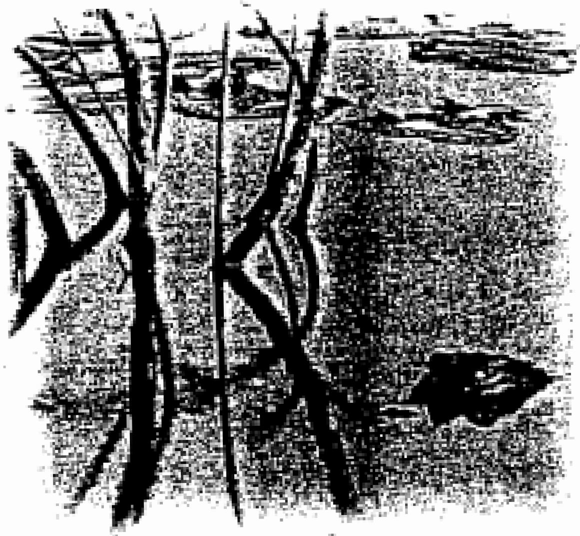
Southwest Florida Water Management District

Northern Tampa Bay
Minimum Flows & Levels White Papers



White Papers Supporting The Establishment of Minimum Flows and Levels For:

- Isolated Cypress Wetlands
- Category 1 and 2 Lakes
- Seawater Intrusion
- Environmental Aquifer Levels, and
- Tampa Bypass Canal

PEER REVIEW FINAL DRAFT
March 19, 1999

Northern Tampa Bay
Minimum Flows and Levels
Overview

The Northern Tampa Bay area is comprised of the counties of Pinellas, Pasco and the northern portion of Hillsborough. These counties are located in southwest Florida and surround the northern half of Tampa Bay.. Pinellas County is almost entirely urbanized, as are much of northwest Hillsborough County and southwestern Pasco County. Inland areas of Pasco are rapidly becoming urbanized also. Potable water supplies for these counties and municipalities within these counties are principally from eleven regional wellfields located in Hillsborough and Pasco counties drawing from the Upper Floridan aquifer.

The first of the regional wellfields began operating in the early 1930's. The eleventh wellfield began operating in 1992. In addition to other sources, wellfields continue to be brought on-line in the area to meet the potable water supply needs of the Northern Tampa Bay area.

The surface water environment within the Northern Tampa Bay area is highly interconnected with the ground water system. Because of the karst geology that characterizes the area, a discontinuous and leaky confining layer provides a relatively good hydraulic connection between the surficial aquifer and the underlying Upper Floridan aquifer. Although localized areas of good confinement exist, overall the Upper Floridan aquifer is described as poorly to moderately confined within the Northern Tampa Bay area. As a result, water levels in the aquifers are linked, and fluctuate similarly.

Without ground water withdrawals, recharge from rainfall to the surficial aquifer and discharge by evapotranspiration and flow from the surficial aquifer are the only significant driving forces of these fluctuations. Very little ground water is contributed to the area from lateral inflow. The variable head in the surficial aquifer in turn largely regulates the recharge to the Upper Floridan aquifer through the leaky semi-confining unit. Therefore, the fluctuations in the surficial aquifer affect the fluctuations in the Upper Floridan aquifer.

An additional stress is introduced to this process when ground water withdrawals from the Upper Floridan aquifer are added. Ground water withdrawals lower the potentiometric surface of the Upper Floridan aquifer, which in turn increase leakage from the surficial aquifer to the Upper Floridan aquifer. This additional recharge is referred to as induced recharge. The result is a lowering of the water table. Assessments have shown that in leaky areas of the Northern Tampa Bay area, most of the water withdrawn from the Upper Floridan aquifer by pumping is derived by vertical leakage downward from the surficial aquifer (Liu and Polmann, 1996). Thus, Upper Floridan aquifer water level fluctuations caused by ground water withdrawals affect surficial aquifer water level fluctuations, as well as the water levels of lakes and wetlands that are connected to the surficial aquifer.

Waters and wetlands account for approximately 23 percent of the land area within the Northern Tampa Bay area.

In the mid 1980's, the District declared the northwest Hillsborough County area and limited portions of Pinellas and Pasco Counties, within which several of the wellfields are located, to be an "area of special concern" regarding the condition of local water resources.

In 1987, the District undertook a water resource assessment project ("WRAP") to examine the water resources within the area of special concern. In 1989, based on preliminary information from the WRAP, the District declared an area as the "Northern Tampa Bay Water Use Caution Area" in recognition of environmental stress identified by the District.

In 1992, the WRAP study area was expanded and became identified as the "Northern Tampa Bay Water Resource Assessment Project" ("NTBWRAP"). The NTBWRAP is the District's most recent attempt at determining the condition of the water resources in the area of the regional wellfields. (The NTBWRAP is among the materials provided with the White Papers).

Due to environmental stress to the water resources in the Northern Tampa Bay area, Section 373.02 Florida Statutes (F.S.), as amended by the Florida Legislature in 1996, directed the District to establish minimum flows and levels for the region before October 1, 1997.

Section 373.042, F.S. defines the minimum flow to a surface water course to be the flow below which additional withdrawals would cause significant harm to the water resources or ecology of the area. Section 373.042, F.S. defines the minimum level of an aquifer or surface water body to be the level below which additional withdrawals would cause significant harm to the water resources of the area. The 1996 amendments to the statute required the District to adopt minimum flows and levels in Hillsborough, Pasco, and Pinellas County for priority waters that are experiencing or may be expected to experience adverse impacts. In response to this legislative direction, the District established 41 minimum wetland levels, minimum levels for 15 lakes, sea water intrusion aquifer levels, narrative aquifer levels and a minimum flow for the Tampa Bypass Canal. Work is ongoing to establish minimum flows and levels in the future for additional water bodies.

Section 373.042, F.S. requires the District to use the best data available to set minimum flows and levels. The legislative requirement to set the levels by October 1, 1997 was absolute, that is, there was a limited time to collect additional information. Because of the time deadline, and the associated requirement to use the best information available, the District was constrained to use existing data complete with any associated limitations of that data.

The process to develop the methods for determination of minimum flows and levels was an open public process with all interested parties invited to participate in the development of methodologies for determining the limit at which significant harm occurs to the lakes, wetlands, surface water courses and aquifers for which levels must be established. Many lay and technical representatives of the interested local governments, environmental groups and individuals did participate in the rule development process through months of meetings, public workshops, and public hearings.

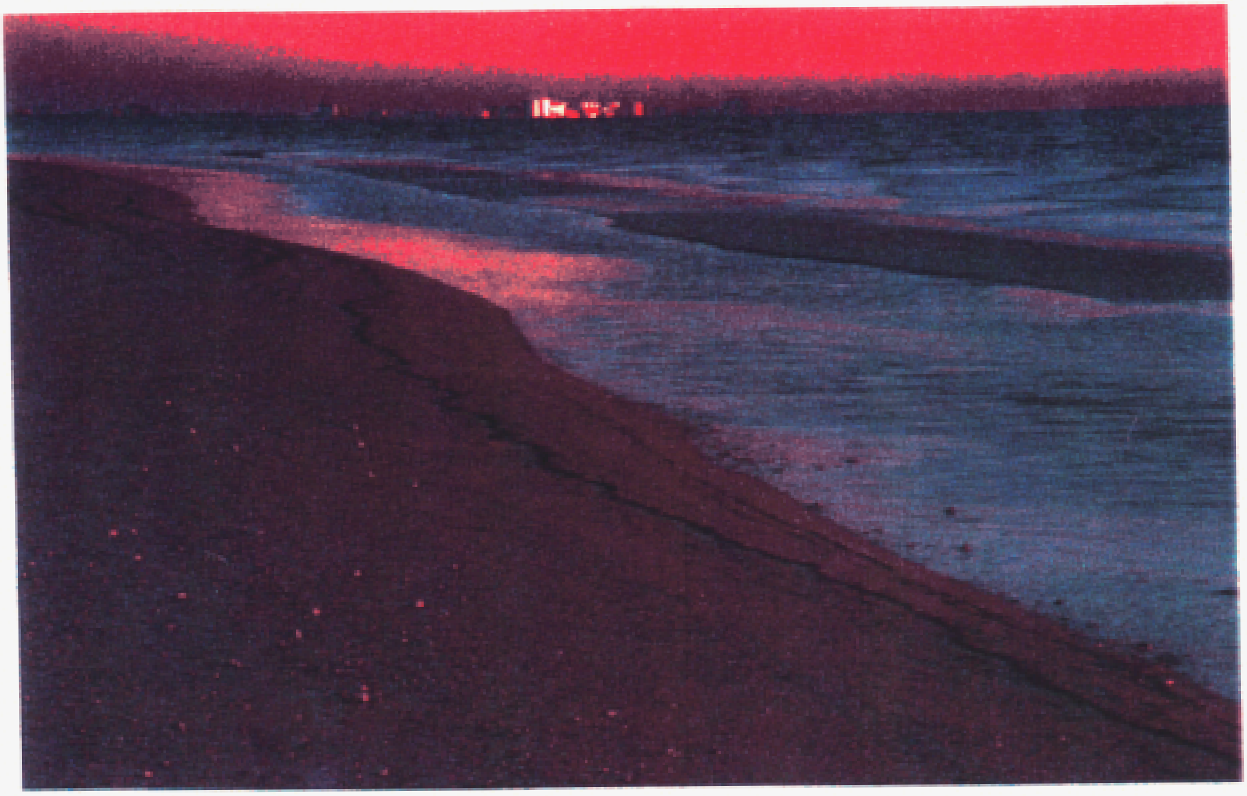
Following this public process the District staff finalized methodologies and minimum levels and flows for approval by the Governing Board. However, effective July 1, 1997, subparagraph 373.042(l)(a), F.S. was added. That paragraph directs the District to consider changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes and alterations have had when establishing minimum flows and levels. Therefore, at the Board's direction, staff reviewed the previous work, additional data as appropriate, continued meetings and workshops with affected parties and held public workshops with the Governing Board to ensure that the changes to the statute had been assimilated into the methodologies.

On October 28, 1998, the Governing Board approved the subject minimum flows and levels.

As permitted under subsection 373.042(4), F.S., five parties requested Scientific Peer Review of the scientific and technical data and methodologies used to determine the flows and levels. The purpose of this series of reports is to document for the Scientific Peer Review Panel scientific and technical data and methodologies used to determine the flows and levels for priority waters in the Northern Tampa Bay area.

The reports are organized in the following sections. This first section provides a general explanation of the area, hydrogeology, the Legislature's direction to the District and the processes and constraints for the District's establishment of minimum flows and levels. The next four sections describe the specific methods developed for determination of minimum levels in certain wetlands, certain lakes, and in the Upper Floridan aquifer, respectively. The last section describes the methods used to develop the minimum flow for the Tampa Bypass Canal.

Seawater Intrusion Minimum Levels for Northern Tampa Bay



DRAFT - March 1999

Hydrologic Evaluation Section
Resource Conservation and Development Department

PROFESSIONAL ENGINEER

The engineering contained in the report Seawater Intrusion Minimum Levels/Northern Tampa Bay (Final Draft - March 1999) was prepared by, or reviewed by, a Registered Professional Engineer in the State of Florida. This report is not final, and intended for review, comments, and recommendations purposes only.

Michael C. Hancock

3/17/99
Date

License No. 44693

PROFESSIONAL GEOLOGIST

The geological evaluation and interpretations contained in the report Seawater Intrusion Minimum Levels/Northern Tampa Bay (Final Draft - March 1999) were prepared by, or reviewed by, a Certified Professional Geologist in the State of Florida. This report is not final, and intended for review, comments, and recommendations purposes only.

Ronald J. Basso

3/17/99
Date

License No. 1325

Seawater Intrusion Minimum Levels in Northern Tampa Bay

1. Introduction

Chapter 373 Florida Statutes requires the Southwest Florida Water Management District (District) to adopt Minimum Levels in areas of Hillsborough, Pasco, and Pinellas County that are experiencing or may be reasonably expected to experience adverse impacts because of ground-water withdrawals. In response to this legislative charge, the District has established Minimum Levels in 1) lakes and wetlands in areas where ground-water withdrawals have contributed to the lowering of surface-water levels below the level associated with significant harm, 2) wetlands in areas where significant ground-water withdrawals are planned, and the potential for significant harm exists, and 3) the Upper Floridan aquifer in these same areas to protect against seawater intrusion.

The purpose of this paper is to document the methodology used to determine Upper Floridan aquifer Minimum Levels that will be used to prevent significant harm of the aquifer in the Northern Tampa Bay (NTB) area by seawater intrusion. The area was recently assessed in the District's Northern Tampa Bay Water Resources Assessment Project (SWFWMD, 1996), and is referred to as the Northern Tampa Bay area throughout this document (Figure 1). This paper also discusses the selection process for choosing monitor wells that will be used as part of the Minimum Levels network for seawater intrusion.

The establishment of seawater intrusion Minimum Levels in the Northern Tampa Bay area was a three-step process. The first step was to assess the current status and anticipated future advancement of seawater intrusion in the Northern Tampa Bay area. Secondly, a proposed goal of the seawater intrusion Minimum Levels in this area was determined. Finally, a network of monitor wells and corresponding water levels were selected to accomplish this goal.

2. Assessment of seawater intrusion in Northern Tampa Bay

Throughout the District, the setting of Minimum Levels must take into account the specific hydrogeologic setting of the area of interest. The hydrogeology of the Northern Tampa Bay area has been discussed in detail in many reports. The Northern Tampa Bay Water Resources Assessment Project report (SWFWMD, 1996) provides a detailed discussion of the regional hydrogeology of this area.

The surface-water environment within the Northern Tampa Bay area is highly interconnected with the ground-water system. Because of the karst geology that characterizes the area, a discontinuous and leaky confining layer provides a relatively good hydraulic connection between the surficial aquifer and the underlying Upper Floridan aquifer. Overall, the Upper Floridan aquifer is described as poorly to moderately confined within the Northern Tampa Bay area. As a result, water levels in the aquifers are linked, and fluctuate similarly.

Without ground-water withdrawals, recharge from rainfall to the surficial aquifer and discharge by evapotranspiration and flow from the surficial aquifer are the only significant driving forces of these fluctuations. The variable head in the surficial aquifer in turn largely regulates the recharge to the Upper Floridan aquifer through the leaky semi-confining unit. Therefore, the fluctuations in the surficial aquifer affect the fluctuations in the Upper Floridan aquifer. An additional stress is introduced to this process when ground-water withdrawals from the Upper Floridan aquifer are added. Ground-water withdrawals lower the potentiometric surface of the Upper Floridan aquifer, which in turn increase leakage from the surficial aquifer to the Upper Floridan aquifer. This additional recharge is referred to as **induced recharge**. The result is a lowering of the water table. Assessments have shown that in leaky areas of the Northern Tampa area, most of the water withdrawn from the Upper Floridan aquifer by pumping is derived by vertical leakage downward from the surficial aquifer (Liu and Polmann, 1996). Thus, Upper Floridan aquifer water level fluctuations caused by ground-water withdrawals affect surficial aquifer water level fluctuations, as well as the water levels of lakes and wetlands that are connected to the surficial aquifer.

In the Northern Tampa Bay area, the terrestrial ground water generally moves from the region of higher potential inland (the Green Swamp and the Pasco High) to a lower potential along the coast (Figure 2). Because of the leaky nature of the confining unit, as well as the effects of induced recharge, the Upper Floridan aquifer is recharged throughout much of the inland portions of the Northern Tampa Bay area. Areas of significant discharge occur along portions of the Hillsborough River, and along the coast. Seawater generally underlies the freshwater of the aquifer near the marine coast. A conceptual hydrogeologic cross-section of this region, oriented perpendicular to the coast, shows the seawater region to form a wedge beneath the freshwater (Figure 3). As the freshwater flows toward the coast, the hydraulic potentials, or heads, are reduced, and the slightly denser seawater forces the freshwater upward where it discharges from the aquifer to the sea floor or an overlying aquifer.

Seawater intrusion is the displacement of water in an aquifer by water of greater salinity. Bear (1979) has shown that *"...there exists a relation between the rate of freshwater discharge to the sea and the extent of seawater intrusion"* (p. 381). In a steady-state system, freshwater discharge is the difference between ground-water recharge, both natural and artificial, and ground-water withdrawals. Decreasing freshwater discharge at the coast increases the extent of seawater intrusion. The extent of intrusion is controlled by controlling the discharge, or *"...alternatively controlling the recharge and/or pumping in the coastal aquifer strip"* (Bear, 1979, p. 396). Reductions in coastal discharge can be detected in declining hydraulic heads near the coast. Therefore, controlling coastal heads and their associated gradients is an appropriate method of maintaining the extent of seawater intrusion.

Although localized variations exist, there is little evidence that regional discharge has significantly changed since predevelopment in the Northern Tampa Bay area (SWFWMD, 1996). Because of the leaky nature of the semi-confining unit separating the Upper Floridan and surficial aquifers, much of the water removed from the Upper Floridan aquifer is replaced by increased leakage from the surficial aquifer. This leakage regionally offsets the Upper Floridan aquifer drawdowns, which in turn tends to offset reductions in discharge to the coast.

Unlike the Upper Floridan aquifer drawdown in the southern portion of the SWFWMD, drawdowns of greater than one or two feet in the Northern Tampa Bay area exist as several individual cones of depression. Because the confining layer is relatively leaky, induced leakage from the surficial aquifer prevents these larger cones of depression from expanding over the entire region (Figure 4). Regional drawdown along the coast is generally minimal, while the greatest drawdowns are found inland. However, some subregional or local declines in hydraulic head in coastal areas have been noted in the Northern Tampa Bay area (SWFWMD, 1996). The reduction in head in northeastern Pinellas County (near the Eldridge-Wilde well field) can be expected to have the greatest effect on the position of the seawater front because 1) hydraulic head declines have been the greatest here, 2) the area is near the coast, and 3) the depth to poor quality water has always been shallow compared to Hillsborough and Pasco Counties (SWFWMD, 1996).

The actual movement of seawater intrusion in response to reduced discharge occurs much more slowly than the change in fluid pressures. The amount of seawater intrusion caused by hydraulic head declines is dependent on aquifer characteristics and the duration of the head declines. Since the seawater front moves slowly, a sustained period of decline in the hydraulic head field is necessary to initiate significant seawater intrusion.

The upwelling of mineralized water from lower portions of the Upper Floridan aquifer is another saline intrusion process. The upwelling is typically indicated by increases in ground-water sulfate concentrations and an increase in the ratio of sulfates to chlorides, results from a decline in the potentiometric surface which may be caused by large aquifer drawdowns. USGS studies (Fretwell, 1988, and Hickey, 1990) discuss potential problems of the upwelling of mineralized water from the evaporitic section of the Avon Park Formation. There is a potential for this type of intrusion process in the well fields of the Northern Tampa Bay area, especially in the northern portion of the area due to the presence of large ground-water withdrawals and lower water quality at depth (Fretwell, 1988), although no evidence of such upwelling has been seen to date (SWFWMD, 1996)

In water production wells, the extent of seawater intrusion caused by ground-water withdrawals from those wells is far greater than that caused by regional declines in hydraulic potential. This means that an increasing chloride concentration trend in water from a production well can be reversed by a reduction or cessation in pumping. This process is reflected in the data of coastal well fields throughout the Northern Tampa Bay area, and is used to locally manage water quality degradation. A smaller increasing (or even decreasing) subregional trend may be present in these areas, but cannot be detected because the regional trend is small in comparison to the local trend. The regional trend may best be measured by nonpumping monitor wells located in areas outside of the local influences of pumping wells.

Within the existing areas of major ground-water withdrawal in the western half of the Northern Tampa area, a balance exists between ground-water flow, ground-water withdrawals and seawater intrusion. In some areas, the underlying geologic formations may have a very low vertical permeability or fractures which strongly influence ground-water flows. Wells have produced and may continue to produce fresh water for decades despite the presence of saline water a short distance below the bottom of the well (Geraghty and Miller, 1976). However, Hickey (1990) studied the middle confining unit of the Upper Floridan aquifer system and expressed concern over potential upwelling of native brines or seawater under areas of major freshwater withdrawals.

The relationship between ground-water withdrawals and water quality is complex. Many variables are involved and may include:

- the frequency of the withdrawal, i.e. continuous versus sporadic
- the degree of stress of the aquifer caused by the withdrawal (i.e., quantity of water withdrawn)
- the location of the withdrawal point in relation to sources of contamination such as seawater or highly mineralized waters
- the presence of other ground-water withdrawal points in the area and their degree of activity
- the hydrogeologic properties of the aquifer, including the degree of confinement and horizontal and vertical conductivities
- the density, size, and orientation of fractures within the aquifer (i.e., heterogeneity)
- the lithologic composition of the aquifer.

The above conditions, and others, not only determine if ground-water withdrawals have an effect on ground-water quality, but also determine the scale of that effect. Withdrawals that are sufficient to cause larger subregional effects on water quality in one area might cause only local effects in another area due to differences in hydrogeologic conditions.

Recent Studies

The status of seawater intrusion in the Northern Tampa Bay area has been assessed in several recent reports. Four of note include the ***Northern Tampa Water Resources Assessment Project*** (SWFWMD, 1996), ***Trends in Chloride, Sulfate, and Dissolved Solids Concentrations in Water From Selected Public Supply and Monitor Wells in the Tampa Bay Area, Florida*** (USGS, 1996), ***Modeling Assessment of the Regional Freshwater-Saltwater Interface in the Northern Tampa Bay Groundwater Basin*** (HydroGeoLogic, Inc., 1994), and ***Investigation of Increasing Chloride and Sulfate Concentrations for Wells RMP-9D, RMP-13PZ, RMP-14D, and RMP-16D, Northwest Hillsborough Regional Wellfield*** (HSW Environmental Consultants, Inc., 1996). In the first two studies, regression analyses were performed on water quality data from Floridan aquifer monitor wells throughout the Northern Tampa Bay area, analyzing both long-term and short-term trends. Both reports concluded that increasing trends in chlorides were found very near some coastal ground-water withdrawal centers, but no regional patterns were apparent. Decreasing trends were found in coastal areas where withdrawals had decreased. Acknowledging the karst nature of the area, both reports conclude that seawater intrusion or saline upconing are probably occurring in some areas, but the problem appears to be a localized rather than a regional concern.

The HydroGeoLogic report supports this conclusion through the use of a regional sharp interface model (SIMLAS). A sharp interface model simplifies the effort of analyzing seawater intrusion by assuming that saltwater and freshwater are immiscible liquids, and that their flow regimes are separated by a "sharp" interface. In reality, there is a transition zone between the saltwater and the freshwater mix, but for purposes of regional analysis, the sharp interface assumption is adequate. Figure 5 demonstrates the results of the analysis by comparing the modeled results of the predevelopment and current locations of the point at which the interface elevation is one-half the total aquifer thickness of the Avon Park layer of the Floridan aquifer. The figure also compares the points at which the interface elevation is at the top and bottom of the Avon Park layer. For the predevelopment scenario, there were no water withdrawals simulated. The current pumping scenario was simulated by incrementally increasing ground-water withdrawal rates in ten year increments based on decade-by-decade estimates of actual withdrawals, and then running the model for 40 additional years with the current withdrawal rate. The current withdrawal rate, simulating conditions in the early 1990s, was approximately 240 million gallons per day (mgd). The 2020 pumping scenario simulates the effect of projected 2020 ground-water withdrawal rates (as projected in early-1990 planning documents). In this scenario, the model is run with a withdrawal rate of approximately 322 mgd for 40 years, beginning with current conditions. Finally, the reduced pumping scenario is simulated by running the model for 40 years at one-half the current withdrawal rate (approximately 120 mgd), also beginning with current conditions.

The conclusion based on the modeling analysis was that seawater intrusion in the Northern Tampa Bay area has been minimal on a regional scale, and that no significant degradation of the ground water through seawater intrusion is expected with anticipated future withdrawal scenarios. Although this modeling effort was performed on a regional scale, evidence of local concerns near the Eldridge-Wilde well field was noted.

The HSW report focused on the Northwest Hillsborough Regional Wellfield area, and concluded that although the existing chloride monitoring network was less than ideal, increasing trends in chloride were found in many Floridan aquifer wells between the well field and the coast of Tampa Bay. However, no increasing trends are evident in other areas surrounding the well field. A new monitoring well network was proposed in a follow-up report (HSW Environmental Consultants, Inc., 1997) that will hopefully more clearly define the extent of the potential problem.

In addition to the reports discussed above, annual reports are published by the water utilities that present the results of water quality monitoring for each of the regional well fields, including the Starkey (Berryman & Henigar, 1997), Eldridge-Wilde (Blasland, Bouck, and Lee, Inc., 1997), and Northwest Hillsborough Regional well fields (Water & Air Research, Inc. and HSW Environmental Consultants, Inc., 1997). Only some of the wells in the Eldridge-Wilde and Northwest Hillsborough Regional well fields show any significant signs of increasing chlorides. The Ambient Ground-Water Quality Monitoring Program (AGWQMP) has also more recently established a Coastal Ground-Water Quality Monitoring Network, in which coastal wells are periodically sampled and a data base is maintained (SWFWMD, 1995). This network is the best available regional measuring tool for detecting increasing chloride trends, and no long-term trends are presently identified.

Interpretation

The conclusions of these reports and others, combined with an assessment of available data near the Eldridge-Wilde, Starkey, Cosme-Odessa, and Northwest Hillsborough Regional well fields, led the District to the conclusion that at current and anticipated withdrawal rates in the Northern Tampa Bay region, seawater intrusion does not appear to be a regional concern at existing or anticipated ground-water withdrawal rates.

There is evidence, however, that seawater intrusion may be a concern in localized areas, such as in the Eldridge-Wilde and Northwest Hillsborough Regional well field area. Furthermore, because increasing chlorides may significantly lag drawdowns in the coastal hydraulic gradient, chloride levels in coastal monitoring wells may continue to increase in these local areas. However, it is not expected that regional saltwater intrusion will advance significantly beyond the point which is predicted in the regional modeling effort.

These conclusions are based upon the best data and analysis available at this time. Improvements in these data and analyses are expected as more high quality data is collected in the AGWQMP Coastal Ground-Water Quality Monitoring Network, as this network is expanded, and as the monitoring programs conducted at the well fields are refined.

3. Goal of Seawater Intrusion Minimum Levels

In the Northern Tampa Bay area, seawater intrusion is a concern in the Upper Floridan aquifer only, and the District has established that the goal of Minimum Levels to prevent seawater intrusion in the Northern Tampa Bay area is to allow no further significant advancement of seawater intrusion to protect the regional freshwater aquifer in the area.

Analysis has shown that any regional seawater intrusion that has already occurred is relatively minor and not expected to significantly advance. Two localized areas within Northern Tampa Bay, the Eldridge-Wilde and Northwest Hillsborough Regional well field areas, may be experiencing localized lateral movement or upconing of the lower quality water. However, current analysis also suggests that the increases are controlled by the rates of ground-water withdrawals from those well fields specifically, and that no other users are significantly affected. Although the District is concerned about effects on the well fields' ability to produce potable public supply water in the future, the assessment and management plan for the well fields can best be addressed through the Chapter 40D-2, F.A.C. water use permitting process. Therefore, as long as current drawdowns in the Upper Floridan aquifer near these areas are not increased, significant advancement of regional seawater intrusion is not expected. In fact, plans for the

Eldridge-Wilde well field include reductions in ground-water withdrawals for lake and wetland recovery purposes, which should provide some remedy to local water quality concerns.

Finally, Section 373.042(3)(1996 supp.) of Florida Statutes requires that the District focus its initial implementation of Minimum Levels in priority areas. Although the District is concerned about protecting all areas from seawater intrusion, the current data and conceptualization of the Northern Tampa Bay area do not support a great concern for seawater intrusion in coastward sections of Hillsborough County where withdrawals are minimal, or in all of Pasco County. Therefore, the District has established Minimum Levels in the Eldridge-Wilde and Northwest Hillsborough Regional well field areas, and future analysis performed by the District and others will determine the need for additional Minimum Levels in other areas.

4. Establishment of Seawater Intrusion Minimum Levels

Given the goal of preventing further significant advancement of regional seawater intrusion, the District has established levels in coastward transects of wells whose water levels define the existing hydraulic gradient and heads of the Upper Floridan aquifer potentiometric surface. The hydraulic gradient and heads established for Minimum Levels represents the current long-term water levels associated with existing drawdown conditions in the Upper Floridan aquifer. It is this gradient and heads that is responsible for the current degree of seawater intrusion. Therefore, if these long-term average heads are maintained, significant seawater intrusion beyond that estimated in current analyses should not occur.

Following a thorough assessment of all existing Floridan aquifer wells in the area of the Eldridge-Wilde and Northwest Hillsborough Regional well fields, seven wells in two transects were chosen for the establishment of Minimum Levels (Table 1). The locations of these wells are shown in Figures 6 through 8. The transects span from the Eldridge-Wilde and Northwest Hillsborough Regional well fields toward the coast. The wells were chosen based upon their ability to represent the potentiometric gradient between each well field and the coast, as well as the availability of data for each well.

Because any advancement of seawater intrusion is controlled by the long-term gradient and heads, rather than the gradient on any particular day, month, or year, the Minimum Levels were determined by averaging the water levels measured in each well over many years, representative of the current withdrawal rates. Likewise, compliance with the Minimum Levels should also be based on long-term averages. "Long-term" is defined as a period which spans the range of hydrologic conditions which can be expected to occur based upon historical records. Ten years of data was used in most wells, however, data limitations in some wells required the use of only six years in two wells. The Minimum Levels determined are presented in Table 1. The data used for the analysis are presented as hydrographs in Figures 9 through 15.

5. References

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Table 1. Wells proposed for Seawater Intrusion Minimum Levels.

Well Name	Total Depth	Casing Depth	Period of Record	Period used for Minimum Level	Seawater Intrusion Minimum Level (feet NGVD)
NW Hillsborough Regional well field area					
Sheldon Road Deep (RMP-16D)	330	315	1973-1998	1988-1997	7.7
RMP-13D	150	100	1987-1998	1988-1997	16.4
RMP-8D1	112		1987-1998	1988-1997	26.8
Eldridge-Wilde well field area					
Tarpon Rd Deep	305	205	1973-1998	1988-1997	9.9
SWI-18S	609	510	1992-1997	1992-1997	14.8
201-M	684	144	1992-1997	1992-1997	13.7
EW 2S Deep	290	61	1973-1998	1988-1997	10.3

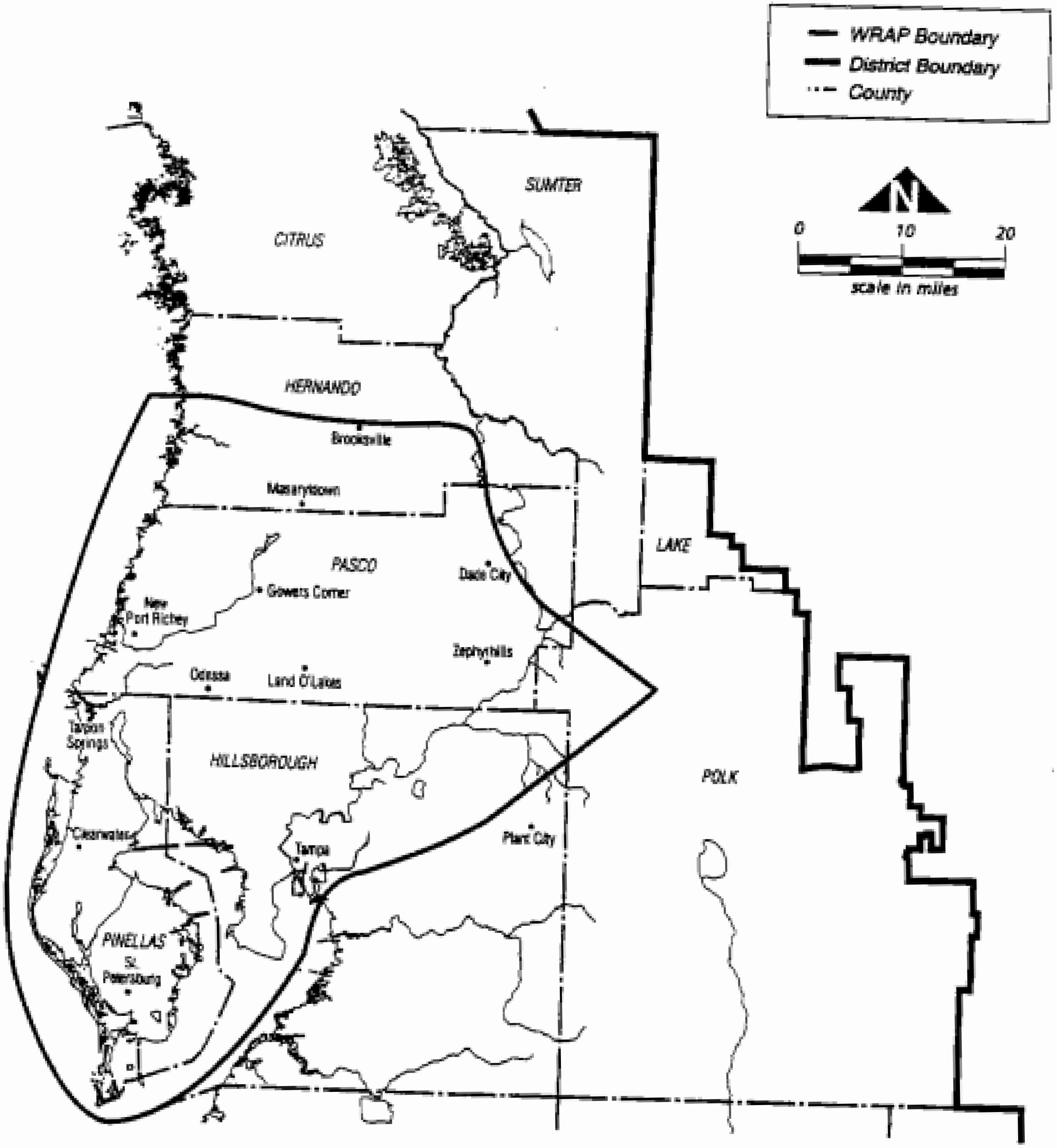

Figure 1. Location of the Northern Tampa Bay Water Resources Assessment Project area.

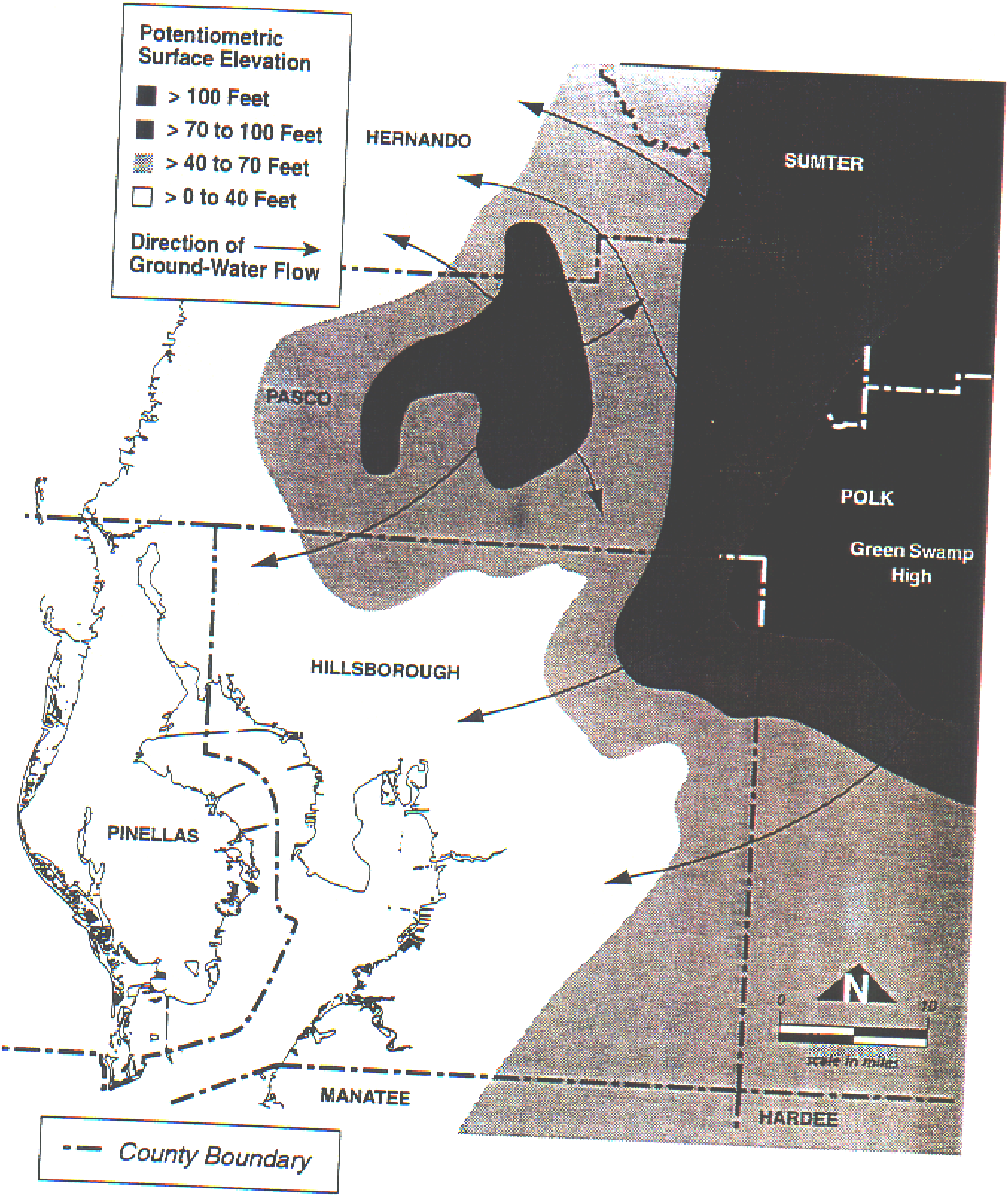

Figure 2. Regional Ground-water Flow in the Floridan Aquifer in the Northern Tampa Bay area.

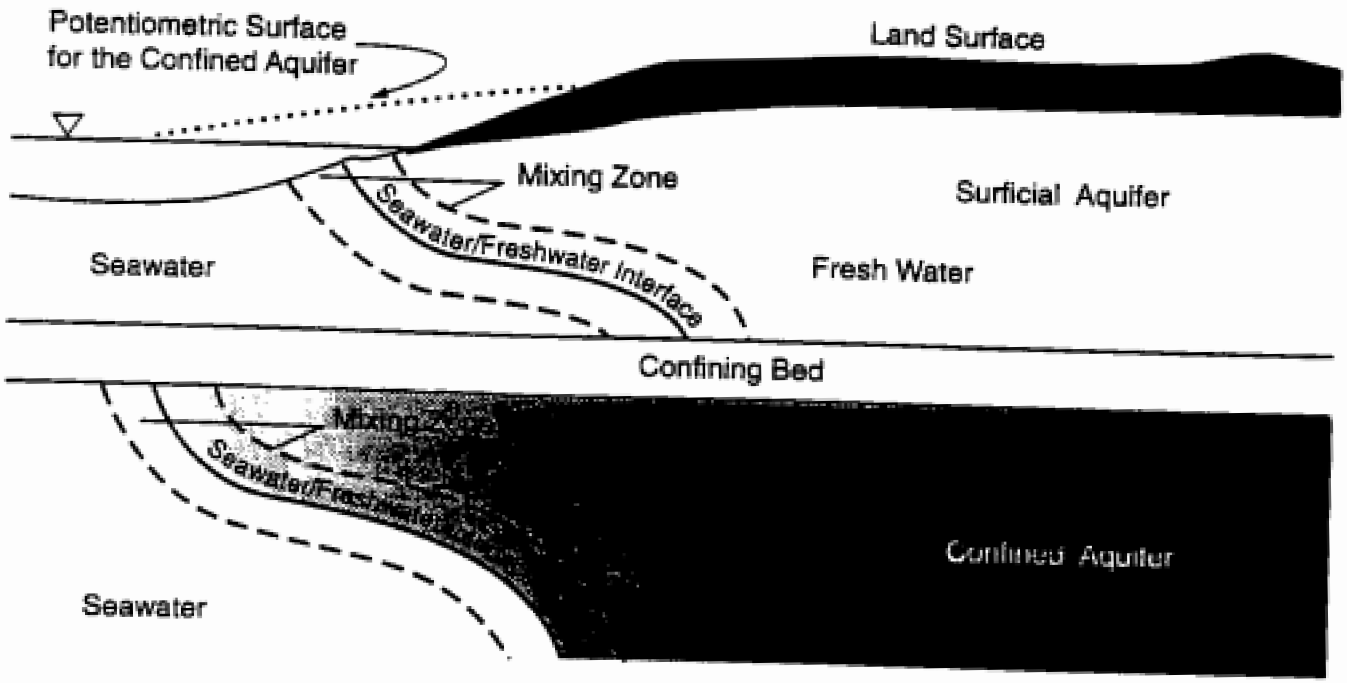

Figure 3. Generalized cross-section of the seawater-freshwater interface in a confined and unconfined coastal aquifer system.

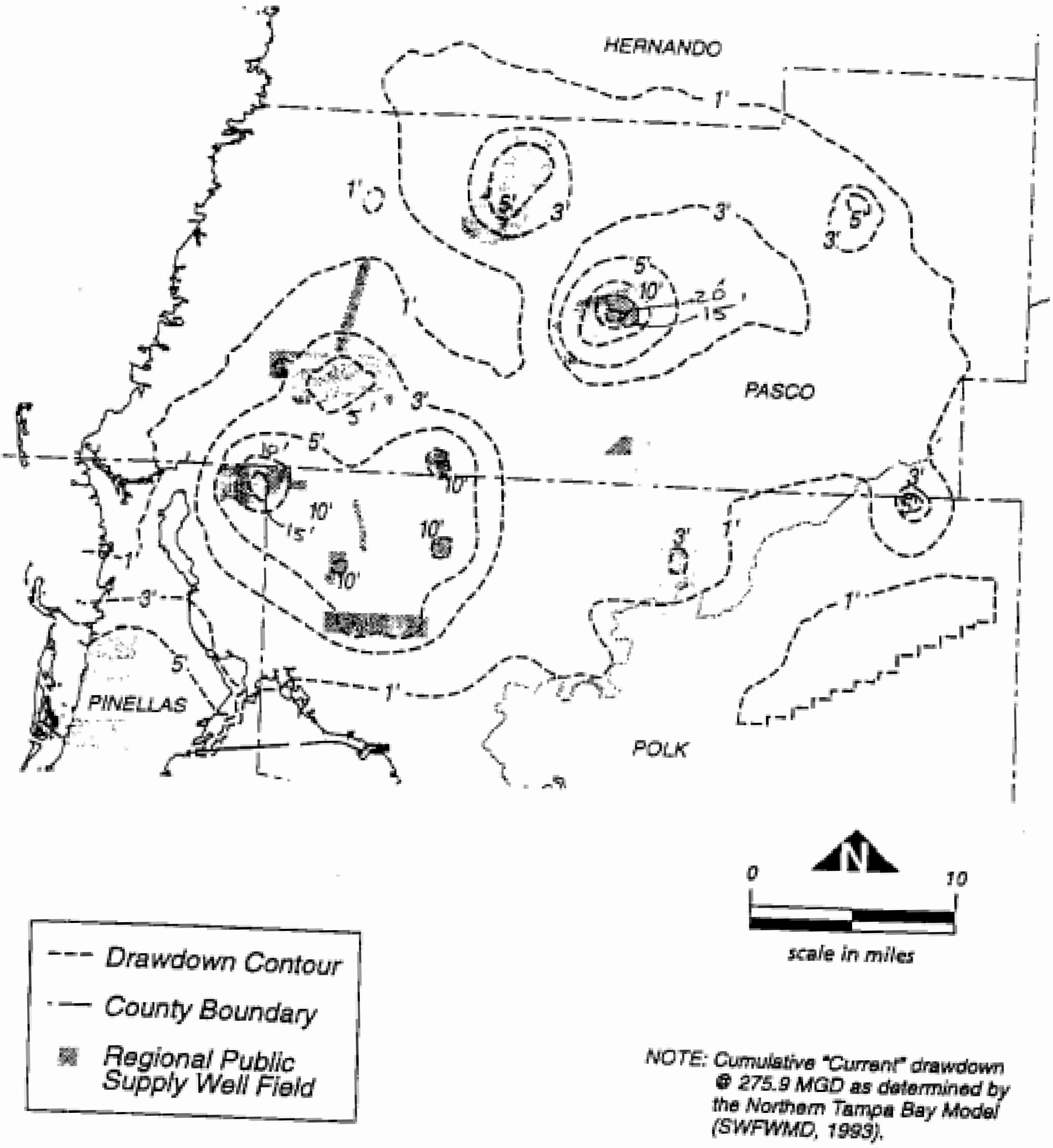

Figure 4. Cumulative Floridan aquifer drawdown in the Northern Tampa Bay area.

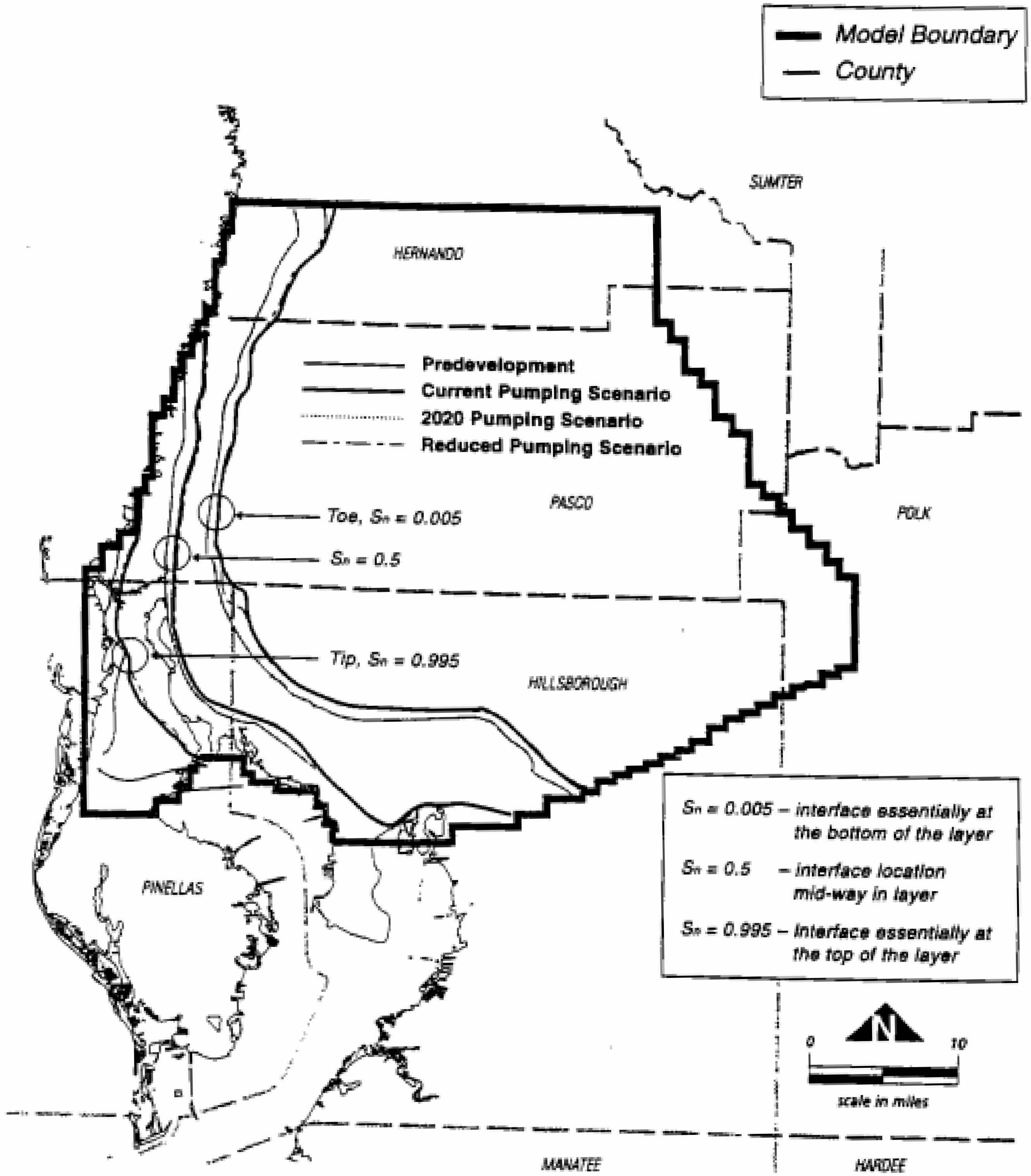

Figure 5. Comparison of interface position in the Avon Park layer between three pumping scenarios and predevelopment conditions (modified from HydroGeoLogic, 1994).

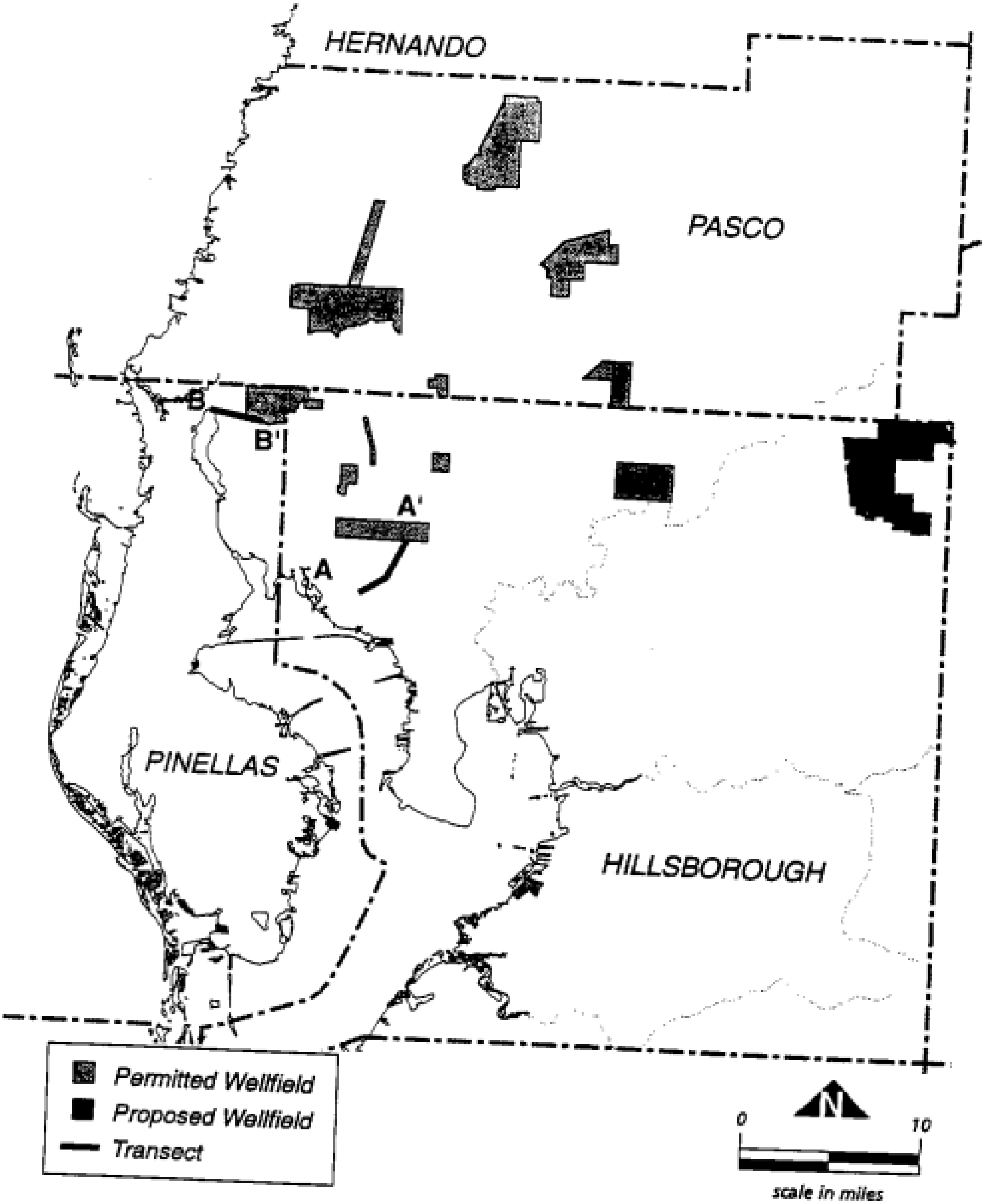

Figure 6. Seawater intrusion minimum well transects for Northern Tampa Bay.

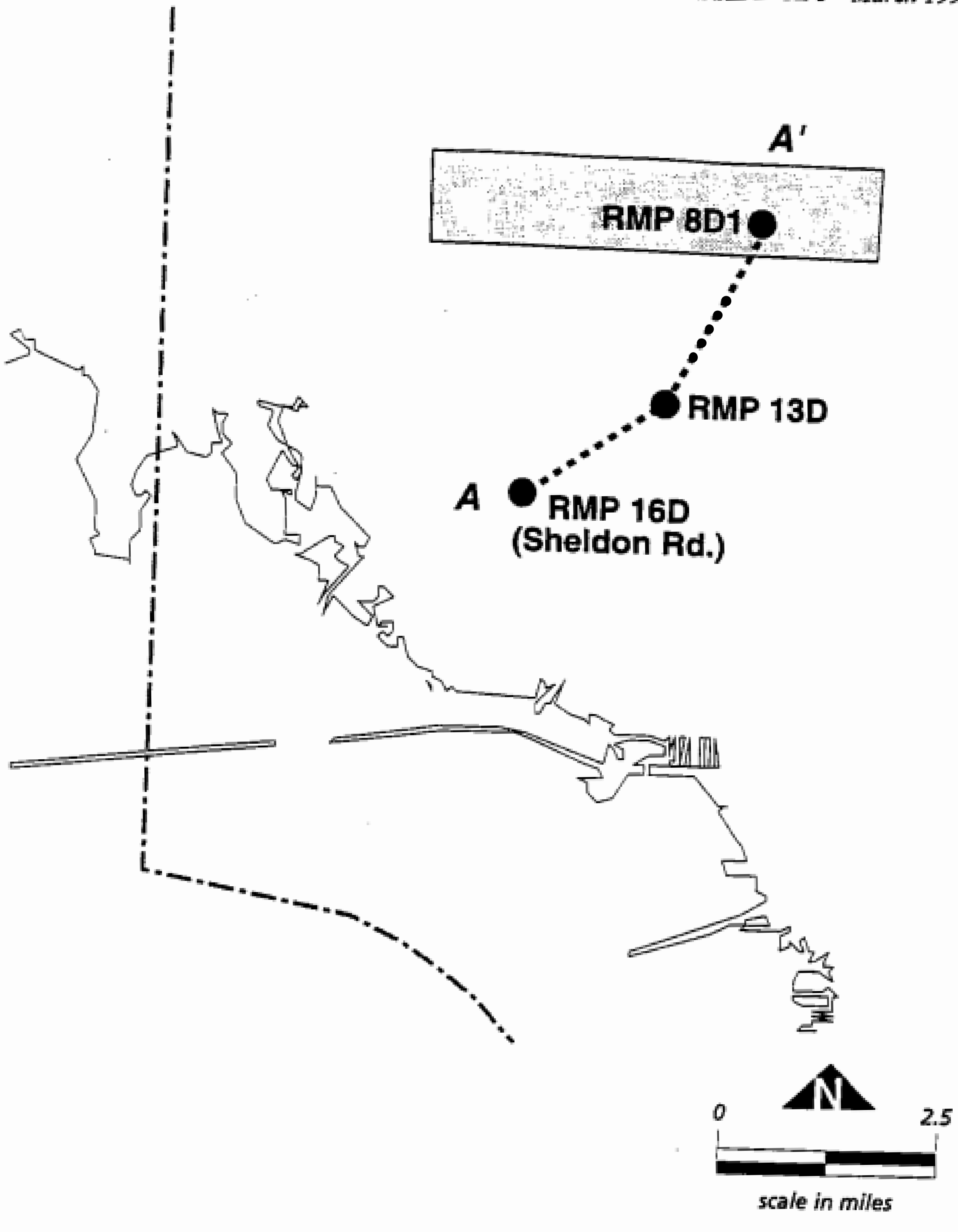

Figure 7. Seawater intrusion minimum level well transect — NW Hillsborough Well Field area.

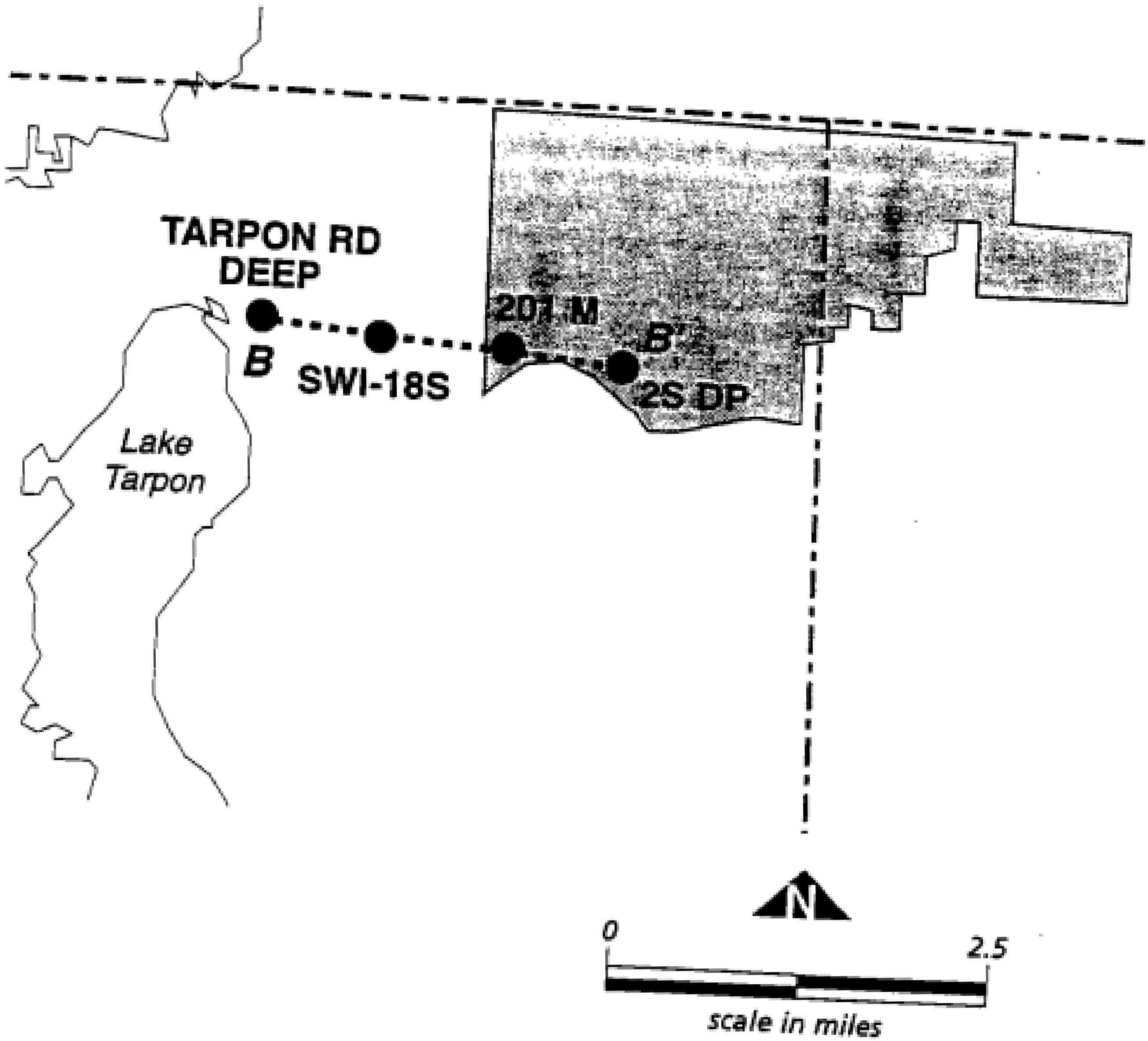

Figure 8. Seawater intrusion minimum level well transect — Eldridge-Wilde area.

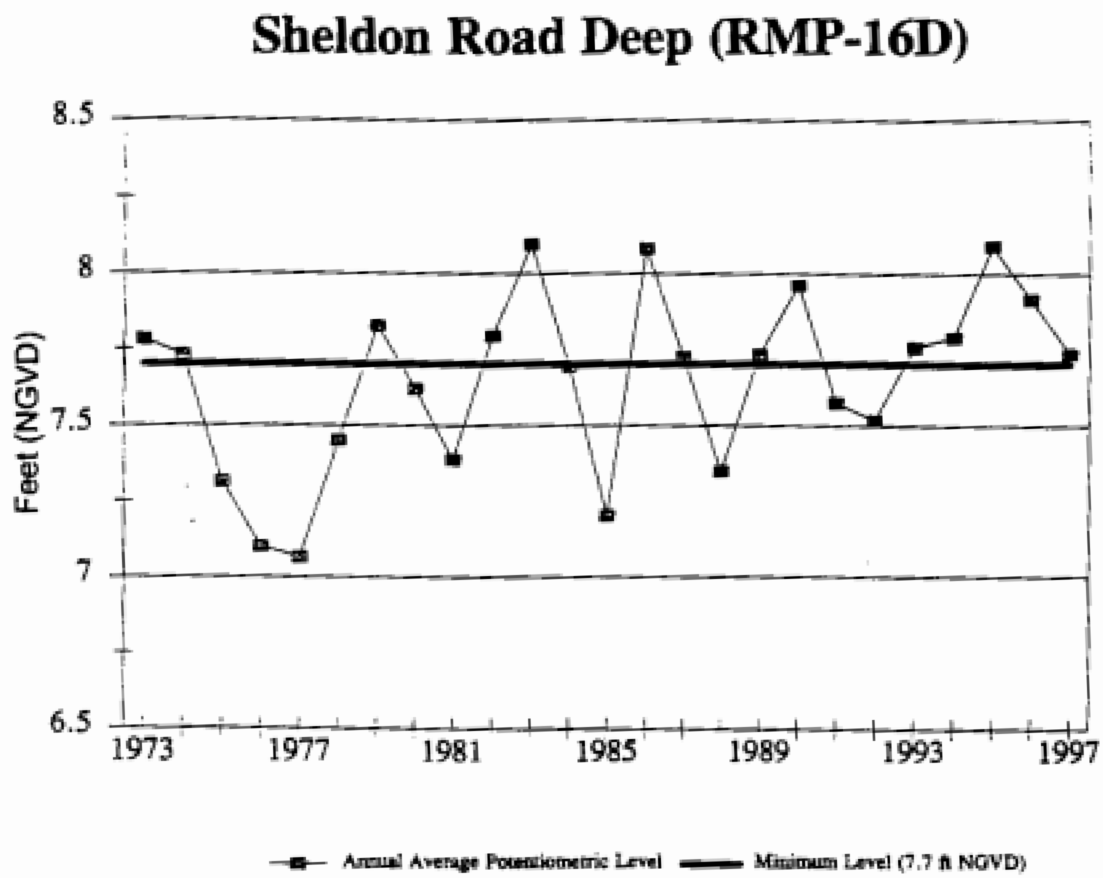

Figure 9. Hydrograph of the Sheldon Road Deep (RMP-16D) Floridan aquifer monitor well.

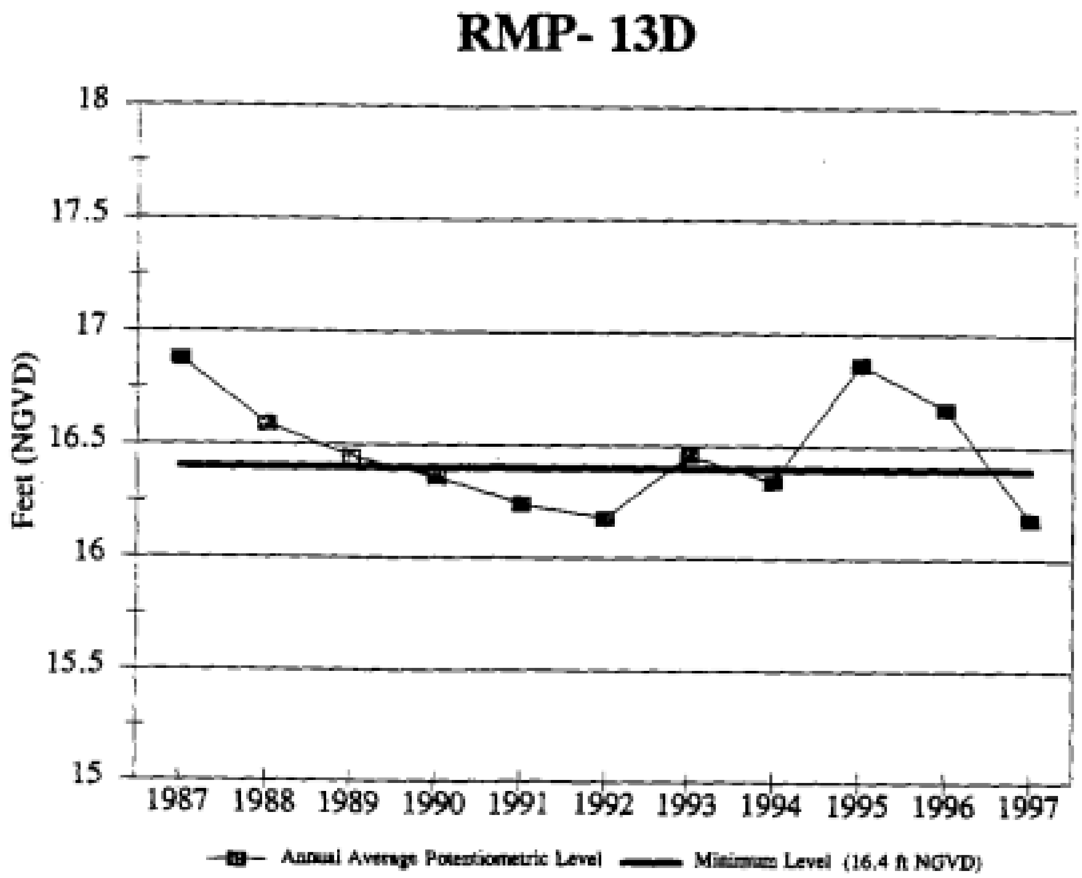

Figure 10. Hydrograph of the RMP-13D Floridan aquifer monitor well.

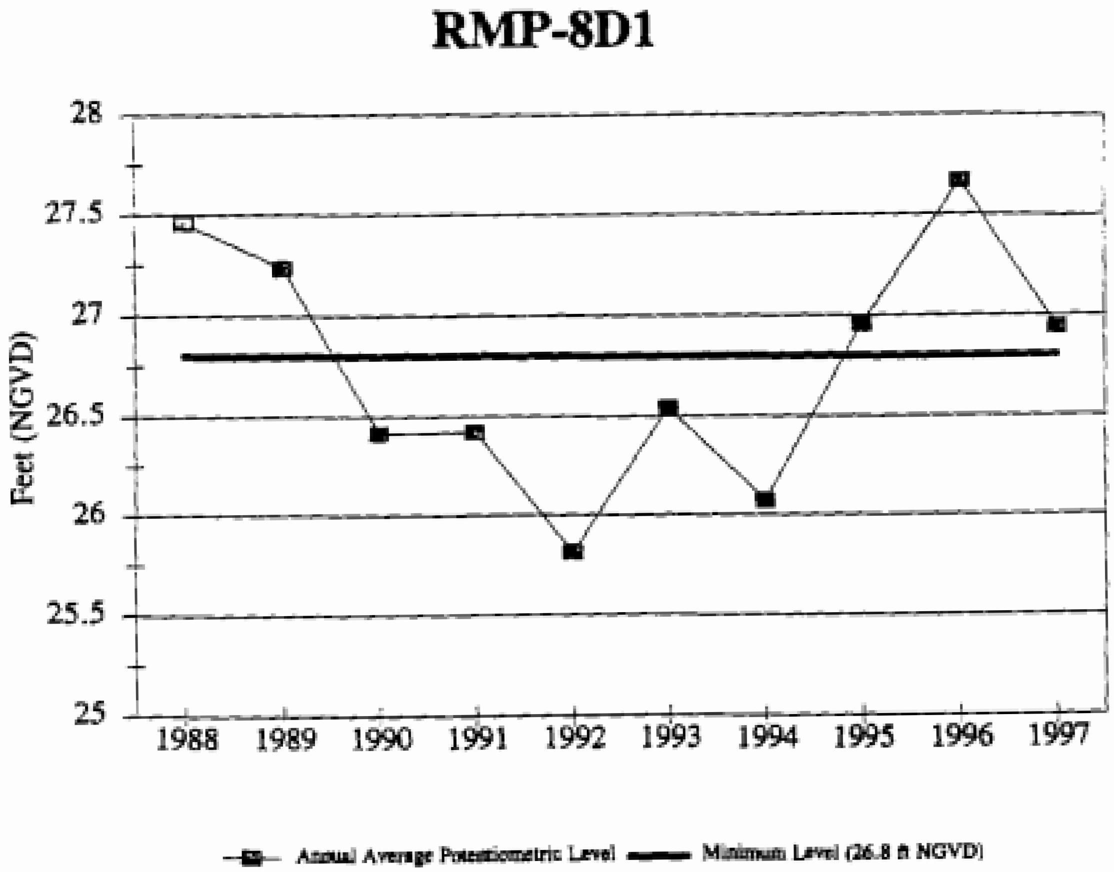

Figure 11. Hydrograph of the RMP-8D1 Floridan aquifer monitor well.

Tarpon Road Deep

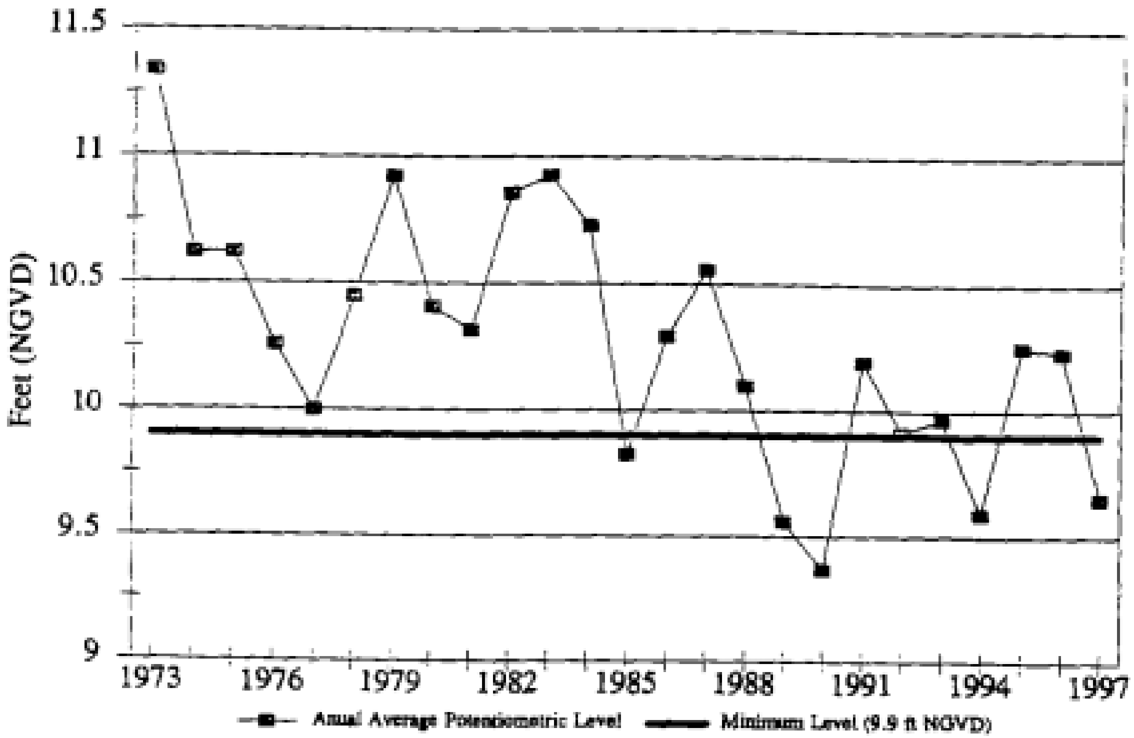

Figure 12. Hydrograph of the Tarpon Road Deep Floridan aquifer monitor well.

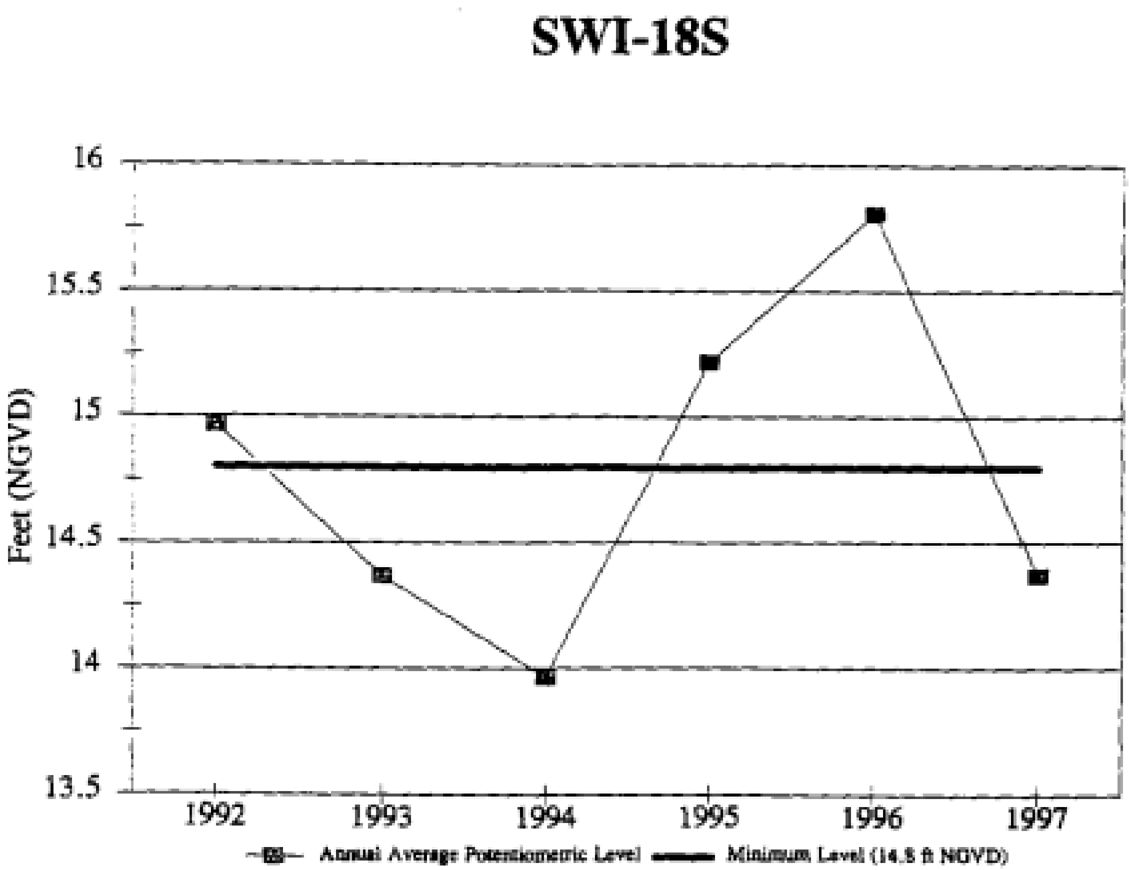

Figure 13. Hydrograph of the SWI-18S Floridan aquifer monitor well.

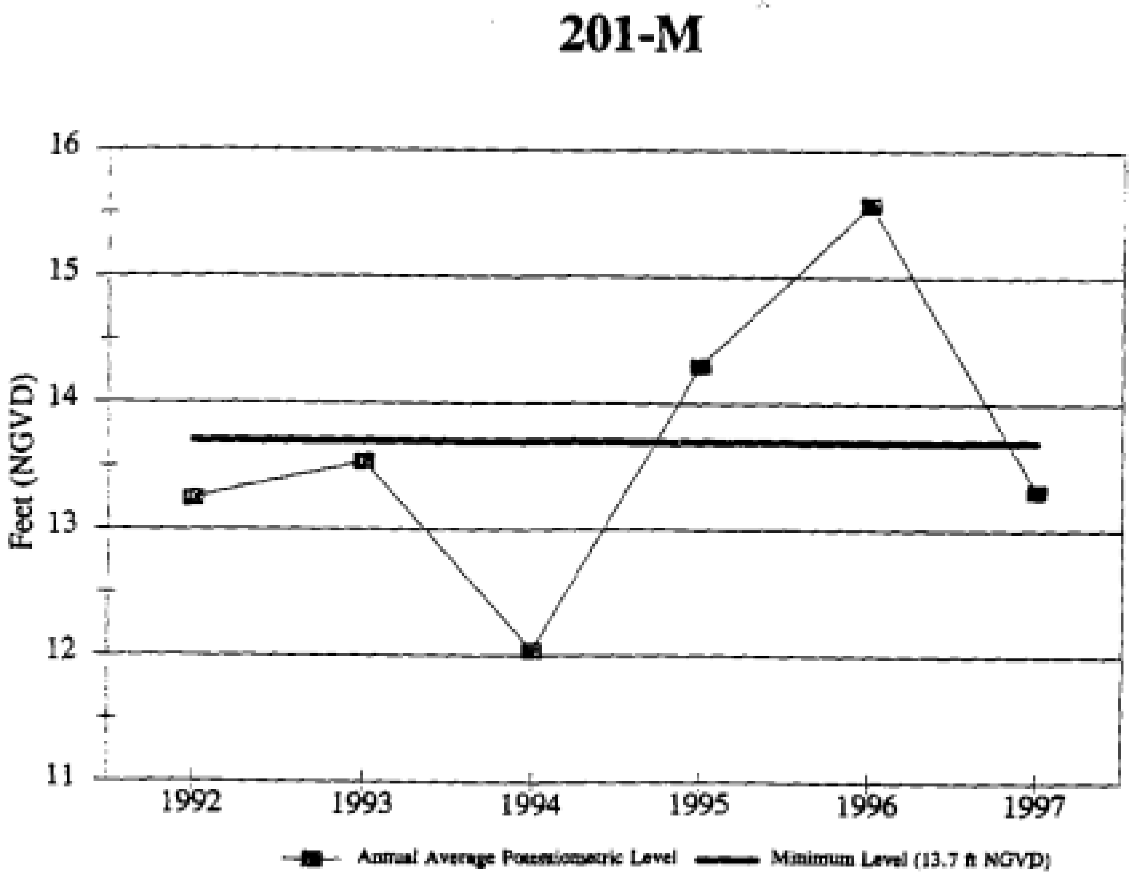

Figure 14. Hydrograph of the 201-M Floridan aquifer monitor well.

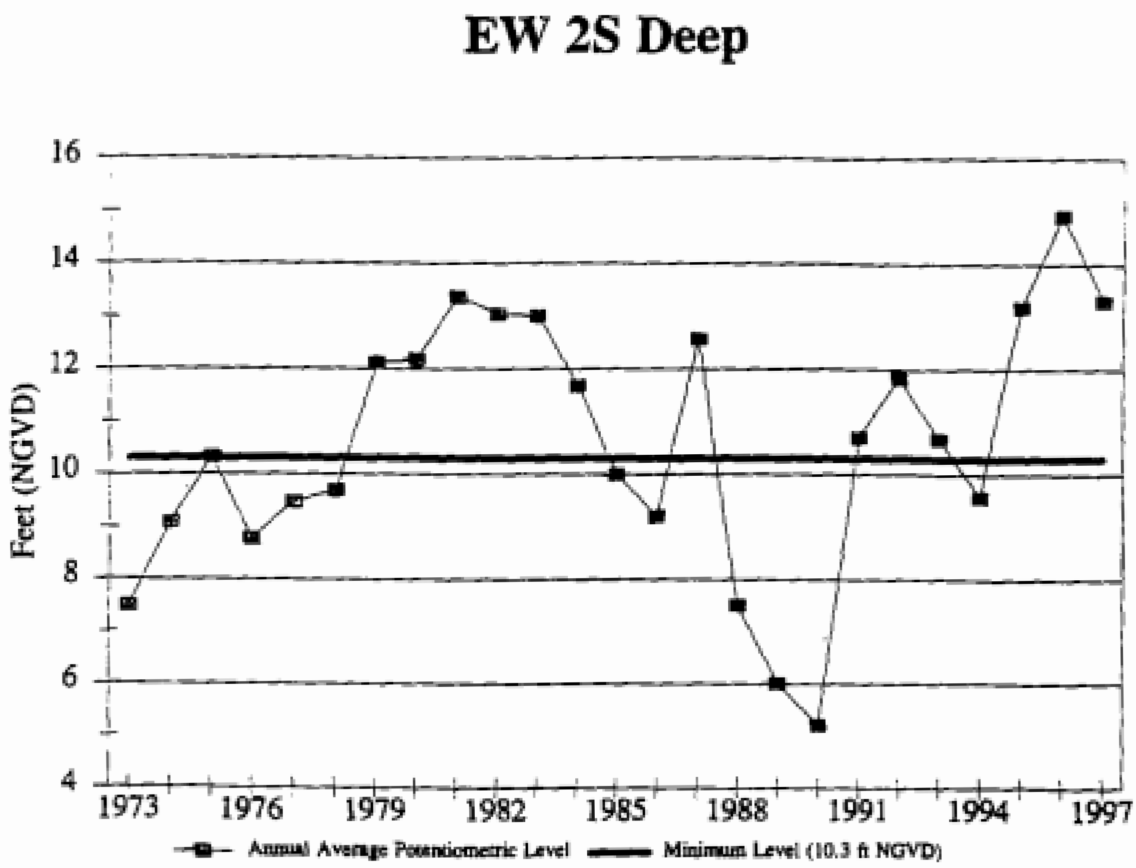

Figure 15. Hydrograph of the EW 2S Deep Floridan aquifer monitor well.