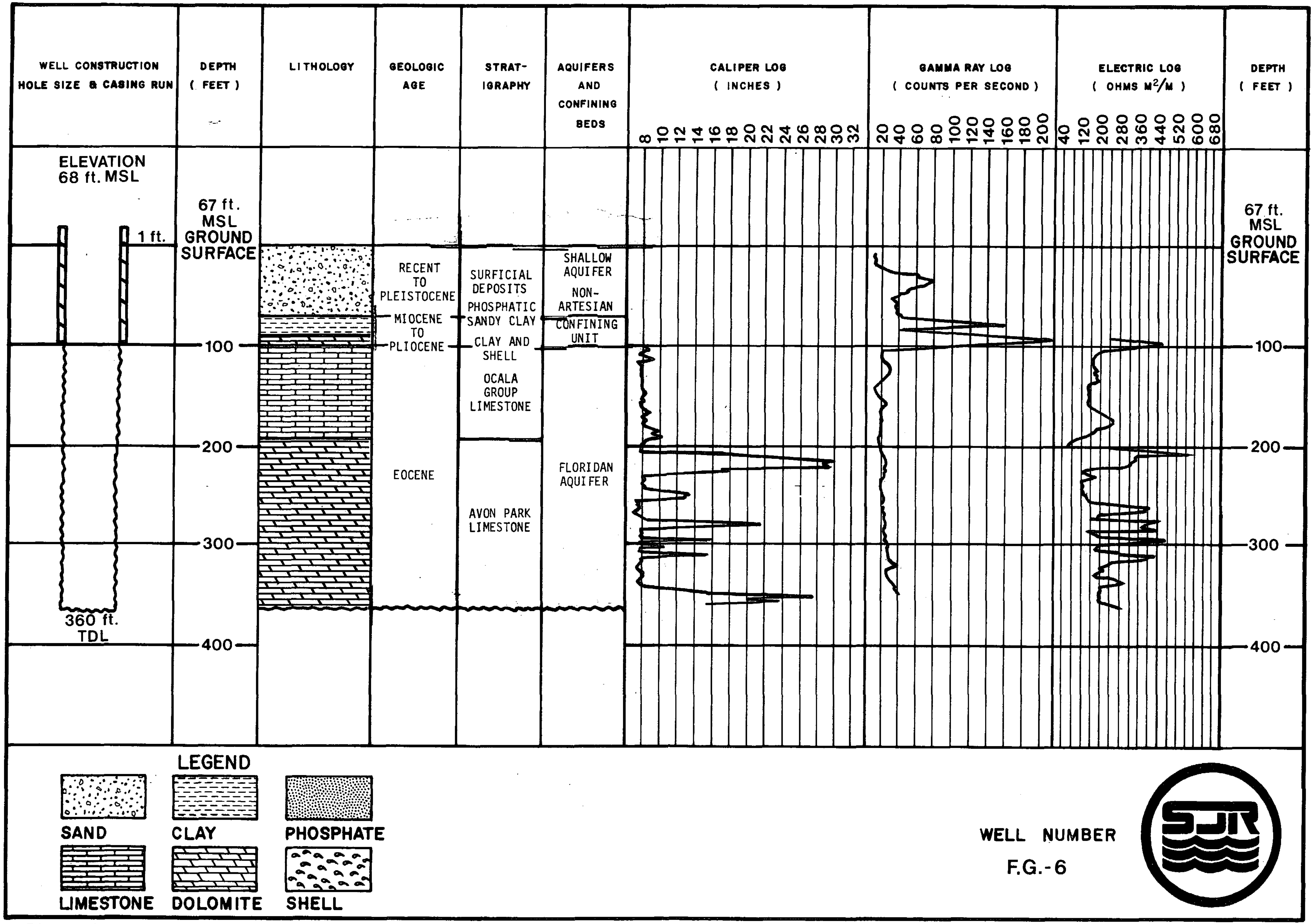

FIGURE A2. -- Hydrogeological and Geophysical Data from Observation Well FG-6

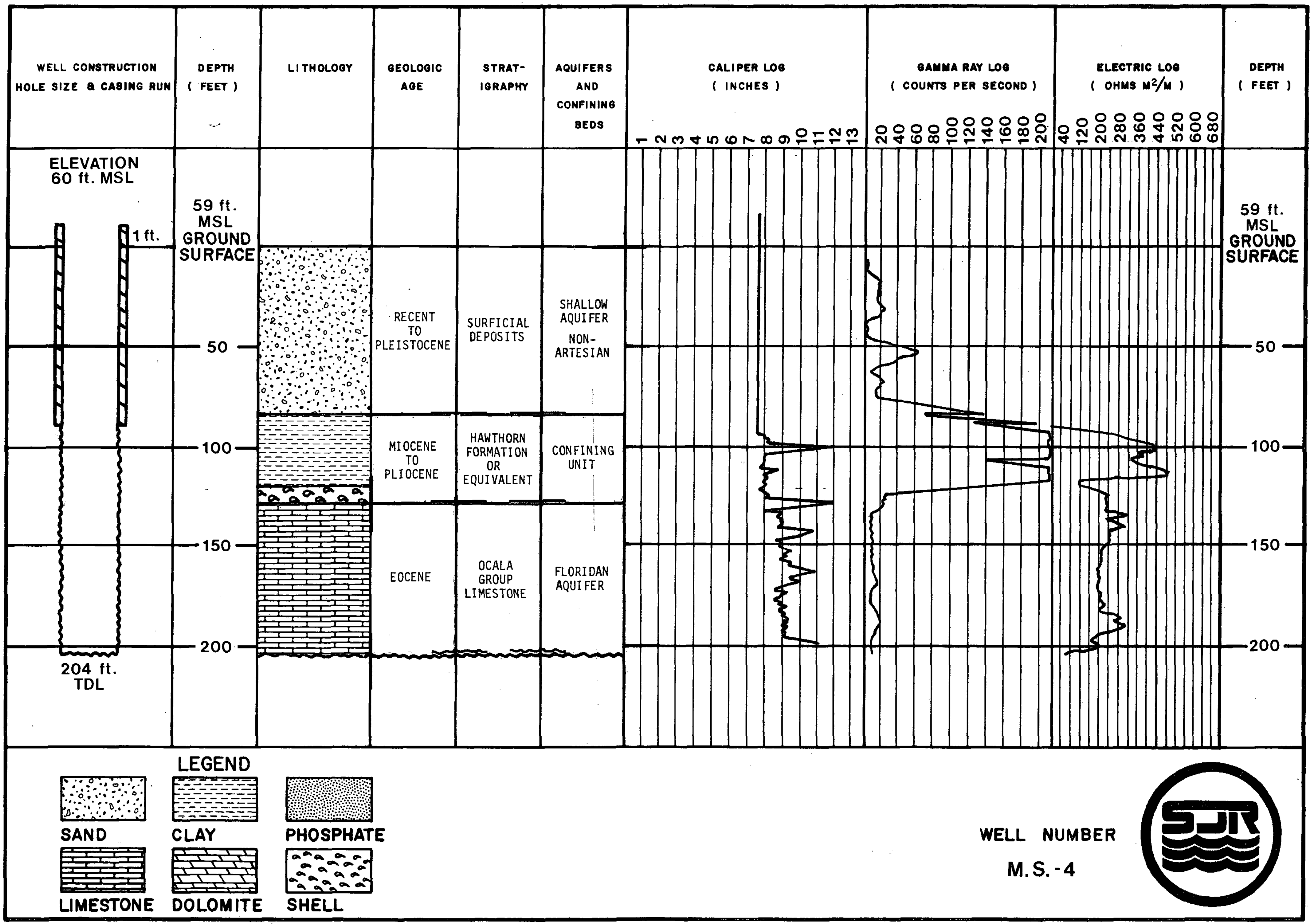

FIGURE A3. -- Hydrogeological and Geophysical Data from Observation Well MS-4

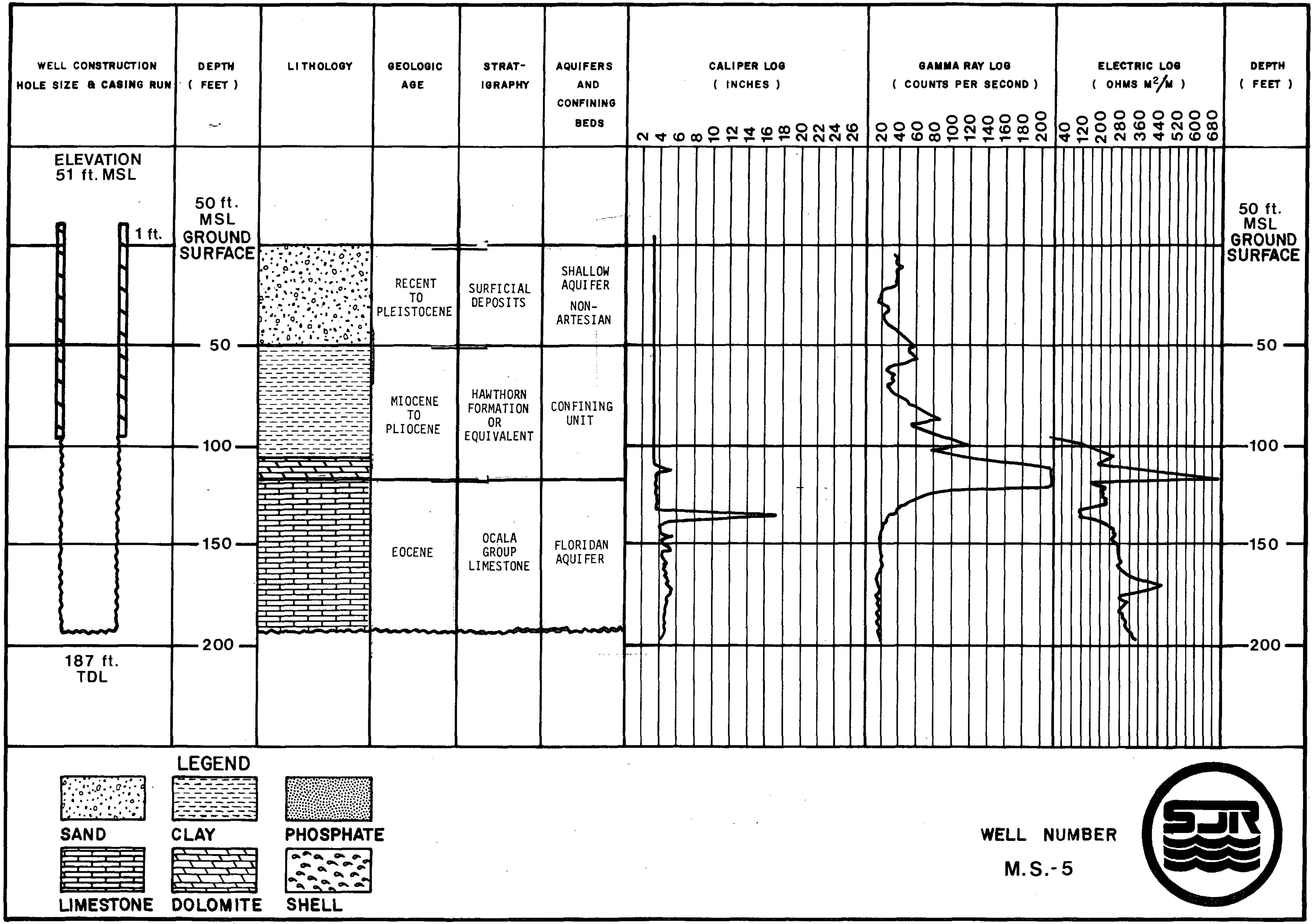

FIGURE A4. -- Hydrogeological and Geophysical Data from Observation Well MS-5

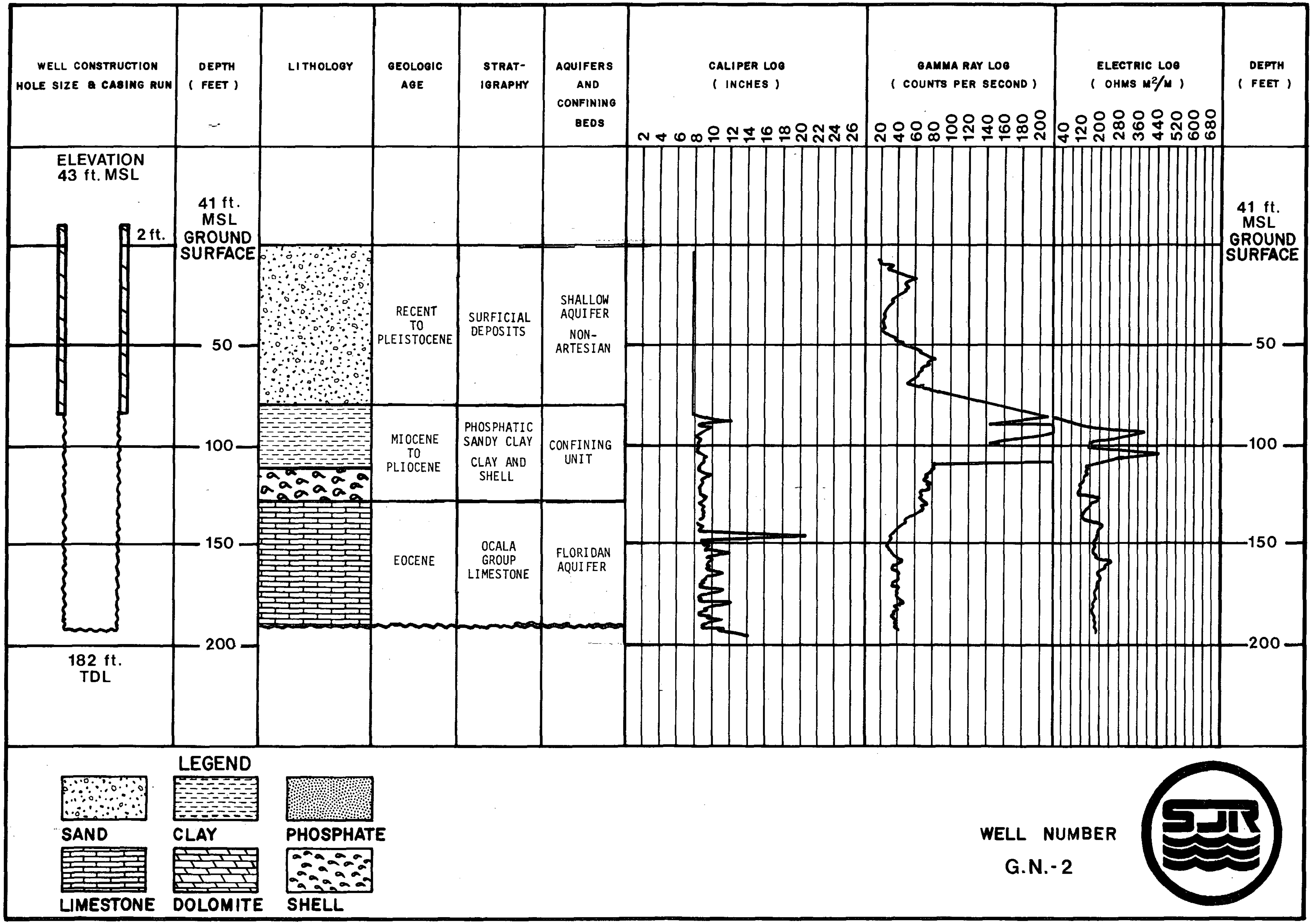

FIGURE A5. -- Hydrogeological and Geophysical Data from Observation Well GN-2

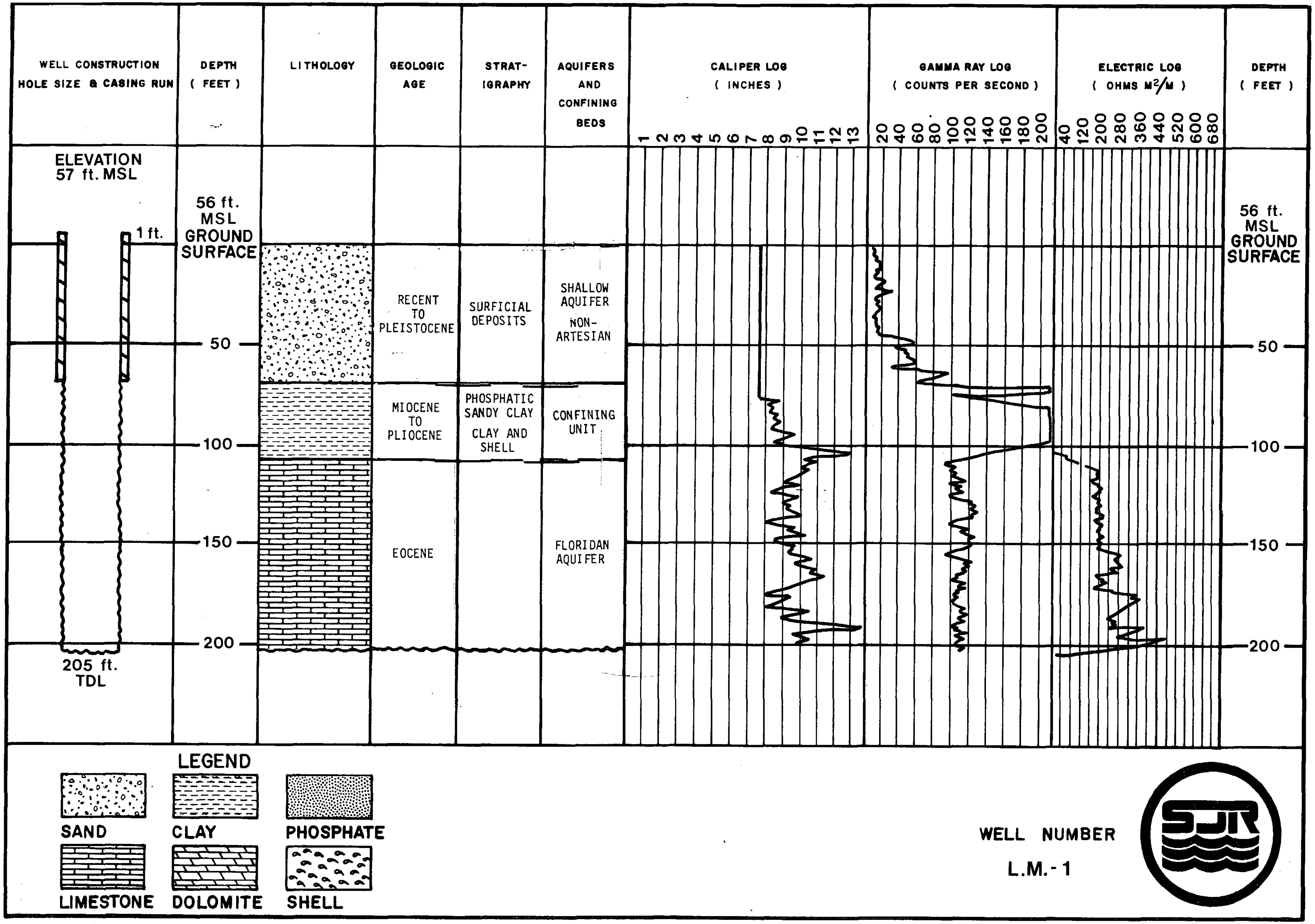

FIGURE A6. -- Hydrogeological and Geophysical Data from Observation Well LM-1