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A STUDY ON THE NEED FOR A SALINITY CONTROL DAM ON THE HALIFAX CANAL AT PORT ORANGE, FLORIDA

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INTRODUCTION

The City of Port Orange is located on the east central coast of Florida, south of Daytona Beach (Figure 1). It consists of an area of 11,200 acres and had a population of 26,566 in 1980 (Florida Statistical Abstract, 1986). The city operates a well field consisting of 15 wells located in the western portion of the city (Figure 2). These wells withdraw water from the Floridan aquifer. Individual domestic wells typically tap the surficial aquifer system, primarily for lawn irrigation.

The Halifax Canal is the main drainage canal in the city. It is connected to the Halifax River at two locations, through Reed Canal in South Daytona Beach and through Rose Bay (Figure 2). During high tides salt water travels upstream into the canal making canal water highly saline or brackish for some distance upstream from the mouth of the canal. Increased withdrawals of ground water from the surficial aquifer system and the presence of tidal waters in the Halifax Canal have been the source of concern about the potential for saltwater intrusion into the surficial aquifer. In February 1983, the City of Port Orange requested that the St. Johns River Water Management District (SJRWMD) design and construct salinity control dams at three sites on the Halifax Canal.

A salinity control dam is a gated or ungated water control structure designed to regulate surface water level and flow to prevent tidal waters from moving upstream in natural or man-made

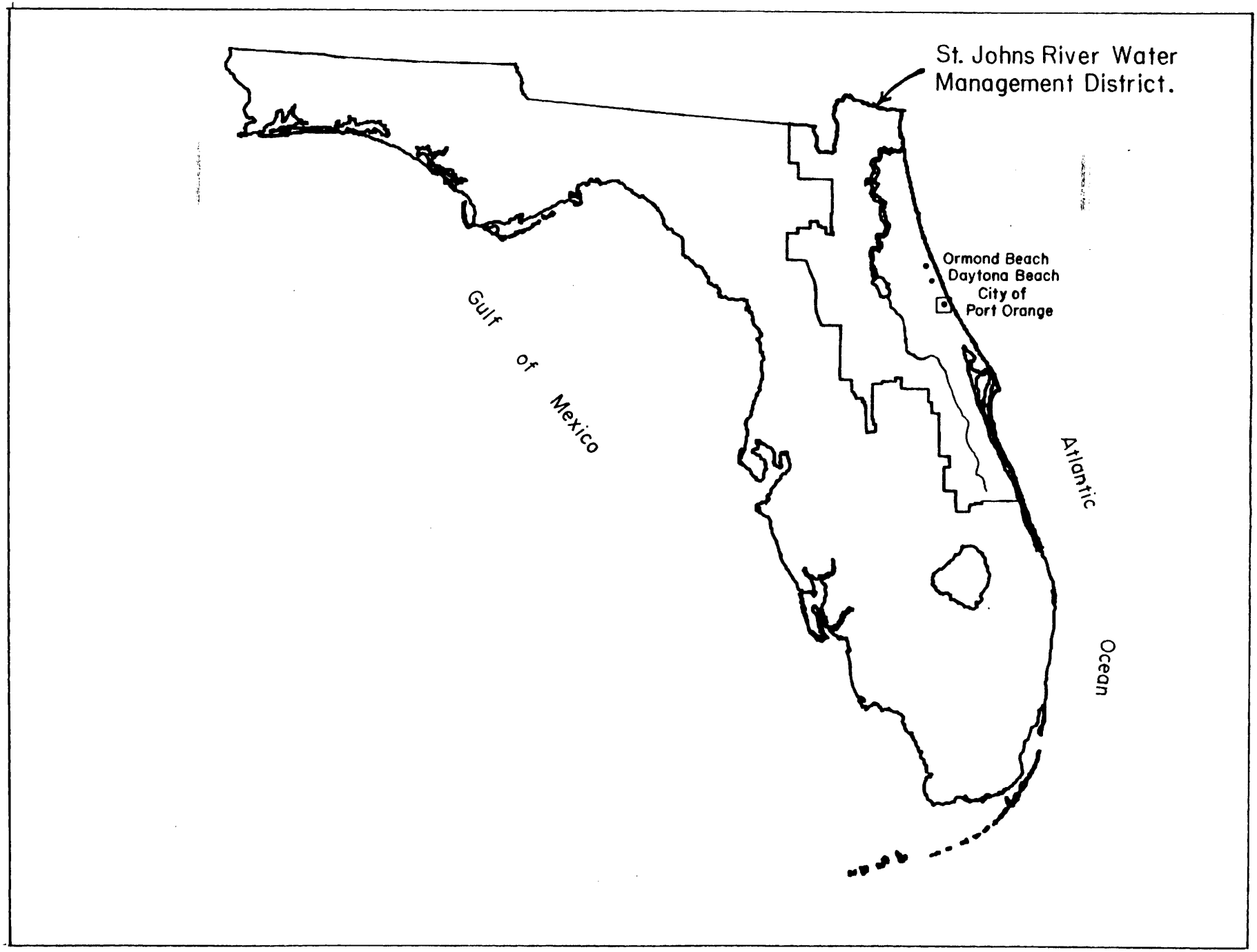

Figure 1 Location of City of Port Orange, Flori

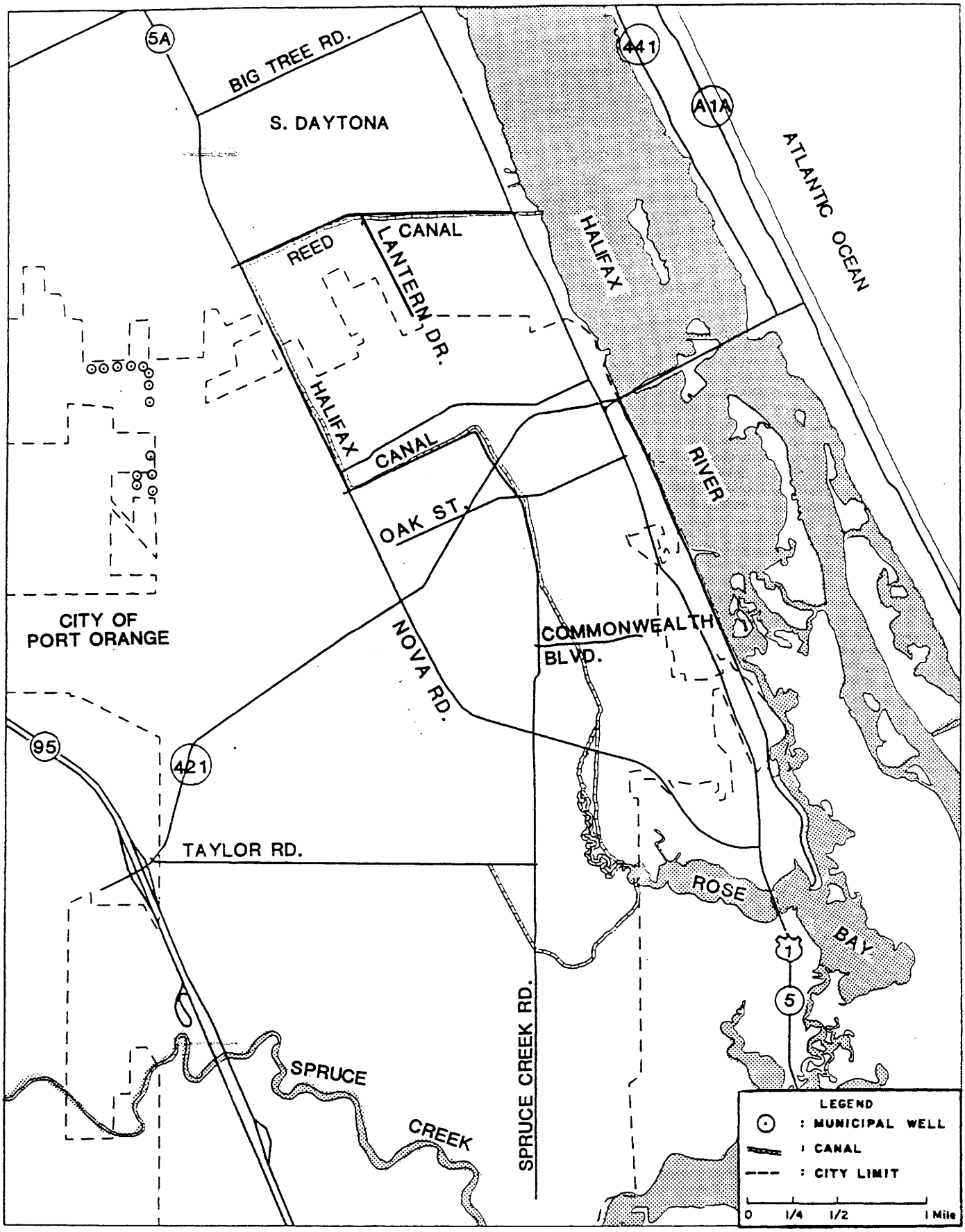

Figure 2 Location of well field in the City of Port Orange

channels (Figure 3). The water level above the structure and the rate of freshwater flow at the control structure prevent the freshwater-saltwater interface in the channel from moving further upstream. The hydraulic pressure upstream of the structure forces the freshwater-saltwater interface within the aquifer to remain deeper underground. These structures were built at several places with successful results in the Miami area (Leach and Grantham 1966, and Hughes 1979).

This study was conducted in response to the city's request to determine the potential for saltwater intrusion into the surficial aquifer by tidal waters in the Halifax Canal. The water quality parameters which indicate the presence of seawater are chloride concentration (mg/l), total dissolved solids (TDS) (mg/l), and electrical conductivity (micro mhos/cm at 25°C). These values increase with increasing concentration of salt water. The recommended limits (standards) for these parameters in public drinking water are: 250 mg/l for chloride concentration, 500 mg/l for TDS (17-550.320, Florida Administrative Code), and 750 micro mhos for electrical conductivity (U.S. Environmental Protection Agency).

The objectives of this investigation are to determine what distance the brackish water from the Halifax River travels upstream into the Halifax Canal and to determine what influence such brackish water has on the water quality of the surficial aquifer system in the City of Port Orange. Both of these objectives were accomplished by collecting surface and ground water

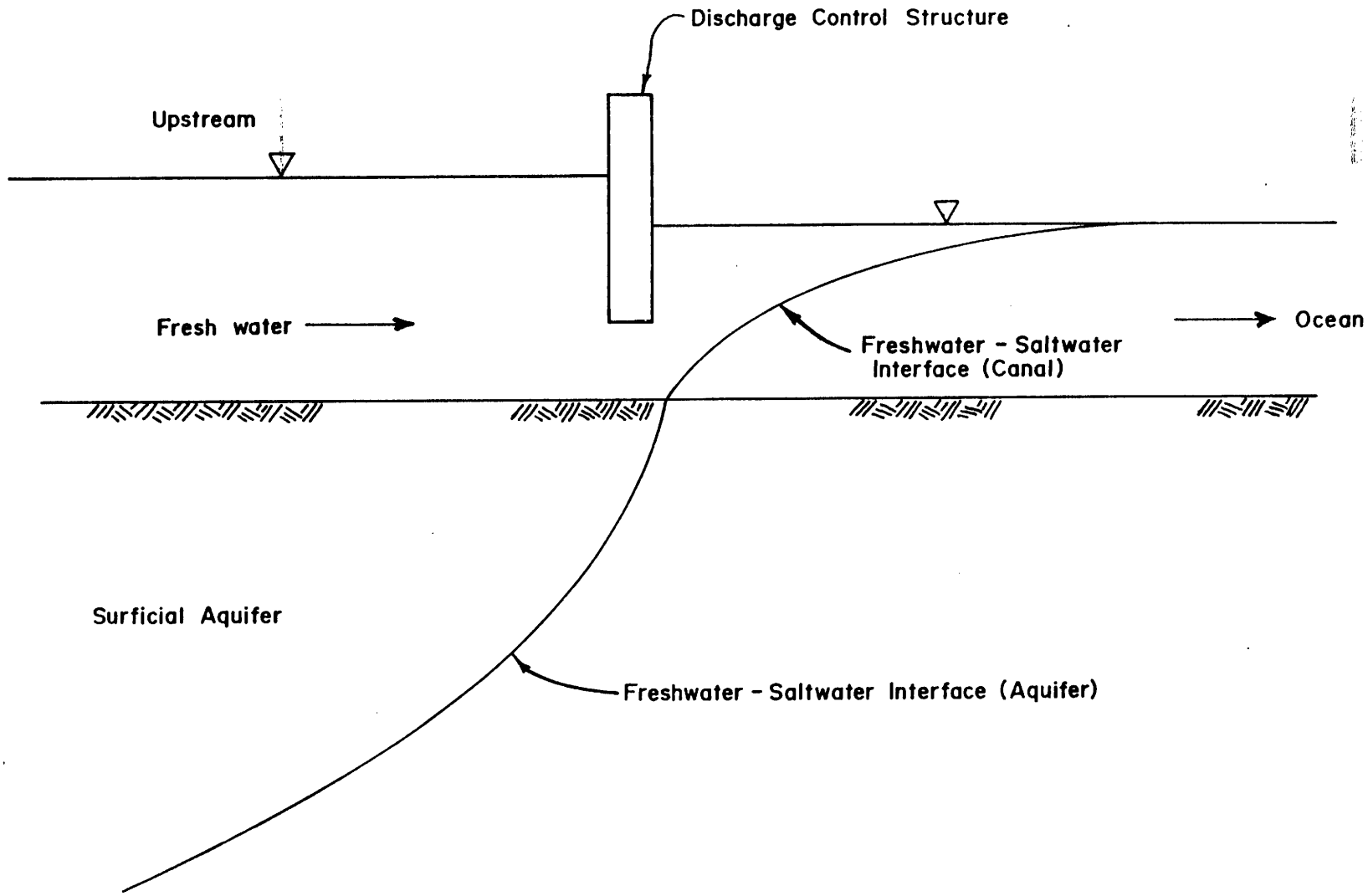

Figure 3 Schematic diagram of a salinity control structure

samples at representative locations along the Halifax Canal and analyzing the samples for the chloride concentration, TDS, and electrical conductivity. Based on the results obtained, a recommendation has been made regarding the necessity of constructing salinity control dams on the Halifax Canal.

DATA COLLECTION AND ANALYSIS

To meet the objectives of this study, three types of data were collected by the SJRWMD:

1) surface water samples in the Halifax and Reed canals;
2) surficial aquifer samples from existing domestic wells distributed throughout the study area; and
3) surficial aquifer samples within 500 feet on either side of the Halifax Canal at Commonwealth Boulevard.

Halifax and Reed Canals--Surface water samples were collected at 12 locations (Figure 4) on May 12, 1987. One set of samples was taken during the rising tide and two sets were taken during the ebbing tide (Table 1). Table 1 presents the electrical conductivity, chloride concentration, and TDS concentration values for these samples. For some distance from the mouth of the canal, these values are extremely high, indicating that water is brackish (Figure 5). Based on these results, it can be stated that the tidal waters extend to Commonwealth Boulevard in the Halifax Canal and to Lantern Drive in the Reed Canal (Figure 4).

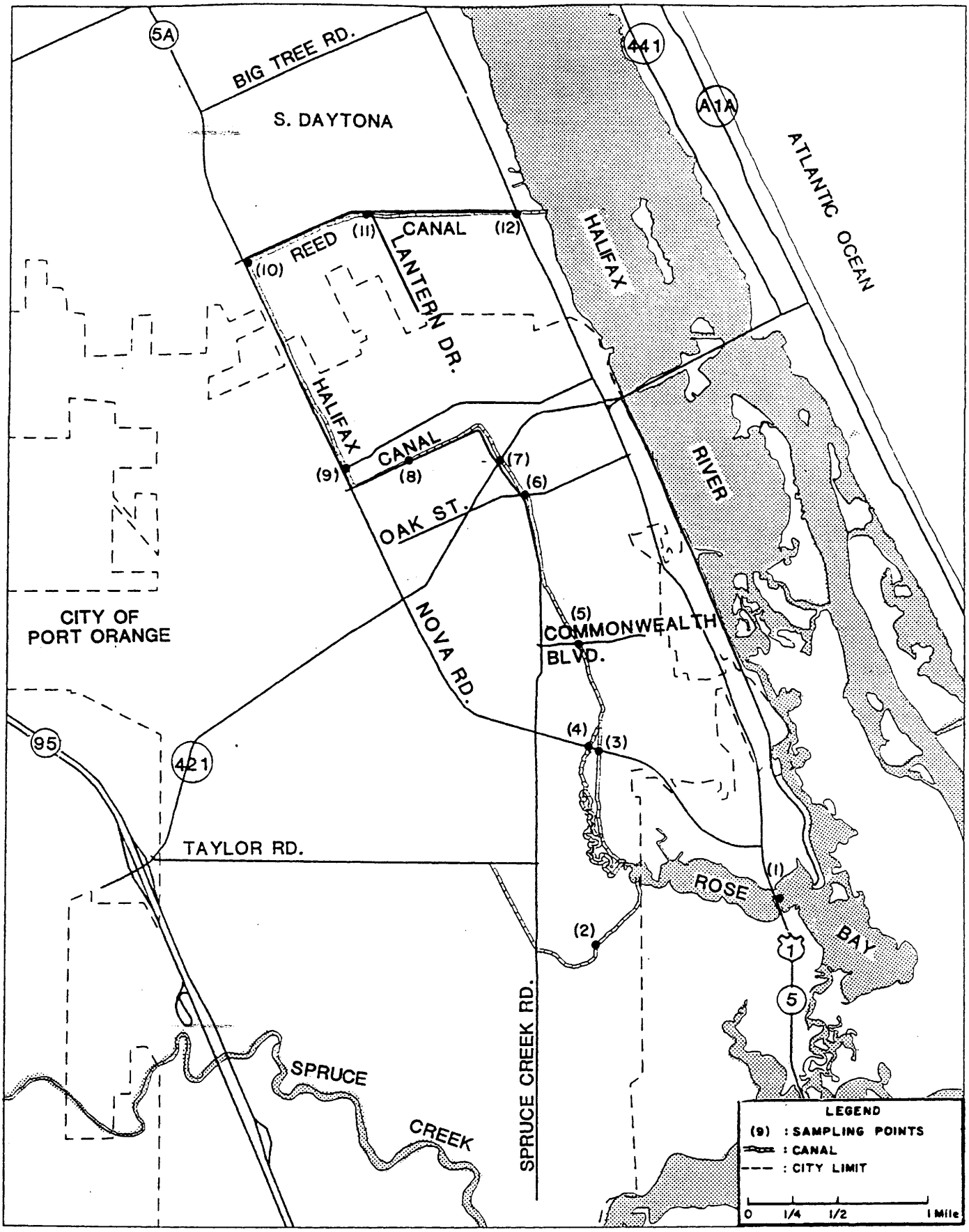

Figure 4 Surface water sampling locations.

Table 1. Salinity levels in the Halifax Canal, City of Port Orange, Florida

Station No.	Date	Time	Tide	Distance from Rose Bay at US 1 (miles)	Electrical Conductivity (micro mhos)	Chlorides (mg/l)	TDS (mg/l)
01	05/12/87	08:35	Rising	0.0			21,000
03	05/12/87	09:10	Rising	1.6			11,500
04	05/12/87	09:20	Rising	1.9			7,000
05	05/12/87	09:30	Rising	2.3	2,300		1,500
06	05/12/87	09:40	High	3.2	700		500
07	05/12/87	09:50	High	3.4	650		500
01	05/12/87	10:15	High	0.0		12,400	20,000
03	05/12/87	10:45	Ebbing	1.6		9,000	
04	05/12/87	11:00	Ebbing	1.9		2,920	7,000
05	05/12/87	11:10	Ebbing	2.3	2,500	580	1,500
06	05/12/87	11:30	Ebbing	3.2	700	43	500
07	05/12/87	11:40	Ebbing	3.4	700	43	500
09	05/12/87	11:50	Ebbing	4.4	600		500
10	05/12/87	12:00	Ebbing	5.7	650		500
11	05/12/87	12:15	Ebbing	6.4	700		500
12	05/12/87	12:25	Ebbing	7.4	6,500		4,000
01	05/12/87	13:03	Ebbing	0.0	30,000	10,290	18,000
03	05/12/87	13:38	Ebbing	1.6	15,000	3,340	8,000
04	05/12/87	13:48	Ebbing	1.9	11,000	3,040	6,000
05	05/12/87	14:00	Ebbing	2.3	850	93	500
06	05/12/87	14:10	Ebbing	3.2	700	46	500

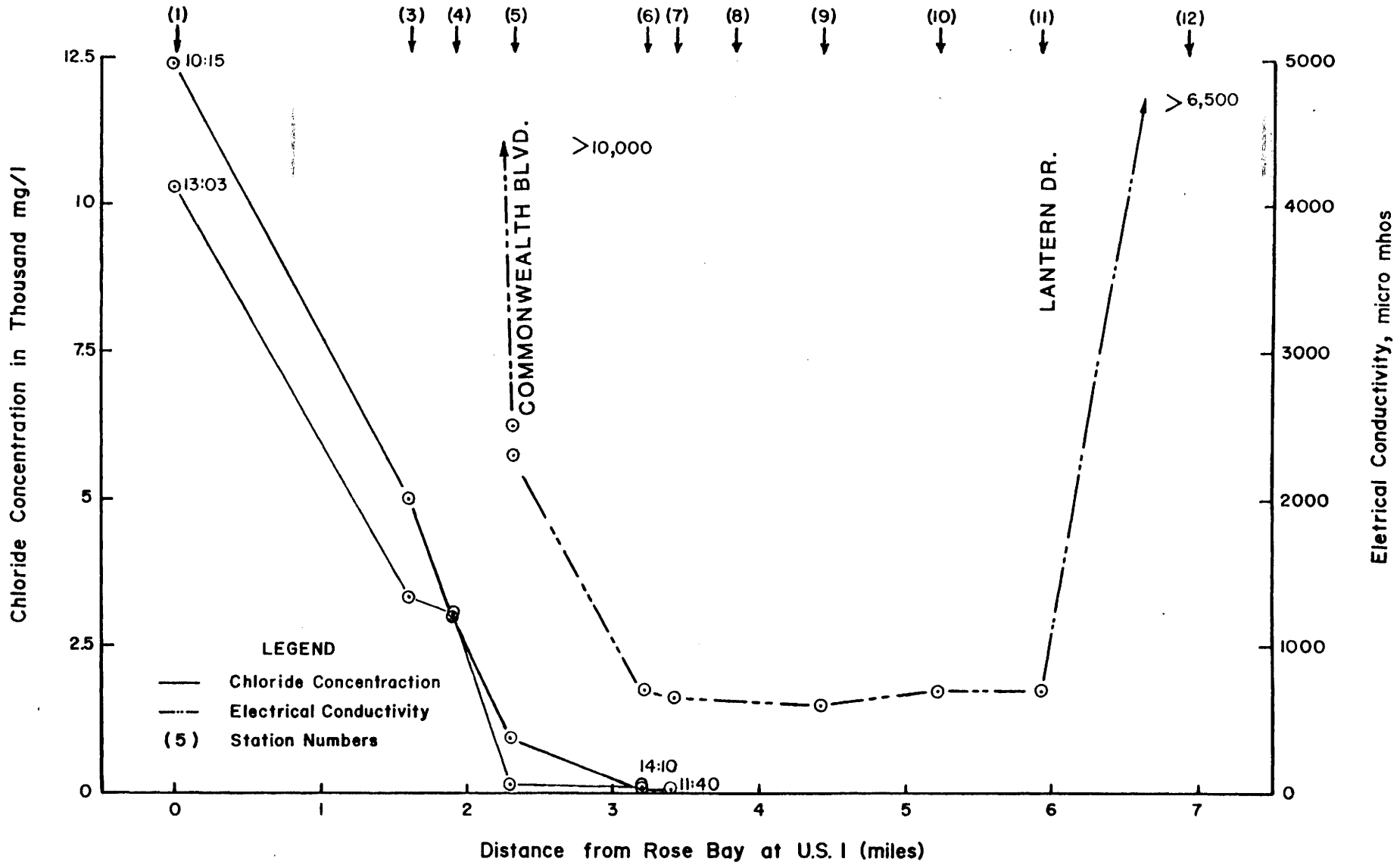

Figure 5 Chloride concentration and electrical conductivity in the Halifax Canal

Surficial Aquifer Samples in the Study Area--Chloride concentrations were determined for water quality samples collected from the surficial aquifer system (Table 2). These samples were collected from existing domestic wells located within about 3/4 mile from the Halifax Canal between Rose Bay and Oak Street (Figure 6). Wells 1 through 17 are located in the section of the Halifax Canal which is affected by the tide. Reed Canal is excluded from the study because it is located outside the city limits of Port Orange. Except for well No. 10, all wells show water quality within the drinking water standards. Well No. 10 with a depth of 56 ft, may have penetrated more saline waters existing in the aquifer. Data from this well, therefore, were excluded from further analysis. Spatial distribution of chloride values in the surficial aquifer shows no relationship between proximity of the wells to the canal and chloride concentration in the wells (Figure 7). The chloride levels in these wells are low compared to the chloride levels in tidal waters in the canal (about 3000 mg/l). Therefore, it does not appear that brackish water from the Halifax Canal has moved into the productive surficial aquifer system or adversely affected that aquifer.

The present use of shallow wells in the area is limited to lawn and garden irrigation. The sampling date, May 27, 1987, coincides with the end of a dry period when the water table was depressed due to active pumpage for lawn irrigation during the preceding dry months. For March, April, and May 1987, Daytona Beach Airport recorded rainfall amounts of 0.25 in, 0.01 in,

Table 2 - Chloride Concentration in the Surficial Aquifer System at Selected Locations, Port Orange (May 27, 1987)

Well No.	Lat.	Long.	Well Depth (feet)	Chlorides (mg/l)
01	29°07'22"	80°59'19"	14	35
02	29°07'23"	80°59'32"	??	64
03	29°07'25"	80°59'33"	10	64
04	29°07'22"	80°59'21"	26	27
05	29°07'20"	80°59'27"	18	21
06	29°07'14"	80°59'19"	22	63
07	29°07'05"	80°59'25"	18	25
08	29°07'15"	80°59'06"	18	26
09	29°07'03"	80°59'29"	??	21
10	29°07'12"	80°59'13"	56	484
11	29°07'09"	80°59'13"	18	14
12	29°07'03"	80°59'04"	??	137
13	29°06'59"	80°58'59"	43	75
14	29°07'00"	80°58'59"	18	25
15	29°07'23"	80°58'56"	20	36
16	29°07'26"	80°59'03"	??	30
17	29°07'17"	80°59'05"	18	46
18	29°07'51"	80°59'13"	20	20
19	29°07'45"	80°59'15"	??	19
20	29°07'37"	80°59'16"	20	24
21	29°07'46"	80°59'35"	20	75
22	29°08'21"	80°59'41"	19	95
23	29°07'33"	80°59'36"	??	43
24	29°06'08"	80°59'43"	47	35
25	29°06'09"	80°59'39"	22	72
26	29°06'05"	80°59'34"	40	49
27	29°07'49"	80°59'56"	??	34
28	29°05'13"	80°59'47"	50	35
29	29°05'48"	80°59'24"	??	38
30	29°05'58"	80°59'41"	??	112
31	29°06'00"	81°00'02"	??	20
32	29°06'17"	80°59'25"	??	20
33	29°06'15"	80°59'30"	19	15
34	29°06'08"	80°59'27"	14	108
35	29°07'59"	81°00'16"	30	65

?? - Depth unknown

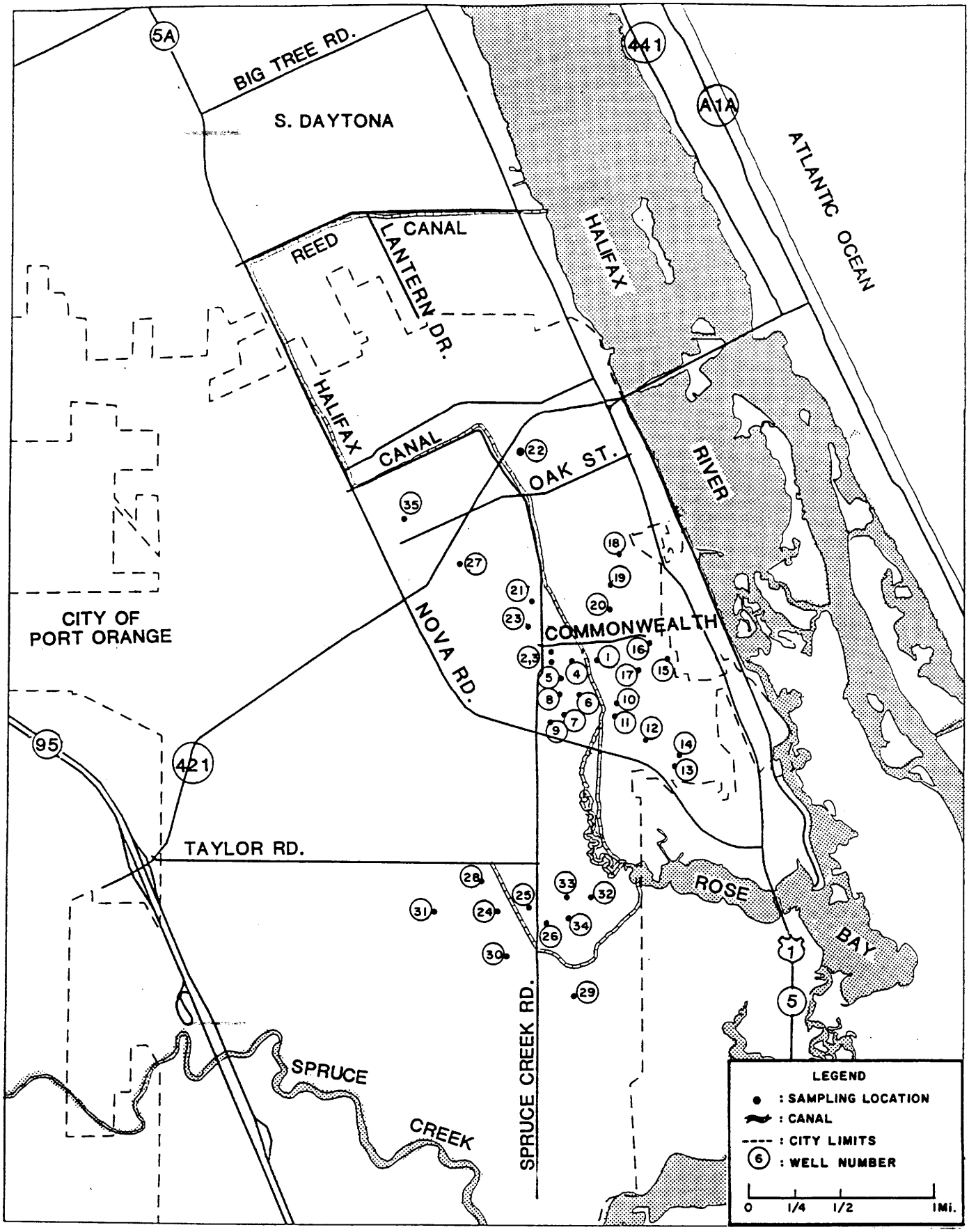

Figure 6 Location of surficial aquifer sampling wells

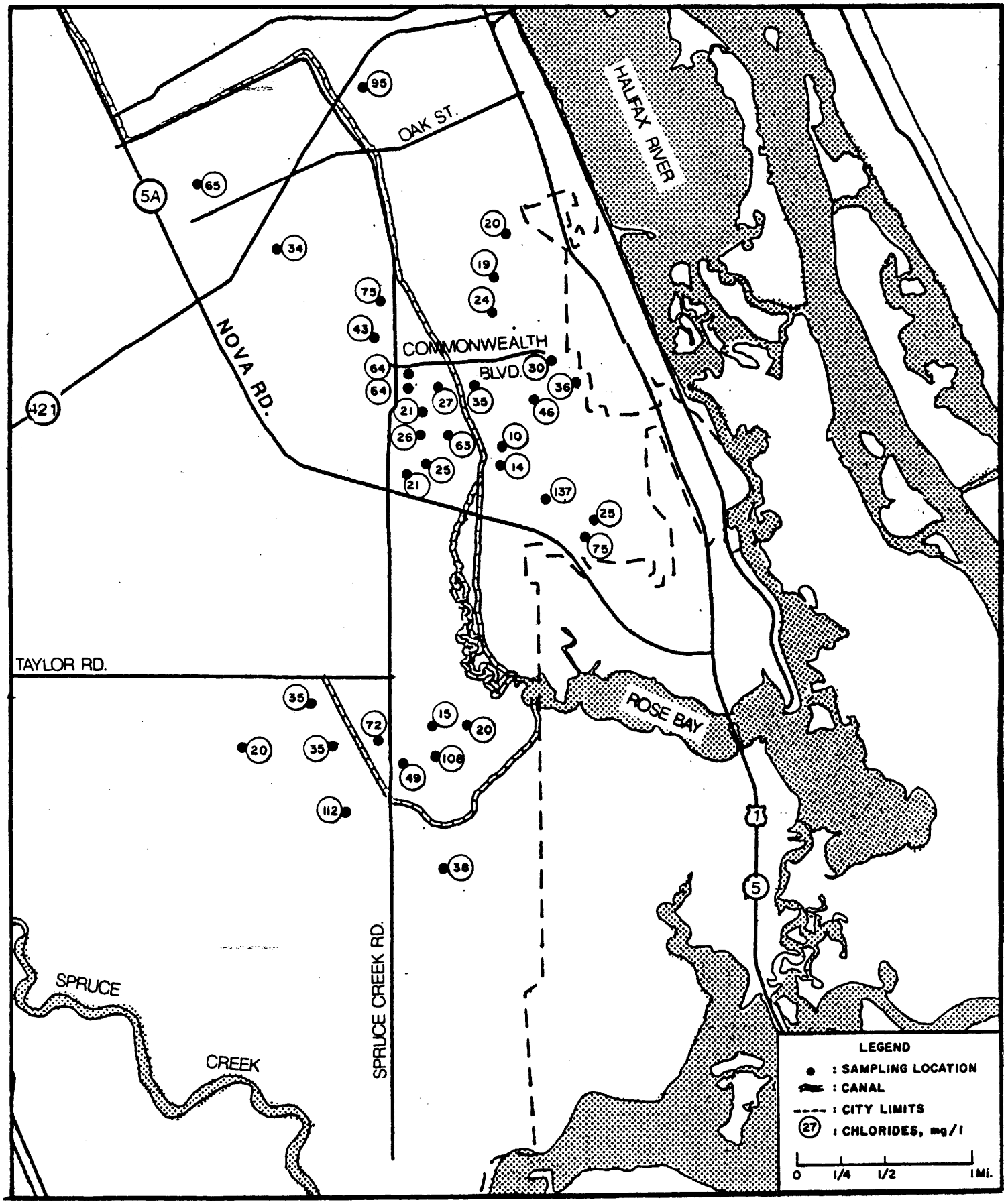

Figure 7 Chloride concentration in the surficial aquifer system near the tidally affected Halifax Canal (May 27, 1987)

and 0.09 in, respectively, while the normal rainfall for the same period is 8.62 in. This was an exceptionally dry period. The conditions in the surficial aquifer system in this area did not show signs of saltwater contamination, even at the end of this severe dry period.

Surficial Aquifer Samples within 500 ft of the Halifax Canal--The surficial aquifer sampling wells discussed in the preceding sections (which did not show any chloride contamination) were located at about 1/8 mile to 3/8 mile from the Halifax Canal. To determine whether the surficial aquifer system very close to the canal is affected by the tidal brackish waters, test wells were installed at 50 ft, 300 ft, and 500 ft on either side of the canal near Commonwealth Boulevard (Figure 8). These 2-in diameter wells extend to a depth of 8.5 ft below land surface. Water quality samples were collected on June 9, 1988, during a relatively dry period, and on July 12, 1988, during a wet period. Samples were analyzed for chloride concentration and water elevations in the wells and canals were noted (see Tables 3 and 4).

June 9, 1988, observations: Samples were collected during a rising tide between 2:30 p.m. and 7:00 p.m., at which time the tide reached its peak. Elevations in the canal varied from 1.30 ft NGVD to 2.28 ft NGVD. Except at the time of peak tide the water table (surficial aquifer) elevation was higher than the

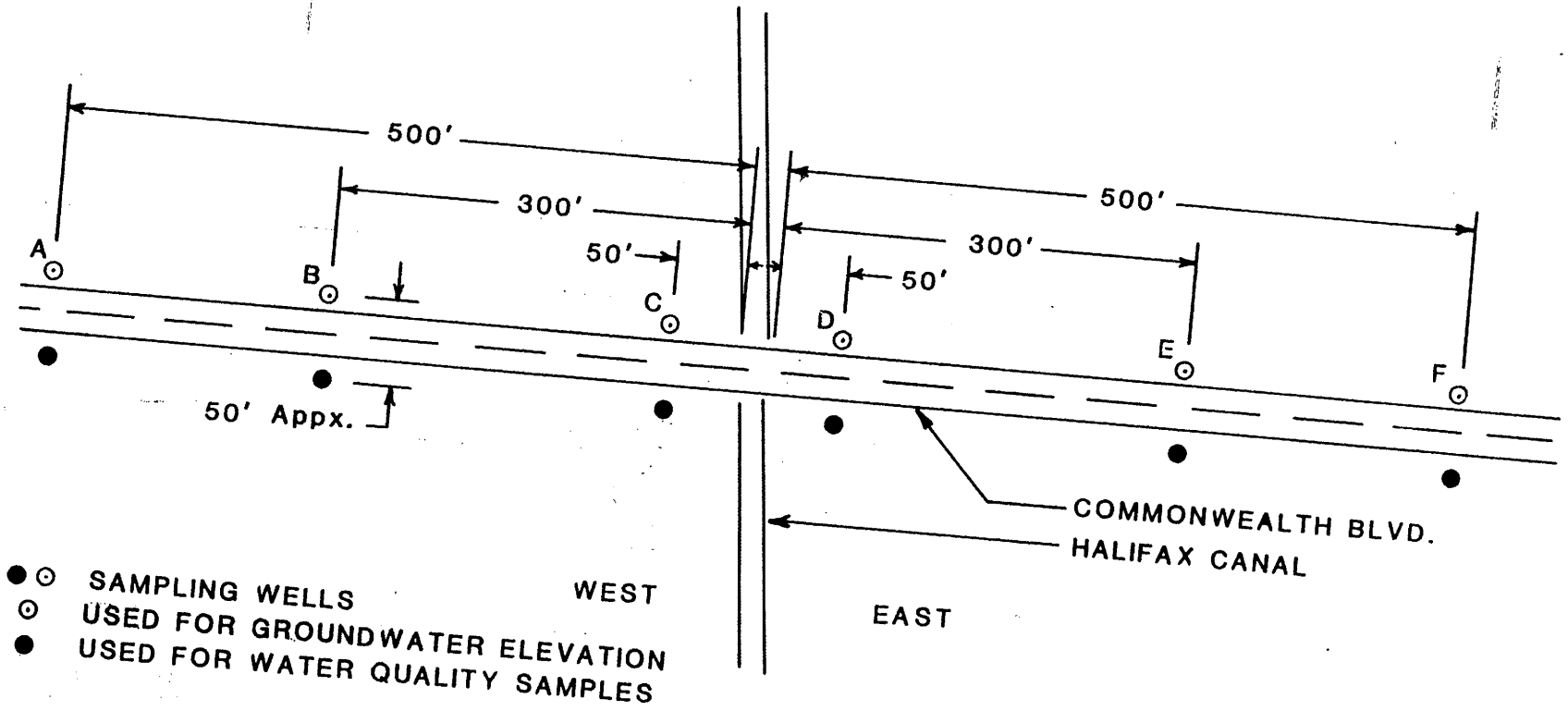

Figure 8 Location of surficial aquifer sampling wells near Commonwealth Boulevard (schematic)

Table 3. Chloride concentration in the surficial aquifer system near Commonwealth Boulevard (June 9, 1988)

Time of Sampling (Rising tide)	Location						
	Well A 500 ft West	Well B 300 ft West	Well C 50 ft West	Canal	Well D 50 ft East	Well E 300 ft East	Well F 500 ft East
2:30 p.m.							
CL @	19.00	100.00	311.00	392.00	295.00	345.00	39.00
ELEV (b)	2.71	2.49	2.00	1.38	1.72	2.10	3.06
4:00 p.m.							
CL @	19.00	-	293.00	342.00	244.00	139.00	39.00
ELEV (b)	2.67	2.46	1.94	1.30	1.66	2.06	3.06
5:30 p.m.							
CL @	19.00	35.00	300.00	333.00	241.00	46.00	36.00
ELEV (b)	2.72	2.42	1.94	1.56	1.70	2.06	3.04
7:00 p.m.							
CL @	18.00	23.00	304.000	2418.00	210.00	136.00	33.00
ELEV (b)	2.59	2.54	2.16	2.28	1.93	2.03	2.96

@ - Chloride (mg/l)
(b) - Elevation (ft NGVD)

Table 4. Chloride concentration in the surficial aquifer system near Commonwealth Boulevard (July 29, 1988)

Time of Sampling (ebbing tide)	Location						
	Well A 500 ft West	Well B 300 ft West	Well C 50 ft West	Canal	Well D 50 ft East	Well E 300 ft East	Well F 500 ft East
11:00 a.m.							
CL @	65.00	-	750.00	3200.00	3040.00	236.00	35.00
ELEV (b)	3.05	2.69	2.57	2.28	2.42	2.98	4.06
12:30 p.m.							
CL @	36.00	-	36.00	1120.00	4190.00	942.00	34.00
ELEV (b)	3.08	2.70	2.48	2.21	2.44	2.95	4.02
2:00 p.m.							
CL @	44.00	-	36.00	414.00	3860.00	834.00	30.00
ELEV (b)	3.07	2.69	2.48	1.97	2.33	2.92	3.99
3:30 p.m.							
CL @	36.00	-	39.00	380.00	3780.00	3220.00	3610.00
ELEV (b)	3.05	2.70	2.41	1.74	2.19	2.92	4.01
5:00 p.m.							
CL @	52.00	-	777.00	391.00	3220.00	782.00	30.00
ELEV (b)	3.07	2.65	2.38	1.58	2.18	2.93	4.02
6:30 p.m.							
CL @	46.00	-	558.00	376.00	3610.00	-	32.00
ELEV (b)	3.07	2.65	2.38	1.45	2.15	2.87	3.98

@ - Chloride concentration in mg/l
(b) - Elevation in ft NGVD

water surface elevation of the canal at all observation locations. At a distance of 500 ft on either side of the canal, the water table elevation was higher than the water surface elevation of the canal even during the peak tide. At this distance, chloride concentrations in the surficial aquifer system were found to be in the range of 18 mg/l to 39 mg/l. The concentration increased to about 300 mg/l at a distance of 50 ft from the canal.

July 29, 1988, observations: Samples were collected during an ebbing tide between 11:00 a.m. (at which time the tide was at its peak) and 6:30 p.m. The water surface elevation in the canal dropped from 2.28 ft NGVD to 1.45 ft NGVD during this period. The water table and chloride concentration exhibited the same trends observed in June 1988. The chloride concentrations in the surficial aquifer system at 500 ft from the canal ranged from 30 mg/l to 65 mg/l, well below the recommended drinking water standard of 250 mg/l. Closer to the canal (50 ft to 300 ft), however, the chloride concentration in the aquifer was found to be much higher than in June 88.

From the foregoing observations, it may be concluded that the surficial aquifer system is contaminated by tidal waters at the Halifax Canal. To determine the zone of influence or contamination, installation of many test wells with depths varying from 10 ft to 100 ft will be necessary. However, at a distance of 500 ft from the canal, the chloride concentration in shallow

wells (about 20 ft depth) does not vary with tides and may be expected to be within recommended drinking water limits. Based on the chloride variation diagram (Figure 9) developed by Cooper (1959) for the Cutler area near Miami, and on the conditions near the Halifax Canal (which, unlike the Miami area, is not subject to the greater tidal fluctuation of the ocean) it may be stated that the potential for saltwater contamination should not create significant problems for the existing shallow wells in the study area.

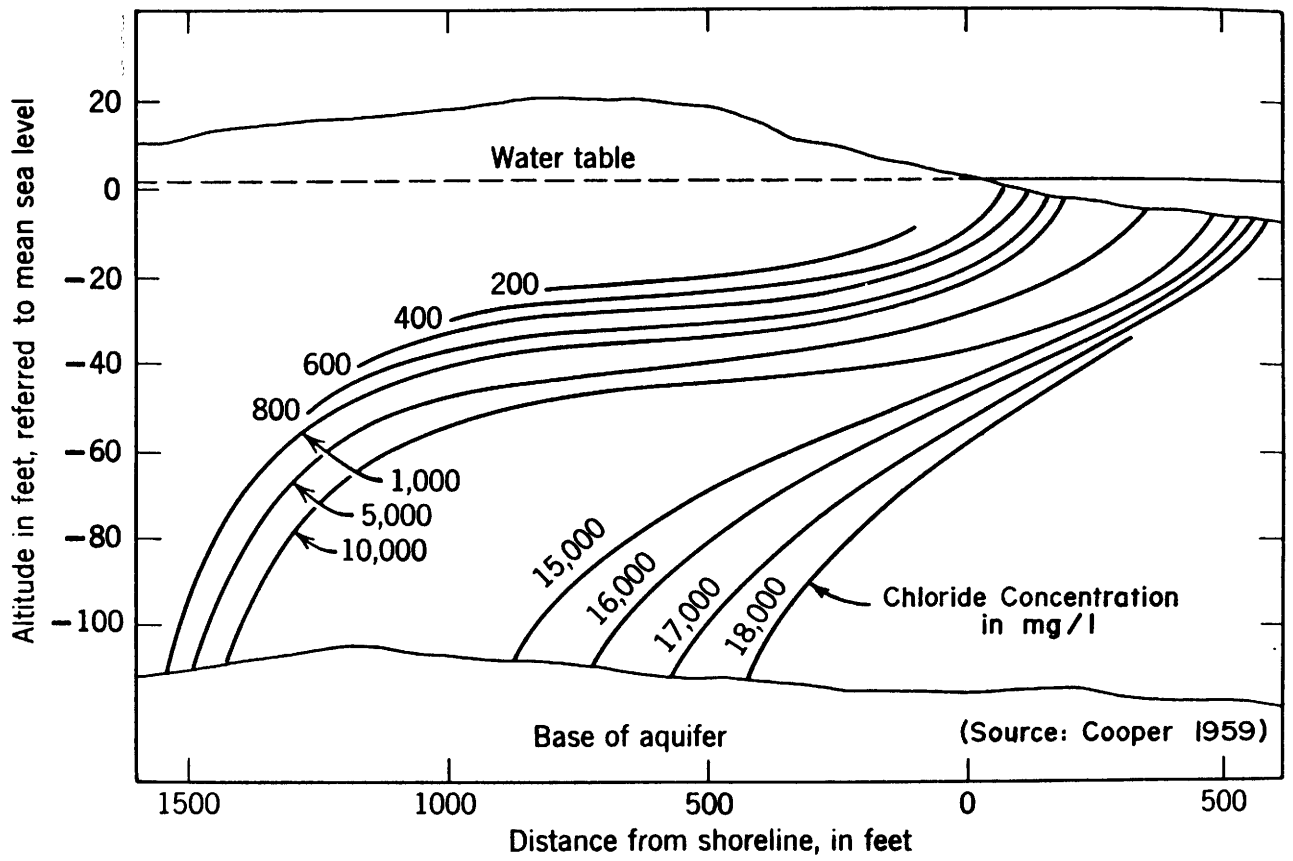

Figure 9 Section through Cutler area near Miami, Florida, showing the variation of chloride content in the surficial aquifer system

NEED FOR A SALINITY CONTROL DAM ON THE HALIFAX CANAL

Results of this study indicate that tidal waters significantly affect salinity levels in the Halifax Canal up to a short distance north of Commonwealth Boulevard (Figure 4), or a distance of about 2.5 miles from the mouth. The effect of brackish waters completely diminishes about one mile upstream from Commonwealth Boulevard, at Oak Street. The surficial aquifer system in the immediate vicinity of the Halifax Canal (up to about 300 ft east and west of the canal) has been found to be contaminated by saltwater intrusion from the tidal waters in the canal and influenced by tidal fluctuations. Shallow wells at a distance of about 500 ft or more from the canal, however, can be expected to be free from the effect of tidal fluctuations. Surficial aquifer water samples collected from numerous domestic wells from this area showed chloride concentration in the range of 14 mg/l to 137 mg/l, well below the recommended public drinking water standard of 250 mg/l. These low chloride concentrations in shallow aquifer wells is an indication that the brackish waters brought into the Halifax Canal by tides have not moved significantly into the productive zone of the surficial aquifer system in the area. For these reasons, there appears to be no need to construct salinity control dams on the Halifax Canal at this time.

A long-term water quality sampling program should be established to monitor the chloride levels in the surficial aquife system in the study area and to determine the change of chloride concentration at different depths and distances from the canal. Sampling once or twice a year would be sufficient to obtain the required information to detect increases in saltwater intrusion.

OBSERVATIONS AND CONCLUSIONS

The following observations were made during this study:

1. Tidal brackish waters extend to a distance of about 2.5 miles from the mouth (up to a short distance north of Commonwealth Boulevard) in the Halifax Canal. The effect of brackish water completely dissipates at about one mile upstream from Commonwealth Boulevard.
2. Tidal waters in the Halifax Canal affect the productive zone of surficial aquifer systems only in the immediate vicinity of the canal, i.e., for less than about 500 ft from the canal.
3. Chloride concentrations in surficial aquifer system wells located at about 1/8 mile to 2/3 mile from the tidally affected Halifax Canal were observed to range from 14 mg/l to 137 mg/l, well below the recommended public drinking water standard of 250 mg/l, at the end of a typical dry period.

The following conclusions are drawn based on these observations:

1. Brackish water in the Halifax Canal has not moved significantly into the surficial aquifer system in the area;
2. Installation of a limited number of additional wells in the area at the same density as existing development is

not likely to cause water quality problems in the surficial aquifer system; and

3. Construction of salinity control dams on the Halifax Canal is not warranted at this time.

RECOMMENDATIONS

Based on this study, it is recommended that no salinity control dams be constructed on the Halifax Canal at this time. A water quality sampling program to monitor chloride levels in the surficial aquifer system in the study area should be established. The purpose of this proposed program is to develop a chloride variation diagram (for a depth of about 80 ft) for the surficial aquifer similar to that shown in Figure 9 and determine if seasonal variations occur in the relationship thus established. If chloride concentrations show major variations with seasons or are found to be higher than those observed during this study, additional analysis should be performed to determine corrective measures (i.e., construction of salinity control dams), if any.

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