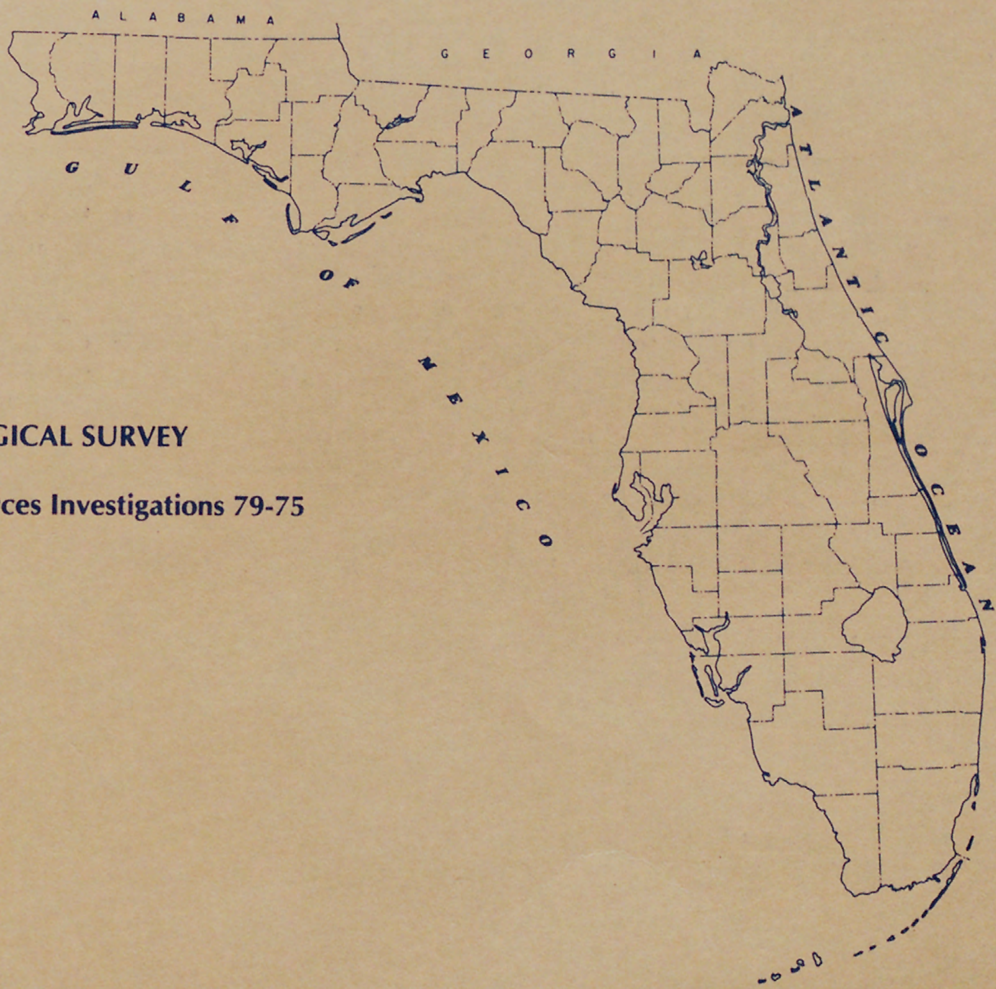
SALTWATER-BARRIER LINE IN FLORIDA: CONCEPTS, CONSIDERATIONS, AND SITE EXAMPLES



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 79-75

Prepared in cooperation with
FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

WRI 79-75 SALTWATER-BARRIER LINE IN FLORIDA: CONCEPTS, CONSIDERATIONS, AND SITE EXAMPLES WRI 79-75

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UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

ILLUSTRATIONS

TABLE

For readers who may prefer to use SI units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Inch-pound unit	By	To obtain SI unit
foot (ft)	3.048×10^{-1}	meter (m)
$foot^2$ (ft^2)	9.29×10^{-2}	$meter^2$ (m^2)
cubic foot (ft^3)	2.832×10^{-2}	cubic meter (m^3)
mile (mi)	1.609	kilometer (km)

SALTWATER-BARRIER LINE IN FLORIDA: CONCEPTS, CONSIDERATIONS, AND SITE EXAMPLES

By Jerry L. Hughes

ABSTRACT

Construction of canals or enlargement of streams and rivers in Florida has been mostly to alleviate impact of floods and to drain wetlands for development with direct access to the ocean. The result of land drainage and heavy pumpage from coastal water-table aquifers has been to degrade potable ground and surface water with saltwater. Control of saltwater intrusion is possible through awareness and implementation of certain hydrologic principles.

State of Florida statute 373.033 provides for establishing a saltwater-barrier line in areas exhibiting saltwater intrusion along canals. A saltwater-barrier line is defined as the allowable landward limit that a canal shall be constructed or enlarged or a stream deepened or enlarged without a salinity-control structure seaward of the saltwater-barrier line. The salinity control structure controls saltwater intrusion along a surface-water channel and also assists in controlling saltwater intrusion into shallow water-table aquifers. This report briefly reviews the fundamentals of saltwater intrusion in surface-water channels and associated coastal aquifers, describes the effect of established saltwater-barrier lines in Florida, and gives a history of the use and benefits of salinity-control structures.

INTRODUCTION

Most of the residential and industrial development in Florida has concentrated along its many miles of coastline. In some areas, particularly southeast Florida, natural drainage was poor and much land was inundated several months each year during the rainy season. Development was accomplished by constructing canals to drain the seasonal flood water to the sea. In addition, the canals provided fill for the lowland areas and created valuable waterfront property with direct access to the ocean by boats.

As the demand for land rose with large influx of people, the number of canals increased and many of the existing canals were enlarged. This pattern of development often resulted in overdrainage which permitted salty water from the ocean to migrate inland during dry periods and affect freshwater supplies. The landward movement of the salty water occurred in two basic forms: (1) Lateral migration of saltwater at depth into ground-water bodies containing freshwater where the water table was lowered near or below sea level, and (2) inland movement of saltwater in canals during periods when freshwater runoff was insufficient to restrict saltwater encroachment. This latter process made saltwater available for leakage directly from the canals into the ground-water system in inland areas. Both processes are amplified by further lowering of freshwater levels in the ground by heavy pumpage from well fields.

Investigations by the U.S. Geological Survey in cooperation with local and State Water Management Districts recognized that saltwater intrusion in the ground-water system and in the canals could be restricted by maintaining freshwater levels in canals higher than mean sea level. Thus, in areas along the southeast coast of Florida where saltwater intrusion along canals was significant, local water management agencies installed salinity-control dams in the canals. The location of the dams and the regulated upstream freshwater levels greatly reduced the extent of saltwater encroachment in the canals and in the underlying water-table aquifers. During drier periods of the year, the canals are used to convey large quantities of freshwater from inland areas to the coast where the salinity-barrier structures restrain the upstream movement of saltwater and permit freshwater to replenish the heavily stressed coastal aquifers.

Most of the salinity dams and efforts to control saltwater intrusion were implemented by local water-management agencies. With the adoption of a Florida State Water Resources Plan (1972), the Florida Department of Environmental Regulation assumed statewide responsibility for protecting freshwater supplies. Included in the plan is statute 373.033 which defines their responsibility to establish a saltwater-barrier line in areas where saltwater intrusion has become a "matter of emergency proportions." The statute says, "The department may at the request of* * *any municipality or water district responsible for the protection of a public water supply, or having determined by adoption of an appropriate resolution that saltwater intrusion has become a matter of emergency proportions, by its own initiative, establish generally along the seacoast, inland from the seashore and within the limits of the area within which the petitioning board has jurisdiction, a saltwater barrier line inland of which no canal shall be constructed or enlarged, and no natural stream shall be deepened or enlarged, which shall discharge into tidal waters without a dam, control structure or spillway at or seaward of the saltwater barrier line, which shall permit the movement of saltwater inland of the saltwater barrier line." It also states,"* * * the department is authorized in cases where saltwater intrusion is not a problem, to waive the requirement of a barrier structure* * *and* * *the authority of* * *a municipality or a water district having jurisdiction over an area in which a saltwater barrier line is established, to expend funds from whatever source may be available to them for the purpose of constructing saltwater barrier dams, dikes and spillways within existing canals and streams in conformity with the purpose and intent of the board in establishing the saltwater barrier line." A saltwater-barrier line may therefore be defined as the allowable landward limit of saltwater intrusion along a surface-water channel.

The purpose of this report is to relate the hydrologic concepts and fundamentals of saltwater intrusion in surface-water channels and associated ground-water systems to a saltwater-barrier line in Florida.

The scope of this report is to: (1) Discuss the hydrologic principles controlling saltwater intrusion along canals and streams and their significance in establishing a saltwater-barrier line, and (2) describe briefly the history of existing salinity-barrier structures and their effectiveness in controlling saltwater intrusion or maintaining a saltwater-barrier line in those areas where such a line has been established.

HYDROLOGIC FUNDAMENTALS OF SALTWATER INTRUSION IN SURFACE-WATER CHANNELS

Physical Aspects

Tidal canals and streams provide an easy path for saltwater intrusion because water from the ocean can move upstream during low flow periods. Control of freshwater discharge from canals to the ocean is a key element in retarding or stopping saltwater intrusion in areas of Florida where canals are prevalent, provided the inland consumptive use of surface water and ground water does not reduce freshwater discharge in the canals below that required for salinity control.

Saltwater enters a canal or stream and moves upstream underneath the outflowing freshwater when the discharge and elevation of the freshwater in a tidal canal decrease below certain levels. Saltwater intrudes in the form of a long tongue-shaped wedge along the bottom of canals with a fairly steep front and is separated from the freshwater by a narrow mixing zone called the interface. The interface extends upstream and becomes indistinct at some point landward in the canal or stream.

Under certain conditions, flow in a canal or stream can consist of two currents moving in opposite directions. "A most interesting effect has been observed near Miami in Snapper Creek canal, which is tidal in its lower reaches. This curious effect occurred when the canal water was rising as a result of tidal rise in Biscayne Bay. A surface layer of freshwater about 0.8 ft deep was flowing downstream at a velocity of about 2 ft/s, and underneath this layer, 2 ft of strongly salty water was flowing upstream at 1.5 ft/s. The two currents seemed to be quite uniform, as indicated by small pieces of suspended material. In the surface between the two layers of water (the interface) were a number of small yellow elliptical leaves, roughly 9 inches apart horizontally. These leaves define a plane and were motionless despite being only a fraction of an inch from waters moving swiftly in opposite directions." (Parker and others, 1955, p. 621).

Inland movement of saltwater in tidal canals and streams is basically a function of the relative densities of freshwater and saltwater, the rate of freshwater discharge, and tidal action. The density of ocean water is 1.025 to 1.027 g/cm^3 compared to 1.000 g/cm^3 for pure water at 4°C (table 1). Using the principle of static equilibrium for fluids of different density, the freshwater density head required to prevent saltwater intrusion in a canal or stream with or without a salinity dam can be calculated as follows (see fig. 1):

$$P_f = \rho_f l_f \qquad P_s = \rho_s l_s$$

$$\rho_f l_f = \rho_s l_s; \text{ let } l_f = h + l_s$$

$$\rho_f (h + l_s) = \rho_s l_s$$

$$h = l_s \frac{(\rho_s - \rho_f)}{\rho_f}$$

Where: P = pressure exerted
f, s = by the freshwater and saltwater
ρ_f, ρ_s = density of freshwater and saltwater
l_f, l_s = length of freshwater and saltwater columns
h = freshwater density head required to prevent saltwater intrusion.

For example, if the depth of a canal containing saltwater is 10 ft, then: $h = \frac{10(1.027 - 1.000)}{1.000} = 0.27$ ft

The velocity of freshwater flow must also be considered when calculating the landward extent of saltwater intrusion in a canal or stream discharging to tidal waters. The velocity is equivalent to a certain amount of the freshwater density head and may be expressed by the velocity head equation:

$$h = v^2/2g$$

Where: v = velocity of the freshwater
g = acceleration of gravity.

Solving this equation for velocity using the freshwater density head computed previously, a freshwater velocity of 4.2 ft/s is equivalent to a freshwater head of 0.27 ft. Figure 1 shows very simply this relationship for a canal or stream with and without a salinity-barrier dam.

Table 1.--Specific gravity of saltwater samples diluted with uncontaminated ground water from the Miami area.

[From Parker and others, 1955].

Sample No.	Gravimetric chloride (mg/L)	Specific gravity (at 25°/25°C)[1]	Computed specific gravity (at 25°/25°C)[2]
[3]1	19,740	1.02680	[4]1.02643
2	15,940	1.02161	1.02124
3	13,260	1.01803	1.01766
4	10,070	1.01374	1.01337
5	6,710	1.00922	1.00886
6	5,050	1.00700	1.00664
7	3,340	1.00472	1.00436
8	2,280	1.00333	1.00297
9	1,594	1.00239	1.00203
10	1,132	1.00179	1.00143
11	907	1.00148	1.00112
12	583	1.00107	1.00071
13	353	1.00078	1.00042
14	214	1.00057	1.00021
15	122	1.00050	1.00014
[5]16	--	1.00036	1.00000

[1] Determined in laboratory and referred to distilled water at 25°C as unity.
[2] Referred to uncontaminated ground water as unity.
[3] Ocean water.
[4] Computation for this value is as follows:

$$\text{Specific gravity} = \frac{1.02680}{1.00036} = 1.02643$$

[5] Ground water.

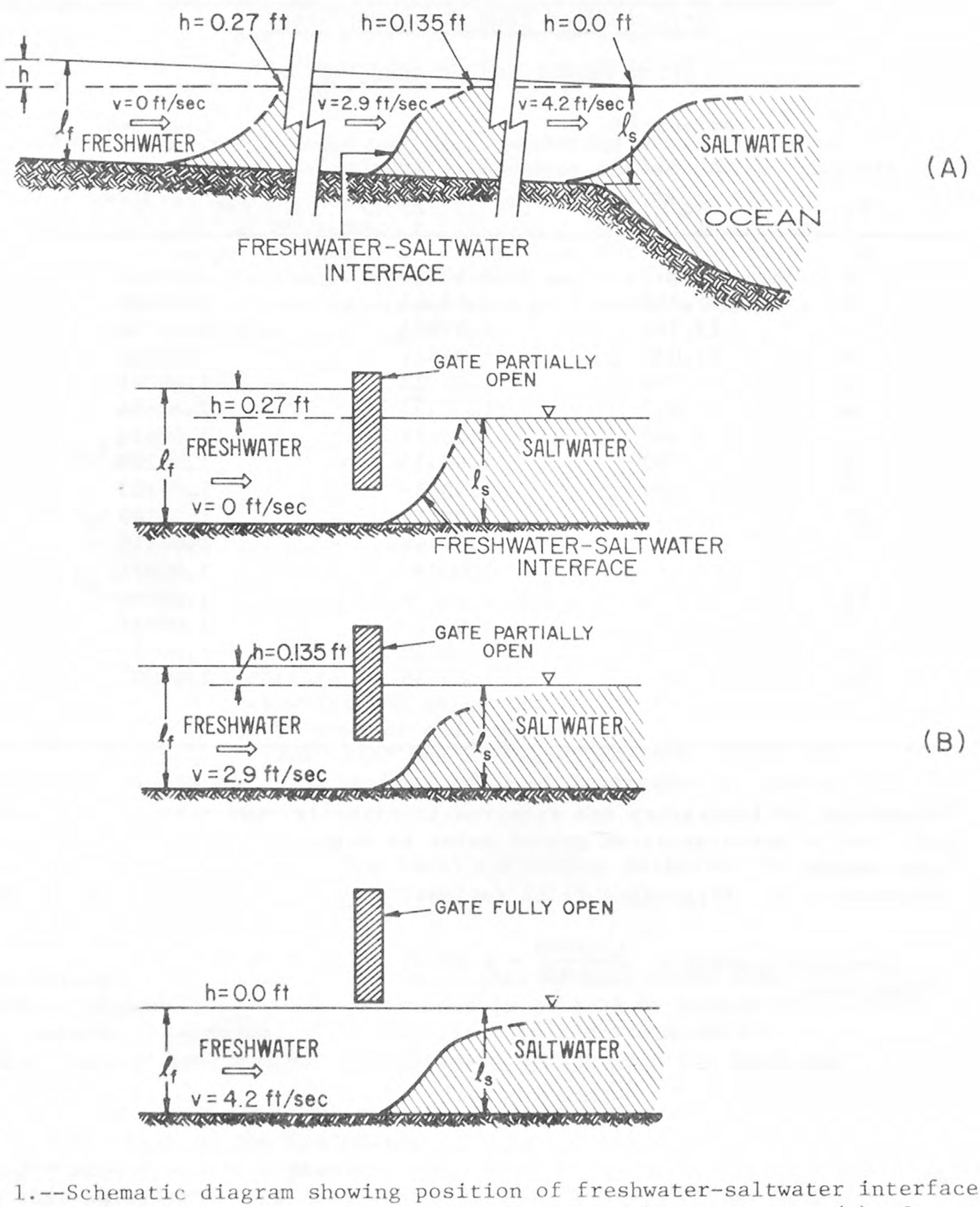


Figure 1.--Schematic diagram showing position of freshwater-saltwater interface of various relationships of density head (h) to velocity (v) of freshwater flow in a surface water channel without a salinity dam (A) and with a salinity dam with various gate openings (B).

Obviously the construction of a canal or enlargement of an existing stream open to tidal waters, increases the l_s which requires a greater h to restrict the landward movement of saltwater. Also, by the relationship, $q = va$, where q is discharge and a is the area of a stream, an increase in the area of a stream for a constant discharge, reduces the velocity.

The shape of the freshwater-saltwater interface shown in figure 1A and 1B assumes a uniform vertical distribution of velocity. Realistically, the velocity distribution, as shown in figure 2, is retarded along the bottom and sides of the canal because of the effects of drag (partially related to the roughness of the channel) and is less at the water surface because of drag associated with surface wind resistance. The velocity is greatest in the center of the stream cross section. The result of the differential velocity profile coupled with the saltwater-freshwater head difference is the distribution of salty water shown in figure 3 in the Miami Canal in 1945. In 1945 the control in this canal consisted of a steel-pile dam which leaked severely (Parker, 1955, p. 624).

The actual situation is not nearly so simple as this discussion of saltwater intrusion has thus far implied because the stage of a bay or of the ocean is constantly changing in response to tides. Tides influence the landward movement of saltwater in a canal by temporarily altering the velocity and density head distribution. The result can be intermittent inland movement of saltwater in a channel without a dam when the combined effect of velocity and density head is below the critical levels for a given channel. The relation between discharge and chloride content in an uncontrolled tidal reach of the North New River Canal at Fort Lauderdale (see fig. 13 for location) is shown in figure 4. During a two year period, the salt front was held downstream from the sampling point when discharge was more than 50 ft^2/s. The implacement of a control structure in a tidal canal provides a means of controlling saltwater intrusion by regulating the freshwater head and flow during rising and falling tide cycles.

Operational Aspects

Kohout and Leach (1964, p. 16-28) in their study of saltwater intrusion in Snake Creek Canal in Miami illustrated many of the concepts discussed thus far (figs. 5-10). The movement of saltwater with the opening of the dam gate during rising tide and remaining open during the falling tide is shown in figures 5 and 6. Comparison of sections 1, 2, and 3 (fig. 5) indicates the landward advance of saltwater was relatively slow during the early part of the rising tide. Significant landward advance of saltwater did not occur until all flow to the ocean had ceased and the component of flow in the canal was negative (upstream) as shown in section 3 (fig. 5). Maximum inland velocity occurred at 7:37 a.m., about 1-1/2 hours before high tide. The high salinity water at the inland toe of the wedge continued to move landward until long after high

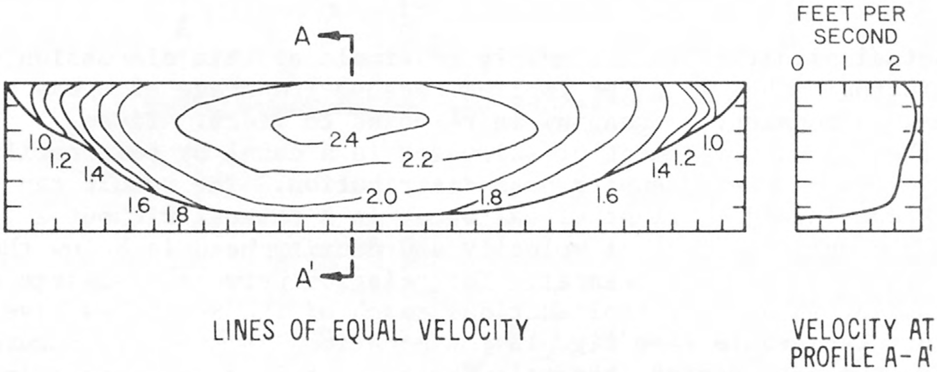


Figure 2.--Typical distribution of velocity in a stream crossection (from Albertson and others, 1960).

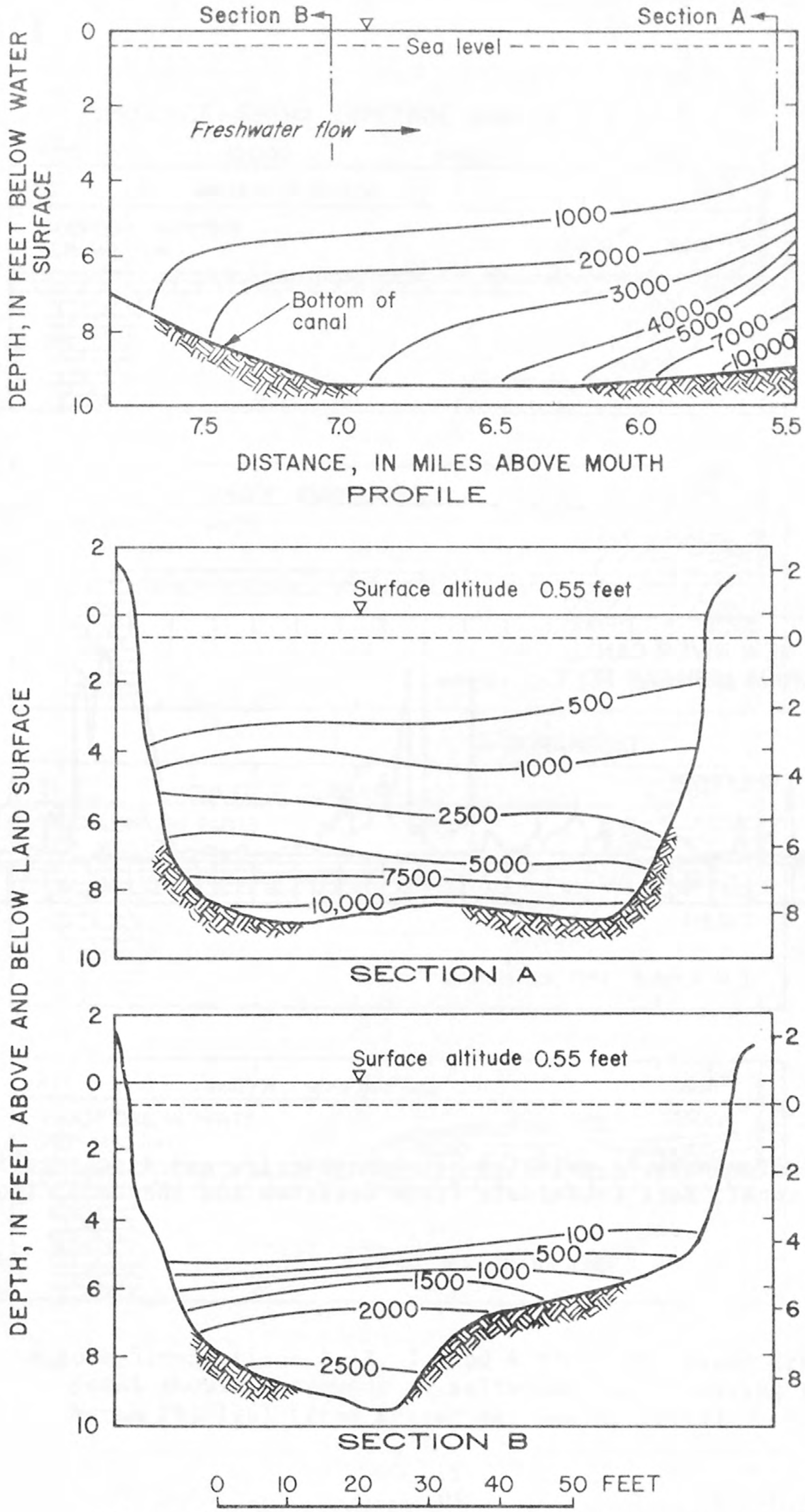


Figure 3.--Diagrammatic sections of Miami Canal showing concentration of chloride in milligrams per liter in 1945 (from Parker and others, 1955).

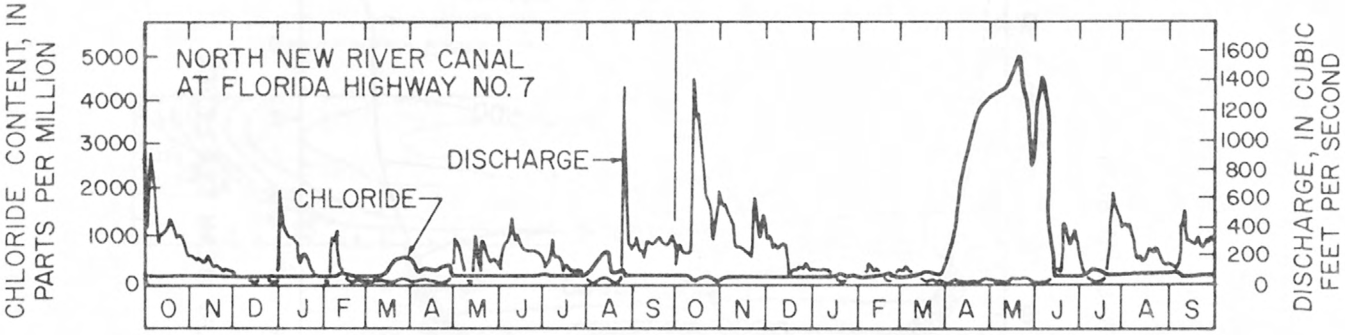


Figure 4.--Diagram showing relation between chloride and discharge in North New River canal, Fort Lauderdale (from Grantham and Sherwood, 1968).

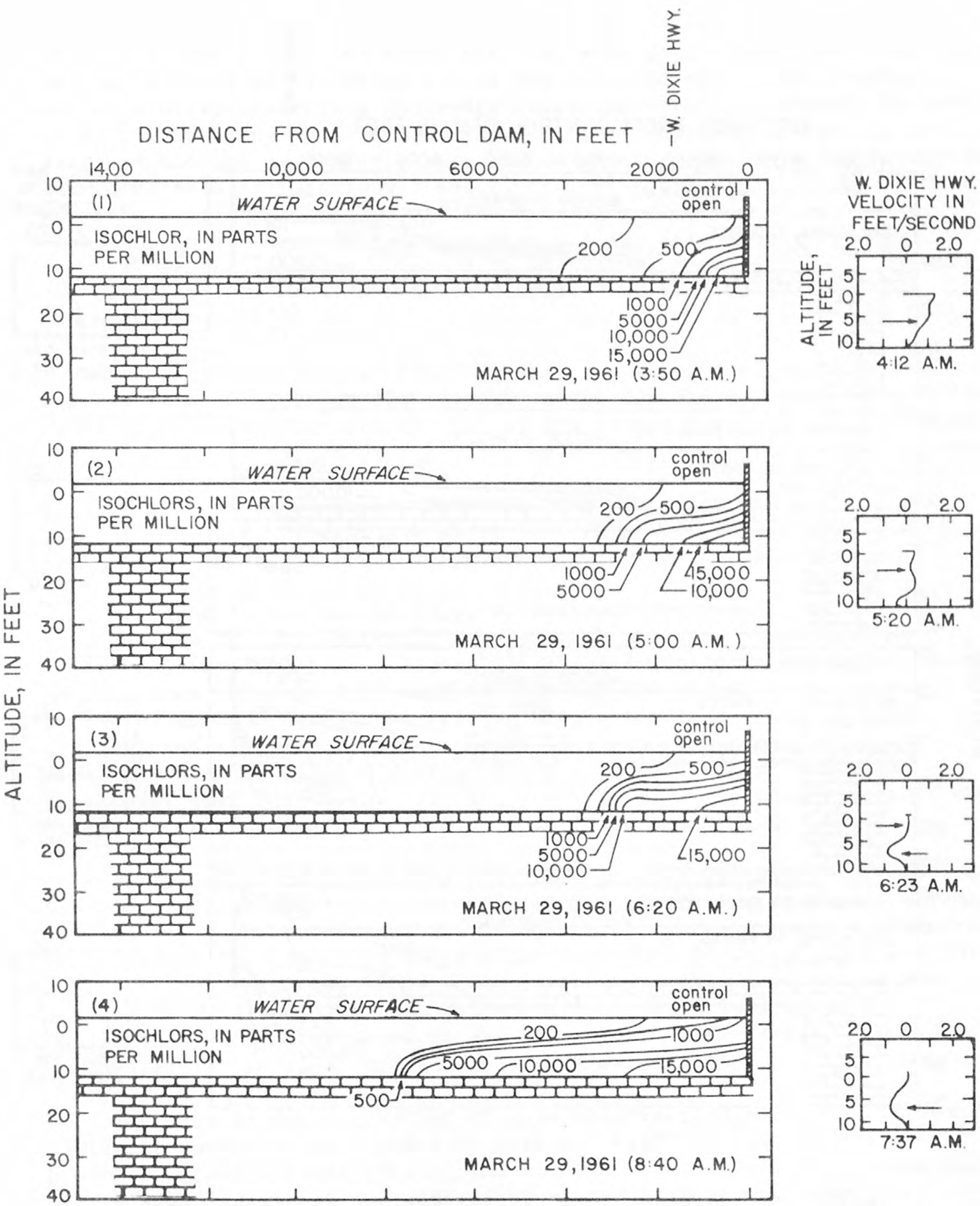


Figure 5.--Sections 1, 2, 3, and 4 along the Snake Creek Canal showing movement of saltwater during rising tide, March 29, 1961 (from Kohout and Leach, 1964.)

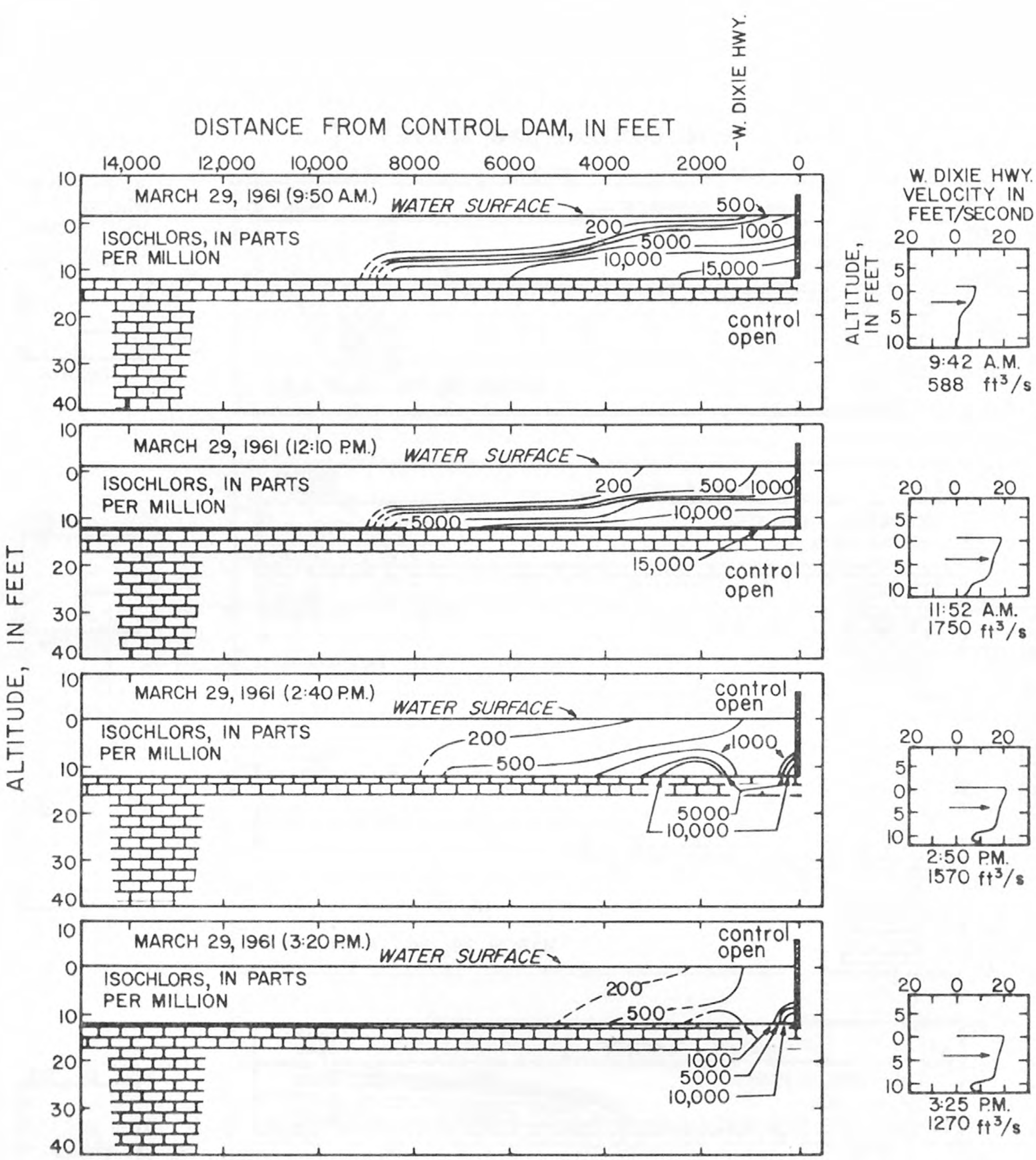


Figure 6.--Sections 5, 6, 7, and 8 along the Snake Creek Canal showing movement of saltwater during the falling tide, March 29, 1961 (from Kohout and Leach, 1964.)

tide. Section 5 (fig. 6) shows that for some time after high tide, the freshwater head at inland points is too small to oppose the landward movement of saltwater and the wedge moved landward as a density current. As the tide begins to fall more rapidly, the density differential is overcome and the saltwater at the bottom of the canal reverses direction and flows seaward (sections 5 and 6, fig. 6). The distribution of salty water in sections 6, 7, and 8 (fig. 6) is a reflection of the velocity distribution in the freshwater as tide falls. Note that even after reversal of the landward movement of saltwater, seaward velocities near the bottom of the canal are small compared to those in the overlying freshwater.

Sections 9 through 11 (fig. 7) show the results of closing the dam too late in a rising tide cycle. After the dam gate was closed, the density difference between the two waters caused the freshwater to move seaward over the saltwater while the saltwater continued to move landward. Salinity measurements indicated that despite the serene water surface, rapid saltwater encroachment was occurring at the bottom of the canal. The rate of landward movement was about 15 ft/min with the saltwater moving nearly 1 mi inland in about 4-1/4 hours after the gates were closed.

Sections 12 through 15 (fig. 8) indicate the results of an effort to flush the trapped saltwater seaward past the dam. The flushing action utilized the head differential created by the falling tide, which in this area is about 2 ft between high and low tides. Thus, for a period of about 6 hours, the falling tide produced a steep seaward gradient and a high rate of discharge of freshwater from the canal. Referring back to section 7 (fig. 6), the seaward velocity of the freshwater just before low tide was about 2 ft/s. At this velocity, the saltwater moved seaward at a rate of at least one mi/h.

In the 4 1/2-hour flushing operation not all saltwater was removed. Wind action plus density differences coupled, perhaps, with some movement of water from the canal into the ground-water system, tended to disperse and stratify the remaining salty water (sections 16-21, figs. 9 and 10). Although some freshwater may be wasted to the ocean, the waste may be preferable to allowing a small volume of saltwater to move inland considerable distances where it may contaminate much larger, volumes of freshwater in the canal and in the ground-water system.

The type of dam and method of gate construction can also influence saltwater intrusion in a canal or stream. Figure 11A shows a fixed-crest structure without gates. The crest of the dam is at or above high tide and will restrict saltwater intrusion but it has no means for avoiding loss of freshwater to the ocean. A similar structure with sluice gates (fig. 11B) reduces such losses because it permits regulation of the freshwater head, and saltwater cannot move landward at the bottom of the channel. This type of dam, however, does not allow direct passage of boats. A boat lift is generally provided with this type of salinity barrier. Also, neither of these structures (11A and 11B) permit flushing of saltwater trapped inland of the dam.

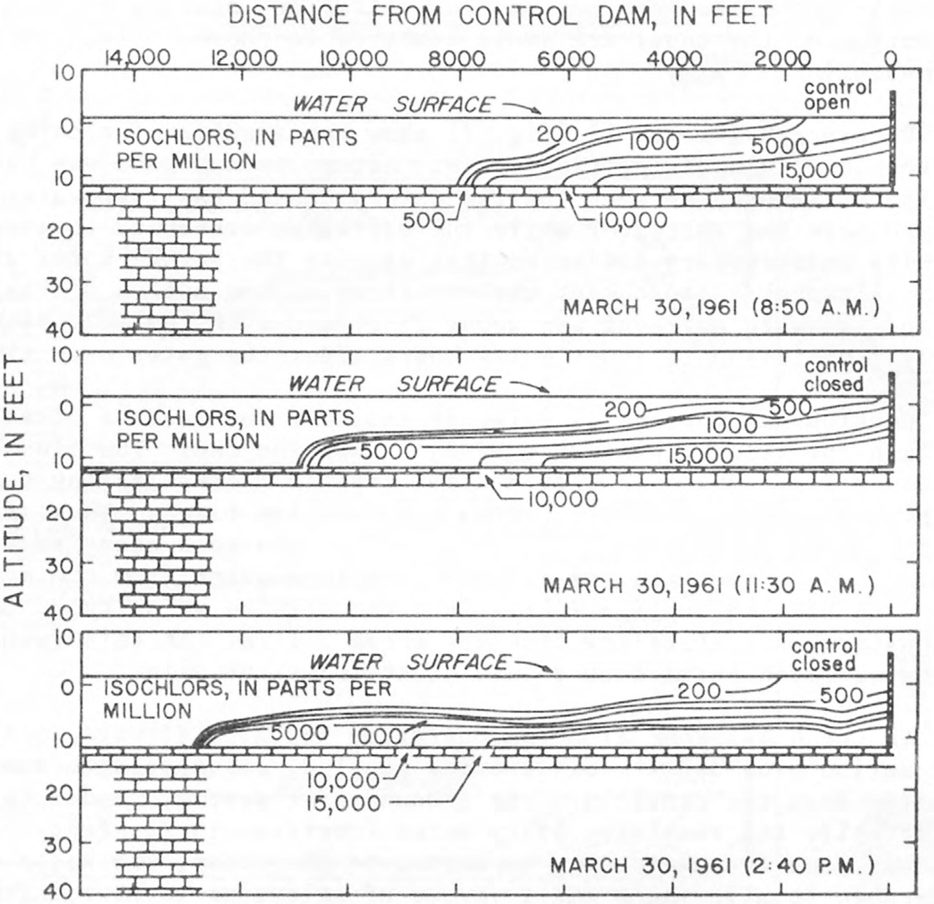


Figure 7.--Sections 9, 10, and 11 along the Snake Creek canal showing movement of saltwater after closing of the control dam at high tide, March 30, 1961.

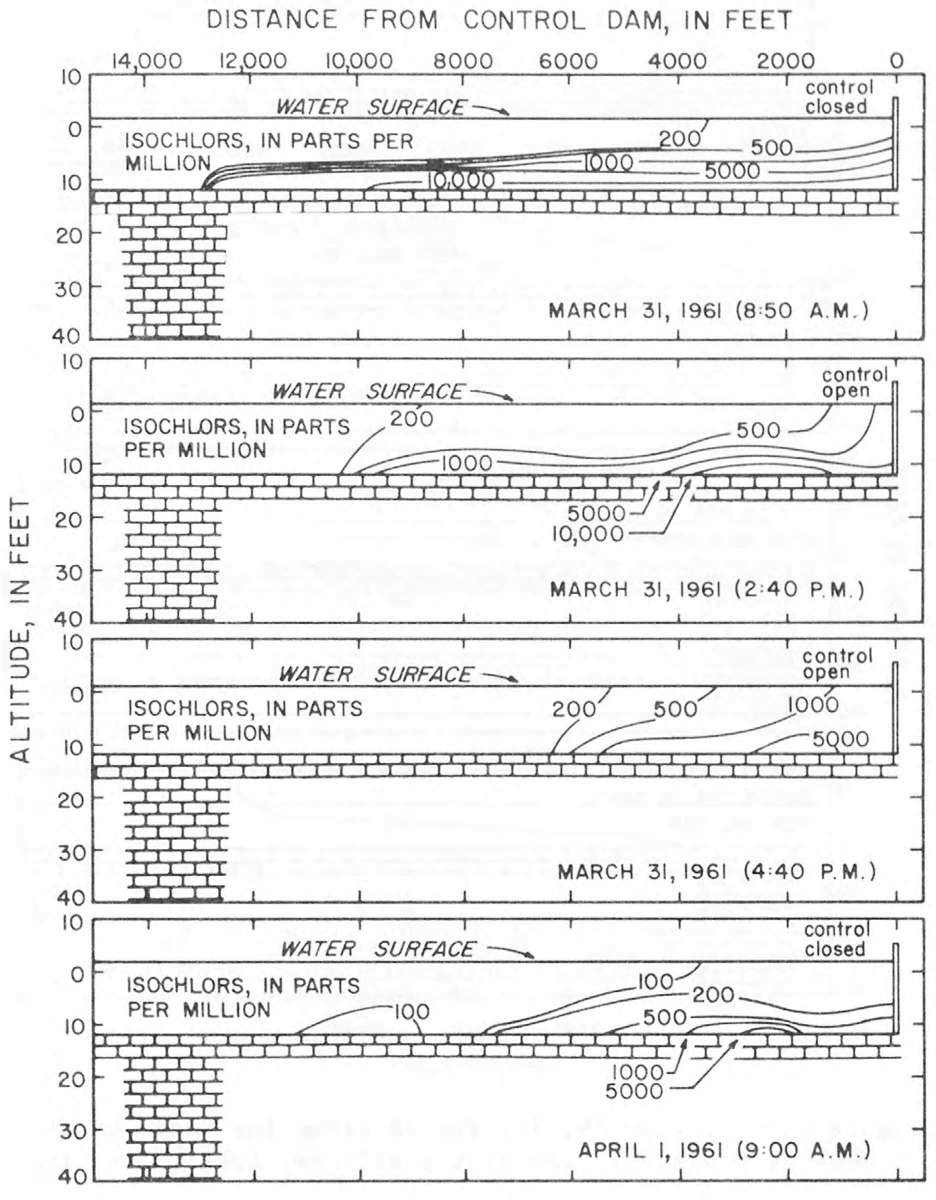


Figure 8.--Sections 12, 13, 14, and 15 along the Snake Creek canal showing movement of saltwater during and after flushing, March 31 to April 1, 1961.

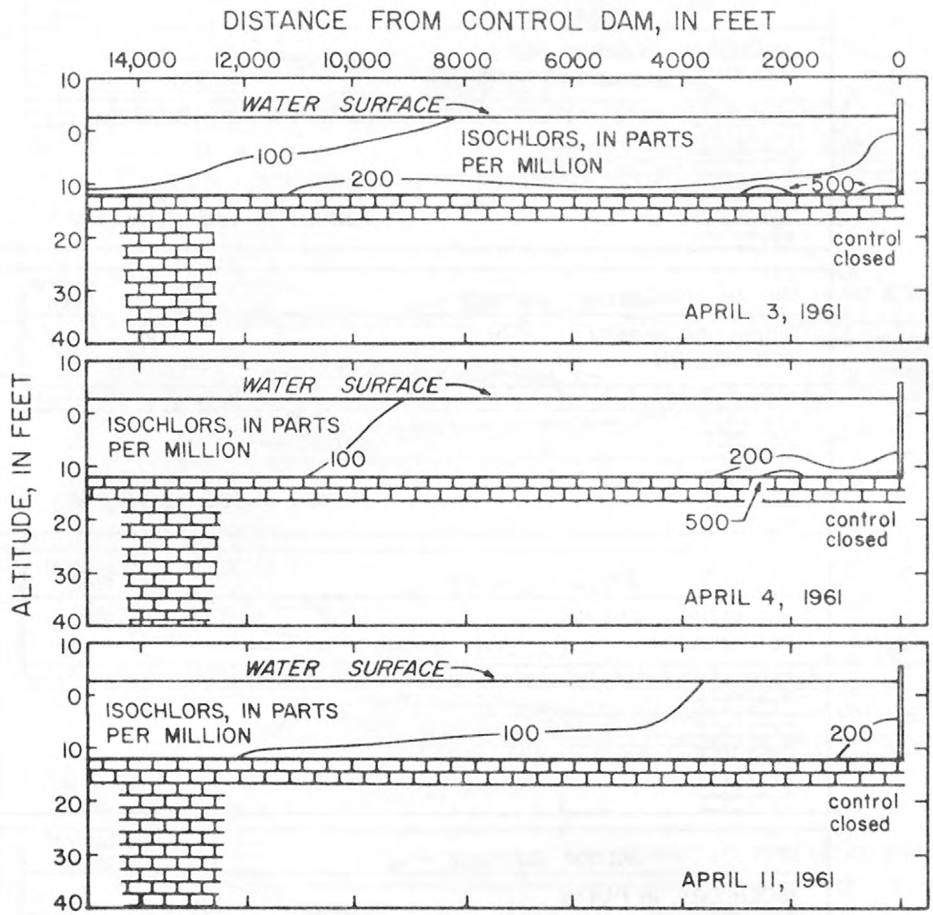


Figure 9.--Sections 16, 17, and 18 along the Snake Creek canal showing changes in isochlor positions, April 3-11, 1961.

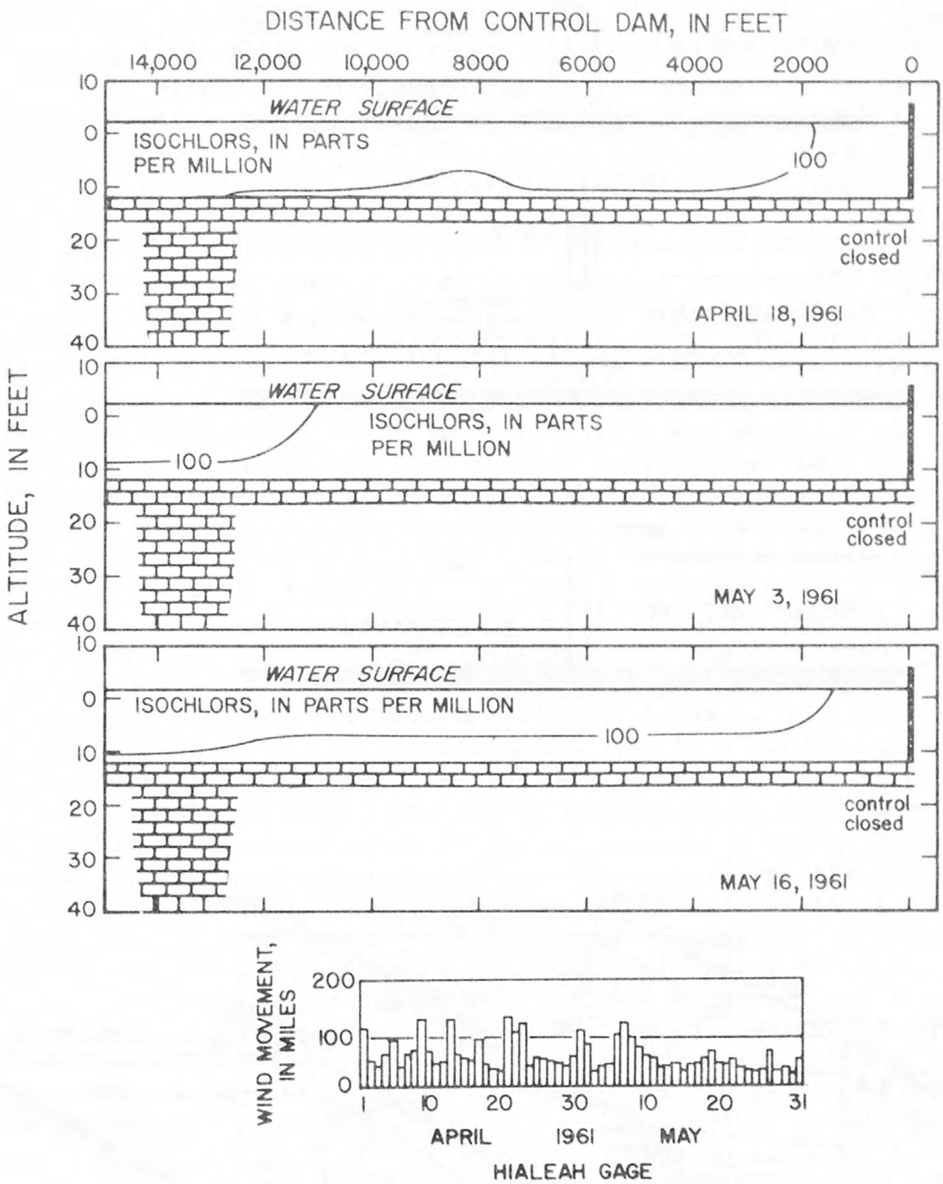


Figure 10.--Sections 19, 20, and 21 along the Snake Creek canal showing changes in isochlor positions, April 18 to May 16, 1961.

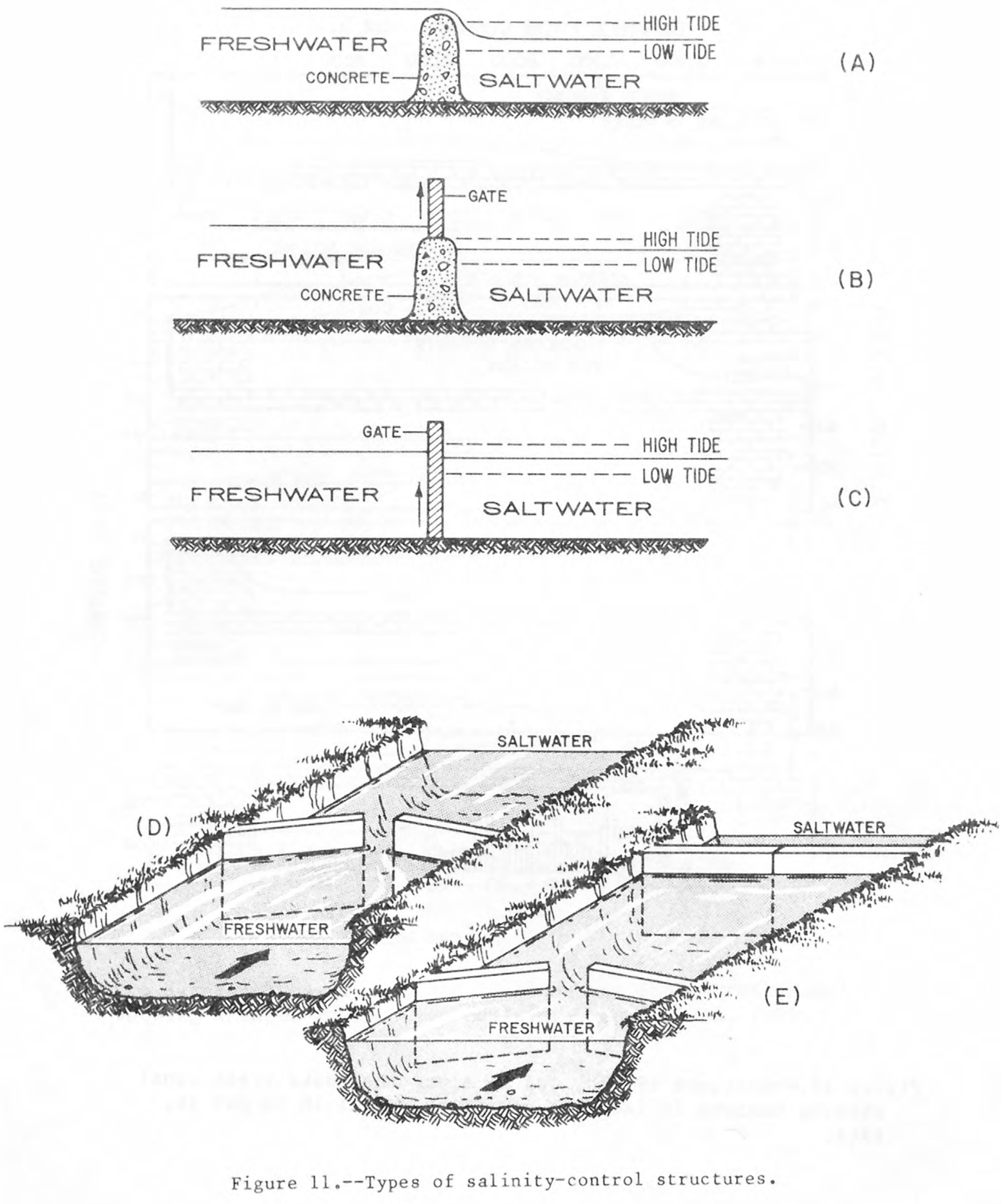


Figure 11.--Types of salinity-control structures.

Figure 11C shows a dam with a sluice gage that raises upward from the bottom of the channel, such as that used in the Snake Creek Canal (fig. 12). Although it regulates saltwater intrusion, its design requires careful regulation of gate opening because saltwater readily moves landward at the bottom of the channel. A boat lift is also required for this type of structure if installed in a navigable channel.

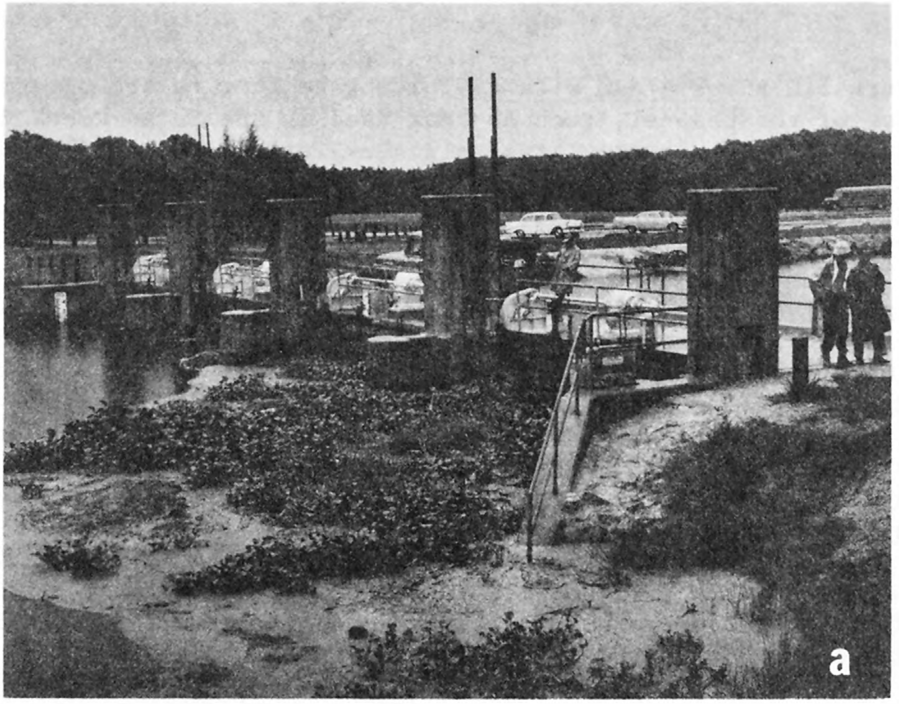
A type of salinity-control structure which allows direct boat passage is shown in figure 11D. It does, however, permit saltwater to readily move landward and also requires careful regulation. Minimizing the gate opening and thus maintaining a greater velocity and freshwater head will tend to minimize the intrusion if coordinated with tide cycles and other fundamentals discussed previously. Ideally, two such structures in series serving as a lock and dam is preferred (fig. 11E). This allows a boat to pass through the upper gate before the lower is opened. Closing the upstream gate and opening the lower allows the boat to move seaward and restricts the landward intrusion of saltwater to the upper gate. With each such operation, flushing of trapped saltwater between the gates would be required.

The application of fundamentals and concepts discussed thus far indicates a program of gate operation in conjunction with tide cycles can allow boat passage without significant landward intrusion of saltwater in a canal if there is an adequate supply of freshwater. Also, the application can be effective in areas where a canal is to be constructed or a stream enlarged. In some areas, topographic relief is sufficient and the base flow of a stream or newly constructed canal is adequate to restrict landward intrusion without a dam; elsewhere, the dam may be required because a seaward freshwater gradient is difficult to maintain despite adequate topographic relief. Such a situation is where the canal is receiving and discharging water to and from a water-table aquifer that is being heavily pumped for water supply. Each case should be considered independently for local hydrologic conditions when a canal is to be constructed or a stream enlarged. The establishing of a saltwater-barrier line inland of which no stream shall be enlarged or canal constructed, must therefore include consideration of the local hydrologic situation.

CONSIDERATIONS AND SITE EXAMPLES

Conditions Amenable to Management by a Saltwater-Barrier Line

Because of Florida's many miles of coastline, saltwater from the ocean is a constant threat to coastal freshwater supplies. The need for a salinity-barrier line in a coastal area is strongly influenced by local hydrologic, geologic, and topographic conditions. The threat of saltwater intrusion in a canal is greatest where the coastal area is flat with surface elevations near sea level and underlain by permeable water-bearing materials. Conversely, the threat is least where land elevations rise appreciably near the shoreline, where subsurface materials are relatively impermeable, or where surface flow toward the sea is consistently high.



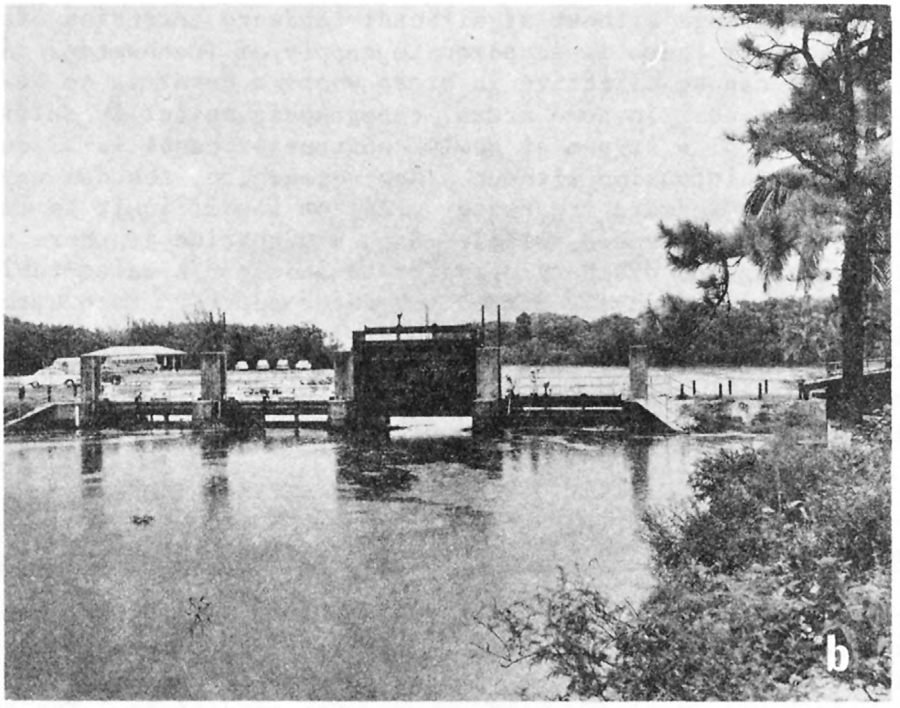


Figure 12.--Photographs of the salinity-control dam (S-29) in the Snake Creek Canal: (a) with right hand-gate opened 1 foot; (b) with one gate fully open (from Kohout and Leach, 1964).

Figure 13 shows areas where public supplies are withdrawn from water-table aquifers and which would be highly vulnerable to saltwater intrusion in coastal areas. Figure 14 shows the depth to the top of the confined Floridan aquifer, and delineates the area where this aquifer could be penetrated by canal construction. In most of the State the top of the confined aquifer is far below the depth of canals and limited saltwater intrusion along a newly constructed canal would generally not affect the quality of water in the aquifer. In general, areas where the confined aquifer is used extensively for water supplies roughly correspond to relatively high surface runoff and higher coastal elevations and are thus less likely to experience significant saltwater intrusion along nearby constructed canals or enlarged streams. It must again be emphasized however, that each area of Florida be reviewed according to the fundamentals and concept of saltwater intrusion discussed herein.

In southeast and southwest Florida where the topographic relief is low and the water-table aquifer is used extensively for freshwater supply, installation of dams and management controls of surface water by such concepts as a saltwater-barrier line are considered essential.

Areas of Successful Application

Salinity control structures in canals are used extensively in the southern areas of Florida to restrict saltwater intrusion. Until these structures were installed, surface-water discharge to the ocean was greatly reduced during dry seasons and saltwater intruded coastal canals, streams, and the water-table aquifer. The rate and extent of saltwater intrusion declined when the structures were constructed and water-management practices employed (fig. 15).

The first salinity structures in south Florida were mainly earth-fill or steel-pile dams. These dams remained until replaced by concrete structures, some as early as 1912-13 (Parker and others, 1955). The early concrete structures were not always maintained and allowed saltwater intrusion to continue inland. As more canals were dug or streams enlarged--to promote land drainage during periods of flooding or make more land available for development--the freshwater head declined in both the surface-water systems and water-table aquifer resulting in increased saltwater intrusion.

Saltwater had significantly degraded water in coastal parts of the water-table aquifer in south Florida until recent years when control structures were permanently installed and maintained on all major canals to regulate freshwater discharge. The effectiveness of the control structures in containing saltwater intrusion in Dade County is illustrated in figure 15. For example, the landward extent of saltwater intrusion in vicinity of the Hialeah-Miami Springs well field near Miami has not significantly changed since about 1950 despite an increase in pumpage of nearly 400 percent between 1941 and 1971 (Meyer, 1972, p. 27). The water-management practices initiated in Dade County have been applied

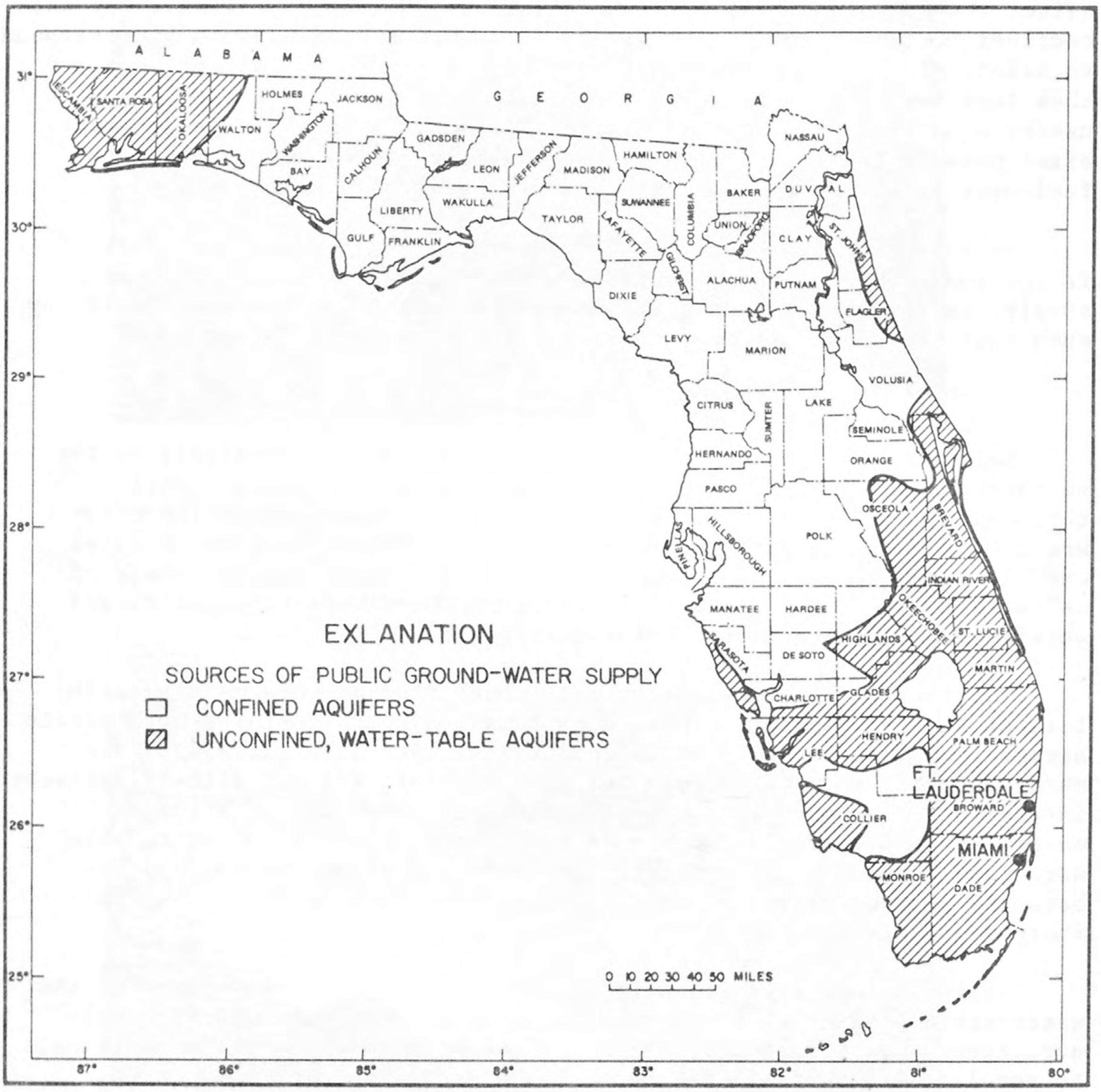


Figure 13.--Sources of ground water for public supply in Florida (from Healy, 1977).

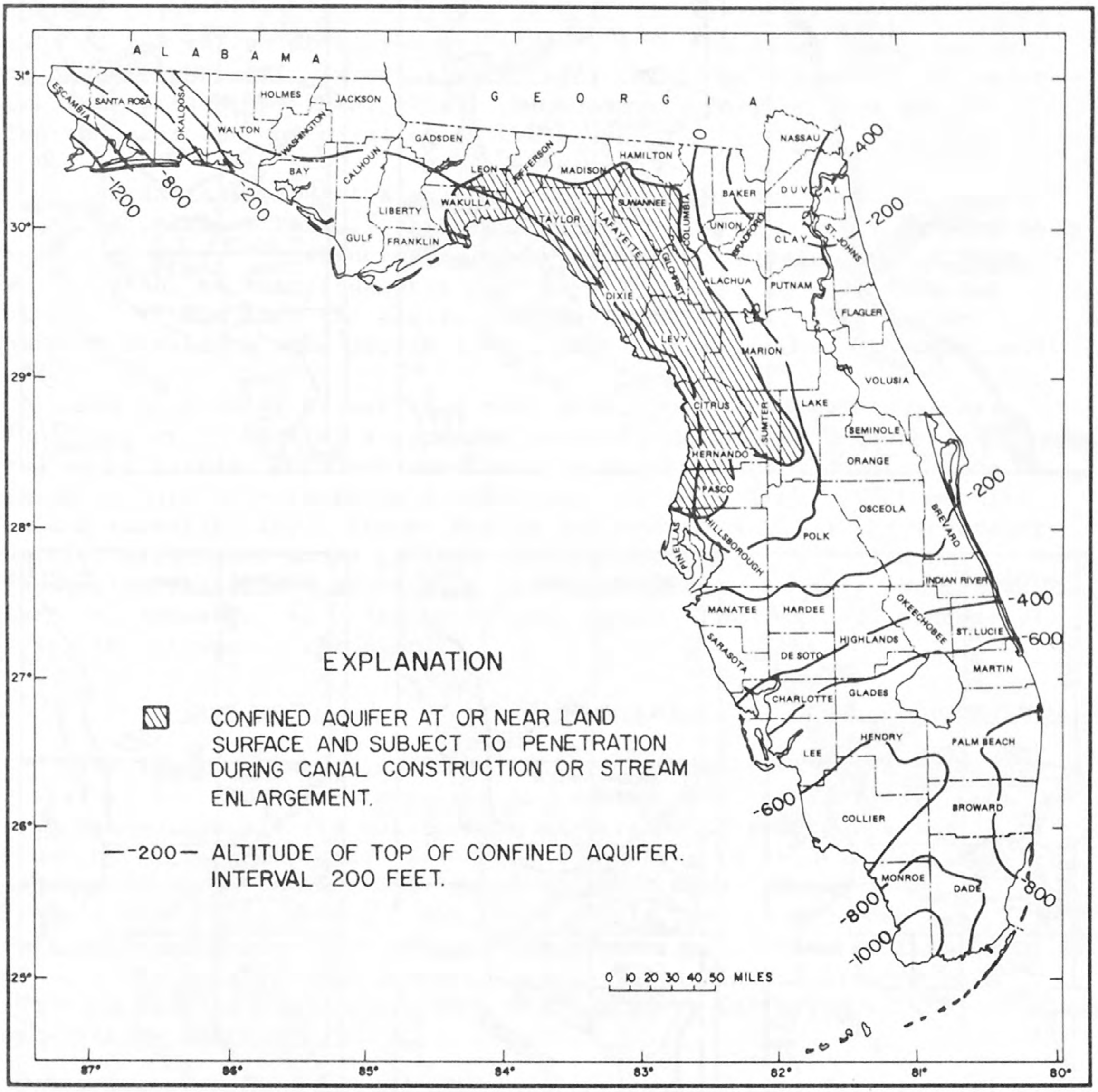


Figure 14.--Depth to top of confined aquifer in Florida (from Vernon, 1973).

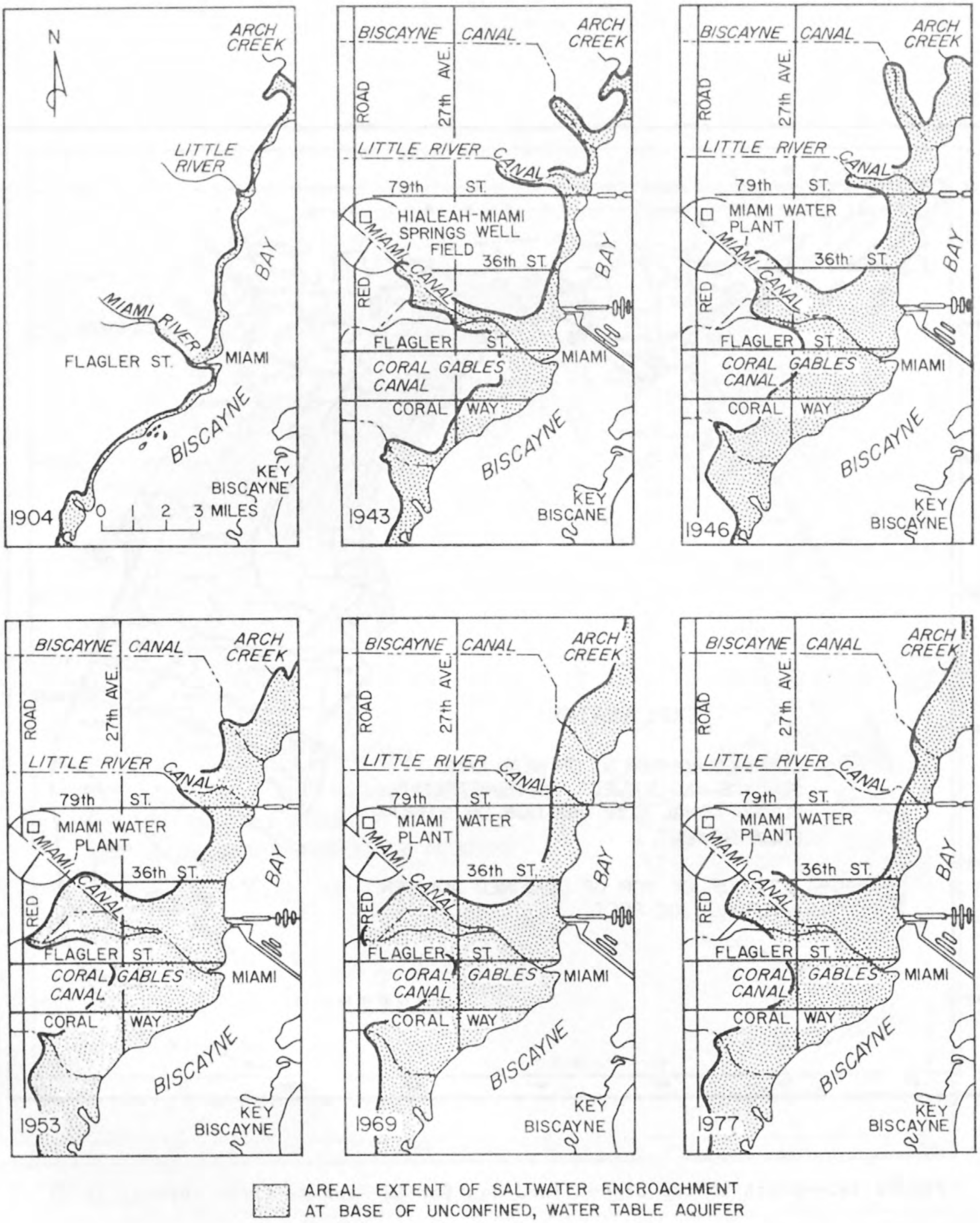


Figure 15.--Saltwater intrusion in Miami area of Dade County, Florida, 1904 to 1977.

with positive results in Broward, Collier, Palm Beach, Martin, and other counties in Florida. A saltwater-barrier line has been established in several areas in Florida including Dade (fig. 16) and Collier Counties and has been an effective method of controlling saltwater intrusion.

As a management objective, barrier lines can be planned so as to connect existing salinity-barrier structures, along the surface expression of the saltwater-freshwater interface in the water-table aquifer, or along the coast. In areas where no significant saltwater intrusion problems presently (1978) exist, the saltwater-barrier line can be located adjacent and parallel to the ocean.

The installation of a salinity barrier structure does not insure that the inland extent of saltwater intrusion is absolutely limited to a line connecting the structures. Pumping large volumes of water from wells inland of the structures can cause saltwater to move from the canal or stream into the aquifer in the immediate vicinity of the barrier structure thus partially negating the purpose of its placement.

The problem of hindering direct access to inland waterways by construction of barrier structures is also a consideration when a saltwater-barrier line and associated structures are planned. Some existing barrier structures provide boat lifts or locks which permit inland accessibility. Proper design and operating rules for saltwater-barrier structures would include consideration of tide cycles and freshwater velocities associated with limited gate opening among other factors discussed, in order to satisfy needs of boaters and concurrently restrict saltwater intrusion.

SUMMARY

The landward intrusion of saltwater from the ocean is a constant threat to the freshwater supplies in coastal areas of Florida. Construction of canals and enlargement of streams to reduce the impact of flooding during the rainy seasons plus the need to recover wetlands for urban development has reduced the freshwater head in some areas of Florida near or below sea level. The result has been encroachment of saltwater along canals and in coastal water-table aquifers. Installation of salinity-barrier dams properly placed in canals and streams have retarded and, in some cases, reversed saltwater intrusion in the associated water-table aquifers.

The application of fundamental mechanics and concepts of saltwater intrusion along surface-water channels to canal construction and placement and regulation of gate opening in salinity dams, provides State water regulatory agencies with a means of evaluating the need for establishing a saltwater-barrier line in areas of Florida. A saltwater-barrier line may be defined as the allowable landward limit of saltwater intrusion along a surface-water channel. Several counties in Florida, including Dade and Collier, have established such a line as a water management objective and have successfully contained or reversed saltwater intrusion in the aquifer.

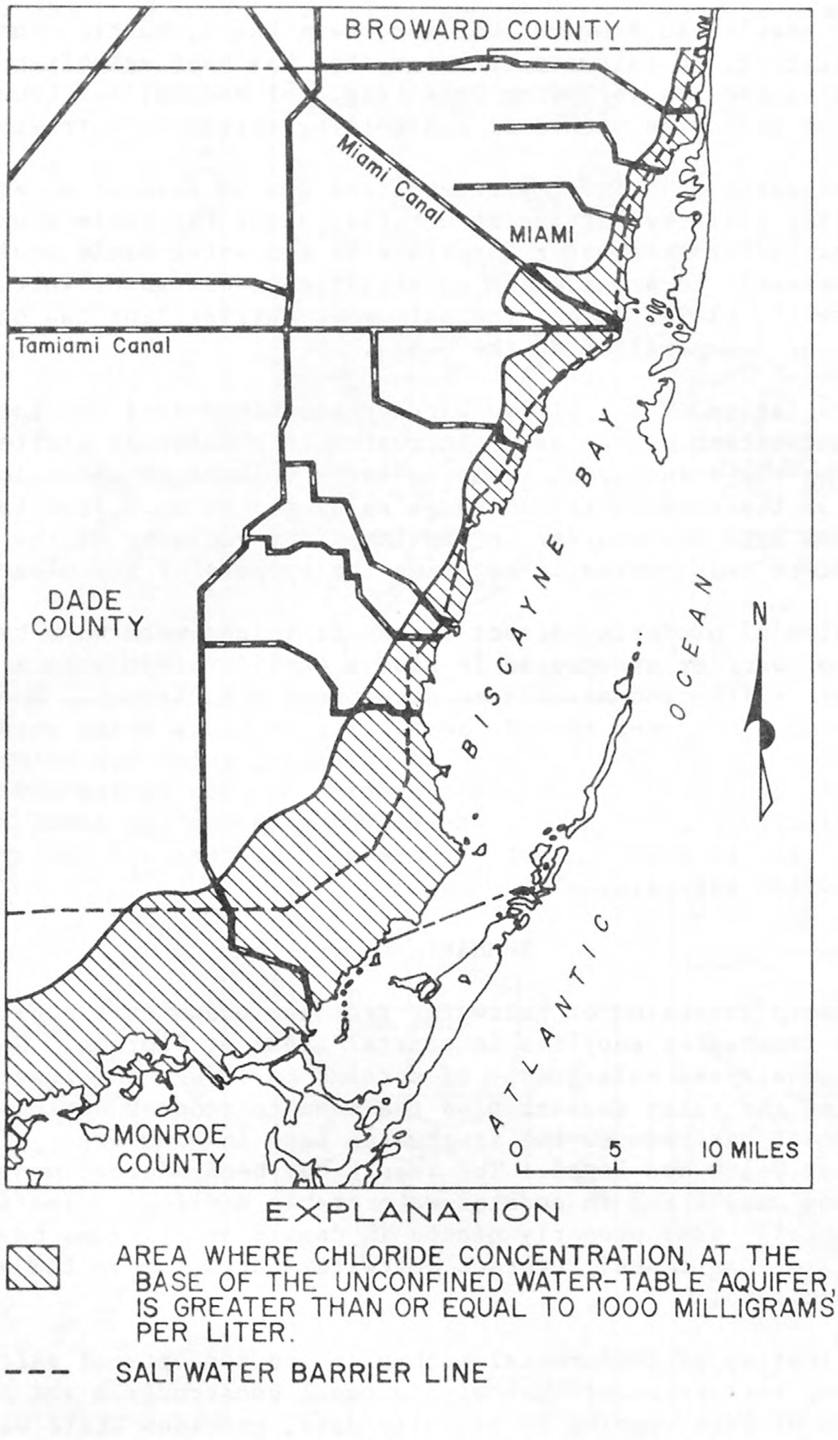


Figure 16.--Location of saltwater barrier line and 1,000 milligrams per liter chloride line at base of unconfined, water-table aquifer in Dade County, Florida, 1975.

Hydrologic conditions in most of south Florida are similar to those in Dade and Collier Counties. A saltwater-barrier line seems to be a viable management tool for the State regulatory agency or the local water management district. In west-central Florida, where the confined aquifer is near land surface and could be penetrated by canal construction or stream enlargement, conditions are such that a saltwater-barrier line could alleviate or forestall a saltwater intrusion problem.

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