Roanoke Island

1993 Ground Water Monitoring Report

North Carolina
Department of Environment, Health, and Natural Resources

Division of Water Resources

May 1994

Roanoke Island 1993 Ground Water Monitoring Report

INTRODUCTION

Background

The Town of Manteo developed a list of ground water management concerns in Resolution #11-92 dated August 5, 1992. Among other issues, the Resolution identified possible over-pumping of the aquifer beneath Roanoke Island supplying ground water to private residents in Wanchese and to the Dare Regional Water Supply System, saltwater intrusion potential, loss of Reverse Osmosis facility production capacity, and the lack of safe yield estimates for the aquifer beneath Roanoke Island. Manteo asked the Environmental Management Commission (EMC) to investigate.

At the request of the EMC the Division of Water Resources contacted ground water users, gathered information from the Dare Regional water system, and prepared a report, dated October 7, 1992, with recommendations to the EMC and to the water users. Those recommendations were as follows: 1) Improve communication between Dare Regional System and its customers, 2) Evaluate the "A" day agreement with North Carolina Power, 3) Examine residential well construction used in Wanchese, 4) Monitor the effects of ground water withdrawal on Roanoke Island using a well network, 5) Investigate water quality concerns with the assistance of the Public Water Supply Section, 6) Establish effective water conservation measures, and 7) Use the local water supply planning process supported by DWR.

DWR initiated a work session, held on November 24, 1992 in Dare County, to discuss these recommendations. Representatives from Dare County, the Towns of Manteo, Kill Devil Hills, and Nags Head, and the Divisions of Environmental Health, Environmental Management, and Water Resources attended this meeting. The work session seemed to improve communication between the Dare Regional System and town officials. Participants were satisfied in the factual discussion of the issues and agreed that the findings of the State's investigation and results of the work session be made public to give citizens accurate information.

Attendees acknowledged that annual reporting of ground water levels and chloride concentrations was needed to give the public and local governments accurate information about this critical resource. Without reliable data upon which to base opinions or decisions, false impressions about the state of ground water resources can develop.

Monitoring Report

With the help of Division of Environmental Management (DEM) employees in the Washington Regional Office, Dare Regional System staff collected data from a series of monitoring wells on Roanoke Island. Those wells were constructed in the early 1970s and early 1980s to monitor effects produced by Skyco water plant supply wells. However, DEM staff infrequently measured water levels between 1986 and 1992. As a result, water level data does not exist for a period of

time in 1992 when Wanchese residents experienced declines in private well water levels.

Many Wanchese residents use well and pump systems that are not compatible. Their wells tap the upper Yorktown aquifer at depths of 160-200 feet below land surface. Water is drawn from the well using a shallow-well pump capable of drawing water from about 20-30 feet down. As ground water levels are drawn down by the County system (especially during the summer months), the levels in the wells drop below the ability of the shallow-well pump to draw water. If a deep-well pump system is used in the private wells, then the lowered water levels caused by the County pumping would not affect Wanchese residents.

DWR research of DEM and County records showed that the reported problems continue to occur because of inadequate water pumps and plumbing. These problems, in combination with drawdowns resulting from water production at the Skyco water plant, illustrated the need for a monitoring network, methods of analyzing the data produced, and a reporting procedure.

This report analyzes the ground water situation in the vicinity of the Skyco water plant. Skyco production is highly dependent upon volumes of water generated through the two other sources in the Dare Regional System. Therefore, it is important to discuss briefly the relationship between those sources.

Overview of Dare Regional Water Supply System

The Dare Regional Water Supply System provides water to Nags Head, Kill Devil Hills, Manteo, and Dare County. Dare County sells its portion to Kitty Hawk, Southern Shores, Duck, and other customers on northern Roanoke Island outside Manteo's city limits. Three sources of water supply the Dare Regional System. The Fresh Pond is a surface source located between Kill Devil Hills and Nags Head. The Skyco water plant draws ground water from the upper Yorktown aquifer using wells on Roanoke Island. The Reverse Osmosis (RO) facility treats saline ground water from the middle Yorktown aquifer pumped by wells located in Kill Devil Hills. All this water is transported via a single transmission line. At various points along this line, tanks provide over 13 million gallons of water storage.

Fresh Pond

The Fresh Pond, a 27-acre surface water supply on the Outer Banks, was developed as a public water source by Kill Devil Hills and Nags Head in the early 1960s. By 1969 it was determined to be insufficient for expected demands. As the Skyco plant began operation in 1980, the Fresh Pond facility stopped production and was kept in emergency reserve. In 1985, after extensive renovation, the Fresh Pond facility reopened with a maximum daily output of 1.5 MGD. In recent years this water plant has operated during summer months to accommodate peak demands.

Skyco Water Plant

The Skyco water plant uses sodium ion exchange treatment for water softening and came on line in August 1980. Freshwater is pumped from the upper Yorktown aquifer at a depth of 170 to 220 feet below sea level by 10 wells. Production capacity of the treatment plant is 5.0 MGD. Maximum capacity is listed as 5.885 MGD to meet peak demands. For some days in the summer of 1983, Skyco was operated at its maximum production rate. Concurrently, water levels in many private Wanchese wells fell below each pump's capability to draw water. After deliberation on complaints beginning in 1981, the County determined that Skyco pumping was in part responsible. These private wells were replaced or new wells were drilled at the County's expense. Where one

well had been shared by up to five houses, new wells were drilled for each house to alleviate the problem.

By 1989 peak regional daily water use reached 6.0 MGD. This demand was met by Skyco and the refurbished Fresh Pond. After the RO plant began production in 1989, and prior to summer 1992, demand for Skyco water dropped 50-60 percent. According to the Dare Regional Water Supply System report for 1991, private well complaints on the south end of Roanoke Island were virtually nonexistent during this period of reduced pumping on Roanoke Island.

However, in the spring of 1992 with the completion of a Missimer & Associates report, the RO plant production was cut back to a maximum of 2.0 MGD and the Skyco plant met the remaining demand. In 1992 Skyco exceeded 5.0 MGD water production several times and will be expected to do so in the future until the RO facility wells can be upgraded.

Reverse Osmosis Plant

The RO water plant came on line in August 1989. Saline water is pumped from eight wells screened from 325 to 425 feet below sea level in the middle Yorktown aquifer. Those eight wells feed three RO units each capable of producing 1.0 MGD (total capacity of 3.0 MGD). In the past three years pumped raw water has become more saline due to upconing of saltier water from a lower, brackish aquifer. Dare County has plans to install an additional set of two wells south of the original eight to decrease the stress on the aquifer and slow saltwater intrusion. This countermeasure was suggested by Missimer & Associates in their 1992 report. Until new wells are installed, the RO plant will be limited to 2.0 MGD summer production and 1.0 MGD winter production levels.

The RO plant participates in a power rate schedule known as "10" which saves them money when they curtail electrical usage during peak summer days or during peak winter days. Under this plan the RO plant is shut down during "A" days when electricity is expensive and the Dare Regional System relies more heavily on the Skyco water plant.

DATA COLLECTION AND INTERPRETATION

Data Collection

Dare County, with DEM's cooperation, began measuring water levels and collecting water samples from five pairs of wells located on Roanoke Island in April of 1993 (Table 1). Each pair of wells was constructed by DEM in the early 1970s or early 1980s to analyze aquifer framework and to measure the water level drawdown caused by the Skyco Water Plant withdrawals from the upper Yorktown aquifer. One well in each group is screened in the surficial aquifer and the other is screened in the upper Yorktown aquifer. One group of wells is located north of the Skyco well field, another in the well field, and three pairs of wells are located south of the well field in Wanchese (see Figure 1).

A portion of the aquifer framework based on data from these monitoring wells is shown in Figure 2. Cross-section A-A' illustrates the relationship between the surficial, upper Yorktown, and middle Yorktown aquifers along a north-south traverse of the island. Typical well depths, locations, and correlation to the Skyco well field are also shown on Figure 2.

Water samples from many of the monitoring wells were analyzed for their chloride content. Besides drawdown effects from the County well field, chloride analysis of water samples might help quantify the stress on the aquifer system. For example, a rise in chloride concentrations at a particular monitoring well during higher water use months may indicate that pumping rates have exceeded the upper Yorktown aquifer's yield.

Table 1. EHNR Monitoring Wells used by Dare County

Well Name	Map ID -- DEM Quad Location	Date of Construc-tion	Aquifer	Top of Screen (feet below land surface)	Bottom of Screen (feet below land surface)
Skyco	J3F4	unk	Surficial	unk	unk
Skyco	J3F3	7/26/72	upper Yorktown	198	208
Manteo Airport	I4V5	3/27/84	Surficial	12	17
Manteo Airport	I4V3	9/12/72	upper Yorktown	148.5	158.5
Wanchese Community Center	J3X9	10/20/83	Surficial	12.6	17.6
Wanchese Community Center	J3X13	11/30/83	upper Yorktown	170.3	180.3
Convict Pit	J3X20	3/22/84	Surficial	5.6	10.6
Convict Pit	J3X17	2/29/84	upper Yorktown	162.3	172.3
Eason	J3Y8	8/24/83	Surficial	9.6	14.6
Eason	J3Y5	8/17/83	upper Yorktown	171	181

Figure 1. Roanoke Island - Skyco Water Plant

Dare Regional Water System

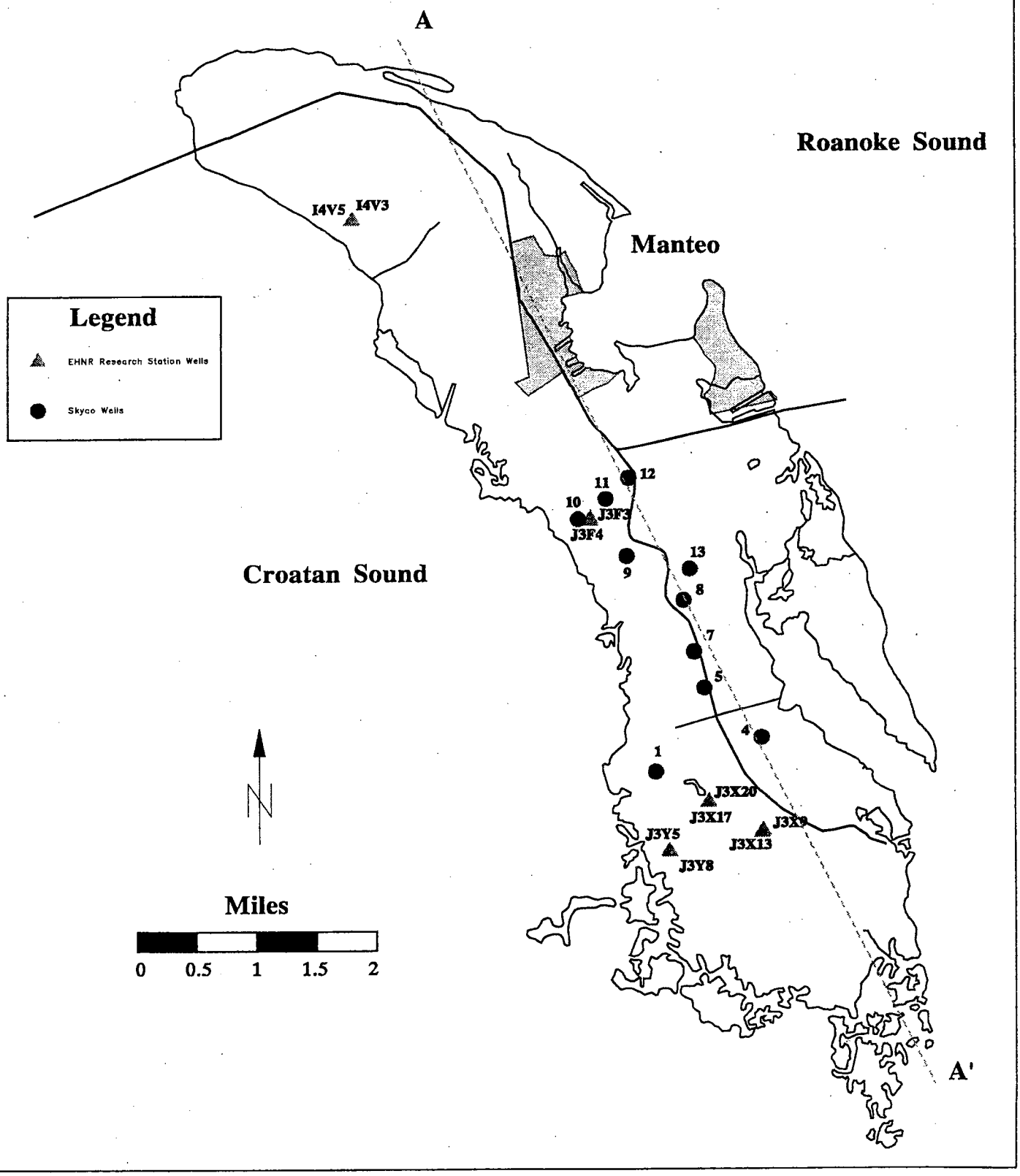
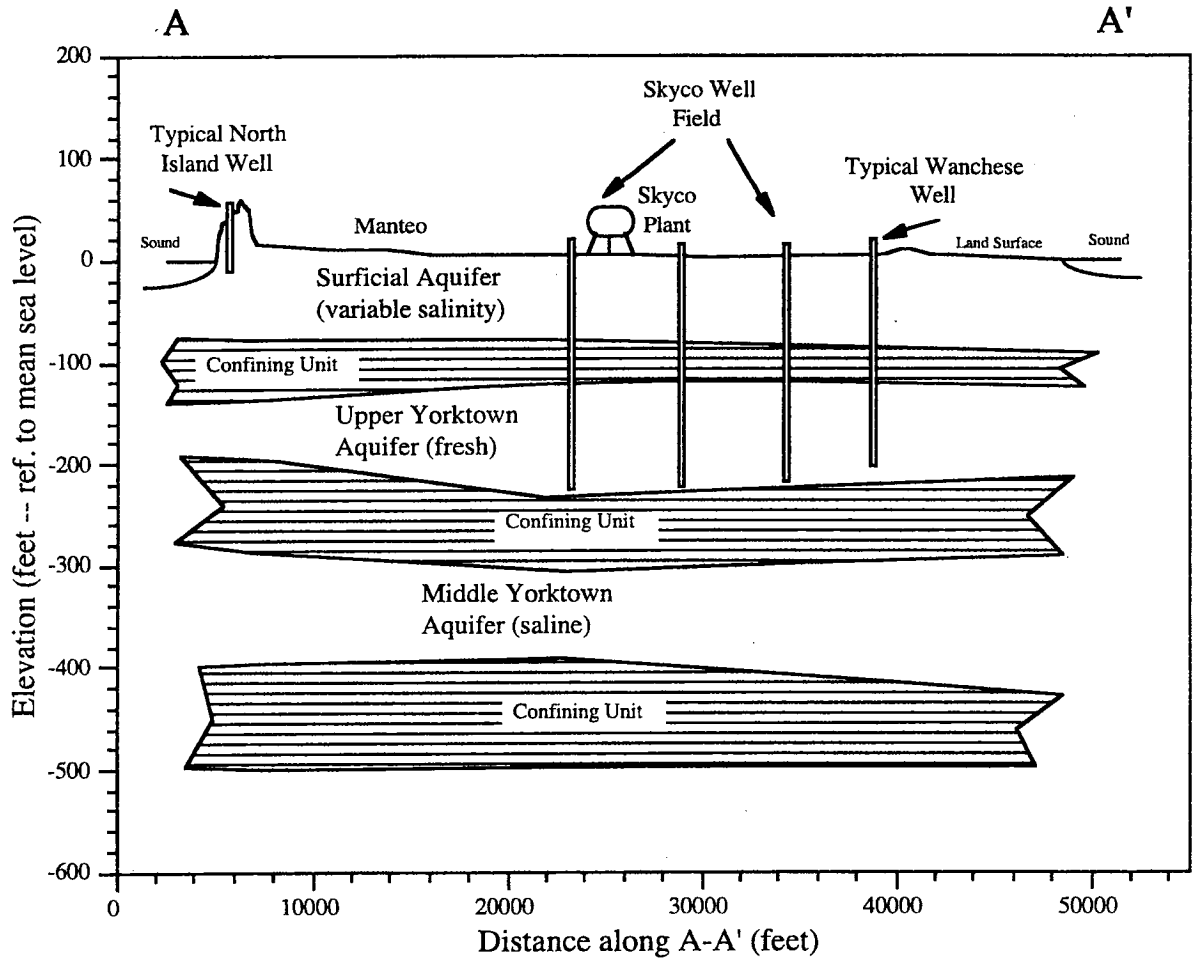


Figure 2. Aquifer framework in cross-section A-A'



Results and Interpretation

Water levels in these monitoring wells are shown in a series of graphs in Appendix A (Figures A-1 through A-20). Each page contains two graphs, one for the surficial aquifer well and the other for the upper Yorktown aquifer well. The first set (Figures A-1 to A-10) contains all water level data and chloride analysis data for that well from 1973 through January 1994. Because data from 1993 are most critical and some of these plots are quite crowded, the second set (Figures A-11 to A-20) for the same wells spans January 1993 to January 1994 only.

Depth below land surface increases downward on the left-hand y-axis as does chloride concentration on the right-hand y-axis (please note the different scales). Years or months progress from left to right on the x-axis. For example, on Figure 3 the deep Skyco monitoring well shows a reduction of water level from about 10 feet below land surface in March 1993 to 25 feet below land surface in July and August 1993. Chloride concentrations appear to be unaffected by the drawdown of water levels (although some data is missing) and remain at about 50 milligrams per liter (mg/l). The drinking water standard for chloride is 250 mg/l.

Figure 3. Skyco Deep (J3F3)

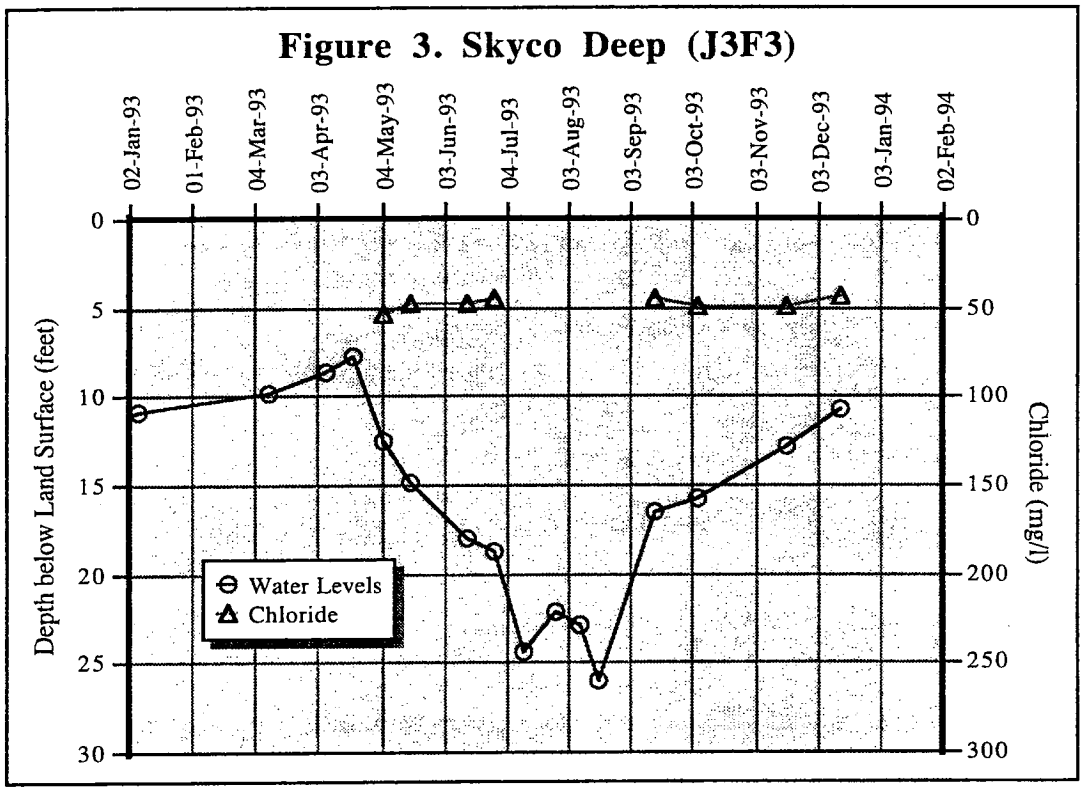


Figure 4. Raw Water Pumped

Skyco Water Plant

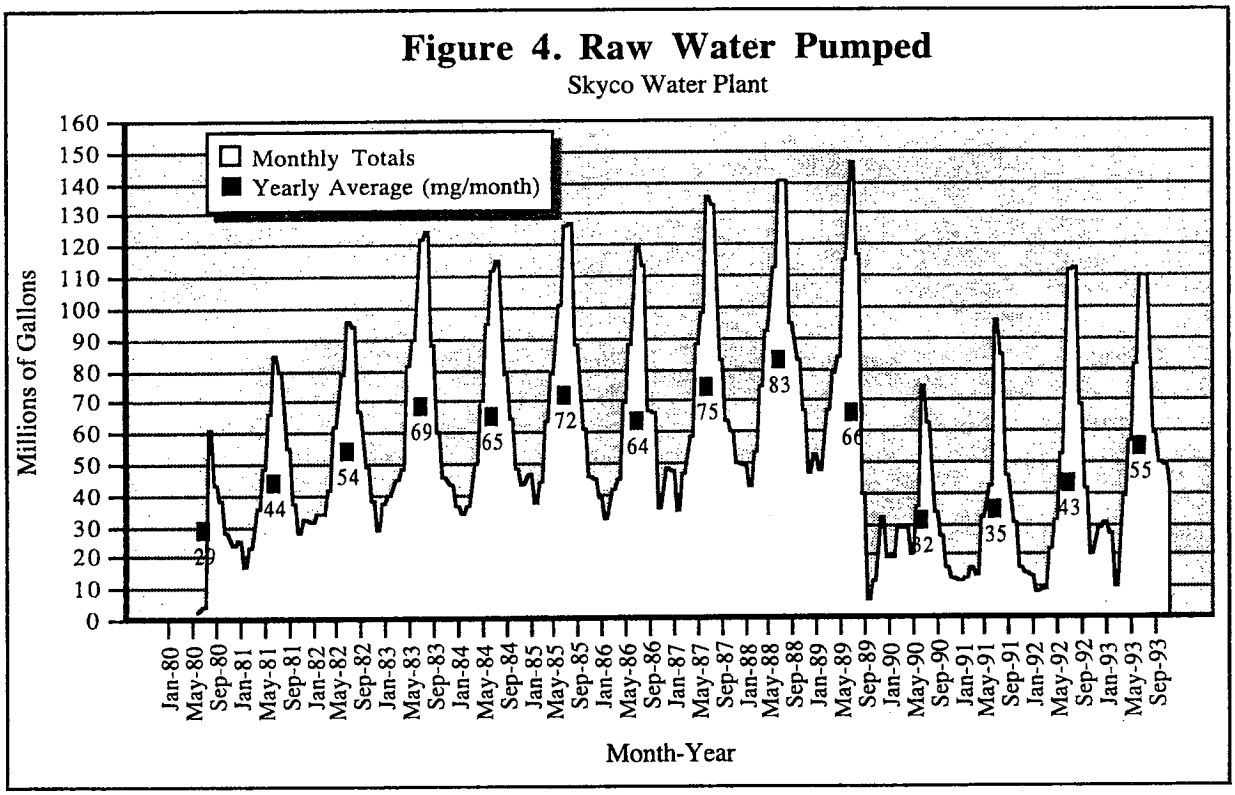


Figure 5. Skyco Deep (J3F3)

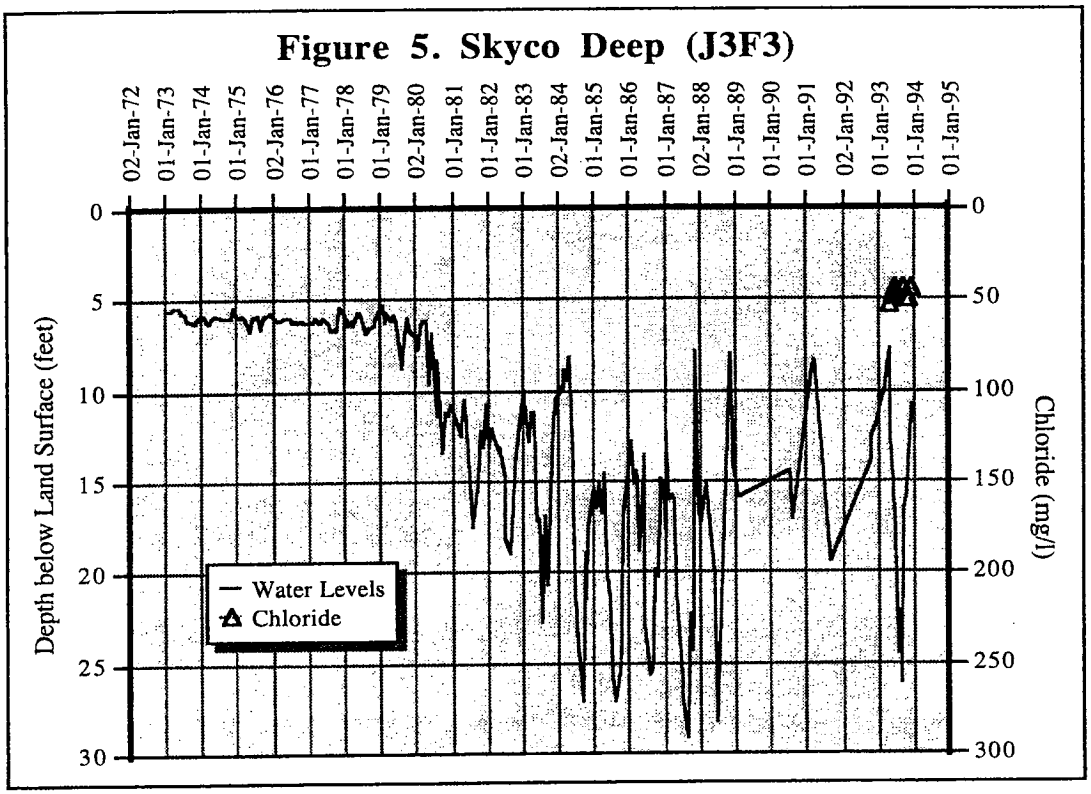
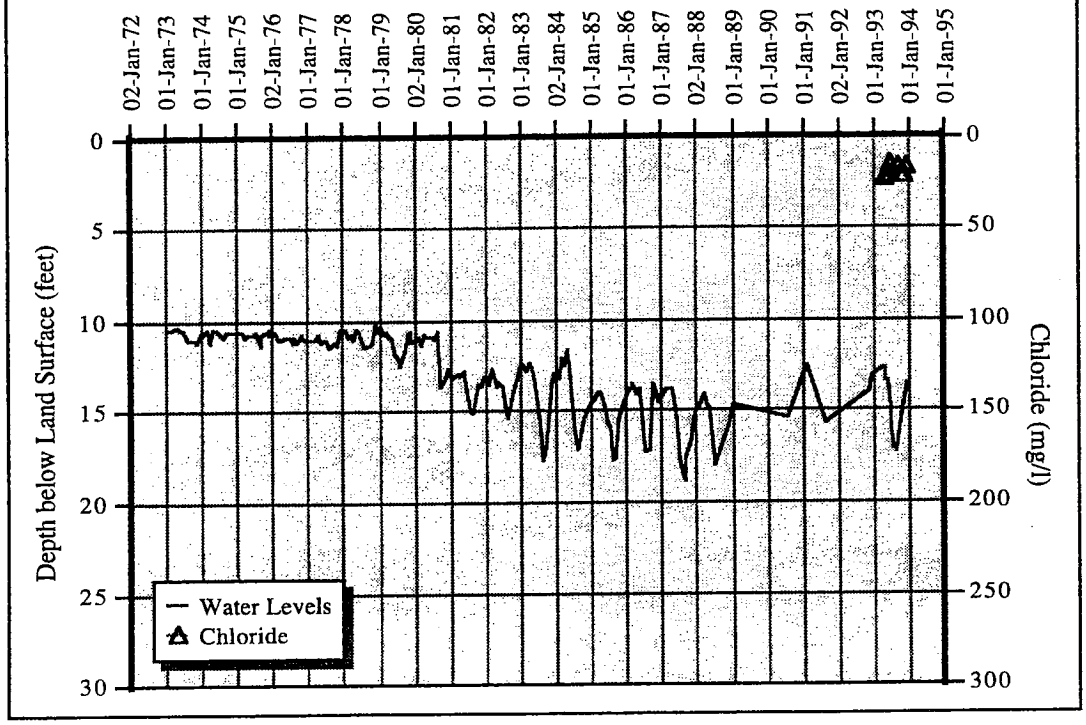


Figure 6. Manteo Airport Deep (I4V3)



It is significant to compare the monitoring well water levels to the total raw water pumped per month from the Skyco well field. The pumping volumes from 1980 through 1993, by month, are presented in Figure 4. The yearly average rate of pumping (millions of gallons per month) is also plotted in this figure. Notice the deepening levels of drawdown recorded at Skyco and Manteo Airport deep wells (Figures 5 and 6) from 1980 to 1988. This correlates to the gradual increase in pumping from Skyco recorded in Figure 4. Although the monitoring data is skimpy from 1988 through 1992 pumping data from Skyco suggest that water levels recovered as the RO plant came on line in 1989. Water levels began dropping again after the RO cut back production in 1992.

Water levels at the Skyco deep monitoring well (Figure 5) exhibited a maximum fluctuation during 1987 by dropping about 19 feet to 29 feet below land surface during the summer. Manteo Airport deep monitoring well (Figure 6) shows a maximum drop in water levels of about six feet from a winter high to a summer low. The Wanchese Community Center, Eason, and Convict Pit deep wells drop a maximum of 8 to 11 feet due to seasonal water usage changes. The cone of depression formed by the Skyco pumping is deepest near the withdrawal site and becomes more shallow radially outward.

The shallow monitoring well water levels fluctuated two to four feet except for one anomalous reading in 1987 at the Eason shallow well. These surficial aquifer levels did not correlate to the increased pumping or the drawdowns seen in the deep monitoring wells. This relationship suggests the two aquifers are hydraulically distinct. The shallow well fluctuations in water levels and chloride concentrations exhibited might represent tidal, local shallow ground water pumping, rainfall, or overwash influences. The Skyco shallow well (Figure A-11) illustrates a possible overwash event during 1993 because of the increase in chloride concentration.

Figures A-11 through A-20 show water level and chloride changes last year. A closer look at 1993 with a monthly time scale may help clarify the relations between water levels in each aquifer, drawdowns and pumping volumes at Skyco, and withdrawals and movement of saline ground water.

The Skyco deep well showed the largest drawdown with a 15-foot change in water level between April and July or August. Manteo Airport deep well exhibited a five foot drawdown and the three southern deep wells had water levels drop about 10 to 12 feet. Water samples from the upper Yorktown wells show chloride levels that were unaffected by the pumping and associated drawdown. The Eason well (Figure 7) had the highest chloride concentrations of the five deep monitoring wells.

Figure 7 also showed a crest in the chloride content in November 1993. This feature was not associated with the pumping at Skyco, because the peak drawdown occurred three months previous to the chloride intrusion. The elevated levels of chlorides (about 200 mg/l) prior to the peak suggest that this well is contaminated by either surficial aquifer water which averages about 300 mg/l or by surface water. Also, the spike in the chloride levels (up to 1000 mg/l) suggests that the contamination is sporadic. Possible causes of contamination include: 1) sound overwash and contamination by surface water through an improperly constructed well; or 2) fluctuation in surficial aquifer chloride content and a leaky confining unit between the surficial and upper Yorktown aquifers. A leaky confining unit does not appear to satisfy the data presented in Figures 7 and 8. The surficial aquifer has a chloride content of about 300 mg/l which is not high enough to be a source for the upper Yorktown contamination. Figure 8 would show a corresponding high in chloride concentration similar to Figure 7 if the surficial aquifer was the source of the chloride. Data presented in Figure 7 may also be the result of both factors.

Figure 7. Eason Deep (J3Y5)

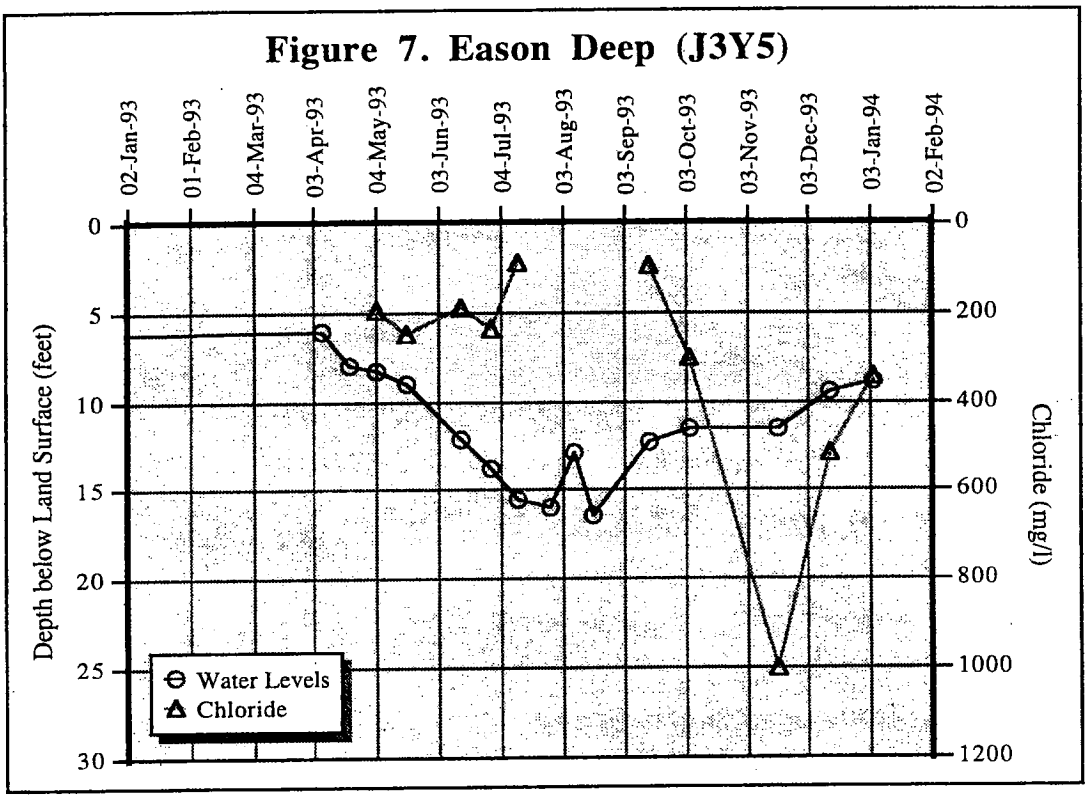
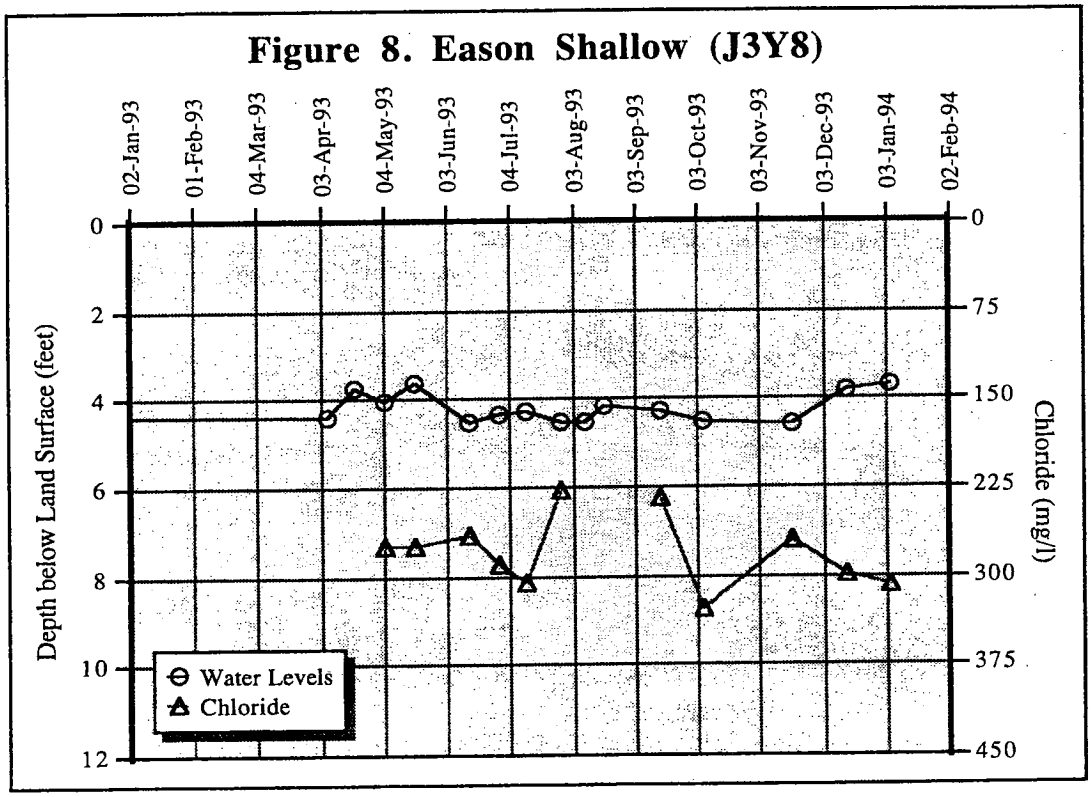


Figure 8. Eason Shallow (J3Y8)



Overall, water levels collected during 1993 seem to agree with those collected in previous years. There is no evidence to indicate that the aquifer system has changed hydraulically. The County reported significant numbers of well complaints in 1983 after increasing the peak monthly withdrawal from a high of 95 mg in 1982 to 123 mg in 1983. Complaints began again in 1992 after monthly withdrawals increased from a peak of 96 mg in 1991 to 112 mg in 1992. This suggests that monthly pumping between 96 and 112 mg or an average daily pumping of between 3.1 and 3.7 mg causes drawdowns to exceed shallow well pump and plumbing capacities in most of Wanchese.

DWR does not have the benefit of historical chloride data to compare to 1993 data; however, a coastal aquifer system usually shows the effects of stress with saltwater encroachment, as evidenced by increased salinity. The Eason monitoring well showing higher chloride levels is questionable. It is likely that chloride concentrations are being influenced by another source, either surface water, the surficial aquifer, or both. The County system does not appear to have stressed the upper Yorktown aquifer to the degree that chloride levels are rising in any of the other monitoring wells.

Examination of the data collected over the years from these monitoring wells reveals distinct water level fluctuations. Many of these changes reflect the pumping cycles from the Skyco water plant and wells. Some water level movement can not be satisfactorily explained and may require additional data collection. It is important to understand that part of the water level record is missing because water levels were recorded only once or twice a month. Frequency of monitoring is linked to the types of questions asked. For example, if the effects of pumps cycling on and off during a day are important, then a monthly sampling frequency will not provide a proper hydrograph to study. Collecting data too frequently will only require averaging at some later time during analysis. The once or twice a month sampling rate seems to give enough information about fluctuations occurring on a seasonal basis. The fall of water levels from a winter high to a summer low, reflecting the increased water use during the busiest season, is of most interest in the Roanoke Island situation.

The Skyco plant draws water levels in the upper Yorktown aquifer down in the Wanchese area, especially during the high water use summer months. However, water levels recover during periods of lower water use. No damage to the aquifer is apparent from the 1973 to January 1994 data presented in this report. Thus, adequate ground water is available for existing uses in the Wanchese area if proper wells and pumps are used.

RECOMMENDATIONS

Data Collection Activities

Dare County's monitoring efforts on Roanoke Island included water-levels and chloride concentrations collected at monthly or twice monthly rates and proved to be helpful to the water system, State, and local observers. From this data it is possible to discern the effects of pumping from Skyco and RO wells. Dare County benefits because they have a network in place to evaluate the aquifer conditions and can plan for contingencies more effectively. The general public can see the true impact of the Skyco pumping. DWR now has more of the tools necessary to analyze the aquifer system and to estimate yield.

Because of these useful products, DWR recommends that monitoring continue as long as Dare County uses the Skyco plant to produce water. The network should be expanded somewhat to include wells at the outer reaches of the island, especially the eastern and southeastern portions so as to better gauge the possibility of saltwater encroachment and cover the entire community of Wanchese. During some parts of the year in 1993, water levels and chloride concentrations were not obtained on all ten wells. DWR or DEM would be glad to help improve methods of data collection. Also, the uncertainty surrounding the monitoring wells at Eason research station must be diagnosed. This may only take further data collection (a complete record), or it may require monitoring an additional well. In any case, DWR and DEM will help Dare County with this issue.

Future of Ground Water Use

Dare County's RO facility is constructed to be expandable to meet increased water demand. Of course, delays will be experienced during the expansion process either to add wells or membrane units. Skyco water plant can be used to meet water demands through those delays. It is important to include in the normal operation of Skyco the monitoring of water levels and chloride concentrations similar to methods used at the RO facility. Also, information given to residents of Roanoke Island not using the Dare Regional system must be consistent. It must include proper well construction and adequate pump and plumbing recommendations. Just as it is important to protect the membranes at the RO plant, the residents of Wanchese need protection against saltwater intrusion.

Preparation of this first annual report on Roanoke Island ground water monitoring is an important step toward ensuring the safe future use of the region's ground water. DWR believes that Dare County is committed to protecting their ground water resources and looks forward to working with them to improve and expand their monitoring effort.

ACKNOWLEDGMENTS

The Division of Water Resources wishes to thank Dare County for its assistance in preparing this report. Much of the data presented in this document was collected by Dare County employees. Special thanks go to Bob Oreskovich, Randy McPhee, and Kathy Wunderlich.

Appendix A. Monitoring Well Hydrographs

Figure A-1. Skyco Shallow (J3F4)

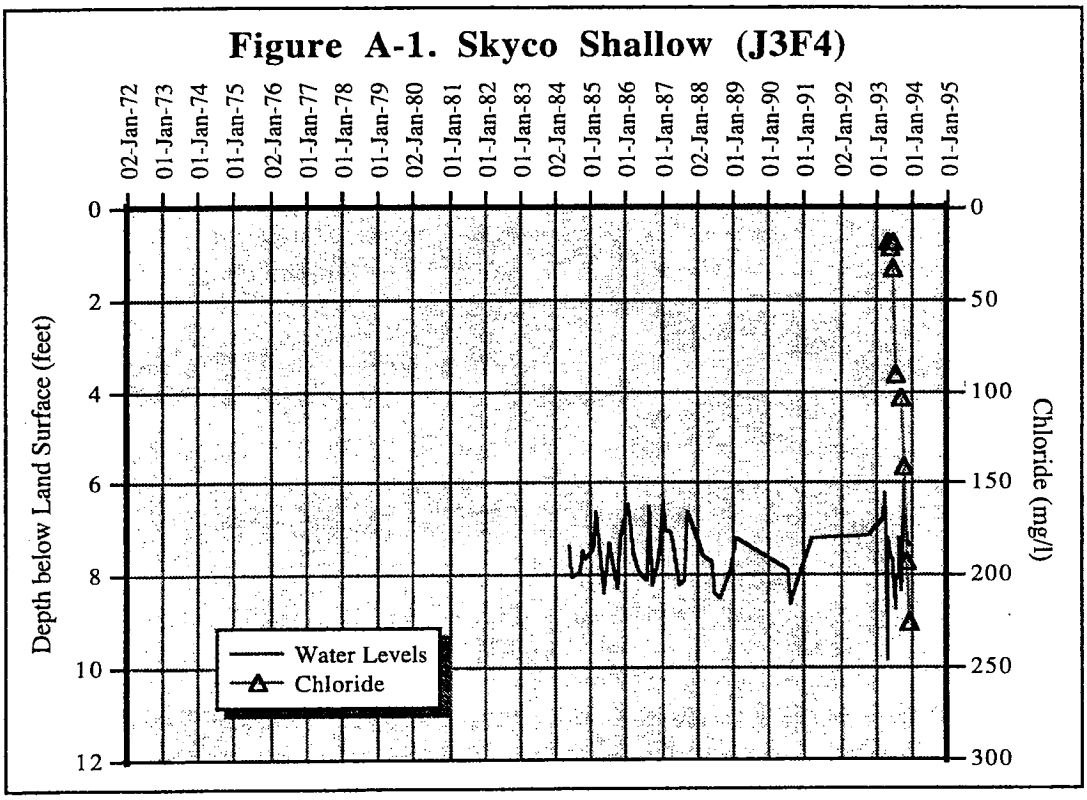


Figure A-2. Skyco Deep (J3F3)

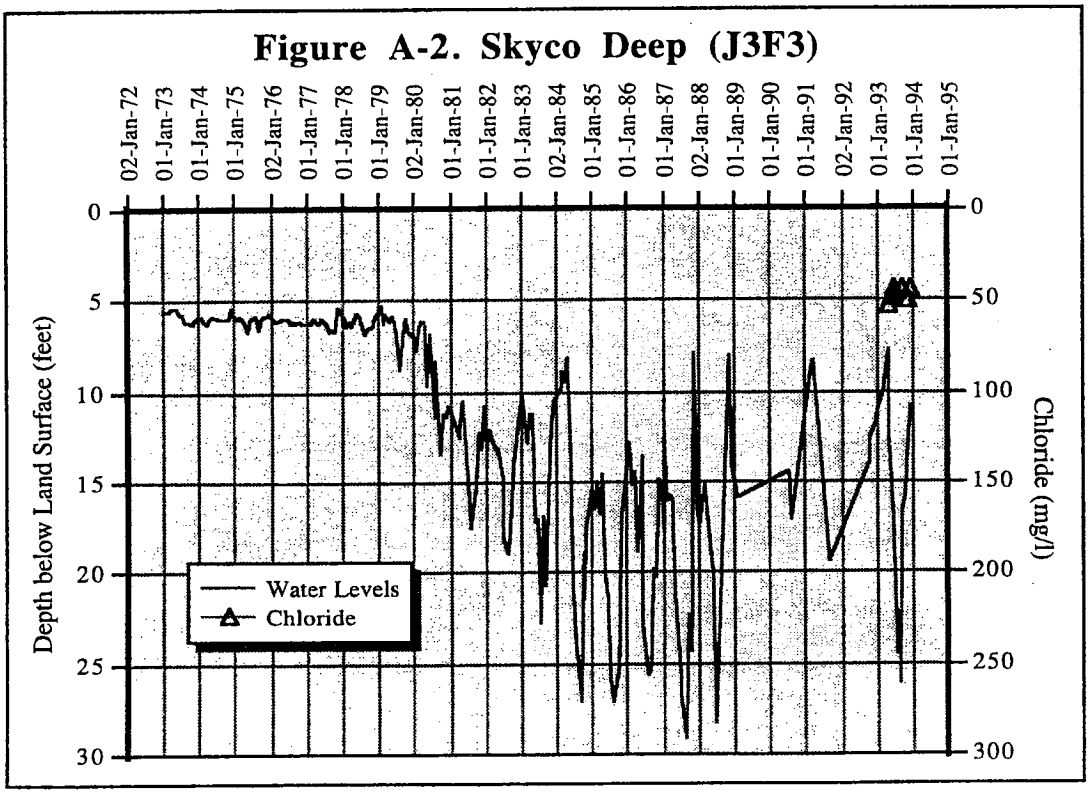


Figure A-3. Manteo Airport Shallow (I4V5)

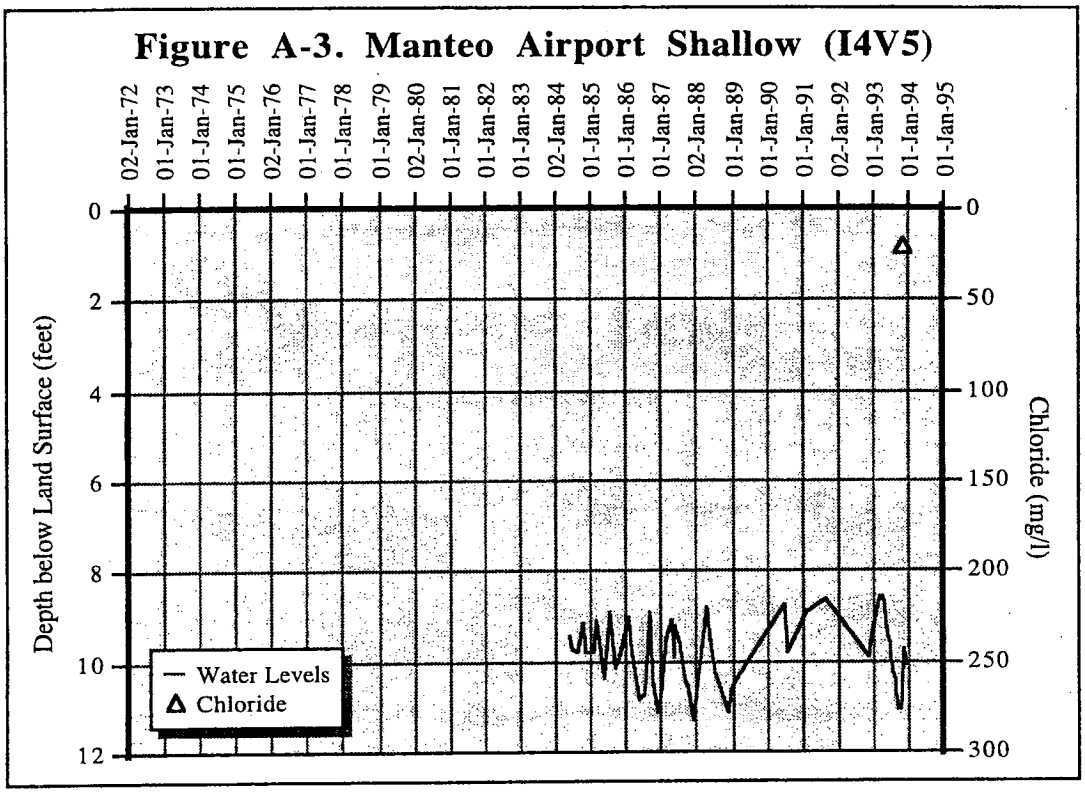


Figure A-4. Manteo Airport Deep (I4V3)

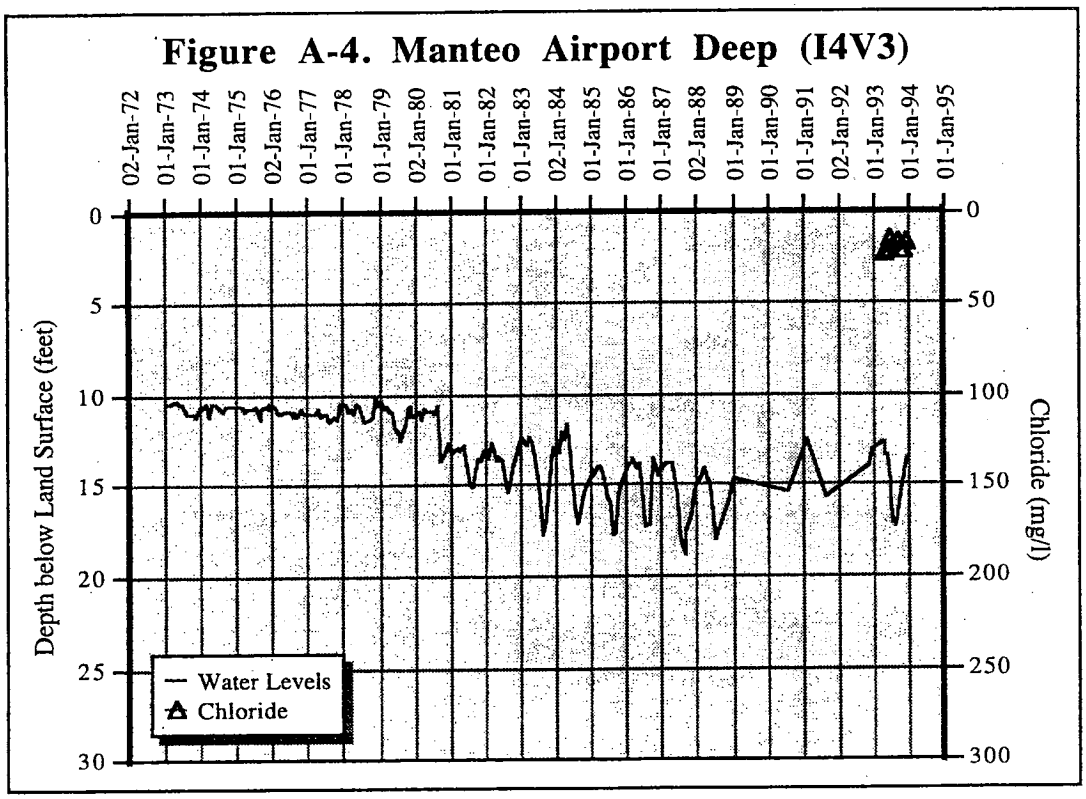


Figure A-5. Wanchese C.C. Shallow (J3X9)

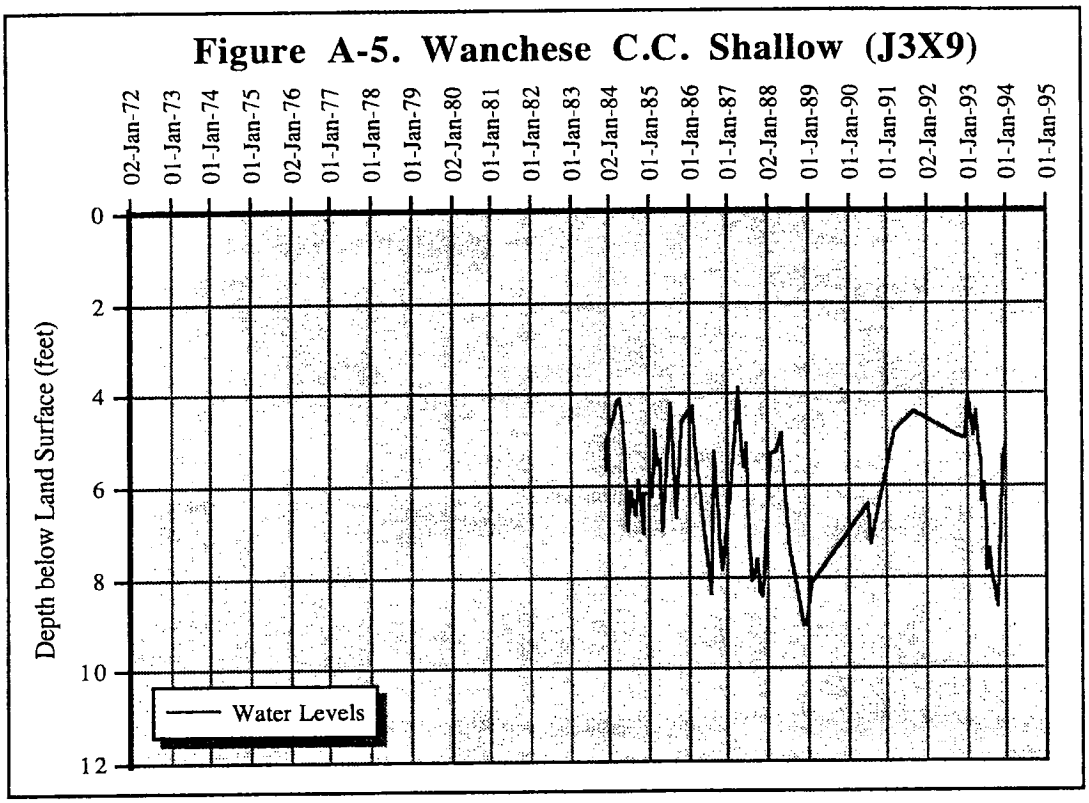


Figure A-6. Wanchese C.C. Deep (J3X13)

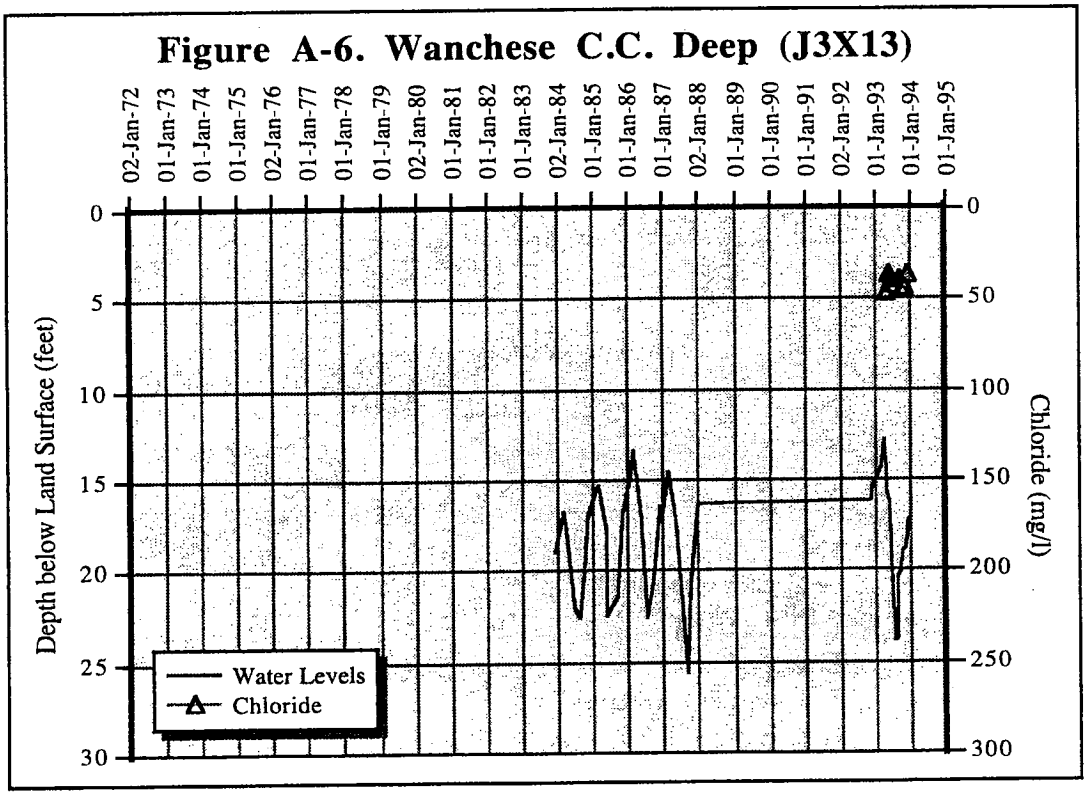


Figure A-7. Convict Pit Shallow (J3X20)

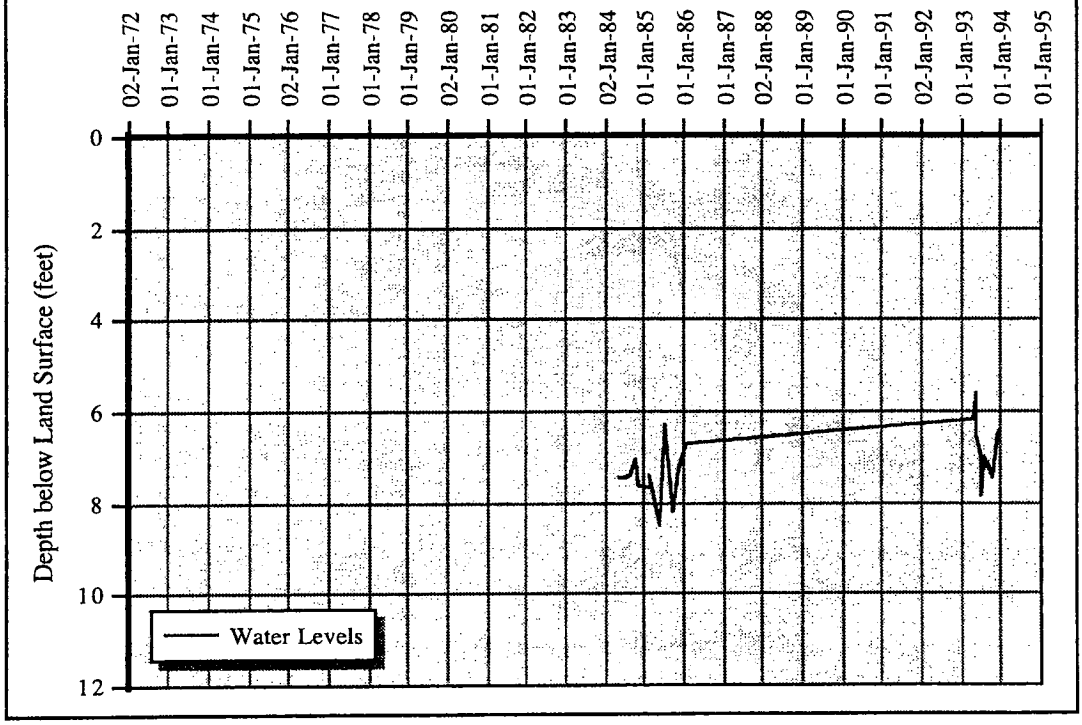


Figure A-8. Convict Pit Deep (J3X17)

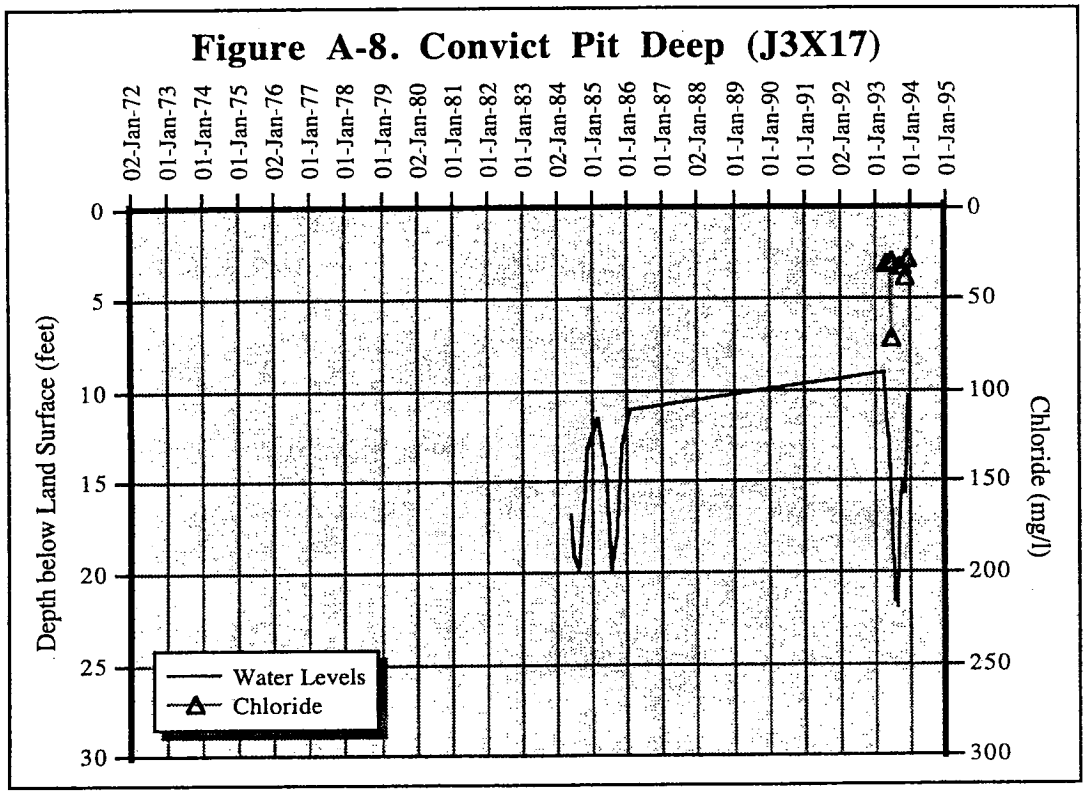


Figure A-9. Eason Shallow (J3Y8)

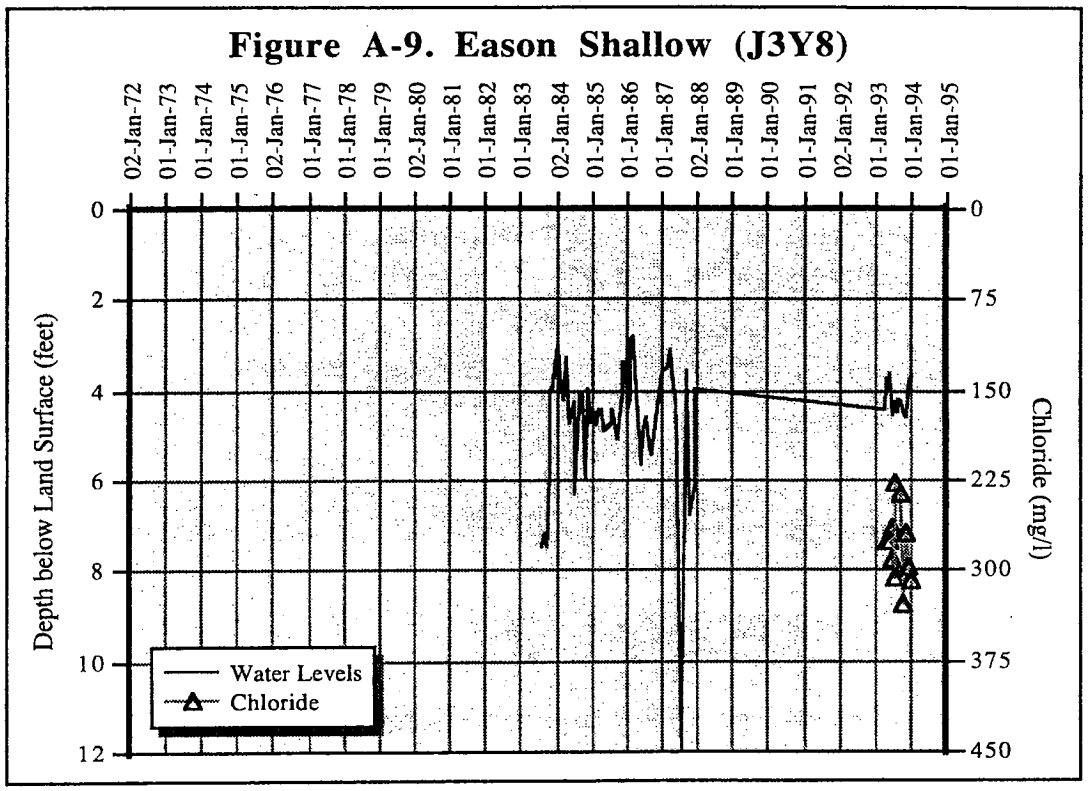


Figure A-10. Eason Deep (J3Y5)

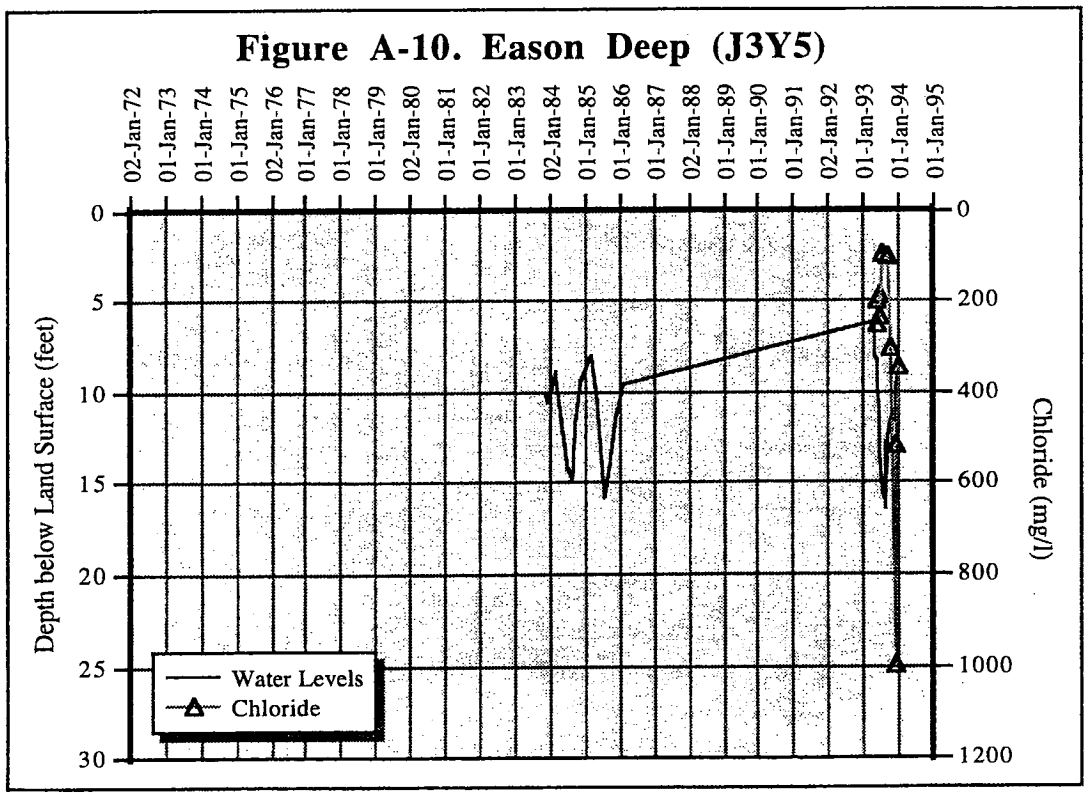


Figure A-11. Skyco Shallow (J3F4)

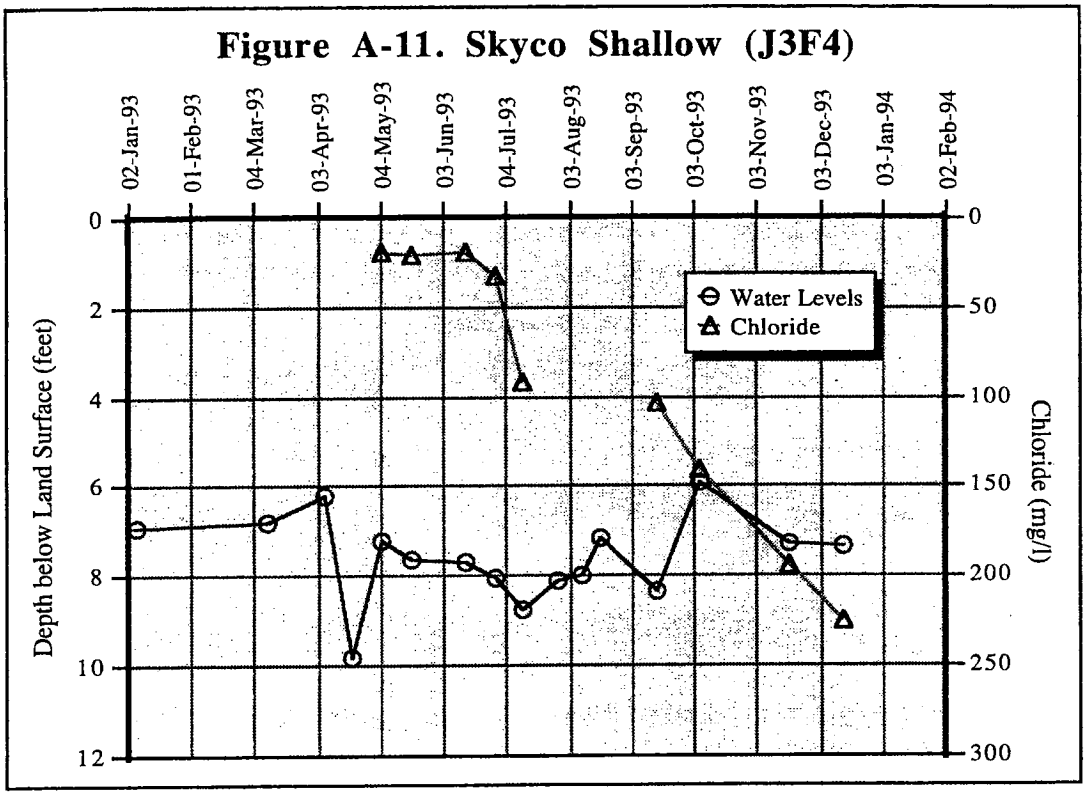


Figure A-12. Skyco Deep (J3F3)

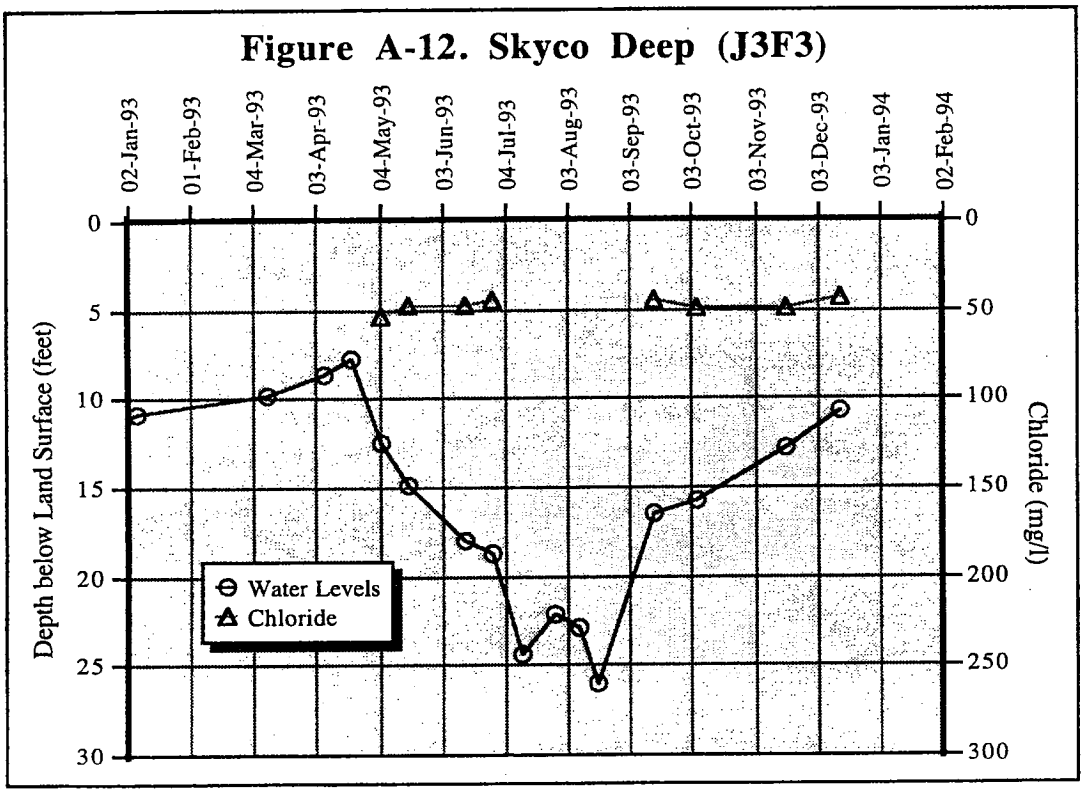


Figure A-13. Manteo Airport Shallow (I4V5)

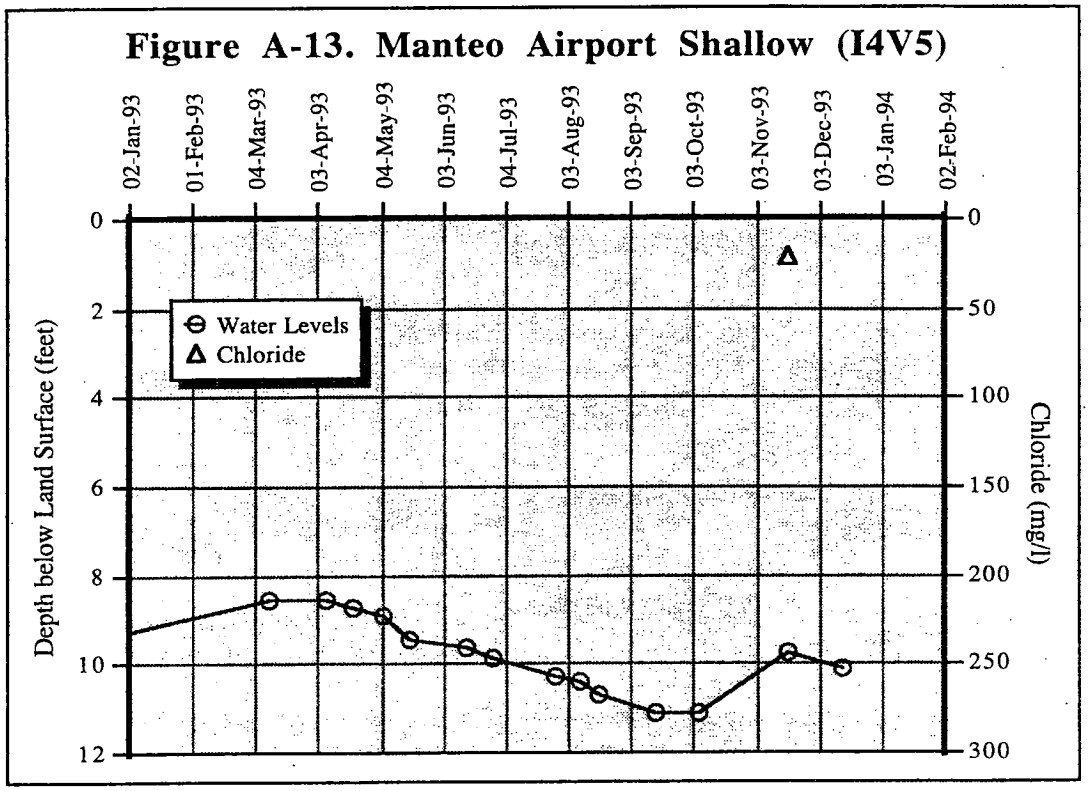


Figure A-14. Manteo Airport Deep (I4V3)

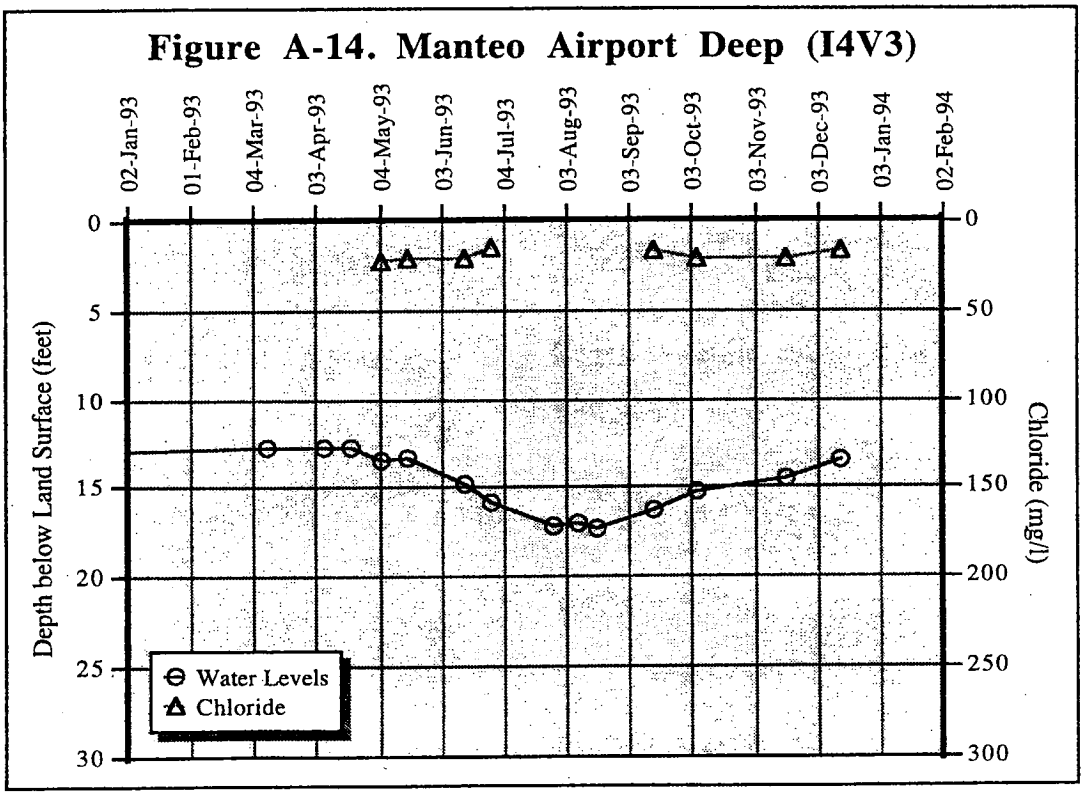


Figure A-15. Wanchese C.C. Shallow (J3X9)

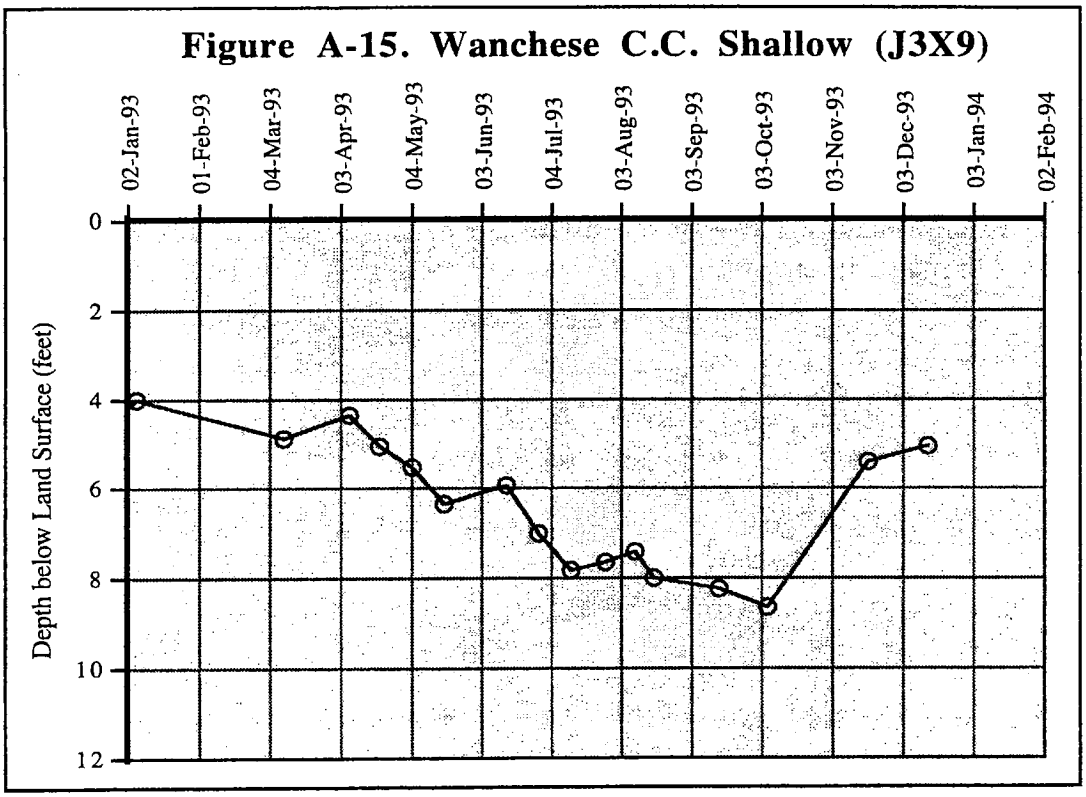


Figure A-16. Wanchese C.C. Deep (J3X13)

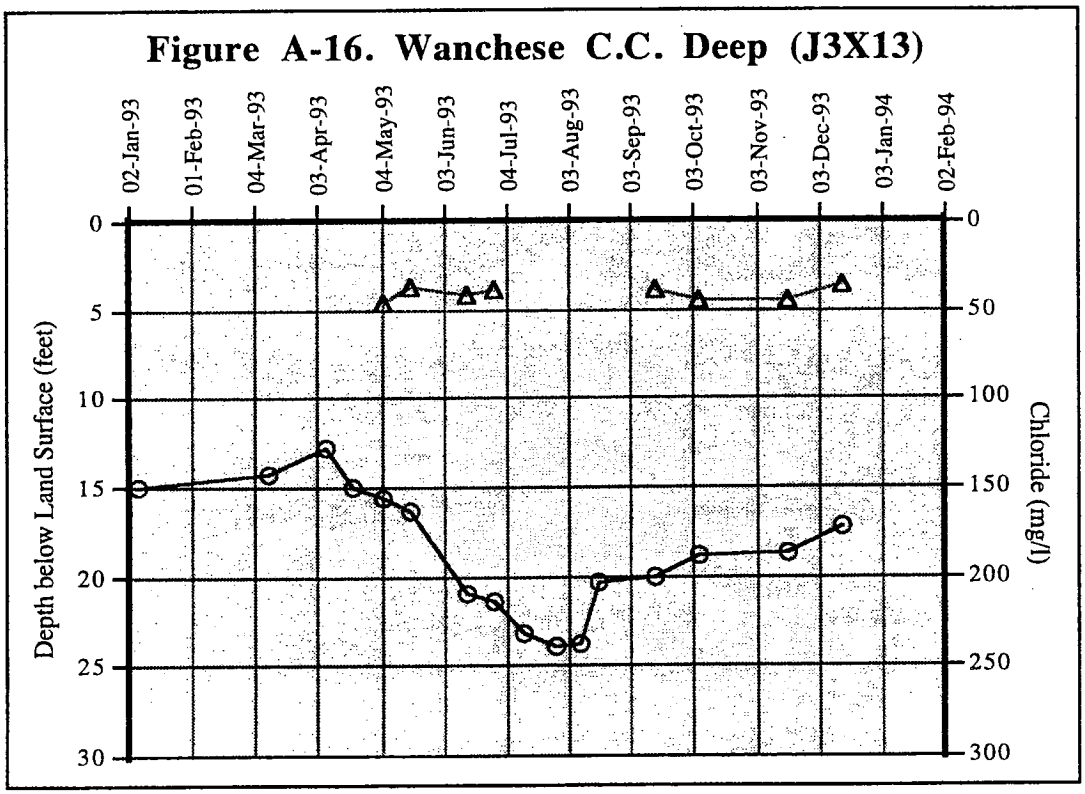


Figure A-17. Convict Pit Shallow (J3X20)

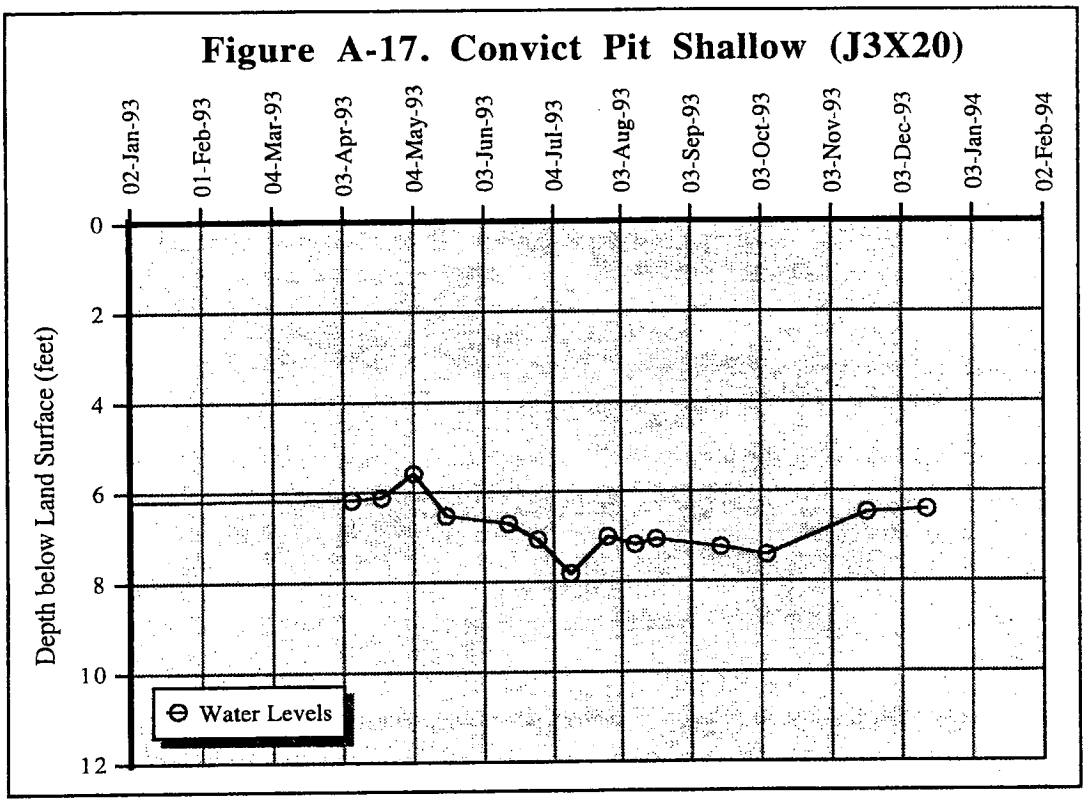


Figure A-18. Convict Pit Deep (J3X17)

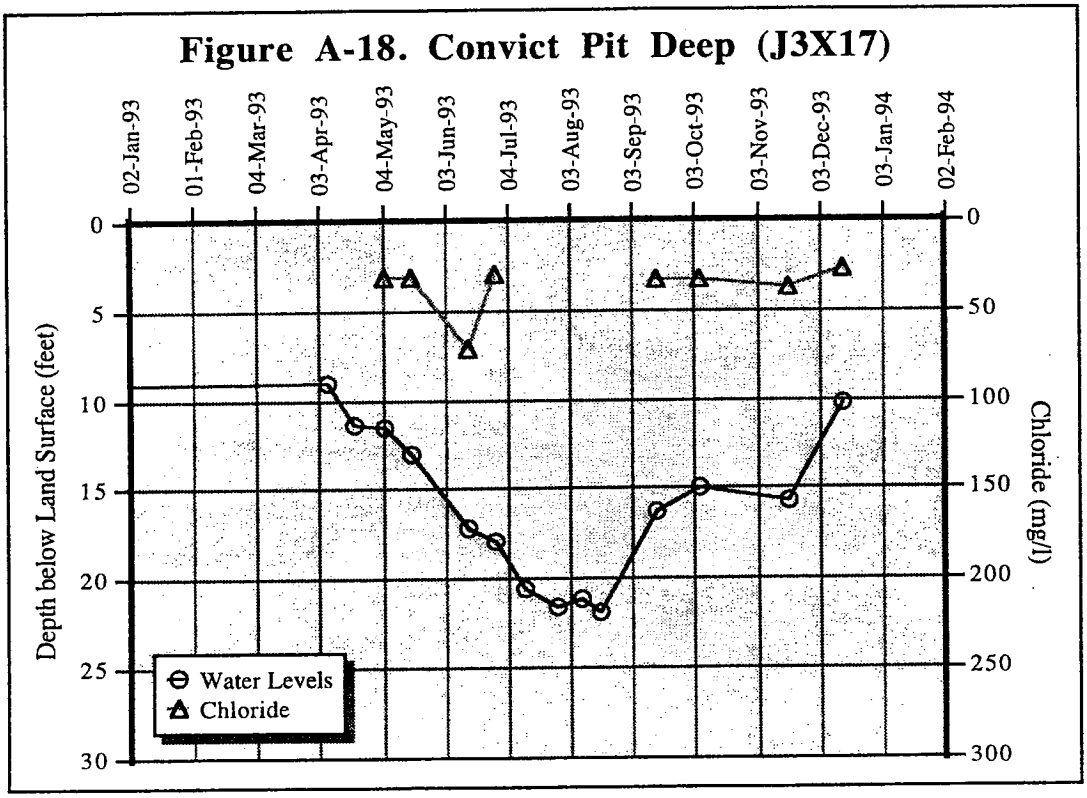


Figure A-19. Eason Shallow (J3Y8)

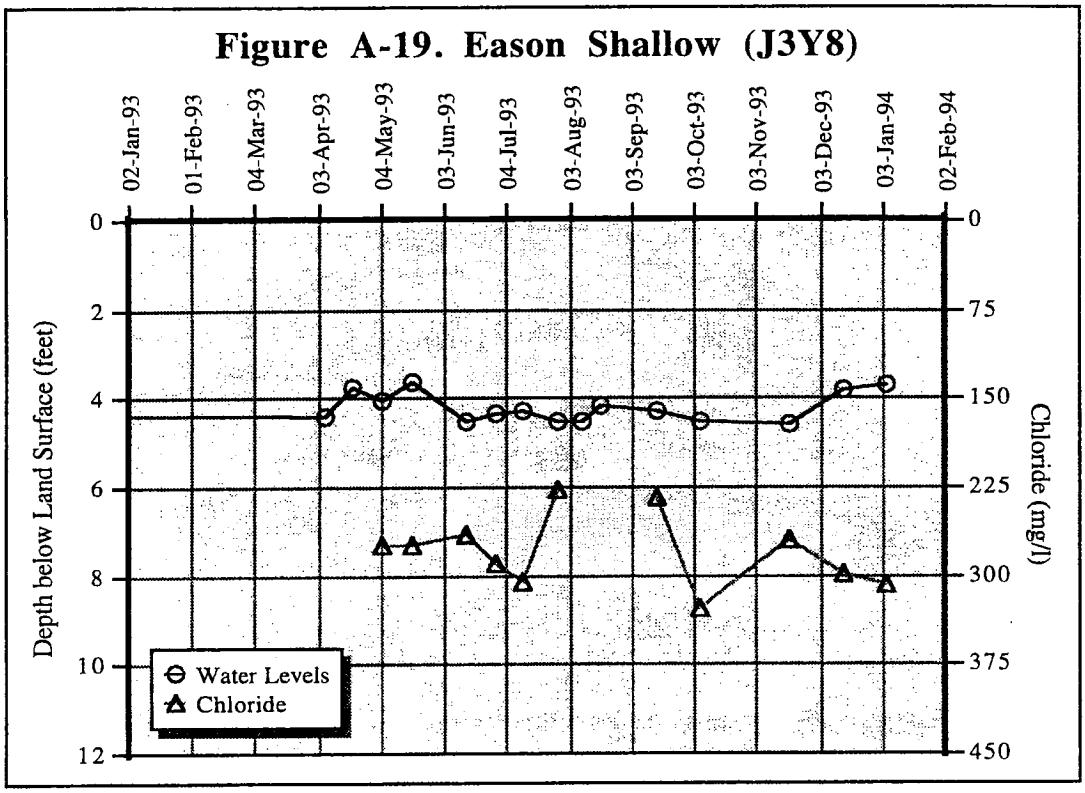


Figure A-20. Eason Deep (J3Y5)