EAST EVERGLADES GROUND WATER QUALITY MONITORING STUDY, 1985-1986

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Department of Research and Evaluation
South Florida Water Management District
West Palm Beach, Florida 33416

Technical Memorandum

EAST EVERGLADES GROUND WATER QUALITY MONITORING STUDY, 1985-1986

by

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West Palm Beach, Florida 33416

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(Promo)

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EXECUTIVE SUMMARY

The South Dade Agricultural Area, located in southern Dade County, Florida, consists of approximately 147 square miles of agricultural and residential development. The Biscayne Aquifer underlies this area and serves as the primary source of fresh water. Out of growing public awareness regarding water quality degradation to the Everglades Region, the Department of Environmental Regulation prompted the South Florida Water Management District (under the guidelines of the Everglades National Park/East Everglades Resource Planning and Management Committee Implementation Plan) to initiate a two year East Everglades ground water monitoring study. This study was proposed in order to determine the potential adverse water quality impact(s) to the Biscayne Aquifer resulting from current agricultural practices conducted within the South Dade Agricultural Area of study. A monitoring network, consisting of both surface and ground water stations, was established within the agricultural areas bordering the L-31 Borrow Canal and sampled throughout the 1985-86 growing seasons. Network stations were sited in areas deemed representative of active and nonactive agricultural practices. Both surface and ground water quality data were compared and contrasted for selected inorganic and organic (pesticides) chemical constituents considered indicators of agricultural application. Results of this study are summarized as follows:

1. The two years of surface and ground water monitoring data indicate a minimal impact to water quality from select inorganic and organic chemical compounds applied within the south Dade County agricultural study area. The noticeable effect(s) on water quality appears to be localized within the heavily farmed areas. However other areas, such as those to the northwest, are slowly being encroached upon by residential and agricultural activity. These areas are beginning to exhibit some degradation due to anthropogenic activities as well.

2. In general, water quality sampling results indicate elevated concentrations of inorganic chemical parameters associated with active agriculture when compared to nonactive agricultural concentrations. A statistical evaluation, conducted on selected constituents, revealed significant differences between nonactive agricultural and active agricultural monitoring station concentrations within the upper zone of the Biscayne Aquifer for the following parameters: potassium, sulphate, chloride, conductivity, and total dissolved solids. The majority of these parameters most likely reflect the use of fertilizers applied within the study area. In all cases, median concentrations from active agricultural areas exceed nonactive agricultural median concentrations. A significant difference exists between surface water and the shallow ground water sampled within the agricultural areas for the parameter potassium. A higher median concentration occurs within the shallow ground water underlying the "active" farming areas. In addition, a significant variation in nitrate concentrations is found to exist with depth within the Biscayne Aquifer throughout the study area. These concentrations appear elevated near the surface and decrease with depth.

3. Six organic pesticide compounds were detected within the surface water and shallow ground water at 14 monitoring sites. These compounds include aldicarb, paraquat, atrazine, metribuzin, chlorothalonil, and permethrin representing a variety of fungicides, insecticides, and herbicides. However, only two isolated areas located west of the L-31N Borrow Canal display the recurrence of more than one pesticide compound during the two year monitoring program.

4. Overall water quality displayed by the Biscayne Aquifer in the area of this study meets established regulatory standards. None of the inorganic parameters analyzed for during this two year program exceed the State of Florida primary safe drinking water standards, and only two parameters, iron and manganese, exceed the state secondary drinking water standards of 0.3 and 0.05 mg/l respectively. In addition, organic pesticide (aldicarb) concentrations did not exceed the federal regulatory standard of 10 ug/l. No regulatory drinking water standards have been established for the remaining five organic pesticide compounds detected.

5. Regional ground water flow within southern Dade County is generally to the south - southeast, toward the coast. Local recharge and discharge to and from the Biscayne Aquifer, depending on the time of year, occurs at the various canals which transect the study area. Although ground water elevations reflecting these seasonal variations fluctuate on an annual basis, the overall hydraulic gradient of $1x10^{-4}$ feet/foot remains fairly constant.

6. Infiltration resulting from rainfall appears to impact existing ground water quality within the study area. In general during the dry season, chemical concentrations within the shallow ground water continue to increase throughout the growing season. However, during the wet season a decrease in chemical application(s) combined with periods of increased rainfall, enables the aquifer to "flush" itself by the process of dilution.

7. Current farming practices combined with the process of dilution attained during the wet season, appear to minimize the overall impact of agriculture on the water resources of the Biscayne Aquifer. Initial monitoring conducted throughout the study area during the growing season, was anticipated to provide a good indication of agricultural land use impact(s) on ground water quality. However, the recurrence of various individual pesticide compounds (within the shallow ground water at two localized areas in the study region) during different stages of the growing season leads to the assumption that any ensuing concentration distribution is localized in extent, and not area pervasive. Thus, any attempt to extrapolate the results of this report on an areal basis without further study is not recommended.

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ACKNOWLEDGEMENTS

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The report underwent significant revisions during the review process. Philip Fairbank, Senior Hydrogeologist, and Keith R. Smith, Acting Director, Hydrogeology Division, were responsible for the bulk of the revisions. Hedy Marshall, Administrative Assistant, coordinated the typing and formatting of the final report. Finally, the authors would like to acknowledge those people, too numerous to list, who reviewed this document during the long review period.

ABSTRACT

Prompted by the Department of Environmental Regulation and under the guidelines of the Everglades National Park/East Everglades Resource Planning and Management Committee Implementation Plan, the South Florida Water Management District initiated a two year East Everglades ground water monitoring study. This study was proposed in order to determine the potential adverse water quality impact(s) to the Biscayne Aquifer resulting from current agricultural practices conducted within the South Dade Agricultural Area of study. A monitoring network consisting of 20 sampling locations, both surface and ground water, was established within the agricultural areas bordering the L-31 Borrow Canal and sampled throughout the 1985-86 growing seasons. Network stations were sited in areas deemed representative of active and nonactive agricultural practices. Both surface and ground water quality data were compared and contrasted for selected indicator inorganic and organic (pesticides) chemical constituents. In general, the water quality data indicate elevated concentrations for select inorganic and organic parameters representative of agricultural activity. However, overall water quality displayed by the Biscayne Aquifer within the area of study meets established regulatory standards. Current farming practices, combined with the process of dilution attained during the wet season, appear to minimize the overall impact of agriculture on the water resources of the Biscayne Aquifer.

INTRODUCTION

PURPOSE AND SCOPE

The Everglades National Park/East Everglades Resource Planning and Management Committee Implementation Plan (Implementation Plan), adopted and approved by the Florida State Legislature, delegated the responsibility of carrying out the Federal East Everglades Resource Planning Project (Project) of 1980 to the Everglades National Park. Under the guidelines of the Implementation Plan, a two year East Everglades Ground Water Monitoring Study was proposed in order to address potential agricultural impact to shallow subsurface water(s).

This report summarizes the South Florida Water Management District's (SFWMD)'s study on the ground water quality existing within the south Dade County agricultural area throughout the 1985-86 growing seasons. Initial work entailed the design of a monitoring network, which included a total of 20 sampling locations (i.e., 16 ground water and 4 surface water monitoring stations). These stations border the L-31 Borrow Canal on the east and west. Monitoring stations were specifically sited within an area which included various crop types deemed representative of row crops and citrus groves common to this agricultural center. Both ground water and surface water quality data within the study area were compared for selected inorganic and organic chemical constituents.

LOCATION OF STUDY AREA

The study area is located in the southeast portion of Dade County, Florida, in a predominantly agricultural area 30 miles southwest of Miami near the town of Homestead (Figure 1). The area encompasses approximately 90 square miles; a 6 mile strip traversing the L-31 Borrow Canal North, and extending for a distance approaching 15 miles between undeveloped wetlands and the Everglades National Park on the west, and the extensively developed residential areas of south Dade County to the east. Three major roadways transect the area, which include State Road 9336 (Old U. S. 27), U.S. Highway 1, and Old Dixie Highway.

PREVIOUS INVESTIGATIONS

In 1974, the Department of Environmental Resource Management (DERM) was founded as a regulatory agency for Metropolitan Dade County. Shortly thereafter, the National Organics Reconnaissance Survey was conducted by DERM to collect data on 15 volatile organic compounds and 12 organochlorine pesticides common to agricultural practices within the area. Results of this survey indicated that neither pesticide nor herbicide contamination was evident within the shallow ground water of the Biscayne Aquifer (Yoder, 1982). In 1975, DERM initiated a special ground water study required by the Clean Water Act of 1972, which included analyses for pesticides, herbicides, trihalomethanes, and other volatile organics and selected inorganics. During this study, high nitrate concentrations were detected in both surface water and shallow ground water in southern Dade County agricultural areas (Yoder, 1982). However, no water quality degradation from organic contaminants were evident.

A monitoring network was designed by DERM in 1982 to address the quality of surface water and ground water in Dade County during both wet and dry seasons of the year. The objective of that network was to characterize ground water quality associated with various land uses. The investigation concluded that concentrations

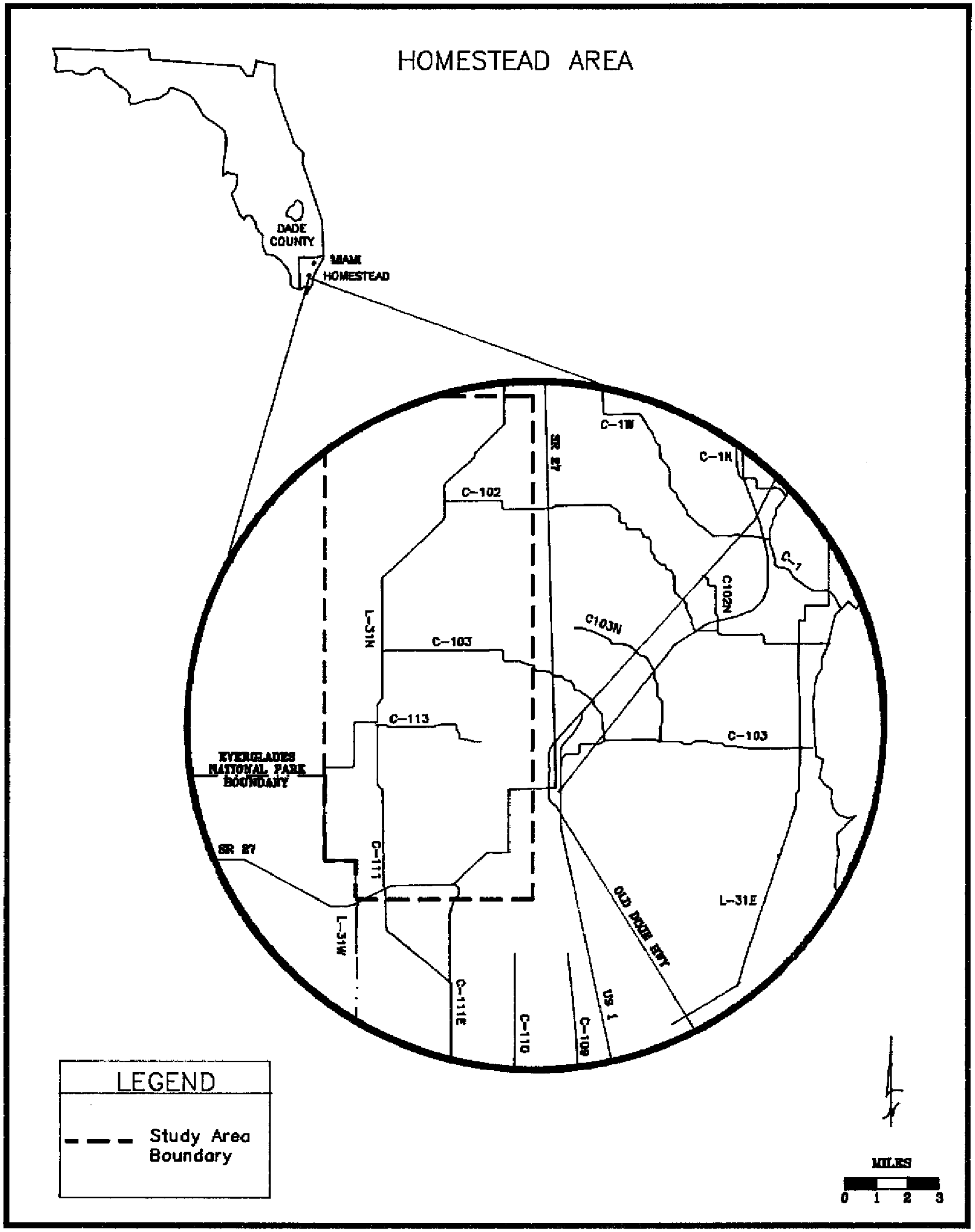

FIGURE 1. Location of Study Area.

of selected inorganic ions in the ground water (e.g., ammonia) reach a maximum level at the end of the dry season and attenuate during the wet season as a function of dilution (Labowski, 1983).

The U. S. Geological Survey conducted a study in the early 1980's to determine the effects of various land use practices on surface water quality in the East Everglades area of Dade County. The results of that study indicate that specific agricultural practices (e.g., rock plowing) can impart a notable effect on surface water quality (Waller, 1981). However, additional investigations concluded that the predominant soil types within the area can selectively accumulate many of the toxic chemicals present before they enter the ground water system, thus providing an effective buffer zone to the water table (Waller, 1982).

The East Everglades Resource Planning Project was conducted in 1980, with financial and technical assistance from the U. S. Environmental Protection Agency under the provision of Section 208 of the Federal Water Pollution Control Act (P.L. 92-500). The purpose of the program was to ensure the future availability of clean water for public and private water supplies in southern Dade County. The Project recommended a steering committee, with the directive to develop a strategy program that would protect the water quality characteristics of surface water and ground water. The steering committee, later known as the 380 Committee, adopted the Implementation Plan. The Implementation Plan, approved by the Governor and Cabinet in 1985, recommended the formulation of the Southern Everglades Technical Committee, which would monitor the technical aspects of the Implementation Plan. In addition, the Implementation Plan recommended the initiation of a two year ground water quality monitoring program.

Prompted by the Florida Department of Environmental Regulation (FDER) and the adoption of the Water Quality Assurance Act of 1983, the SFWMD initiated the study of the South Dade Agricultural Pilot Site in 1984. The purpose of this study was to investigate the effects of certain land use(s) on ground water quality within the Biscayne Aquifer. This was accomplished by drilling and sampling 21 monitor wells within the pilot study area. The results of the study showed slight elevations of selected inorganic parameters and trace metals above local background levels (i.e., nitrate, ammonia, sulfate, potassium, total and total dissolved kjeldahl nitrogen, copper, zinc, lead, and manganese). In addition, trace amounts of relic pesticides were detected. However, all toxic chemical concentrations with established drinking water standards were within those standards (Anderson, 1986).

TOPOGRAPHY

The local topography of the area reflects a land surface that gently slopes (less than 1 percent) toward the southwest in the southern portion of the study area, and slightly south and eastward in the northern portion. Ground elevations range from less than five feet above National Geodetic Vertical Datum (NGVD) in the southern part of the study area, to more than nine feet above NGVD to the north.

PHYSIOGRAPHY

The study area is located within a distinct physiographic unit known as the Florida Section (Brooks, 1981). This unit is characterized by the influences that solution or weathering of the underlying limestones have had on the development of the surrounding topography. Specifically, the area lies within a region containing the south and southeastward drainage basins of Lake Okeechobee, referred to as the

Gold Coast-Florida Bay District (Brooks, 1981) or the "Southern" Distal Zone (White, 1970).

Within the Gold Coast-Florida Bay District, three principal subdivisions occur adjacent to and inclusive of the area of investigation. These include, from northwest to southeast, the Everglades (Shark River Ridges and Sloughs), the Southern Atlantic Coastal Strip (Miami Rock Ridge), and the Southern Atlantic Coastal Strip (Silver Bluff-Coastal Marsh Terrace).

CLIMATE

General climatic conditions within southeast Florida range from a zone of transition between subtropical and tropical. Summers are long, warm, and relatively humid. Winters, although punctuated with periodic invasions of cold northern air, are mild due to the southern latitude and adjacent warm ocean waters.

Southeast Florida receives a considerable amount of rainfall. On the peninsula, generally greater than one-half of the average annual precipitation occurs during the four month period, June through September (Bradley, 1972). The average annual rainfall for Dade County is 60 inches, while locally the average annual rainfall at the Homestead Experimental Station is 63 inches.

Mean annual temperatures, in degrees Fahrenheit (°F), within southeast Florida range from the low 80's in the summer to the low 70's in the winter. Within the study area, the average annual temperatures based on a 20 year period (1959-1979) range from a minimum of 67°F to a maximum of 83°F.

In general, variations in relative humidity across southeastern Florida are small, reflecting an annual mean of approximately 74 percent.

SOILS

The soils within the study area are representative of two principal types: the organic histosoils, and more recently developed entisoils. The histosoils represent very poorly drained organic soils underlain by marl and/or limestone. The entisoils represent very poorly drained marly soils and very thin sandy soils underlain by limestone. These soils provide an adequate medium in which to grow many of the agricultural products attributable to this area. However, frequent applications of fertilizer(s) are necessary in order to supplement the naturally low organic matter content (Waller, 1982).

The Florida General Soils Atlas (July 1975) illustrates the study area as a composite of seven (7) general soil associations. These include the Rockdale, Urban Land-Hallandale, the Rockdale-Hallandale, the Ochopee-Broward, the Perrine-Ochopee, the Tidal Swamp-Tidal Marsh, and the Rockland associations. Of these, the Rockdale-Hallandale and the Perrine-Ochopee associations cover approximately 90 percent of the study area.

GEOLOGY

A review of the regional subsurface geology and boring data indicate that within the study area, two prominent geologic formations of Pleistocene age are present to a maximum depth of 70 feet below ground surface. These are the Fort Thompson Formation and the Miami Oolite.

The Fort Thompson Formation consists of a sequence of carbonate sediments of both marine and freshwater origin. The alternating marine and freshwater limestones, marl beds, and mudstones contain abundant fossils, particularly in the lower portion of the formation. Examples of these include the freshwater gastropod Helisoma sp. contained within the mudstones and the marine pelycypod Chione cancellata marking the Coffee Mill Hammock member of the formation. The base of the formation is marked by an arenaceous carbonate unit signifying the contact between the Fort Thompson Formation and the underlying Tamiami Formation. The thickness of the Fort Thompson Formation within Dade County increases from a few feet in the west to more than 150 feet in the east (Schroeder et al., 1958).

The Miami Oolite extends throughout most of Dade County and rests conformably atop the Fort Thompson Formation. The formation consists of a sequence of massive to stratified and cross-bedded marine carbonates of two principal facies, oolitic, and bryozoan. The dominant lithology may be described as a white to yellowish oolitic limestone containing various amounts of quartz sand (up to approximately 40 percent) (Shaw, 1985). The average thickness of the Miami Oolite within Dade County ranges from 20 to 30 feet along the coastal ridge; however, it thins westward towards the Everglades (Parker, 1951).

SURFACE WATER HYDROLOGY

The south Dade County agricultural area is located in a region of southeast Florida which displays very poor naturally integrated surface drainage. Because of this, a heavily managed canal network has been constructed, which provides both relief from flooding during the wet season and release of water for irrigation during the dry season. Water levels and discharges are strictly controlled due to the large volume(s) handled on a daily basis. For example, the Miami Canal can deliver up to 350 million gallons of water per day to Dade County (Kenner et al., 1969).

The study area is surrounded on all sides by an integrated system of levees and canals known as the South Dade Conveyance Canal System (Figure 2). Three major canals transect the study area in a east-west direction (i.e., C-102, C-103 and C-113) with two major canals, L-31N and C-111 , transecting the study area in a north-south direction.

Locally, surface water and ground water flow proceeds in a south/southwesterly direction toward Florida Bay at the southern tip of the state. The drainage canals can alter the shallow surface flow patterns due to localized recharge, especially during water releases prompted by ongoing water management practices (Neidrauer and Cooper, 1988).

As previously stated, the average annual rainfall for Dade County is 60 inches. Of this annual amount, it is estimated that 20 inches is lost due to evaporation, and the remaining 40 inches accounts for surface water runoff and infiltration to ground water. Within the area of interest, the average annual runoff ranges from 0 - 10 inches (Kenner, 1966). This is a reflection of the high infiltration rates witnessed throughout south Dade County.

GROUND WATER HYDROLOGY

The Fort Thompson Formation and the Miami Oolite are the principal geologic units which comprise the Surficial Aquifer System, known as the Biscayne Aquifer within Dade County (Parker et al., 1955) (Table 1).

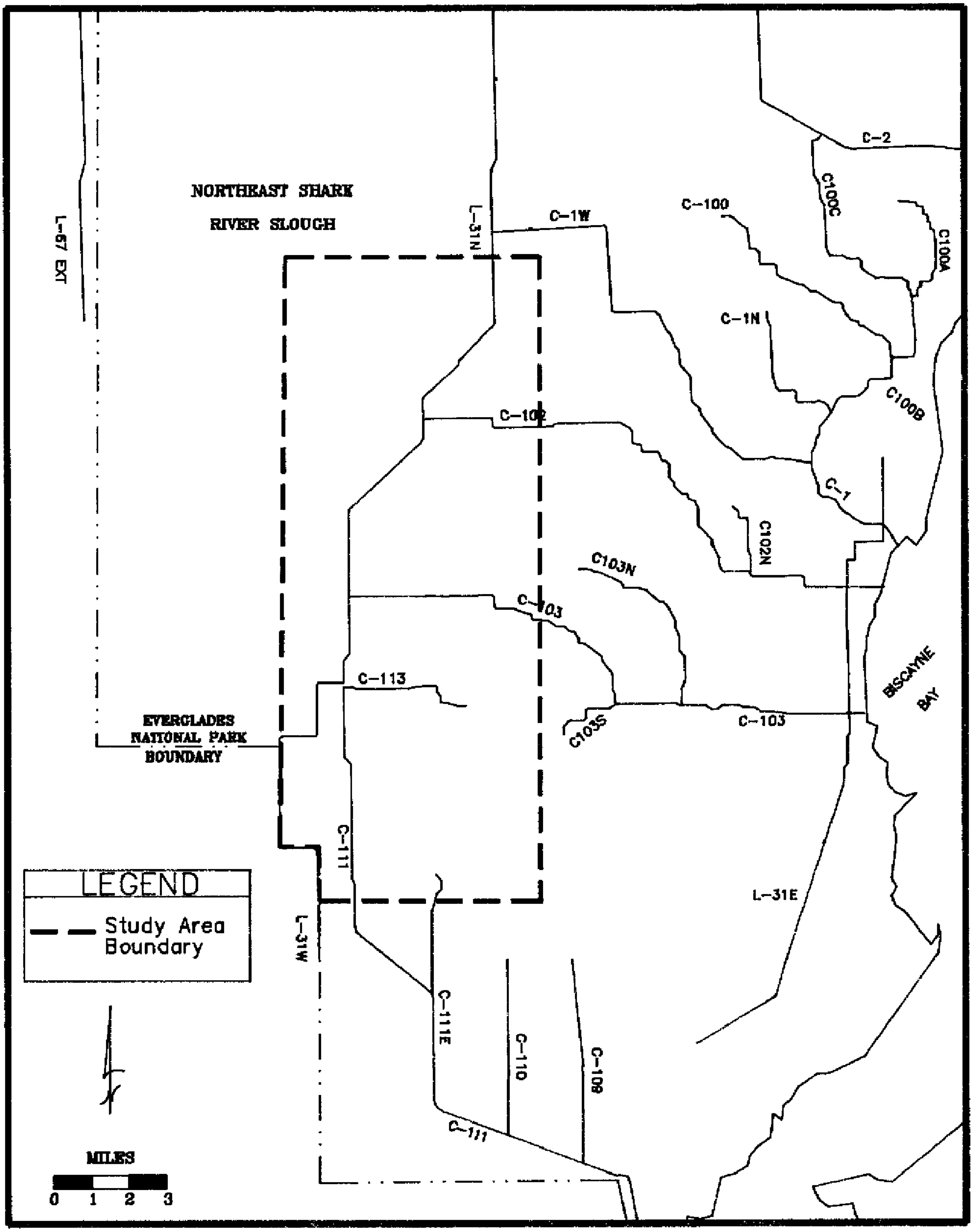

FIGURE 2. South Dade Conveyance Canal System.

TABLE 1. GENERALIZED STRATIGRAPHY OF THE SURFICIAL AQUIFER SYSTEM WITHIN DADE COUNTY

Aquifer System	Formation	Thickness (Ft.)	Geologic Description
Surficial Aquifer System (Biscayne Aquifer)	Miami Limestone (dominant)	0 - 20	White to Yellow Orange Massive Oolitic Limestone. High Percentages of Bryozoms Present in Some Areas
	Key Largo Limestone (discontin.)	0 - 60	Coralline Limestone, Comprised of Coral Skeletons, Fine to Medium Grained Cemented Calcareous Sand and Other Reef Deritus
	Ft. Thompson Formation (dominant)	0 - 200	Alternating Marine, Brackish, and Freshwater Marl, Limestones and Sandstones
	Tamiami Formation (upper)	0 - 150	Creamy-White Limestone, and Greenish-Gray Clayey and Calcareous Marl, Silty and Shelly Sands and Shell Marl

Table 1 depicts the generalized stratigraphy of the Surficial Aquifer System within Dade County.The Biscayne Aquifer is the most important source of freshwater within southeast Florida. The aquifer underlies Dade, Broward, and parts of Palm Beach Counties. Within the study area the aquifer slopes from west to east, ranging in thickness from 30 feet along the western boundary and increasing to 70 feet along the eastern boundary. Depth to water is fairly consistent throughout the area of interest and averages approximately three to four feet below ground surface (Shaw, 1985).

The Biscayne Aquifer represents an unconfined system with good hydraulic connection existing between the surrounding surface water canal system. Ground water recharge within the Biscayne Aquifer occurs by direct and rapid infiltration of rainfall to the water table and by leakage from canals. However, discharge from the aquifer to the canals can occur when the canal stages are lower than surrounding ground water levels. It is estimated that approximately two-thirds of the annual rainfall infiltrates the zone of saturation in Dade County (Parker et al., 1955).

Well yields commonly exceed 2,000 gallons per minute (Pascale, 1975). An estimated 98 billion gallons of water was pumped from a 600 square mile area in the coastal ridge in 1965 for agricultural use (Todd, 1983). Although copious supplies are available, one of the major factors limiting withdrawals from the Biscayne Aquifer system is the susceptibility of the aquifer to saltwater encroachment. However, current water management practices have effectively limited this risk while providing for maximized freshwater yields.

The ground water quality displayed by the Biscayne Aquifer varies slightly over its areal extent; most differences in quality are related to the geochemistry of the aquifer matrix and local land use (Pitt et al., 1975). In southern Dade County ground water quality generally meets state drinking water criteria. Typical water treatment plant procedures within this area require the addition of standard disinfectants in order to maintain permissible quality. In general, the water is hard, a calcium bicarbonate type, and contains abundant iron.

FARMING PRACTICES AND CROP TYPES

Because the soils of south Dade County are very thin, and in some areas do not exist, a common agricultural land use technique involves the application of rock plowing to generate a thicker soil stratum.

Rock plowing, within the study area, entails the plowing of the top surface layer of consolidated material, which consists of a carbonate matrix (e.g., limestone). This procedure physically crushes the rock, and by continually re-working with large discs integrating the soil already present, ultimately provides additional soil material which is suitable for planting.

Rock plowing has been utilized on a yearly basis since the 1950's. This practice not only enhances the infiltration of rainfall but also increases the organic matter content of the soil. However, this organic content decreases rapidly with time based on the heavy agricultural activity. Because of this, these soils require frequent applications of fertilizers. The practice of returning crop residue and regularly adding organic matter helps to improve the soil's fertility.

Current agricultural practices within the study area concentrate on the production of row crops and citrus trees. Row crops occupy approximately 53,000 planted acres, and fruit trees encompass another 18,000 planted acres. In this report, the term "row crops" refers primarily to tomatoes, corn, pole beans, minor amounts of squash and peppers, and various Hispanic food row crops. "Citrus trees" include limes, avocados, and other subtropical fruits such as mangoes.

EAST EVERGLADES WATER QUALITY MONITORING NETWORK

The water quality monitoring network divides the study area into three areas. One area is located on the east side of the L-31 Borrow Canal and is representative of long term established agricultural practices, while a second area on the west side of the canal represents newly permitted agricultural plots. The third area (consisting of two sites, one north and one south) were chosen to represent nonactive agricultural areas. It is important to distinguish the nonactive agricultural areas from those areas which have never been farmed. The nonagricultural areas studied for this report have been formed previous to this study, but were not actively cultivated during the study period.

The phase one labeling system identifies each water quality station with a letter code and site number which follows a directional pattern north to south; increasing numbers towards the south. The two stations designated to represent nonactive agricultural areas are identified by a two letter code followed by a north or south designation. Additional stations placed in the second phase of the project are designated by a letter and a number. Those stations comprising monitor wells in both phases, are designated by top, middle, or bottom in order to delineate that part of the aquifer system being sampled. Table 2 portrays, by phase and agricultural area, the water quality station numbering system, sampling depth, and station location existing within the study area.

PHASE 1

The first phase of the East Everglades Ground Water Monitoring Project consisted of the design and installation of ten monitoring stations, as shown in Figure 3. This phase was conducted at a reconnaissance level in order to prepare for a more intensified study to be initiated during the succeeding year. Each station consists of a cluster of three ground water monitoring wells screened in the top, middle, and bottom zones of the Biscayne Aquifer, averaging 10, 20, and 40 feet in depth, respectively.

PHASE 2

The second phase of work was designed to intensify the monitoring efforts of the first phase during the 1985-86 growing season. This phase of the monitoring network consisted of a total of 20 monitoring stations, which included the phase one monitoring stations discussed above and six additional ground water monitoring stations (Figure 4). The additional agricultural monitoring sites were included in order to study the potential impact of current farming practice(s) on newly permitted land. Four surface water monitoring sites (S1 through S4) made up the remaining network. The four surface water stations assisted in the evaluation of water quality conditions entering the study area and traveling through the major canal system; a possible source of water quality degradation during periods of aquifer recharge. As with phase one, all monitoring well stations contain a cluster of three wells screened in the top, middle, and bottom zones of the Biscayne Aquifer.

The second phase also included the addition of 12 soil stations as shown in Figure 5. These 12 soil stations were established at representative locations reflecting the various soil types encountered within the study site. The location of the soil sampling stations with respect to the nonactive agricultural, active agricultural east, and active agricultural west areas is shown in Table 3.

TABLE 2. WATER QUALITY STATION LABELING SYSTEM - PHASE 1

Station I.D.	Casing (Feet)	Total Depth (Feet)	Lat (Deg Min Sec)	Long (Deg Min Sec)
Agricultural NonActive				
BKN Top	10	12	25 39 07	80 31 43
BKN Middle	20	22	25 39 07	80 31 43
BKN Bottom	50	55	25 39 07	80 31 43
BKS Top	16	20	25 27 42	80 30 47
BKS Middle	27	30	25 27 42	80 30 47
BKS Bottom	52	54	25 27 42	80 30 47
Agricultural East				
E1 Top	10	16	25 35 12	80 30 37
EI Middle	21	32	25 35 12	80 30 37
E1 Bottom	42	55	25 35 12	80 30 37
E2 Top	12	14	25 30 59	80 32 59
E2 Middle	22	27	25 30 59	80 32 59
E2 Bottom	53	57	25 30 59	80 32 59
E3 Top	17	20	25 29 10	80 33 24
E3 Middle	22	25	25 29 10	80 33 24
E3 Bottom	43	47	25 29 10	80 33 24
E4 Top	-	13	25 30 30	80 29 12
E4 Middle	-	35	25 30 30	80 29 12
E4 Bottom	-	60	25 30 30	80 29 12
Agricultural West				
W1 Top	12	14	25 36 36	80 30 44
W1 Middle	22	28	25 36 36	80 30 44
W1 Bottom	48	58	25 36 36	80 30 44
W2 Top	16	21	25 33 05	80 33 35
W2 Middle	28	31	25 33 05	80 33 35
W2 Bottom	47	50	25 33 05	80 33 35
W3 Top	12	13	25 30 18	80 34 12
W3 Middle	22	25	25 30 18	80 34 12
W3 Bottom	48	56	25 30 18	80 34 12
W4 Top	10	11	25 24 13	80 35 58
W4 Middle	20	22	25 24 13	80 35 58
W4 Bottom	42	50	25 24 13	80 35 58

TABLE 2 (CONTINUED). WATER QUALITY STATION LABELING SYSTEM - PHASE 2

Station I.D.	Casing (Feet)	Total Depth (Feet)	Lat (Deg Min Sec)	Long (Deg Min Sec)
Agricultural East				
X1 Top	12	15	25 36 25	80 30 47
X1 Middle	22	27	25 36 25	80 30 47
X1 Bottom	48	55	25 36 25	80 30 47
X4 Top	14	21	25 31 10	80 31 11
X4 Middle	21	26	25 31 10	80 31 11
Agricultural West				
X2 Top	12	19	25 35 38	80 31 45
X2 Middle	20	27	25 35 38	80 31 45
X2 Bottom	53	60	25 35 38	80 31 45
X3 Top	17	20	25 34 42	80 31 43
X3 Middle	26	31	25 34 42	80 31 43
X3 Bottom	51	60	25 34 42	80 31 43
X5 Top	10	10.5	25 31 12	80 32 59
X5 Middle	14	16	25 31 12	80 32 59
X5 Bottom	48	53	25 31 12	80 32 59
X6 Top	10	11	25 25 06	80 34 02
X6 Middle	19	21	25 25 06	80 34 02
X6 Bottom	38	42	25 25 06	80 34 02
Surface Water Stations				
S1	N/A	N/A	25 45 42	80 40 27
S2	N/A	N/A	25 36 36	80 30 40
S3	N/A	N/A	25 25 24	80 35 24
S4	N/A	N/A	25 24 07	80 33 29

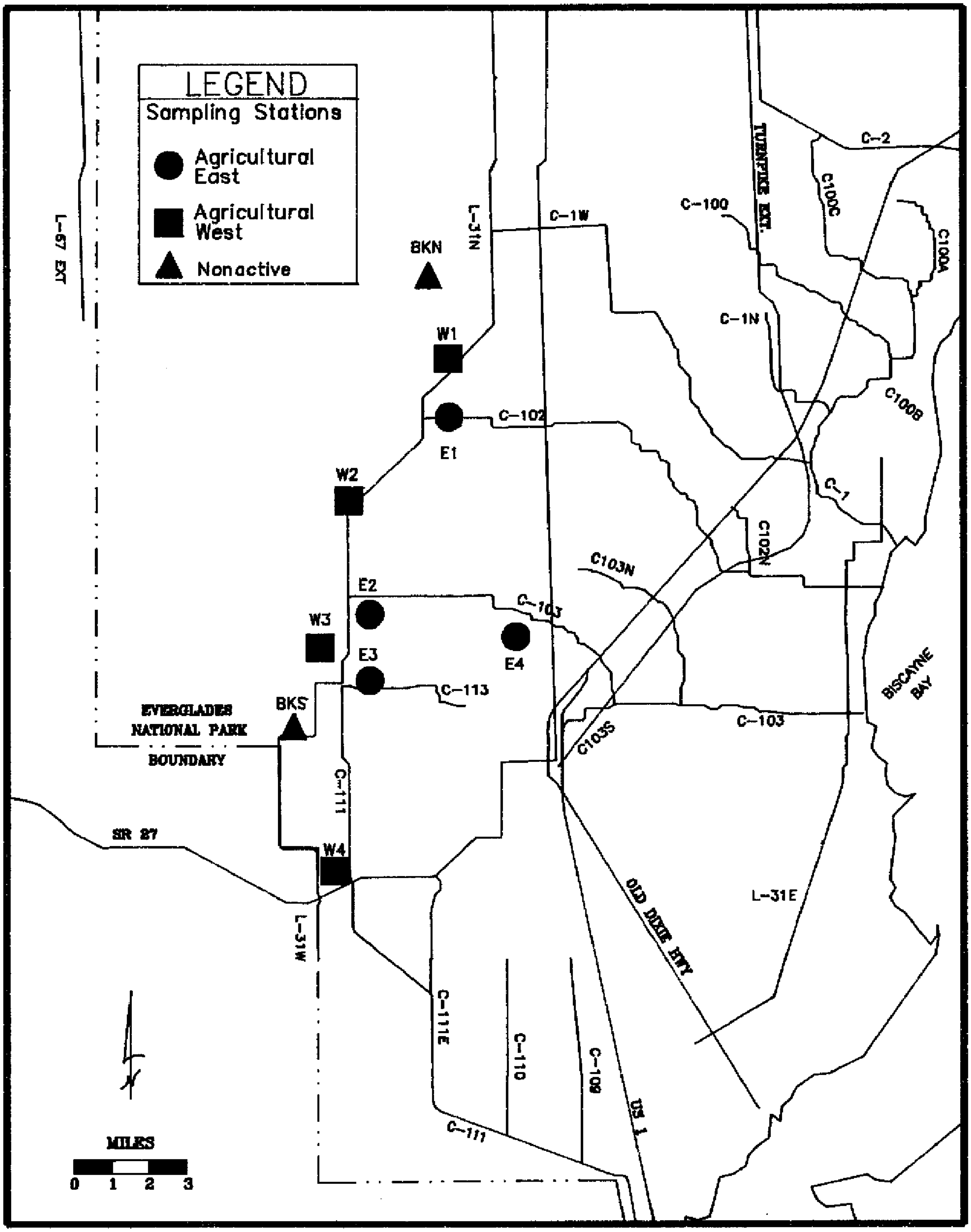

FIGURE 3. Phase 1 Monitoring Well Station Locations.

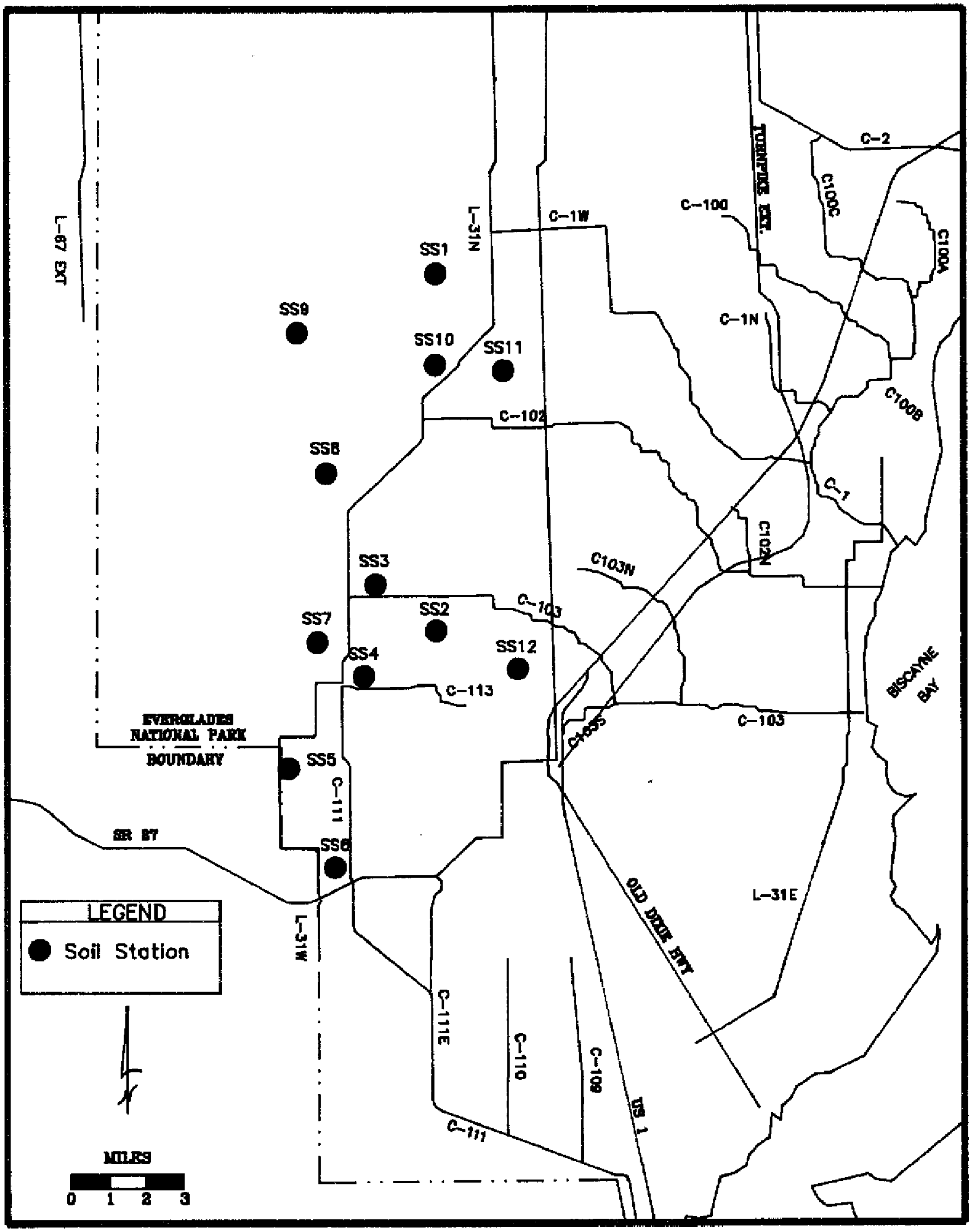

FIGURE 5. Location of Soil Sampling Stations.

TABLE 3. REPRESENTATIVE LOCATIONS OF SOIL SAMPLING STATIONS

Soil Station	Non Active Agricultural	Agricultural East	Agricultural West
S1	X		
S2		X	
S3		X	
S4		X	
S5			X
S6			X
S7			X
S8			X
S9	X		
S10			X
S11		X	
S12		X	

Approximately 360 soil cores were collected from the various soil stations. The samples were collected using an Oakville sampler, which provided a soil core from the upper six inches of profile. Depth to bedrock was recorded at each sampling station, and laboratory analyses were performed to determine grain size (hydrometer method) and organic matter content (ignition method).

SAMPLING PROCEDURES AND LABORATORY QUALITY ASSURANCE/ QUALITY CONTROL

All wells were purged a minimum of three well volumes prior to collecting samples. The well volume was determined by taking a water level measurement and calculating the volume of water in the well, based on the well construction. Depending on the size of the well and the volume to be purged, either a 2-inch centrifugal pump or a peristaltic pump was used to purge the well. The purging rate was determined by measuring the time required to fill a container of known volume. The rate was continuously measured during purging. Suction hoses were cleaned or replaced in the field immediately prior to purging each well. Suction hoses were kept as near as possible to the top of the water column during purging to assure that all water in the well was purged. After a well was purged using the pump, approximately 2.5 gallons or the top five feet of water (whichever is less) was removed using a teflon bailer This was done to remove any water that came in contact with the suction hose.

Unfiltered samples to be analyzed for inorganic constituents were collected using a teflon bailer and transferred directly to the sample bottle. The polyethylene sample bottles were obtained form the lab and rinsed three times with sample water prior to being filled with the actual sample. The sample bottle was filled as full as possible and preserved (acidized) if necessary. The sample was then placed on ice in a closed container, where it was kept until delivered to the lab. All sample bottles were labeled with tags listing the station ID, sample number, parameters to be analyzed, date, time, and names of the sampling personnel.

Unfiltered samples to be analyzed for organic constituents were collected in a similar manner to inorganic samples, with the following modifications. The sample was transferred from the bailer to a bottom emptying device (100% teflon) to minimize agitation and exposure to air. This device was used to completely fill the glass sample bottle, which was immediately placed on ice in a closed container. The sample was labeled in the same manner as inorganic samples.

Filtered samples were collected using a teflon bailer. Samples were transferred from the bailer to a container where they were filtered using a 0.45 micron filter. The first 100 milliliters was used as rinse water for the sample bottle.

All sampling equipment was cleaned, rinsed with analyte free water, and air dried at each site immediately prior to sample collection. A chain of custody was not observed for this study. Field blanks were kept with the sample bottles to ensure that the samples did not become contaminated. Field blanks accounted for approximately 5% of the samples that were analyzed.

Analyses for organic parameters was done at the University of Miami. Analyses for inorganic parameters was done at the South Florida Water Management District Chemistry Laboratory in West Palm Beach. A copy of the lab's current quality assurance plan is available from the District (SFWMD, 1990).

GEOLOGY OF THE STUDY AREA

SOILS

The soils encountered within the area of study are composed of calcareous sandy silty sediments (i.e., marls) of marine and freshwater origin. The existing soil cover is very thin, ranging on average from three to five inches. In some locations, however, up to a maximum of two feet of overburden cover solution cavities existing within the eroding bedrock surface. Most of the soils encountered on site are variations of the Rockdale series.

In general, the alkaline soils are described as soft, light to dark brown clayey silty sands (loam, ML through OL) containing abundant organic debris. In the active agricultural areas, rock plowing has also added abundant limestone detritus. The percent detritus, or coarse fraction, was determined at each soil sampling station. The coarse fractions provided a relative indicator of the quantity of bedrock contained within the shallow soils at each soil sampling station as a function of various stages of farming practices. Table 4 displays the percentage of coarse versus fine sediments located at each soil sampling field station.

Sieve and hydrometer analyses performed on the soil cores (fine fraction) reveal a grain size distribution averaging 43.13 percent sand, 32.94 percent silt, and 23.93 percent clay. As illustrated in Table 5, the highest percentage of sand occurred in sample SS11, located in the active agricultural west area of row crop farming. The lowest percentage of sand occurred in samples SS5 and SS7, located in an area of newly permitted active agriculture.

TABLE 4. SOIL SEDIMENT FRACTIONS

Soil Analysis				
Sample No.	Coarse Wt. (grams)	Coarse %	Fine Wt. (grams)	Fine %
SS1	36.80	9.6	345.06	90.4
SS2	101.14	28.9	249.20	71.1
SS3	227.51	49.7	230.60	50.3
SS4	310.75	58.3	221.87	41.7
SS5	143.74	47.3	159.91	52.7
SS6	350.62	76.8	106.09	23.2
SS7	45.67	11.6	346.56	88.4
SS8	171.23	40.5	251.36	59.5
SS9	103.13	30.6	234.03	69.4
SS10	128.24	35.1	236.82	64.9
SS11	119.37	28.5	299.02	71.5
SS12	193.74	54.5	161.90	45.5

TABLE 5. GRAIN SIZE DISTRIBUTION AND ORGANIC MATTER CONTENT OF SOILS

Sample No.	Texture	Soil to Bedrock (in.)	% Sand	% Silt	% Clay	% Org. Matter	% $CaCO_3$
SS1	Clay Loam	4-6	35.28	35.44	29.28	9.62	54.23
SS2	Loam	3-4	54.28	31.44	23.28	14.72	48.96
SS3	Loam	3-4	45.28	31.44	23.28	6.28	84.84
SS4	Sandy Clay Loam	3-4	52.56	23.44	24.00	6.71	84.49
SS5	Silty Clay Loam	3-4	20.56	47.44	32.00	10.67	81.22
SS6	Sandy Clay Loam	5-6	48.56	23.44	28.00	4.63	89.98
SS7	Silty Clay Loam	1-5	14.56	57.44	28.00	7.56	88.09
SS8	Loam	0-2	42.56	37.44	20.00	10.36	70.29
SS9	Loam	1-9	46.56	33.44	20.00	18.00	39.76
SS10	Loam	1-3	42.56	35.44	22.00	12.21	62.58
SS11	Sandy Loam	1-3	75.28	11.44	13.28	4.86	29.82
SS12	Sandy Clay Loam	1-2	48.56	27.44	24.00	10.36	57.39

GRAIN SIZE:
SAND = 2.0 - .05 mm SILT = .05 - .002 mm CLAY = < .002 mm

The average value of organic matter displayed by all 12 soil cores taken within the study area is 9.66 percent, ranging from a low 4.6 percent at station SS6 to a high of 18.0 percent at station SS9 (Table 5). Soil sampling field station SS9 represented the most natural undisturbed conditions within the area and probably reflected a pre-agricultural Everglades environment. Stations SS6 and SS11, which display the lowest organic matter perecentages, were located in areas of extensive rock plowing and farming.

HYDROSTRATIGRAPHY

The lithologic logs, detailing all borings drilled during this investigation, support previous interpretations of the local hydrostratigraphy found beneath the study area. One principal shallow hydrogeologic zone is identified and consists of cross-bedded, massive white to yellowish oolitic and fossiliferous limestones, interbedded with white to buff carbonate sands and sandstones, and gray mudstones. The lithified sediments are extremely vuggy and friable in nature.

The near-surface stratigraphy which incorporates this zone (i.e., the upper 70 feet), consists of consolidated sediments from two distinct geologic formations. These include, from bottom to top, the Fort Thompson Formation and the Miami Oolite. These two units, although distinct in terms of their carbonate lithology and depositional environments, provide subtle clues as to formational contact. Within the area of study, the contact zone is not sharp and distinct but rather gradational, indicated by either a transition to a calcareous sandstone or the resemblance of a pseudo-breccia.

A series of north-south and east-west cross sections are presented in Figures 6 and 7, respectively, to illustrate the near-surface stratigraphy beneath the study area.

Both the Fort Thompson and Miami Oolite Formations are recognizable and traceable throughout this region.

The thicknesses of these formations vary across the study area. As indicated in Figures 6 and 7, the Fort Thompson and Miami Oolite Formations thin to the north and west, and thicken to the east and south. The thickness of the Fort Thompson Formation varies from approximately 5 feet in the northwest to approximately 55 feet in the southeast. The maximum thickness of the Miami Oolite (up to approximately 20 feet) occurs in the southeast and decreases to approximately 5 feet in the northwest.

MINERALOGY

Visual analyses of bedrock cores were conducted on representative samples from the Fort Thompson and Miami Oolite Formations. The purpose of the analyses was to define the general mineralogic composition of the sediments and subsequently evaluate the chemical reactivity, in terms of sorption capability, of these sediments within the saturated zone.

Four continuous cores taken at boring sites BKN, BKS, E1, and W2, reflect the carbonate lithologies present from the surface to 60 feet below ground surface within the study area. Primary mineralogic constituents include calcite ($CaCO_3$), dolomite ($CaMg(CO_3)2$), and quartz (SiO_2), and make up approximately 95 percent of the total volume. The remaining 5 percent includes various unidentifiable secondary and trace constituents from a variety of mineral groups such as the clays and sulfates.

Although the carbonates serve as sources for major ionic species such as Ca, Mg, etc., none of the mineralogic constituents examined, excluding the clay fraction, serve as primary sinks for chemical solutes. The clay fraction is known to react with many inorganic and organic constituents and can provide an effective sink within the ground water regime (see Murriman and Koutz, 1972). However, based on the percentage of clay exhibited by the cores analyzed, this does not appear to provide a significant attenuation mechanism to chemical solutes within the formations themselves.

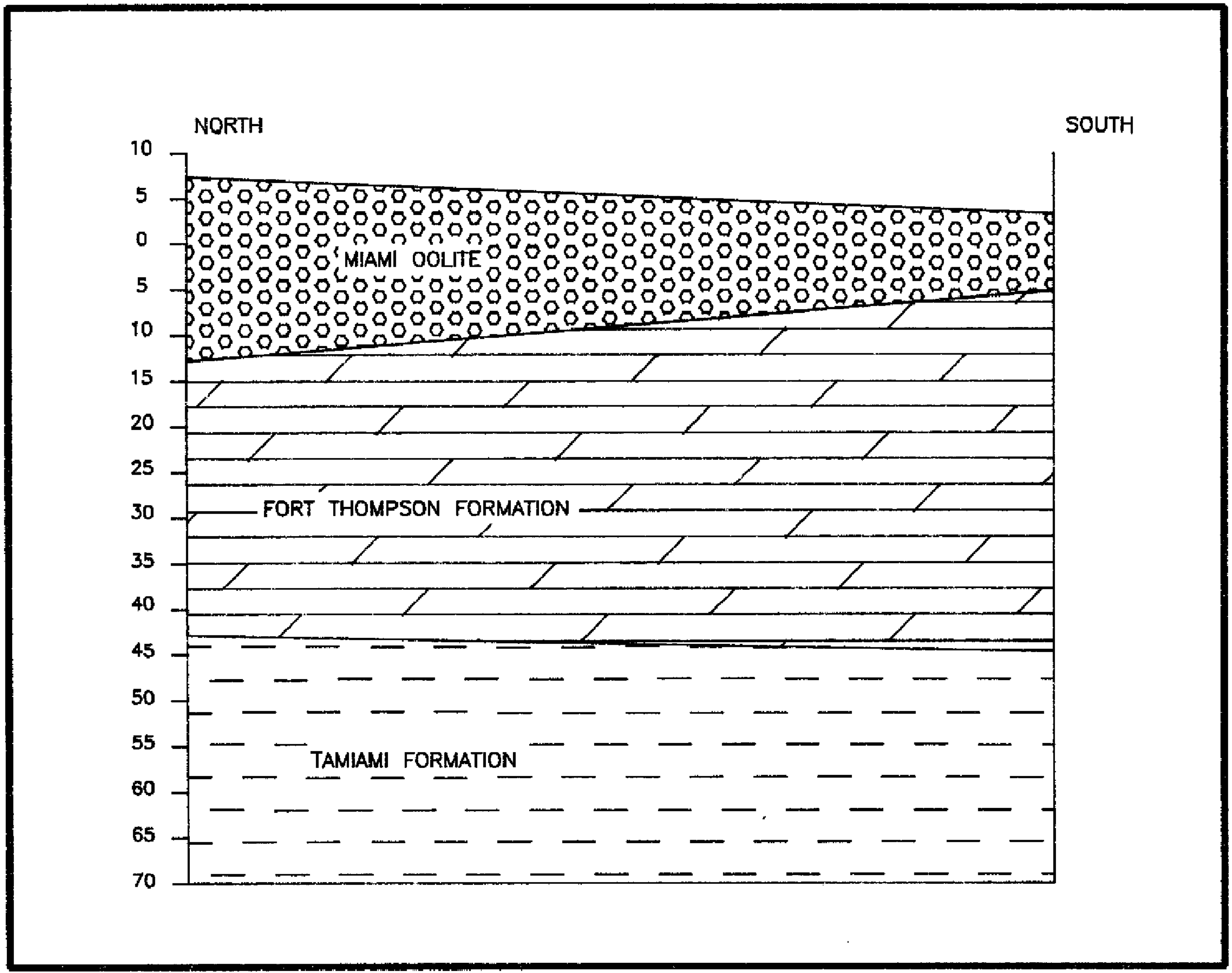

FIGURE 6. Generalized North-South Geologic Cross Section.

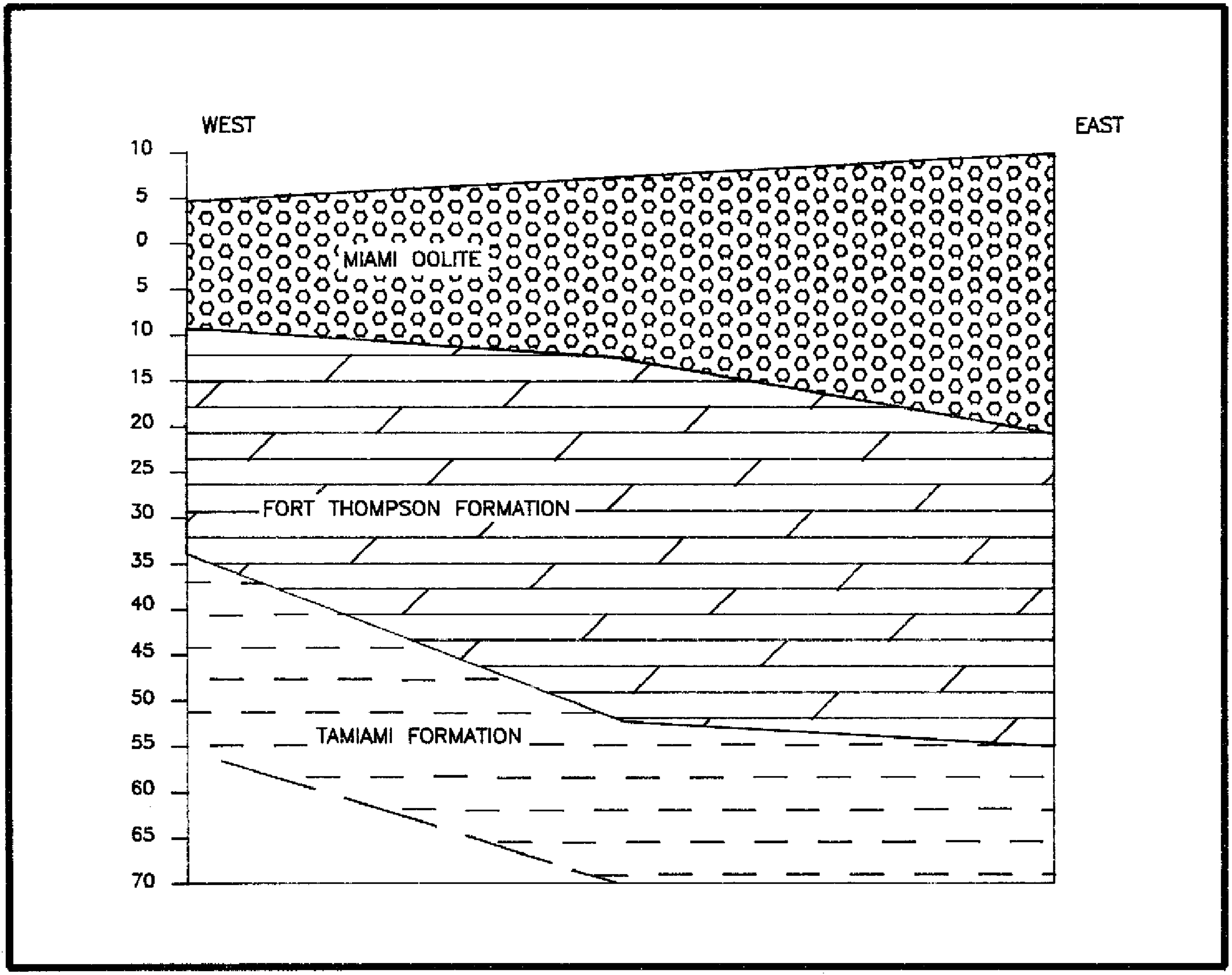

FIGURE 7. Generalized East-West Cross Section.

HYDROGEOLOGY OF THE STUDY AREA

A shallow unconfined water bearing zone known as the Biscayne Aquifer is situated beneath the study area. This zone is composed of alternating sequences of limestones, mudstones, and sandstones of relatively high permeability. The aquifer is continuous and traceable throughout the area, exhibiting both thickness and lithology variation (with respect to areal distribution) as previously discussed in the Geology Section and indicated by site boring logs (Shaw, 1985).

POTENTIOMETRIC SURFACE OF THE BISCAYNE AQUIFER

Depth-to-water measurements were recorded throughout the two-year period of this study within select USGS monitor wells located in and adjacent to the study area. These measurements were retrieved from continuous strip chart recorders and reduced to NGVD. The data reflects two principal seasonal variations; wet and dry. Examples of potentiometric surface maps for October 1982 and May 1983, reflecting these seasonal variations, are presented in Figures 8 and 9, respectively. These maps are consistent with previous interpretations conducted within this region and illustrate uniform hydraulic gradient trends with time (see Sonnenshein, 1983).

The potentiometric surface maps illustrate a water table which slopes gradually toward the coast. This produces a regional ground water flow across the study area from northwest to southeast. Local recharge and discharge to and from the aquifer, depending on the time of year, occur at the various canals which transect the area. Although ground water elevations reflecting these seasonal variations fluctuate on an annual basis, the overall hydraulic gradient remains fairly constant. The computed shallow hydraulic gradient of the Biscayne Aquifer within the study area approaches $1\text{x}10^{-4}$ feet per foot.

AQUIFER CHARACTERISTICS

Both the Fort Thompson Formation and Miami Oolite are highly permeable units, resulting from the numerous solution channels and cavities present within the carbonate fraction and along formational contacts. The greater permeability is reflected in the upper 20 feet of the Biscayne Aquifer where the Miami Oolite is located. Laboratory permeability values generated from cores removed from this unit range from 0.0037 to 0.0130 feet per second (Shaw, 1985).

Extensive aquifer pump testing has been conducted within south Florida to determine transmissivity and storage coefficients, enabling conservative estimates to be made with respect to aquifer yield. Transmissivity values within the Biscayne Aquifer range from four to eight million gallons per day per foot (Appel,1973). Specific yields reported within the Biscayne Aquifer range from 0.10 to 0.35 (Schroeder et al., 1958).

Effective porosity within the Biscayne Aquifer is assumed to approximate the storativity ranges listed above. This porosity is largely the result of dissolution within the carbonate rock matrix, which provides a network of secondary solution channels ranging in diameter from 0.20 to 1.57 inches (Shaw, 1985).

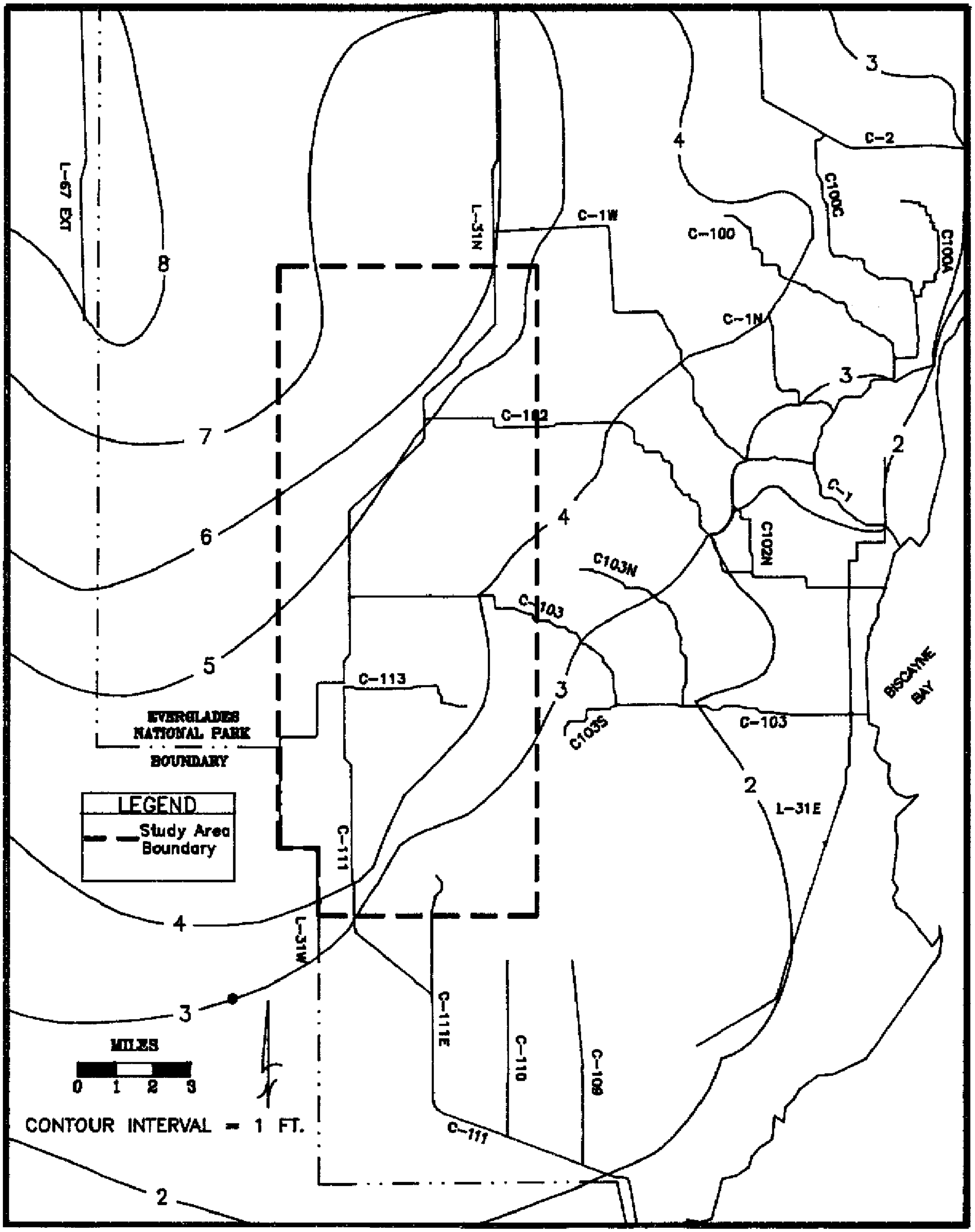

FIGURE 8. Potentiometric Surface of the Biscayne Aquifer Within the Study Area October 1982 (After Sonnenshein, Unpublished).

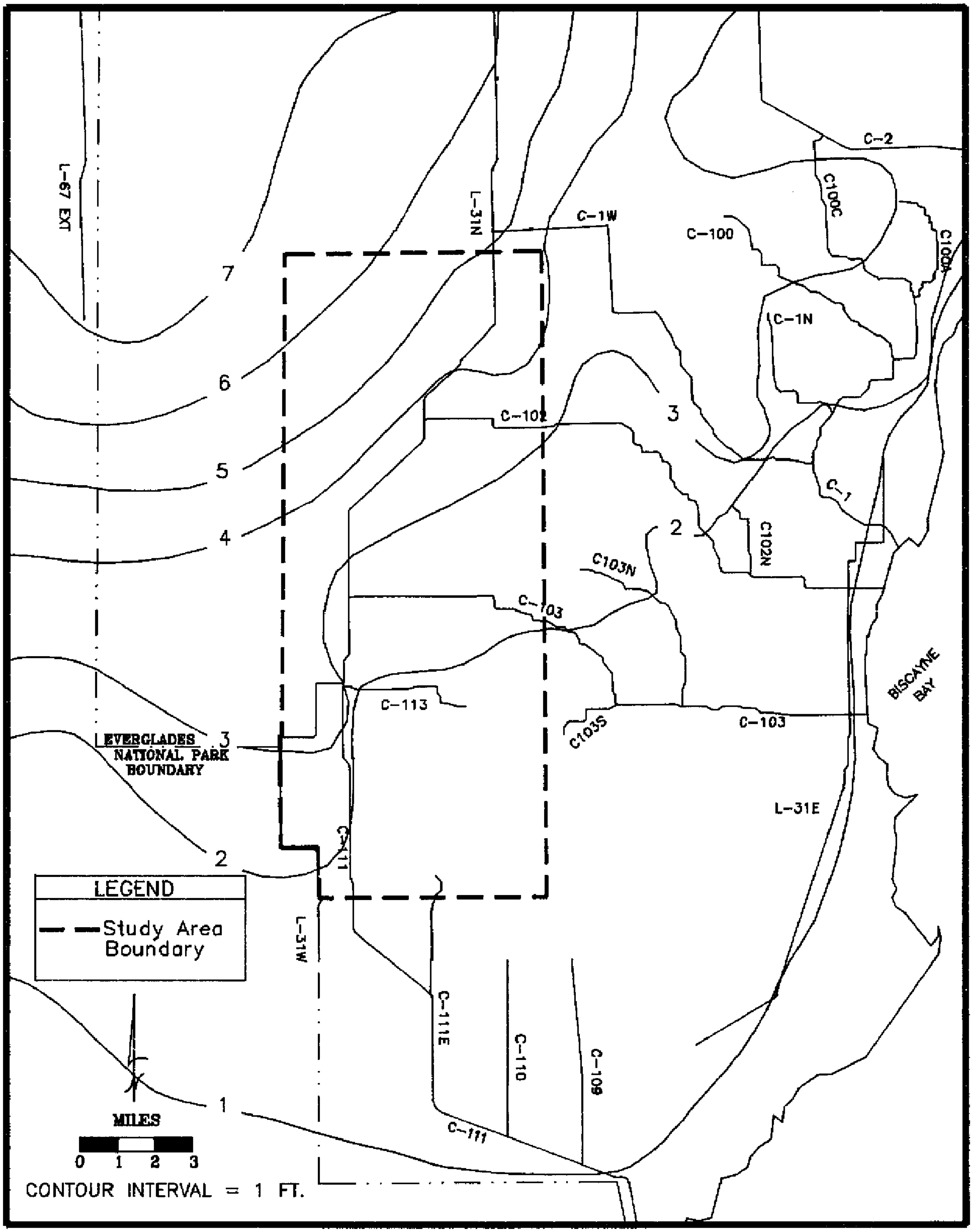

FIGURE 9. Potentiometric Surface of the Biscayne Aquifer Within the Study Area, May 1983 (After Sonnenshein, Unpublished).

GROUND WATER VELOCITY

The average linear horizontal ground water seepage velocity (V_s) existing within the Biscayne Aquifer beneath the study area can be calculated using the following equation:

$$V_s = Ki/n_e = Ti/Dn_e$$

where:
V_s = seepage velocity (L/T)
K = hydraulic conductivity (L/T) = T/D
T = transmissivity (L^2/T)
D = saturated thickness (L)
i = hydraulic gradient (L/L)
n_e = effective porosity (percent)

Assuming the following hydraulic parameters, the conservative estimated seepage velocity within the study area is:

if:
T = 6,000,000.0 gal/day/ft,
D = 45.0 ft,
i = 0.000123 ft/ft, and
n_e = 0.225
then:
V_s = 9.76 ft/day (2.98 m/day)

A previous ground water investigation conducted within the C-103 basin in Dade County revealed a negligible vertical hydraulic gradient within the Biscayne Aquifer (Shaw, 1985). Therefore, ground water flow within the area of this study is assumed to be principally in the horizontal rather than vertical direction.

INORGANIC WATER QUALITY RESULTS

INTRODUCTION

Results from data collected during the two year water quality monitoring study are presented in this section. Selected chemical analyses conducted on samples taken from two monitoring stations located in the non-active agricultural area are compared with the results of 14 active agricultural monitoring stations selected on the east and west sides of the L-31 Borrow Canal. Water quality variation(s) existing between the top, middle, and bottom zones within the Biscayne Aquifer is discussed, including a comparison of ground water quality with four surface water quality monitoring stations. All laboratory analytical results are presented in Appendix A. In addition, a statistical evaluation conducted on selected inorganic parameters in order to determine any significant concentration variation(s) with respect to area and depth is also presented. The data summarized in Table 6 show, for all inorganic parameters analyzed, the combined average concentrations for all three aquifer zones monitored and compares the results for the non-active agricultural area with the active east and west agricultural areas. Parameters not detected in an analysis were included in the calculations as having concentrations equal to the minimum detection limit. Table 7 compares the average inorganic parameter concentrations, from the top, middle and bottom zones, within each of the three agricultural areas

.

TABLE 6. COMBINED AVERAGE CONCENTRATIONS FOR SELECTED PARAMETERS WITHIN EACH AGRICULTURAL AREA

Parameter	Non Active Agricultural	Agricultural East	Agricultural West
Temp (°C)	24.13	24.78	24.33
Alkalinity ($CaCO_3$)	198.86	214.94	212.18
Spec. Cond. (umhos/cm)	435.33	608.92	594.13
NA (mg/L)	11.38	32.22	31.12
K (mg/L)	0.54	3.02	3.42
CL (mg/L)	20.29	51.98	48.79
SO_4 (mg/L)	9.41	18.85	18.86
TDS (mg/L)	247.17	344.24	340.22
NO_3 (mg/L)	0.10	0.34	0.27
CR (µg/L)	2.19	10.74	8.06
CU (µg/L)	2.85	1.94	1.99
PB (µg/L)	1.97	2.64	1.89
HG (µg/L)	0.18	0.19	0.25
AS (µg/L)	1.20	1.41	1.40
CD (µg/L)	0.38	0.35	0.36

SAMPLING PROGRAM

The water quality investigation involved six sampling events, which included the subsequent collection and evaluation of 254 ground water and 16 surface water samples. Field measurements, used for determining physical parameter values, were conducted on all samples collected prior to laboratory submittal. Laboratory analyses included the following parameters: macronutrients, major ions, trace metals, and select pesticides.

TABLE 7. AVERAGE CONCENTRATIONS FOR SELECTED PARAMETERS BY AQUIFER ZONES WITHIN EACH AGRICULTURAL AREA

	Parameter	Top	Middle	Bottom
NonActive Ag				
	Temp (°C)	24.37	24.16	23.88
	Alkalinity ($CaCO_3$)	197.25	199.17	200.17
	Spec. Cond.(umhos/cm)	436.00	431.60	438.40
	NA (mg/L)	11.53	9.89	12.72
	K (mg/L)	0.63	0.50	0.50
	CL (mg/L)	25.04	17.14	18.68
	SO_4 (mg/L)	11.52	8.71	7.99
	TDS (mg/L)	250.47	242.14	248.91
	NO_3 (mg/L)	0.12	0.10	0.05
	CR (µg/L)	1.43	4.00	1.15
	CU (µg/L)	6.20	1.53	0.81
	PB (µg/L)	1.93	1.64	2.35
	HG (µg/L)	0.18	0.18	0.18
	AS (µg/L)	1.24	1.24	1.10
	CD (µg/L)	0.38	0.38	0.38
Ag East				
	Temp (°C)	25.37	24.77	23.93
	Alkalinity ($CaCO_3$)	217.73	216.37	209.14
	Spec. Cond.(umhos/cm)	628.83	611.90	579.44
	NA (mg/L)	34.20	32.33	29.23
	K (mg/L)	2.99	3.02	3.07
	CL (mg/L)	54.14	51.28	49.76
	SO_4 (mg/L)	17.75	18.96	20.27
	TDS (mg/L)	349.88	347.71	333.77
	NO_3 (mg/L)	0.36	0.42	0.20
	CR (µg/L)	2.79	2.25	32.87
	CU (µg/L)	1.56	2.04	2.37
	PB (µg/L)	2.21	2.10	3.96
	HG (µg/L)	0.20	0.18	0.19
	AS (µg/L)	1.48	1.30	1.24
	CD (µg/L)	0.36	0.34	0.32
Ag West				
	Temp (°C)	24.41	24.42	24.15
	Alkalinity ($CaCO_3$)	214.00	214.65	207.88
	Spec. Cond.(umhos/cm)	601.96	606.82	573.61
	NA (mg/L)	32.24	32.98	28.21
	K (mg/L)	3.98	3.61	2.66
	CL (mg/L)	48.91	51.28	46.19
	SO_4 (mg/L)	20.34	17.74	18.51
	TDS (mg/L)	354.09	343.64	322.93
	NO_3 (mg/L)	0.46	0.24	0.06
	CR (µg/L)	10.28	2.45	11.44
	CU (µg/L)	2.02	2.20	1.77
	PB (µg/L)	1.82	2.52	1.34
	HG (µg/L)	0.37	0.19	0.19
	AS (µg/L)	1.48	1.48	1.24
	CD (µg/L)	0.36	0.36	0.36

Samples collected during these events were divided into three regions for comparison purposes; nonactive agricultural, active agricultural east, and active agricultural west areas. The east and west geographic designations represent those areas of sample collection with respect to the L-31 Borrow Canal. Descriptive statistics were calculated and data results are tabulated over a two year monitoring period.

Two sampling events represent the latter half of the 1984-85 growing season, and four sampling events represent the 1985-86 growing season. Table 8 lists each sampling event, the time of year sampling was conducted, and the farming activity (i.e., growing vs. non-growing season) represented in the active agricultural areas. Sampling events 1 and 2 occurred during the application of various insecticides in May and during periods of major rainfall in July, representing flushing events typical of the wet season. The following year, sampling events 3 through 6 represented the entire growing season consisting of a variety of farming stages. Sampling event 3 occurred in November during field preparation and early planting. Sampling event 4 occurred in March during the major month of early harvesting and planting of the second set of row crops. Sampling event 5 occurred in May during the end of the growing season with the last applications of fungicides and insecticides. This is also the period of field preparation for the summer months which entails the application of herbicides and rock plowing. Sampling event 6 occurred in August during the summer wet season. During this time of year increased infiltration, combined with a high water table, resulted in localized flushing of the aquifer.

TABLE 8. SAMPLING EVENT SCHEDULE

Sampling Event No.	Time of Year	Representation
1	May 1985	End of Growing Season (84-85)
2	July 1985	Rainfall Event (Non-Growing Season)
3	November 1985	Start of Growing Season (85-86)
4	March 1986	Mid Growing Season (85-86)
5	May 1986	End of Growing Season (85-86)
6	August 1986	Rainfall Event (Non-Growing Season)

PHYSICAL PARAMETERS

Several parameters including temperature, alkalinity, and specific conductance were measured in the field from the water samples collected. As previously illustrated in Table 6, no apparent changes in temperature were evident throughout the three agricultural areas. Alkalinity values were slightly higher in the active agricultural areas. Conductivity was markedly higher in the both the east and west active agricultural areas displaying values of 609 µmhos/cm and 594 µmhos/cm, respectively. Conductivity in the nonactive agricultural areas averaged 435 µmhos/cm. There were no marked changes in temperature and alkalinity values with respect to depth for either of the three agricultural areas (refer to Table 7).

MAJOR IONS

Major ions which exhibited apparent variations throughout the study area included: potassium, sodium, sulfate, chloride, and nitrate. In general, the sampling results showed increased concentrations of approximately two to three fold within the active agricultural areas verses non-active agricultural areas.

Chloride concentrations decreased with depth in each of the three areas. In general, sulfate concentrations also decreased with depth except in the active east agricultural area, where elevated concentrations occurred.

TOTAL DISSOLVED SOLIDS

Total dissolved solids concentrations were approximately 340 mg/L in the active agricultural areas, as compared to an average concentration of 247 mg/L for the nonactive agricultural area.

There were no distinguishable changes in total dissolved solids concentrations with depth.

TRACE METALS

Four trace metals displayed apparent variation throughout the study area. They included: chromium, copper, lead, and mercury.

Chromium

Variations in chromium concentrations were observed throughout the study area. Nonactive monitoring stations displayed an average concentration of 2.19 µg/L, and the east and west active agricultural monitoring stations displayed an average concentration of 10.74 and 8.06 µg/L, respectively. Very high concentrations (i.e., exceeding the drinking water standard of 5.0 µg/L) were evidenced throughout the study area at the end of the growing season during Event 5. The highest chromium concentration appeared at that time and was obtained from agricultural monitoring well (E1). A comparison of the mean chromium concentrations with depth indicated an increase in chromium concentration toward the bottom of the aquifer in the active agricultural areas. No such pattern was evident in the nonactive agricultural area.

Copper

Nonactive monitoring stations within the study area displayed a mean concentration for copper of 2.85 µg/L, while active east and west agricultural monitoring stations displayed a mean concentration of 1.94 and 1.99 µg/L, respectively. The nonactive monitoring station BKS produced several high residual copper concentrations, leading to a higher average copper value in the non-active agricultural areas. Results throughout the study area do not display any trend as to vertical distribution of copper.

Lead

Lead concentrations, obtained from the nonactive monitoring stations exceeded concentrations for those stations located on the east side of the L-31 levee, while lead concentrations for those stations located on the west side were below concentrations obtained from the nonactive monitoring stations.. The non-active monitoring stations displayed a mean lead concentration of 1.97 µg/L, the eastern active agricultural monitoring stations displayed a mean concentration of 2.64 µg/L, and the western active agricultural monitoring stations displayed a mean concentration of 1.89 µg/L.

Lead concentrations appear to vary throughout the study area, showing a general increase with depth in the middle and bottom monitoring zones of the aquifer. These elevated concentrations (i.e., greater than 2.0 µg/L) are apparent within both nonactive, as well as active, agricultural monitoring areas.

Mercury

Mercury concentrations were approximately an order of magnitude lower than drinking water standards. However, the active agricultural west area showed an elevated concentration of 0.25 µg/L, as compared to 0.19 and 0.18 µg/L, for the active east and nonactive agricultural areas, respectively. Results illustrate no apparent trend as to vertical distribution of mercury concentration throughout the study area.

SURFACE WATER

A comparison of mean concentrations for inorganic parameters from non-active agricultural, surface water, and active agricultural stations is presented in Table 9. In general, this table illustrates that surface water quality within the study area is comparable to the ground water quality in areas affected by agriculture. Local canals can play an important role in enhancing the distribution of non-point source contaminant entry into the surrounding ground water. Within the study area, a percentage of chemical compounds is transported to the canal system by surface runoff. Assuming that the net flux of concentration is directed away from the canals during periods of storm loading (i.e., the canals act principally as an "influent" system during this time), the induced hydraulic gradient would provide a driving mechanism to amplify ground water concentrations within the vicinity of the canal system. This influent situation was shown to be the predominant condition by Shaw (1985). In order to obtain useful estimates concerning parameter "loading" in areas such as this, the runoff component from agricultural land use should be evaluated more extensively.

TABLE 9. AVERAGE CONCENTRATION OF SELECTED PARAMETERS FOR ALL SURFACE WATER STATIONS VERSUS THE AGRICULTURAL AREAS

Parameter		S1	S2	S3	S4	NonActive Agricultural	Agricultural East	Agricultural West
NA	(mg/L)	48.72	43.55	24.88	43.00	11.38	32.22	31.12
K	(mg/L)	3.47	1.78	1.35	2.27	0.54	3.02	3.42
CL	(mg/L)	73.62	58.73	40.80	55.12	20.29	51.98	48.79
SO_4	(mg/L)	17.07	10.62	13.80	23.63	9.41	18.85	18.86
TDS	(mg/L)	366.25	377.25	279.25	360.00	247.17	344.24	340.22
NO_3	(mg/L)	0.14	0.01	0.06	0.13	0.10	0.34	0.27
CR	(µg/L)	7.52	30.18	1.59	0.80	2.19	10.74	8.06
CU	(µg/L)	1.59	1.25	0.92	1.42	2.85	1.94	1.99
PB	(µg/L)	0.59	2.11	0.83	0.77	1.97	2.64	1.89
HG	(µg/L)	0.20	0.20	0.20	0.20	0.18	0.19	0.25
AS	(µg/L)	2.22	1.38	1.39	1.29	1.20	1.41	1.40
CD	(µg/L)	0.25	0.25	0.30	0.25	0.38	0.35	0.36

STATISTICAL ANALYSIS

A statistical evaluation was conducted on selected inorganic parameters in order to determine significant concentration variation(s) (with respect to central tendency differences between population sets) existing within the Biscayne Aquifer. A nonparametric procedure, the Mann-Whitney pairs test, was applied in order to accommodate the relatively small size of the data sets involved and the non-normal distribution behavior inherent in the concentration values analyzed.

Data collected from three different zones within the Biscayne Aquifer (the top, middle, and bottom), and surface water stations, were used in the spacial analysis. Those parameters that serve as indicators of agricultural practices were selected for testing. Table 10 lists the water quality parameters chosen for statistical analysis.

TABLE 10. WATER QUALITY PARAMETERS SELECTED FOR STATISTICAL ANALYSIS

Parameters		
Cond	-	Conductivity
TDS	-	Total Dissolved Solids
NO_3	-	Nitrate
SO_4	-	Sulfate
CU	-	Copper
PB	-	Lead
CR	-	Chromium
CL	-	Chloride
K	-	Potassium

The pairs test was applied to those parameters (samples) selected above, in a sequential order as outlined in Table 11. The procedure (STATGRAPHICS, 1986) combines and ranks all the data from the selected parameters two at a time. The ranks are then summed over all observations contained in each sample and a statistic is calculated to compare the average ranks. If the statistic is large (i.e., $Z > 1.64$ at the 95 percent confidence level), one must reject the hypothesis that the samples have identical location parameters (i.e., comparable medians).

In general, the results of the statistical analysis, as summarized in Table 11, indicate the following information:

1. Significant differences existed between the nonactive agricultural and active agricultural east, and nonactive agricultural and active agricultural west concentrations within the upper zone of the Biscayne Aquifer for the following parameters: COND, TDS, SO_4, Cl, and K. These parameter concentrations are likely by-products of both natural existing conditions and anthropogenic (agriculture dominant) effects. However, potassium concentrations probably reflect anthropogenic processes to a larger extent due to the absence of naturally existing source (parent) material. In all cases, median concentrations from active agricultural areas exceed non-active agricultural median concentrations. No significant variations in concentration were found to exist for nitrate or the trace metals copper, lead, and chromium; most likely representative of anthropogenic processes as well.

TABLE 11. STATISTICAL RESULTS OF THE MANN - WHITNEY PAIRS TEST

	Comparisons									
Parameters	BGNTOP ETOP	BGNTOP WTOP	ETOP WTOP	SW EWTOP	BGNTOP BGNMID	BGNMID BGNBOT	BGNTOP BGNBOT	EWTOP EWMID	EWMID EWBOT	EWTOP EWBOT
Cond	SV	SV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV
TDS	SV	SV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV
NO_3	NSV	NSV	NSV	NSV	SV	NSV	SV	SV	SV	SV
SO_4	SV	SV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV
CU	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV
PB	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV
CR	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV
CL	SV	SV	NSV	NSV	NSV	NSV	NSV	NSV	NSV	NSV
K	SV	SV	NSV	SV	NSV	NSV	NSV	NSV	NSV	NSV

BKNTOP = BACKGROUND MONITORING SITES, TOP OF AQUIFER ZONE
BKNMID = BACKGROUND MONITORING SITES, MIDDLE OF AQUIFER ZONE
BKNBOT = BACKGROUND MONITORING SITES, BOTTOM OF AQUIFER ZONE
ETOP = EASTERN MONITORING SITES, TOP OF AQUIFER ZONE
WTOP = WESTERN MONITORING SITES, TOP OF AQUIFER ZONE
EWTOP = EASTERN AND WESTERN MONITORING SITES COMBINED, TOP OF AQUIFER ZONE
EWMID = EASTERN AND WESTERN MONITORING SITES COMBINED, MIDDLE OF AQUIFER ZONE
EWBOT = EASTERN AND WESTERN MONITORING SITES COMBINED, BOTTOM OF AQUIFER ZONE
SW = SURFACE WATER MONITORING SITES
SV = SIGNIFICANT VARIATION BETWEEN POPULATION MEDIANS
NSV = NO SIGNIFICANT VARIATION BETWEEN POPULATION MEDIANS

NOTE: FOR ALL SAMPLES, REJECT NULL HYPOTHESES FOR Z > 1.64 AT THE 95 PERCENT CONFIDENCE LEVEL.

2. No significant differences existed between the active agricultural east and west concentrations within the upper zone of the Biscayne Aquifer for the parameters tested.

3. A significant difference existed between surface water and active agricultural (east and west) combined concentrations within the upper zone of the Biscayne Aquifer for the parameter potassium. The median potassium concentration displayed from the active agricultural areas exceeded the median surface water concentration. No other significant differences were evidenced for the remaining parameters.

4. A significant variation in concentration for nitrate was found to exist with depth within the Biscayne Aquifer for both the non-active agricultural, and active agricultural east and west combined concentrations. As expected, nitrate concentrations appeared to attenuate with depth. No other significant differences were evidenced for the remaining parameters.

PESTICIDE RESULTS

The East Everglades Ground Water Monitoring Study is one of the first programs designed by the SFWMD to monitor and ascertain levels of pesticide residues within ground water. This investigation targeted the monitoring of the most heavily used pesticide compounds applied to the soils and various row/citrus crops within the south Dade County agricultural area. The following section contains separate discussions of the pesticide results of the ground water monitoring program during the first and second years of the investigation.

FIRST YEAR RESULTS

The monitoring network, installed in the shallow zone of the Biscayne Aquifer, was sampled during the months of May and July 1985 (Events 1 and 2), for the first year of the investigation. A list of the pesticide compounds that were analyzed for during the first year of this program, analytical detection limits, and concentrations and well stations of detected compounds, is presented in Table 12.

TABLE 12. PESTICIDE COMPOUNDS ANALYZED AND CONCENTRATIONS DETECTED - 1985 GROWING SEASON (EVENTS 1 AND 2)

	Event 1, (May, 1985)			Event 2 (July, 1985)		
Compound	MDL (ppb)	Concent (ppb)	Monitor Well Stat.	MDL (ppb)	Concent (ppb)	Monitor Well Stat.
Alachlor	1.0			0.10		
Aldicarb	0.010	1.3	BKN	0.010		
Atrazine	0.10			0.10		
Benomyl	20.0			20.0		
Chlordane	0.010			0.010		
Chlorothalonil	0.002	0.24	W1	0.002		
Chloropyrifos	0.006			0.006		
Chloropicrin	0.10			0.10		
DBCP	10.10			0.10		
EDB	10.02			0.02		
Lindane	0.002			0.002		
Maneb	1.0			1.0		
Methomyl	20.0			20.0		
Methyl Bromide	0.10			0.10		
Metribuzin	0.003			0.003		
Metalochlor	0.010			0.010		
Oxamyl	2.0			2.0		
Parathion	0.006			0.006		
Paraquat	3.0			3.0	25.0	E4
Permethrin	0.20	18.5	W1	0.20		
Phorate	0.006			0.006		
Simazine	0.10			0.10		

The first year of ground water monitoring within the area of interest, represented by Events 1 and 2, indicated a minimal influence to water quality from organic compounds used for agricultural activity. Sampling results indicated the presence of four pesticide compounds within the shallow ground water regime (Table 12). Analyses conducted on water samples collected during Event 1 showed three pesticide compounds present in the northern portion of the study area including aldicarb, chlorothalonil, and permethrin. Active agricultural monitor well station W1 contained two of these compounds: chlorothalonil at 0.24 µg/L and permethrin (total) at 18.5 µg/L. Chlorothalonil is a substituted aromatic broad spectrum fungicide, and permethrin is a synthetic pyrethroid insecticide. Both of these organic compounds display low solubilities in water. Nonactive agricultural monitor well station BKN contained aldicarb at 1.3 µg/L. Aldicarb is a carbamate systemic insecticide, acaricide, and nematicide. The occurrence of this pesticide compound within the shallow ground water was unexpected, considering its relict nature, and subsequently was investigated in the second year of this project.

Analyses conducted on water samples collected during Event 2 indicated the presence of only one pesticide compound. Active agricultural monitor well station E4 contained paraquat at 25.0 µg/L, which is a bipyridylium herbicide.

SECOND YEAR RESULTS

The second year of ground water monitoring for pesticides within the study area involved a total of four sampling events. November, March, May, and August (Events 3-6) were selected as representative months during the 1986 growing season. In addition to re-sampling the shallow zone within the Biscayne Aquifer, the middle and bottom zones were included as well during Events 4, 5 and 6. The growing season commenced in November with field preparation and fumigation of existing soil cover. Event 3 was scheduled at the end of November to evaluate this entire preparation process. Event 4 was scheduled in March to coincide with the harvesting of the first 90 day set of row crops. Event 5 was scheduled in May to accommodate the end of the 1986 growing season, and Event 6 was scheduled in August to coincide with a major rainfall event "post" growing season. A list of the pesticide compounds that were analyzed for during the second year of this program, analytical detection limits and concentrations and well locations of detected compounds, is presented in Table 13.

All of the pesticide compounds detected during the second year of study occurred during Event 3, which represents the start of the growing season. Four compounds were detected and occurred at several sampling stations throughout the study area.

During Event 3 permethrin was detected at a concentration of 7.2 µg/L at active agricultural monitoring well station W1. Atrazine was detected at a concentration of 0.17 µg/L at active agricultural monitoring well station W4. Metribuzin was also detected at active agricultural monitoring well station W4, at a concentration of 0.30 µg/L. Atrazine and metribuzin are pre-emergence herbicides used at the beginning of the growing season for row crop field maintenance. Atrazine is also used on corn, which is grown throughout the study area.

Aldicarb was detected at 12 monitoring well stations and extensively distributed throughout the study area during Event 3. Concentrations ranged from below analytical detection of 0.10 µg/L to 0.20 µg/L at station W3. The values were measured as a result of a new methodology, applied by the University of Miami Epidemiology Laboratory, developed to detect aldicarb or its daughter products, aldicarb sulfoxide and aldicarb sulfone, to within one tenth of one part per billion.

TABLE 13. PESTICIDE COMPOUNDS ANALYZED AND CONCENTRATIONS DETECTED -- 1986 GROWING SEASON (EVENTS 3, 4, 5, AND 6)

Event 3 (November, 1986)

Compound	MDL (ppb)	Concent. (ppb)	Monitor Well Stat.
Alachlor	0.010		
Aldicarb	0.10	0.15	W2
		0.13	BKN
		0.11	W1
		0.11	S2
		0.14	S3
		0.12	S4
		0.18	W4
		0.15	S1
		0.18	E1
		0.15	E4
		0.13	X4
		0.20	W3
Atrazine	0.10	0.17	W4
Benomyl	20.0		
Carbofuran	10.0		
Chlorothalonil	0.002		
Chloropyrifos	0.006		
DBCP	0.10		
EDB	0.02		
Lindane	0.002		
Metalochlor	0.010		
Methamidophos	0.20		
Methomyl	20		
Metribuzin	0.003	0.30	W4
Oxamyl	2.0		
Parathion	0.006		
Paraquat	3.0		
Permethrin	0.20	7.2	W1

This exceeds previous levels of detection as that which was applied during the first year of this study by one order of magnitude. No pesticide concentrations exceeded State or EPA drinking water standards of 9 and 10 µg/L, respectively.

CONCLUSIONS AND RECOMMENDATIONS

1. The two years of surface and ground water monitoring data indicates an impact to water quality from select inorganic and organic chemical compounds applied within the south Dade County agricultural study area. The noticeable effect(s) on water quality, with respect to the non-active agricultural area, appears to be localized principally within the heavily farmed areas. However other areas, such as those surrounding the northern non-active agricultural monitoring station BKN, are slowly being encroached upon by residential and agricultural activity, and are beginning to exhibit some degradation due to anthropogenic processes as well.

2. In general, water quality sampling results indicate elevated concentrations of inorganic chemical parameters associated with active agriculture when compared to non-active agricultural concentrations. A statistical evaluation conducted on selected constituents revealed significant differences existing between non-active agricultural and active agricultural monitoring station concentrations within the upper zone of the Biscayne Aquifer for the following parameters: potassium, sulphate, chloride, conductivity, and total dissolved solids. The majority of these parameters most likely reflect the use of fertilizers applied within the study area. In all cases, median concentrations from active agricultural areas exceed non-active agricultural median concentrations. A significant difference exists between surface water and the shallow ground water sampled within the active agricultural areas for the parameter potassium. A higher median concentration occurs within the shallow ground water underlying the "active" farming areas. In addition, a significant variation in nitrate concentrations was found to exist with depth within the Biscayne Aquifer throughout the study area. These concentrations appear elevated nearer the surface and attenuate with depth.

3. Six organic pesticide compounds were detected within the surface water and shallow ground water at 14 monitoring stations. These compounds include: aldicarb, paraquat, atrazine, metribuzin, chlorothalonil, and permethrin representing a variety of fungicides, insecticides, and herbicides. Only two isolated areas located west of the L-31N Borrow Canal, however, displayed the recurrence of more than one pesticide compound during the two year monitoring program.

4. Overall water quality displayed by the Biscayne Aquifer in the area of this study lies within acceptable established regulatory standards. None of the inorganic parameters analyzed for during this two year program exceeded the State of Florida primary safe drinking water standards; and only three parameters, iron, manganese, and chromium exceeded the state secondary drinking water standards of 0.3 mg/l, 0.05 mg/L, and 5.0 µg/l, respectively. In addition, organic pesticide aldicarb concentrations did not exceed the federal regulatory standard of 10 µg/L. At this time, no regulatory drinking water standards have been established for the remaining five organic pesticide compounds detected.

5. Regional ground water flow within south Dade County agricultural area is generally to the south - southeast, toward the coast. Local recharge and discharge to and from the Biscayne Aquifer, depending on the time of year, occurs at the various canals which transect the study area. Although ground water elevations reflecting these seasonal variations fluctuate on an annual

basis, the overall hydraulic gradient of 1x10-4 feet per foot remains fairly constant.

6. Infiltration resulting from rainfall appears to impact existing ground water quality within the study area. In general, during the dry season chemical concentrations within the shallow ground water continue to increase throughout the growing season. During the wet season, however, a decrease in chemical application(s), combined with periods of increased rainfall, enable the aquifer to "flush" itself by the process of dilution.

7. Current farming practices, combined with the process of dilution attained during the wet season, appear to minimize the overall impact of agriculture on the water resources of the Biscayne Aquifer. Initial water quality monitoring conducted throughout the study area during the growing season was anticipated to provide a good indication of agricultural land use impact(s) on ground water quality. The recurrence of various individual pesticide compounds within the shallow ground water at two localized areas within the study region (i.e., near S-331 and active agricultural monitoring well station W1, and near the vicinity of the Frog Pond or active agricultural monitoring well station W4) during different stages of the growing season, however, leads to the assumption that any ensuing concentration distribution is localized in extent, and not area pervasive. Thus, any attempt to extrapolate the results of this report on an areal basis without further study is not recommended.

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APPENDIX A

APPENDIX A

LABORATORY ANALYTICAL RESULTS

(UNITS)

Temp	°C
Cond	µmhos/cm
Alk	$CaCO_3$
Ca	mg/L
Mg	mg/L
Na	mg/L
K	mg/L
Cl	mg/L
SO_4	mg/L
SiO_2	mg/L
TDS	mg/L
Org (N)	mgN/L
NH_3	mgN/L
NO_2	mgN/L
NO_3	mgN/L
TOT (N)	mg/L
OPO_4	mgP/L
TPO_4	mgP/L
AS	µg/L
CD	µg/L
CR	µg/L
CU	µg/L
FE	µg/L
PB	µg/L
MN	µg/L
HG	µg/L
ZN	µg/L

BKN MIDDLE

	5/85	7/85	11/85	3/86	5/86	8/86
TEMP	24.4	23.3	24.5	23.3	23.2	24.1
COND	443	443	-	461	456	469
ALK	202	188	212	229	204	198
CA	77.1	80.4	75.4	79.7	80.9	79.30
MG	3.58	3.53	3.47	3.46	3.50	3.44
NA	11.4	13.1	12.80	13.10	14.60	13.80
K	0.26	0.24	0.22	<1.50	0.28	<0.20
CL	18.2	16.7	20.1	22.6	25.4	14.6
SO4	4.2	<2.0	6.3	4.9	8.5	18.3
SIO2	3.8	3.5	3.5	5.2	3.6	5.5
TDS	271	267	243.8	254.1	255.9	269.9
ORG(N)	0.6	<0.5	0.75	<0.5	0.77	0.82
NA3	.38	.35	0.31	0.37	0.35	0.35
NO2	<.004	<.004	<.004	<.004	<.004	<.004
NO3	.010	.001	.003	.000	.000	.008
TOT(N)	0.99	0.72	1.07	<0.50	1.12	1.18
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
OPO4	.005	.013	.005	.010	<.004	0.005
AS	2.55	<1.5	<0.9	<1.2	<1.2	<1.3
CD	<.6	<.5	<0.2	<0.3	-	-
CR	3.23	30.0	1.01	3.34	3.02	<.3
CU	5.81	1.95	0.50	0.98	<0.3	1.36
FE	1110	1270	-	1270	1160	970
PB	5.84	<.3	1.24	2.28	<0.4	.36
MN	15.92	19.34	20.26	27.75	30.35	22.45
HG	<.110	<.3	<0.2	<0.2	-	-
ZN	<30	<20	<20	183.7	<10	<10

BKN BOTTOM

	5/85	7/85	11/85	3/86	5/86	8/86
TEMP	24.0	23.4	23.6	23.7	23.5	23.9
COND	427	451	-	470	466	480
ALK	204	190	220	233	205	198
CA	78.3	80	78.2	78.6	80.4	78.70
MG	3.86	3.80	3.77	3.75	3.67	3.57
NA	12.9	14.4	14.50	14.00	16.40	15.10
K	0.23	0.23	0.21	<1.50	0.21	<0.20
CL	20.6	17.8	20.6	24.7	26.6	13.0
SO4	5.7	<2.0	6.9	4.9	8.5	17.8
SIO2	4.0	3.7	4.2	5.5	3.8	5.9
TDS	271	279	264	264.9	264	271
ORG(N)	<0.5	1.32	0.97	<0.5	0.74	<0.5
NH3	0.43	0.40	0.37	0.42	0.39	0.43
NO2	.004	<.004	<.004	<.004	<.004	<.004
NO3	.000	.001	.000	.007	.000	.001
TOT(N)	.75	1.73	1.34	<0.50	1.13	<0.5
OPO4	<.004	<.004	<.004	<.004	<.004	.014
TPO4	<.004	.024	.006	.009	<.004	0.006
AS	<.90	<1.5	<0.9	<1.2	<1.2	<1.3
CD	<.60	<.50	<0.2	<0.3	-	-
CR	2.23	2.41	1.73	0.90	1.98	<0.3
CU	0.23	2.28	0.64	2.01	<0.3	1.41
FE	1410	1260	-	-	1200	1050
PB	5.8	5.89	1.64	<0.3	<0.4	.59
MN	15.5	15.04	20.29	24.1	23.75	24.3
HG	<.110	<.3	<0.2	<0.2	-	-
ZN	<30	<20	<20	64.6	<10	13.4

BKS TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.9	25.0	25.3	24.4	24.2	24.6
COND	391	458	-	420	417	410
ALK	179	182	204	204	197	174
CA	74.6	63.3	71.6	74.8	74.7	77.20
MG	2.93	4.73	3.41	2.94	2.87	2.02
NA	8.7	12.9	13.4	8.2	6.1	6.90
K	0.36	1.05	.79	<1.5	0.41	0.75
CL	13.2	20.4	74.1	13.7	13.7	10.5
SO4	7.2	19.6	12.3	25.4	8.0	19.1
SIO2	3.7	3.5	3.7	4.4	3.1	4.0
TDS	234	254	240	230	225	233
ORG(N)	<.5	0.7	0.53	<0.5	0.59	<0.5
NH3	0.2	0.2	0.2	0.13	0.20	0.11
NO2	<.004	<.004	<.004	.005	.007	.025
NO3	.009	.065	0.079	0.105	0.091	0.83
TOT(N)	.57	.97	.81	.61	.89	.86
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.010	<.004	.007	<.004	.006
AS	1.30	2.27	1.49	<1.2	<1.2	<0.7
CD	<.6	<.4	<.2	<.2	-	-
CR	2.64	<.3	.72	1.32	1.48	<0.4
CU	<.2	<.6	64.05	2.05	.53	<0.5
FE	350	480	0	0	1210	160
PB	.42	.84	2.33	<.9	10.43	0.7
MN	4.88	5.68	9.31	7.43	8.46	5.65
HG	<.110	.150	<.2	<.2	-	-
ZN	<30	<20	<10	12.7	<20	38.1

BKS BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.6	23.2	24.3	24.1	23.8	24.4
COND	383	400	-	442	422	443
ALK	176	183	203	211	193	186
CA	69.5	69.3	71.50	73.1	73.5	73.00
MG	3.11	3.37	2.99	3.44	3.18	3.18
NA	10.4	12.3	9.9	13.5	8.0	11.3
K	0.38	0.39	.37	<1.5	0.39	0.40
CL	16.9	11.9	14.0	20.7	18.1	19.3
SO4	3.7	16.0	7.7	4.7	6.9	11.1
SIO2	7.1	3.9	3.6	6.3	9.7	5.6
TDS	206	237	220	240	228	242
ORG(N)	.920	<.50	<0.5	<0.5	0.63	0.68
NH3	0.27	0.28	0.25	0.24	0.26	0.26
NO2	<.004	<.004	<.004	<.004	<.004	.004
NO3	.002	.003	.000	.000	.000	.306
TOT(N)	1.2	.51	.67	.61	.89	1.25
OPO4	.006	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.007	.004	.006	<.004	<.004
AS	<.9	<1.2	<.90	<1.2	<1.2	<0.7
CD	<.6	<.4	<.2	<.2	-	-
CR	1.52	<.3	<0.6	.89	<.5	<0.4
CU	<.2	.190	.61	.88	<.5	<0.5
FE	560	980	1090	0	830	1180
PB	<.4	.88	2.63	<.9	<.6	8.18
MN	4.72	6.82	11.86	9.89	7.85	14.59
HG	<.110	<.1	<.2	<.2	-	-
ZN	<30	<20	22.9	<10	<20	29.6

E1 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.7	25.6	26.3	23.9	25.6	26.5
COND	760	662	-	635	825	580
ALK	236	199	227	243	228	202
CA	95.4	84.4	80.60	99.40	80.10	75.30
MG	11.94	8.47	3.98	4.04	9.09	6.49
NA	49.6	34.3	33.50	23.50	53.50	37.10
K	6.48	5.31	5.21	6.30	2.18	2.18
CL	82.0	51.5	50.7	38.1	44.6	58.4
SO4	50.2	35.7	28.6	35.8	10.1	12.3
SOI2	5.0	3.8	5.3	4.1	5.0	7.5
TDS	484	417	352	363	400	343
ORG(N)	0.93	<.5	1.06	0.57	1.13	<0.5
NH3	<0.01	.04	0.23	0.08	0.24	0.50
NO2	0.1	<.004	.006	<.004	<.004	<.004
NO3	0.385	<.004	.003	.000	.000	.096
ORG(N)	1.43	<.500	1.30	0.65	1.37	<0.5
TOPO4	.004	<.004	.004	<.004	<.004	<.004
TPO4	.009	.015	.016	.010	.008	.010
AS	1.35	<0.5	1.64	<0.2	1.36	4.3
CD	<.6	<.5	<0.3	<0.3	-	-
CR	0.66	5.39	.56	5.31	1.55	<.03
CU	0.81	.74	<0.9	1.51	4.23	0.81
FE	50.0	330	650	0.00	800	640
PB	<.4	<.3	<0.4	18.03	2.37	<.3
MN	3.56	9.0	12.67	11.99	19.11	11.17
HG	<.110	<.3	<.02	<0.2	-	-
ZN	<30	<20	<10	66.9	20.5	14.8

E1 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	23.3	24.1	24.0	23.2	24.6
COND	-	643	-	239	813	600
ALK	-	212	243	-	227	200
CA	-	98.4	98.30	10.78	100.6	78.50
MG	-	4.25	3.93	4.31	4.07	4.47
NA	-	24.7	23.60	24.70	25.60	30.90
K	-	6.37	5.76	6.65	6.95	5.26
CL	-	39.4	39.8	46.9	41.7	51.5
SO4	-	36.8	35.9	3.0	44.6	19.0
SIO2	-	2.6	2.9	<1.0	2.2	4.5
TDS	-	386	368	126	369	350
ORG(N)	-	<.5	0.85	1.00	<0.5	0.88
NH3	-	.140	0.04	0.22	0.07	0.27
NO2	-	<.004	<.004	<.004	<.004	<.004
NO3	-	.001	.000	.000	.012	.088
TOT(N)	-	0.5	0.89	1.22	0.54	1.24
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.006	<.004	.008	.004	.016
AS	-	<1.5	<0.9	<1.2	<1.3	<1.3
CD	-	<.5	<0.3	<0.3	-	-
CR	-	<1.5	0.4	<0.4	876.5	0.86
CU	-	2.18	<0.9	2.42	4.72	15.48
FE	-	140	<50	500	600	8200
PB	-	3.42	<0.4	26.65	<0.4	34.7
MN	-	10.59	11.32	20.90	34.0	38.39
HG	-	<.3	<0.2	<0.2	-	-
ZN	-	30.9	45.1	278.2	101	16.2

E2 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	25.9	27.8	26.0	23.2	25.5	26.7
COND	843	718	-	642	667	598
ALK	231	199	221.5	235	231	213
CA	87.3	69.1	71.5	75.2	80.0	76.0
MG	19.51	13.25	7.37	8.70	8.70	7.12
NA	65.3	42	35.7	42.0	49.10	39.30
K	5.89	3.72	1.87	2.29	2.04	2.86
CL	106	66.2	90.3	61.4	73.3	62.5
SO4	54.7	26.5	3.0	5.9	9.6	12.4
SIO2	9.1	6.3	5.3	5.5	5.3	6.5
TDS	533	380	152	358	384	350
ORG(N)	1.83	1.25	0.71	0.84	1.12	1.18
NH3	0.04	0.070	0.37	0.05	0.38	0.74
NO2	0.214	<.004	<.004	<.004	<.004	<.004
NO3	0.620	.000	0.014	.002	.000	0.435
TOT(N)	2.7	1.33	1.14	0.89	1.5	<0.5
OPO4	<.004	<.004	0.005	<.004	<.004	<.004
TPO4	0.011	.006	0.014	0.007	.007	.017
AS	1.47	1.5	1.99	<1.2	<1.2	1.67
CD	<.6	<.5	0.31	<0.2	-	-
CR	2.95	6.20	0.82	<0.4	1.98	.59
CU	2.77	1.56	1.28	0.63	0.86	1.29
FE	820	180	2900	0.00	4550	1480
PB	<.4	<.3	2.95	1.22	1.79	6.53
MN	19.57	17.49	21.15	9.37	55.35	23.12
HG	<0.11	0.15	<0.2	<0.2	-	-
ZN	30	<20	-	<10	60.2	31.6

E2 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.6	25.9	26.3	23.1	25.3	25.1
COND	722	705	-	627	663	627
ALK	204	199	224	237	237	213
CA	76.0	72.7	74.0	76.5	80.2	78.50
MG	16.18	12.87	7.56	9.13	8.91	7.51
NA	53.70	43.8	34.9	44.3	52.10	39.80
K	4.49	3.74	1.88	2.29	2.06	2.52
CL	83.8	71.0	55.0	64.2	72.6	64.0
SO4	37.4	26.9	6.7	8.0	9.4	14.3
SIO2	6.1	4.5	6.5	5.8	5.0	6.7
TDS	451.0	383	326	369	397	363
ORG(N)	1.52	<.5	0.87	0.82	1.11	0.99
NH3	<.01	.120	0.42	0.04	0.36	0.50
NO2	0.017	<.004	<.004	<.004	<.004	<.004
NO3	.007	.006	.000	.004	.001	0.160
TOT(N)	1.55	<.5	1.24	0.88	1.48	1.65
OPO4	<.004	<.004	0.005	<.004	<.004	<.004
TPO4	.007	.005	0.015	0.008	.006	.012
AS	1.31	1.86	1.94	<1.2	1.56	1.57
CD	<.6	<.4	<0.2	<0.2	-	-
CR	2.91	9.63	1.25	<0.4	<0.5	0.42
CU	1.37	1.23	<.5	<.2	<0.5	17.89
FE	190	210	1710	480	2800	1130
PB	<.4	<.6	<0.4	0.99	2.2	1.81
MN	20.95	14.73	25.6	10.28	35.69	14.17
HG	<.110	<.10	<0.2	<0.2	-	-
ZN	510	<20	<20	<10	143	21.1

E2 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	22.8	22.2	23.3	22.7	23.2	24.4
COND	725	637	-	638	606	624
ALK	200	196	225	235	216	205
CA	76.0	74.4	80.7	77.8	79.0	79.3
MG	10.29	9.32	7.68	7.59	7.43	7.00
NA	44.3	41.9	41.1	42.0	42.80	40.10
K	2.49	2.38	2.18	2.12	2.30	2.33
CL	67.9	66.7	56.0	63.9	60.1	61.9
SO4	19.4	17.9	7.1	5.9	13.0	18.4
SIO2	4.3	5.7	3.8	7.5	4.4	5.8
TDS	382	384	364	365	345	336
ORG(N)	1.48	<.5	0.75	0.75	0.97	0.94
NH3	<.01	.120	0.14	0.10	0.15	0.15
NO2	<.004	<.004	<.004	<.004	<.004	<.004
NO3	.001	.000	.014	.002	.000	.018
TOT(N)	1.49	.510	0.91	0.86	1.12	1.11
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	.006	.004	0.007	0.008	.004	.005
AS	1.53	1.25	1.66	<1.2	<1.2	<0.7
CD	<.6	<.4	<0.2	<.02	-	-
CR	1.65	2.35	1.03	<0.4	<0.5	0.58
CU	<.2	0.93	<.5	<.2	<0.5	4.73
FE	700	840	1770	570	3200	1310
PB	<.4	0.6	5.43	<0.9	2.48	14.41
MN	5.42	7.08	10.47	<0.6	25.39	16.74
HG	<.110	<0.1	<0.2	<0.2	-	-
ZN	<30	<20	35.8	<10	43.8	51.9

E3 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.8	27.8	24.0	23.9	25.5	24.7
COND	577	606	-	627	671	614
ALK	204	192	212	222	236	198
CA	80.3	74.8	82.2	79.3	83.10	78.7
MG	6.41	6.4	6.19	7.04	9.08	7.07
NA	34.8	36.5	47.3	41.6	39.0	38.0
K	2.78	2.75	2.65	3.38	2.08	3.53
CL	57.1	61.9	60.8	59.2	72.1	60.0
SO4	9.8	22.4	9.7	19.6	7.8	23.5
SOP2	4.1	4.2	4.0	5.8	5.1	6.3
TDS	354.0	367	391	369	384	351
ORG(N)	1.35	<.5	1.41	0.66	1.30	0.93
NH3	.140	.140	0.14	0.15	0.36	0.17
NO2	<.004	<.004	<.004	<.004	<.004	<.004
NO3	.011	.017	.000	.008	.000	0.0966
TOT(N)	1.51	.520	1.55	0.82	1.66	2.07
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.010	.008	.007	.004	.011
AS	2.06	1.54	1.46	1.36	<0.2	1.19
CD	<.6	<.4	<.2	<.2	-	-
CR	2.08	1.11	1.12	0.65	1.42	<0.4
CU	<.2	.93	<.4	2.1	2.72	<0.5
FE	1150	830	.000	.000	27.50	90.0
PB	1.18	<.6	0.7	1.21	6.69	0.90
MN	7.39	6.97	7.1	8.47	25.75	11.42
HG	<.110	.24	<.2	<.2	-	-
ZN	<30	211	<10	<10	41.2	28.6

E3 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.8	26.9	24.1	24.1	25.6	24.5
COND	583	633	-	622	673	610
ALK	205	191	212	222	234	190
CA	82.7	71.8	81.5	78.1	82.3	79.7
MG	6.55	6.35	6.30	6.99	8.90	7.06
NA	34.8	36.2	46.5	41.6	50.4	39.0
K	2.86	2.6	2.74	3.35	2.15	3.48
CL	58.7	62.1	73.9	59.1	74.3	58.2
SO4	9.7	13.9	33.4	22.0	8.2	22.4
SOP2	3.6	4.0	4.3	5.8	5.3	6.3
TDS	360	370	394	371	385	359
ORG(N)	1.04	<.5	0.79	0.67	1.27	1.11
NH3	.150	.140	0.13	0.16	0.39	0.19
NO2	<.004	<.004	<.004	<.004	<.004	<.004
NO3	.003	.014	.000	.000	.000	2.81
TOT(N)	1.2	.520	0.92	0.83	1.66	4.15
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.006	.010	.005	.006	.008
AS	<.9	1.53	1.57	<1.2	<1.2	1.11
CD	<.6	<.4	<.2	<.2	-	-
CR	2.88	1.9	0.6	1.08	.9	<0.4
CU	1.81	1.07	1.32	<.2	.39	<0.5
FE	570	60	.000	.000	1420	520
PB	1.77	.94	4.11	<.9	.81	.62
MN	6.19	7.13	8.37	6.55	8.95	5.91
HG	<.110	.150	<.2	<.2	-	-
ZN	<30	<20	28.2	10.6	45.9	30.6

E3 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.3	26.7	24.0	24.0	24.2	24.4
COND	569	632	-	630	628	617
ALK	206	197	212	220	212	196
CA	82.6	76.1	82.7	78.6	82.0	78.9
MG	6.2	6.35	6.21	6.71	6.98	6.83
NA	33.2	34.8	45.7	42.3	44.0	39.0
K	2.62	2.49	2.54	2.78	3.08	3.16
CL	55.3	60.3	73.8	61.4	63.2	61.5
SO4	8.5	21.1	32.9	22.8	16.2	22.6
SOP2	3.7	3.5	3.4	5.5	4.4	6.1
TDS	349	358	408	365	347	354
ORG(N)	1.0	.74	0.73	0.54	0.92	<0.5
NH3	.150	.14	0.13	0.15	0.16	0.18
NO2	<.004	<.004	<.004	<.004	<.004	<.004
MO3	.001	.003	.000	.000	.007	.489
TOT(N)	1.150	.89	0.86	0.69	1.09	<0.5
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.008	.006	.006	<.004	.005
AS	.61	1.86	1.77	<1.2	1.48	1.58
CD	<.6	<.4	<.2	<.2	-	-
CR	2.49	<.3	2.24	<.4	<.5	<0.4
CU	1.7	1.91	2.57	7.48	<.5	<0.5
FE	880	710	.000	.000	660	920
PB	268	1.73	1.69	<.9	1.25	0.43
MN	7.58	6.25	8.84	7.64	7.09	6.93
HG	<.110	<.1	<.2	<.2	-	-
ZN	<30	<20	29.9	<10	54.5	26.1

E4 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.5	26.4	25.7	25.0	24.3	25.2
COND	557	517	-	616	599	589
ALK	208	198	223	225	209	201
CA	88.2	81.0	87.10	86.80	88.70	87.80
MG	3.55	3.3	3.21	3.75	3.79	3.14
NA	24.9	21.3	21.2	31.0	33.6	26.80
K	4.28	4.06	3.82	4.60	4.85	4.46
CL	39.8	32.4	34.6	49.5	51.9	46.6
SO4	20.0	26.3	20.4	20.3	27.7	24.5
SIO2	2.6	2.1	3.2	3.6	3.0	3.3
TDS	326	319	308	337	341	357
ORG(N)	<.5	<.5	0.74	<0.5	<0.5	<0.5
NH3	.30	<.010	<.010	0.01	0.02	0.04
NO2	.004	<.004	<.004	.004	<.004	.005
NO3	0.476	0.056	1.49	.749	1.20	1.66
TOT(N)	1.98	1.56	2.28	1.25	1.74	2.22
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	.007	.007	0.016	.007	.005	.008
AS	<.9	<1.2	<.9	<1.2	<1.3	<1.3
CD	<.6	<.4	<.3	<.2	-	-
CR	2.11	<.3	.76	.77	48.7	0.96
CU	2.24	2.04	1.12	5.24	5.69	2.31
FE	870	190	380	<50	570	120
PB	1.18	.82	5.28	1.96	2.17	2.38
MN	4.23	3.81	16.63	4.95	9.21	2.89
HG	<.110	.29	<.2	<.2	-	-
ZN	<30	<20	<10	46.6	<10	29.4

E4 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	25.3	25.6	25.0	25.0	24.4	24.7
COND	555	556	-	607	598	617
ALK	202	195	222	223	207	198
CA	89.1	81.4	85.40	88.70	86.30	86.40
MG	3.52	3.51	3.72	3.76	3.82	3.59
NA	25.7	23.0	26.9	30.6	34.1	33.4
K	4.19	4.25	4.05	4.43	4.74	4.72
CL	40.1	37.2	44.3	50.7	51.8	56.2
SO4	19.5	26.9	24.4	19.5	26.9	27.4
SIO2	2.5	2.3	3.5	3.9	3.2	4.1
TDS	326	316	324	335	341	368
ORG(N)	<.5	<.5	0.78	<0.5	<0.5	<0.5
NH3	.020	<.010	<.010	0.01	<0.01	0.09
NO2	.004	<.004	.004	0.043	<.004	0.032
NO3	1.326	.012	.685	.705	1.10	1.438
TOT(N)	1.83	<.5	1.52	1.25	1.64	1.98
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	.004	.004	.006	<.004	<.004	<.004
AS	.29	<1.2	<.9	<1.2	<1.3	<0.7
CD	<.6	<.4	<.3	<.2	-	-
CR	1.38	<.3	<.4	.42	35.4	<0.4
CU	.88	1.79	1.17	0.93	0.91	2.4
FE	420	120	80	50	210	280
PB	<.4	2.17	31.65	<.9	<.4	<.3
MN	1.3	1.19	11.19	2.29	3.85	3.55
HG	<.110	.190	<.2	<.2	-	-
ZN	<30	<20	<10	<10	17.7	24.3

E4 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	-	-	24.8	24.5	25.1
COND	-	-	-	596	553	609
ALK	-	-	-	223	207	199
CA	-	-	-	86.90	87.70	85.40
MG	-	-	-	3.53	3.62	3.38
NA	-	-	-	29.80	31.3	31.90
K	-	-	-	4.34	4.70	4.52
CL	-	-	-	47.1	51.0	54.8
SO4	-	-	-	19.7	27.2	27.4
SIO2	-	-	-	4.4	3.0	5.2
TDS	-	-	-	323	335	355
ORG(N)	-	-	-	<0.5	<0.5	0.50
NH3	-	-	-	0.01	<0.01	0.05
NO2	-	-	-	.004	.008	.049
NO3	-	-	-	0.749	1.08	1.091
TOT(N)	-	-	-	1.25	1.66	1.69
OPO4	-	-	-	<.004	<.004	<.004
TPO4	-	-	-	<.004	<.004	<.004
AS	-	-	-	<1.2	<1.3	<0.7
CD	-	-	-	<.2	-	-
CR	-	-	-	<.4	80.6	<0.4
CU	-	-	-	0.76	1.52	0.96
FE	-	-	-	50	490	530
PB	-	-	-	<.9	<.4	<.4
MN	-	-	-	3.18	6.44	6.1
HG	-	-	-	<.2	-	-
ZN	-	-	-	<10	23.3	32.0

W1 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	22.8	27.3	26.3	23.1	23.4	24.7
COND	679	718	-	634	612	601
ALK	187	179	227	235	226	220
CA	69.4	73.3	77.20	76.50	78.80	82.50
MG	15.67	13.68	7.40	7.87	8.25	6.95
NA	56.9	52.6	31.10	36.0	39.20	32.30
K	4.57	4.18	2.10	2.07	2.22	2.03
CL	89.3	70.1	23.6	54.7	66.8	50.1
SO4	60.5	24.8	9.6	6.2	11.0	18.4
SIO2	6.4	6.4	5.3	8.5	4.6	6.4
TDS	456	426	338	341	362	325
ORG(N)	.97	.72	0.90	<0.5	0.94	0.81
NH3	.080	.080	0.33	0.29	0.34	0.21
NO2	<.004	0.19	<.004	<.004	.007	.009
NO3	.005	.000	.000	.005	0.232	0.153
TOT(N)	1.08	.800	1.23	<.5	1.52	1.18
OPO4	<.004	<.005	<.004	<.004	<.004	.0005
TPO4	<.004	.015	.007	.007	.013	.006
AS	4.09	1.74	1.71	<1.2	<1.3	4.3
CD	<.60	<.5	<.2	<.3	-	-
CR	2.29	<1.5	1.42	5.44	145.8	<0.3
CU	<.2	1.08	.71	1.55	<.3	1.29
FE	310	430	770	560	700	650
PB	1.52	<.3	.62	.39	<.4	1.24
MN	5.75	7.82	9.67	9.13	11.59	10.47
HG	<.110	<.3	<.2	<.2	-	-
ZN	<30	<20	14	14.7	14.7	<10

W2 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	26.8	23.9	24.7	23.5	24.7	24.4
COND	945	598	-	572	653	628
ALK	241	195	214	229	234	205
CA	102.3	80.6	87.30	83.0	84.2	83.0
MG	23.17	6.04	4.84	4.54	8.16	4.89
NA	72.30	30.80	33.40	28.80	51.20	39.0
K	7.29	1.59	1.28	1.16	1.83	1.58
CL	118.3	47.60	55.8	47.6	72.1	63.8
SO4	66.8	11.30	11.4	4.4	8.8	15.7
SIO2	7.0	3.4	3.2	6.5	4.6	4.8
TDS	643	352	320	315	374	360
ORG(N)	2.37	.500	0.58	<0.5	1.09	<.5
NH3	.010	.160	0.15	.22	0.43	0.23
NO2	.024	.029	<.004	<.004	<.004	<.004
NO3	2.156	0.35	.002	.000	.000	0.205
TOT(N)	4.56	7.20	.74	.51	1.52	<.
OPO4	<.004	<.004	<.004	>.004	>.004	<.004
TPO4	.020	.018	.008	.009	.010	.007
AS	2.59	<1.5	2.85	<1.2	<1.2	<0.7
CD	<.6	<.5	<.2	<.3	-	-
CR	2.2	4.92	.40	<.4	2.51	<.4
CU	4.5	1.49	<.5	1.26	3.84	1.18
FE	380	.000	920	000	1750	730
PB	.44	.930	<.4	<.3	1.19	0.57
MN	3.21	9.15	15.37	9.1	119.4	11.04
HG	<.110	2.34	<.2	<.2	-	-
ZN	<30	<20	<20	<10	138.6	36.6

W2 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	26.1	23.5	24.6	23.7	24.1	24.3
COND	907	576	-	573	630	619
ALK	260	194	218	227	222	203
CA	99.1	83.0	59.30	81.10	85.0	81.4
MG	20.95	5.7	3.67	4.57	6.51	4.7
NA	71.5	32.1	33.0	28.60	45.80	36.90
K	6.25	1.34	1.09	1.07	1.50	1.21
CL	117.0	46.7	54.4	47.9	67.3	65.5
SO4	64.2	4.3	8.3	4.7	9.5	15.0
SIO2	7.0	3.4	3.2	4.5	3.9	4.8
TDS	629.0	342	308	314	356	334
ORG(N)	2.03	<.5	0.96	<.5	0.84	0.64
NH3	<.010	.150	.16	.04	.32	0.24
NO2	.014	.021	<.004	.007	<.004	.004
NO3	2.036	.076	.003	0.199	.000	0.100
TOT(N)	4.09	.600	1.13	.71	1.16	0.98
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	.012	.014	.005	.007	.004	.005
AS	1.49	<1.5	<1.3	1.43	<1.2	<0.7
CD	<.6	<.5	<.2	<.3	-	-
CR	1.93	<1.5	.69	<.4	<.5	<0.4
CU	3.76	3.02	.85	1.41	<.5	<0.5
FE	390	460	420	000	2000	700
PB	<.4	2.09	<.4	<.3	1.78	1.28
MN	4.03	7.24	13.6	9.13	11.56	12.38
HG	<.110	<.3	<.2	<.2	-	-
ZN	<30	<20	20.4	<10	154.2	17.0

W2 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.4	23.1	24.2	23.8	23.6	24.3
COND	642	580	-	571	586	617
ALK	184	193	217	224	214	199
CA	76.6	81.20	74.90	80.50	85.60	81010
MG	9.06	6.03	4.61	4.63	4.76	4.60
NA	48.0	35.9	33.90	29.20	37.70	37.60
K	2.3	1.43	1.05	1.05	1.05	1.13
CL	75.40	51.60	54.8	49.9	59.4	64.8
SO4	29.10	14.30	7.3	5.0	9.9	14.5
SIO2	3.7	3.4	3.5	1.8	3.3	4.6
TDS	402	344	304	313	329	338
ORG(N)	1.22	<.5	0.78	<0.5	0.52	0.54
NH3	.120	.24	.17	.24	.23	0.25
NO2	<.004	<.004	<.004	<.004	<.004	<.004
NO3	.000	.006	.000	.000	.000	0.100
TOT(N)	1.34	.510	.95	.67	.75	0.89
OPO4	.004	<.004	<.004	<.004	<.004	<.004
TPO4	.006	.017	.004	.007	<.004	.005
AS	<.9	<1.5	<1.3	<1.2	<1.2	<0.7
CD	<.6	<.5	<.2	<.3	-	-
CR	2.32	<1.5	1.8	<.4	<.5	<0.4
CU	<.2	.93	2.13	1.39	<.5	<0.5
FE	1310	510	770	000	980	740
PB	<.4	<.3	3.65	<.3	<.6	<.4
MN	10.34	7.77	19.14	10.23	10.07	16.17
HG	<.110	<.3	<.2	<.2	-	-
ZN	<30	<20	25.3	<10	26.1	19.2

W3 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.2	24.5	25.2	23.7	23.4	25.0
COND	496	531	-	510	520	484
ALK	199	196	224	229	213	198
CA	86.4	84.9	79.80	88.70	89.30	79.80
MG	3.52	3.58	3.22	3.60	3.69	3.11
NA	16.5	16.40	12.0	14.4	20.9	11.60
K	2.91	2.74	2.13	2.90	3.14	2.26
CL	29.2	26.80	20.1	25.0	30.3	20.6
SO4	10.1	11.70	8.3	14.2	16.9	18.4
SIO2	2.9	3.1	2.9	4.6	2.9	4.2
TDS	307	314	279	282	295	284
ORG(N)	4.05	<.50	0.54	<0.5	0.6	<0.5
NH3	.20	.160	0.11	0.18	0.14	0.18
NO2	<.004	<.004	<.004	<.004	<.004	.006
NO3	.012	.017	.000	.000	.000	0.225
TOT(N)	4.27	.600	0.65	0.65	0.74	0.70
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.007	.005	.009	<.004	.005
AS	1.68	<1.5	<.9	<1.2	<1.2	<0.7
CD	<.6	<.5	<.3	<.3	-	-
CR	2.41	<1.5	1.35	<.4	1.52	<0.4
CU	6.19	.210	.95	.84	.89	<0.5
FE	560	.000	1160	410	1460	440
PB	2.36	1.47	5.33	<.3	1.73	0.98
MN	10.58	7.11	15.73	9.20	20.23	9.29
HG	<.110	<.100	<.2	<.2	-	-
ZN	<30	<20	<10	100.2	136	26.8

W3 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	23.3	23.9	24.8	23.6	23.4	24.4
COND	496	525	-	515	520	537
ALK	198	197	218	227	222	201
CA	85.1	82.1	80.10	84.80	45.10	84.20
MG	3.51	3.57	3.30	3.54	2.12	3.05
NA	16.80	16.20	11.7	15.50	32.1	11.4
K	2.97	2.77	2.07	2.82	3.07	2.40
CL	29.3	27.90	20.5	25.0	30.5	21.6
SO4	10.2	10.8	10.0	14.3	18.7	17.8
SIO2	2.9	3.1	2.7	4.8	2.9	4.4
TDS	297.7	304	268	282	296	275
ORG(N)	2.56	<.5	0.91	<0.5	0.54	0.71
NH3	.190	.190	0.15	0.16	0.14	0.23
NO2	<.004	<.004	<.004	<.004	<.004	<.004
NO3	.002	.005	.000	.002	.000	0.126
TOT(N)	2.76	.510	1.06	<.5	0.68	0.89
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.008	.010	.011	<.004	.006
AS	.99	<1.5	<.9	<1.2	<1.2	<0.7
CD	<.6	<.5	<.3	<.3	-	-
CR	3.71	<1.5	<.4	1.93	<.5	1.25
CU	2.56	.320	1.23	.82	<.5	<0.5
FE	280	610	.000	.000	570	550
PB	6.58	1.07	<.4	.6	.3	3.25
MN	10.63	7.02	8.73	12.22	9.80	8.99
HG	<.110	<.100	<.2	<.2	-	-
ZN	<30	<20	<10	20.7	<20	15.9

W3 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	23.9	23.7	23.7	23.8	23.5	24.0
COND	466	484	–	485	490	484
ALK	274	187	217	224	199	198
CA	83.5	77.3	76.90	81.80	85.30	84.20
MG	3.45	3.52	3.35	3.41	3.53	3.25
NA	14.4	12.8	12.1	13.6	18.0	12.3
K	1.76	1.65	1.41	1.88	2.06	2.48
CL	24.0	20.3	22.0	24.1	27.6	23.1
SO4	7.6	8.8	7.4	9.9	14.4	16.9
SIO2	3.2	3.4	3.4	4.9	3.1	4.8
TDS	275.5	277	254	262	268	284
ORG(N)	1.19	<.50	0.54	0.54	<0.5	<0.5
NH3	.270	.250	0.23	0.27	0.25	0.23
NO2	<.004	<.004	<.004	<.004	<.004	<.004
NO3	.007	.003	.000	.000	.000	.009
TOT(N)	1.47	.510	0.77	0.81	<.5	0.70
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.006	<.004	.010	<.004	<.004
AS	1.36	<1.5	<.9	<1.2	<1.2	<0.7
CD	<.6	<.5	<.3	<.3	-	-
CR	1.88	<1.5	<.4	.91	<.5	<0.4
CU	1.27	.600	<.9	1.24	<.5	<0.5
FE	90.0	0.999	190	320	1280	580
PB	<.400	.620	<.4	<.3	1.72	0.95
MN	8.88	6.47	9.48	11.27	13.38	9.29
HG	<.110	.150	<.2	<.2	-	-
ZN	<30	<20	<10	<10	46.6	26.8

W4 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	23.8	25.9	25.7	24.3	23.5	25.7
COND	566	592	-	658	645	690
ALK	202	194	225	228	213	198
CA	82.9	82.7	97.30	88.70	90.40	95.80
MG	4.73	5.25	5.53	5.53	5.64	5.35
NA	27.4	31.9	25.20	33.40	34.0	34.80
K	6.75	10.35	23.95	2.26	10.65	12.50
CL	44.4	42.4	31.7	49.7	55.6	57.8
SO4	19.3	39.8	38.9	53.1	44.4	49.0
SIO2	2.8	2.9	3.0	4.0	2.7	4.5
TDS	493	350	410	364	361	397
ORG(N)	1.4	<.50	1.40	<0.5	0.50	0.82
NH3	<.010	<.010	.01	.02	.02	0.04
NO2	<.004	.043	0.019	0.02	.051	0.34
NO3	.102	1.647	3.081	0.732	0.32	1.426
TOT(N)	1.52	2.19	3.93	1.25	.89	2.32
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.005	.011	.005	<.004	.005
AS	<.9	<1.2	1.14	<1.2	<1.3	<0.7
CD	<.6	<.4	<.3	<.2	-	-
CR	1.93	<.3	1.13	.88	5.71	1.49
CU	<.2	1.86	3.77	4.06	1.88	10.73
FE	130	80.0	1320	50	510	120
PB	1.44	.98	11.71	<.9	1.44	3.39
MN	4.13	3.13	7.63	3.88	10.83	11.98
HG	<.110	<.10	<.2	<.2	-	-
ZN	<30	<20	<10	14.8	14.7	156.9

W4 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.3	24.3	25.4	24.4	23.6	24.7
COND	567	570	-	642	640	658
ALK	199	192	220	225	202	197
CA	80.5	76.7	88.30	88.40	91.10	88.90
MG	4.73	4.95	4.84	5.37	5.70	4.97
NA	29.8	28.0	28.20	30.10	34.30	36.50
K	5.67	6.69	9.20	9.30	14.10	8.52
CL	48.9	47.4	51.1	53.2	60.1	59.8
SO4	16.7	28.6	5.6	49.3	30.2	42.2
SIO2	2.7	2.7	3.1	4.0	3.1	5.4
TDS	340	354	358	357	363	380
ORG(N)	<.50	<.50	<0.5	<0.5	<0.5	0.78
NH3	.050	.010	0.03	.03	.06	0.05
NO2	<.004	.014	0.024	0.006	.006	0.010
NO3	.017	.421	1.216	.256	.001	.232
TOT(N)	.520	.940	1.95	.76	.54	1.07
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	.006	.004	.007	.007	<.004	.006
AS	1.43	<1.2	1.73	<1.2	<1.3	<0.7
CD	<.6	<.4	<.3	<.2	-	-
CR	3.45	<.3	1.10	.59	6.17	<0.4
CU	2.42	2.09	3.40	1.79	2.54	0.52
FE	1070	270	310	000	180	710
PB	3.04	4.94	6.53	<.9	14.87	0.69
MN	10.14	7.21	16.30	6.63	11.8	7.89
HG	<.110	<.100	<.2	<.2	-	-
ZN	<30	<20	<10	11.1	22.9	49.6

W4 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	24.8	23.7	25.4	24.7	24.7	25.5
COND	551	549	-	610	626	630
ALK	198	184	108	219	211	195
CA	82.7	72.1	33.10	82.30	84.80	85.10
MG	4.37	4.47	4.02	4.50	4.92	4.64
NA	27.7	27.5	32.00	32.30	38.00	36.10
K	5.12	4.96	5.05	5.28	6.11	5.65
CL	45.9	46.8	44.8	53.0	54.8	60.0
SO4	14.7	23.2	8.4	39.4	46.5	33.9
SIO2	2.8	2.6	<1.0	4.1	4.3	5.5
TDS	328	330	182	340	346	365
ORG(N)	1.58	<.50	<0.5	<0.5	0.62	0.90
NH3	.02	.020	<.01	.03	.01	0.05
NO2	<.004	<.004	<.004	<.004	.053	<.004
NO3	.000	.037	.029	.000	.339	.181
TOT(N)	1.6	.540	0.53	.50	1.02	1.14
OPO4	<.004	<.004	<.004	<.004	<.004	<.004
TPO4	<.004	.005	.038	.005	<.004	.009
AS	<.9	<1.2	<.9	1.2	<1.3	<0.7
CD	<.6	<.4	<.3	<.2	-	-
CR	2.67	<.3	1.76	1.14	3.59	0.64
CU	<.2	1.12	5.16	.65	<.3	0.62
FE	320	260	1300	000	2200	1900
PB	.77	1.67	2.12	<.9	<.4	0.79
MN	8.36	5.65	34.05	9.01	33.0	12.43
HG	<.110	<.10	<.2	<.2	-	-
ZN	<30	<20	<10	11.6	13.7	47.3

X1 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	24.2	24.9	24.1	24.0	25.5
COND	-	585	-	637	674	573
ALK	-	198	231	232	217	206
CA	-	83.30	81.20	82.00	84.60	75.60
MG	-	7.24	6.44	7.33	7.29	6.60
NA	-	40.50	28.70	38.80	26.0	35.90
K	-	2.28	1.88	2.40	2.76	2.02
CL	-	58.1	43.5	56.6	56.4	54.7
SO4	-	10.2	9.8	16.5	16.8	15.8
SIO2	-	4.2	4.0	6.2	4.6	6.1
TDS	-	380	346	363	352	340
ORG(N)	-	<0.5	0.80	<0.5	0.86	<0.5
NH3	-	0.25	0.21	0.28	0.09	0.38
NO2	-	.004	.012	<.004	.008	<.004
NO3	-	.057	.000	.000	.080	0.099
TOT(N)	-	0.56	1.03	<.5	<04	<.5
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	0.016	.006	.006	.004	.008
AS	-	<1.5	1.09	2.12	1.72	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	<1.5	0.73	2.01	0.96	<0.3
CU	-	0.42	<.4	2.15	<0.5	<0.2
FE	-	670	590	480	1490	660
PB	-	<0.3	1.09	8.84	1.07	<.3
MN	-	7.75	11.17	10.66	17.4	11.89
HG	-	<.3	<.2	<.2	-	-
ZN	-	<20	<20	133	23.2	11.4

X1 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	23.9	24.3	24.0	24.1	24.7
COND	-	632		627	598	562
ALK	-	195	237	233	220	208
CA	-	83.20	84.20	81.00	86.50	79.50
MG	-	6.91	5.34	7.29	7.03	6.11
NA	-	35.60	23.20	37.0	27.50	31.40
K	-	1.86	1.69	2.13	2.19	2.01
CL	-	57.9	33.4	55.1	50.0	48.5
SO4	-	17.7	9.4	16.9	13.6	16.3
SIO2	-	4.1	3.9	6.4	4.4	6.5
TDS	-	384	316	36.1	335	325
ORG(N)	-	<.5	1.48	<.5	0.84	1.00
NH3	-	0.25	0.23	0.40	0.24	0.36
NO2	-	.004	<.004	<.004	<.004	<.004
NO3	-	.002	.000	.005	.000	0.10
TOT(N)	-	0.57	1.69	<.5	1.08	1.46
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.015	.008	.011	.004	.008
AS	-	<1.5	1.31	<1.2	1.72	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	<1.5	0.80	1.51	2.12	<0.3
CU	-	0.58	4.08	0.87	<.5	1.99
FE	-	810	.000	540	210	590
PB	-	<0.3	1.31	<0.3	1.07	1.9
MN	-	9.08	16.36	11.21	17.4	12.45
HG	-	<.3	<.2	<.2	-	-
ZN	-	<20	<20	37.5	23.2	23.1

X1 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	23.6	24.2	23.9	23.8	25.0
COND	-	576	0.009	617	539	394
ALK	-	198	240	233	230	217
CA	-	85.80	84.40	78.90	88.70	83.0
MG	-	5.70	4.37	7.19	5.22	3.83
NA	-	28.40	15.80	35.30	13.60	12.5
K	-	1.74	1.56	2.08	1.94	1.58
CL	-	35.4	23.4	51.8	28.7	21.5
SO4	-	16.2	14.7	14.0	11.7	17.9
SIO2	-	4.7	3.3	6.3	3.7	5.9
TDS	-	349	292	361	300	296
ORG(N)	-	<0.5	<0.5	0.69	0.76	0.68
NH3	-	0.21	0.18	0.31	0.22	0.21
NO2	-	.004	<.004	<.004	<.004	<.004
NO3	-	.002	.000	.000	.017	0.356
TOT(N)	-	0.55	0.67	1.00	1.00	1.25
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.013	.004	.005	<.004	.006
AS	-	<1.5	<0.9	<1.2	<1.2	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	1.83	1.38	1.76	1.18	<.3
CU	-	0.62	8.16	1.78	1.06	1.20
FE	-	770	.000	000	1300	1090
PB	-	<0.3	9.66	<0.3	3.7	0.48
MN	-	9.81	14.27	13.62	13.70	16.59
HG	-	<.3	<.2	<.2	-	-
ZN	-	<20	<20	<10	39.8	<10

X2 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	23.4	24.3	23.1	24.6	23.8
COND	-	336		482	657	513
ALK	-	191	236	233	233	199
CA	-	82.10	88.20	86.90	86.60	80.80
MG	-	3.88	3.55	3.31	7.93	4.31
NA	-	9.7	9.7	8.7	47.1	19.50
K	-	1.62	1.96	1.72	1.99	1.83
CL	-	12.0	14.4	15.6	70.5	33.9
SO4	-	6.4	10.9	8.1	11.0	17.3
SIO2	-	3.2	3.0	4.4	4.6	6.3
TDS	-	273	270	262	379	305
ORG(N)	-	<0.5	<0.5	<0.5	1.08	<0.5
NH3	-	0.05	0.04	0.04	0.39	0.25
NO2	-	<.004	.010	<.004	<.004	<.004
NO3	-	.000	.000	.005	.009	.055
TOT(N)	-	<.5	<.5	.51	1.48	<0.5
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.005	<.004	.007	.007	.011
AS	-	<1.5	1.73	<1.2	1.65	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	<1.5	1.41	<.4	155.7	<0.3
CU	-	1.28	3.05	<.8	8.53	<0.2
FE	-	190	3240	0.00	7500	300
PB	-	0.43	2.49	<0.3	15.66	<.3
MN	-	6.13	17.46	7.63	41.85	9.87
HG	-	<.3	<.2	<.2	-	-
ZN	-	<20	<20	<10	<10	10.2

X2 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	23.2	23.9	23.1	24.0	23.9
COND	-	443	-	477	603	523
ALK	-	189	222	232	228	203
CA	-	80.20	83.10	83.80	0.00	80.5
MG	-	3.63	3.55	3.35	0.00	4.52
NA	-	9.3	10.0	8.8	0.00	22.80
K	-	1.26	1.61	1.49	0.00	1.91
CL	-	11.3	15.8	15.5	54.8	36.3
SO4	-	5.4	7.1	8.0	11.6	17.4
SIO2	-	3.3	3.3	4.5	4.0	6.5
TDS	-	258	260	265	348	312
ORG(N)	-	<0.5	<0.5	<0.5	0.89	<0.5
NH3	-	0.08	0.03	0.06	0.39	0.35
NO2	-	<.004	<.004	<.004	<.004	<.004
NO3	-	.005	.000	.000	.000	.484
TOT(N)	-	.51	<.5	.50	1.15	<0.5
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.008	<.004	.006	.005	.007
AS	-	<1.5	1.99	<1.2	1.53	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	<1.5	1.62	<.4	28.35	<0.3
CU	-	1.11	21.52	<.8	0.5	1.25
FE	-	360	250	0.00	2250	400
PB	-	<.3	12.81	<0.3	1.62	0.8
MN	-	7.56	32.07	8.56	13.56	9.5
HG	-	<.3	<.2	<.2	-	-
ZN	-	<20	<20	41.9	<10	21.8

X2 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	23.3	23.7	23.3	23.5	23.7
COND	-	446		444	537	508
ALK	-	185	225	223	221	204
CA	-	76.90	83.90	78.90	85.80	81.30
MG	-	3.41	3.54	3.27	4.67	4.11
NA	-	8.1	9.9	8.8	27.0	18.0
K	-	0.69	1.31	<1.5	1.96	1.94
CL	-	10.7	15.9	15.5	35.0	31.5
SO4	-	3.9	5.5	5.1	12.9	18.7
SIO2	-	3.2	3.2	4.7	3.3	4.9
TDS	-	255	254	245	303	310
ORG(N)	-	<0.5	1.54	0.52	0.65	0.73
NH3	-	0.14	0.06	0.17	0.12	0.21
NO2	-	.004	<.004	<.004	<.004	<.004
NO3	-	.004	.082	.000	.000	0.178
TOT(N)	-	.51	1.69	.69	0.77	1.12
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.006	<.004	.013	<.004	.006
AS	-	<1.5	<.9	<1.2	<1.3	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	<1.5	1.00	1.19	333.8	<0.3
CU	-	0.28	4.56	.99	2.41	10.56
FE	-	.000	0.00	0.00	920	310
PB	-	<.3	1.16	1.61	<0.4	2.39
MN	-	7.81	12.62	9.32	15.62	8.19
HG	-	<.3	<.2	<.2	-	-
ZN	-	<20	23	16.9	<10	46.5

X3 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	22.9	23.7	23.5	23.6	26.5
COND	-	626	-	665	660	584
ALK	-	174	221	233	242	203
CA	-	72.9	71.8	73.9	86.6	73.0
MG	-	13.73	7.27	8.03	9.27	6.73
NA	-	49.0	37.9	39.0	53.10	37.20
K	-	4.27	1.70	2.05	1.92	1.86
CL	-	72.4	56.9	58.1	76.5	59.2
SO4	-	30.8	3.0	5.0	8.8	17.1
SIO2	-	6.5	6.3	5.5	5.0	6.3
TDS	-	440	340	346	393	283
ORG(N)	-	1.38	1.45	0.82	1.23	1.22
NH3	-	0.05	<0.01	0.04	0.02	0.54
NO2	-	.009	<.004	<.004	<.004	.004
NO3	-	.031	.000	.001	.000	0.137
TOT(N)	-	1.47	1.85	0.87	1.72	1.90
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.017	.011	.013	.004	.009
AS	-	3.42	1.64	1.44	<1.2	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	<1.5	1.01	<.4	.52	<0.3
CU	-	.41	1.45	1.64	<.5	0.7
FE	-	480	0.00	240	750	880
PB	-	<.3	1.01	<.3	<.6	<.3
MN	-	7.36	14.39	8.27	12.6	13.23
HG	-	<.3	<.2	<.2	-	-
ZN	-	<20	<20	<10	33.3	23.7

X3 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	25.4	26.3	23.5	25.4	26.4
COND	-	719	-	625	673	595
ALK	-	200	222	234	240	198
CA	-	76.7	70.9	76.8	84.0	74.7
MG	-	12.36	7.23	8.54	9.14	6.85
NA	-	44.6	37.1	41.1	54.5	38.0
K	-	4.35	1.90	2.26	2.10	2.09
CL	-	68.9	56.4	63.0	75.2	57.3
SO4	-	35.5	5.3	4.9	8.8	17.3
SIO2	-	5.5	5.0	5.7	5.0	5.9
TDS	-	435	338	366	387	349
ORG(N)	-	<0.5	1.87	0.85	1.13	1.42
NH3	-	0.04	0.38	0.07	0.46	0.46
NO2	-	<.004	<.004	<.004	<.004	0.017
NO3	-	.003	.000	.000	.000	0.172
TOTN	-	0.51	2.25	0.92	1.59	2.07
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.009	.010	.007	.004	.007
AS	-	1.95	2.23	1.63	<1.2	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	<1.5	1.39	6.66	<.5	<0.3
CU	-	.04	9.79	<.8	.87	0.76
FE	-	270	620	0.00	1950	820
PB	-	2.24	5.15	<.3	10.04	<.3
MN	-	5.4	16.96	8.16	14.68	10.9
HG	-	<.3	<.2	<.2	-	-
ZN	-	<20	<20	<10	161.9	19.3

X3 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	27.3	26.2	23.8	25.7	24.3
COND	-	715	-	611	683	677
ALK	-	202	219	228	215	201
CA	-	90.1	92.6	95.1	99.0	95.20
MG	-	5.28	4.23	4.09	4.15	3.81
NA	-	31.2	32.0	32.8	37.6	34.70
K	-	2.84	2.90	3.16	3.83	3.54
CL	-	51.9	59.9	62.4	63.6	68.6
SO4	-	23.8	18.3	22.0	29.9	35.6
SIO2	-	3.2	3.4	4.4	2.9	5.3
TDS	-	367	364	374	368	381
ORG(N)	-	<0.5	1.12	<0.5	<0.5	0.50
NH3	-	0.05	0.40	0.04	0.49	0.09
NO2	-	.008	<.004	<.004	<.004	<.004
NO3	-	.004	.000	.000	.000	.107
TOT(N)	-	0.51	1.13	<0.5	<0.5	0.7
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.005	<.004	.006	<.004	<.004
AS	-	<1.5	1.55	<1.2	<1.2	<1.3
CD	-	<.5	<.2	<.3	-	-
CR	-	<1.5	2.26	1.17	6.85	<0.3
CU	-	.71	9.53	<.8	1.95	2.26
FE	-	460	490	0.00	1250	650
PB	-	<.3	9.33	<.3	5.89	<.3
MN	-	7.1	43.11	9.47	18.6	10.46
HG	-	.15	<.2	<.2	-	-
ZN	-	<20	<20	21.4	17.9	16.1

X4 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	28.1	25.7	24.9	24.5	26.6
COND	-	691	-	607	612	574
ALK	-	207	222	234	211	204
CA	-	72.10	73.20	75.60	78.30	74.30
MG	-	11.22	7.10	8.19	8.02	6.30
NA	-	36.60	34.00	37.90	39.80	35.10
K	-	3.01	1.55	2.00	2.40	2.01
CL	-	57.4	55.0	58.6	60.0	57.3
SO4	-	14.8	13.0	7.6	16.6	14.2
SIO2	-	5.7	6.1	5.8	4.3	6.1
TDS	-	362	332	345	334	347
ORG(N)	-	<0.5	1.14	1.78	0.94	1.23
NH3	-	0.01	0.10	0.01	0.11	0.51
NO2	-	<.004	<.004	.046	<.004	.004
NO3	-	.000	.000	.136	.051	.481
TOT(N)	-	<.5	1.24	1.97	1.11	2.22
OPO4	-	<.004	<.004	<.004	<.004	.009
TPO4	-	0.012	.009	.008	.007	.023
AS	-	2.63	1.11	<1.2	3.13	<1.3
CD	-	<.4	<.3	.23	-	-
CR	-	2.08	4.59	2.23	1.78	<0.3
CU	-	1.53	1.20	0.74	1.45	<0.2
FE	-	240	0.00	110	2400	1020
PB	-	0.69	2.72	6.83	1.86	<.3
MN	-	20.53	11.82	9.88	22.6	16.85
HG	-	.15	<.2	<.2	-	-
ZN	-	<20	<10	11.4	20.4	12.1

X6 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	26.4	25.2	22.7	23.1	24.9
COND	-	466	-	493	497	507
ALK	-	194	243	255	219	215
CA	-	81.70	89.00	93.90	90.00	91.0
MG	-	2.72	2.37	2.65	2.92	2.65
NA	-	5.30	8.30	8.60	10.70	11.90
K	-	1.11	1.54	1.24	1.36	1.99
CL	-	47.7	<0.4	14.1	19.9	23.5
SO4	-	18.6	5.7	8.8	18.7	19.3
SIO2	-	2.4	2.3	3.4	1.8	6.1
TDS	-	272	260	263	266	287
ORG(N)	-	<0.5	<0.5	<.05	<.05	0.71
NH3	-	0.14	0.14	0.15	0.19	0.22
NO2	-	.008	.008	<.004	<.004	<.004
NO3	-	.080	.000	.000	.000	.221
TOT(N)	-	0.59	<.5	<.5	.51	1.07
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.006	.017	.011	.004	.008
AS	-	<1.2	<.9	<1.2	<1.3	<0.7
CD	-	0.00	<.3	<.3	-	-
CR	-	<.3	2.42	1.04	5.73	0.88
CU	-	1.12	1.21	0.85	<.3	<0.5
FE	-	370	230	0.00	230	2120
PB	-	6.98	0.53	<.3	<.4	<.4
MN	-	13.38	15.50	13.41	14.05	12.69
HG	-	.150	<.2	<.2	-	-
ZN	-	<20	<10	<10	16.2	52.7

X6 MIDDLE

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	25.6	24.9	23.3	22.9	24.2
COND	-	463	-	502	503	529
ALK	-	208	235	242	215	209
CA	-	77.90	87.80	91.20	91.00	89.70
MG	-	2.89	2.56	2.95	3.07	2.72
NA	-	5.70	9.00	11.30	9.90	13.10
K	-	1.12	1.48	1.52	1.53	1.61
CL	-	10.0	15.5	20.1	22.4	23.5
SO4	-	20.0	15.1	14.6	21.0	19.3
SIO2	-	2.5	2.8	5.2	2.0	4.6
TDS	-	268	262	275	265	289
ORG(N)	-	<.5	<.5	<.5	0.54	0.71
NH3	-	0.19	0.28	0.26	0.22	0.25
NO2	-	.006	<.004	<.004	<.004	.006
NO3	-	.035	.000	.000	.000	.874
TOT(N)	-	.54	<.5	<.5	.76	0.71
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.005	.051	.018	.006	.008
AS	-	1.32	<.9	<1.2	<1.3	<0.7
CD	-	<.4	<.3	<.1	-	-
CR	-	<.3	2.93	<.4	2.36	0.88
CU	-	0.94	1.70	<.5	<.3	<.5
FE	-	360	1070	400	670	2120
PB	-	0.75	1.73	<.3	<.4	<.4
MN	-	8.84	27.75	14.03	12.04	22.44
HG	-	<.1	<.2	<.2	-	-
ZN	-	<20	<10	<10	11.6	35.9

X6 BOTTOM

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	23.4	23.8	23.3	23.1	24.1
COND	-	466	-	506	496	533
ALK	-	207	219	241	210	202
CA	-	79.70	87.30	90.50	90.70	86.10
MG	-	3.06	2.85	3.03	3.31	3.06
NA	-	6.20	10.00	12.00	14.20	15.20
K	-	1.28	1.47	1.63	1.94	1.84
CL	-	9.3	19.8	124.0	26.5	28.3
SO4	-	23.8	19.5	16.9	27.1	27.0
SIO2	-	2.4	2.5	3.9	2.3	3.7
TDS	-	260	266	276	281	303
ORG(N)	-	<0.5	0.63	<0.5	<0.5	0.64
NH3	-	0.29	0.27	0.30	0.27	0.36
NO2	-	<.004	<.004	<.004	<.004	<.004
NO3	-	.006	.000	.002	.000	0.161
TOT(N)	-	.51	0.90	<.5	.72	1.16
OPO4	-	<.004	<.004	<.004	<.004	<.004
TPO4	-	.007	.047	.011	<.004	.007
AS	-	1.74	1.21	<1.2	1.56	1.4
CD	-	<.4	<.3	<.1	-	-
CR	-	<.3	3.17	<.4	1.57	<0.4
CU	-	<.6	5.81	<.5	<.3	<.5
FE	-	190	690	0.00	440	630
PB	-	<.6	5.23	<.3	<.4	.55
MN	-	4.86	42.2	9.17	8.79	7.99
HG	-	.15	<.2	<.2	-	-
ZN	-	<20	<10	<10	16.3	39.1

X7 TOP

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	28.3	-	25.4	26.4	26.5
COND	-	735	-	605	828	579
ALK	-	212	-	233	236	200
CA	-	76.50	-	79.10	83.10	72.30
MG	-	12.94	-	7.48	9.59	6.66
NA	-	43.50	-	38.40	53.40	36.50
K	-	3.61	-	1.94	2.11	1.95
CL	-	61.8	-	58.2	75.3	58.7
SO4	-	11.4	-	5.2	11.2	12.4
SIO2	-	8.2	-	5.9	5.7	6.1
TDS	-	396	-	353	395	335
ORG(N)	-	<0.5	-	1.10	1.22	0.99
NH3	-	0.68	-	0.05	0.27	0.58
NO2	-	.005	-	.007	<.004	0.064
NO3	-	<.016	-	.318	.012	.038
TOT(N)	-	<.5	-	1.47	1.51	1.67
OPO4	-	.017	-	<.004	<.004	.004
TPO4	-	.050	-	.007	.019	.018
AS	-	10.51	-	22.28	3.6	<1.3
CD	-	<.5	-	<.3	-	-
CR	-	<1.5	-	<.4	3.14	<0.3
CU	-	0.37	-	6.07	2.56	2.57
FE	-	11900	-	250	3550	1340
PB	-	0.86	-	<.3	<.4	0.65
MN	-	24.7	-	4.06	24.4	19.67
HG	-	<.3	-	<.2	-	-
ZN	-	<20	-	20.6	17.3	37.5

S1

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	-	25.2	24.2	26.9	29.4
COND	-	-	-	741	475	561
ALK	-	-	215	226	159	173
CA	-	-	63.60	60.80	55.30	56.0
MG	-	-	11.81	16.11	7.77	11.59
NA	-	-	50.0	66.10	37.0	41.80
K	-	-	3.25	4.71	2.63	3.28
CL	-	-	76.4	100.0	53.2	64.9
SO4	-	-	13.6	29.2	9.9	15.6
SIO2	-	-	7.4	3.5	4.8	9.3
TDS	-	-	396	159	294	346
ORG(N)	-	-	1.58	<0.5	1.93	1.43
NH3	-	-	.000	0.19	.03	.05
NO2	-	-	.005	.177	.004	.005
NO3	-	-	.116	.343	.026	.079
TOT(N)	-	-	1.70	0.52	1.99	1.56
OPO4	-	-	<.004	<.004	<.004	<.004
TPO4	-	-	.008	.016	.015	.011
AS	-	-	1.10	<1.2	2.28	4.3
CD	-	-	<.03	<0.2	-	-
CR	-	-	.68	1.32	27.7	<.4
CU	-	-	<0.9	0.21	3.26	1.98
FE	-	-	120	630	260	190
PB	-	-	0.63	<0.9	0.52	<.3
MN	-	-	4.51	2.76	7.17	6.53
HG	-	-	<0.2	<0.2	-	-
ZN	-	-	<10	2137	17.0	13.8

S2

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	-	25.8	24.2	25.8	27.1
COND	-	-	-	624	689	578
ALK	-	-	221	237	240	198
CA	-	-	76.30	77.0	81.60	72.20
MG	-	-	688	7.87	9.87	6.98
NA	-	-	38.20	41.70	55.20	39.10
K	-	-	1.69	1.69	2.09	1.67
CL	-	-	31.6	63.7	79.5	60.1
SO4	-	-	10.3	5.7	10.2	16.3
SIO2	-	-	8.4	5.0	5.2	7.5
TDS	-	-	346	405	412	346
ORG(N)	-	-	2.28	1.00	1.32	1.15
NH3	-	-	0.46	0.63	0.45	0.46
NO2	-	-	<.004	<.004	<.004	<.004
NO3	-	-	.001	.004	.008	.010
TOT(N)	-	-	2.74	1.64	1.78	1.62
OPO4	-	-	<.004	<.004	<.004	<.004
TPO4	-	-	.006	.010	.004	.008
AS	-	-	1.7	<1.2	<1.3	<1.3
CD	-	-	<.2	<.3	-	-
CR	-	-	0.91	6.60	112.9	<0.3
CU	-	-	1.42	1.99	<.3	1.29
FE	-	-	0.00	520	510	710
PB	-	-	3.89	<.3	3.94	<.3
MN	-	-	10.92	18.68	16.12	15.46
HG	-	-	<.2	<.2	-	-
ZN	-	-	<10	15.6	11.3	25.7

S3

	5/85	7/25	11/85	3/86	5/87	8/86
TEMP	-	-	25.7	26.1	28.4	24.1
COND	-	-	-	441	543	533
ALK	-	-	209	214	208	199
CA	-	-	70.70	72.50	75.80	72.90
MG	-	-	4.49	3.66	6.36	5.93
NA	-	-	20.70	13.10	33.30	32.40
K	-	-	0.91	1.50	1.49	1.52
CL	-	-	44.1	21.4	48.7	49.0
SO4	-	-	8.4	22.7	11.3	12.8
SIO2	-	-	4.0	4.6	3.9	5.7
TDS	-	-	262	239	298	318
ORG(N)	-	-	0.57	<0.5	0.93	1.05
NH3	-	-	0.20	0.24	0.18	0.41
NO2	-	-	<.004	.010	<.004	<.004
NO3	-	-	.008	.021	.035	.191
TOT(N)	-	-	0.78	0.53	1.15	1.65
OPO4	-	-	<.004	<.004	<.004	<.004
TPO4	-	-	.005	.009	.013	.006
AS	-	-	1.62	<1.2	1.45	<1.3
CD	-	-	0.41	<.2	-	-
CR	-	-	1.18	0.5	3.7	1.0
CU	-	-	<.4	1.68	<.3	1.29
FE	-	-	430	170	260	640
PB	-	-	1.39	<.9	0.62	<.4
MN	-	-	10.15	7.96	10.0	101.7
HG	-	-	<.2	<.2	-	-
ZN	-	-	<10	10.5	28.0	38.0

S4

	5/85	7/85	11/85	3/86	5/87	8/86
TEMP	-	-	25.5	27.0	25.4	26.3
COND	-	-	-	667	673	578
ALK	-	-	221	236	237	207
CA	-	-	75.90	76.10	84.90	76.90
MG	-	-	6.44	0.00	9.12	6.52
NA	-	-	33.40	49.50	52.50	36.60
K	-	-	1.88	3.12	2.02	2.07
CL	-	-	14.4	74.6	75.1	56.4
SO4	-	-	51.2	21.6	8.0	13.7
SIO2	-	-	4.6	5.8	5.0	6.2
TDS	-	-	330	381	389	340
ORG(N)	-	-	1.06	<0.5	1.50	1.28
NH3	-	-	0.32	0.97	0.42	0.40
NO2	-	-	<.004	.391	<.004	.006
NO3	-	-	.021	.394	.012	.104
TOT(N)	-	-	1.40	1.85	1.94	1.79
OPO4	-	-	<.004	<.004	<.004	<.004
TPO4	-	-	.014	.008	.006	.020
AS	-	-	1.75	<1.2	<1.2	1.02
CD	-	-	<.3	<.2	-	-
CR	-	-	1.37	0.93	<.5	<.4
CU	-	-	1.33	3.35	<.5	<.5
FE	-	-	440	200	270	850
PB	-	-	1.18	<.9	<.6	<.4
MN	-	-	10.58	5.3	9.92	14.19
HG	-	-	<.2	<.2	-	-
ZN	-	-	<10	<10	26.3	26.8