FINAL TECHNICAL REPORT

PRELIMINARY WATER AND SEDIMENT QUALITY ASSESSMENT OF THE INDIAN RIVER LAGOON

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM MELBOURNE, FLORIDA

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INTERNATIONAL SYSTEM (SI METRIC)/ U.S. CUSTOMARY CONVERSION TABLES

TO CONVERT FROM	TO	MUTLIPLY BY
LENGTH		
centimeters	inches	0.3937
inches	centimeters	2.5400
feet	meters	0.3048
meters	feet	3.2808
kilometers	meters feet miles	1.0×10^3 $3.280\ 84 \times 10^3$ 0.621 37
miles	kilometers	1.609 34
AREA		
acres	hectares square feet square kilometers (km^2) square miles	0.404 69 4.356×10^4 .00404 .00156
hectares	square meters acres	1.0×10^4 2.471
square kilometers	hectares acres square miles (mi^2)	100.0 274.105 38 0.3861
square miles	hectares square kilometers (km^2) square feet acres	258.998 81 2.589 99 $2.787\ 84 \times 10^7$ 640.0
VOLUME		
liters	cubic feet gallons	0.035 31 0.264 17
gallons	liters cubic feet	3.785 41 0.133 68
cubic feet	cubic meters (m^3) gallons (gal) acre-feet (acre-ft)	$28.316\ 85 \times 10^{-3}$ 7.480 52 $22.956\ 84 \times 10^{-6}$
cubic yards	cubic meters cubic feet	0.764 55 27.0

INTERNATIONAL SYSTEM (SI METRIC)/ U.S. CUSTOMARY CONVERSION TABLES, Continued

TO CONVERT FROM	TO	MUTLIPLY BY
VOLUME		
cubic meters	gallons cubic feet cubic yards acre-feet	264.1721 35.314 67 1.307 95 8.107×10^{-4}
acre-feet	cubic feet gallons	43.560×10^{3} 325.8514×10^{3}
TEMPERATURE		
	degrees Celsius (C) (t_c)	$t_c = (t_f-32)/1.8 = t_k - 273.15$
	degrees Fahrenheit (F)	$t_f = t_c/1.8 + 32$
VELOCITY		
kilometers per hour	meters per second miles per hour	0.277 78 0.621 47
miles per hour	kilometers per hour meters per second	1.609 34 0.447 04
FORCE		
kilograms	pounds (lbs)	2.2046
MASS		
pounds (avdp)	kilograms	0.453 59
VOLUME PER UNIT TIME FLOW		
cubic feet per second	cubic meters per second (m^3/s) gallons per minute (gal/min) acre-feet per day (acre-ft/d) cubic feet per minute (ft^3/min)	0.028 32 448.831 17 1.983 47 60.0
gallons per minute	cubic meters per second cubic feet per second (ft^3/s) acre-feet per day	0.631×10^{-4} 2.228×10^{-3} 4.4192×10^{-3}
acre-feet per day	cubic meters per second cubic feet per second	0.014 28 0.504 17

1.0
INTRODUCTION

1.1 OBJECTIVES AND ORGANIZATION

This is one of eight volumes of Technical Reports prepared to support the Indian River Lagoon Characterization for the Indian River Lagoon National Estuary Program (IRLNEP). Overall, these volumes, which can be obtained from IRLNEP, include:

- Physical Features
- Biological Resources
- Uses of the Indian River Lagoon
- Historical Imagery Inventory and Seagrass Assessment
- Non-Governmental and Governmental Programs
- Preliminary Water and Sediment Quality Assessment
- Point and Nonpoint Source Loads Assessment
- Status and Trends Assessment

The objective of this volume is to discuss and assess the current water and sediment quality of the Lagoon. A companion Loadings Assessment Technical Report presents data from a modeling study used to estimate existing and future loads of key materials to the Lagoon based on soils and land use. The Status and Trends Technical Report summarizes both of these volumes and discusses the apparent relationship of the regional loadings pattern to the water quality patterns within the Lagoon.

Section 2.0 discusses various state and other water quality standards and guidelines that are applicable to the waters of the Indian River Lagoon system, while Section 3.0 summarizes some of the previous water quality studies and literature. Section 4.0 presents an overview of the existing water quality monitoring network in the Lagoon and of the data set and methods used in this report for the assessment of current water quality trends and conditions in the Lagoon.

The water quality monitoring results for the most recent period in which an essentially complete data set is available for the entire Lagoon network are presented in Section 5.0. This section presents data on the Lagoon complex itself and on selected tributaries. The assessment in Section 5.0 focuses on several parameters which are key indicators of water quality conditions and for which there are adequate data for a Lagoon-wide assessment. Sections 6.0 and 7.0 discuss the status of trace metal concentrations in the water column, bottom sediments, and biological organisms of the Lagoon. Section 9.0 presents an evaluation of data gaps, problems, and recommendations for further research or action that has developed from this assessment. The assessment results are discussed and summarized in Section 10.0.

The water quality assessment has been conducted by segments of the Indian River Lagoon complex. The segments used for this analysis are shown in Figure 1-1. These segments and the methods for defining them have been described in the Physical Features Technical Report. Figure 1-2 shows the distribution of major landmarks of the system, including many of the tributaries mentioned in this report.

1.2 BACKGROUND

Water, and to a lesser extent sediment, quality has been sampled in the Indian River Lagoon system for many years and a large volume of data has been produced. The data from the period prior to 1987 has been summarized previously by Windsor and Steward (1987). Up to that time, water quality monitoring was done primarily by local governmental agencies and some state agencies (FDER and FDNR) in an essentially independent manner. These water quality monitoring programs were not designed to provide a Lagoon-wide perspective on water quality, but were intended to monitor local areas or activities of concern. Consequently, there was little coordination among agencies. Different standards of quality assurance, different monitoring frequencies and parameters, different laboratory standards and methods, and different methods of compiling and storing data were employed by different organizations.

One of the key initial activities of the Indian River Lagoon SWIM (Surface Water Improvement and Management) programs, developed under the auspices of the St. Johns River Water Management District (SJRWMD) and South Florida Water Management District (SFWMD), was to develop a Lagoon-wide water quality monitoring network (SJRWMD and SFWMD, 1993). This network was begun in 1987 to provide for a quality-controlled database for monitoring water quality in the Lagoon and for detecting water quality trends,

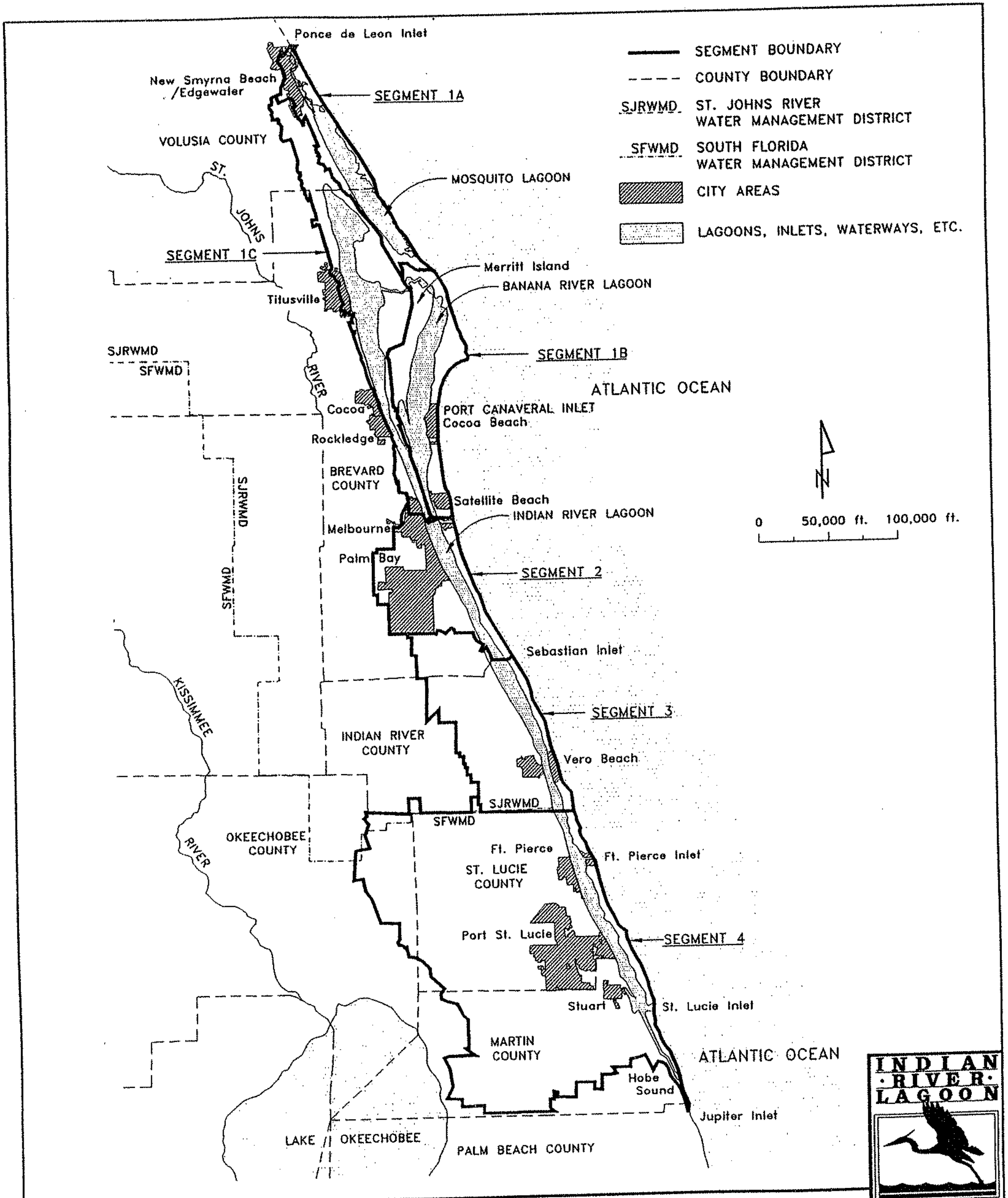

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FIGURE 1-1 MAP OF INDIAN RIVER LAGOON SYSTEM AND WATERSHED SHOWING SEGMENTS

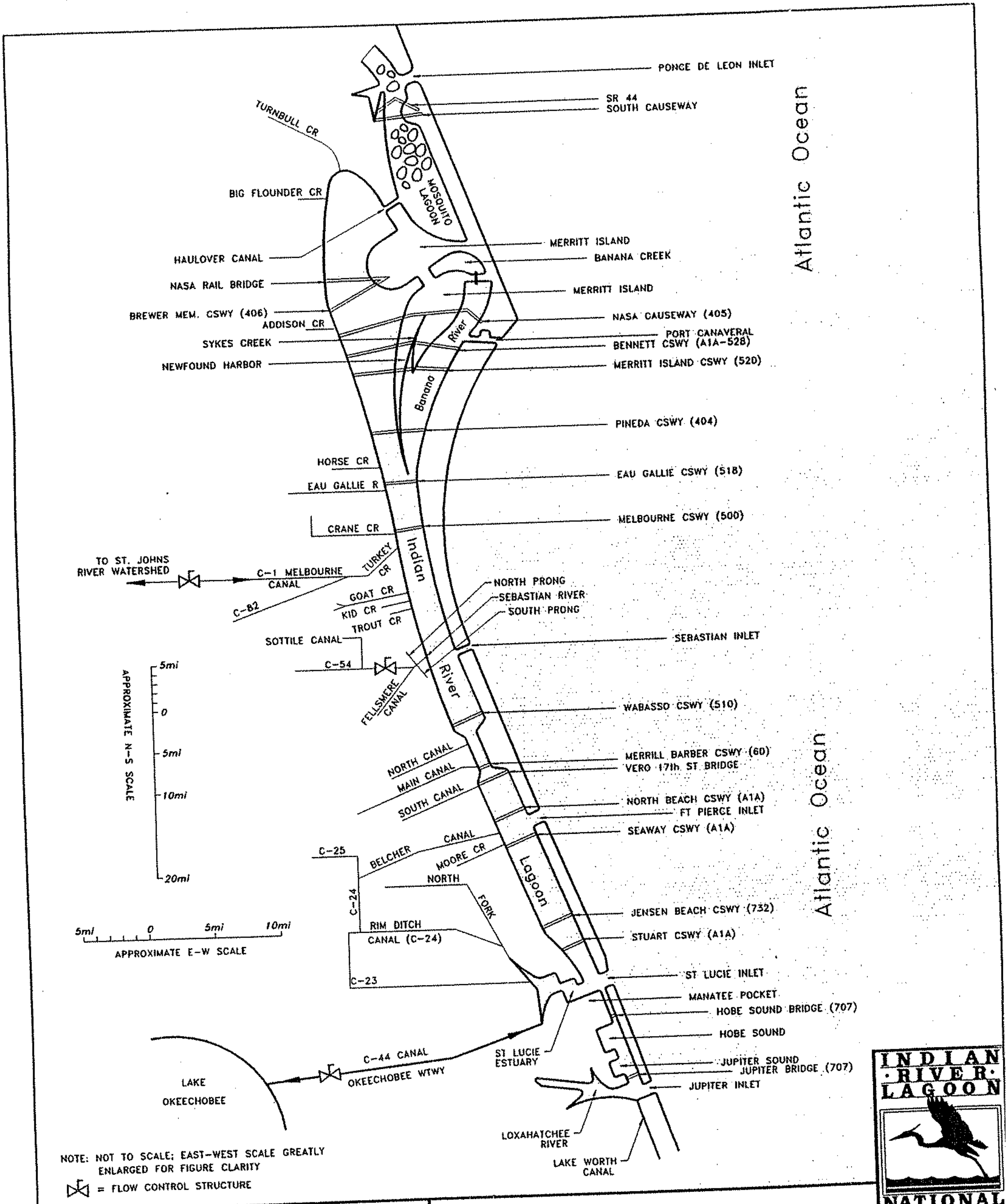

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FIGURE 1-2 MAJOR LANDMARKS OF THE INDIAN RIVER LAGOON SYSTEM particularly those impacting the ecology of the Lagoon system. For the first time, a Lagoon-wide network was defined and stations were identified and collected in a central inventory.

Although initial attempts to coordinate data collection by the IRLNEP and the SWIM programs are relatively successful, each monitoring agency independently maintains a raw water quality database using Quattro Pro, SAS, Oracle, or D-Base. The assembly of the data requires obtaining the data from each of these agencies and reformatting the data using a common database program. The data collected since the SWIM network was established has been validated and verified by IRLNEP staff, and then archived at the SJRWMD office. The more recent water quality data is stored in SAS format. For the purpose of this report, these data are referred to as the SWIM Network data set or SWIM data set.

1.3 LIMITATIONS OF THIS ASSESSMENT

The primary purpose of this report is to discuss current water quality of the entire Indian River Lagoon in order to define its present condition. This information may serve as a benchmark for future analysis of water quality and trends within the Indian River Lagoon. Because of the large volume of data and the variability in coverage and reliability of much of the data that has been collected for the Lagoon, it has not been possible to assess all of the information that has been collected for many years in the Lagoon. This report is intended to summarize and present mean values for selected water quality parameters for representative locations and to present the data in a simple format to allow comparison of mean values throughout the Indian River Lagoon system. This is the first time that data from a consistent data set has been summarized for the entire length of the system.

In consultation with the IRLNEP, the scope of this project has therefore been limited to an evaluation of the most recently available and compiled data set in order to define the currently existing conditions in the Lagoon. This evaluation has therefore been limited to the Indian River Lagoon SWIM Network data set covering the period between 1987 and 1992 that has been compiled by the water management districts. This report is based on the data available in digital form as of June, 1993. Data were obtained from SJRWMD for the region including Indian River, Brevard, and Volusia Counties and from SFWMD for St. Lucie, Martin, and Palm Beach Counties. Not all of the data provided was analyzed because of differences in parameters sampled at each location, time and budget limitations, and/or questionable values. There was only an approximately three-year period that was common to all monitoring stations.

Data from previous periods and various other publications have been referenced to some extent in this report. However, none of the previous data is comprehensive to the entire Lagoon system and identical laboratory or sampling methods or station locations may not have been used. Comparisons have been limited in this study. A good example of non-comparability of data is turbidity data. Older data (prior to about the early 1980s) was measured in Jackson Turbidity Units (JTU) while more recent data is measured in Nephelometric Turbidity Units (NTU). These two turbidity scales are not directly convertible and thus the data should not be directly compared. Direct comparison should therefore be made only with caution.

Therefore, the approach used in Section 5.0 of this report is to assess the most recent consistent data in the SWIM data set. Within this data set, water quality data have been compared by station in order to present a picture of the spatial water quality patterns within segments and between segments. This geographic analysis is based on data from the 1987 through 1992 period of record of the SWIM data set. In some segments, this period is as long as six years while in other segments it is as short as three years. The period of record for each data set is given in Section 4.0.

Data from all stations within a segment were also combined to evaluate temporal changes within a segment for a three-year period from January 1989 through December 1991. The data have been expressed as averages of all stations within a segment for each month during this period. This particular period was selected as the only period for which there was nearly consistent coverage for all segments in order to allow direct comparisons of segments throughout the Lagoon system. Long-term changes and anthropogenic changes are not easily detected in such a short-term data set. However, this will provide a basis for future comparisons and trend analysis.

2.0 WATER QUALITY STANDARDS AND DESIGNATIONS

2.1 STATE WATER QUALITY STANDARDS

The quality of the water in the Indian River Lagoon system can be evaluated in a number of ways. One of these is by comparison to water quality standards promulgated by the Florida Department of Environmental Protection (FDEP) in Chapter 17-302 FAC, Surface Water Quality Standards (revised May 25, 1993). These regulations set standards for the physical (e.g., temperature) and chemical (e.g., toxic contaminants) water quality attributes based on ranges that are not expected to impact human health nor significantly degrade the natural resources within the surface waters of the state of Florida. Defining the water quality of the Lagoon often appears to be a straight-forward endeavor - compare measurements to standards. However, this approach is useful primarily when assessing violations of standards or as a general evaluation of conditions, and may not be adequate to describe trends which might foretell degrading environmental conditions before significant ecological damage occurs.

Chapter 17-302 establishes several different types of classes or categories for water quality standards of Florida waters. All surface waters in Florida are classified in one of five categories. With the exception of secondary and tertiary canals wholly within agricultural areas and used for agricultural water supplies, all of the surface waters of the Indian River Lagoon system and its watershed are classified as either Class II or Class III waters (Chapter 17-302 FAC). Class II waters are of sufficient quality that they are suitable for shellfish propagation or harvesting. Class III waters are of slightly lower quality than Class II waters, but are of sufficient quality to support recreation as well as the propagation and maintenance of a "healthy, well-balanced population of fish and wildlife" (Chapter 17-302, FAC). Figure 2-1 (a-f) shows the estuarine areas of the Indian River Lagoon complex that are specified as Class II by Chapter 17-302. All other areas are Class III.

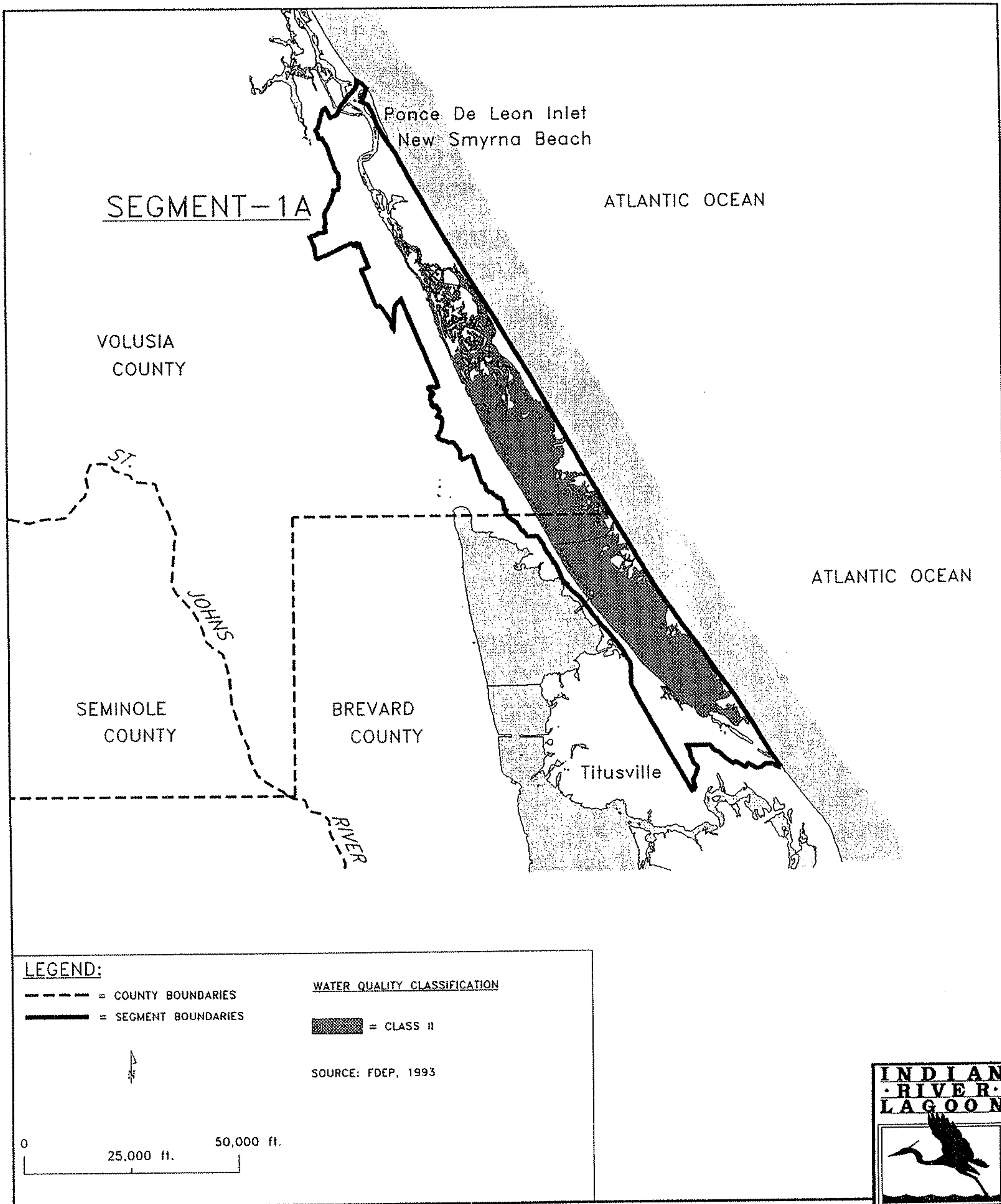

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FIGURE 2-1 STATE DESIGNATED CLASS II WATERS IN THE INDIAN RIVER LAGOON a) SEGMENT 1A - MOSQUITO LAGOON

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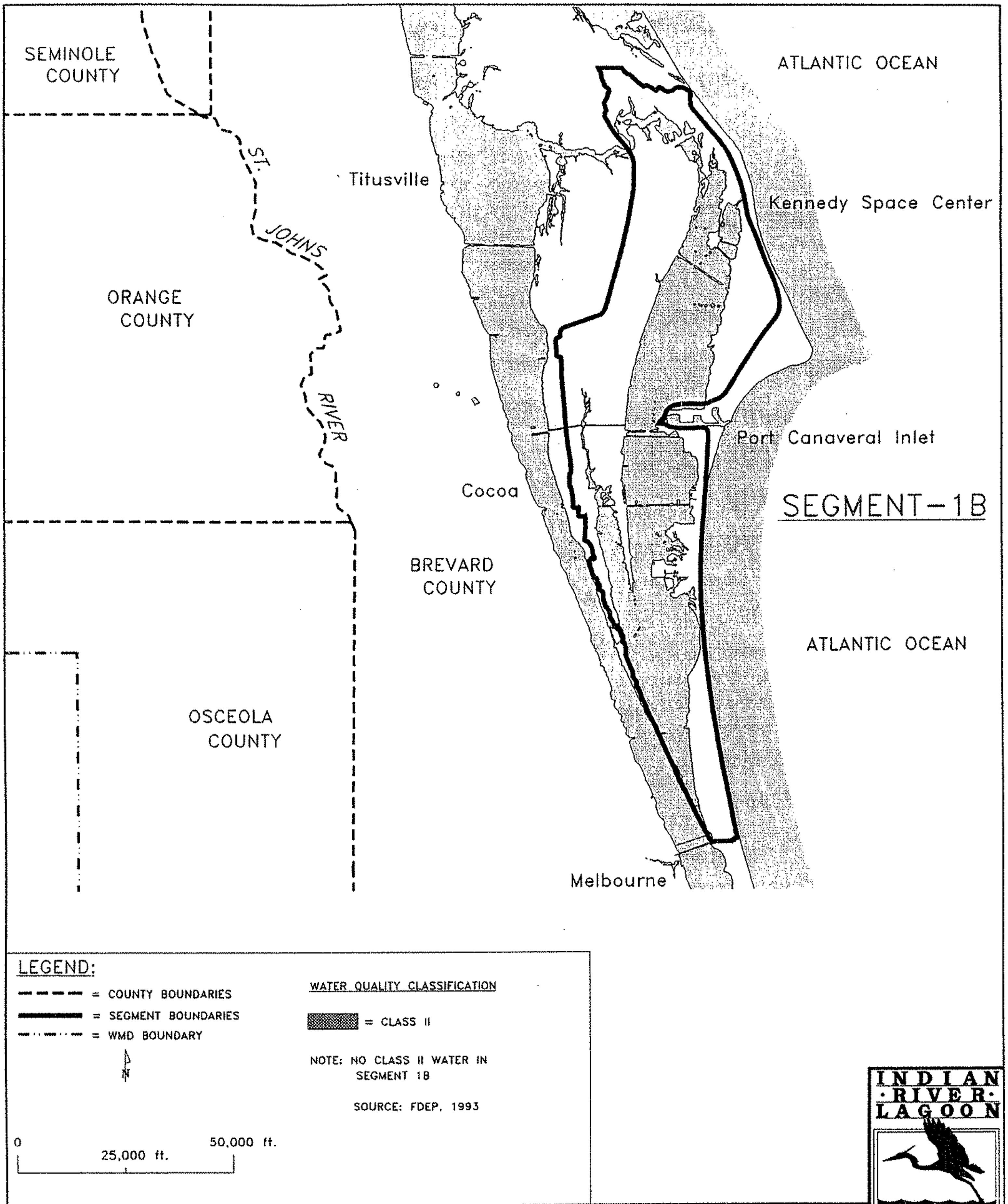

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DATE: 6-27-94

FIGURE 2-1 STATE DESIGNATED CLASS II WATERS IN THE INDIAN RIVER LAGOON b) SEGMENT 1B - BANANA RIVER

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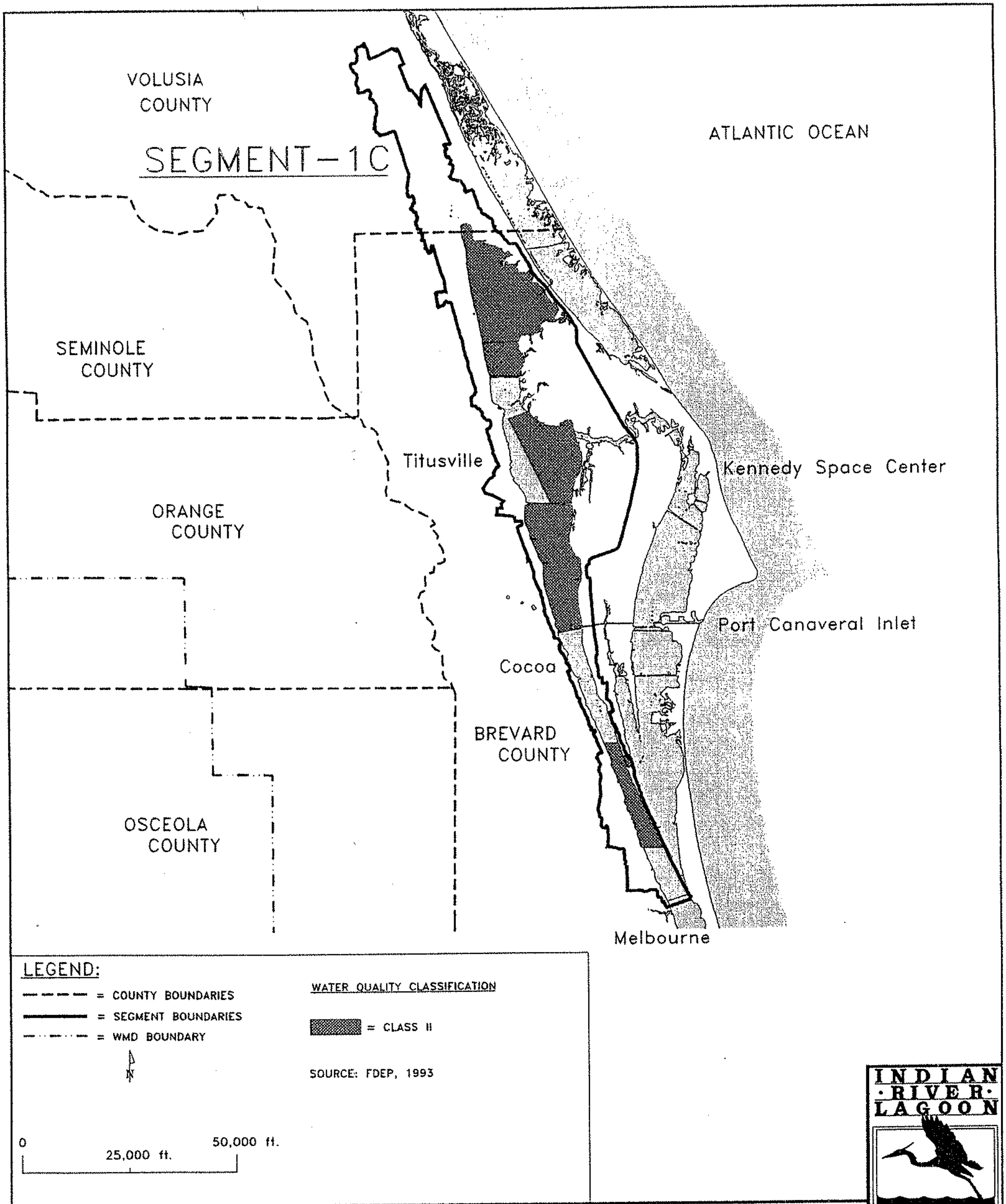

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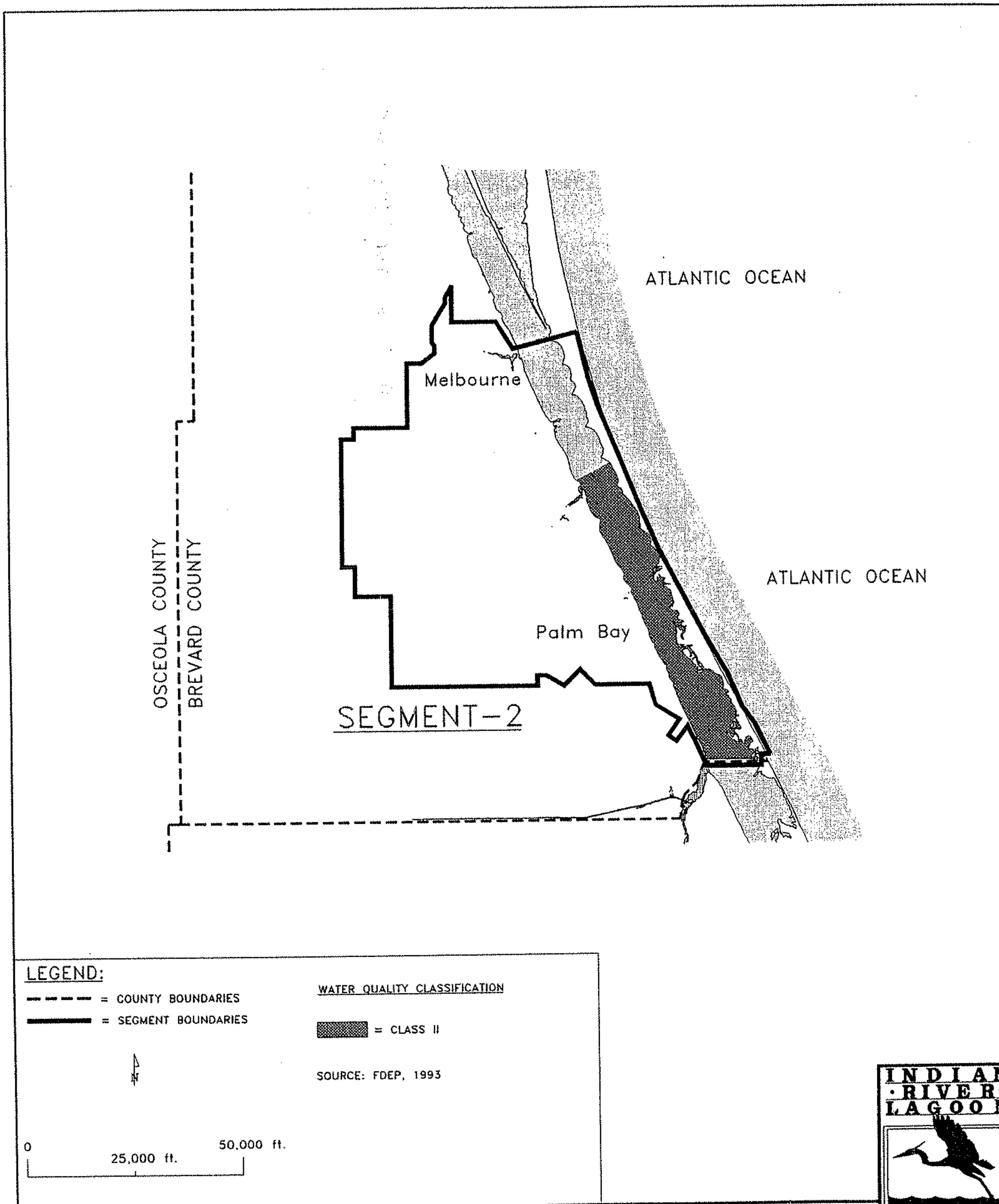
FIGURE 2-1 STATE DESIGNATED CLASS II WATERS IN THE INDIAN RIVER LAGOON c) SEGMENT 1C - NORTH INDIAN RIVER LAGOON



•Woodward–Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: SEG2WC.DWG DATE: 6-27-94	FIGURE 2-1	STATE DESIGNATED CLASS II WATERS IN THE INDIAN RIVER LAGOON d) SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON

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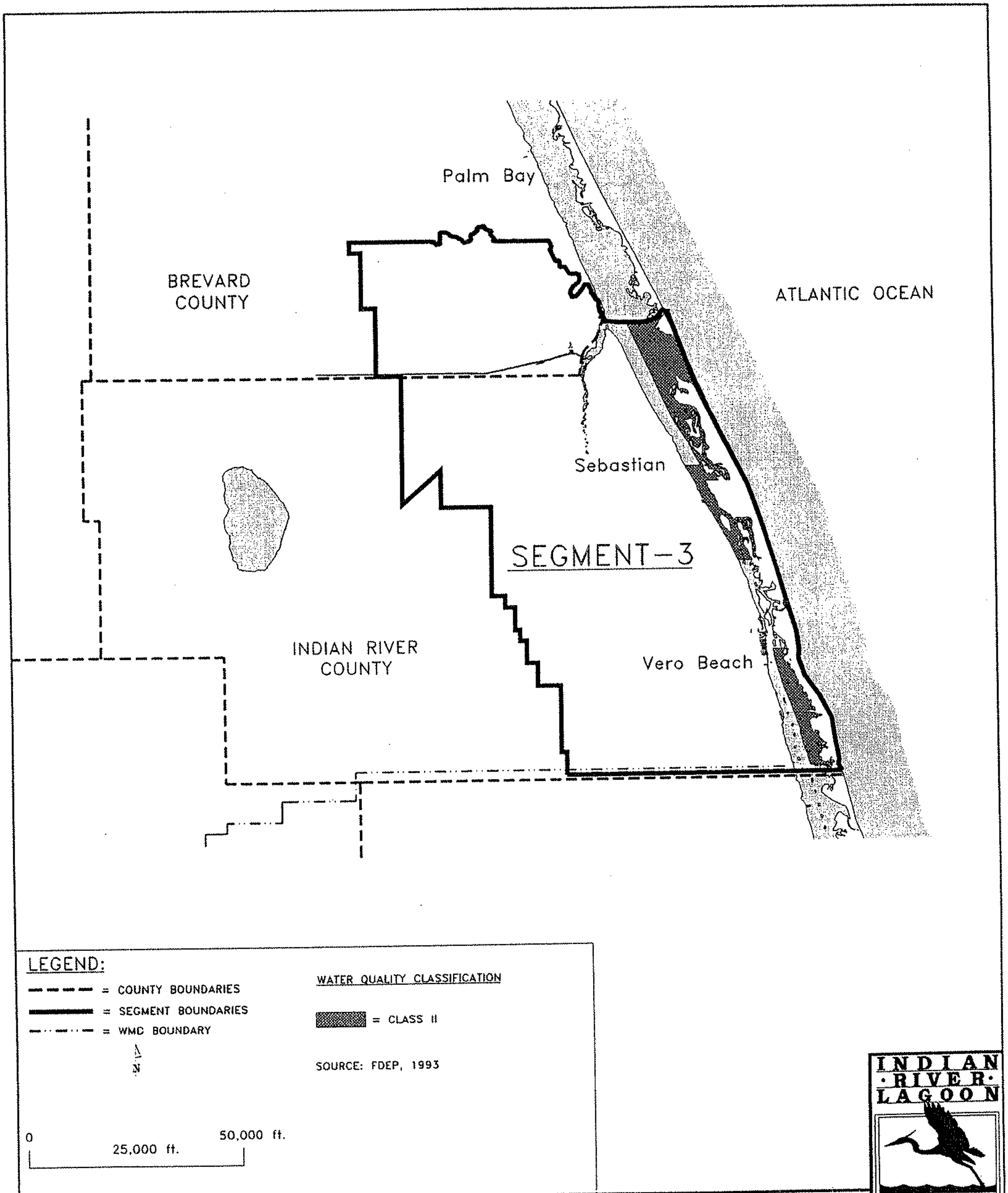

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•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: SEG3WC.DWG DATE: 6-27-94	FIGURE 2-1	STATE DESIGNATED CLASS II WATERS IN THE INDIAN RIVER LAGOON e) SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON

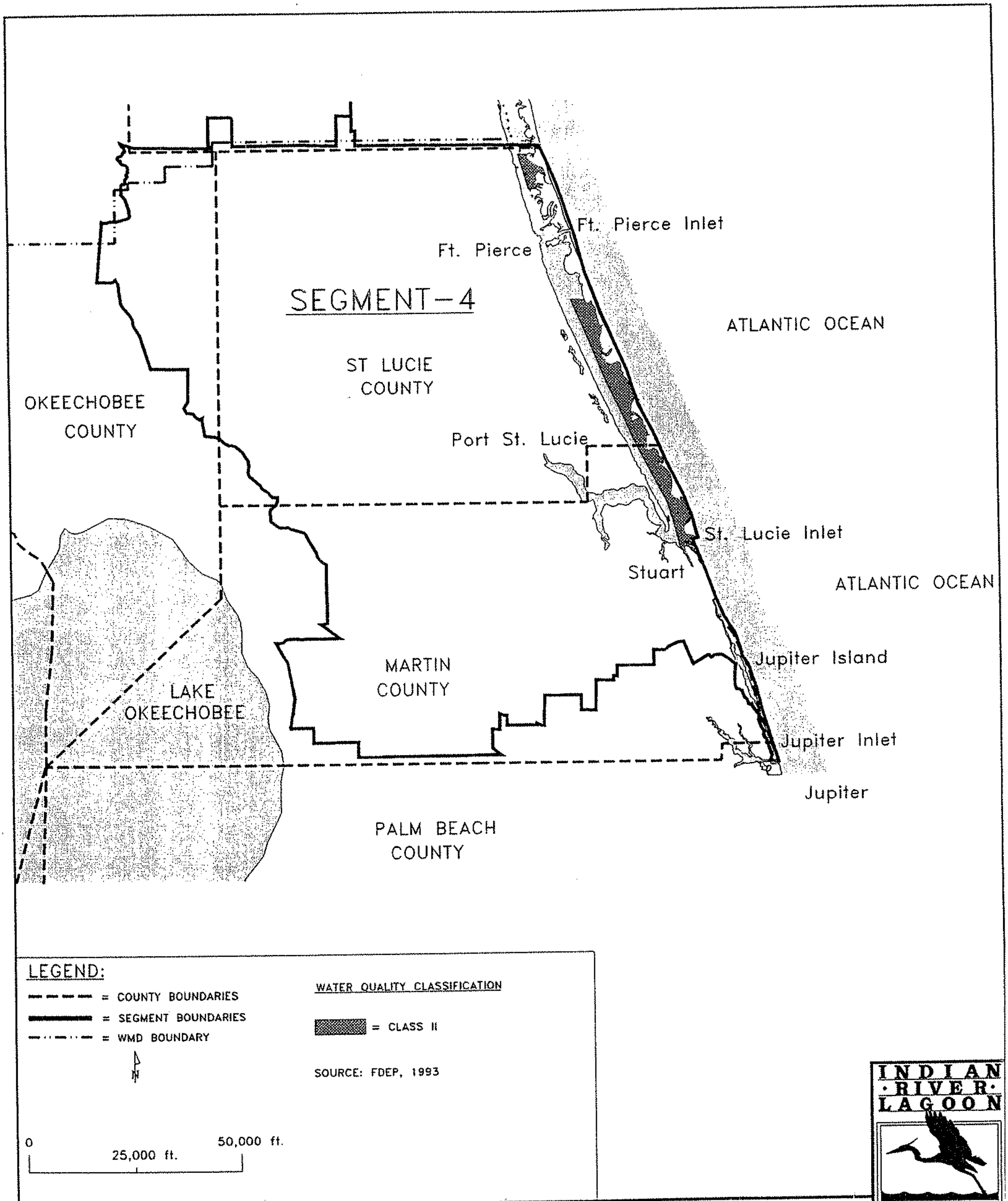

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FIGURE 2-1 STATE DESIGNATED CLASS II WATERS IN THE INDIAN RIVER LAGOON f) SEGMENT 4 – SOUTH INDIAN RIVER LAGOON

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Class II and III water quality standards are identical for all but a few parameters related to shellfish growth and human consumption where the Class II standards are more restrictive. Class II waters have a standard of 0.1 mg/L for manganese (not listed for Class III waters). The Class II standard for fluorides is 1.5 mg/L while the Class III standard is 5 mg/L for marine waters and 10 mg/L for freshwater. The primary difference between Class II and Class III waters is in the bacteriological standards. In a simplified form, Class II fecal coliform and total coliform bacteria standards are a median coliform MPN (Most Probable Number) of less than 14 and 70 per 100 ml respectively while those for Class III are less than 200 and 1,000 respectively per 100 ml.

Many of the water quality parameters that are commonly used to assess the condition of an estuary do not have specific standards in 17-302, FAC. With respect to the general water quality parameters that have been examined for this study, the following specific criteria are defined in 17-302.530:

- **Salinity** - no criteria
- **Secchi disk depth** - in terms of "transparency", for both Class II and III waters, it shall not be reduced more than 10% of natural background value
- **Total suspended solids (TSS)** - no criteria
- **Dissolved oxygen (DO)** - For Class II and III waters, DO shall not average less than 5.0 mg/L in a 24 hour period and shall never be less than 4.0 mg/L
- **Total nitrogen (TN), total Kjeldahl nitrogen (TKN), and total phosphorous (TP)** - no specific criteria, addressed under nutrients; it is stated that nutrients shall be limited as necessary to prevent violations of other standards, and in no case, shall nutrients cause an imbalance in natural populations of aquatic flora and fauna
- **Chlorophyll *a*** - no criteria

- **Turbidity** - for both Class II and III waters, turbidity must be ≤ 29 NTU above natural background conditions

- **Color** - no criteria

Additional criteria for metals are discussed in Section 6.0.

Although specific criteria for some parameters and problems such as salinity, nutrients, and organic matter have not defined, the standards regarding violation of other conditions allow for some enforcement contingencies. For example, failure to meet shellfish water quality standards could lead to a Class II area of the Lagoon being found in violation of Chapter 17-302 standards and closed for shellfish harvesting. Particular impacts that have been identified as detrimental to shellfish populations include the accumulation of muck due to suspended solids settling from solution or the reduction of salinity (Barile, et al., 1986; Funderburk, et al., 1991).

2.2 SHELLFISH PROPAGATION AND HARVESTING AREAS

Although much of the water of the Indian River Lagoon designated as Class II may be suitable for shellfish propagation and harvesting, harvesting is not actually allowed by FDEP in all of this water. In some cases, even though a Class II designation is in place, certain conditions such as high fecal coliform bacteria levels have led the FDEP Shellfish Environmental Assessment Section to prohibit shellfish harvesting. Under authority of Chapter 16B-28 FAC, FDEP has authority to regulate shellfish propagation by establishing Approved, Conditionally Approved, Restricted, Conditionally Restricted, or Prohibited shellfish harvesting areas based on the potential for contamination of certain shellfish (oysters and clams). These areas, shown in Figure 2-2 (a-g), are similar, but not identical to, the Class II designated waters. Data for these figures was derived from the Shellfish Harvesting Areas Atlas (FDEP, 1993a), and represents conditions as of May, 1993. These areas are reviewed and revised periodically by FDEP based on local conditions and findings developed in Comprehensive Shellfish Harvesting Area Survey reports. The south half of Mosquito Lagoon (Segment 1A), the northern end of Indian River Lagoon (Body A) in Segment 1C, and an area north of Ft. Pierce in the South Indian River Lagoon (Segment 4) in St. Lucie

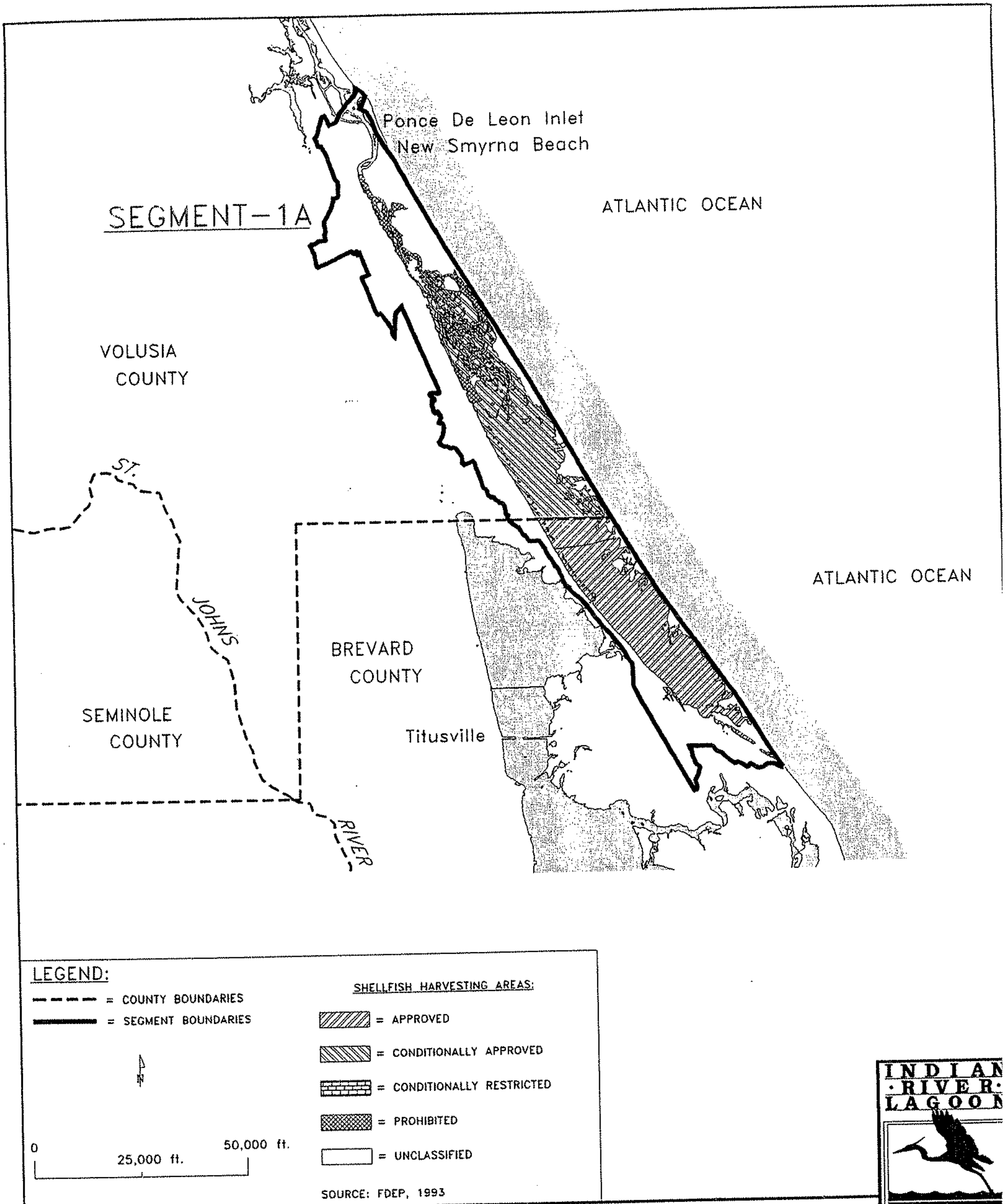

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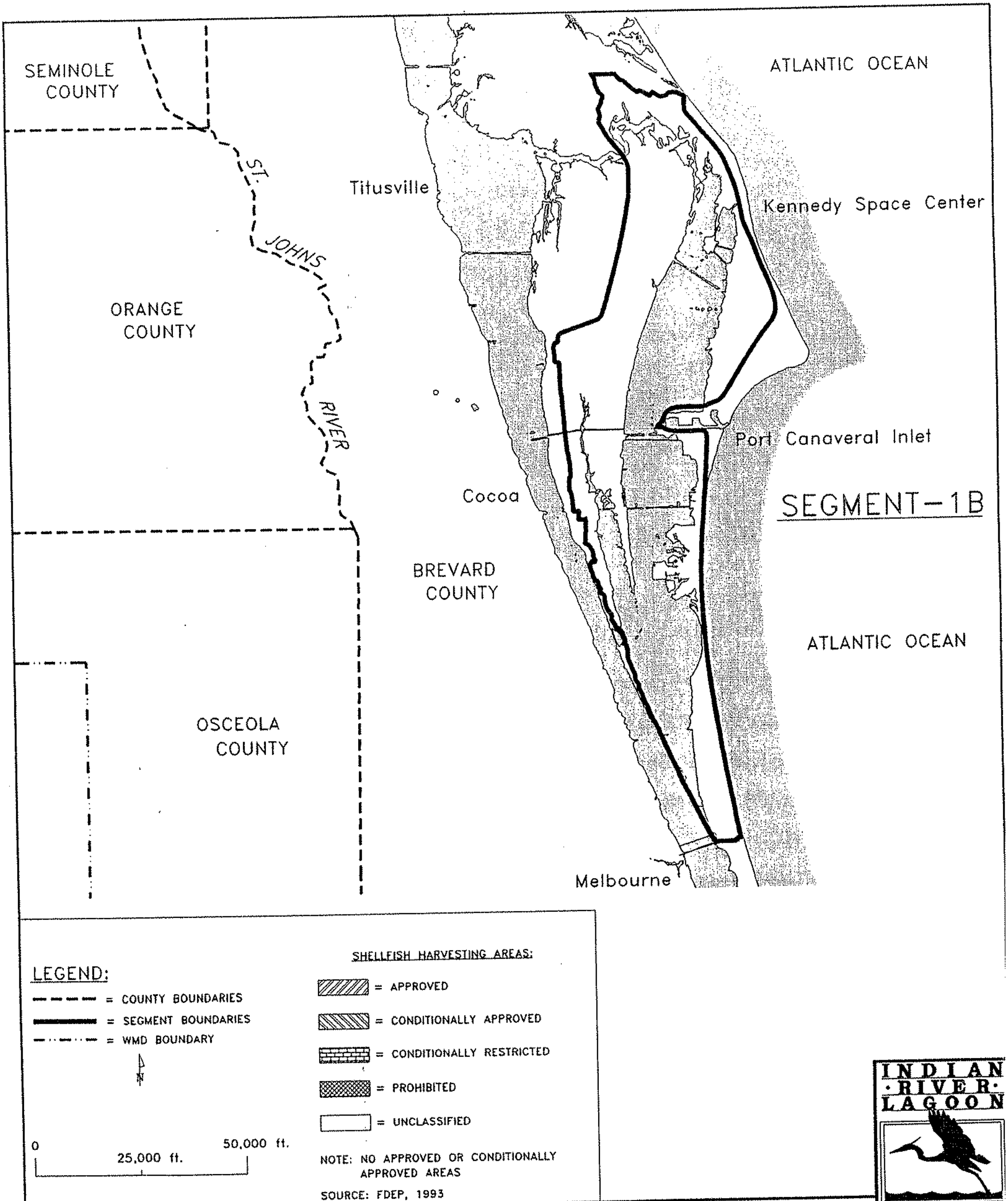
FIGURE 2-2 DESIGNATED SHELLFISH HARVESTING AREAS IN THE INDIAN RIVER LAGOON a) SEGMENT 1A - MOSQUITO LAGOON



•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: SEG1BSF.DWG DATE: 9-26-94	FIGURE 2-2	DESIGNATED SHELLFISH HARVESTING AREAS IN THE INDIAN RIVER LAGOON b) SEGMENT 1B - BANANA RIVER

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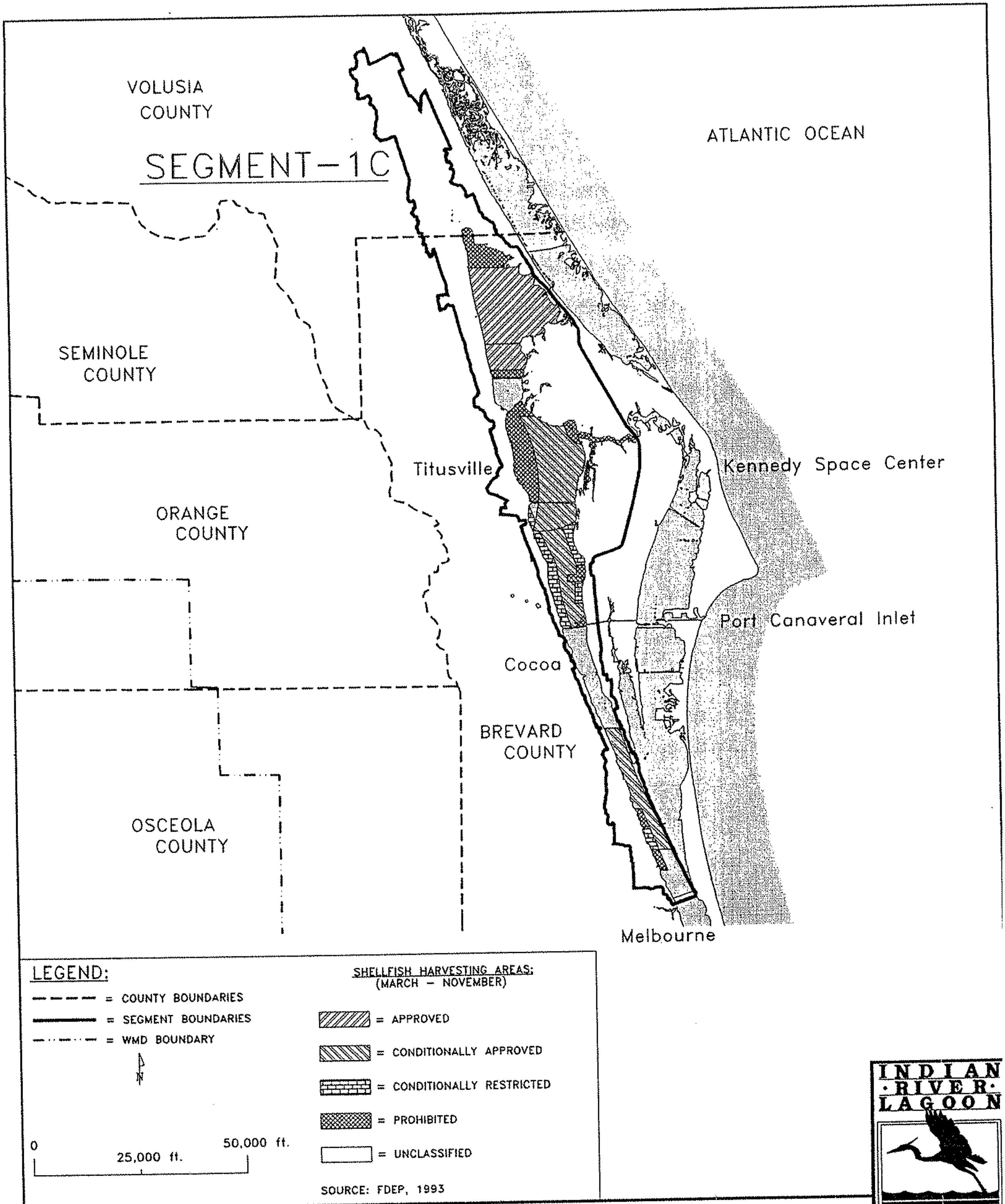

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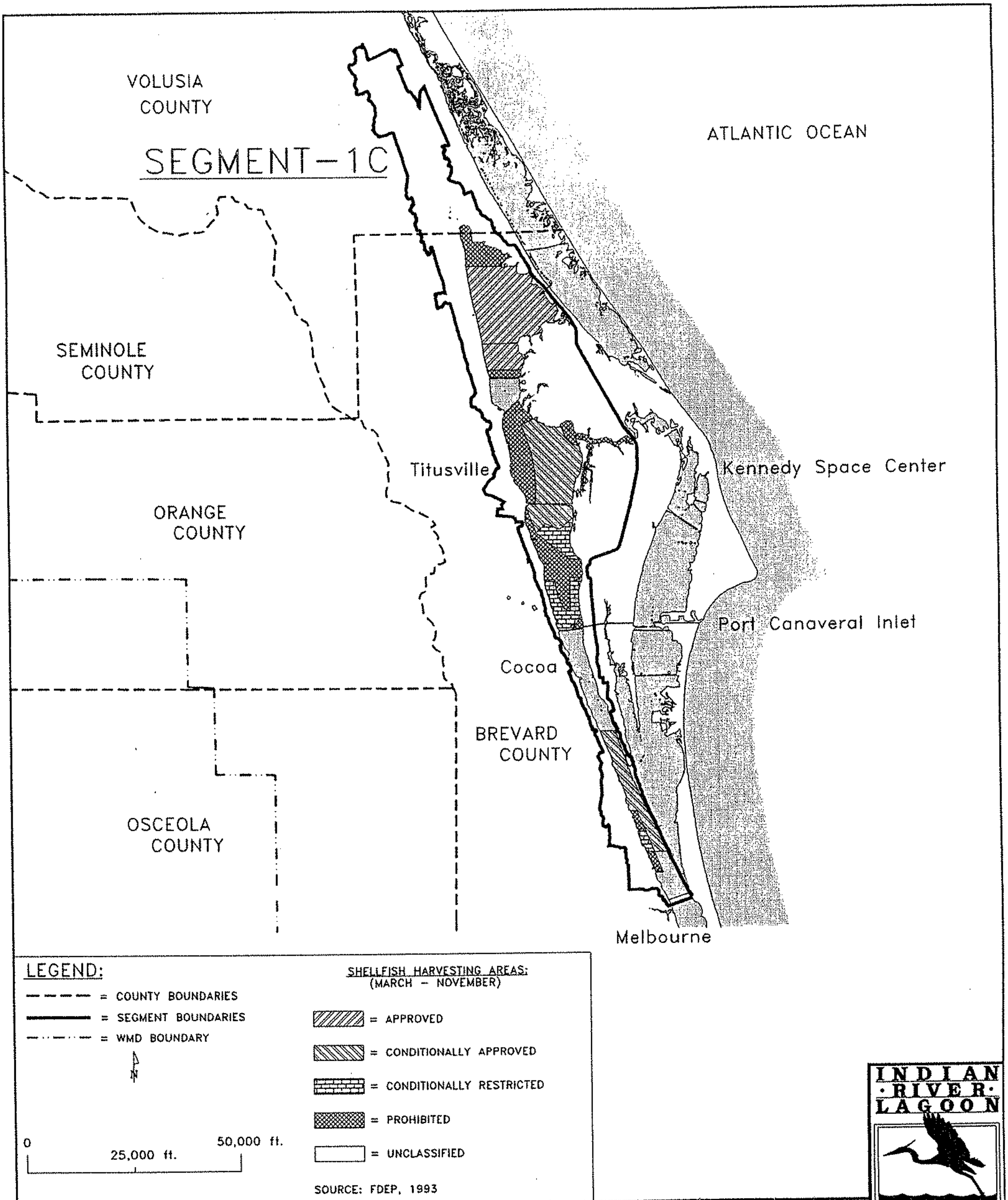
FIGURE 2–2 DESIGNATED SHELLFISH HARVESTING AREAS IN THE INDIAN RIVER LAGOON c) SEGMENT 1C – NORTH INDIAN RIVER LAGOON – SUMMER



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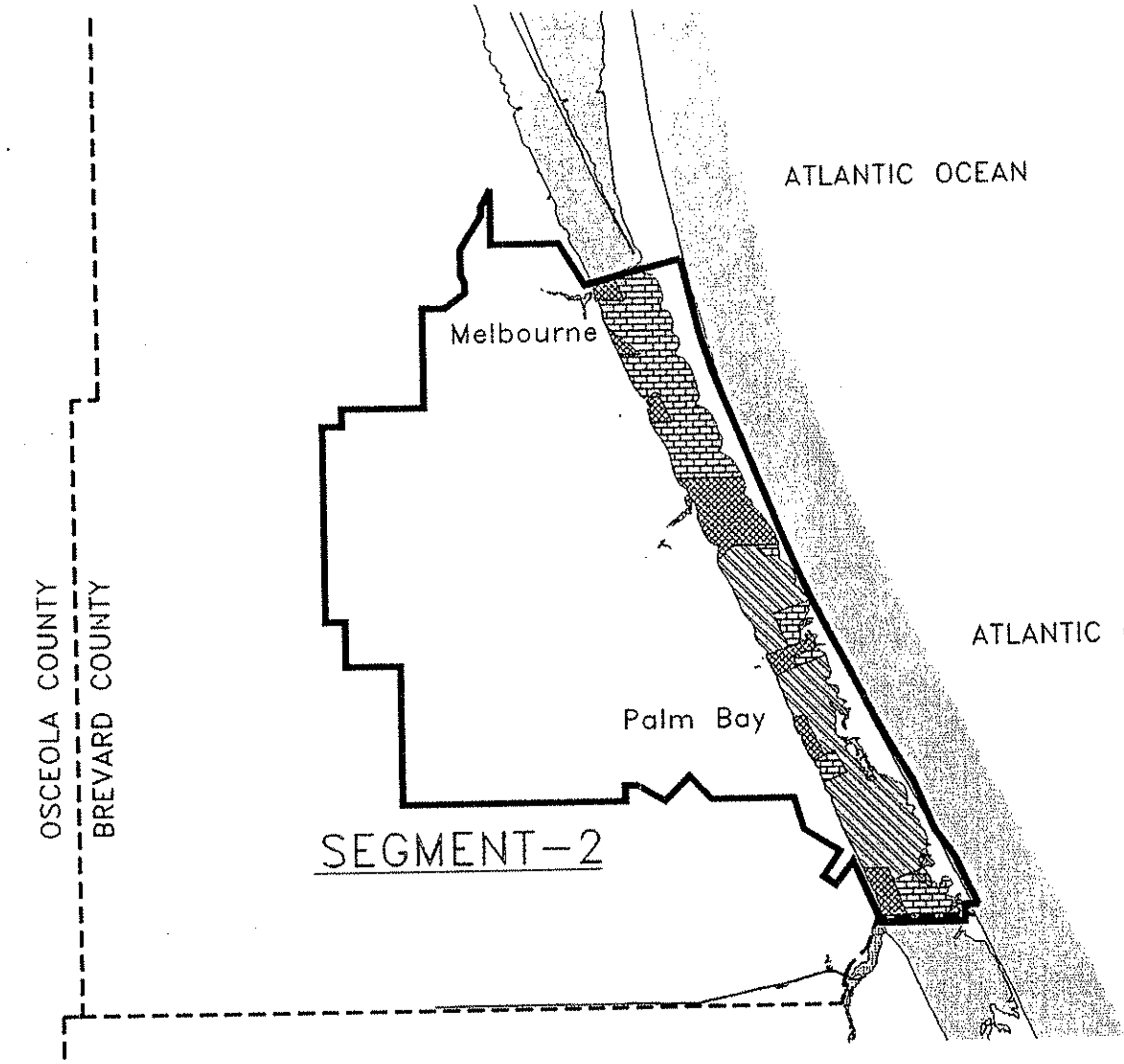
•Woodward–Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: SEG1CSF2.DWG DATE: 9-26-94	FIGURE 2–2 DESIGNATED SHELLFISH HARVESTING AREAS IN THE INDIAN RIVER LAGOON d) SEGMENT 1C – NORTH INDIAN RIVER LAGOON – WINTER



LEGEND:

- - - - = COUNTY BOUNDARIES
▬▬▬ = SEGMENT BOUNDARIES

N

0 25,000 ft. 50,000 ft.

SHELLFISH HARVESTING AREAS:

= APPROVED
= CONDITIONALLY APPROVED
= CONDITIONALLY RESTRICTED
= PROHIBITED
= UNCLASSIFIED

NOTE: NO APPROVED AREAS
SOURCE: FDEP, 1993

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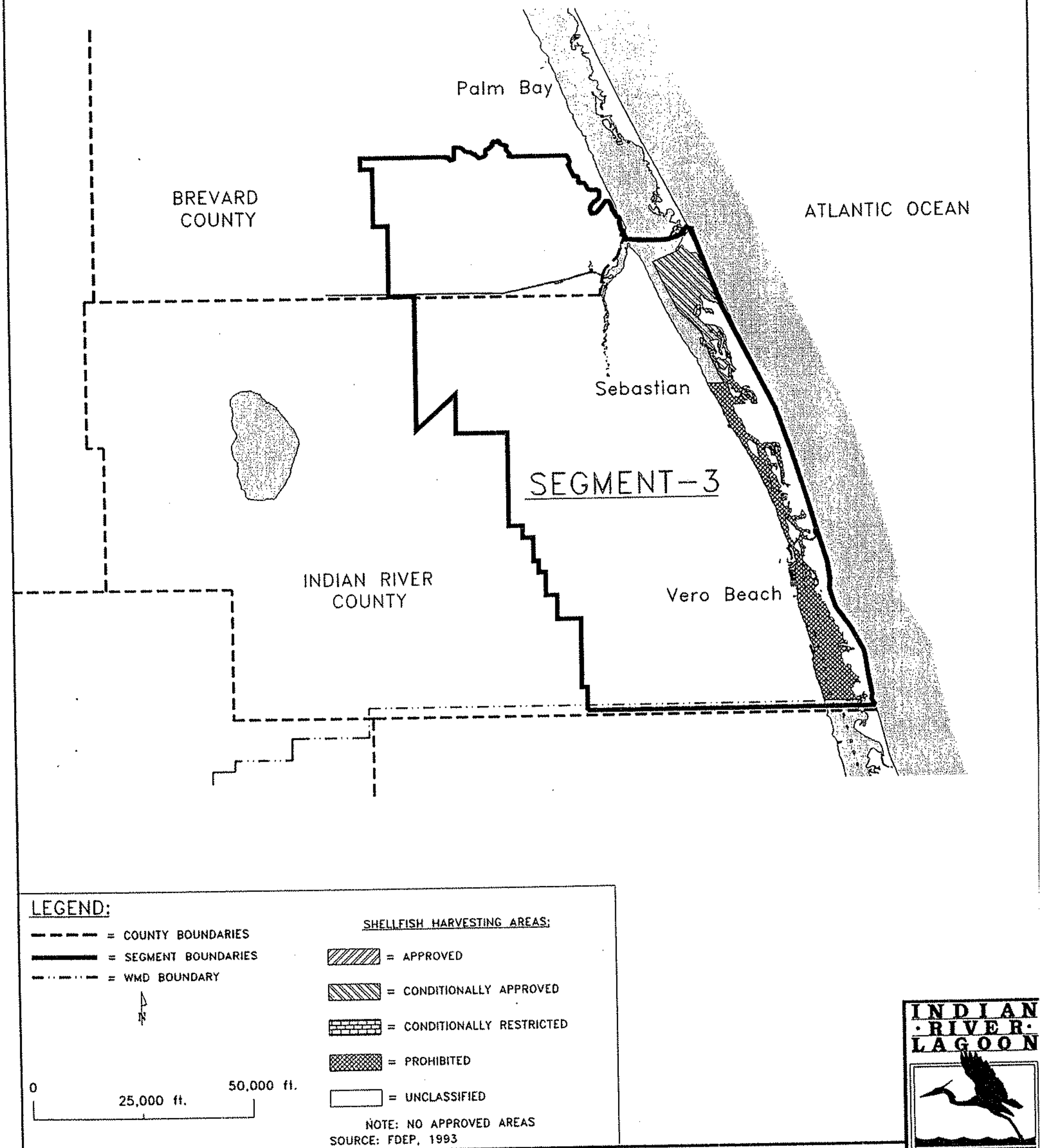

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FIGURE 2-2 DESIGNATED SHELLFISH HARVESTING AREAS IN THE INDIAN RIVER LAGOON f) SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON

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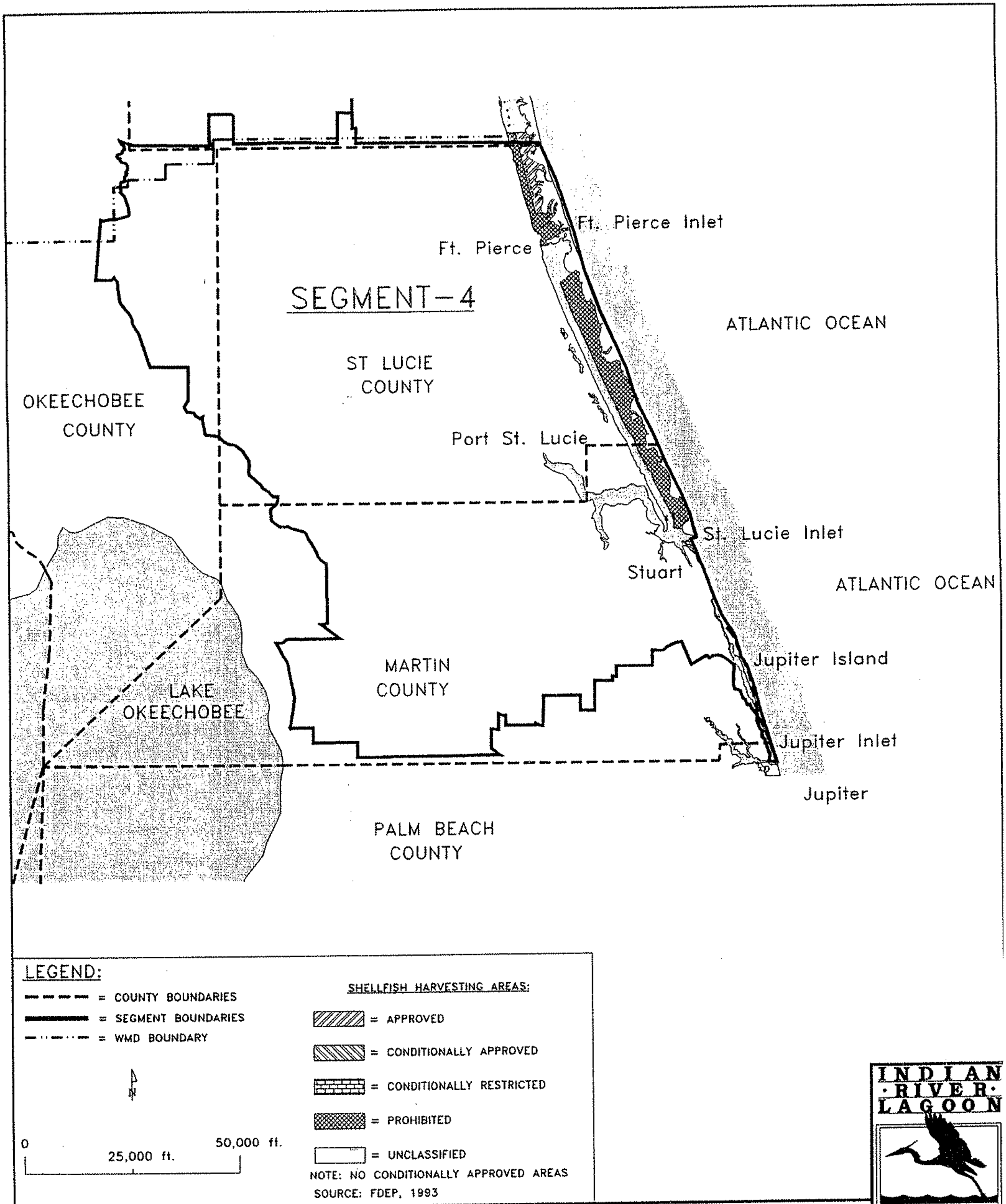

•Woodward–Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: SEG4SF.DWG DATE: 9-26-94	FIGURE 2-2	DESIGNATED SHELLFISH HARVESTING AREAS IN THE INDIAN RIVER LAGOON g) SEGMENT 4 – SOUTH INDIAN RIVER LAGOON

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County are the only areas that are currently unconditionally approved for shellfish harvesting. Designations differ seasonally for Body C in the Indian River Lagoon in Brevard County between NASA Causeway (SR 405) and Bennett Causeway (SR 528) because of differences in potential bacterial loads from nearby septic systems and package WWTPs caused by seasonal influxes of residents (Vanderbleek, 1993).

These categories have been defined by FDEP (1993b) as follows:

> ***Approved Area*** - Normally open to shellfish harvesting; may be temporarily closed under extraordinary circumstances such as red tides, hurricanes and sewage spills. The 14/43 standard must be met for all combinations of defined adverse pollution conditions (tide, rainfall, river, tide/rainfall, tide/river and tide/rainfall/river).
>
> ***Conditionally Approved Area*** - Periodically closed to shellfish harvesting based on pollutional events, such as rainfall or increased river flow. The 14/43 standard must be met when the management plan parameter (rainfall, river stage, and/or river discharge) is less than the adverse pollution condition during all other adverse pollution conditions.
>
> ***Restricted Area*** - Normally open to relaying or controlled purification, allowed only by special permit and supervision; may be temporarily closed under extraordinary circumstances such as red tides, hurricanes and sewage spills. The 88/260 standard must be met for all combinations of defined adverse pollution conditions (tide, rainfall, river, tide/rainfall, tide/river and tide/rainfall/river).
>
> ***Conditionally Restricted Area*** - Periodically, relay and controlled purification activity is temporarily suspended based on pollutional events, such as rainfall or increased river flow. The 88/260 standard must be met when the management plan parameter (rainfall, river stage, and/or river discharge) is less than the adverse pollution condition during all other adverse pollution conditions.
>
> ***Prohibited*** - Shellfish harvesting is not permitted due to actual or potential pollution. This classification is least desirable, and is used only when standards are exceeded

for Approved, Conditionally Approved, Restricted and Conditionally Restricted classification management schemes.

Unclassified - Shellfish harvesting is not permitted pending bacteriological and sanitary surveys.

The Conditionally Approved designation indicates areas that are routinely closed for oyster or clam harvesting after rainfall events and reopened for harvesting only when management plan conditions are met, based on surveys in which water quality monitoring indicates that bacterial standards are not exceeded. A special license and state approved monitors are required for shellfish harvesting from Conditionally Restricted or Restricted areas. Relaying or other forms of purification are also required from Restricted or Conditionally Restricted areas. Prohibited or closed areas have been found to be routinely unsafe and commercial harvesting is prohibited in those areas (Vanderbleek, 1992).

The bacteriological standards referenced in the FDEP (1993b) definitions refer to the fecal coliform bacteria levels found in the water during the sampling. The number of bacteria in a sample are expressed in units of the mean occurrence and Most Probable Number (MPN) per 100 ml of water. The 14/43 standard for Approved and Conditionally Approved waters requires a sample mean no more than 14 MPN/100 ml and the MPN not to exceed 43 MPN/100 ml more than 10% of the time. For the 88/260 standard for Restricted or Conditionally Restricted the sample mean can not exceed 88 MPN/100 ml and the MPN can not exceed 260 MPN/100 ml more than 10% of the time.

2.3 OTHER RELEVANT WATER QUALITY DESIGNATIONS AND AREAS

Chapter 17-302.700 also provides protection for areas designated as Outstanding Florida Waters and Outstanding National Resource Waters. These waters include areas within state and federal parks, preserves including Aquatic Preserves created under Chapter 258 F.S., and other similar publicly owned or designated lands, as well as lands acquired by the state under the Conservation and Recreational Lands (CARL) program and similar programs (described in the Biological Resources Technical Report). In the Indian River Lagoon, the designated preserves include waters within the boundaries of:

- Canaveral National Seashore
- Merritt Island, Hobe Sound, and Pelican Island National Wildlife Refuges
- Ft. Pierce Inlet and Sebastian Inlet State Recreation Areas
- St. Lucie Inlet State Park
- Jonathan Dickinson State Park
- Indian River Malabar to Vero Beach State Aquatic Preserve
- Indian River Vero Beach to Ft. Pierce State Aquatic Preserve
- Jenson Beach to Jupiter Inlet State Aquatic Preserve
- Mosquito Lagoon State Aquatic Preserve
- Banana River State Aquatic Preserve

This designation is intended to preserve the exceptional ecological or recreational significance of these waters by allowing no action that causes degradation of water quality as defined by a certain baseline period in these areas. This additional criteria for these specially protected waters is important in the review of permit applications and consideration of allowable uses within and adjacent to these potential waters.

2.4 FLORIDA STATEWIDE WATER QUALITY ASSESSMENT PROGRAM

The FDEP has maintained a statewide water quality monitoring network for several years. This network includes 14 estuarine stations within the Indian River Lagoon complex and 10 stations on tributaries of the Indian River Lagoon that have been monitored since 1982 and whose data have been entered in the EPA STORET data base. Periodically, FDEP publishes the most recent summary of all stations within the state and utilizes this information to compile statewide and basin-wide averages for water quality parameters. The most recent compilation was the 1992 Florida Water Quality Assessment: 305(b) Main Report and Technical Appendix (Hand and Paulic, 1992).

This assessment of FDEP data provides a good summary of overall long-term average conditions for the Lagoon. However, with only 14 stations covering the entire Lagoon complex and only 11 of these having periods of record greater than two years or more than 24 observations, this data is generally too limited for use in detailed assessment of spatial patterns in the Lagoon or for determining sources of pollution. Many of the stations essentially overlap stations of the SWIM monitoring network. However, the data does provide a long-term baseline of conditions within Florida and within the Lagoon, comparison to which can provide additional insight into trends over time and can in some cases provide information where the SWIM program leaves gaps.

The FDEP water quality assessment and data network for the Lagoon for most stations covers the period from 1982 through 1990, although the period of record for some stations ends in 1983 or 1986. This data is referenced in this report primarily for background or long-term average conditions. FDEP has used the data to define two basins for the Indian River Lagoon complex. These are the Middle East Coast Basin which extends from Ponce de Leon Inlet to Sebastian Inlet and the Indian River South Basin from Sebastian Inlet to St. Lucie Inlet. FDEP has made a general assessment of the water quality in these basins, although based on a very limited data set.

In the tables in Section 5.0 showing monthly and annual average water quality values from the characterization study, the average annual values (1982 - 1990) from the FDEP stations of the 1992 assessment (Hand and Paulic, 1992) within that segment are also shown for comparison. The averages from the FDEP data are only based on between 2 and 5 stations for each segment. In addition, the turbidity data is not directly comparable between the SWIM data set and the FDEP data because the SWIM data is presented in NTU units of measure while the FDEP data is presented in JTU units, and these scales are not directly comparable.

3.0
WATER QUALITY LITERATURE

Until recently, there has been no systematic Lagoon-wide monitoring program, other than the FDEP network, which has only a limited number of stations. However, there have been several uncoordinated data collection programs (Haunert and Startzman, 1985; Clark, 1991; Provancha, et al., 1992; Graves and Strom, 1992). Windsor and Steward (1987) described the state of Lagoon monitoring in the early 1980s, and identified the lack of adequate long-term monitoring data as a problem. Tables presenting monitored sites and data with adequate quality assurance were presented by Windsor and Steward (1987). Windsor and Steward (1987) concluded that the Lagoon was impacted by wastewater treatment plant effluent, freshwater discharges, urban stormwater runoff, and agricultural runoff.

In the 1992 Florida Water Quality Assessment (Hand and Paulic, 1992), Florida's statewide major surface water quality problems were summarized as consisting of urban stormwater, agricultural runoff, domestic wastewater, industrial wastewater, and hydrological modifications. Major causes of impacts to estuaries were listed as nutrient enrichment, organic enrichment, high suspended solids, and increased light attenuation. Major impacts were attributed to industrial point sources and urban runoff, while moderate and minor impacts were attributed to urban runoff, municipal point sources, on-site wastewater systems (septic tanks), and agriculture. A compilation of the water quality issues perceived by FDER (Hand and Paulic, 1992) in the Indian River Lagoon system is presented in Table 3-1.

FDER (Hand and Paulic, 1992) listed suspected major pollution sources in the Middle East Coast Basin (from Ponce de Leon Inlet to Sebastian Inlet) as urban runoff and wastewater treatment plants. Best water quality areas occurred in the Indian River Lagoon at Sebastian Inlet and north of Titusville, and in Mosquito Lagoon north of Haulover Canal and south of Edgewater. Mosquito Lagoon (Segment 1A) was presented as a well-mixed waterbody with few point sources and relatively low development. Since much of the watershed is rural land

TABLE 3-1

SUMMARY OF INFORMATION PRESENTED IN THE TECHNICAL APPENDIX TO THE 1992 FLORIDA WATER QUALITY ASSESSMENT (FDER 1992)

SEGMENT	AREAS WITH GOOD WATER QUALITY	AREAS WITH DEGRADED CONDITION	WATER QUALITY RATING AS PRESENTED	MAIN WATER QUALITY ISSUES
1A - Mosquito Lagoon	North of Haulover Canal and South of Edgewater		Good	Septic Tanks
1B - Banana River		Sykes Creek/Newfound Harbor, Cocoa Beach, Patrick AFB, Port Canaveral, Merritt Island	Poor	Algae Blooms, Seagrass Loss, Fish Kills, WWTP Discharges (now ceased), WWTP (still discharging), Urban Runoff, Canal Systems, Causeways
1C - North Indian River Lagoon	North of Titusville	Rockledge, Cocoa, Merritt Island	Fair	Drainage Canals, WWTP Discharges (now ceased), Urban Runoff
2 - North Central Indian River Lagoon		Turkey Creek, Crane Creek, Eau Gallic River	Fair	Urban Runoff, WWTP Discharges, Freshwater Discharge, Dairy Runoff
3 - South Central Indian River Lagoon	Sebastian Inlet	Sebastian River, Sebastian Creek North Prong, Sebastian Creek South Prong, IRL from Sebastian Inlet to Ft. Pierce	Fair	Urban Runoff, WWTP Discharge, Freshwater Discharges, Rangeland Runoff, Citrus Runoff
4 - South[1] Indian River Lagoon	South of Ft. Pierce	Belcher Canal	Fair	Urban Runoff, WWTP Discharge, Freshwater Discharges, Rangeland Runoff, Citrus Runoff

Source: FDER, 1992

1 = St. Lucie Estuary was not included

with limited agriculture, FDER indicated that a primary source of pollution for much of this segment was thought to be septic tanks.

The worst water quality areas listed were Newfound Harbor, Sykes Creek, and much of the southern Banana River, as well as Crane Creek in the Indian River Lagoon watershed. Little change in water quality since the previous water quality assessment (Hand, et al., 1986) was reported for six of the sites that were monitored, but worsening quality was reported in Sykes Creek and in portions of Indian River adjacent to Merritt Island and the City of Cocoa (FDER, 1992). In the Sykes Creek/Newfound Harbor area, algae blooms, seagrass loss, and occasional fish kills were presented by FDER (Hand and Paulic, 1992) as resulting from water quality impacts.

Even though wastewater treatment plants no longer discharged into Sykes Creek, the creek still exhibited high levels of nutrients and chlorophyll *a* and low Secchi disk depth values in the early 1990s. FDER (Hand and Paulic, 1992) also perceived a worsening trend in water quality in the Sykes Creek area during the 1982 to 1991 period. The Banana River also received effluent from the City of Cocoa Beach and Patrick Air Force Base wastewater treatment plants. Pollution in Port Canaveral was attributed to shipping traffic discharge and seafood processing wastewater treatment plant effluent.

With respect to anthropogenic impacts, the basin units used by FDER may be too large to definitively identify localized water quality problem sources. However, FDER (Hand and Paulic, 1992) did report that poor water quality existed in the vicinities of Turkey Creek, Crane Creek, and the Eau Gallie River. Pollution sources for Turkey Creek were felt to be a drainage canal in the St. Johns River basin diversion area (South Brevard Water Control District) and urban runoff from the Melbourne urban area. Crane Creek was reported to have been degraded by discharges from the City of Melbourne Grant Street wastewater treatment plant and the City of West Melbourne WWTP (both of which have now ceased discharging and are using deep well injection for effluent disposal). The cause for degradation of the Eau Gallie River was postulated to be urban runoff and discharge from the D. B. Lee WWTP in Melbourne.

An additional major pollution source to the Lagoon was in the Rockledge/Cocoa area where nutrient and BOD loadings were identified as coming from wastewater treatment plants and from urban runoff (Hand and Paulic, 1992). The area from Titusville to Cocoa was listed as having poor water quality along the developed western side due to Titusville wastewater treatment plant discharges, significant urban runoff from canal systems, and causeway bridges which limit water circulation. Because development and associated pollution is significantly reduced north of Titusville, water quality in that area was assumed by FDER to be good to excellent.

In the Indian River South Basin, major pollution sources were presented by FDER (Hand and Paulic, 1992) as dairy, citrus, and ranch operations; wastewater treatment plants; and urban runoff. The area of best water quality was found in the Indian River Lagoon south of Ft. Pierce. Water quality was improving in Belcher Canal and the South Indian River Lagoon. The St. Lucie Estuary was not included in the assessment, however, due to lack of data.

The poorest water quality in the Indian River South basin was found in the Sebastian River watershed. The South Prong of Sebastian Creek was said to have a history of elevated bacteria and BOD loads from dairy farms and rangeland runoff, but recently had showed improvements in water quality. The North Prong of the Sebastian River also had high bacteria and low DO concentrations. However, this may now be improving because dairies have now been removed from that basin (Hand and Paulic, 1992).

Anthropogenic impacts in the Indian River South Basin were described as primarily urban runoff from waterfront development. However, at Ft. Pierce the problems included high nutrients and excessive freshwater input from the Belcher Canal and the Ft. Pierce wastewater treatment plant. Pollution problems in the Vero Beach area were reported as primarily increased nutrients.

The 1986 version of the FDER Florida Water Quality Assessment (Hand, et al., 1986) also characterized Mosquito Lagoon as a well-mixed water body with few water quality problems. While the northern half of Banana River was regarded as having fair water quality, the southern half was rated as having poor water quality. In the Indian River Lagoon itself, the portions near Titusville and Rockledge/Cocoa, between Eau Gallie River and Turkey Creek, and in the Vero Beach area had only poor to fair water quality. High nutrient, chlorophyll *a*, and BOD levels were generally the primary problems.

The 1986 FDER assessment (Hand, et al., 1986) also found Sykes Creek to have some of the poorest water quality in the Lagoon system, with high nutrients and chlorophyll *a* levels and low Secchi disk readings. Although this report stated that water quality problems probably were present in the Eau Gallie River, Crane Creek, and Turkey Creek, it concluded that there was insufficient data to make a definitive conclusion. The North and South Prongs of the Sebastian River, however, were both described as having very poor water quality with high nutrients and bacteria and low DO.

Several of the areas identified by FDER (Hand and Paulic, 1992) as having good or poor water quality have been similarly described in other studies. Jettmar, et al. (1975) described Mosquito Lagoon and the Indian River north of Titusville as having good water quality and low development in the early 1970s, whereas Sykes Creek, Eau Gallie River, Crane Creek, and Turkey Creek were all identified as having poor water quality with elevated nutrients in the early 1970s. Portions of the Indian River Lagoon between Titusville and Cocoa were also described as having poor water quality with elevated nutrient and chlorophyll *a* levels.

Windsor and Steward (1987) found that conditions in Mosquito Lagoon between 1980 and 1985 indicated good water quality conditions with high salinities and low nutrients although the number of stations and sampling data was very small. Spatial patterns of salinity, nutrients, and chlorophyll *a* appeared to be present in the Banana River (Segment 1B) and North Indian River Lagoon (Segment 1C), with salinity decreasing and nutrients and chlorophyll *a* increasing from north to south.

Windsor and Steward (1987) also reported the continuation of the salinity decrease in the North Central Indian River Lagoon (Segment 2) as far south as Turkey Creek for the 1980 to 1985 period, with a substantial variation among years. For example, the mean annual salinity in the Lagoon between the Eau Gallie River and Crane Creek ranged from 17 parts per thousand (ppt) in 1983 to 28 ppt in 1981. Windsor and Steward (1987) also found nutrient levels (TP and TN) to be 2 to 3 times higher in the Eau Gallie River and Crane Creek than in the Lagoon, although levels in Turkey Creek were more similar to those of the Lagoon. Greatly elevated chlorophyll *a* levels were also reported from the Eau Gallie River (62 μg/L) and Crane Creek (21 μg/L). Low dissolved oxygen values were reported to be a problem in Crane Creek.

Windsor and Steward (1987) found only very limited data available for the South Central (Segment 3) and South (Segment 4) Indian River Lagoon, with no stations actually reported within the Lagoon. Only four tributary stations (C-25 Canal, St. Lucie Estuary North Fork, C-24 Canal, and C-44 Canal) had sufficient data to report. This data only included DO, TN, and TP. TN concentration was reported as high for the three St. Lucie stations, but low for C-25, with a continuing decrease from 1980 through 1985, thought to be a result of a decrease in organic nitrogen. TP was also elevated in the three St. Lucie tributaries, with no apparent change in concentration over time.

4.0 METHODOLOGY FOR WATER QUALITY DATA ANALYSIS

4.1 DATA SET

Degraded water quality in an estuary may be indicated by above natural background levels of certain constituents, such as nitrogen, phosphorous, chlorophyll *a*, suspended solids, turbidity, and color as well as below natural background levels of other constituents such as dissolved oxygen and salinity. In combination with the condition of the bottom sediments, the concentrations of these constituents in the water column strongly affect the biological community that is present. Therefore, water quality data can provide significant knowledge regarding the status of the estuary. When comparatively analyzed over space and time, trends in water quality can be identified that may help with management decisions.

Data collected from any monitoring program will have limitations because of the inherent nature of water column sampling. To begin with, funding is often inadequate to continuously sample and analyze any parameters. Inescapable human error must also be considered. Therefore, experience and judgement must be used in the development of any sampling program and particularly in the analysis of the data that are collected. The latter is particularly true when the compilation and analysis of raw data is being performed by someone who was not involved in the sampling and laboratory analysis effort. However, an unbiased scientific opinion of the raw data that results from a sampling program should provide quality assurance to both the sampling program and the conclusions that are drawn by the outside analyzer.

The SWIM monitoring network has coordinated sampling programs throughout the Lagoon through the development of consensus of the existing monitoring programs on comparable and compatible parameters and laboratory analysis methodologies. Where possible, sampling dates are coordinated. The monitoring effort was initiated in most locations in 1988, leaving a gap of three or four years between the data in the Reconnaissance Report (Windsor and Steward, 1987) and the data of the current water quality network. The data collected since the network was established is being collected, validated, and verified at the SJRWMD office in Palatka by IRLNEP staff.

However, at the time of preparation of this technical report, a statistical analysis of the raw data had not been performed nor had the data been compiled beyond the creation of a data set of individual raw data points for each sampling event. Therefore, it has been necessary to convert the raw data into a database for status and trend analysis as a part of the characterization process, rather than relying on established data bases.

The SWIM water quality sampling network includes stations that are located throughout the Indian River Lagoon system. Seven separate agencies - Brevard County, Volusia County, FDEP, NASA, U.S. Geological Survey (USGS), SJRWMD, and SFWMD - have had monitoring stations throughout various parts of the Lagoon. Indian River County is now maintaining the FDEP stations in that county. Some of the agencies sample quarterly while other agencies sample on a monthly basis. Sampling stations are also located within some of the tributaries to the Lagoon. More detailed information regarding stations and locations is presented later in this report.

As of June, 1993, the SWIM data set for both the SJRWMD and the SFWMD regions had been collated into a standard format. Certain values that were considered questionable by IRLNEP staff had been flagged, but were still included in the data base. In the additional evaluation of the data for this report, other data inconsistencies were noted, in addition to data already flagged. Among the additional noted problems were:

- Data from several stations were missing from the data set.
- Temporal coverage varied substantially, both in the period of record and in the frequency of sampling for different stations.
- For some stations, only limited parameters were included in the data set, and for other stations coverage was both limited and sporadic.
- There were some negative values and values that differed substantially from expected values based on examination of other stations or dates, or other data sets.
- There were unexplainable changes between successive sampling periods.

Data from the Eau Gallie River and Crane Creek tributary stations, from Brevard County Stations ML1 and ML2 in Mosquito Lagoon, and from NASA stations had numerous questionable values which appeared to be indicative of abnormal events that had not been described. Transposition of data at some point prior to the conversion of raw data to the final entering into the SWIM data base appeared to be a possible cause of some of these data inconsistencies. It was impossible to verify all of these data points or to obtain further information in the time frame available in this project. As a result, some stations have not been included in the analysis. The problems with the ML1 and ML2 Stations were identified by SJRWMD and these stations were subsequently included in the evaluation.

After compiling of the data bases the following water quality parameters maintained a sufficient scope of coverage to allow a meaningful Lagoon-wide evaluation:

- Salinity
- Dissolved oxygen (DO)
- Total suspended solids (TSS)
- Chlorophyll *a*
- Total nitrogen (TN)
- Total Kjeldahl nitrogen (TKN)
- Total phosphorus (TP)
- Color
- Secchi disk depth
- Turbidity

Data gaps remained even in some of these parameters, primarily due to longer sampling intervals and occasional data gaps among parameters such as color, chlorophyll *a*, and TN at some stations. Data from some locations were not present in the digital data set and could not be obtained in time for inclusion in this evaluation. Data from monitoring stations in all tributaries in the SFWMD region (Segment 4 - South Indian River Lagoon) were not provided.

4.2 DATA REDUCTION

The raw data were obtained from IRLNEP in SAS format and in ASCII form, and then imported into the Paradox for Windows® database program. The first step after importing files was to conduct a preliminary inspection in order to determine which data points appeared suspect. Even though the data had been represented by the individual reporting agencies to be "accurate as reported", it was clear in a number of instances that inaccurate or non-representative data points were present in the raw data set. Therefore, some data points were eliminated when inconsistencies were obvious. Rosner's test for detecting outliers (Gilbert, 1987) was used to evaluate outlying data points. Outlying data points greater than two standard deviations from the mean were eliminated. Only a small percentage (approximately 15 data points out of over 19,000) of the data points were eliminated in this step.

The next task was to convert non-numeric comment characters that had previously been inserted into the data and to remove raw data points that had been classified as "below detection limits" or "known to be lower than the value that was given", since statistical procedures cannot be performed when raw data includes such non-quantified information.

After this data reconfiguration and elimination of unusable characters, the remaining data was sorted and examined for completeness. At this point in the analysis, it became obvious that the remaining data for certain parameters and stations were so incomplete that they were not suitable for use in this Lagoon-wide assessment. Therefore, only certain key parameters were chosen for inclusion in this analysis.

4.3 PARAMETERS

At the beginning of the study, it was hoped that certain parameters that have been reported (Funderburk, et al., 1991) to be valuable indicators of the status of phytoplankton and seagrass condition could be included in this analysis. These parameters included salinity, Secchi disk depth, total suspended solids (TSS), chlorophyll *a*, dissolved inorganic nitrogen (DIN), and dissolved inorganic phosphorous (DIP).

However, of this list, only salinity, Secchi disk depth, TSS, and chlorophyll *a* data were available from the resultant database in a sufficiently complete form to be utilized. Total nitrogen (TN), total Kjeldahl nitrogen (TKN) and total phosphorous (TP) were substituted for DIN and DIP as measures of these important nutrients.

Other water quality parameters important for the well-being of fish and shellfish resources are dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD). Because of the importance of these two parameters, DO was also evaluated. The BOD data set however was insufficient for analysis and could not be used. Turbidity was also included in the analysis because of the strength of the data throughout the Lagoon.

Dissolved oxygen (DO) concentration is a function of the temperature and salinity of the water, the depth of the sample and atmospheric pressure, and the time of day and season that the measurement is taken, as well as other factors. For example, at 10° C the solution of oxygen in fresh water is 11.3 mg/L and in 35 ppt salt water is 7.1 mg/L. At 30° C, the solubility in fresh water is 7.6 mg/L and in salt water it is 4.8 mg/l.

Thus DO concentration changes reported by water quality monitoring programs may be simply responses to normal changes in water temperature or salinity as opposed to results of water quality problems such as oxygen consumption through Chemical Oxygen Demand (COD) or BOD. The concentration of DO may be expected to change naturally on both a daily and seasonal basis in response to normal temperature changes. Differences in temperature, density, or salinity at different depths may also result in different concentrations of DO in different parts of the water column.

As a result of these considerations, care must be taken in evaluating reported DO values from any sampling program. Differences in depth of collection, time of day, or temperature at time of collection can lead to fairly large differences in reported DO values. One means of accounting for the effects of such variables is to convert DO value (mg/L) to percent saturation value, which accounts for the effect of temperature and salinity. This allows DO data collected under different conditions to be more directly comparable in terms of the actual amount of oxygen present in relationship to that which could be present.

However, DO concentration is the form in which this data is normally presented in most water quality reports. State water quality standards are also expressed in terms of DO concentration as mg/L. Thus data is reported in this form for this report.

Effects on organisms and oxygen-dependent chemical reactions in the water are dependent on % saturation, and effects of a given DO concentration in mg/L may be different under different conditions of temperature or salinity. Because of these differences, the inferences that are made concerning DO values and effects are necessarily limited in this report. Insufficient data on temperature were available to allow conversion of all individual DO values, so the data have been retained in the mg/L format, and this data has been averaged to show regional trends in the same fashion as for other parameters. This level of evaluation may tend to identify areas in which DO values have been generally higher or lower than average and may give indications as to differences in either water quality or physical conditions in different areas of the system. Low average values may indicate areas where DO problems may be expected. However, the results should not be construed as statements that an area has "good" or "bad" DO levels just because it falls above or below a fixed standard. The SWIM data set does contain temperature data for most data points, so it may prove useful in the future for researchers seeking to perform a more detailed DO analysis for specific areas of the Lagoon.

Once the set of parameters to be analyzed was established, the Paradox database program was used to organize the data so that spatial and temporal trends could be evaluated. Averages of the selected parameters were obtained. The following values for each of the selected parameters were derived from this refined data base:

- Wet season and dry season average values for each parameter for each station in the Lagoon complex. This data is organized by segment of the Lagoon and presented in Section 5.0 as line graphs showing stations on a north to south basis for each segment. The average values and standard deviations of the mean for each station are shown in Appendices A and B, respectively.

- A monthly (or quarterly, depending on parameter) time series analysis of the average concentration of all stations within each segment of the Lagoon for each parameter. This analysis includes only the 1989-91 3-year period because this was the only period of record for which data was available from nearly all stations.

- Average monthly values for each parameter for all of the stations combined within each segment for the period from 1989 through 1991.

- Number of samples, maximum, minimum, and average values and the standard deviation, reported by segment.

The tables in Section 5.0 summarize the average monthly water quality values for various segments of the Lagoon. These values also are compared to the 1982 to 1990 long-term average summarized by FDEP in the 1992 Water Quality Assessment (WQA) (Hand and Paulic, 1992) for the state of Florida. In these tables, turbidity is reported in NTU for the SWIM data set, but the averages from the FDER WQA data are shown as JTU. These are two different analytical scales based on different analytical procedures which can not be directly compared. The JTU unit of measure was replaced by the NTU method in the 1980s.

4.4 STATIONS

Tables 4-1 and 4-2 show the period of record of usable data available for each station of the Lagoon and of the tributaries from this refined data set. The stations in Tables 4-1 and 4-2 are listed from north to south; locations are shown in figures in Section 5.0 under the segment in which they occur. The wet and dry season averages reported for each station are based on the entire period of record for the station, as shown in Tables 4-1 and 4-2 in order to provide a long-term reference period and maximum level of resolution on which to evaluate spatial distribution of concentrations within the Lagoon. The monthly averages and the time series analysis are based only on data from the 1/89 to 12/91 period in order to provide the most consistent comparison among all the segments of the Lagoon.

TABLE 4-1

PERIODS OF RECORD USED FOR WATER QUALITY MONITORING STATIONS WITHIN INDIAN RIVER LAGOON

STATIONS	SEGMENT	PERIOD OF RECORD
V1 - V20	1A	10/88 to 12/91
ML01 - ML02	1A	01/87 to 12/92
B01 - B10	1B	01/87 to 12/92
I1 to I20	1C	01/88 to 12/91
I20 - I28	2	01/88 to 12/91
I29	3	01/88 to 12/91
IRJ01 - IRJ02	3	03/88 to 04/90
IRJ03	3	03/88 to 11/91
IRJ04 - IRJ08	3	03/88 to 04/90
IRJ09	3	03/88 to 11/91
IRL39 - IRL01	4	10/88 to 10/92

Data Source: SJRWMD, 1993

TABLE 4-2

PERIODS OF RECORD USED FOR WATER QUALITY MONITORING STATIONS ON TRIBUTARIES OF THE INDIAN RIVER LAGOON

TRIBUTARY	STATION	SEGMENT	PERIOD OF RECORD
Turnbull Creek	TBC	1C	01/89 to 12/91
Big Flounder Creek	BFC	1C	03/89 to 10/91
Addison Creek	AUS	1C	02/89 to 10/91
Horse Creek	HUS	1C	02/89 to 10/91
Turkey Creek - Highway 1	TUS	2	01/88 to 10/91
Turkey Creek - Pt. Malabar Boulevard	TPM	2	02/88 to 07/89
Goat Creek	GUS	2	01/88 to 10/91
Trout Creek	TRU	2	02/89 to 10/91
Sebastian River	SUS	3	01/88 to 12/91
Vero North Canal	VNC	3	02/89 to 10/91
Vero Main Canal	VMC	3	02/89 to 10/91
Vero South Canal	VSC	3	02/89 to 10/91

Data Source: SJRWMD, 1993

All of the Segment 3 series of Stations IRJ01 to IRJ09 actually had data sets for the period 3/88 to 11/91. However, the data for most of the stations in the period subsequent to 4/90 had many inconsistencies, and abnormal or obviously wrong values with indications that data may have been switched between parameters. For example, salinity values for some Lagoon stations never rose above 10 ppt while Secchi disk depths of 20 m were reported for some stations. The problems with these data could not be traced and/or corrected in the available time frame, so all but one station (I29) in Segment 3 are limited to a data set ending in 4/90. Because of these problems with the IRJ data set, the South Central Indian River (Segment 3) is represented by time series data only for the period 01/89 to 04/90, because this was the only part of this period with data from all ten (IRJ01-IRJ09 and I29) of the stations in this segment.

In addition to stations within the Lagoon complex itself, data were evaluated for 12 tributaries (Table 4-2) that had an available period of record of at least 2 years. All tributary stations used in this analysis are stations monitored by SJRWMD. There are also several stations maintained by Brevard County, but only stations monitored by SJRWMD were analyzed. Data for several key tributaries were missing from the Brevard County data set and could not be obtained in time for the analysis. These include the Newfound Harbor/Sykes Creek Stations in Segment 1B (Banana River) which were not in either the SJRWMD or Brevard County data sets supplied by SJRWMD for analysis. In addition, none of the tributary data for Segment 4 (South Indian River Lagoon) was available from SFWMD during the time frame of this analysis. Data for these tributaries (St. Lucie River, Taylor Creek/Belcher Canal) had not been verified for release by SFWMD at the time of the analysis.

Data for two other tributaries, the Eau Gallie River and Crane Creek, were obtained in the SJRWMD tributary data set but the period of record did not cover the entire period of the other 12 stations. This data was not used because the tributary evaluation was intended to cover representative areas of the Lagoon as only water quality data on tributaries in other areas (Volusia County and Segment 4) had not been provided and because of the short period of record which would not be consistent with the other tributaries. For each evaluated tributary, the average monthly values for each parameter for the selected tributary sites are reported on a monthly basis for each segment in Section 5.2.

5.0 INDIAN RIVER LAGOON WATER QUALITY MONITORING NETWORK - 1989-1991

5.1 LAGOON WATER QUALITY

The Indian River Lagoon SWIM Network data (1989-1991) were used to analyze the spatial and temporal variation in water quality parameters for each segment of the Indian River Lagoon basin. Parameters for which adequate data were generally available include salinity, Secchi disk depth, total suspended solids (TSS), dissolved oxygen (DO), total nitrogen (TN) total Kjeldahl nitrogen (TKN), total phosphorous (TP), chlorophyll *a*, turbidity, and color.

5.1.1 Segment 1A - Mosquito Lagoon

Table 5-1 presents the segment-wide monthly averaged concentrations for selected water quality parameters for Mosquito Lagoon. This table gives an indication of average conditions within the Mosquito Lagoon segment (1A) during the 10/88 through 12/91 period of record. These values are compared to the 1982 to 1990 long-term average summarized by FDEP in the 1992 Water Quality Assessment (WQA) for the state of Florida. The two data sets show similar results.

<u>Spatial Patterns</u>

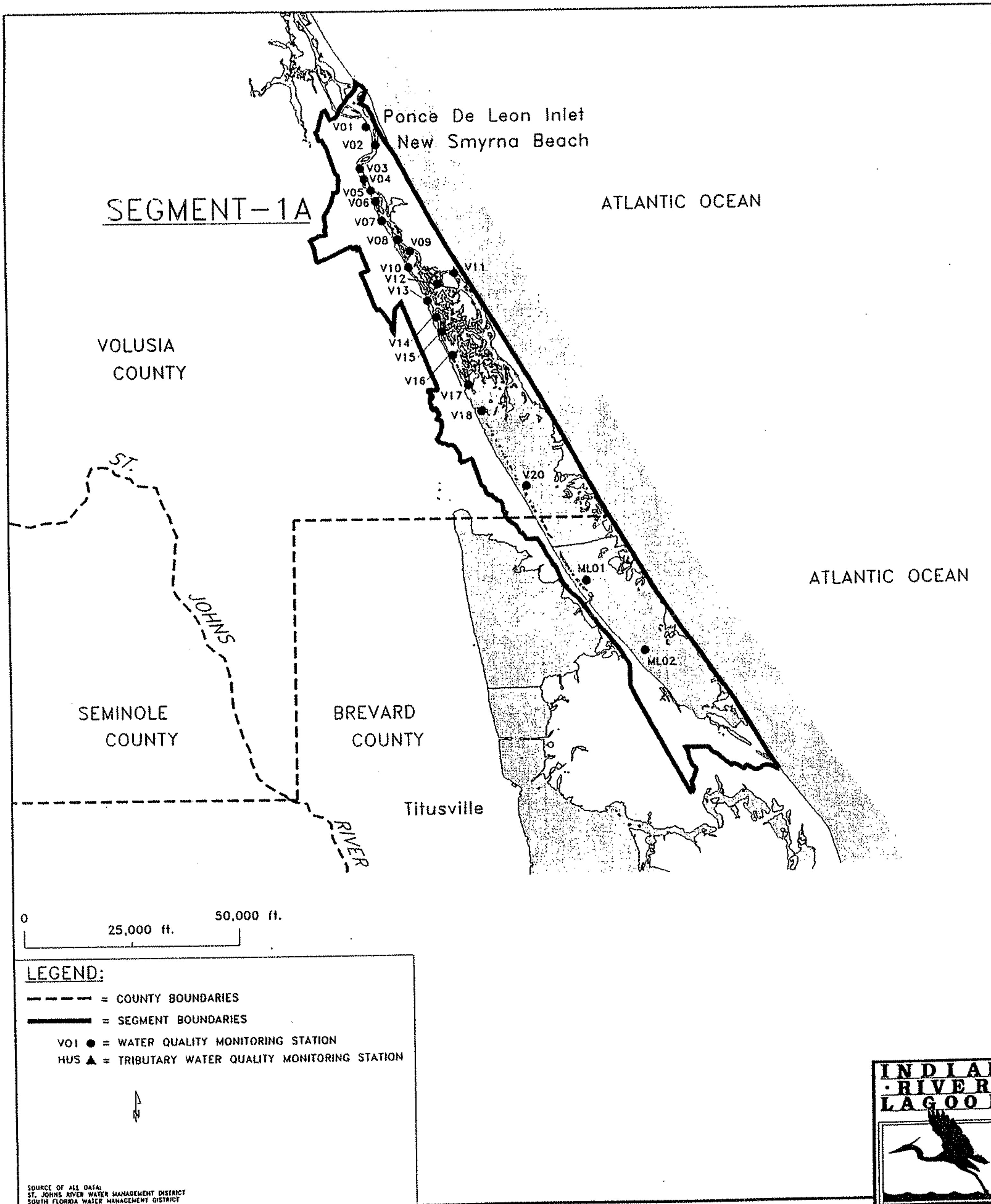
Figure 5-1 shows the location of the Volusia County and Brevard County monitoring stations within Mosquito Lagoon. For reference to major point sources in this segment, the City of New Smyrna Beach and City of Edgewater wastewater treatment plants are located near Station V-03 and between Stations V-06 and V-07, respectively. NASA also has monitoring stations in Mosquito Lagoon, but the locations and the data could not be confirmed and verified within the time frame of this study. Figure 5-2 indicates the spatial variation of wet and dry season averaged water quality parameters within Segment 1A.

TABLE 5-1

AVERAGE VALUES[1] FOR SELECTED CONSTITUENTS FOR WATER IN THE MOSQUITO LAGOON PORTION (SEGMENT 1A) OF THE INDIAN RIVER LAGOON SYSTEM

MONTH	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	TSS (mg/L)	TOTAL P (mg/L)	CHLOROPHYLL *a* (μg/L)	TKN (mg/L)
January	7.58	31.3	1.16	5.53	15.5	0.19[2]	4.1 (C)	0.62
February	7.64	32.1	1.35	4.09	8.5	0.09[2]	4.1 (C)	0.55
March	7.78	32.0	1.34	3.94	9.5	0.07[2]	2.6 (C)	0.63
April	6.28	31.4	1.02	6.50	17.7	0.04[2]	6.8 (C)	1.22
May	6.08	34.0	1.02	6.62	17.4	0.07[2]	5.6 (C)	1.16
June	6.36	34.5	0.86	8.16	33.1	0.07[2]	11.3 (C)	1.21
July	5.35	33.9	0.85	8.61	35.1	0.06[2]	9.7 (C)	1.42
August	5.76	33.1	0.85	8.72	28.5	0.08[2]	11.6 (C)	1.43
September	5.77	34.4	0.87	9.15	16.9	—[2]	10.5 (C)	1.36
October	5.61	31.2	0.84	8.95	16.7	0.05[2]	8.9 (C)	1.40
November	6.41	33.6	1.02	5.99	14.1	0.04[2]	4.3 (C)	0.87
December	7.67	34.2	1.44	3.69	7.4	0.02[2]	2.7 (C)	0.85
Average	6.52	33.0	1.05	6.66	18.4	0.07[2]	6.9 (C)	1.06
FDER WQA Average[3] (1992)	**6.60**	---	**0.80**	**9.2 (JTU)**	**19.0**	**0.09**	**8.0**	---

1 = Average monthly values for all stations within segment for the period from 10/88 to 12/91 unless otherwise noted. Frequency of sampling varies from monthly to quarterly.
2 = Incomplete data (based on less than 3 years of data)
3 = Source: FDER, 1992
U = Uncorrected
C = Corrected



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·Natural Systems Analysts

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DATE: 7-5-94

FIGURE 5-1 WATER QUALITY MONITORING STATIONS IN SEGMENT 1A -MOSQUITO LAGOON

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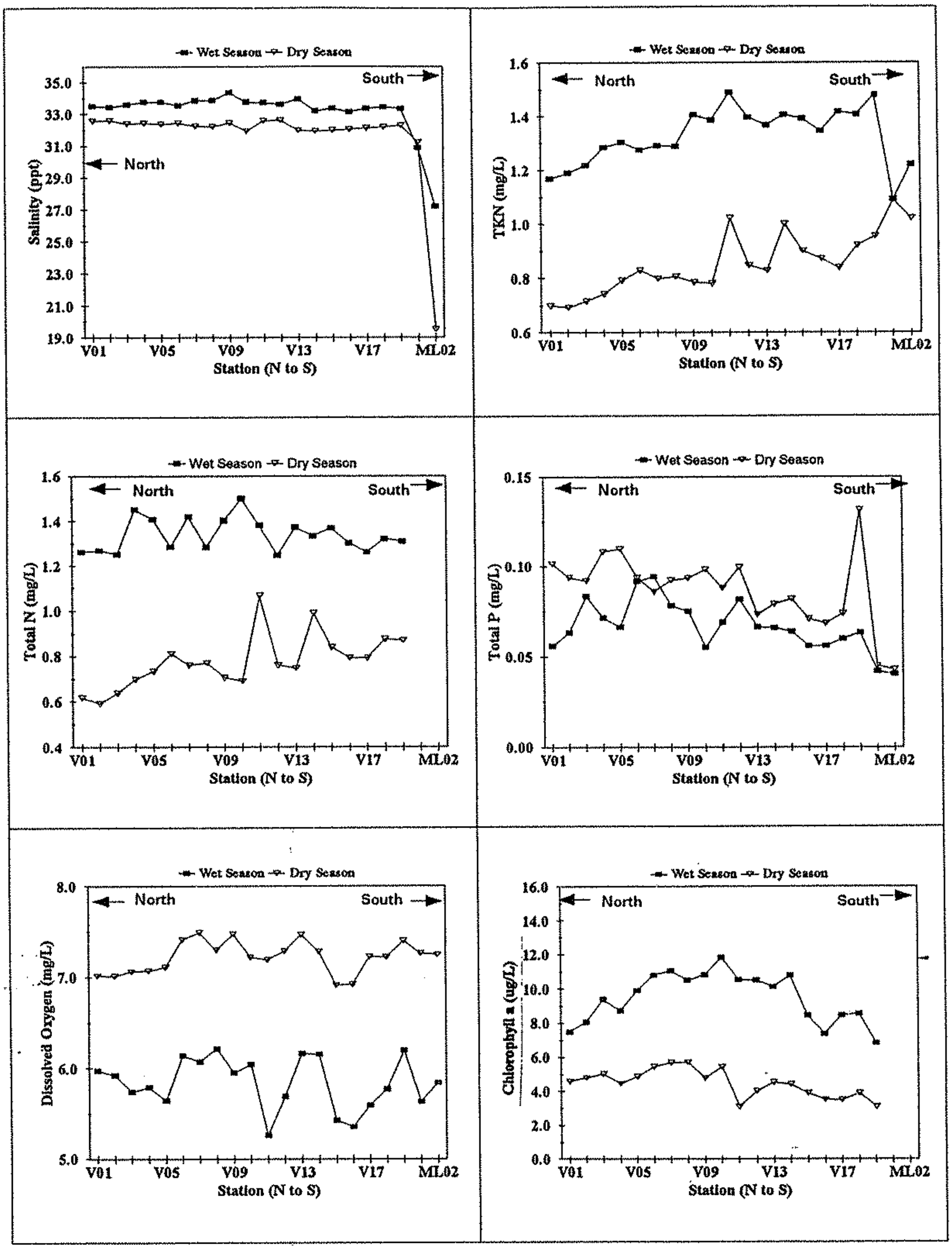
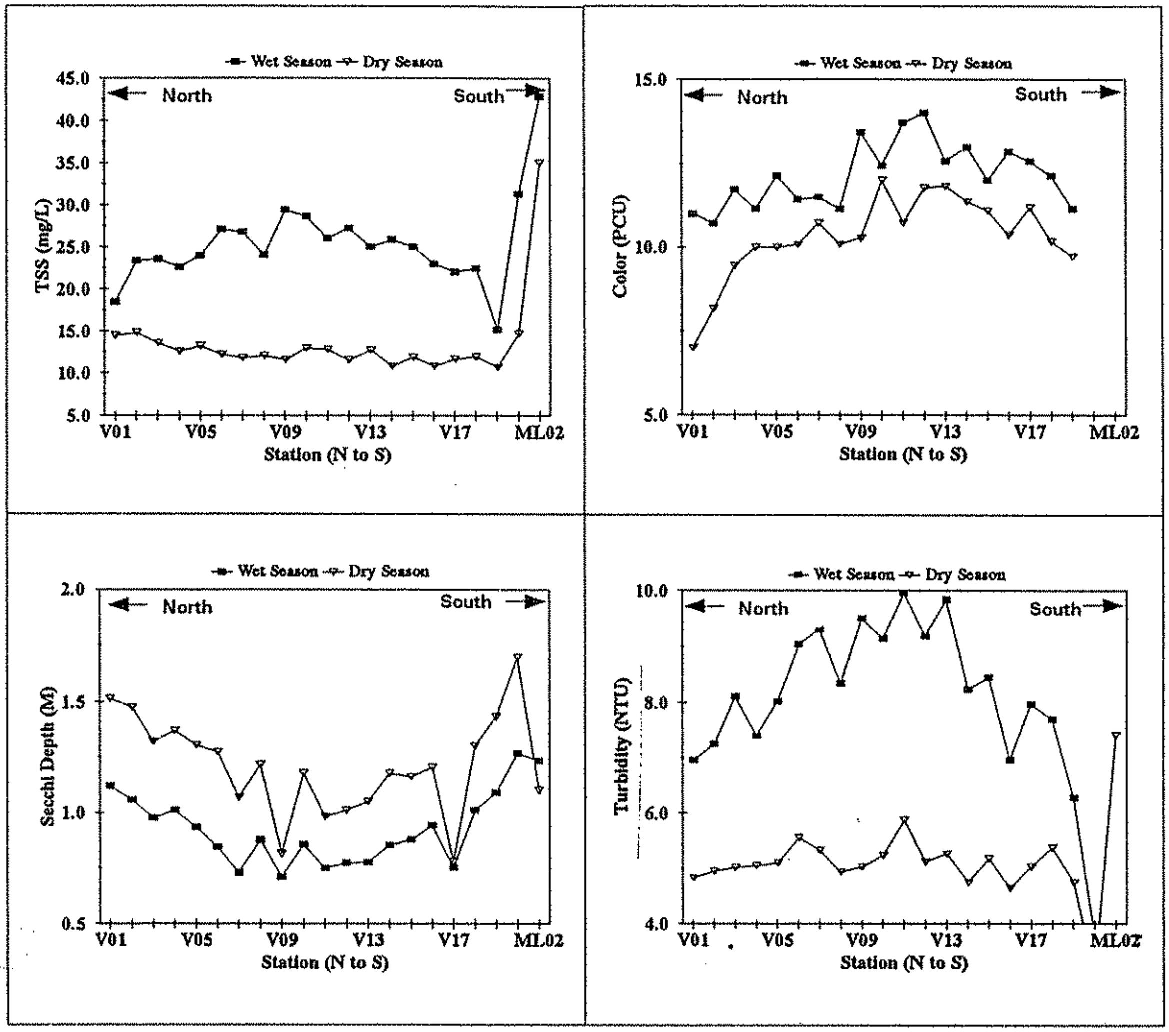


Data Source: SJRWMD, 1993

• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 5-2	SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 1A -MOSQUITO LAGOON

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



Data Source: SJRWMD, 1993

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FIGURE 5-2 (CON'T)

SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 1A -MOSQUITO LAGOON

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With the exception of anomalous data for Station ML02, salinities are spatially uniform in the portion of Mosquito Lagoon that was assessed. During the 1988-1991 period, salinity was relatively constant, averaging 33.5 ppt during the wet season and 32.5 ppt during the dry season. These salinities are nearly identical to ocean water and thus emphasize the small amount of freshwater discharge to the Mosquito Lagoon. Because tidal flushing in this segment is insignificant, evaporation and precipitation must be closely balanced to maintain such uniform salinities throughout the year. Notable interannual salinity variability also demonstrates this balance. Windsor and Steward's (1987) data for 1980 to 1986 also indicated this temporal variability.

Total Kjeldahl nitrogen was considerably higher in the wet season than during the dry season. TKN was comparatively higher at the south end of the Mosquito Lagoon for both periods. During the wet season, concentrations varied from 1.2 to 1.5 milligrams per liter (mg/L), and during the dry season concentrations varied from 0.7 to 1.0 mg/L. Total nitrogen follows a similar pattern, with wet season TN higher than dry season by a factor of approximately two. There is possibly a general pattern of higher values for TP during the dry season than during the wet season. Total phosphorous concentration appears to vary more throughout Mosquito Lagoon. Generally, phosphorous varies between 0.05 and 0.10 mg/L during the wet season and varies between 0.05 and 0.13 mg/L for the dry season.

As might be expected, DO appears to be higher during the dry, cool winter season. Dry (winter) season values are relatively constant from north to south. Wet (summer) season values are more variable throughout the Lagoon. Some of the lower values may be associated with stations in the Intracoastal Waterway (ICWW). Generally, DO concentrations range between 5.0 mg/L and 6.5 mg/L during the wet season and 7.0 to 7.5 mg/L during the dry season, although care should be taken when comparing DO concentration values taken under different conditions.

Chlorophyll *a* (corrected) is higher in the wet season than in the dry season and is slightly variable during both seasons throughout Mosquito Lagoon, with the highest levels generally occurring in the Edgewater area. Chlorophyll *a* (corrected) varies between 7.0 and 12.0 μg/L in the wet season and 3.0 and 5.5 μg/L during the dry season for this segment.

Color, turbidity, and TSS are all higher in the wet season and are usually greater along the urbanized areas of New Smyrna Beach and Edgewater (Stations V03 to V15). Secchi disk depth pattern is almost the opposite of these three parameters, with the lowest values occurring in the wet season and along channels of the Edgewater urban area.

Total suspended solids concentration is relatively constant during the dry season but more variable and higher during the wet season. During the dry season, the variation is minimal (11.0 to 15.0 mg/L). Wet season total suspended solids vary between 16.0 and 29.0 mg/L, except for anomalous values at ML01 and ML02.

Color, a parameter for which there is not much data in most other segments, is well represented by data in this segment. Color values in this segment are higher in the wet season. Dry season color is much lower at the extreme north end of Mosquito Lagoon, probably due to the effect of Ponce de Leon Inlet. Color varies between 10.0 and 13.0 platinum color units (PCU) during the wet season and 7.0 and 12.0 PCU during the dry season.

Turbidity also is higher during the wet season, varying between 6.5 and 9.5 nephelometric turbidity units (NTU). During the dry season it is relatively constant throughout Mosquito Lagoon at about 5.0 NTU.

Secchi disk depth varies, but is higher in the dry season than in the wet season at all stations. Secchi disk depth is also lower in the more urbanized portion of the segment away from the less developed north and south ends. During the wet season, Secchi disk depth varies between 0.4 and 1.3 meters (m). During the dry season, it varies from 0.5 to 1.5 m.

Seasonal and Annual Patterns

With respect to temporal variations, Figure 5-3 presents the same parameters over time for the period January 1989 through December 1991. Each data point for each parameter is an average of all stations for the monthly sampling event that is reported.

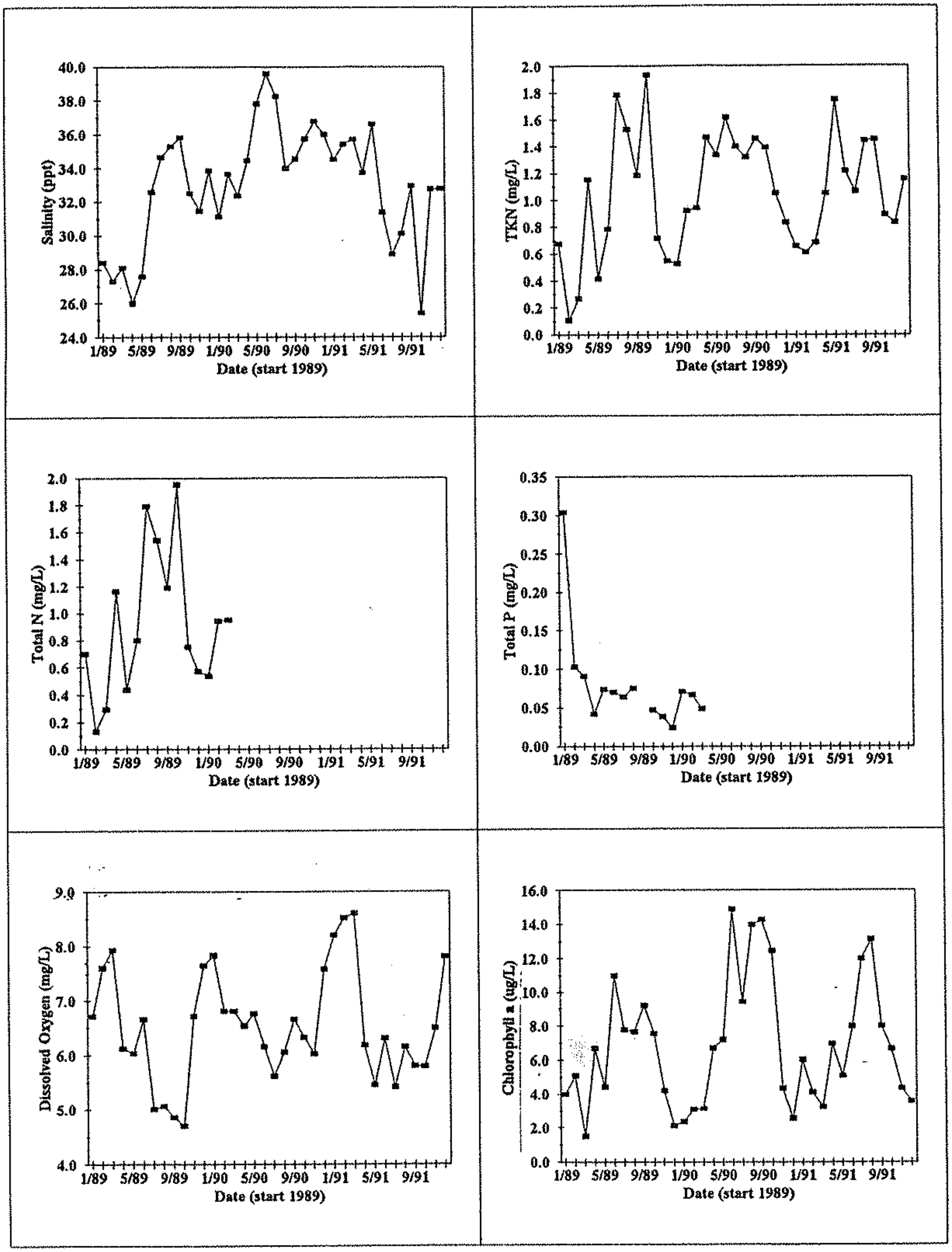

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FIGURE 5-3 TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 1A - MOSQUITO LAGOON

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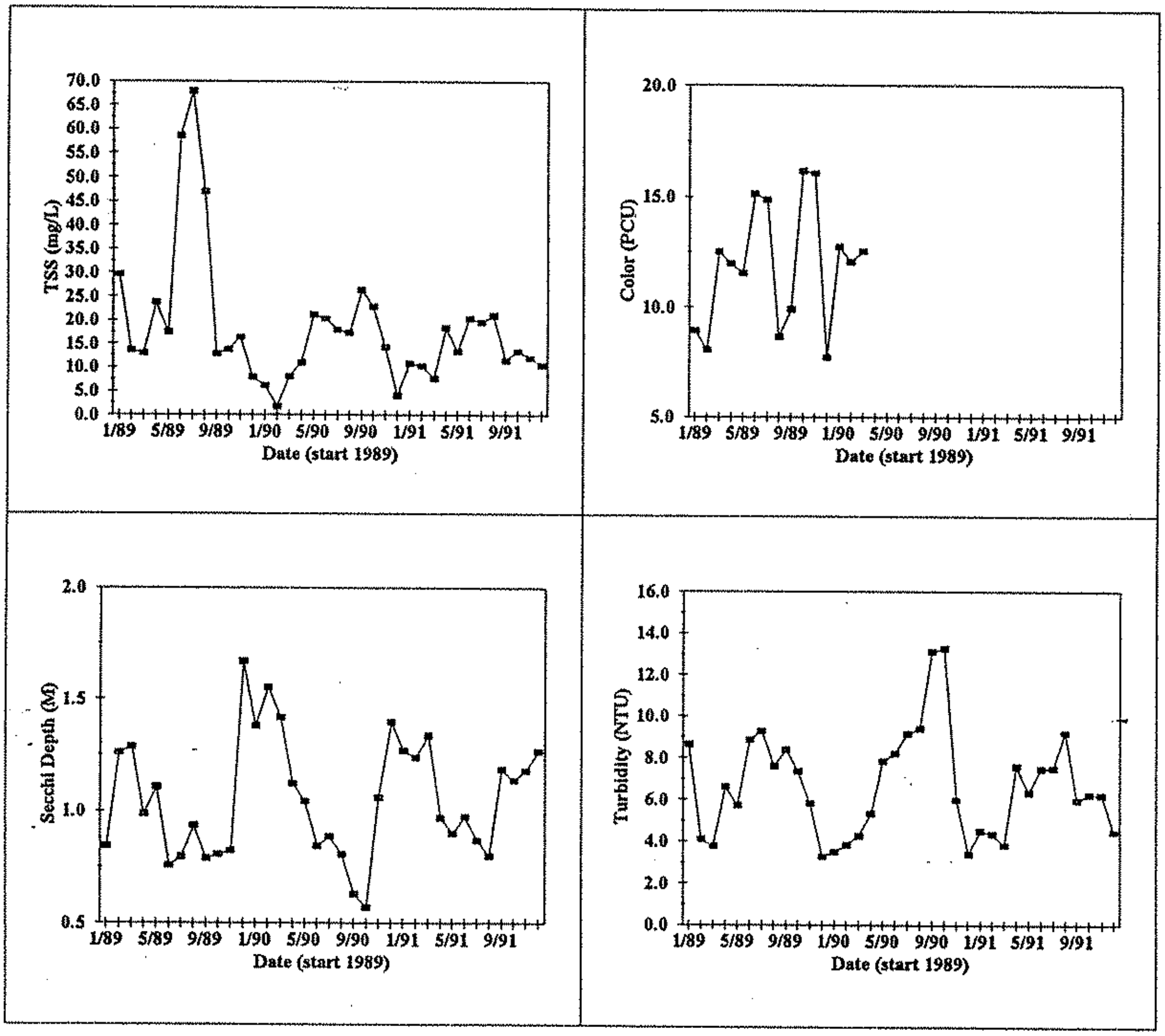

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FIGURE 5-3 (CONT) TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 1A - MOSQUITO LAGOON

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

Total nitrogen, TP, and color data were reported only for the period 1/89 to 4/90, and data for only this period is shown for these parameters in the graphs on Figure 5-3.

An analysis of the wet season/dry season information indicates that Mosquito Lagoon behaves as a relatively healthy estuarine body, with definite seasonal patterns for most parameters. Salinity varies only slightly from wet season to dry season with no sharp drops, even though several of the sampling stations are located near wastewater treatment plant or small drainage ditch outfalls. There does appear to be a longer-term salinity variation between years, which may be related to drought cycles, as suggested by Windsor and Steward (1987). As might be expected, TSS, TKN, TN, chlorophyll *a*, turbidity, and color all were higher during the wet season. On the other hand, Secchi disk depths were lower in the wet season as were DO and TP. Dissolved oxygen probably remains lower during the wet season due to higher temperatures and bacterial decomposition.

5.1.2 Segment 1B - Banana River

Table 5-2 presents the segment-wide monthly and annual averaged concentrations for selected water quality parameters for the Banana River, compared to the FDER 1982 to 1990 long-term WQA data. The annual averages for the 1/87 to 12/92 period are similar to those of the long-term FDER average except for TSS, which is much higher, and TP, which may be lower in the 1/87 to 12/92 SWIM data set.

Figure 5-4 shows sampling station locations in the Banana River. Figure 5-5 shows the spatial variation of water quality parameters within the Banana River.

Spatial Patterns

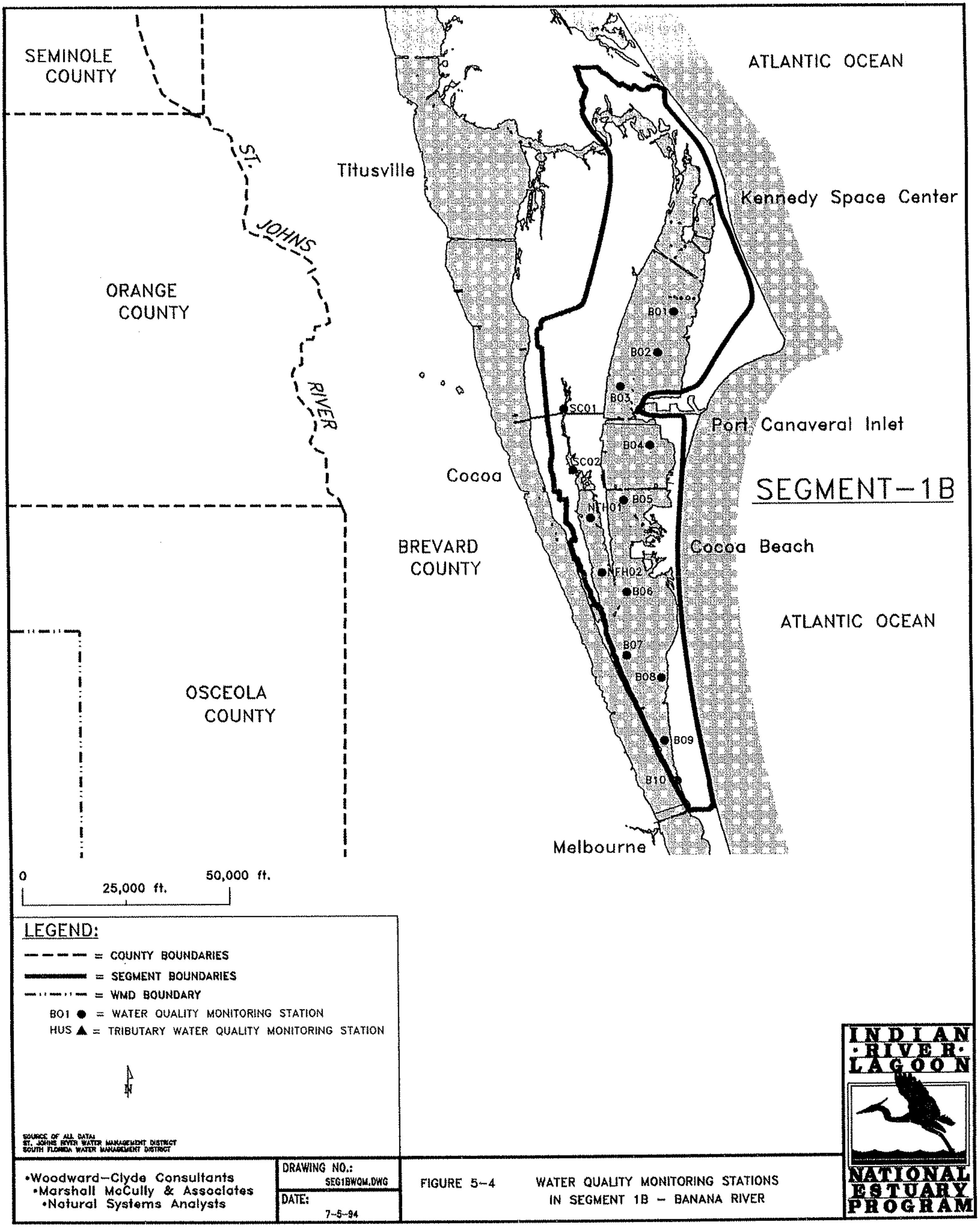
Salinity is slightly higher in the wet season than in the dry season, with a clear pattern of increasing salinity towards the north. This probably reflects the progressive domination of evaporation over precipitation in the north. Circulation is restricted by shallow depths and the absence of astronomical tide, possibly resulting in such limited mixing that the effect of evaporation (that in other estuaries is usually very subtle) is dominant in the Banana River.

TABLE 5-2

AVERAGE VALUES[1] FOR SELECTED CONSTITUENTS FOR WATER IN THE BANANA RIVER PORTION (SEGMENT 1B) OF THE INDIAN RIVER LAGOON SYSTEM

MONTH	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	TSS (mg/L)	TOTAL P (mg/L)	CHLOROPHYLL *a* (μg/L)	TKN (mg/L)
January	6.98	25.1	1.35	3.17	8.83	0.05	11.32 (U)	1.26
February	7.71	25.3	1.44	—	—	—	—	—
March	7.61	24.9	1.31	3.86	39.35	0.03	5.40 (U)	1.30
April	6.55	25.1	1.11	5.96	17.79	0.06	10.61 (U)	1.61
May	6.01	26.3	1.33	—	—	—	—	—
June	5.76	27.0	1.45	—	—	—	—	—
July	5.00	25.2	1.24	3.52	22.58	0.07	11.28 (U)	1.43
August	5.29	24.1	1.15	—	—	—	—	—
September	5.40	25.1	1.07	—	—	—	—	—
October	5.91	23.5	1.23	4.03	24.81	0.05	15.26 (U)	1.50
November	7.94	23.7	1.28	—	—	—	—	—
December	7.57	23.9	1.38	—	—	—	—	—
Average	6.48	24.9	1.28	4.11	22.67	0.05	10.77 (U)	1.42
FDER WQA Average[3] (1992)	**6.4**	---	**1.20**	**5.3 (JTU)**	**6.4**	**0.10**	**10.70**	---

1 = Average monthly values for all stations within segment for the period from 1/87 to 12/92 unless otherwise noted. Frequency of sampling varies from monthly to quarterly.
2 = Incomplete data (based on less than 3 years of data)
3 = Source: FDER, 1992
U = Uncorrected
C = Corrected


SEMINOLE COUNTY
ORANGE COUNTY
OSCEOLA COUNTY
BREVARD COUNTY
ST. JOHNS RIVER
ATLANTIC OCEAN
Titusville
Kennedy Space Center
Port Canaveral Inlet
Cocoa
Cocoa Beach
Melbourne
SEGMENT-1B
B01
B02
B03
B04
B05
B06
B07
B08
B09
B10
SC01
SC02
NTH01
NFH02
0
25,000 ft.
50,000 ft.
LEGEND:
= COUNTY BOUNDARIES
= SEGMENT BOUNDARIES
= WMD BOUNDARY
B01 ● = WATER QUALITY MONITORING STATION
HUS ▲ = TRIBUTARY WATER QUALITY MONITORING STATION
N
SOURCE OF ALL DATA:
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
•Woodward-Clyde Consultants
•Marshall McCully & Associates
•Natural Systems Analysts
DRAWING NO.: SEG1BWQM.DWG
DATE: 7-5-94
FIGURE 5-4 WATER QUALITY MONITORING STATIONS IN SEGMENT 1B - BANANA RIVER
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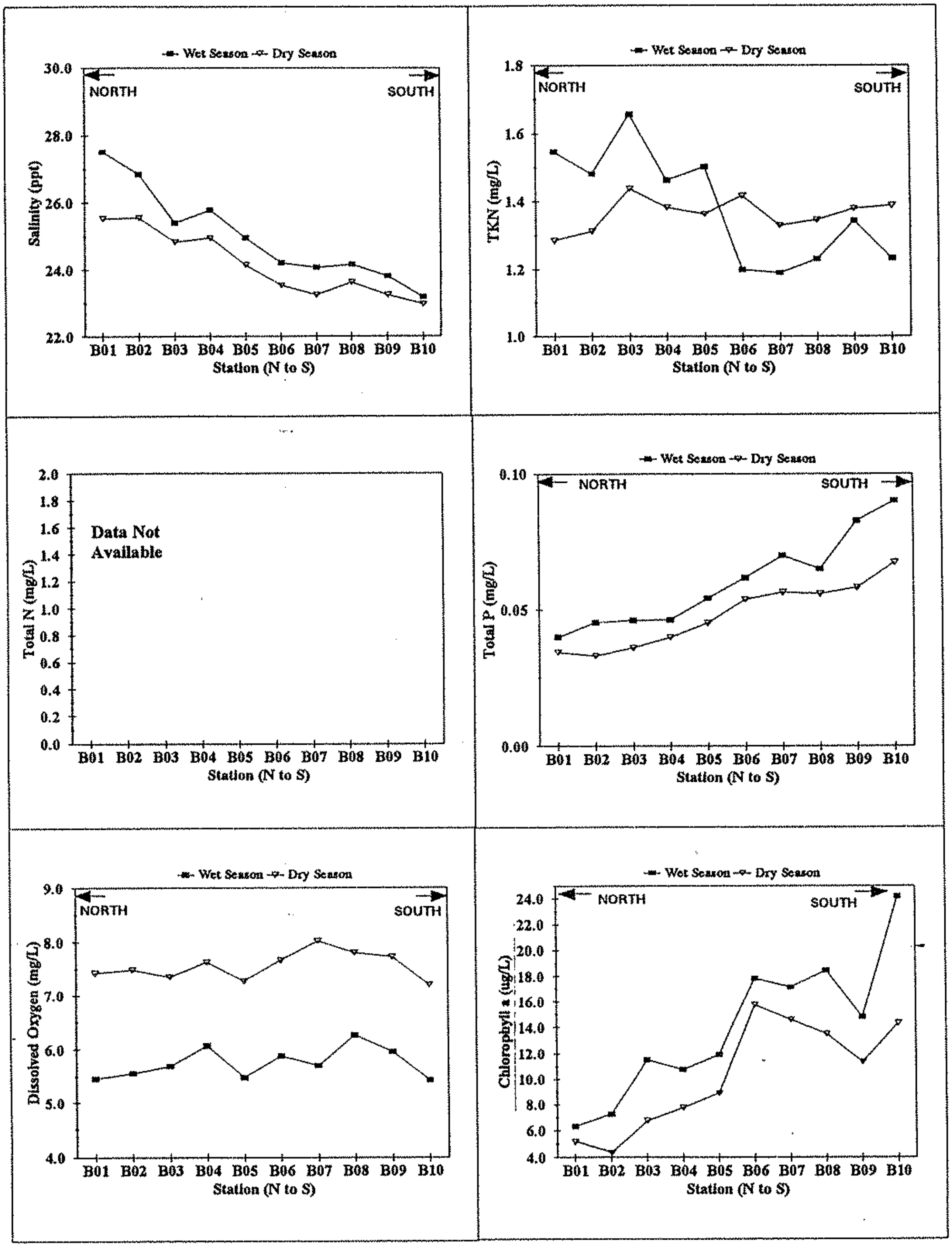

Data Source: SJRWMD, 1993

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FIGURE 5-5 SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 1B - BANANA RIVER

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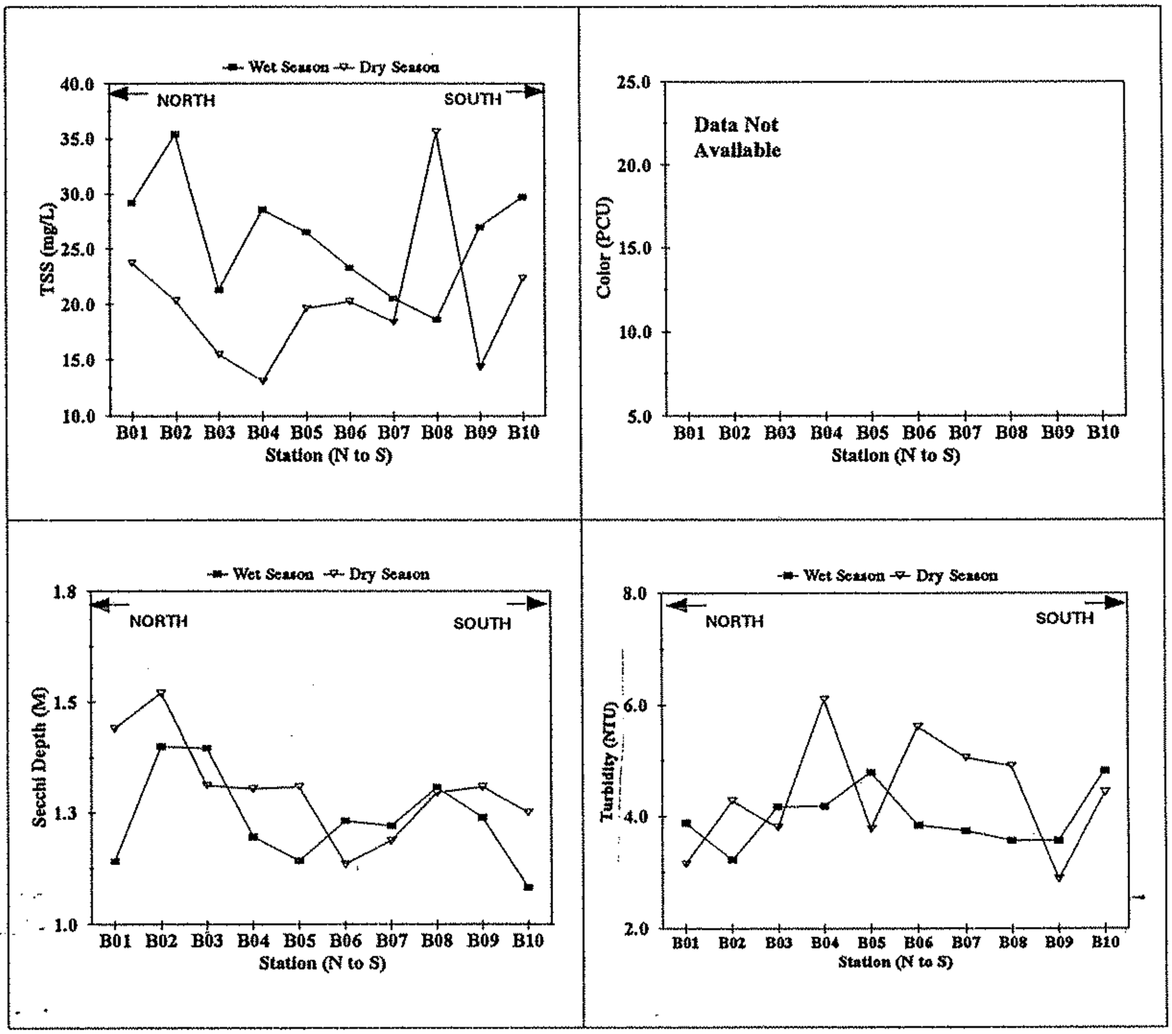

Data Source: SJRWMD, 1993

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FIGURE 5-5 (CON'T)

SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 1B - BANANA RIVER

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

For TKN, wet season values are high compared to dry season values for stations north of Cocoa Beach (B01 through B05) and wet season values are lower than dry season values for the south Banana River Stations (B06 through B10), which are south of Cocoa Beach and the entrance point to Newfound Harbor. Dry season TKN for all stations is relatively constant at about 1.4 mg/L. For stations B01 through B05, wet season TKN varies between 1.5 and 1.7 mg/L, and for Stations B06 through B10, wet season TKN varies between 1.2 and 1.4 mg/L.

Wet season TP concentrations appear to be slightly higher than dry season values for all stations. There is a pattern toward higher TP values in the south. Total phosphorous concentrations vary from 0.04 to 0.10 mg/L.

Dissolved oxygen values are lower in the warm wet season than in the dry season. Difference between the two periods is approximately 2 mg/L. Dry season averages about 7.5 mg/L and wet season averages about 5.5 mg/L. There is no readily discernable DO trend from the north end to the south end of the Banana River.

The chlorophyll *a* values for the Banana River are uncorrected values. Chlorophyll *a* wet (warm) season concentration averages are higher than dry (cool) season for all stations, with a strong tendency towards higher values for both wet and dry seasons from north to south along Banana River. At Station B06, south of Cocoa Beach, a distinct increase in concentration is seen.

No data are available for color, and the TSS and turbidity data are variable with little apparent pattern. Wet season TSS values are slightly higher than dry season values at all stations except one, but the differences are small and probably not significant. There is no discernable north-south TSS gradient in the Banana River. There also is no discernable trend in maximum turbidity values, since five stations (B01, B03, B05, B09, B10) show higher values in the wet season and five different stations (B02, B04, B06, B07, B08) show higher values during the dry season.

The Secchi disk depth is similar in both seasons, indicating that stormwater inflow of TSS may have little effect on the water clarity in this segment. Values range from approximately 1.2 to 1.5 m. Except for one station (B01) near the NASA launch complexes, the Secchi disk depths are highest north of NASA Causeway (SR 405), and lowest south of Cocoa Beach (Station B06) and at the extreme south end of the Lagoon (Station B10). The relationship of the Secchi disk pattern to those of chlorophyll *a* and nutrients indicates that phytoplankton populations controlled by nutrient levels may be a primary determinant of water clarity and light penetration in this segment.

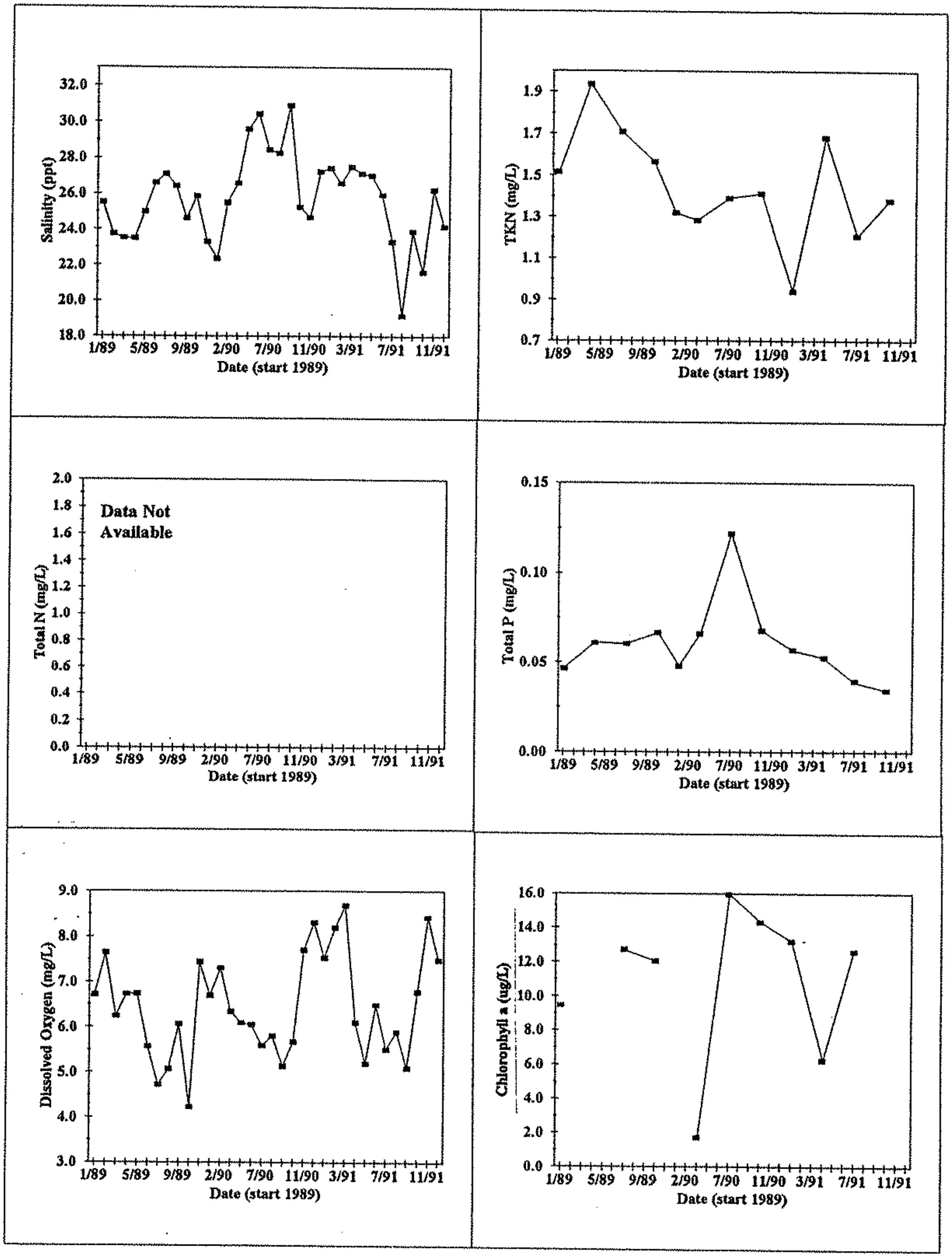
Seasonal and Annual Patterns

Variation over time of the segment-wide monthly average values is shown on Figure 5-6. Salinity shows typically lower values during the winter (dry) season. Dissolved oxygen shows the characteristic higher values during the winter (dry) season. The DO concentration range for this segment is from approximately 4 mg/L to 9 mg/L. Generally mean values less than 5 mg/L occur each year at the end of the summer. Total phosphorous remains relatively constant over time, while chlorophyll *a* is characteristically higher in the summer (wet season) and lower in the dry season. No patterns are readily discerned for TKN, turbidity, and TSS.

Not all parameters were sampled on a monthly basis in this segment. Total Kjeldahl nitrogen, TP, chlorophyll *a*, TSS, and turbidity are shown as quarterly data. In cases where data are missing from the normal sampling sequence for a parameter, as in the chlorophyll *a* data, the data points are not joined by a line on the graph. This convention is used for all segments.

5.1.3 Segment 1C - North Indian River Lagoon

Table 5-3 presents the segment-wide monthly averaged concentrations for selected water quality parameters for the North Indian River Lagoon. As in previous segments, these values are compared to the FDER 1982-1990 WQA long-term average data. The TP annual average for the period 1/88 through 12/91 appears to be lower than the FDER long-term average and the Secchi disk depth may be greater, but all other values appear to be similar to the long-term average.



• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.:	FIGURE 5-6 TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 1B - BANANA RIVER
	DATE:	

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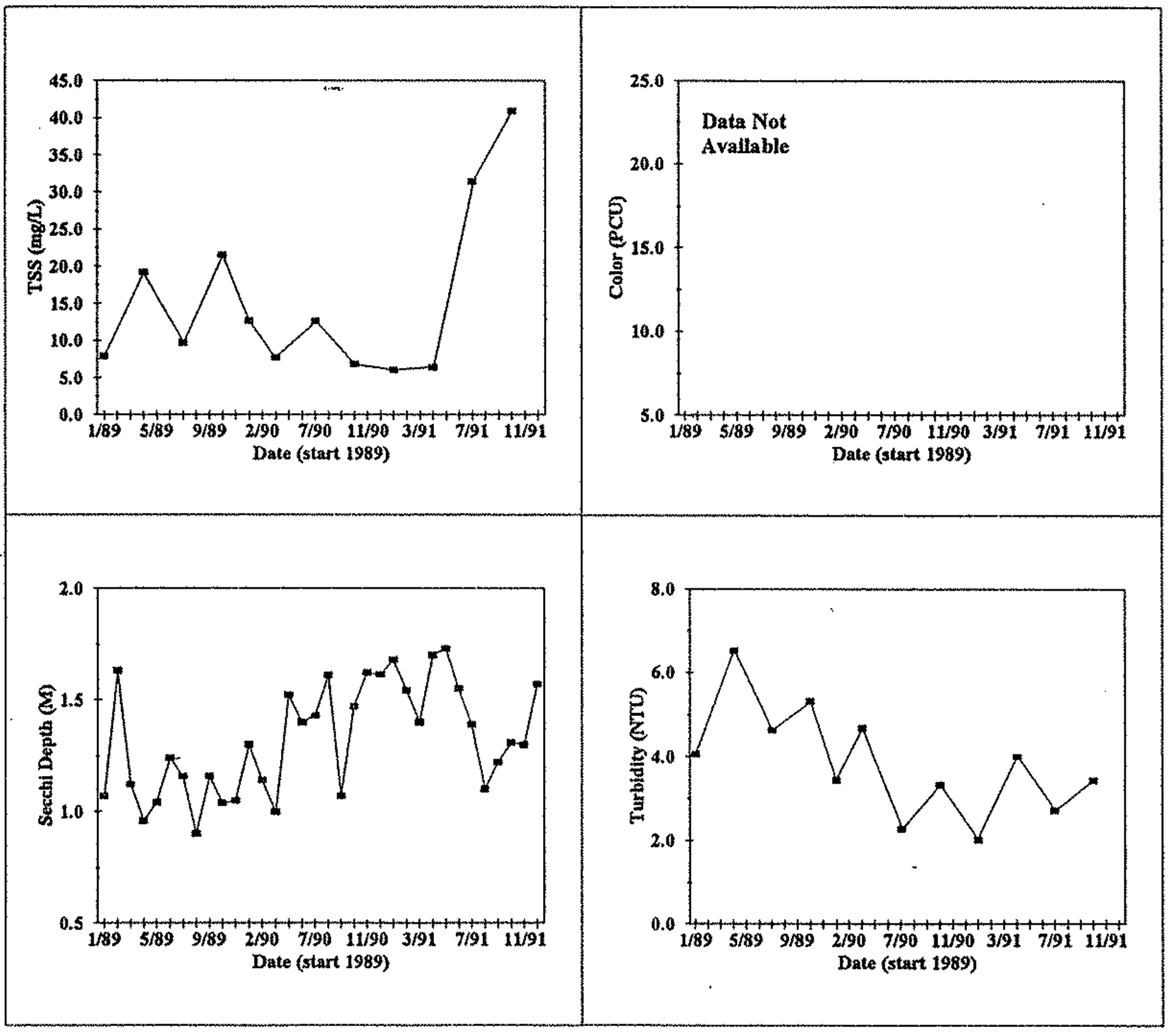

• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 5-6 (CONT) TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 1B - BANANA RIVER

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TABLE 5-3

AVERAGE VALUES[1] FOR SELECTED CONSTITUENTS FOR WATER IN THE NORTH INDIAN RIVER LAGOON PORTION (SEGMENT 1C) OF THE INDIAN RIVER LAGOON SYSTEM

MONTH	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	TSS (mg/L)	TOTAL P (mg/L)	CHLOROPHYLL *a* (µg/L)	TKN (mg/L)
January	7.77	27.9	1.66	2.42	7.23	0.04	9.6 (U)	1.13
February	7.44	27.9	1.46	—	—	—	—	—
March	7.25	28.3	1.71	—	—	—	—	—
April	7.05	28.4	1.61	4.36	9.91	0.04	10.3 (U)	1.49
May	6.62	28.1	1.71	—	—	—	—	—
June	6.19	29.2	1.81	—	—	—	—	—
July	5.92	27.8	1.84	6.31	14.35	0.05	8.4 (U)	1.33
August	5.72	21.3	1.47	—	—	—	—	—
September	5.54	26.3	1.64	—	—	—	—	—
October	7.21	24.3	1.37	3.58	20.00	0.05	16.9 (U)	1.28
November	7.44	25.8	1.73	—	—	—	—	—
December	8.36	26.9	1.78	—	—	—	—	—
Average	6.88	26.9	1.65	4.17	12.87	0.05	11.3 (U)	1.31
FDER WQA Average[3] (1992)	**6.70**	—	**1.20**	**4.7 (JTU)**	—	**0.09**	**9.0**	—

1 = Average monthly values for all stations within segment for the period from 1/88 to 12/91 unless otherwise noted.. Frequency of sampling varies from monthly to quarterly.
2 = Incomplete data (based on less than 3 years of data)
3 = Source: FDER, 1992
U = Uncorrected
C = Corrected

Figure 5-7 shows sampling station locations for the North Indian River Lagoon. Additionally, Figure 5-8 presents the spatial variations of water quality parameters for wet and dry seasons.

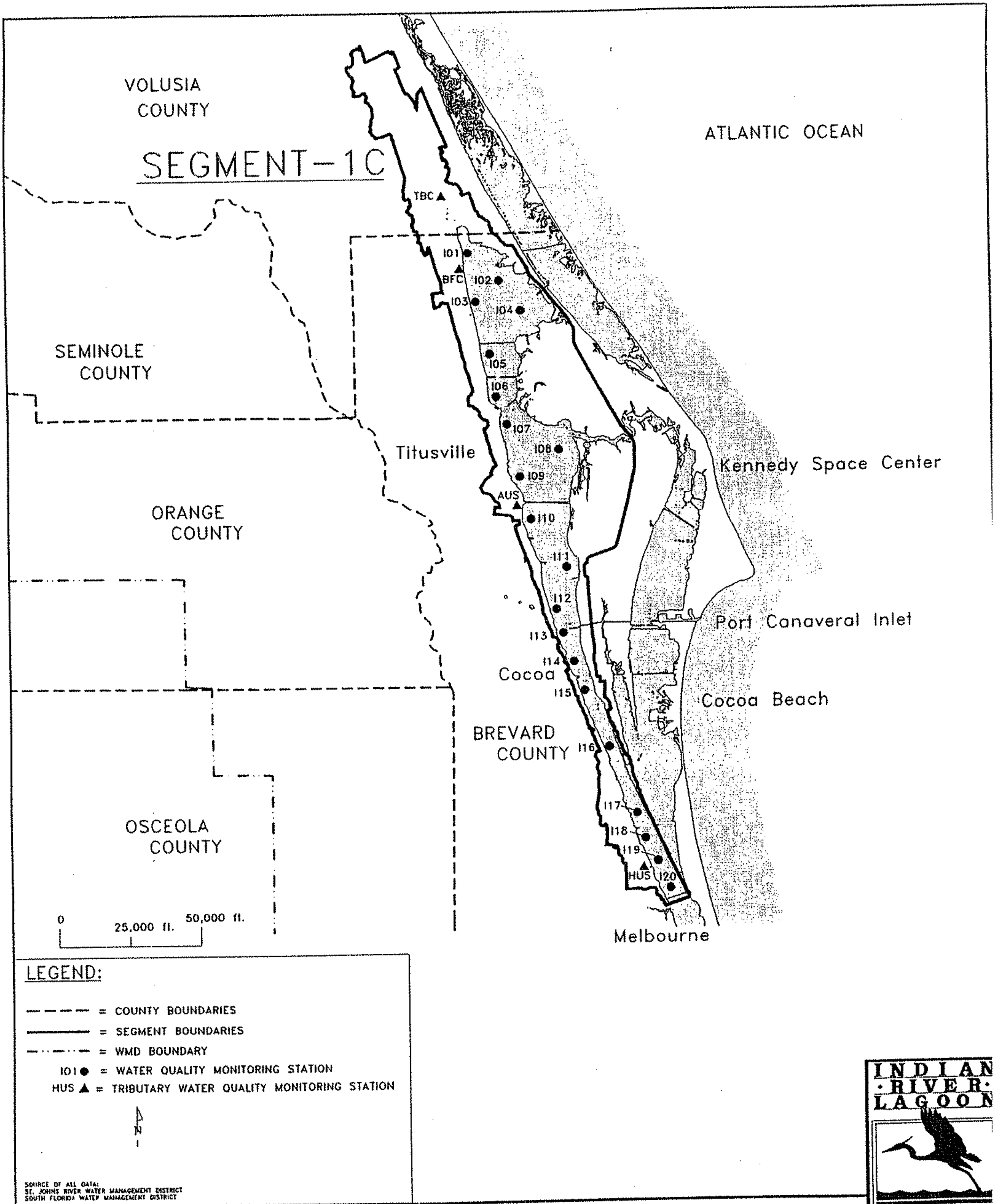
Spatial Patterns

The data for this segment indicate only slight salinity differences between wet season and dry season values, with dry season values higher except in the extreme southern part of this segment. From a location viewpoint, salinities decrease greatly from north to south throughout this segment. Salinity values during the dry season in the north are in the 30-31.5 ppt range, and in the south during the dry season they are about 24 ppt. For the wet season salinity values are about 29 ppt and decrease to about 24.5 ppt in the south. The higher salinity in the northern part of the segment may be caused by a high ratio of evaporation over rainfall in this segment as explained in the Physical Features Technical Report.

The highest TKN values were measured at Stations I12 through I15 during the wet season. These stations are adjacent to Cocoa and Rockledge. Wet season concentrations ranged between 1.0 and 1.7 mg/L. The highest dry season values occur in the Melbourne area at Stations I16 through I20. Dry season TKN values range from 1.1 to 1.6 mg/L. Total nitrogen data is too limited to show any patterns, although the highest wet season values may occur near Cocoa (Stations I12 to I14).

Virtually no difference between wet season and dry season values is apparent for TP, although a geographic distribution pattern is evident. Total phosphorous is approximately twice as high in the south half of the segment, rising from approximately 0.035 mg/L north of Cocoa to about 0.05-0.06 mg/L between Cocoa and Melbourne.

Dissolved oxygen shows the typical trend for the wet season with lower values compared to dry season. The dry season values are relatively constant north to south, with concentrations between 7.0 and 8.0 mg/L. Wet season concentrations range between 5.7 and 6.7 mg/L and tend to show greater variation among stations than dry season averages.



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DATE: 7-5-94

FIGURE 5-7 WATER QUALITY MONITORING STATIONS IN SEGMENT 1C - NORTH INDIAN RIVER LAGOON

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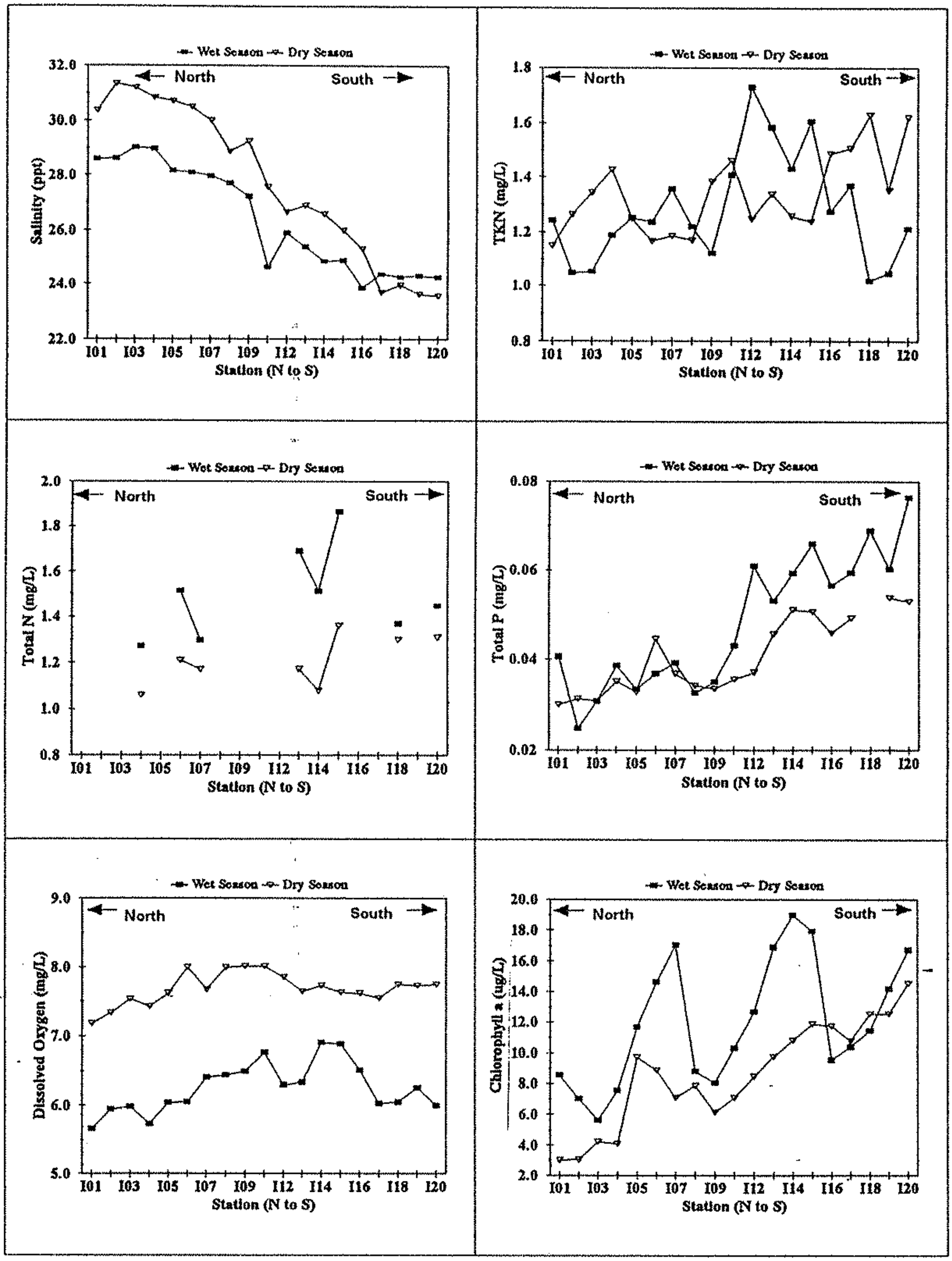

Data Source: SJRWMD, 1993

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FIGURE 5-8 SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 1C - NORTH INDIAN RIVER LAGOON

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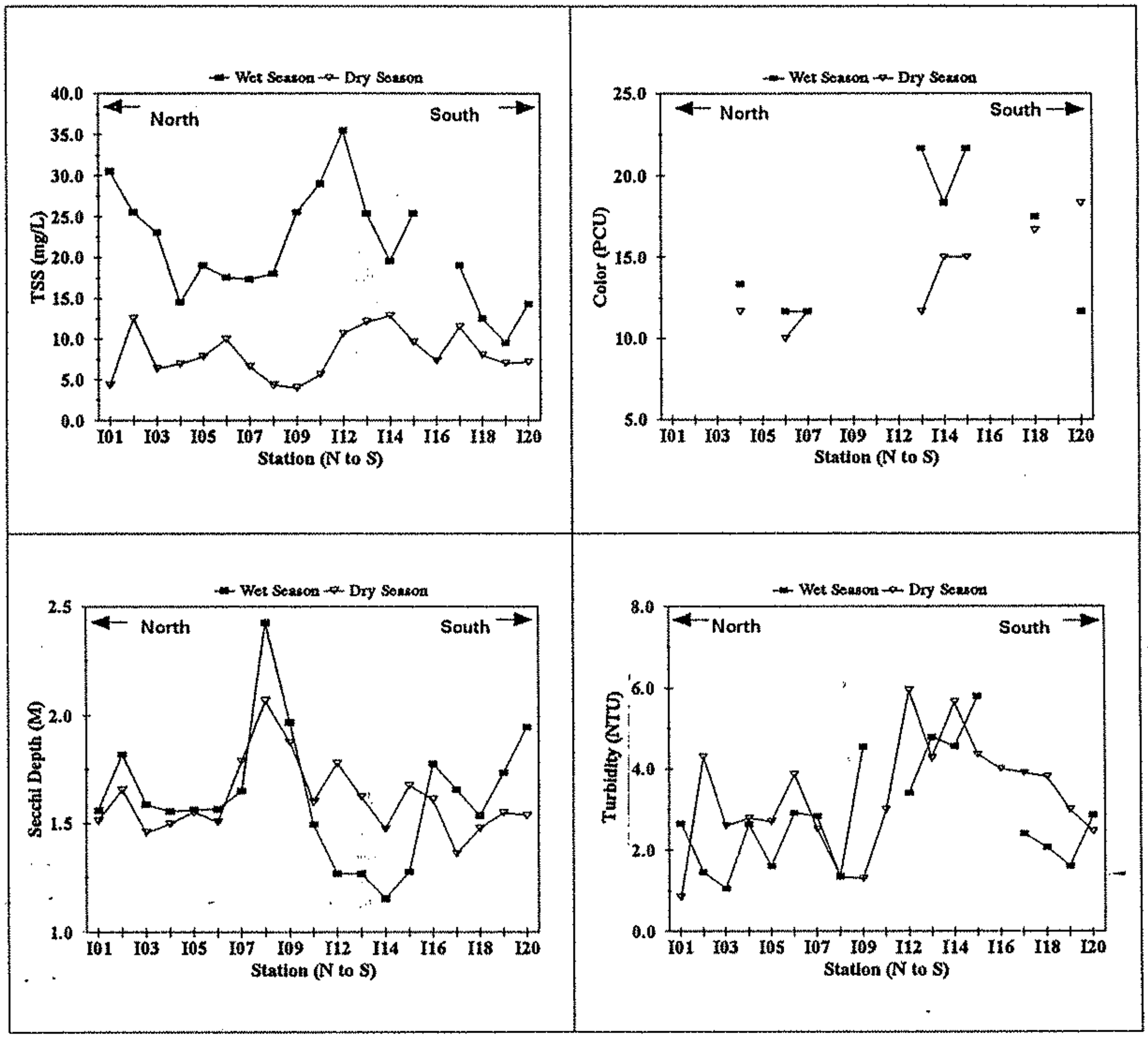

Data Source: SJRWMD, 1993

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 5-8 (CON'T)	SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 1C - NORTH INDIAN RIVER LAGOON

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The chlorophyll *a* data (uncorrected) for this segment indicates higher wet season averages than in the dry season. Notable are the high peaks, particularly in the wet season, around Titusville (Stations I05 to I07) and at the stations (I12 to I15) near the outfalls of the Cocoa and Rockledge municipal wastewater treatment plants. There also seems to be a trend toward higher values toward the south end of the segment, but a statistical analysis has not been done to confirm this trend.

Total suspended solids appear to be higher in the wet season, reflecting a rainfall influence, but turbidity does not seem to follow any discernable seasonal patterns or relationship to other parameters. Both TSS and turbidity peak in the area of the Lagoon between Cocoa and Melbourne. Secchi disk depth generally is similar throughout the segment, with the exception of Station I08 where it is reported as higher than at all other stations in the Lagoon. The greater reported water clarity at Station I08 may be due to the fact that, unlike most other stations, Station I08 is in relatively shallow water near the undeveloped east side of the Lagoon and may be less subject to the influence of the urbanized coastline on the west shore. However, the data may also be inaccurate because the reported 2.4 m dry season average Secchi disk depth may be greater than water depth in the reported station site.

Seasonal and Annual Patterns

The temporal variation in water quality parameters is presented by Figure 5-9. Salinity concentration stayed relatively constant until August, 1991 at which time it dropped from between 25 and 30 ppt to about 20 to 22 ppt. The data also showed an abrupt drop to less than 18 ppt in August, 1990 with a return to higher levels in September. This one-month drop may have been a response to short term events, but the status of the data set has not been sufficiently evaluated to determine whether it represents a segment-wide occurrence or an aberration of a few stations.

Total Kjeldahl nitrogen and TP show some variability over time, but no specific seasonal pattern or long-term trend is apparent without more detailed analysis. Dissolved oxygen shows the standard pattern of decreasing summer levels. However, the period with the highest chlorophyll *a* occurred in January, 1990 rather than in summer. Data for the other parameters generally shows no consistent patterns over this time period, although abnormally

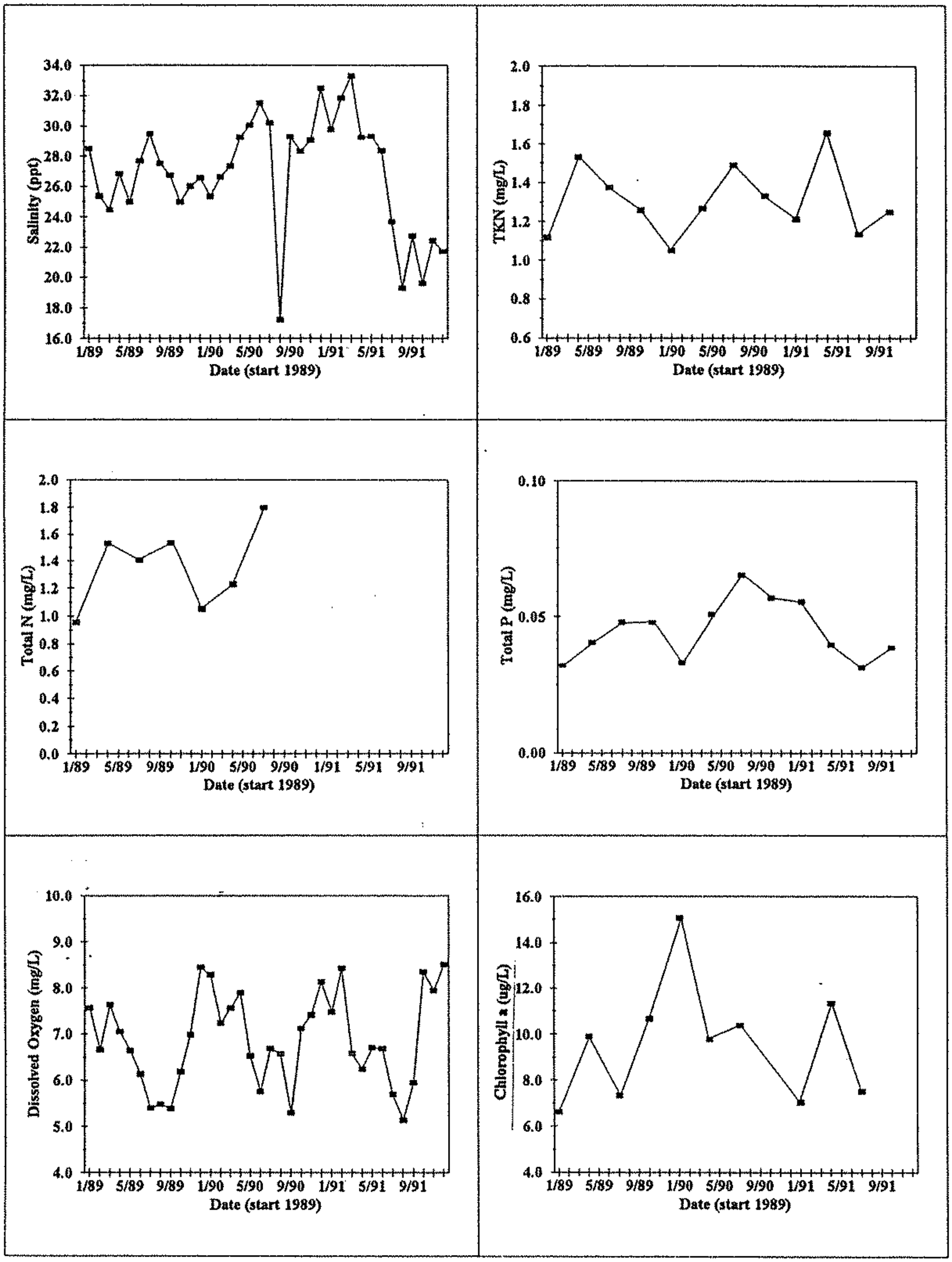

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FIGURE 5-9 TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 1C - NORTH INDIAN RIVER LAGOON

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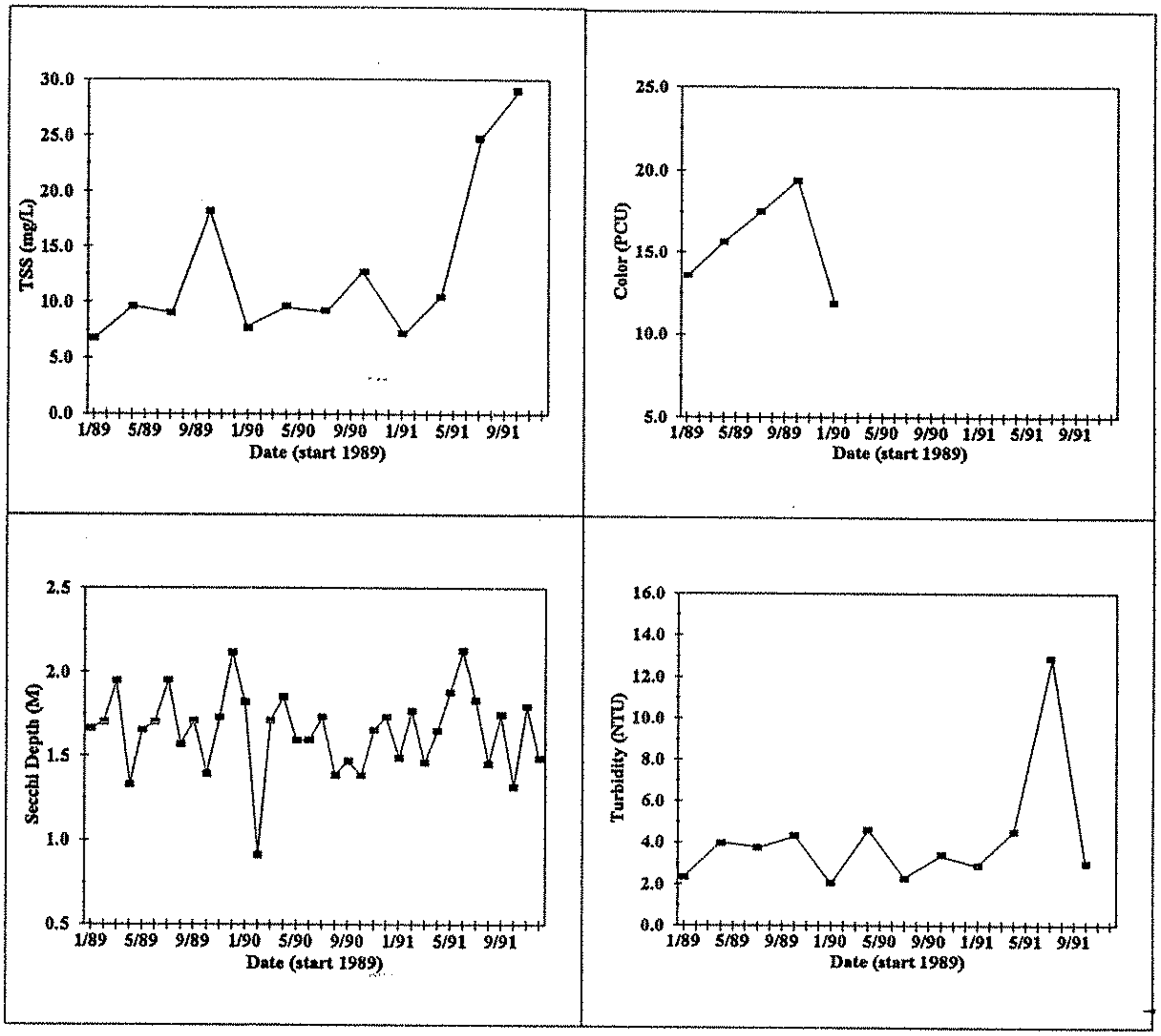

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 5-9 (CONT) TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 1C - NORTH INDIAN RIVER LAGOON

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high turbidity and TSS concentrations occurred during July 1991, a period which closely follows the drop in salinity in mid-1991. Secchi disk depth shows no trend over time. Values are generally between 1.5 and 2.0 m.

5.1.4 Segment 2 - North Central Indian River Lagoon

Table 5-4 presents monthly average and overall average values for water quality parameters compared with the long-term FDER WQA data. Variations occur between the data sets dependent on the parameters. Of the data that are expressed in identical units that can be directly compared, all parameters except TP appear to have similar averages. The 1989-91 average for TP is approximately half the long-term average, indicating a possible decrease in TP levels in the more recent period.

Figure 5-10 shows sampling locations for the North Central Indian River Lagoon, and Figure 5-11 presents the spatial variation of water quality parameters corresponding to stations in this segment.

Spatial Patterns

Maximum salinity values are generally lower in this segment compared to the northern segments. The low values seen in the south end of Segment 1C continue southward in this segment to a point between Stations I24 and I25, opposite the mouth of Turkey Creek, where salinity begins to rise to a maximum of about 28.5 ppt just north of Sebastian Inlet. In addition to Turkey Creek, there are two large freshwater discharges (Eau Gallie River and Crane Creek) in the north half of this segment, and several smaller ones (Trout Creek, Goat Creek, Kid Creek) in the south half. The Eau Gallie River discharges at the north end of the segment near Station I21, and Crane Creek discharges between Stations I-22 and I-23.

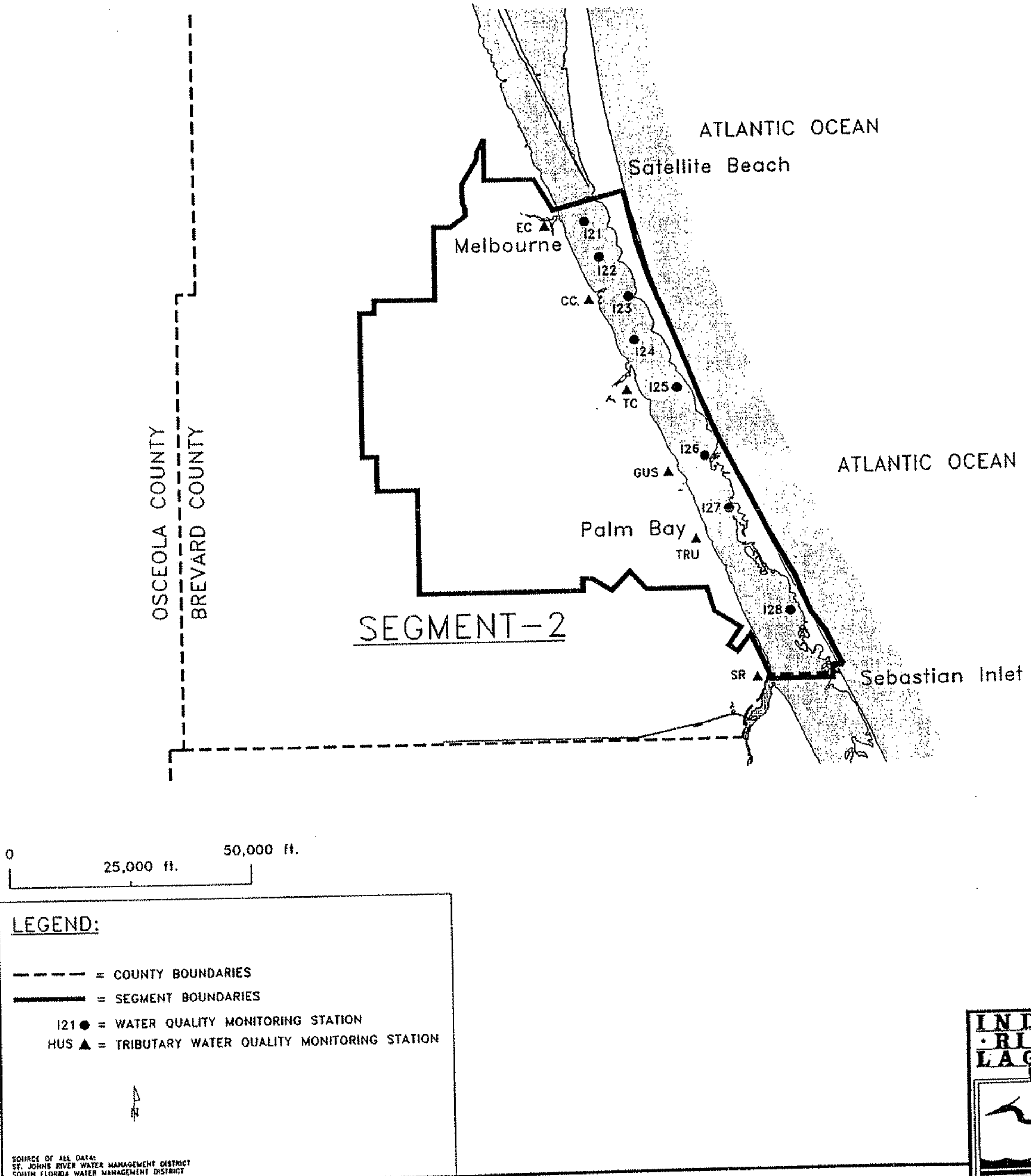
Wet season and dry season salinity concentrations appears to vary only slightly between seasons. The data indicates that wet season salinity may be about 1-2 ppt higher, a condition which is unusual in respect to the other segments and to expectations for the region. This

TABLE 5-4

AVERAGE VALUES[1] FOR SELECTED CONSTITUENTS FOR WATER IN THE NORTH CENTRAL INDIAN RIVER LAGOON PORTION (SEGMENT 2) OF THE INDIAN RIVER LAGOON SYSTEM

MONTH	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	TSS (mg/L)	TOTAL P (mg/L)	CHLOROPHYLL *a* (µg/L)	TKN (mg/L)
January	8.06	23.5	1.55	2.45	8.5	0.07	14.4 (C)	1.36
February	7.71	23.3	1.62	—	—	—	—	—
March	7.77	24.1	1.30	—	—	—	—	—
April	7.34	26.0	1.52	3.21	13.5	0.06	7.9 (C)	1.40
May	6.31	28.7	1.72	—	—	—	—	—
June	6.77	30.6	1.58	—	—	—	—	—
July	6.72	26.8	1.59	2.95	16.9	0.08	10.1 (C)	1.19
August	6.11	23.9	1.53	—	—	—	—	—
September	5.34	24.0	1.37	—	—	—	—	—
October	7.79[2]	19.2	1.12	3.91	19.5	0.05	12.6 (C)	0.95
November	7.73	23.4	1.47	—	—	—	—	—
December	9.11	21.9	1.65	2.20	—	—	—	—
Average	7.23	24.6	1.50	2.94	14.6	0.07	11.3 (C)	1.23
FDER WQA Average[3] (1992)	**7.2**	—	**1.4**	**5.5 (JTU)**	**13**	**0.13**	**8 (U)**	—

1 = Average monthly values for all stations within segment for the period from 1/88 to 12/91 unless otherwise noted. Frequency of sampling varies from monthly to quarterly.
2 = Incomplete data (based on less than 3 years of data)
3 = Source: FDER, 1992
U = Uncorrected
C = Corrected



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DATE: 7-5-94

FIGURE 5-10 WATER QUALITY MONITORING STATIONS IN SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON

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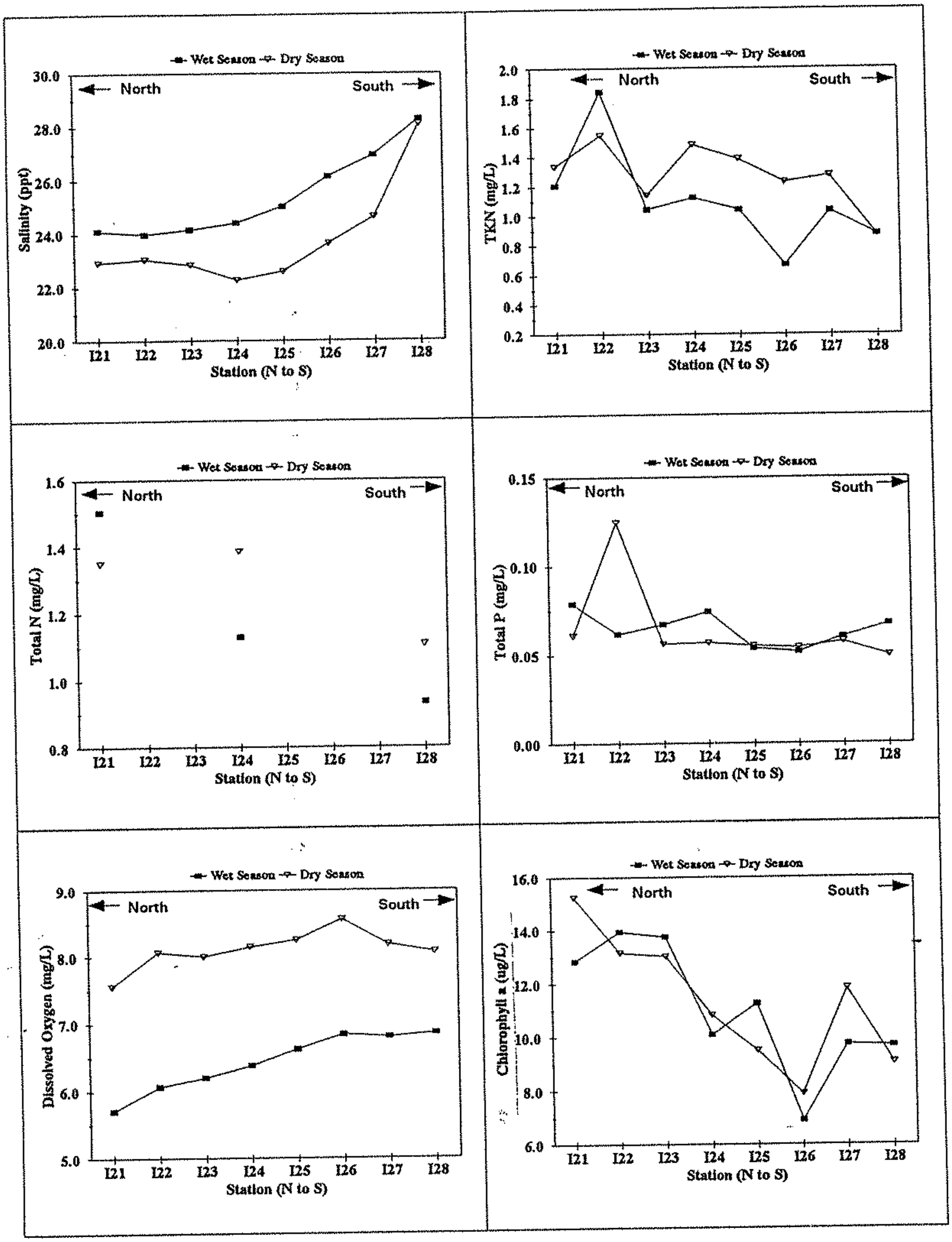

Data Source: SJRWMD, 1993

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FIGURE 5-11 SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON

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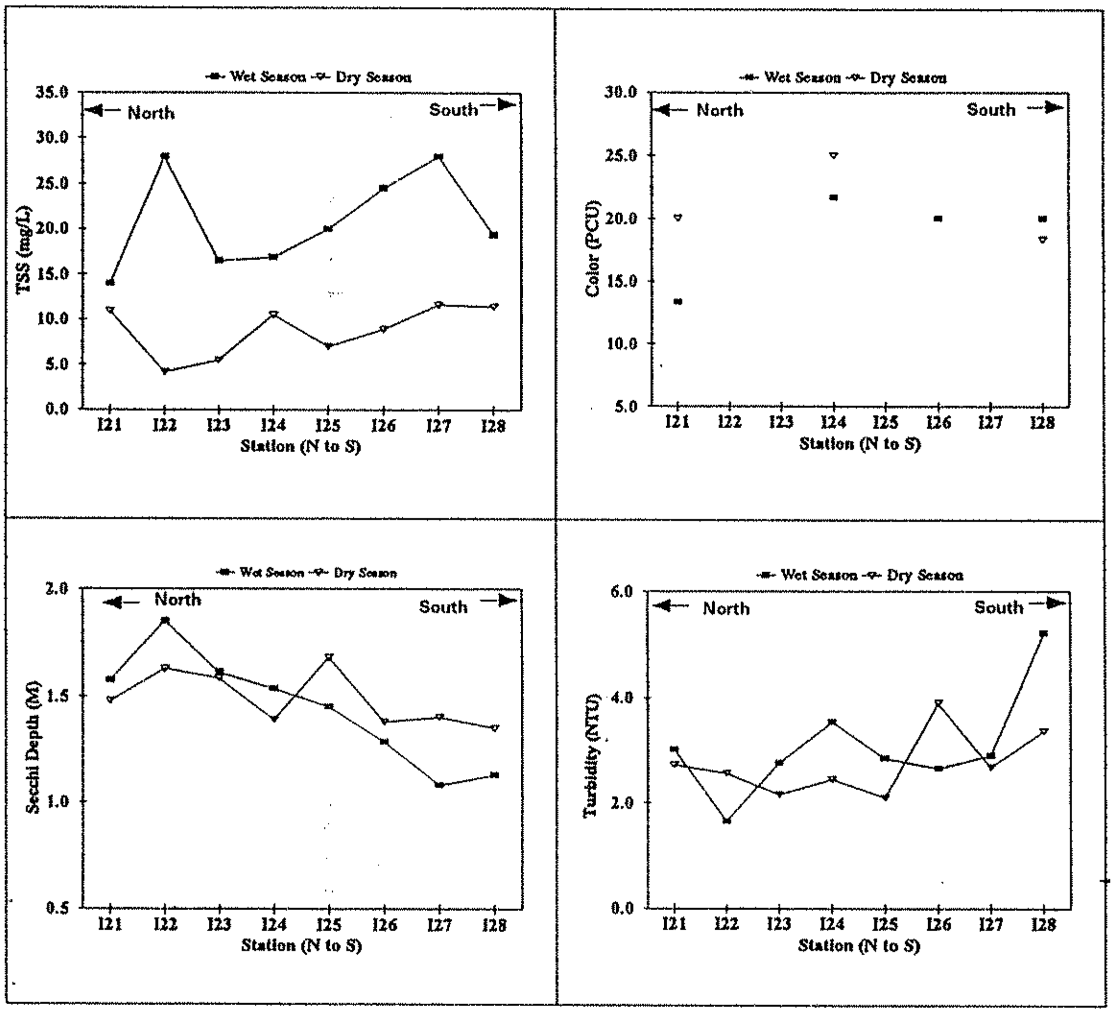

Data Source: SJRWMD, 1993

•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: DATE: 6-9-94	FIGURE 5-11 (CON'T)	SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON

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is especially true considering the number of freshwater tributaries in this segment. The salinity range is lower in this segment than for other segments, and this lower range may be one explanation. The data by station indicate several instances of very low (<18 ppt) salinity in the periods between October and December. It is also possible that the data may be inaccurate.

TKN was measured quarterly in this segment. Values are generally higher for the dry season than the wet season with the exception of the station to the north of Crane Creek, (Station I22). There may be a slight trend towards lower values at the south end of this segment compared to the north. Except for Station I22 which averaged 1.85 mg/L, wet season TKN concentrations are between 0.65 and 1.5 mg/L. Dry season values for all stations were between 0.9 and 1.2 mg/L.

Total nitrogen was also measured quarterly. However, the data is limited to only three locations and the year 1989. The TN level at the northernmost station of the three measured stations is the highest and the southernmost station is the lowest, indicating that the spatial pattern of decreasing TKN toward the south represents a general nitrogen trend.

Station I22, between the Eau Gallie River and Crane Creek, shows a relatively high value for TP during the dry season, but the wet season average remains similar to those of the other stations in the segment. Other than this abnormally high dry season average at Station I22, the TP concentration is essentially identical at all stations for both seasons, with a narrow range between 0.05 and 0.085 mg/L.

Dissolved oxygen values in this segment again are lower in the wet season than in the dry season, with a slight tendency in both wet and dry seasons towards higher values at the south end of the segment. Values in this segment are between 5.5 to 6.5 mg/L for the wet season and between 7.5 and 8.5 mg/L for the dry season.

There appears to be surprisingly little difference in chlorophyll *a* values between the wet season and the dry season in this segment. Values vary between 7.0 and 15.5 μg/L. As in the Banana River and to a lesser extent in the North Indian River Lagoon, the spatial differences are larger in this segment than the seasonal differences. In general, values are lower toward the south end of the segment, with the minimum values between Goat Creek and Trout Creek.

This chlorophyll *a* pattern shows some similarity to the nutrient patterns, particularly to the wet season TKN graph. The highest TKN, TN, and TP values occur at stations I21 or I22 in the Melbourne/Eau Gallie River/Crane Creek area, and highest chlorophyll *a* values also occur in this area. The data (Figure 5-11) provide some indication that nitrogen, rather than phosphorus, may be the limiting nutrient factor in this segment, at least in the wet season.

Total suspended solids values are higher during the wet season at all stations. Wet season values are between 14.0 and 28.0 mg/L, while dry season values are 5.0 to 1.0 mg/L. There is little or no spatial pattern readily apparent for TSS in this segment. The highest quarterly average TSS value (19.5 mg/L) occurred in October and the lowest was in January (8.5 mg/L). Turbidity data shows a slight tendency toward higher values in the south end.

Color was measured at only 4 stations in this segment and for only one year (1989). Consequently little information on trends can be derived. Wet season values ranged from 14.0 to 21.0 PCU. Dry season values ranged from 19.0 to 25.0 PCU.

Secchi disk depth patterns appear to differ by season. The data show a decrease in wet season Secchi disk depth from north to south, while the dry season Secchi disk depths may be more nearly uniform across the segment. Secchi disk depth is generally greatest at the north end, where chlorophyll *a* levels are highest, indicating a fairly low influence of chlorophyll *a* concentration on water clarity in this segment. Secchi disk depth varies from about 1.1 to 1.6 m during the wet season and between 1.3 and 1.7 m during the dry season. The highest monthly average (1.7 m) occurred in May and the lowest (1.1 m) was in October.

Seasonal and Annual Patterns

Figure 5-12 shows the temporal variation of selected water quality parameters within Segment 2. Total Kjeldahl nitrogen, TP, chlorophyll *a*, TSS, color, and turbidity were only

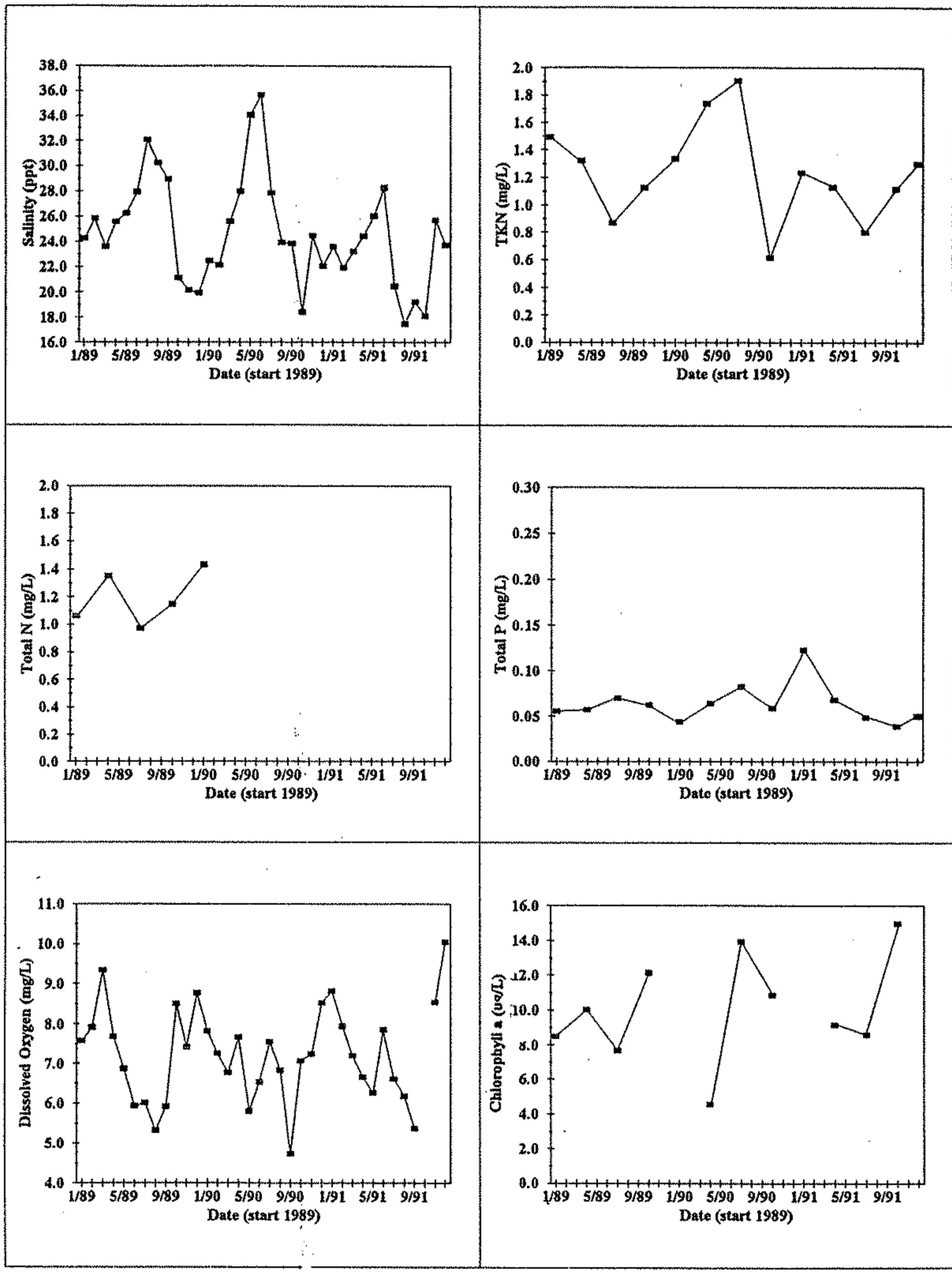

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FIGURE 5-12 TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON

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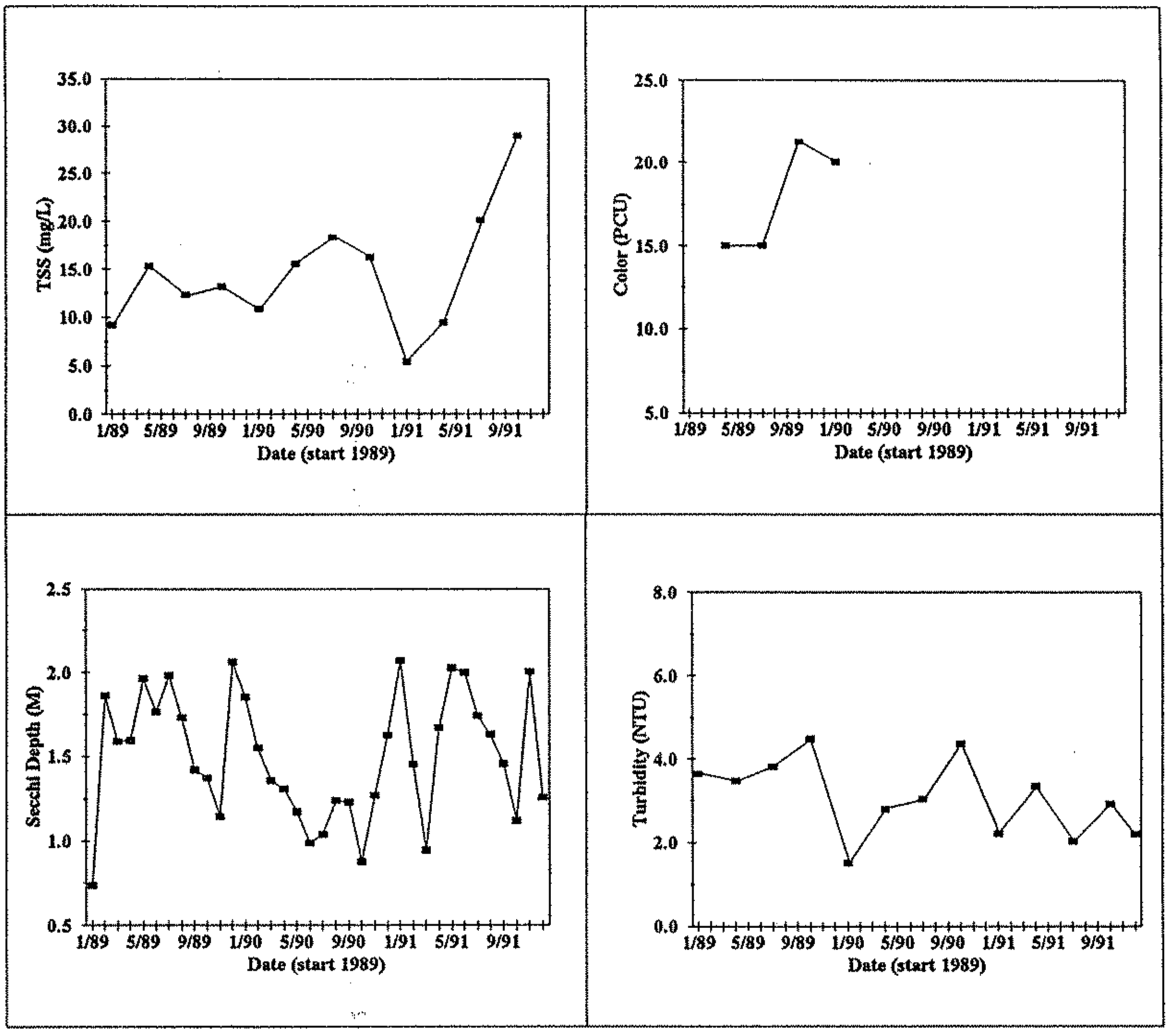

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measured quarterly. Total nitrogen and color were only measured for one year. Several data points are missing for chlorophyll *a*. Consequently, much of the data for this segment is also limited in its utility for identification of water quality trends.

Although the wet and dry season average salinity values for this segment (Figure 5-11) appear to be fairly similar, salinity appears to show a greater degree of seasonal variability within individual years (Figure 5-12). This seasonal variability is more pronounced than in the segments to the north. The highest average monthly salinity value (30.6 ppt) occurs in June and the lowest (19.2 ppt) is in October.

The highest quarterly average TKN value occurred in January (1.4 mg/L) and the lowest occurred in October (0.95 mg/L), but no real trend over time is apparent.

The other parameters show no strong or consistent trends over time. For the period of three years of record, the TSS values may be increasing slightly, while turbidity may be decreasing slightly. Although DO does show some of the typical pattern of lower wet season values, this pattern appears to be less distinct with greater variability throughout the year in this segment. There also appears to be either no trend over time or insufficient data to establish trends for TN, TP, or chlorophyll *a*.

5.1.5 Segment 3 - South Central Indian River Lagoon

Table 5-5 presents the segment-wide monthly averaged concentrations for selected water quality parameters for the South Central Indian River Lagoon. These values are compared to FDER 1982-90 WQA data. However, the water quality data set for this segment is incomplete. Nine of the 10 stations in this segment have been maintained by FDEP and Indian River County, while the tenth (I29) is a Brevard County station at the north end of the segment. Station I29 is the only station in which there is a continuous record from 1989 through 1991 on which to base the time series analysis. The data for the other 9 stations (IRJ01 through IRJ09) were available only for an 18-month period ending in April, 1990. Thus it is not possible to define average conditions in the segment for the period after 4/90.

TABLE 5-5

AVERAGE VALUES[1] FOR SELECTED CONSTITUENTS FOR WATER IN THE SOUTH CENTRAL INDIAN RIVER LAGOON PORTION (SEGMENT 3) OF THE INDIAN RIVER LAGOON SYSTEM

MONTH	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	TSS (mg/L)	TOTAL P (mg/L)	CHLOROPHYLL *a* (μg/L)	TKN (mg/L)
January	7.47	27.2	1.35	4.47[2]	17.51[2]	0.08	6.15 (U)	0.80
February	7.70	27.2	1.47	—	—	—	—	—
March	7.93	30.7	1.25	—	—	—	—	—
April	6.76	27.5	1.07	8.22	20.21	0.14	11.97 (U)	0.77
May	6.00	33.0	1.45	—	—	—	—	—
June	7.63	32.2	1.11	—	—	—	—	—
July	6.76	28.6	1.04	5.82[2]	26.69[2]	0.07	8.25 (U)	0.66
August	6.73	28.3	0.84	—	—	—	—	—
September	5.96	26.2	1.07	11.6[2]	—	—	—	—
October	8.85	21.0	1.09	2.3[2]	34.5[2]	0.07	14.02 (U)	0.76
November	7.92	23.8	0.78[2]	8.3[2]	20.0[2]	—	—	0.95
December	9.43	23.6	1.09	—	—	—	—	0.95
Average	7.43	27.4	1.13	6.79	23.78	0.09	10.09 (U)	0.82
FDER WQA Average[3] (1992)	**6.2**	--	—	**7.1 (JTU)**	**16.0**	**0.12**	**7.0**	—

1 = Average monthly values for all stations within segment for the period from 3/88 to 4/90 unless otherwise noted. Frequency of sampling varies from monthly to quarterly.
2 = Incomplete data (based on less than 3 years of data)
3 = Source: FDER, 1992
U = Uncorrected
C = Corrected

This also means that the data for Station I29 at the north end of the segment, because of its longer period of record, is more heavily weighted in the monthly averages than the other stations and may be skewing the monthly and annual averages. However, the number of stations used to compile the FDER long-term average for this segment consists of only two stations (near Sebastian River and Vero Main Canal), so this data base is also of limited utility.

Within these constraints, the data indicate that the TSS and chlorophyll *a* levels in the 1989-91 period may be higher than the longer-term FDER WQA average, but that TP levels may be less. The DO average may also be higher. Station location of the limited FDER data set may be a major factor in the difference of averages, with the Vero Main Canal discharge being over-represented in the FDER average.

Spatial Patterns

Figure 5-13 shows the location of sampling stations for the South Central Indian River Lagoon segment. Additionally, Figure 5-14 presents the spatial variation for wet season/dry season conditions.

Wet and dry season salinities are similar in the northern part of this segment, while salinity is slightly lower in the southern part (Stations IRJ04 through IRJ09) during the wet season. The stations in the southern part are in the vicinity of the discharges of the Vero North, Vero Main, and Vero South Canals of the Indian River Farms Water Control District, and the lower wet season values may reflect freshwater storm discharge from these tributaries. There are essentially no freshwater tributaries in the vicinity of Stations IRJ01 to IRJ03.

Although TKN wet season values appear to be essentially the same throughout the segment, the dry season TKN values show a peak that is higher than wet season values in the middle of this segment (Stations IRJ03 to IRJ06) in the Vero Beach area. However, the variability of TKN values between stations appears to be relatively small. In general, TKN values are between 0.7 and 1 mg/L. No TN data was available from the stations in this segment.

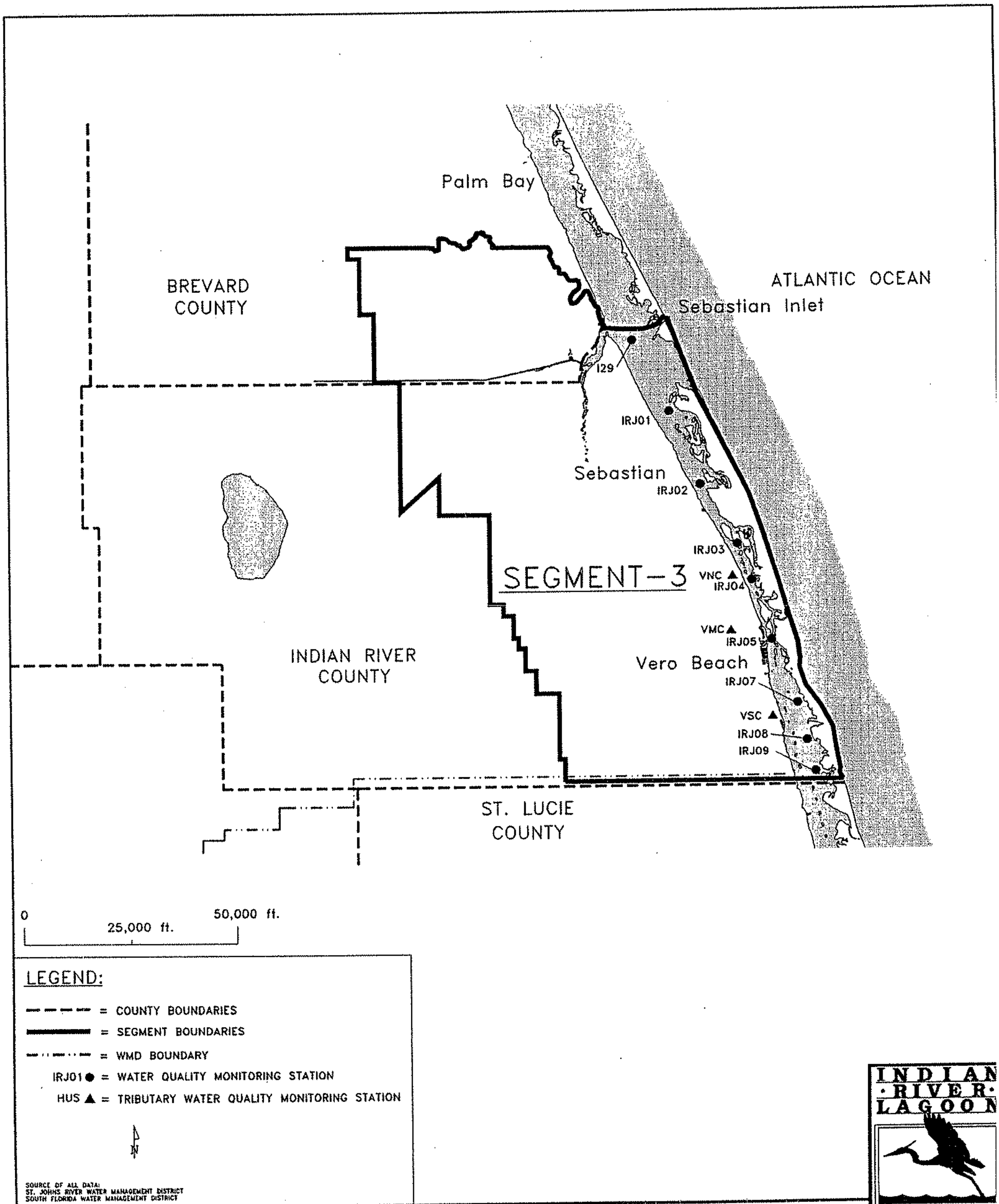

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FIGURE 5-13 WATER QUALITY MONITORING STATIONS IN SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON

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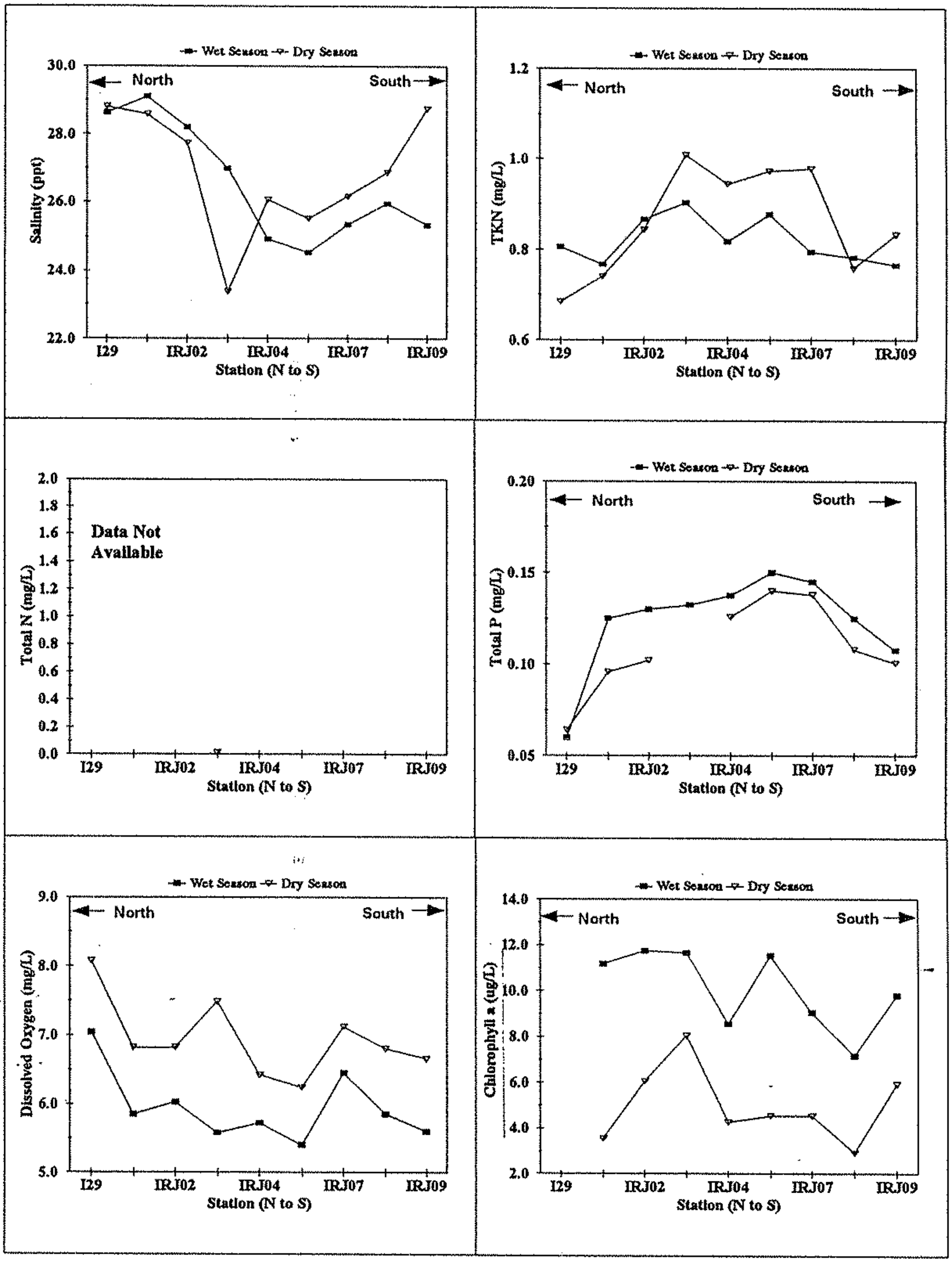

Data Source: SJRWMD, 1993

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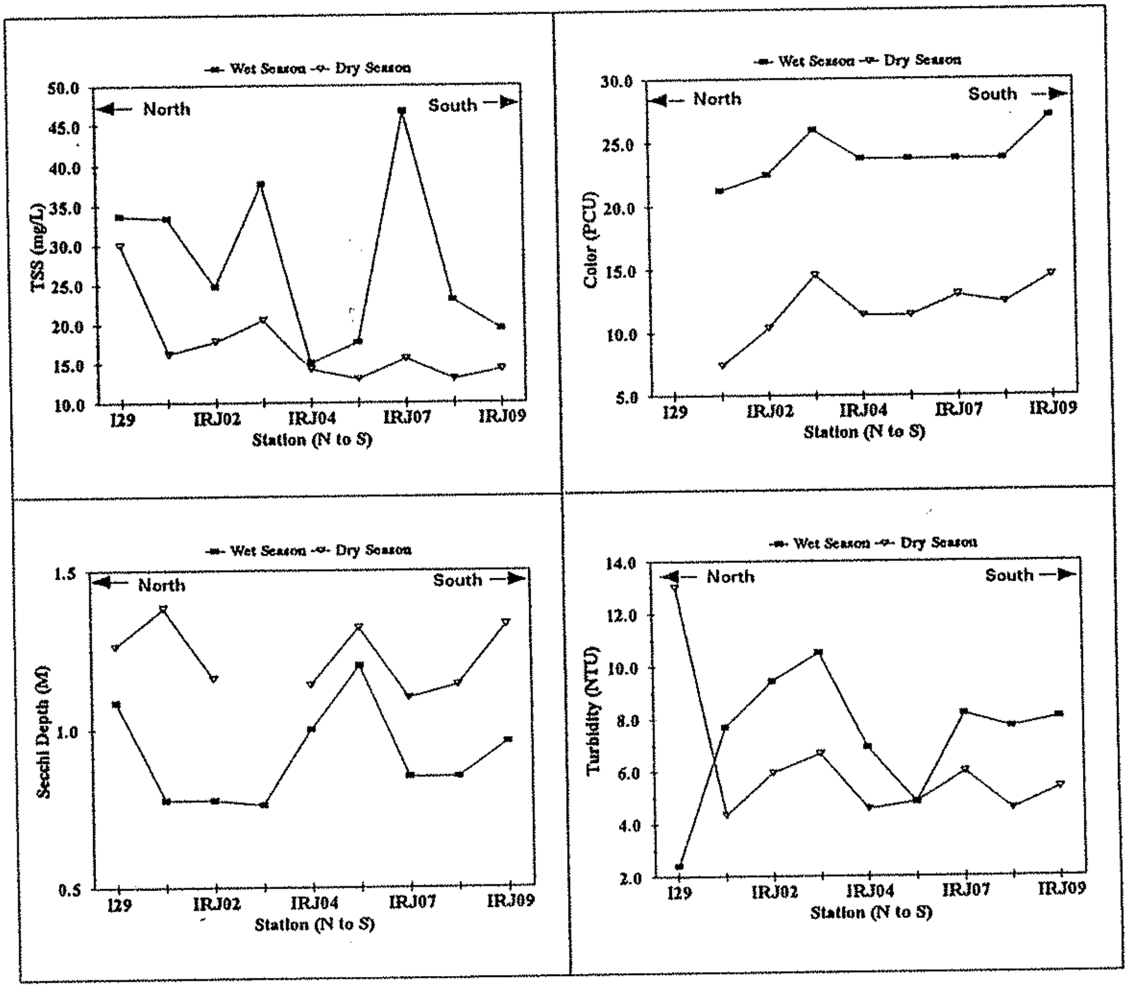

Data Source: SJRWMD, 1993

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FIGURE 5-14 (CON'T)

SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON

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Total phosphorous may be somewhat higher during the wet season than during the dry season. It is lower at the northernmost and southernmost stations for both seasons. However, there are increased TP levels in the central portion of this segment, where averages increase to between 0.12 and 0.15 mg/L from Stations IRJ01 to IRJ08. These TP levels (above 0.12 mg/L in the area between Sebastian and the Vero South Canal) are higher than anywhere else in the Lagoon complex.

Wet season DO concentrations are lower than dry season concentrations. There is little spatial differentiation, but some decrease may occur from north to south. The northernmost station (I29) near Sebastian Inlet is slightly higher than the others. Wet season values are generally between 5.5 and 7.0 mg/L and dry season values are generally between 6.5 and 8.0 mg/L.

Chlorophyll *a* (corrected) is markedly higher in the wet season than in the dry season in this segment, but the data is inadequate to define other patterns. Dry season chlorophyll *a* varies between 3.5 and 8.5 μg/L, whereas wet season varies between 8.5 and 12 μg/L.

Wet season TSS values are higher than or equal to dry season values at all stations. Generally, wet season TSS can be more variable between stations than the dry season values. Inordinately high values are present at Stations IRJ03 and IRJ07. Wet season TSS values varied between 14.0 and 47.0 mg/L and dry season values varied between 12.0 and 20.0 mg/L, except for Station I29 which remained nearly constant at 30.0 mg/L despite the season.

Color is markedly higher during the wet season. Color values vary between 5 and 15 mg/L during the dry season and between 22 and 30 mg/L during the wet season. The effect of the highly colored discharges from the three discharges from the Indian River Farms Water Control District are a possible influence on this parameter.

For Secchi disk depths, dry season values are higher than wet season values, indicating an effect of stormwater on water clarity in this segment. Color and possibly chlorophyll *a* values may be the factors most influencing Secchi disk depth. Values for wet season vary between 0.5 m and 1.2 m, and for the dry season the range is between 1.2 and 1.4 m. There is no apparent trend from north to south within the segment.

Turbidity is generally higher during the wet season, but an unexplained and abnormal situation is shown by the data for Station I29. Wet season turbidity values vary between 2.0 and 11.0 NTU, while dry season values vary between 4.0 and 13.0 NTU.

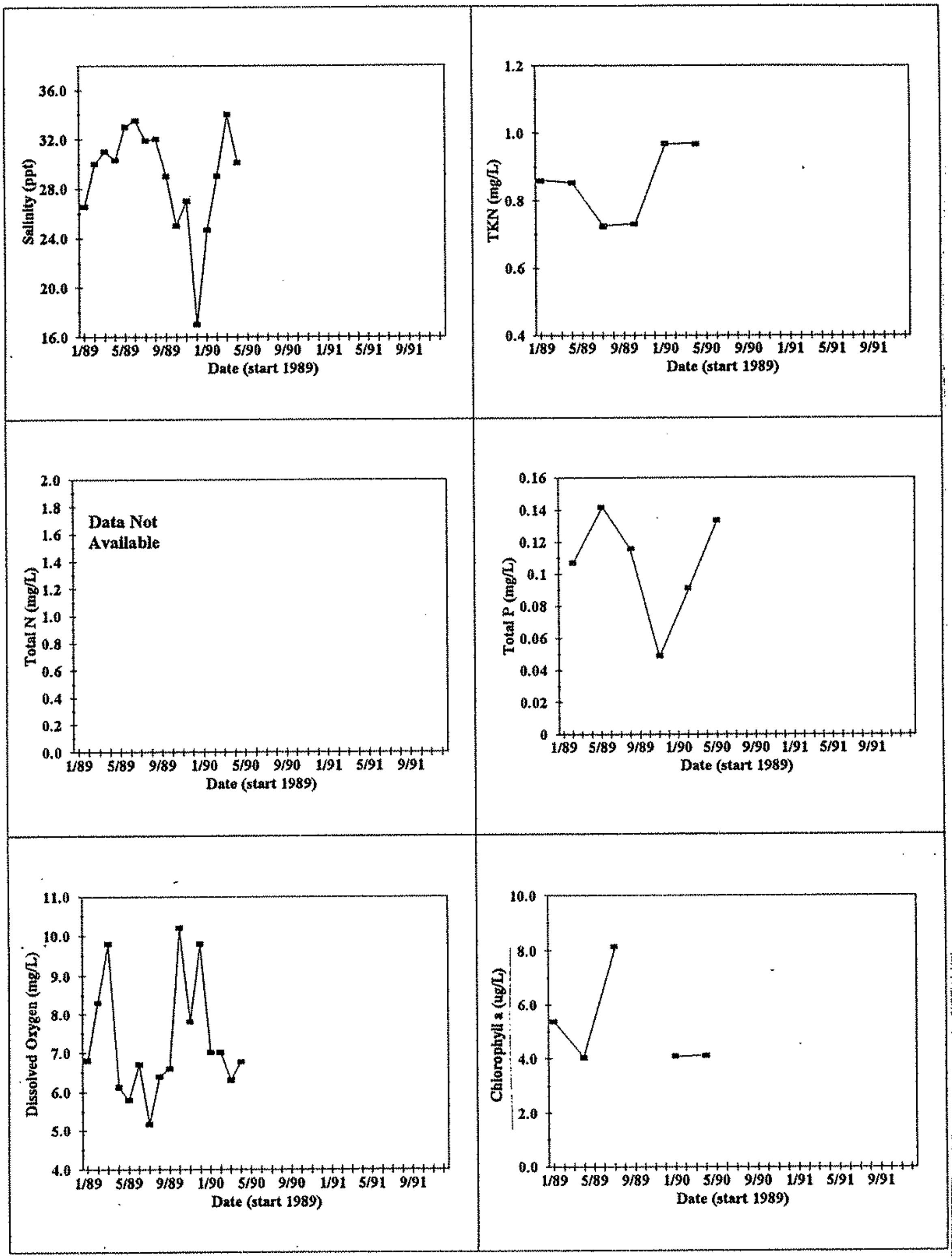
Seasonal and Annual Patterns

The variation with time of the water quality parameters in Figure 5-15 shows data only for the period through April, 1990 since the data sets for most stations after this date were unusable. The only parameters that have been sampled monthly are salinity, DO, and Secchi disk depth at Station I29. All other parameters were measured quarterly at I29, and all parameters were measured quarterly at Stations IRJ01 through IRJ09. Thus the monthly averages shown in Figure 5-15 do not show fully comparable data for all months.

Salinity appears to show little long-term trend over time, although a large drop is indicated for December, 1989. However, only Station I29 was sampled in 12/89, while the other stations were sampled in 1/90. Thus, the abnormally low value represents data from only 1 of 10 stations and cannot be considered representative. This segment differs from the North Central Indian River Lagoon (Segment 2) in that the lowest recorded salinity value during the 18-month reporting period was 17 ppt, whereas there were several values below 10 ppt at Stations I23 through I27 in Segment 2.

There is insufficient data to show temporal trends for TKN, TP, and chlorophyll *a* and no data for TN. The TKN values are typical of the Lagoon overall, while TP values are above average.

Secchi disk depths are quite variable and do not appear to show any seasonal pattern. Total suspended solids also show no discernable trend over time. Dissolved oxygen is variable over time but shows no long-term trend. Dissolved oxygen values, however, do show warm-wet versus cool-dry variations.



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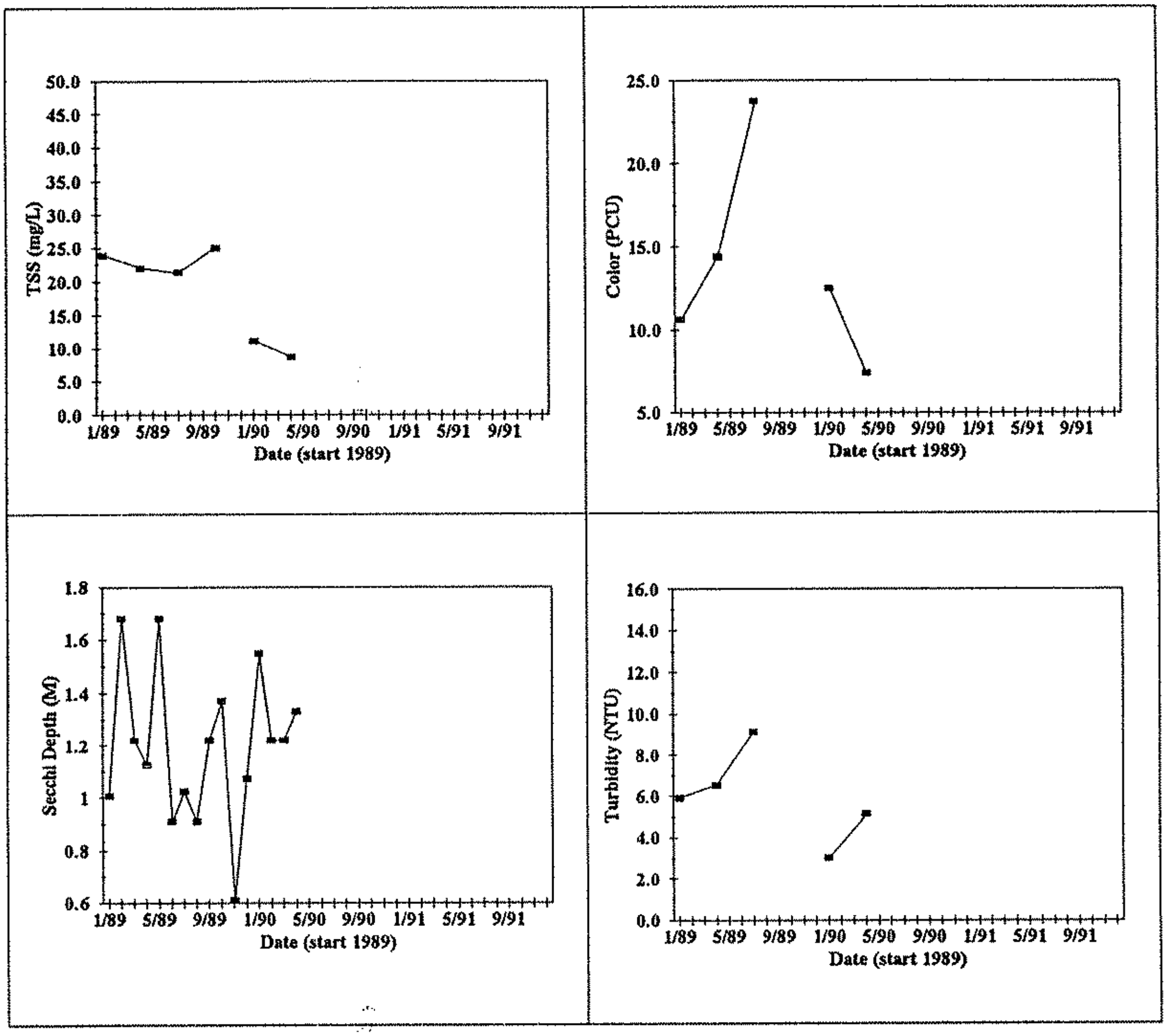

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FIGURE 5-15 (CONT) TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON

5.1.6 Segment 4 - South Indian River Lagoon

Table 5-6 presents the segment-wide monthly and annual averaged concentration data and compares this data to the long-term FDER 1982-90 WQA data. In comparison of the 1989-91 period to the long-term FDER averages, DO, TSS, and chlorophyll *a* values are similar, but TP appears to show a decrease in the more recent period.

The period of record for the 39 stations in this segment is from 10/88 to 10/92 with quarterly (Jan, Apr, Aug, Oct) sampling plus sampling in November and December, 1988. Large data gaps in some parameters occur, such as missing salinity data for many stations after mid-1990. No data is present for Secchi disk depth or color.

<u>Spatial Patterns</u>

Figure 5-16 shows the location of sampling stations in the South Indian River Lagoon segment. Figure 5-17 presents the spatial variation of water quality parameters for wet and dry seasons.

Salinity values within this segment are very similar in wet and dry seasons. There is a general increase in salinity around Ft. Pierce Inlet (Stations IRL30, IRL34, IRL35) and Jupiter Inlet (Station IRL01). There also is some increase adjacent to St. Lucie Inlet, but a large wet season decrease is experienced at the mouth of the St. Lucie Estuary (IRL16). Salinity consistently ranges from 30.0 to 36.0 ppt, except near the mouth of the St. Lucie Estuary (IRL15), where it drops to an average of 25 ppt in the wet season.

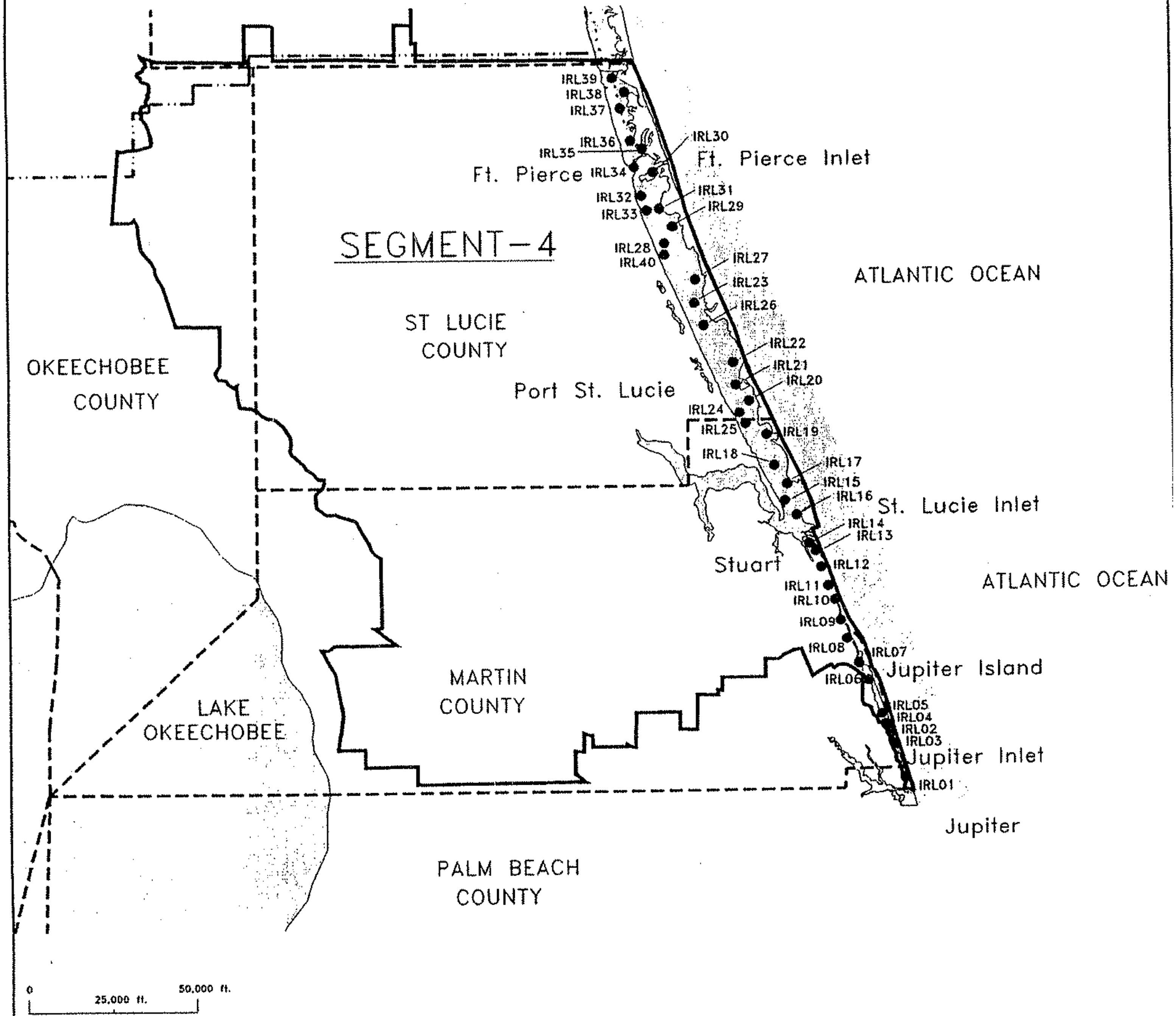
In general TKN, TN, and TP wet season values are slightly higher than dry season, with the greatest seasonal difference occurring in the Jupiter Narrows and in the ICWW and Pecks Lake area (Stations IRL07 to IRL13) between Hobe Sound and St. Lucie Inlet. The highest values of TKN, TN, and TP, both during the wet season and dry season, may be higher in the area around St. Lucie Inlet (Stations IRL13 to IRL16), with a declining trend south from the inlet. Nutrient levels appear to be lower in the Jupiter Inlet to Hobe Sound portion (Stations IRL01 to IRL05) than elsewhere in Segment 4. Relatively constant TKN, TN, and

TABLE 5-6

AVERAGE VALUES[1] FOR SELECTED CONSTITUENTS FOR WATER IN THE SOUTH INDIAN RIVER LAGOON PORTION (SEGMENT 4) OF THE INDIAN RIVER LAGOON SYSTEM

MONTH	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	TSS (mg/L)	TOTAL P (mg/L)	CHLOROPHYLL *a* (μg/L)	TKN (mg/L)
January	6.48	33.9[2]	—	5.27	33.45	0.03	7.0[2] (U)	0.53
February	—	—	—	—	—	—	—	—
March	—	—	—	—	—	—	—	—
April	6.19	36.1[2]	—	5.77	38.26	0.03	5.2[2] (U)	0.56
May	—	—	—	—	—	—	—	—
June	—	—	—	—	—	—	—	—
July	6.21	35.7[2]	—	4.77	28.62	0.04	4.9[2] (U)	0.68
August	—	—	—	—	—	—	—	—
September	—	—	—	—	—	—	—	—
October	5.92	32.0[2]	—	4.75	41.72	0.05	12.2[2] (U)	0.62
November	6.33[2]	32.7[2]	—	3.89[2]	59.05[2]	0.06[2]	—	0.48[2]
December	6.38[2]	31.7[2]	—	4.34[2]	66.95[2]	0.06[2]	—	0.40[2]
Average	6.25	33.7[2]	—	4.80	44.68	0.05	7.3[2] (U)	0.55
FDER WQA Average[3] (1992)	**6.7**	---	---	**4.5 (JTU)**	**50.0**	**0.09**	**7.7**	---

1 = Average monthly values for all stations within segment for the period from 10/88 to 10/92 unless otherwise noted. Frequency of sampling varies from monthly to quarterly.
2 = Incomplete data (based on less than 3 years of data)
3 = Source: FDER, 1992
U = Uncorrected
C = Corrected



LEGEND:

- — — — = COUNTY BOUNDARIES
- ▬▬▬ = SEGMENT BOUNDARIES
- — · — · · = WMD BOUNDARY
- IRL01 ● = WATER QUALITY MONITORING STATION
- HUS ▲ = TRIBUTARY WATER QUALITY MONITORING STATION

N

SOURCE OF ALL DATA:
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: SEG4WQM.DWG DATE: 7-5-94	FIGURE 5-16	WATER QUALITY MONITORING STATIONS IN SEGMENT 4 - SOUTH INDIAN RIVER LAGOON

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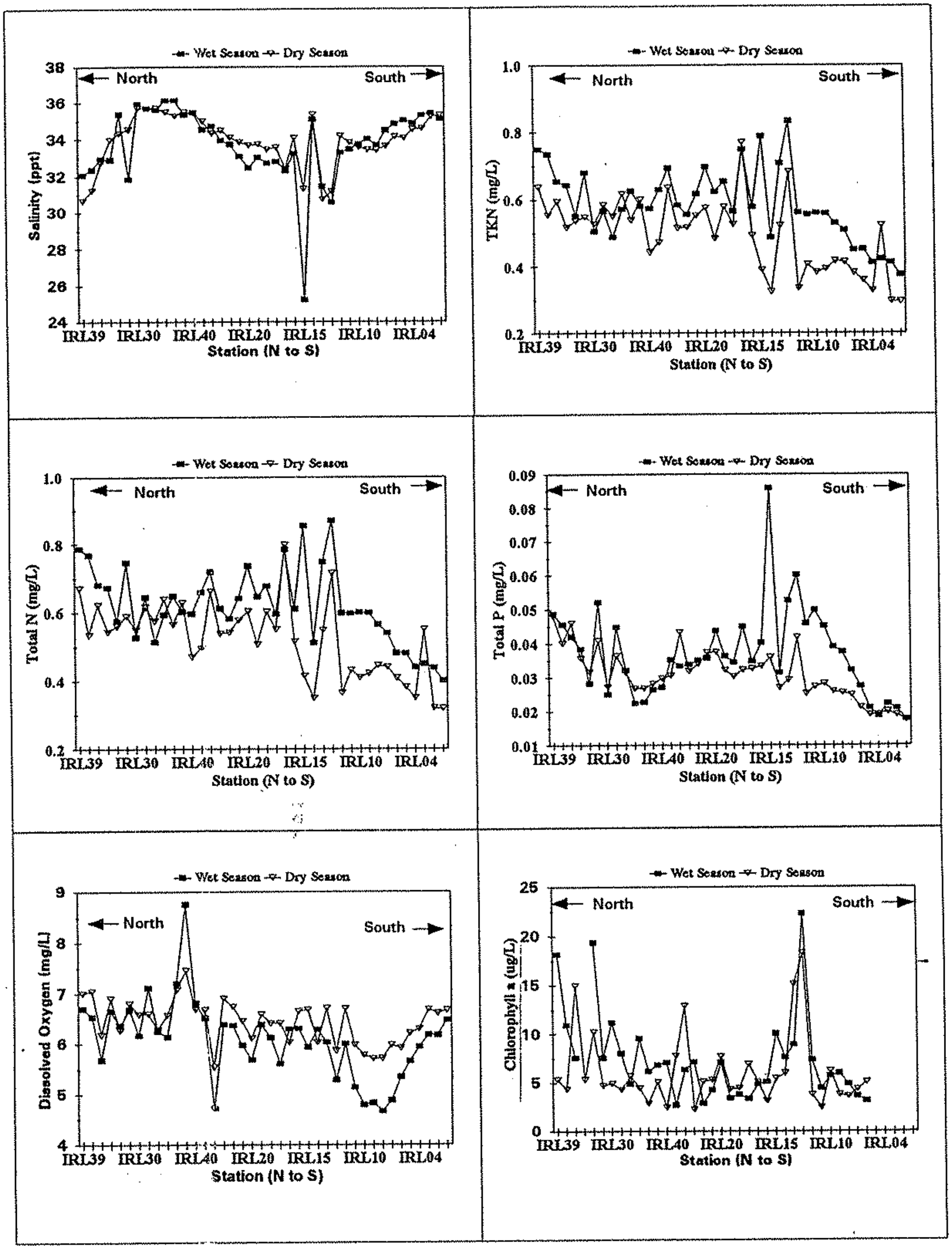

Data Source: SFWMD, 1993

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysis	DRAWING NO.: DATE:	FIGURE 5-17	SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 4 - SOUTH INDIAN RIVER LAGOON

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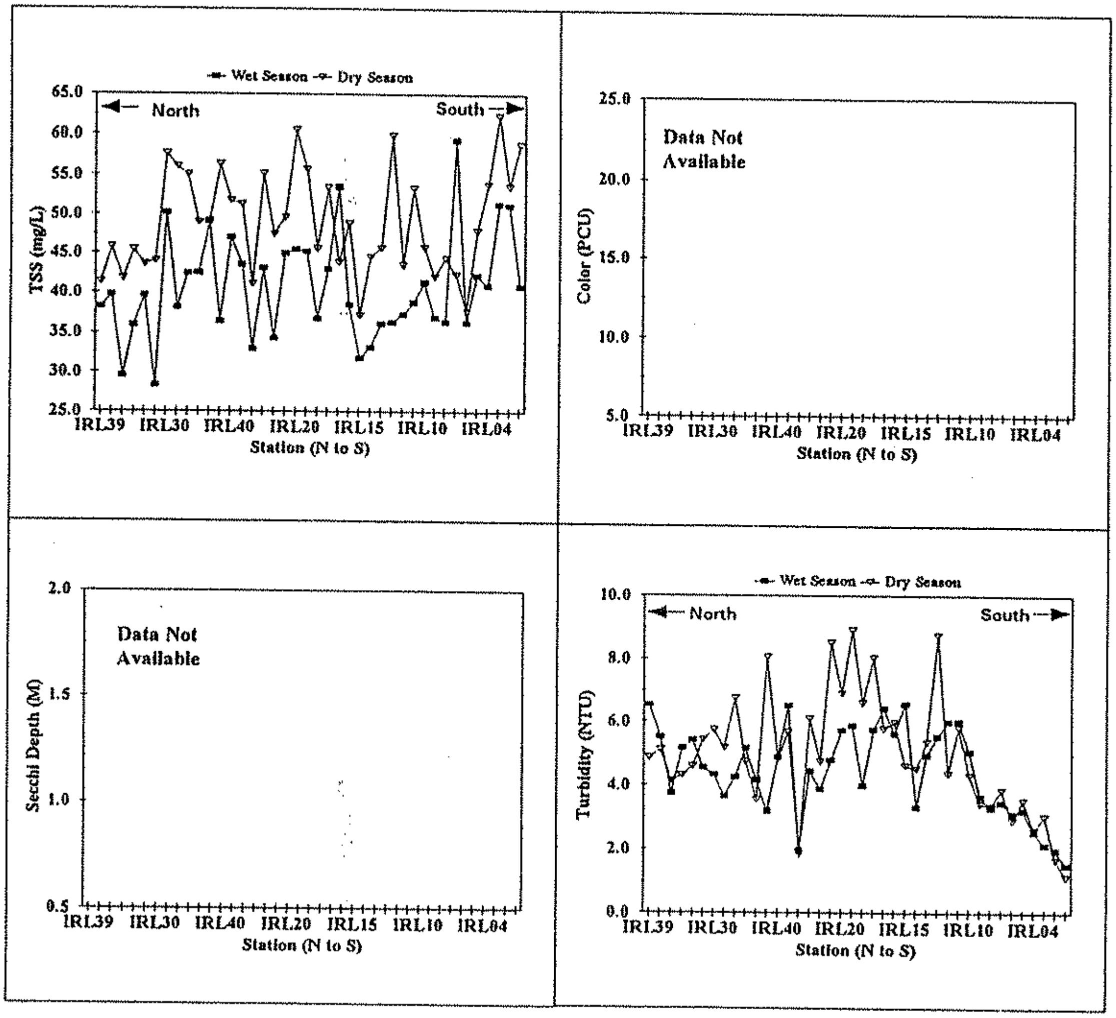

Data Source: SFWMD, 1993

·Woodward-Clyde Consultants ·Marshall McCully & Associates ·Natural Systems Analysts	DRAWING NO.: DATE: 6-19-94	FIGURE 5-17 (CON'T)	SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS IN SEGMENT 4 - SOUTH INDIAN RIVER LAGOON

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TP values occur throughout the segment north of St. Lucie Inlet, with wet season TKN varying between 0.4 and 0.8 mg/L and dry season values between 0.3 and 0.7 mg/L. Total phosphorous concentrations vary between 0.025 and 0.08 mg/L.

Dissolved oxygen data indicate little difference in the wet season and dry season values in most of this segment, except in the Jupiter Narrows area (Stations IRL07 to IRL12). Wet season DO concentrations vary from 5.0 to 9.0 mg/L, and dry season concentrations vary between 6.0 and 7.0 mg/L.

Chlorophyll *a* values are generally low throughout this segment, in comparison to values in other segments. However, some very high values occur in both seasons. The areas of high chlorophyll *a* content are at Stations IRL13 and IRL14 near the entrance of St. Lucie Inlet and from Ft. Pierce Inlet north (Stations IRL30, IRL35, IRL37, and IRL39). Values in the Jupiter Narrows area appear to have little seasonal difference.

Total suspended solids values are generally higher in the dry season. The seasonal difference is low north of Ft. Pierce Inlet and quite variable between Ft. Pierce Inlet and St. Lucie Inlet. At the stations around the St. Lucie Estuary, total suspended solids values drop noticeably during the wet season. Concentrations vary between 30.0 and 60.0 mg/L in the wet season and between 37.0 and 61.0 mg/L in the dry season.

Secchi disk depth data were not collected for the South Indian River Lagoon segment. Also, there is no color data available for the south segment.

Turbidity values in the area between St. Lucie and Ft. Pierce Inlets tend to be higher in the dry season. In the Jupiter Narrows area there is very little difference between the wet season and dry season, and there is a trend towards lower turbidity from north to south in the Jupiter Narrows area. Turbidity, in general, varies between 2 and 9 NTU.

<u>**Seasonal and Annual Patterns**</u>

Figure 5-18 shows variations in Segment 4 of water quality parameters over time. Only 18 months of quarterly data were available for salinity and 12 months for chlorophyll *a*. The

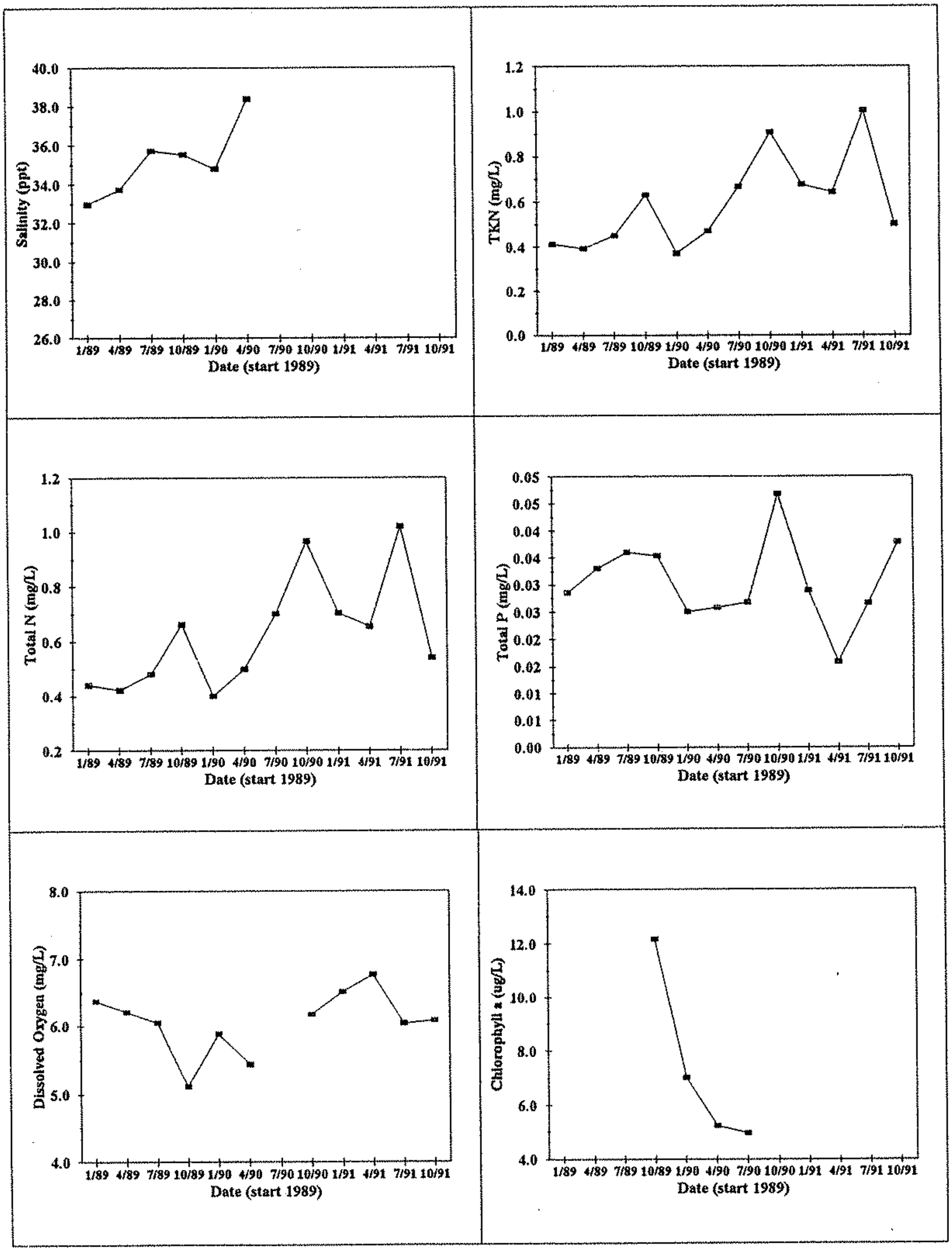

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FIGURE 5-18 TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 4 - SOUTH INDIAN RIVER LAGOON

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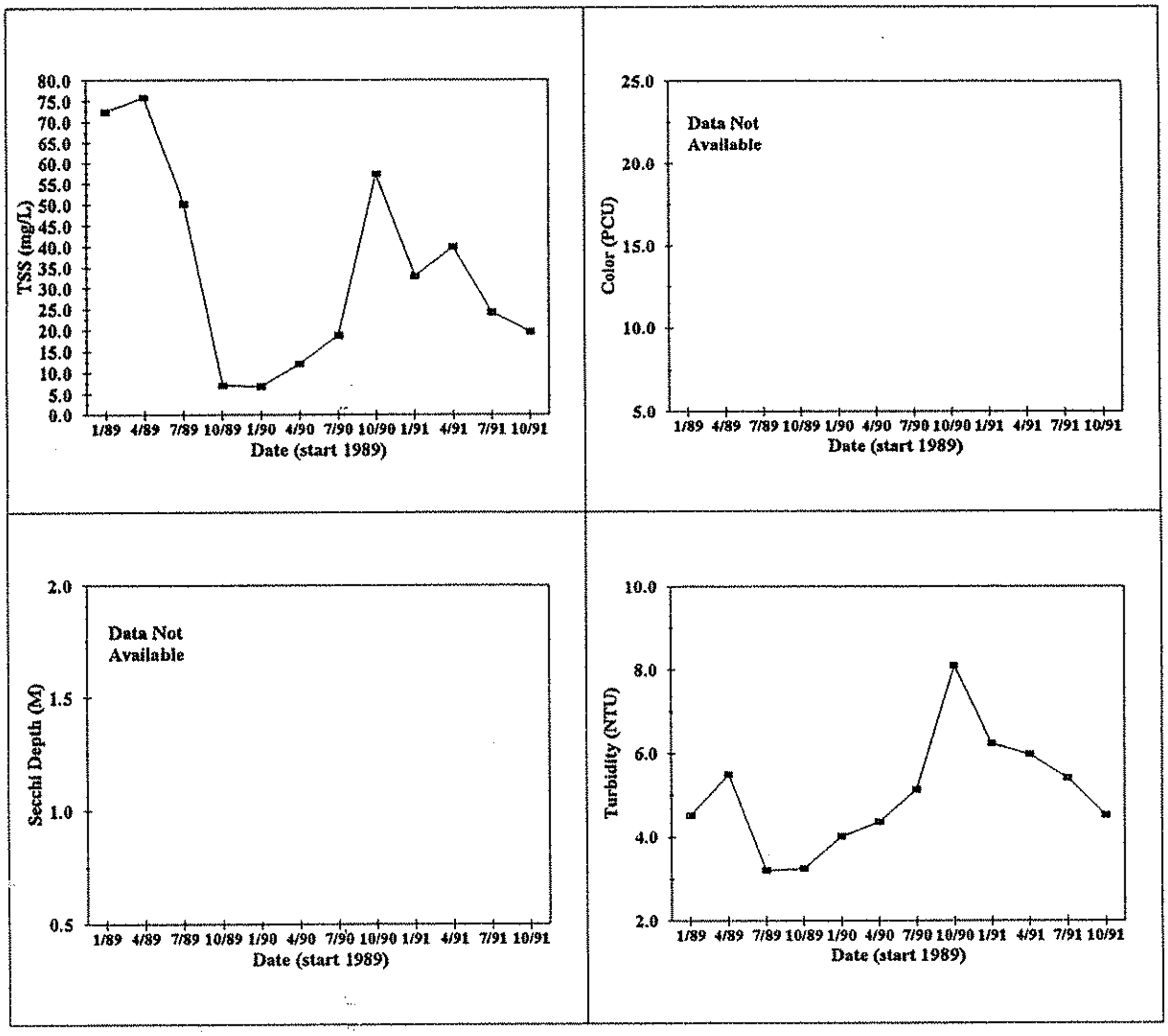

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FIGURE 5-18 (CONT) TIME SERIES OF WATER QUALITY PARAMETERS IN SEGMENT 4 - SOUTH INDIAN RIVER LAGOON

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data indicate a slight increase in salinity from 33 to over 38 ppt during this period. TKN and TN are somewhat variable but appear to be rising slightly with time, while total phosphorous remains relatively uniform but seasonally variable. Dissolved oxygen stays relatively constant over time. There are not enough data to draw any conclusions regarding the time variations of chlorophyll *a*, which was only measured quarterly for one year.

Total suspended solids also shows no trend with time, while turbidity shows no discernable seasonal trend over time, but a peak value of about 8 NTU occurred in October, 1990.

5.2 WATER QUALITY OF THE TRIBUTARIES

Tributaries to the Indian River Lagoon include unaltered natural streams or creeks, altered natural drainages and man-made canals. Altered natural flowways have been extended or channelized, usually to drain an additional area or to alleviate a flooding situation. Almost all natural tributaries to the Indian River Lagoon have been altered. The tributary which has been altered the least and may be most representative of natural conditions is Turnbull Creek at the north end of Segment 1C of the Indian River Lagoon.

An example of a severely altered natural system in the Indian River Lagoon watershed is the North Fork of the St. Lucie River (Segment 4). Its tributaries - Ten Mile Creek, Five Mile Creek, and the North Fork of the St. Lucie River - serve as primary conduits for miles of canals designed to lower the ground water table and drain the land. A good example of man-made systems are the Vero North, Main and South Canals of the Indian River Farms Water Control District, near Vero Beach in Segment 3. These three primary canals also receive flows from miles of secondary canals. They are not part of an altered natural system; instead they have been cut through the Atlantic Coastal Ridge to discharge directly into the Lagoon.

Water quality data are available for tributaries of the Banana River (Segment 1B), North Indian River Lagoon (Segment 1C), North Central Indian River Lagoon (Segment 2), and South Central Indian River Lagoon (Segment 3). In the watershed of Mosquito Lagoon (Segment 1A), the few tributaries which are present have not been individually mapped or monitored. In the South Indian River Lagoon basin (Segment 4), there are basically only two tributaries (Taylor Creek and the St. Lucie River) and both are well mapped, but no water quality monitoring data was available in the SWIM data set at the time of this analysis.

Table 5-7 presents statistical information for all segments for which tributary data were available. None of the freshwater tributaries of Segment 1A are included in this data set. In addition, the SWIM data set at the time of this analysis did not include any water quality data for any tributaries of Segment 4, and thus Taylor Creek and the St. Lucie River could not be included in this analysis.

5.2.1 Segment 1B - Banana River Tributaries

The only significant tributary system in this segment is the Sykes Creek/Newfound Harbor system (Figure 5-4). However, there is very little seasonal difference in water quality values in this tributary system (Figure 5-19). This lack of seasonal patterns indicates that there is probably little influence of seasonal rainfall on water quality of Sykes Creek, and consequently this tributary might be considered more as a brackish extension of Banana River than as a true flowing tributary.

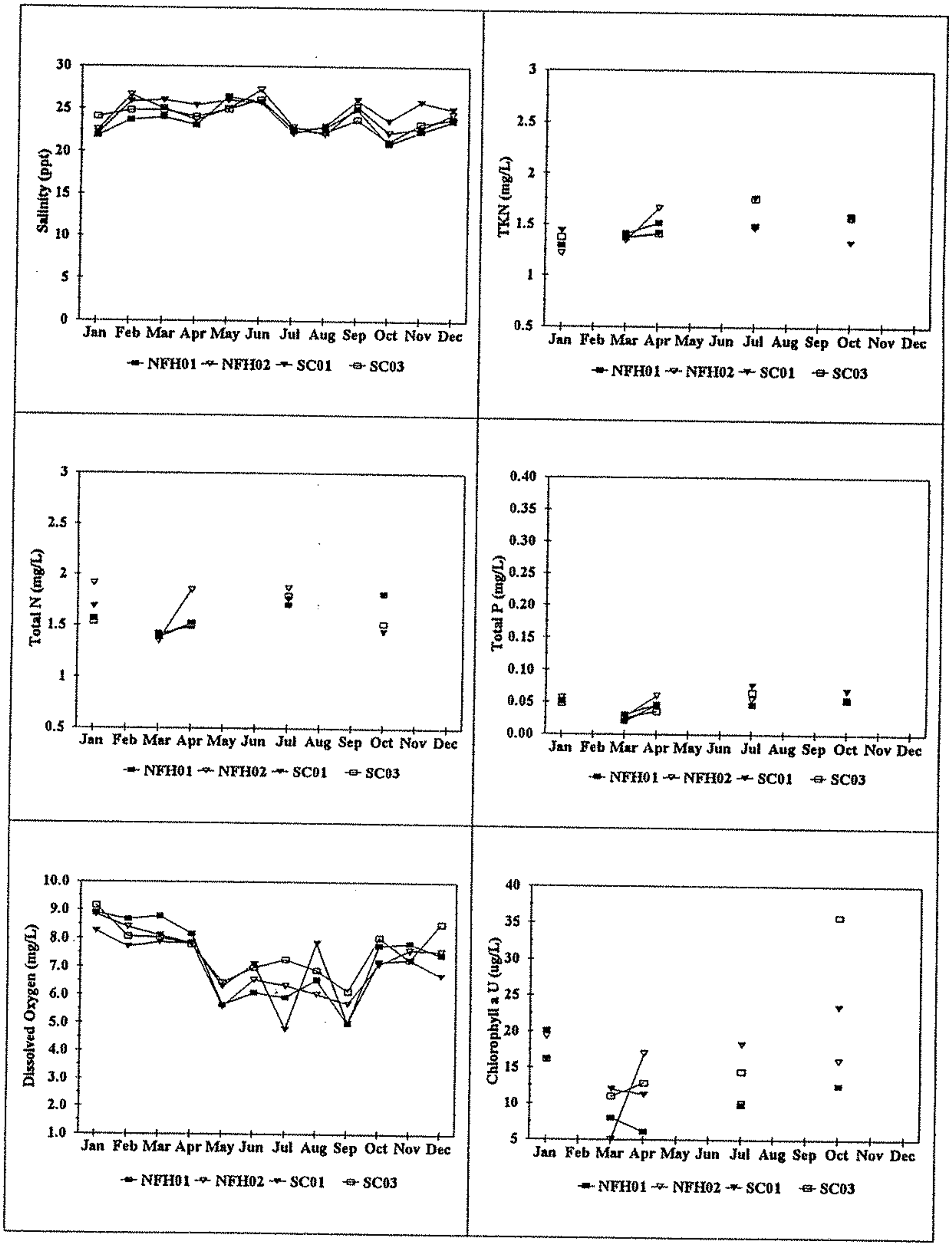
In the SWIM data set, values for most water quality parameters are slightly higher in the Sykes Creek stations (SC01, SC03) than in Newfound Harbor (NFH01, NFH02), but the ranges are generally comparable. The values are also similar to those found in the southern half of the Banana River proper. The 1988-1991 data from Newfound Harbor indicates that recent TP levels (0.02-0.08 mg/L) are about half as high as those (0.09-1.13 mg/L) reported by Windsor and Steward (1987) for the 1980-1985 period. The recent TN values (1.4 - 1.9 mg/L) are similar to the range (1.4 - 2.1 mg/L) reported for the 1980-1985 period. However, the TN concentrations in upper Sykes Creek (SC01) appear to have increased from annual means of about 0.6 mg/L in 1980 and 1.2 mg/L in 1985 (Windsor and Steward, 1987). Recent chlorophyll *a* concentrations (5 - 17 μg/L) are generally near the lower range of the 1980-1985 values (12 - 30 μg/L) for Newfound Harbor.

TABLE 5-7

TRIBUTARY WATER QUALITY STATISTICS BY SEGMENT

STATISTICAL PARAMETERS	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL *a* (µg/L)	TKN (mg/L)
SEGMENT 1C - NORTH INDIAN RIVER LAGOON										
Number of Samples	131	128	75	131	131	130	124	119	—	123
Maximum Concentration	8.60	38.5	2.00	32.0	600	112	0.48	3.57	—	4.01
Minimum Concentration	0.40	0.00	0.02	0.85	30.0	1.00	0.02	0.46	—	0.36
Average Concentration	4.50	11.7	0.57	7.75	122	12.0	0.13	1.69	—	1.55
Standard Deviation	1.81	12.9	0.32	7.20	101	17.3	0.08	0.75	—	0.80
SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON										
Number of Samples	122	117	83	116	105	107	101	98	—	101
Maximum Concentration	12.0	30.9	1.70	21.0	800	49.7	0.66	5.34	—	5.28
Minimum Concentration	0.54	0.00	0.25	0.14	10.0	1.00	0.006	0.13	—	0.05
Average Concentration	5.41	8.01	0.72	5.20	100	8.31	0.0797	1.11	—	1.10
Standard Deviation	1.92	9.41	0.26	3.86	127	9.25	0.075	0.60	—	0.60
SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON										
Number of Samples	129	123	136	127	123	123	117	102	12	118
Maximum Concentration	11.4	35.5	1.40	360	400	341	2.59	3.59	8.95	3.13
Minimum Concentration	2.40	0.00	0.05	0.50	5.00	1	0.02	0.08	1.02	0.4
Average Concentration	6.42	4.67	0.69	9.32	85.2	12.8	0.23	1.48	4.28	1.21
Standard Deviation	1.53	9.85	0.26	32.4	62.8	34.1	0.25	0.73	3.11	0.56

Note: Segment 2 data includes only Turkey Creek, Goat Creek, and Trout Creek.



Explanation: NFH01 = Newfound Harbor Station 1, NFH02 = Newfound Harbor Station 2
SC01 = Sykes Creek Station 1, SC02 = Sykes Creek Station 2

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FIGURE 5-19 MONTHLY AVERAGES FOR WATER QUALITY PARAMETERS OF THE TRIBUTARIES IN SEGMENT 1B - BANANA RIVER

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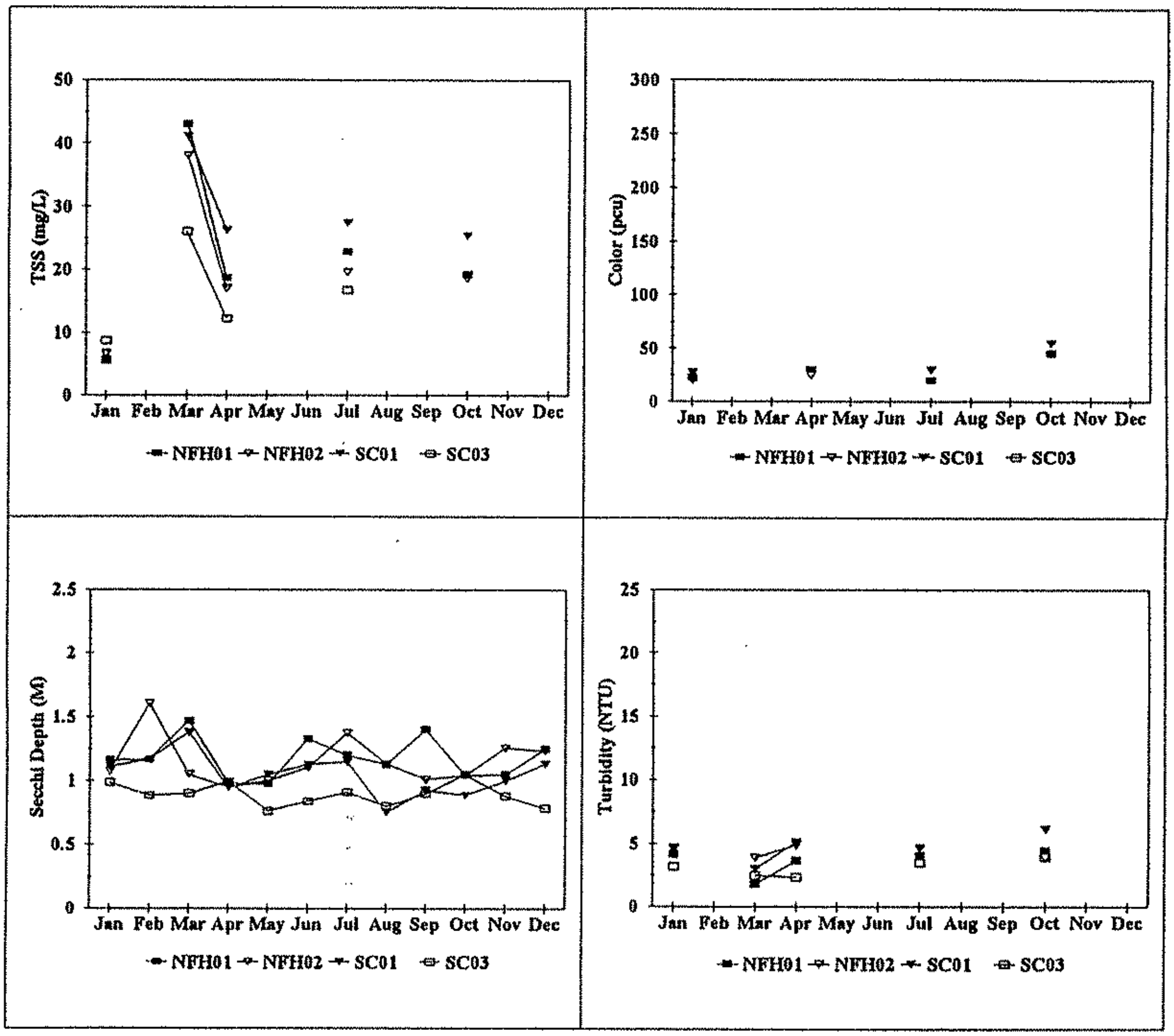

Explanation: NFH01 = Newfound Harbor Station 1, NFH02 = Newfound Harbor Station 2
SC01 = Sykes Creek Station 1, SC02 = Sykes Creek Station 2

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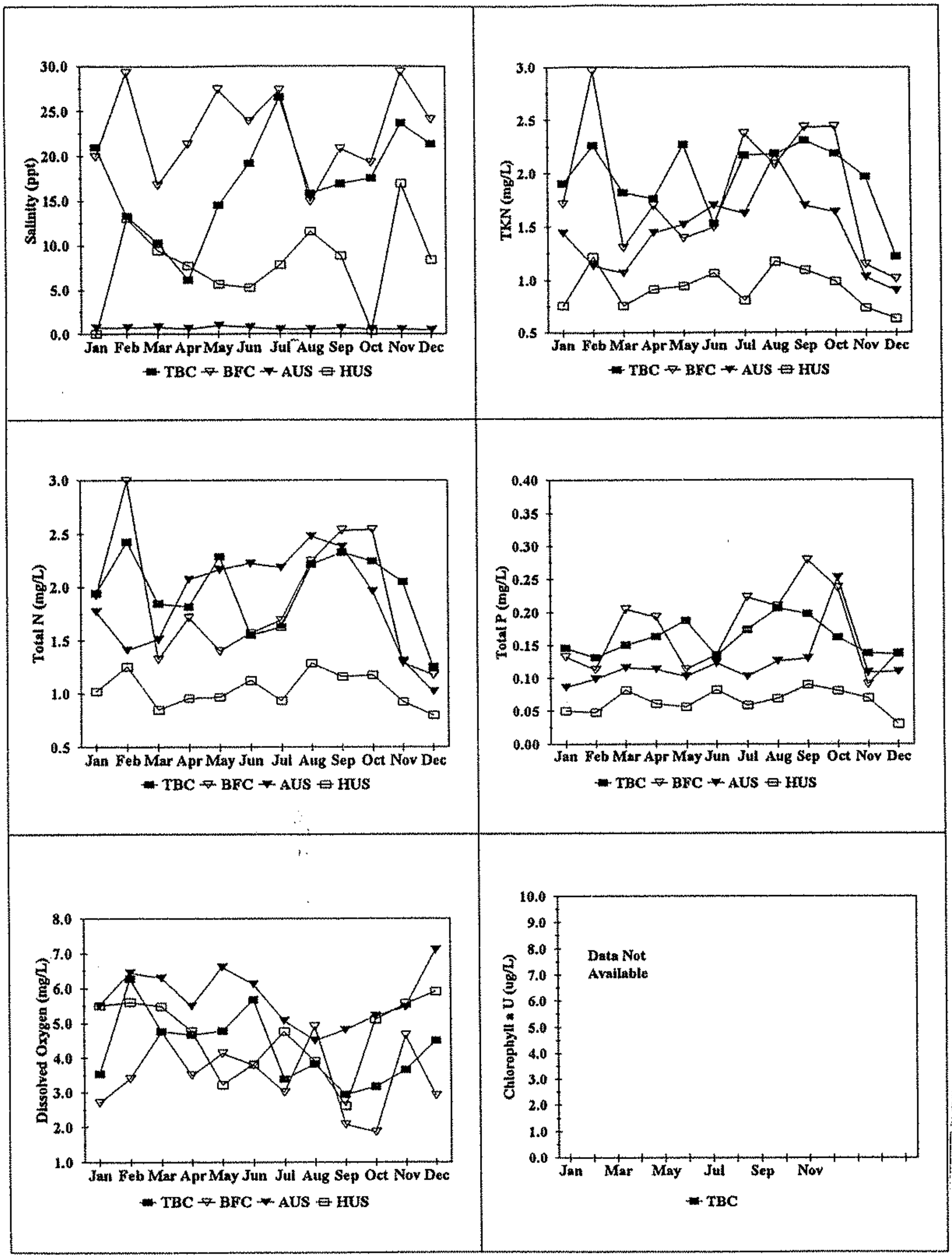
5.2.2 Segment 1C - North Indian River Lagoon Tributaries

Data are available for Turnbull, Big Flounder, Addison, and Horse Creeks (Figure 5-7). Turnbull Creek is at the extreme north end of Indian River Lagoon. Big Flounder Creek is also in the northern area, near Scottsmoor. Addison Creek is south of Titusville and previously drained a relatively large watershed before connections were severed. Horse Creek is at the southern end of the segment.

Figure 5-20 shows the monthly average water quality data from near the mouth of each of these four tributaries from the period 1989 to 1992. Although the period of measurement was identical for all tributaries, the monthly averages differ greatly. The highest salinity values are found in Big Flounder Creek (BFC) (15 to 29 ppt) and Turnbull Creek (TBC) (7 to 27 ppt). Turnbull Creek shows a seasonal cycle, being lower during the dry season. This is counter-intuitive because freshwater flows increase during the wet season. However, the location of the mouth of Turnbull Creek may subject it to wind driven flows from south and southeastern winds that are prevalent during the summer season (see Physical Features Technical Report). Saline water may be driven into Turnbull Creek, causing the high salinities in July. Addison Creek (AUS) is seen to be constantly fresh, at about 1 ppt. Horse Creek (HUS) is also relatively fresh, but more variable, ranging from 0.5 to 17 ppt.

The highest TKN concentrations also occur in Turnbull Creek and Big Flounder Creek. Horse Creek has relatively low TKN concentrations, close to the 1.1 mg/L average value for open water in the adjoining Lagoon, but the other three tributaries generally measure above 1.5 mg/L. There is a decline in November and December. In general, TKN concentrations in the tributaries exceeded the open water values by a factor of about 2 and are between 0.5 and 3.0 mg/L. For TN, the patterns are similar and the values for TKN and TN are not significantly different, except in Addison Creek. This indicates that organic nitrogen forms the bulk of the TN load from these creeks. In Addison Creek, TN is 0.25 to 1.0 mg/L higher than TKN, indicating a relatively high inorganic nitrogen (NO_2+NO_3) contribution from this watershed.

Total phosphorous in the tributaries is also higher than the Lagoon average concentration. The highest concentrations are in Turnbull Creek and Big Flounder Creek, with the lowest



Explanation: TBC=Turnbull Creek, BFC=Big Flounder Creek, AUS=Addison Creek at U.S. 1, HUS=Horse Creek at U.S. 1

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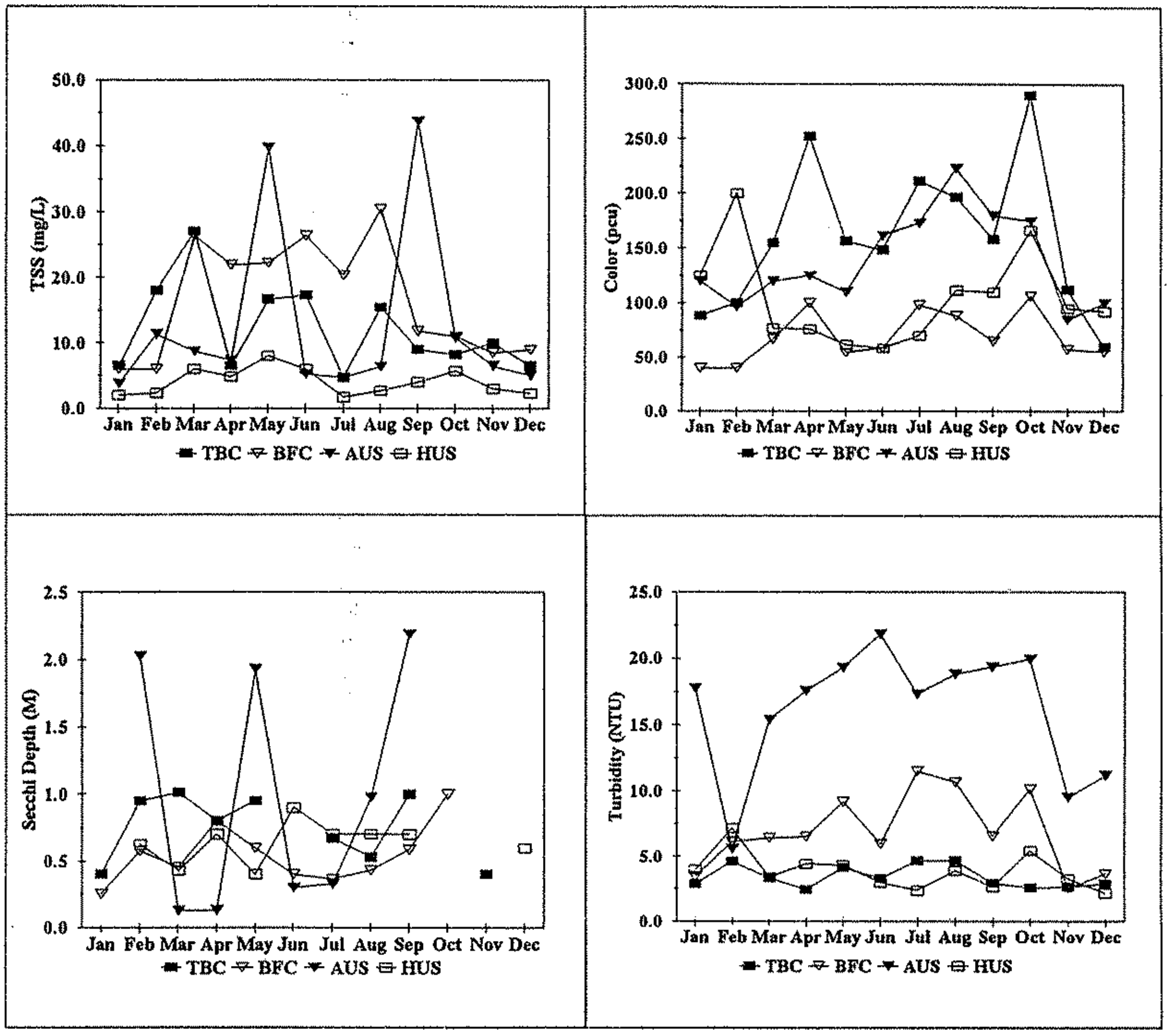

Explanation: TBC=Turnbull Creek, BFC=Big Flounder Creek, AUS=Addison Creek at U.S. 1, HUS=Horse Creek at U.S. 1

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values in Horse Creek. Horse Creek values range from 0.025 to 0.075 mg/L, while the values for the other three tributaries vary between 0.075 and 0.275 mg/L. No chlorophyll *a* data are available for these tributaries.

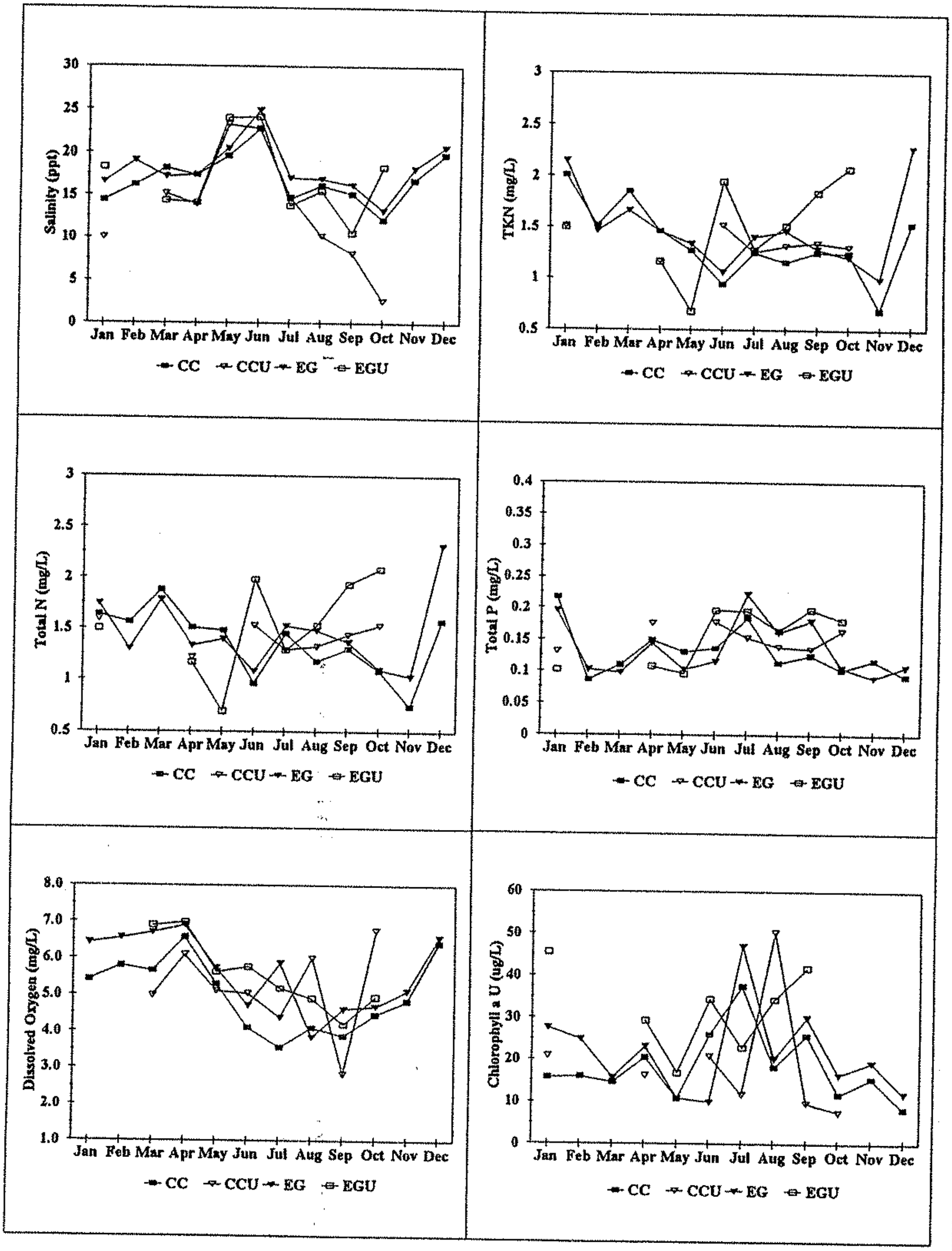
Dissolved oxygen is variable for all tributaries on a month-by-month comparison. A slight trend toward a wet season (summer) minimum is seen. In general, the highest DO values are seen in Addison Creek and the lowest in Big Flounder Creek. In Turnbull Creek, only two monthly averages are above 5.0 mg/L. In Big Flounder Creek, no values exceed 5.0 mg/L. For all four tributaries, monthly values were between 2.0 and 6.5 mg/L.

Total suspended solids values for Horse Creek are relatively constant and lower than at the other three stations, varying between 1.0 and 8.0 mg/L. Turnbull Creek and Big Flounder Creek are highly variable, ranging between 5.0 and 27.0 mg/L. Addison Creek varies between 5.0 and 45.0 mg/L for suspended solids, and shows large spikes for May and September. Turbidity is lowest in Turnbull Creek and Horse Creek, between 2.5 and 5.0 NTU. In Big Flounder Creek, turbidity value varies between 3.0 and 11.0 NTU. Addison Creek turbidity values are generally higher, from 5.0 to 22.0 NTU.

Tributary color values are 5 to 25 times higher than the Lagoon water average concentration (11 PCU). The lowest color concentrations are seen in Big Flounder Creek, ranging between 40 and 95 PCU. Turnbull Creek concentrations are among the highest values in the region, ranging between 50 and 280 PCU. Addison Creek and Horse Creek values are between these two stations.

5.2.3 Segment 2 - North Central Indian River Lagoon Tributaries

There are many altered natural tributaries in this basin. However, sufficient data for analysis are available only for the Eau Gallie River, Crane Creek, Turkey Creek, Goat Creek, and Trout Creek. Two stations on Turkey Creek - TUS at U.S. Highway No. 1 and TPM at Port Malabar Boulevard - have water quality data. There are also two stations each on Crane Creek and the Eau Gallie River. The Goat Creek (GUS) and Trout Creek (TRU) stations are at the U.S. Highway No. 1 bridge crossings. Figure 5-10 shows the location of tributary monitoring stations in this segment. Figures 5-21 and 5-22 present the data.



Explanation: CC = Crane Creek, CCU = Crane Creek At U.S. 1, EG = Eau Gallie River, EGU = Eau Gallie River At U.S. 1

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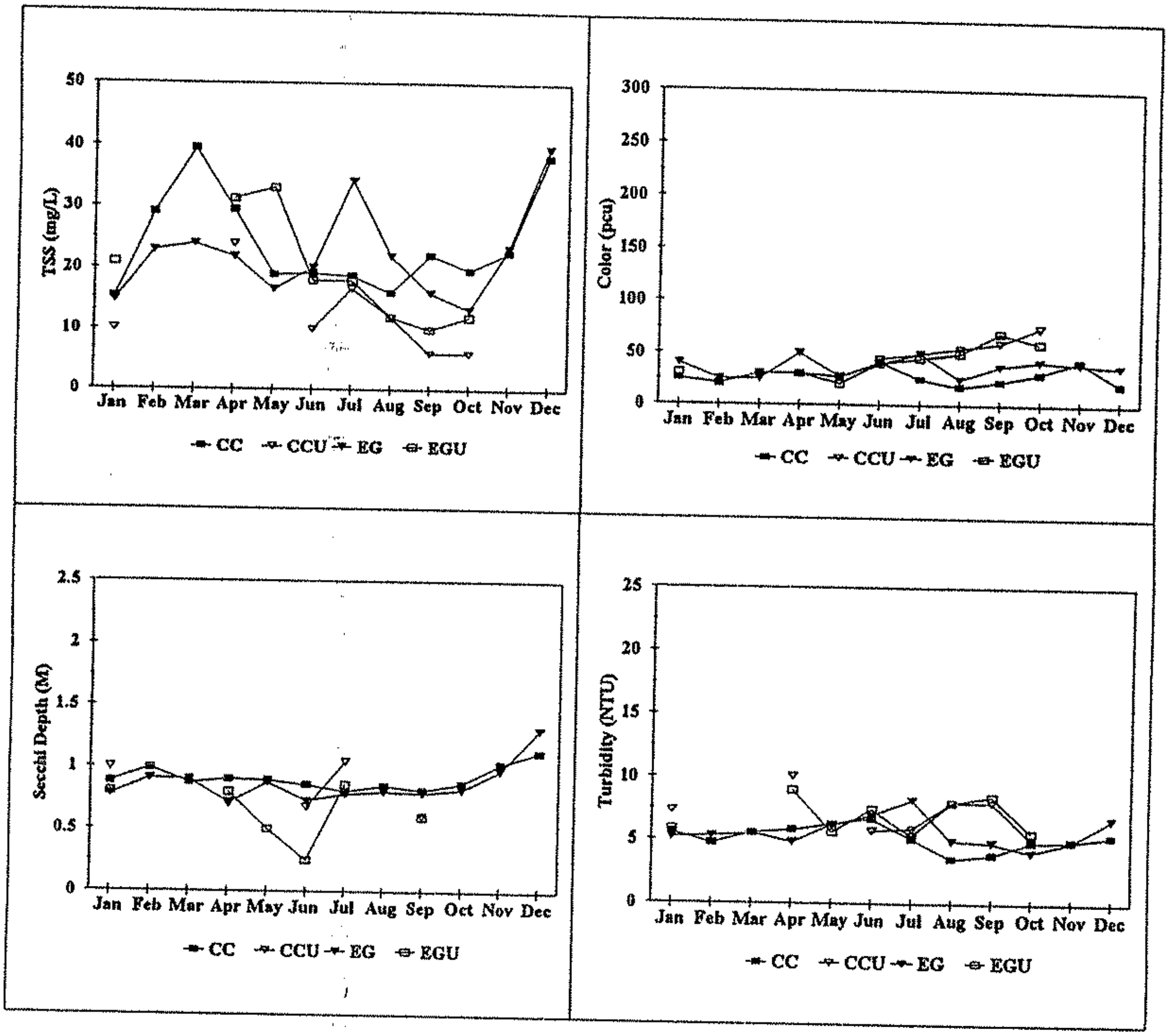

Explanation: CC = Crane Creek, CCU = Crane Creek At U.S. 1, EG = Eau Gallie River, EGU = Eau Gallie River At U.S. 1

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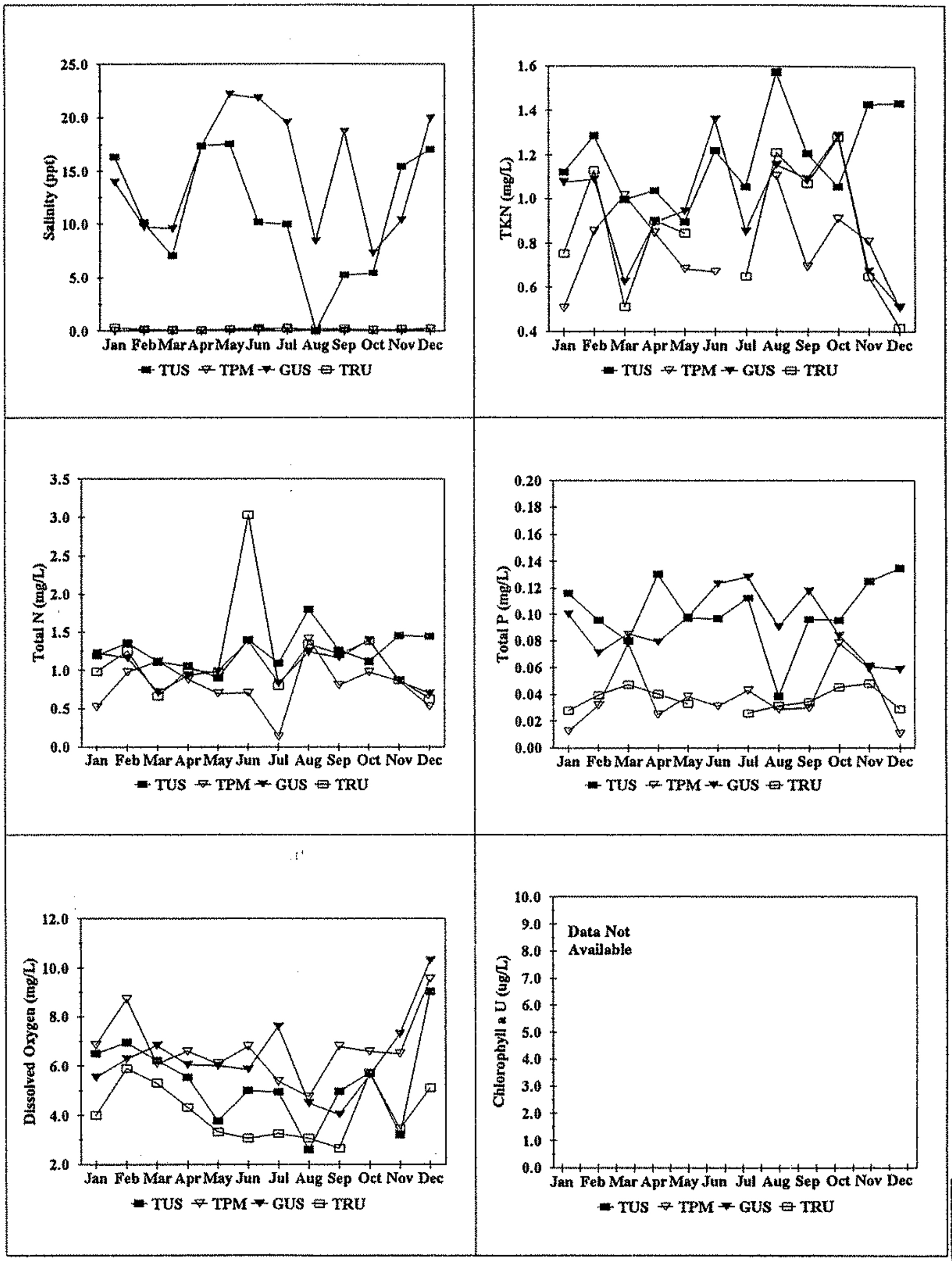

Explanation: TUS=Turkey Creek at U.S. 1, TPM=Turkey Creek at Port Malabar Blvd., GUS=Goat Creek at U.S. 1, TRU=Trout Creek at U.S. 1

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 5-22 MONTHLY AVERAGES FOR WATER QUALITY PARAMETERS OF THE SOUTHERN TRIBUTARIES IN SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON

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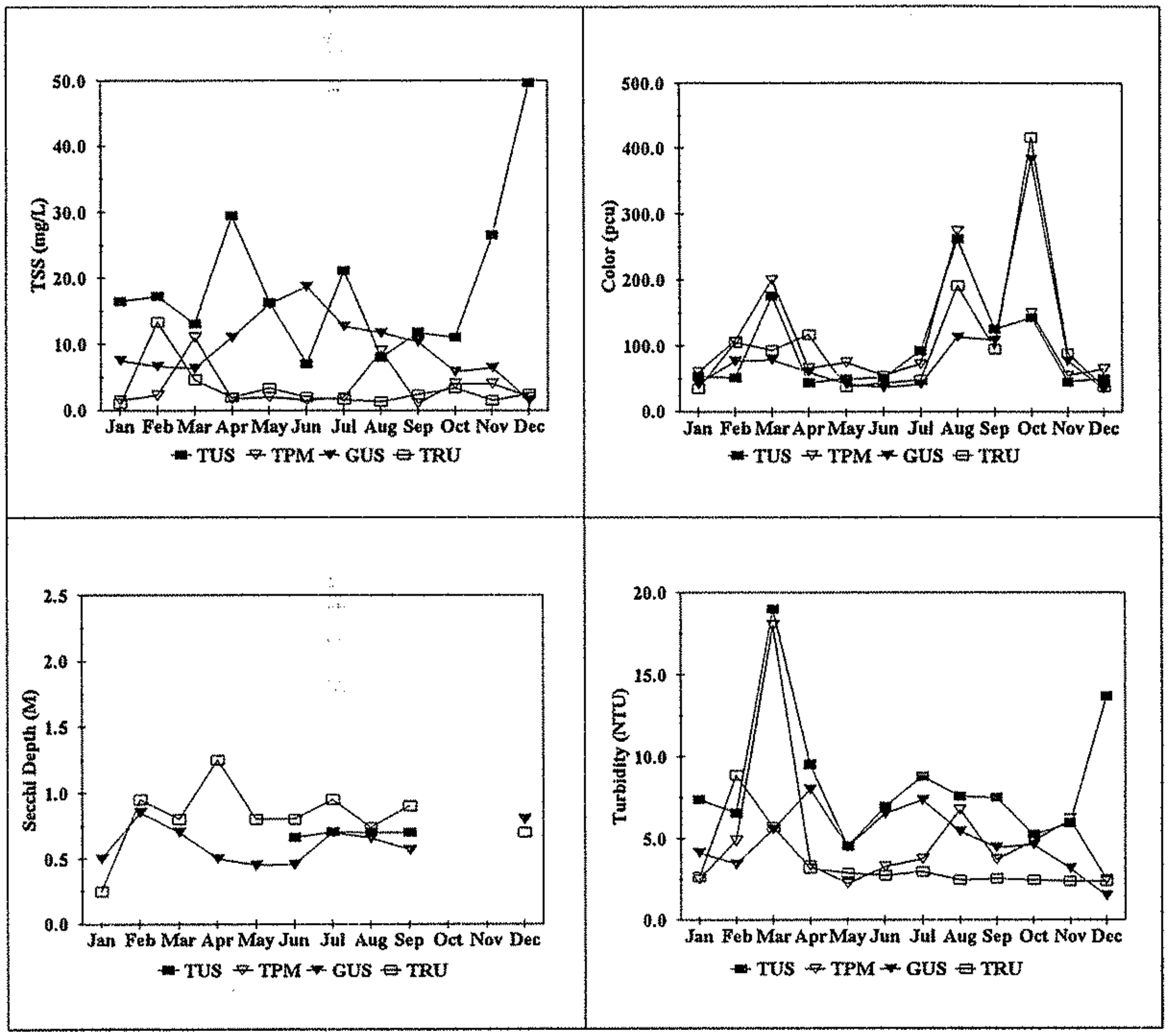

Explanation: TUS=Turkey Creek at U.S. 1, TPM=Turkey Creek at Port Malabar Blvd., GUS=Goat Creek at U.S. 1, TRU=Trout Creek at U.S. 1

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Salinity measurements show Trout Creek and Goat Creek to be essentially freshwater (0 ppt). Turkey Creek at U.S. Highway No. 1 and at Port Malabar Boulevard show variable behavior. Salinity at these stations varies from 0 to 22 ppt. Salinity in Crane Creek is similar to the Eau Gallie River, usually ranging between 12 and 22 ppt with peaks in May and June and a wet season decline from July to October.

Lowest TKN values are generally measured in Goat Creek. Higher concentrations occur in Turkey Creek at between 0.5 and 1.6 mg/L. Goat Creek averages between 0.5 and 1.1 mg/L, while the Trout Creek concentrations are between 0.4 and 1.3 mg/L. Total Kjeldahl nitrogen concentrations in Crane Creek and the Eau Gallie River are higher than in the other tributaries, generally ranging from 0.9 to 2.0 mg/L. By comparison, the average value in the open water of the adjoining Lagoon segment is 1.1 mg/L, not very much different than the tributary concentrations. Total nitrogen shows much less variability than TKN, and the TN values are quite similar for all tributaries in this segment.

Total phosphorous values for Goat Creek and Trout Creek are generally lower than in Turkey Creek, varying between 0.01 and 0.08 mg/L. Turkey Creek values vary between 0.04 and 0.14 mg/L, but are usually between 0.08 and 0.12 mg/L. The average TP concentration in the Lagoon in this segment is the same as the 0.07 mg/L average value for Turkey Creek. Crane Creek and the Eau Gallie River have high TP concentrations, from 0.1 to 0.21 mg/L. No seasonal behavior is readily apparent for any tributary. There are chlorophyll *a* data only for the Eau Gallie River and Crane Creek in this segment. Chlorophyll *a* concentrations in these two tributaries are among the highest in the Indian River Lagoon region, with values consistently above 15 μg/L. Average monthly chlorophyll *a* concentrations between 30 and 40 μg/L are common between June and September. Dissolved oxygen concentrations are highest in Goat Creek and lowest in Trout Creek. In Goat Creek, DO concentrations vary between 5.0 and 10.0 mg/L. In Turkey Creek, concentrations vary between 2.8 and 10.2 mg/L. In Trout Creek, the average DO concentrations are 3.5 mg/L or less for the months of May, June, July, August, and September. Highest values for Trout Creek occur in February (5.9 mg/L) and October (5.8 mg/L).

Values for total suspended solids are generally higher and more variable in the Eau Gallie River, Crane Creek, and Turkey Creek than in the other two tributaries. Goat Creek and

Trout Creek concentrations vary between 1.0 and 14.0 mg/L. Turkey Creek concentrations vary between 1.0 and 50.0 mg/L. Levels in Crane Creek and the Eau Gallie River generally range between 10.0 and 35.0 mg/L.

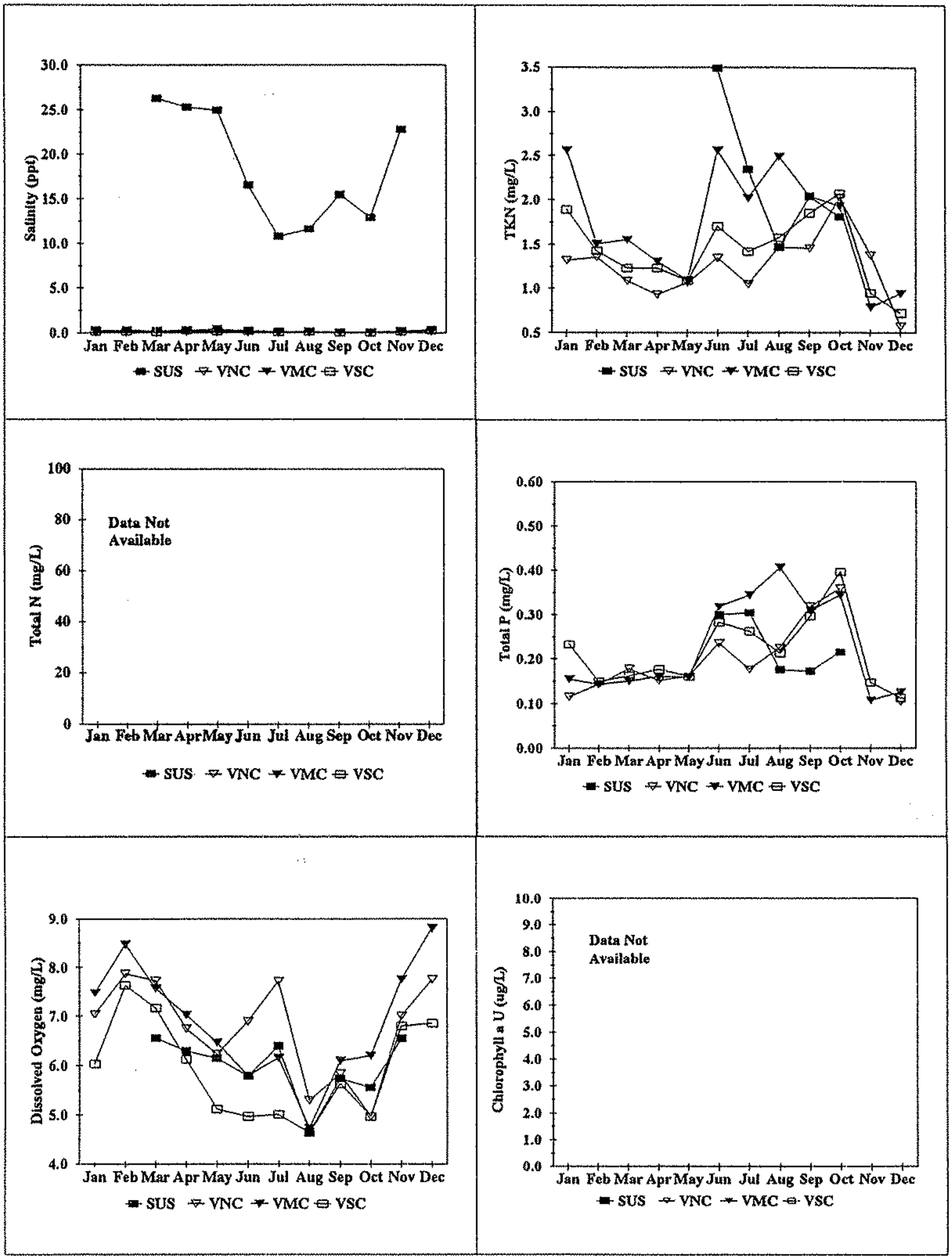
The Trout Creek turbidity values are generally the lowest, varying between 2.5 and 5.0 NTU. Goat Creek ranges from 2.5 to 7.0 NTU, except for one monthly average (March) of 18.0 NTU. The Eau Gallie River and Crane Creek turbidity values are similar to Trout Creek. Turkey Creek generally has the highest concentrations and the greatest range in monthly averages (2.0 to 19.0 NTU). There is no discernable seasonal trend.

Color values are similar for most tributary stations in this basin. Color concentration varies between 40 and 425 PCU, except in Crane Creek and the Eau Gallie River where it rarely exceeds 50 PCU. An increase in color concentration is seen from August through October in the wet season. The average Lagoon open water color value for this segment as shown is 11.6 PCU, so these tributaries very likely affect the color of the Lagoon water column.

In general, the concentration of most parameters is higher in Turkey Creek, Crane Creek, and the Eau Gallie River than in Goat or Trout Creek, although Trout Creek can be seen to have very low dissolved oxygen concentrations in the wet season.

5.2.4 Segment 3 - South Central Indian River Lagoon Tributaries

In the South Central Indian River Lagoon basin, four tributaries have sufficient water quality data for analysis. Figure 5-13 shows the location of monitoring stations. One station is in the Sebastian River at U.S. Highway No. 1 (SUS). The other three are just upstream from the discharge point of each of the primary canals serving the Indian River Farms Water Control District. These are designated VNC (Vero North Canal), VMC (Vero Main Canal), and VSC (Vero South Canal). Figure 5-23 presents the data for the tributary sites in this basin. Salinity is essentially zero in the three drainage canals. In the Sebastian River, salinity varies between 10.0 and 26.0 ppt.



Explanation: SUS=Sebastian River at U.S. 1, VNC=Vero North Canal, VMC=Vero Main Canal, VSC=Vero South Canal

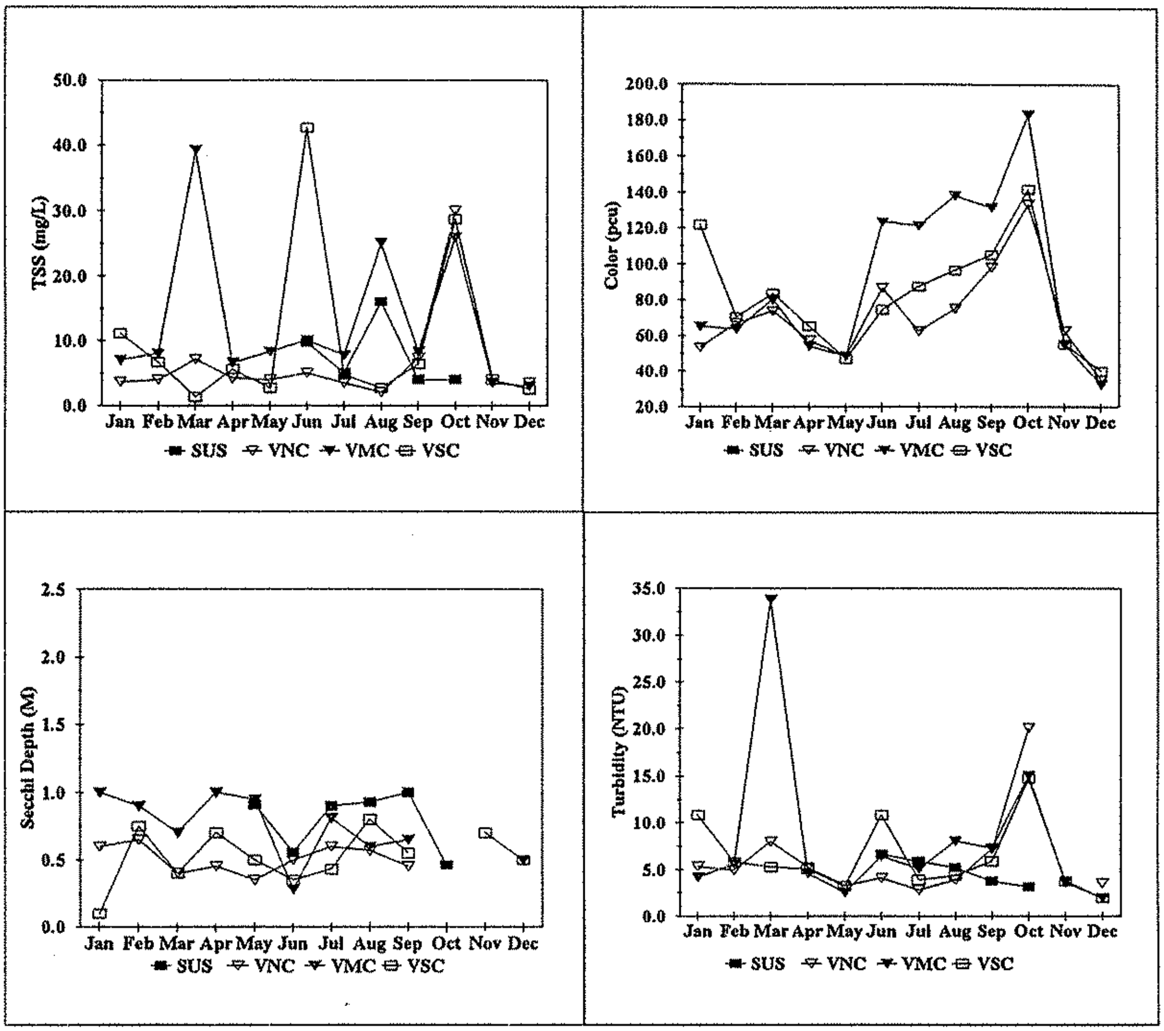
- Woodward–Clyde Consultants
- Marshall McCully & Associates
- Natural Systems Analysts

DRAWING NO.:

DATE:

FIGURE 5-23 MONTHLY AVERAGES FOR WATER QUALITY PARAMETERS OF THE TRIBUTARIES IN SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



Explanation: SUS=Sebastian River at U.S. 1, VNC=Vero North Canal, VMC=Vero Main Canal, VSC=Vero South Canal

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 5-23 (CONT) MONTHLY AVERAGES FOR WATER QUALITY PARAMETERS OF THE TRIBUTARIES IN SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

TKN is generally higher in the wet season. Concentrations are variable for all tributaries, ranging from 0.4 to 3.5 mg/L. No TN values are available for this segment. Total phosphorous values also show a trend toward higher wet season concentrations in all tributaries. From February to May, the concentration stays relatively constant at about 0.15 mg/L. From June through October, concentrations vary from 0.17 to 0.42 mg/L. Open water TP concentrations in this segment of the Lagoon are much lower, averaging 0.07 mg/L. No chlorophyll *a* data are available for the tributaries in this segment.

Dissolved oxygen shows a tendency toward lower values during the warm wet season for all stations. Only in August do the concentrations drop below 5.0 mg/L. In general, the concentrations vary between 4.7 and 8.8 mg/L.

Total suspended solids are highest in the Vero Main Canal (VMC). Values for all tributaries vary between 1.0 and 41.0 mg/L. Turbidity shows no seasonal trend and similar values occur in most months. With the exception of one data point, turbidity varies between 3.0 and 20.0 NTU.

Color shows the usual wet season increase. No color data are available from the Sebastian River. For February through May, color values vary between 48 and 81 PCU. From June through October, values vary from 60 to 185 PCU.

Table 5-8 presents average values of water quality parameters from a study of the Fellsmere Farms, Sebastian River, and Indian River Farms Water Control Districts (Harper and Marshall, 1993). This table shows that TKN, TN, and TP concentrations are consistently high compared to the Lagoon open water values shown in Table 5-5.

TABLE 5-8

AVERAGE CONCENTRATIONS FOR SELECTED WATER QUALITY PARAMETERS FOR FELLSMERE FARMS, SEBASTIAN RIVER, AND INDIAN RIVER FARMS WATER CONTROL DISTRICTS

PARAMETER	UNITS	SAMPLE SITE											
		1	2	3	4	5	6	7	8	9	10	11	12
pH (Field)[1]	s.u.	7.35	7.24	7.23	7.25	7.35	7.25	7.26	7.38	7.30	7.24	7.47	7.49
Dissolved Oxygen (Field)[1]	mg/L	5.6	5.0	4.9	4.7	5.2	4.7	5.1	6.0	5.9	4.2	7.6	5.9
Specific Conductivity (Field)[1]	μohms/cm	1193	1352	1236	1132	1253	1189	775	968	881	1930	1213	4886
Ammonia-N	μg/L	121	272	206	132	98	141	99	57	130	131	62	56
NO_x-N	μg/L	363	534	327	140	231	187	166	364	586	119	118	99
Dissolved Organic Nitrogen	μg/L	852	918	790	764	719	732	619	677	586	752	657	699
Particulate Organic Nitrogen	μg/L	261	207	173	178	225	153	264	113	162	256	124	249
Total Nitrogen	μg/L	1598	1929	1498	1213	1273	1214	1150	1207	1459	1257	965	1102
Dissolved Ortho-Phosphorus	μg/L	247	148	144	230	159	289	48	50	55	246	89	212
Dissolved Organic Phosphorus	μg/L	22	25	24	23	19	27	11	13	16	26	14	18
Particulate Phosphorus	μg/L	50	84	65	67	73	52	68	36	53	82	64	66
Total Phosphorus	μg/L	320	257	233	319	251	368	126	99	123	354	167	296
S.S.	mg/L	30.6	5.3	6.8	5.3	9.2	3.5	26.7	6.1	10.8	5.7	9.3	7.9
V.S.S.	mg/L	6.2	2.5	3.0	2.9	3.7	2.1	6.5	2.4	3.6	3.1	3.0	4.0

1 = Average of vertical depth profiles collected at each station.

6.0
TRACE METALS IN THE INDIAN RIVER LAGOON SYSTEM

In unimpacted systems, the presence of metals in water, sediments, and organisms is relatively low and is characterized by relatively stable background average levels and ratios between several metals. Increased concentrations in Florida are generally associated with the fairly recent development of industrial technologies which have increased levels of metals such as copper (Cu), cadmium (Cd), mercury (Hg), lead (Pb), and Zinc (Zn). In Florida there has been relatively little anthropogenic introduction of aluminum (Al).

Consequently the ratio of the concentration of aluminum to other metals within sediments has been used as an indicator of the level of metal pollution or of the degree to which a metal is present above natural "background" levels in sediments (Trefry, et al., 1987; Hand and Paulic, 1992). In Florida, FDEP (Hand and Paulic, 1992) has performed extensive sampling for metal concentrations and has developed estimates of the natural ranges or background levels of metals in surface waters, sediment, and tissues of some organisms. For each type of metal, the estimate is based on either the ratio of the metal concentration to that of aluminum in the sample material (for sediments only) or on the average concentration of the metal found in the extensive sampling program. While no state standards exist for metal concentrations in sediments or tissues, these FDEP background levels can be used as indicators of the relative level of metals pollution in a system.

The primary means of expressing the metals data in Sections 6.0 and 7.0 depends on the units most often reported by the original researchers. In most cases, this has been in parts per million (ppm) or parts per billion (ppb) for tissue and sediment samples and as μg/L for water samples. Both metric concentration and ppm values are given for sediment and tissue data in the text. Any conversion shown from μg/L to ppm or ppb is approximate since the actual ratio depends on density factors of water influenced by salinity or temperature. However, 1 μg/L is approximately equal to 1 ppb.

FDEP has established state water quality standards for metals in surface waters under Chapter 17-302, FAC. The standards for metals covered in this report which are applicable to the Indian River Lagoon and are identical for both Class II and Class III waters, are a maximum less than or equal to:

- 9.3 μg/L for cadmium (Cd)
- 2.9 μg/L for copper (Cu)
- 0.3 μg/L for iron (Fe)
- 0.025 μg/L for mercury (Hg)
- 5.6 μg/L for lead (Pb)
- 86.0 μg/L for zinc (Zn)

Sections 6.1 and 6.2 discuss the status of trace metals in the surface waters and in tissues of organisms in the Indian River Lagoon. Section 7.0 includes data on the metals concentrations in sediments.

The SWIM Indian River Water Quality Monitoring Network does not include a component for the trace metals, so information for describing the status must come from other sources. Information for identifying the full spatial extent of trace metal distribution is relatively limited for the Indian River Lagoon system. Previous studies which have evaluated the occurrence of trace metals in the water column and sediments include Scofield (1973), Fettes (1975), Tower (1975), Takayanagi (1978), Trefry, et al. (1987), Trefry, et al. (1990a), Hand and Paulic (1992), and Trocine and Trefry (1993). Much of this discussion is based on the Trocine and Trefry, 1993 report which provides a good discussion of trace metal distribution in the Lagoon. Trace metal data collected prior to 1975 generally is considered to be unreliable because of analytical inadequacies of the period, or sampling contamination during collection or laboratory analysis (Trocine and Trefry, 1993). In this chapter, the trace metals status in waters of each of the segments of the Lagoon is first discussed, followed by a summary of the data concerning accumulation in living organisms of the Lagoon.

6.1 TRACE METALS IN THE WATER COLUMN

6.1.1 Historic Data

The available data for the Indian River Lagoon system prior to 1992 are limited mainly to unpublished data collected by FDEP in 1983-1984 (Hand, et al., 1986; Hand and Paulic, 1992). Locations where data were collected include Port Canaveral, Banana River, and the Canaveral Barge Canal. This data indicates that cadmium (Cd), copper (Cu), and nickel (Ni) were apparently within FDER (now FDEP) surface water quality standards in Mosquito Lagoon (Segment 1A), Banana River (Segment 1B), and the North Indian River (Segment 1C) areas. Iron (Fe), mercury (Hg), and zinc (Zn) had very high reported values, but these data may not be truly indicative of the condition due to possible inadequacies of analytical methods.

Very high Cu concentrations [ranging from 0.6 to 5.6 μg/L (approximately 0.6 to 5.6 ppb)] were reported in the FDEP 1983-84 data near marinas between the Eau Gallie River at Melbourne and Sebastian River in the North Central Indian River Lagoon (Segment 2). FDEP associated these high levels with antifouling paints used on boats. Holbrook (1984) found that Cu concentrations in the marina basins were 3 to 10 times higher than background levels established in Eau Gallie Harbor. Goulet (1985) reported that urban runoff to this segment of the Lagoon contained soluble lead (Pb) ranging from 19.5 to 200 μg/L and particulate Pb ranging from 23 to 76 μg/L.

The FDEP (1983-1984) data for the Ft. Pierce area in the South and South Central Indian River Lagoon (Segments 3 and 4) gives only limited indications of trace metal concentrations in surface water within these segments. The highest concentrations recorded at Ft. Pierce Harbor and Taylor Creek within the South Indian River Lagoon area (Segment 4) are listed in Table 6-1.

All of the maximum values shown in Table 6-1 were below the FDEP surface water quality standards except for iron and mercury. Mercury values were noted to have a high detection limit (1 μ/L), and thus can not be compared to the current standard which is below this detection limit. Maximum iron concentrations in both Taylor Creek and Ft. Pierce harbor were much greater than state standards.

TABLE 6-1

MAXIMUM REPORTED METALS CONCENTRATIONS IN WATERS OF THE INDIAN RIVER LAGOON SYSTEM FROM FDER SAMPLING IN 1983-84

MAXIMUM REPORTED VALUES IN SOUTH INDIAN RIVER LAGOON (SEGMENT 4) - 1983-84		
	CONCENTRATION (μg/L)	
TRACE METAL	TAYLOR CREEK	FT. PIERCE HARBOR
Cd	0.07	0.12
Cu	2.6	1.2
Fe	36	17
Hg	<0.1	<0.1
Ni	0.88	1.3
Pb	0.47	0.59
Zn	2.2	2.0

Source: Trocine and Trefry, 1993

6.1.2 Recent Surveys

In 1992, a system-wide survey was conducted for trace metals in water, sediment, and organisms (Trocine and Trefry, 1993). A summary of the information for concentrations in water are presented below. For the 1992 study, sampling protocols and methods were established for a network of sampling locations that ranged the full length of the system. The comprehensive baseline study, which consisted of field sampling at 36 locations from February to October 1992, used dissolved Cd, Cu, and Pb as indicators of potential toxicity to biota in the Lagoon (Trocine and Trefry, 1993).

<u>Cadmium</u>

The mean surface water dissolved Cd concentration in 1992 within the Indian River Lagoon system was found to be 0.006 ± 0.005 μg/L, while the range varied from 0.001 to 0.021 μg/L (Trocine and Trefry, 1993). Concentrations greater than 0.016 μg/L for Cd occurred at Taylor Creek near its confluence with Indian River Lagoon, and in the south end of Banana River near Patrick Air Force Base. The concentrations between 0.016 and 0.021 μg/L are, however, within the normal range of coastal ocean values for Cd. The concentrations at the remaining sites within the Lagoon are much lower than this upper range and may be more typical of the Lagoon as a whole.

The highest Cd levels were about three times higher than the Lagoon-wide average, but all values were substantially below FDEP surface water quality standards. Probable sources of Cd for the Lagoon are unknown, but Cd is generally of industrial origin.

<u>Copper</u>

Dissolved Cu concentrations within the surface water of the system ranged from 0.207 to 5.55 μg/L. The Cu data indicates an overall increase in concentrations from north to south, with a greater anthropogenic input to the Lagoon of Cu than of Cd. The data indicated the same geographic patterns as the pre-1992 data, with elevated Cu concentrations at Eau Gallie Harbor, Melbourne Harbor, and Turkey Creek in Segment 2, and in all of the Indian River Lagoon stations between Vero Beach and Manatee Pocket. The highest concentrations were found within Manatee Pocket. All stations with elevated Cu levels were described as being in areas with high boat densities. Release from marine antifouling paints was considered to be a major source of Cu.

The established background value for dissolved Cu within the open waters of Indian River Lagoon was reported as 0.4 ± 0.2 μg/L (Trocine and Trefry, 1993), so some of the reported values were ten times higher than the average level. The high Cu concentrations found in Manatee Pocket were above the FDEP surface water quality standard for Cu, with the highest level almost twice the state standard. Average levels within the Lagoon itself were about ten times lower than the standard.

<u>Lead</u>

Dissolved Pb concentrations within the Lagoon system ranged from 0.003 to 0.132 μg/L. The pattern of Pb concentration within the system is similar to that of Cu. Freshwater outfalls and sheltered harbors contained elevated Pb concentrations, whereas the open waters of the Lagoon were at or below the established statewide background level (0.014 ± 0.007 μg/L). The highest dissolved Pb values (over 0.100 μg/L) were found in Manatee Pocket. A comparison of trends between Pb and Cu showed dissimilarities at three areas. The Titusville stations showed enriched Pb, but relatively low Cu concentrations. For the Vero Beach and Jensen Beach stations, dissolved Pb was low and dissolved Cu was relatively high.

Trefry and Trocine (1993) point out that substantially higher Cu and Pb levels have been reported from several other United States estuaries than have been found in the Indian River Lagoon survey. The lead levels found in the 1992 Indian River Lagoon survey appear to be within state surface water quality standards. Possible sources of Pb may include stormwater polluted with Pb from automobile emissions, gasoline spills, and lead in paint (including marine anti-fouling paints). Lead has now been removed from gasoline and paints, so inputs to the Lagoon may now be decreasing.

In summary, dissolved Cd concentrations in the Indian River Lagoon as a whole are relatively low and within the FDEP-assumed normal range for coastal waters and within the state water quality standards. As such, they should not pose a threat to organisms (Trocine and Trefry, 1993). Dissolved Pb and Cu concentrations are higher, but overall are still much less than those found in many other estuaries. The highest Cu and Pb levels recorded in the Lagoon have been up to ten times higher than the Lagoon average or normal background levels. Some copper levels may be above state surface water quality limits, but overall, Cu and Pb levels do not appear to be a threat. The highest water column concentrations of metals have been found in the south Banana River (Cd), Eau Gallie and Melbourne Harbors (Cu, Pb), Taylor Creek (Cd), Manatee Pocket (Cu, Pb), and the Indian River Lagoon itself from about Vero Beach to the St. Lucie Estuary (Cu).

The range of Cu values reported in the 1992 survey was very similar to that of the 1983-84 data (Hand, et al., 1986), with nearly identical maximum values of about 5.6 μg/L in both periods. Maximum Pb concentrations in the 1992 survey were substantially less than those reported in 1983-84. These numbers indicate that lead levels may be decreasing in the surface waters of the Lagoon system, while copper levels may be remaining relatively constant. There is insufficient historic data on the other metals to draw any conclusions.

6.2 TRACE METALS IN ORGANISMS

Cardeilhac, et al. (1981) reported that one of the most notable metal contamination events associated with pollution occurred in 1980 within the northern-most segments of the Indian River Lagoon complex. At that time, the death of more than 100 red drum fish was attributed to high concentrations of arsenic, copper, and zinc. No actual sources of metals, however, were verified, but stomach analyses indicated that blue crabs may have been involved as a carrier. Steward, et al. (1980) have reported that cadmium, copper, lead and zinc in the hard clam *(Mercenaria mercenaria)* were 3 times higher in clams collected in Port Canaveral than in clams found within the North Central Indian River Lagoon (Segment 2). Fettes (1975) concluded that chromium and copper concentrations in plant tissue of white mangrove (*Laguncularia racemosa*) did not vary significantly throughout the Banana River. However, Cd, Fe, Pb, and Zn concentrations were variable. The Fettes (1975) study concluded that the Kennedy Space Center was not creating a metal contamination problem. Within the South Central Indian River Lagoon (Segment 3), Scofield (1973) believed that low concentrations of mercury within oyster (*Crassostrea virginica*) tissue in 1973 indicated only limited sources of mercury in the Lagoon watershed. In a 1980 study of Cu and Fe in hard clam tissues at five sites from Melbourne to Vero Beach, Steward (1980) concluded that concentrations of Cu and Fe in clam tissues decreased with increasing size of the clam and that dissolved and particulate Cu and Fe were the metal contaminants of the clams.

Venuto and Trefry (1983) reported Cu and Zn concentrations for muscle tissue of the ubiquitous black mullet (*Mugil cephalus*) collected from Turkey Creek averaged less than 1.1 ppm (1.1 $\mu g/g$) for Cu and 13 ppm (13 $\mu g/g$) dry wt for Zn. These values are slightly higher than those reported in other areas of the Lagoon and coastal regions of Florida (Venuto and Trefry, 1983). Barber and Trefry (1981) and Trefry, et al. (1983) studied Cu and Zn concentrations from barnacles (*Balanus eburneus*) in Eau Gallie Harbor. Their results indicated that Cu concentrations were 5 to 10 times higher than in barnacles collected outside of the harbor. Zinc levels in barnacles within the harbor were 14 to 29 times greater than samples from outside the harbor. These studies also indicated that Cu in samples of the blue crab (*Callinectes sapidus*) were higher in individuals within the harbor than in adjacent Lagoon waters. Morton (1978) collected bluefish (*Pomatomus salatrix*) samples from Sebastian Inlet and determined that Cd, Cu, and Zn concentrations in liver tissues were relatively low and within natural levels.

Bivalve mollusks have been often used as indicator organisms for trace metal contamination. The 1992 Toxic Substances Survey (Trocine and Trefry, 1993) used the filter-feeding hard clam to evaluate bioaccumulation within the Lagoon system. In the open waters of the Lagoon, the number of clams found decreased greatly south of Sebastian Inlet. No clam samples were collected in Eau Gallie Harbor, Melbourne Harbor, Turkey Creek, Sebastian River, and Manatee Pockets reportedly due to the fact that clams cannot survive within the sulfide-rich muck sediments of these areas (Trocine and Trefry, 1993).

The range of Cd concentrations in clams of the Indian River Lagoon complex was found to range from 0.07 to 1.09 ppm (Trocine and Trefry, 1993). The highest concentrations were found in clams from the south Banana River. Heil (1986) reported mean values in clams to be 0.14 ppm and 0.21 for the Body C and Body F shellfish areas respectively in Brevard County and 0.28 ppm for Indian River and St. Lucie Counties (Vanderbleek, 1992, 1993; Royal, et al., 1992). The Cd values found are generally at the low range of Cd concentrations (0.7 to 5.1 ppm) from oysters (*Ostra equestris and C. virginica*) collected throughout Florida's coastal waters (Trocine and Trefry, 1993) and similar to the ranges

(0.05 to 1.05 ppm) reported from clams in Florida Approved or Conditionally Approved shellfish waters (Royal, et al., 1992).

Chromium concentrations of clam samples in 1992 ranged from 0.16 to 0.53 ppm. The highest Cr concentration was found in samples collected in Banana River (Segment 1B) near Patrick Air Force Base. Values reported from 1984 averaged 0.19 ppm for Body C, 0.20 ppm for Body F, and 0.28 ppm for Indian River and St. Lucie Counties (Heil, 1986). The baseline average concentration of Cr in hard clams from the Lagoon system is estimated at <0.3 ppm (Trocine and Trefry, 1993).

In 1984, mean Cu values of 3.30 ppm in Body C, 1.81 ppm in Body F, and 2.09 ppm in the Indian River/St. Lucie Counties area were obtained (Heil, 1986). Copper concentrations in clam tissue samples in 1992 ranged from 6.3 to 26.9 ppm with the highest values found in clams from the Titusville and Cocoa areas of the North Indian River Lagoon (Segment 1C). Trocine and Trefry (1993) estimated that natural concentrations of Cu in hard clams were less than 10 ppm, while the reported statewide range for approved waters was from 1.0 to 4.7 ppm (Royal, et al., 1992). Mortality of mature clams has been reported to occur when dissolved Cu concentrations in the water column exceed 25 ppb (25 μg/L), and larval mortality has been reported at 16.4 ppb (16.4 μg/L) Cu in the water column (Shuster and Pringle, 1968; Calabrese, et al., 1977). As reported in Section 6.1, Cu concentrations in Indian River Lagoon waters have been found to be generally about an order of magnitude below these possibly toxic levels.

Trocine and Trefry (1993) found Hg concentrations in hard clams ranged from 0.012 ppm to 0.117 ppm in the Indian River Lagoon system. Mercury concentrations over 0.1 ppm were encountered only in clams from just outside Eau Gallie Harbor in the Indian River Lagoon proper and from the Banana River south of Patrick Air Force Base. Mercury concentrations in clam tissues in 1984 were reported to average 0.02 ppm near Bodies C and F in Brevard County and 0.03 ppm in St. Lucie and Indian River Counties with a maximum of 0.05 ppm noted (Heil, 1986). Although Trefry and Trocine (1993) estimated average natural background Hg levels in clams in the Indian River Lagoon system to be no greater than 0.05 ppm, about half of their 1992 sample stations had concentrations above the maximum 0.05 ppm maximum noted in the 1984 data. The data suggest that Hg is not a significant contaminant in Indian River Lagoon clams (Trocine and Trefry, 1993).

Iron concentrations in Lagoon clams ranged from 55 to 332 ppm (Trocine and Trefry, 1993). The highest values were found north of the Bennett Causeway (SR 528) at Cocoa. Trocine and Trefry (1993) suggest that the baseline average Fe concentration is <100 ppm for clams. Mean Fe concentrations in clams in 1984 were recorded as 50 ppm in Body C, 57 ppm in Body F, and 65 ppm in St. Lucie/Indian River Counties (Heil, 1986). These levels were similar to statewide averages.

Lead concentrations in clams in 1992 ranged from 0.29 to 11.54 ppm with the higher concentrations in Segment 1C in the Cocoa area and to a lesser degree in Banana River (Segment 1B) near Patrick Air Force Base (Trocine and Trefry, 1993). The high concentrations may be associated with wastewater discharge and urban/industrial runoff (Trocine and Trefry, 1993). Some lead concentrations in clams in this study were significantly greater than the ranges found for clams (0.23 ppm to 1.36 ppm) and oysters (0.1 to 1.6 ppm) collected throughout Florida's coastal waters in 1984 (Vanderbleek, 1992). Mean Pb values in Indian River Lagoon clams were reported as 0.44 ppm and 0.49 ppm near Bodies C and F and 2.1 ppm in St. Lucie/Indian River Counties in 1984 (Heil, 1986). The natural concentration for Pb in clams in the Lagoon is considered to be less than or equal to 1 ppm (Trocine and Trefry, 1993).

The 1992 distribution of Zn was found to be similar to that for Pb, with values in clams ranging from 11 to 353 ppm. The baseline value for Zn in clam tissues of the Lagoon, according to Trocine and Trefry, (1993) is less than 70 ppm. Values reported from 1984 included a maximum concentration of 25 ppm (Heil, 1986). Zinc concentrations are considered to be more toxic to bivalves than Pb.

The data for metal accumulation in tissues of Indian River Lagoon organisms is still too limited to support definitive conclusions concerning the levels of metal contamination in tissue and the potential effect on the organisms. It is far too limited to identify trends at this time. Preliminary indications are that Cu, Pb, and Zn levels in some locations may be at a level potentially affecting hard clams and oysters, particularly in parts of Banana River (Segment 1B), around the Eau Gallie Harbor (Segment 2 - North Central Indian River Lagoon), and in parts of the Cocoa-Titusville area of the North Indian River Lagoon (Segment 1C).

Numerous bivalve tissue samples have been collected throughout Florida estuaries as part of the "Mussel Watch" element of the national NOAA Status and Trends Program (Goldberg, et al., 1983; Boehm, et al., 1988). Trefry and Trocine (1993) indicate that, in comparison to average data from this program, hard clams in some parts of the Indian River Lagoon may have a higher range of Zn and Pb tissue concentration than the average ranges found throughout the state, but that concentrations of other metals are generally at or below average levels.

At present, standards or guidelines for permissible levels of metals in shellfish for human consumption have been established only for mercury. An action level of 1.0 ppm has been established for methyl mercury expressed as mercury (Hg) by the U.S. Food and Drug Administration (USFDA, 1993). The action level is a level at which FDA will take legal action to remove shellfish from the market. The highest concentrations found by Trefry and Trocine (1993) in hard clam tissues have been well below this action level, so existing information and guidelines appear to indicate that metals concentrations in hard clams in most of the Indian River Lagoon do not constitute a human health problem at this time.

7.0 SEDIMENTS

The Indian River Lagoon is a dynamic settling basin. Although sedimentary processes are slow in comparison with the characteristic time scales of waves and currents, these processes are constantly acting to change the shape and composition of the Lagoon. The consideration of sediments in the Lagoon system can be separated into discussions of physical and chemical parameters. In this chapter, there is a brief description of the overall distribution of sediments in the Lagoon, followed by a summary of information regarding sediment contamination. Finally, there is a discussion of shoaling and maintenance dredging issues.

Sandy sediments, comprised mainly of quartz and shell fragments, make up the major portion of the bottom sediments throughout the Lagoon system. The sand and shell particles that comprise these sandy sediments have relatively low affinities for particle-reactive contaminants in comparison to more fine-grained sediments, and as such contaminants are typically not found as often where there is a sandy bottom. Places with fine grained silt and clay deposits, often in association with organic material, are the areas where sediment contamination is most apparent in the Indian River Lagoon (Trefry, et al., 1990a, 1990b; Trocine and Trefry, 1993).

7.1 TRACE METALS IN SEDIMENTS

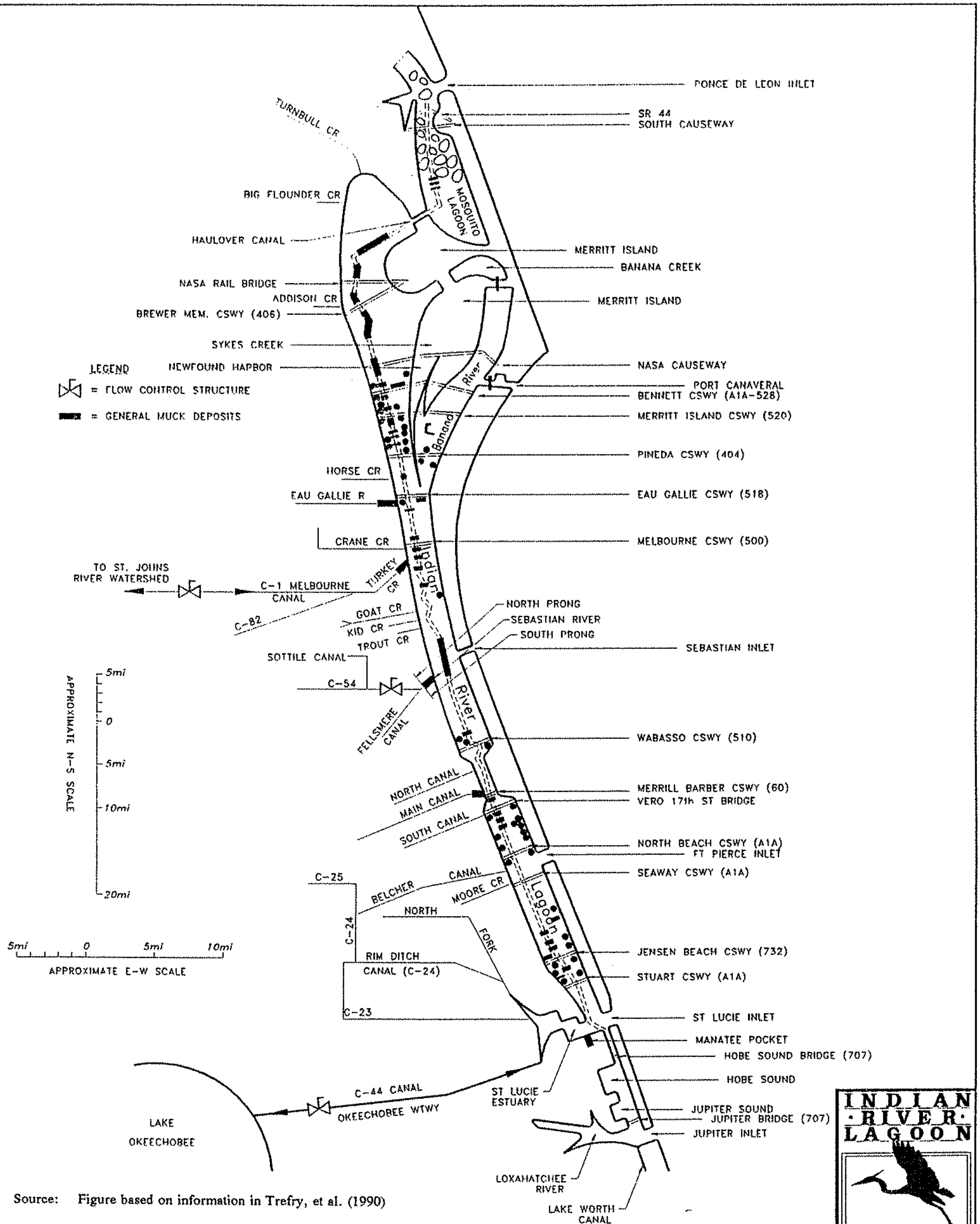
There have been two recent studies designed to provide system-wide baseline data on sediment distribution and composition in the Lagoon. Trefry, et al. (1990a) performed a survey primarily to estimate the distribution of fine-grained organic-rich sediments in the Indian River Lagoon system. This sediment can be easily resuspended and in natural conditions is thought to be a very minor component of the bottom sediments over most of the Lagoon. This material is referred to as organic-rich mud or more commonly as muck. It can be associated with particle-reactive contaminants such as synthetic organic compounds and metals. Trefry, et al. (1990a) report that muck deposits in the Lagoon vary in thickness from less than about 1/2 inch (1 cm) to more than 6 ft (about 2 m). Because the muck tends to occur as a surface layer, often with a sharp interface with the underlying quartz and shell fragment material, it can be readily resuspended by storms and flooding events, or by the action of boats and propeller wash. This resuspension can result in transport and re-deposit of contaminant loads within the estuary, in the process increasing turbidity so that light penetration is reduced, and blanketing benthic communities as it settles to the bottom. These muck sediments also tend to have high oxygen demand and can be significant contributors to oxygen depletion in the water column where they have accumulated (Trocine and Trefry, 1993).

The 1989 system-wide muck survey (Trefry, et al., 1990a) was an expansion of an earlier limited survey (Trefry, et al., 1987). More than 635 discrete sediment cores were taken in the 1989 survey. Trefry, et al. (1990a) indicate that the typical muck sediment is black with high water content, more than 10% organic material by dry weight, and over 60% silt and clay by dry weight. Trefry, et al. (1990a) state that the biogenic fraction of the muck gives the sediment its black color and may be an indicator of high plant productivity in the system, that could have been caused by nutrient inputs from sewage and/or fertilizer runoff. Muck deposits in the northern and southern thirds of the Lagoon average more sand, 6% less organic material, and 10% less silt and clay in comparison with deposits in the central third.

Figure 7-1 is a schematic representation of the detailed muck maps given in the Trefry, et al. (1990a) report. The data in the original report, which show four thickness ranges of the muck deposits, have been generalized. Deposits of less than 2 in (5 cm) that are shown on the original maps are not portrayed on the schematic map. All other muck deposits are represented in Figure 7-1 as a single class covering thicknesses from 2 in to greater than 6 ft (5 cm to 200 cm).

Lagoon-wide, less than 10% of the bottom is composed of muck deposits, which generally are found in relatively deep or sheltered areas where the wave action and current strength are limited. The larger accumulations are in the mouths of the numerous tributary creeks, in sheltered areas near causeways, and in the ICWW. About 40% of the ICWW bottom is comprised of muck deposits (Trefry, et al., 1990a).

There is a particularly large muck deposit in the portion of the St. Lucie Estuary known as Manatee Pocket. Fine-grained organic-rich muck-like sediments have been found in 21 cores



Source: Figure based on information in Trefry, et al. (1990)

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•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: INDIAN06.DWG DATE: 7-5-94	FIGURE 7-1 DISTRIBUTION OF MAJOR MUCK AREAS

taken in this embayment (Trefry, et al., 1990a). This study found that the muck varied considerably in thickness from 0.1 in to 6.3 ft (0.2 cm to 198 cm) with an average of 2.8 ft (84 cm). Trefry, et al. (1990b) estimated the total volume of muck in the Manatee Pocket at 445,000 yd^3 (340,000 m^3). The largest amounts are in the deeper areas of the pocket. It should be noted that muck was not found in the St. Lucie Estuary itself adjoining Manatee Pocket.

Trefry, et al. (1990a) also determined the sedimentation rates and estimated the vertical profiles of contamination concentrations to explore the origin of the mud deposits. Two radiometric methods, Cesium-137 (Cs-137) and Lead-210 (Pb-210), were used to evaluate the sedimentation rates. These radionuclides are man-made substances first introduced into the environment by above-ground nuclear tests in about 1953, reaching a peak in the atmosphere in 1963 (Trefry, et al., 1990a). As these nuclides settled, they became incorporated into sediments. Therefore, a corresponding maximum value in sediment Cs-137 values can sometimes be found when sediment mixing processes have not distorted the profile. The part of the sediment with the maximum Cs-137 can be used to date some of these sediments as a benchmark to the 1963 maximum. No Cs-137 will be found in sediments deposited prior to 1950 unless some downward mixing of "newer" sediment has occurred.

These methods were applied by Trefry, et al. (1990a) to cores taken in the Manatee Pocket and in the Indian River Lagoon in the Melbourne area. In the center of Manatee Pocket, the Cs-137 concentrations were below detection limits at depths greater than 8 in (20 cm). The Cs-137 maximum values were located between 0.3 and 0.5 ft (10 and 15 cm) in the core indicating that this was the mud surface in approximately 1963. These findings indicate that the average sedimentation rate at this location has been about 0.2 inch/yr (0.5 cm/yr). Profiles were obtained from two other cores in Manatee Pocket which showed no presence of Cs-137 below 1.3 ft (40 cm). This suggests a sedimentation rate about twice that indicated by the first core. It is reasonable to state that overall the sedimentation rate in Manatee Pocket varies, but is less than 0.5 in (1 cm)/yr. If the sedimentation rates for the muck have been reasonably constant, these cores indicate that muck started to accumulate between 50 and 100 years ago. The absence of Cs-137 below 1.3 ft (40 cm) implies that the muck below this 1.3 ft depth in Manatee Pocket accumulated prior to 1950. In some cores, this deeper layer may represent 80% of the total muck profile, indicating substantial accumulation prior to 1950.

Lead-210 was used on two cores from the Indian River Lagoon near the mouth of Crane Creek, near Melbourne. These cores yielded sedimentation rates of 0.4 in (1 cm)/yr from a 0.6 ft (19 cm) thick muck deposit and 0.08 in (0.2 cm)/yr for a 0.2 ft (7 cm) thick deposit. These results indicate that muck in this location has been accumulating for the 20 to 35 years preceding 1990, with little accumulation prior to that period.

There are not enough data to definitively state that these results are representative of muck deposits over the whole of the Lagoon, but the Pb-210 results imply that muck deposits are a relatively recent phenomena.

In their study, Trefry, et al. (1990a) also obtained vertical profiles of trace metal contamination in Manatee Pocket and the Indian River Lagoon near Melbourne. In the Manatee Pocket cores the profiles show high levels of copper, zinc, mercury, lead and cadmium. The vertical profiles showed that these high values were near the surface and diminished rapidly in the zone 20 to 30 cm down in the cores. Below this depth the contamination is absent. This indicates that the muck that was deposited in Manatee Pocket prior to the 1950s or 1960s was generally free of metal contamination. The excess loading of the metals appears to be a recent development going back 30 to 40 years, with peaks in the period from 1950 to about the 1970s (Trefry, et al., 1990a).

Similar evaluation of the vertical profiles of trace metals from cores taken in the Melbourne area shows that mercury and lead have relatively high concentrations, but not as high as in Manatee Pocket. Trefry, et al. (1990a) report that muck with these contaminants has been accumulating since the 1960s.

The muck project described above was followed by another system-wide chemical reconnaissance of water, sediments, and shellfish (Trocine and Trefry, 1993). About 45 stations were sampled between the northern end of the Indian River Lagoon proper and Jensen Beach/Stuart during the February through October 1992 interval. Sediments were analyzed for silver (Ag), aluminum, cadmium, copper, chromium (Cr), iron, mercury, magnesium, lead, and zinc. The measurements of the trace metals were reviewed based on

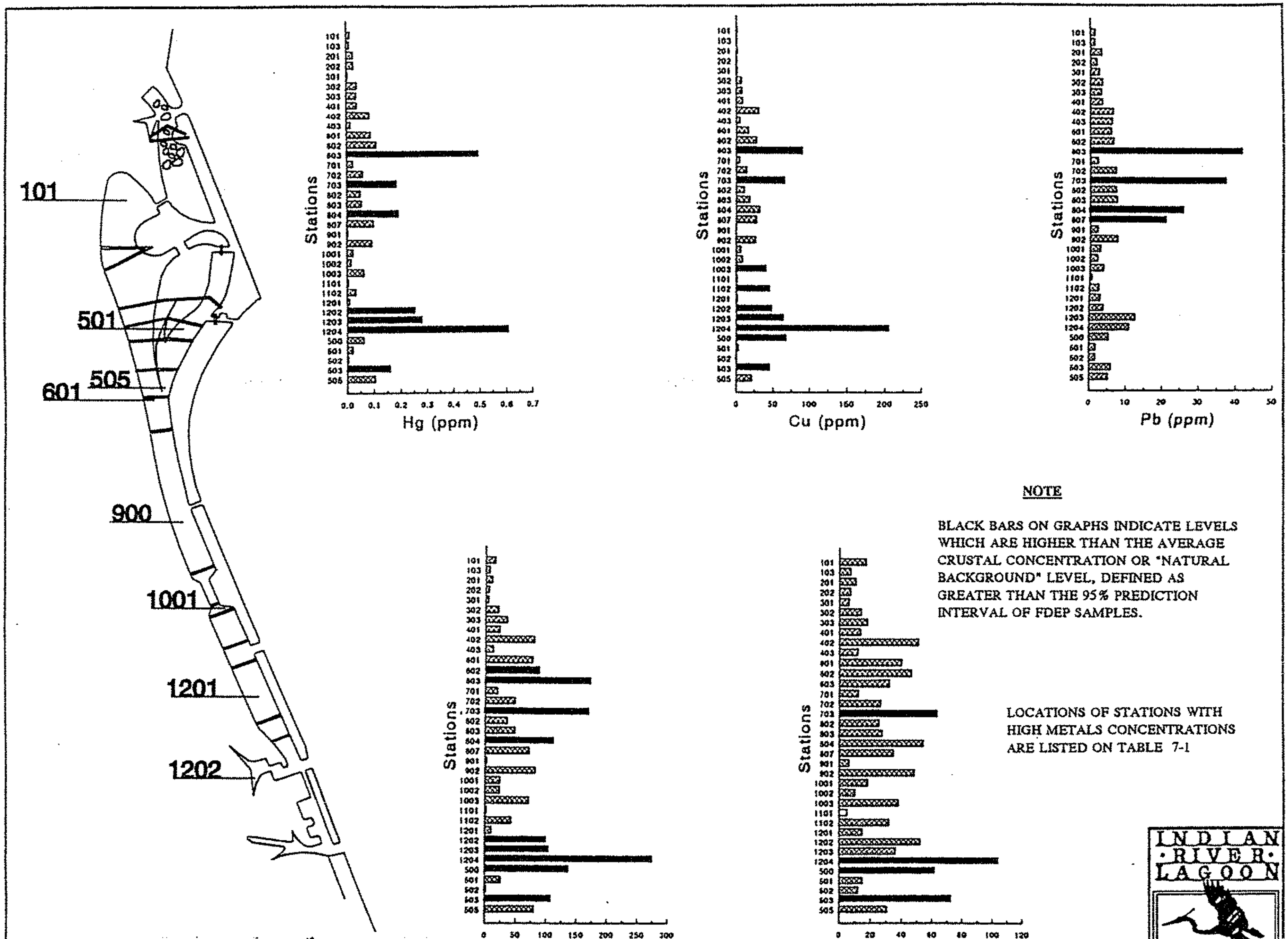
FDEP guidelines (Schropp and Windom, 1988). These guidelines include an initial screening which considers sediment metal concentrations. If the sediment metal concentration exceeds the screening guideline, then the relationship of the particular metal concentration to the concentration of aluminum in sediment at the sample site is determined. If the ratio is within the 95% prediction interval for natural sediments, the sediment is considered to be uncontaminated. Values outside of this interval are considered contaminated (Schropp and Windom, 1988; Schropp, et al., 1990).

The results of this system-wide reconnaissance survey are shown on Figure 7-2 and 7-3. Stations in which concentrations greater than estimated background levels (above 95% prediction interval) for each metal were found are indicated by the black bars in the graphs. Table 7-1 summarizes the stations at which these background levels were exceeded.

<u>Mercury</u>

Trocine and Trefry (1993) state that sediment mercury concentrations in the Lagoon are enriched relative to the average crustal Hg/Ag ratio. Although there is no state guideline for mercury contamination, values over the average crustal value of just under 0.08 parts per million (ppm) are considered indicative of increased Hg accumulation (Trocine and Trefry, 1993). The concentrations found in the Lagoon range between 0.004 and 0.749 ppm as compared with the estimated contaminated threshold of just under 0.08 ppm. For these reason values over 0.1 ppm are shown by the black bars as being relatively high on Figure 7-2. The high values tend to be found in sheltered harbors and the mouths of creeks. Relatively high concentrations occur near Patrick Air Force Base (Station 503), in Eau Gallie (Station 603) and Melbourne (Station 703) Harbors, in the mouth of Turkey Creek (Station 804), and in Manatee Pocket (Stations 1202-1204). Trefry, et al. (1987) reported that levels of Hg in the Indian River Lagoon near the mouth of Crane Creek were 3 times background level and stated that Crane Creek was clearly a source of Hg pollution.

Earlier data include 1983-1984 FDER sampling results from several stations in the Lagoon (in Trocine and Trefry, 1993). These data indicate that most stations had Hg concentrations



Source: From Trocine and Trefry, 1993

NOTE

BLACK BARS ON GRAPHS INDICATE LEVELS WHICH ARE HIGHER THAN THE AVERAGE CRUSTAL CONCENTRATION OR "NATURAL BACKGROUND" LEVEL, DEFINED AS GREATER THAN THE 95% PREDICTION INTERVAL OF FDEP SAMPLES.

LOCATIONS OF STATIONS WITH HIGH METALS CONCENTRATIONS ARE LISTED ON TABLE 7-1

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 7-2	SEDIMENT CONCENTRATIONS FOR Hg, Cu, Pb, Zn, AND Cr

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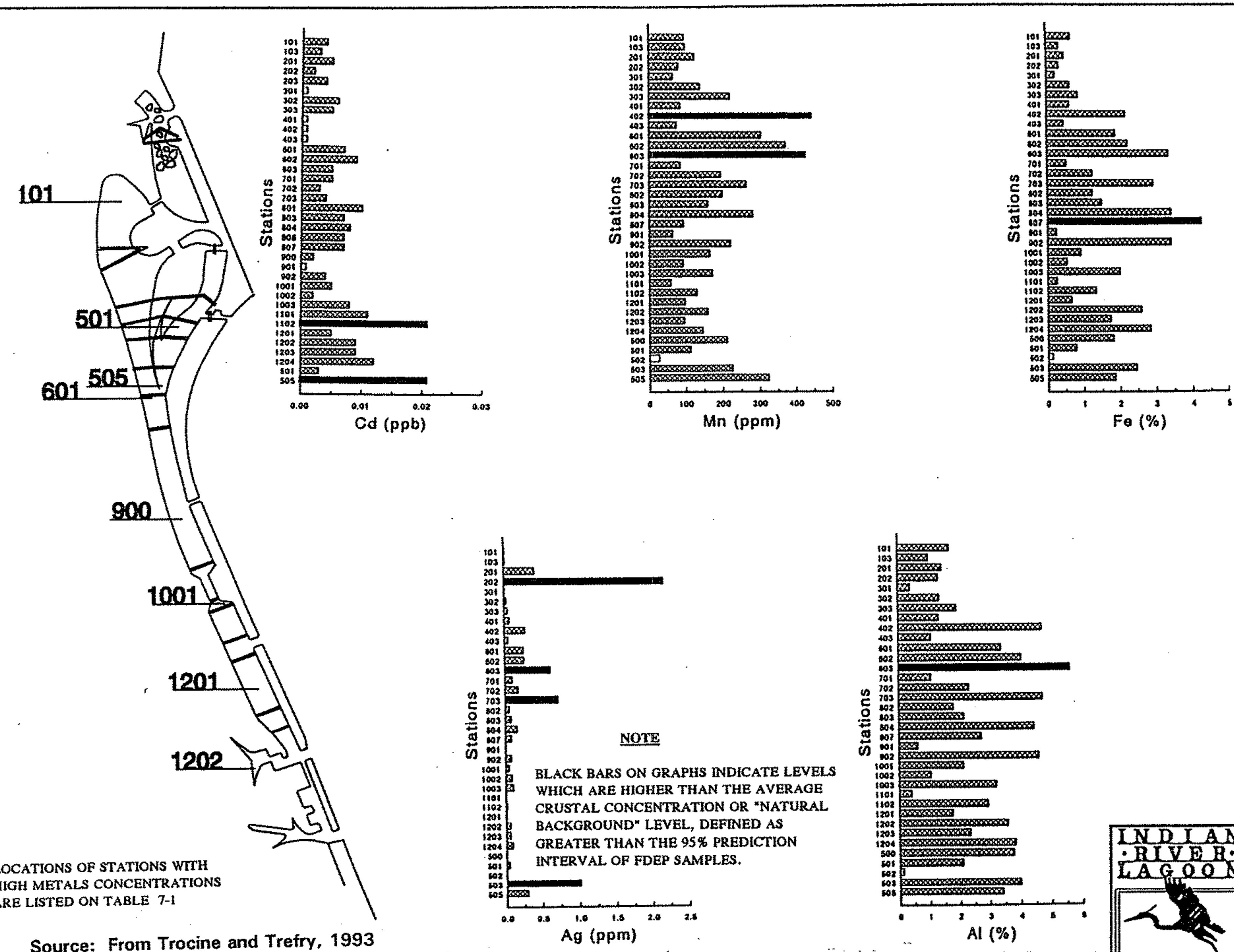

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BLACK BARS ON GRAPHS INDICATE LEVELS WHICH ARE HIGHER THAN THE AVERAGE CRUSTAL CONCENTRATION OR "NATURAL BACKGROUND" LEVEL, DEFINED AS GREATER THAN THE 95% PREDICTION INTERVAL OF FDEP SAMPLES.

Source: From Trocine and Trefry, 1993

• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 7-3	SEDIMENT CONCENTRATIONS FOR Cd, Mn, Fe, Ag, AND Al

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TABLE 7-1

MATRIX OF LOCATIONS WITH SEDIMENT METAL CONCENTRATIONS GREATER THAN THE FDEP ESTIMATED BACKGROUND LEVEL[1,2]

STATION	LOCATION	Al	Ag	Cd	Cu	Cr	Fe	Hg	Mn	Pb	Zn	NUMBER OF METALS ABOVE AVERAGE
202	Indian River Lagoon-Titusville		•									1
402	Indian River Lagoon-Cocoa								•			1
500	Port Canaveral				•	•					•	3
503	South Banana River		•		•	•		•			•	5
505	Banana River-South End			•								1
602	Indian River Lagoon near Eau Gallie										•	1
603	Eau Gallie Harbor	•	•		•			•	•	•	•	7
703	Melbourne Harbor		•		•	•		•		•	•	6
804	Turkey Creek Mouth							•		•	•	3
807	Indian River Lagoon near Turkey Creek						•			•		2
1003	Indian River Lagoon South of Vero Beach				•							1
1102	Indian River Lagoon near Taylor Creek			•	•							2
1202	Manatee Pocket				•			•			•	3
1203	Manatee Pocket				•			•			•	3
1204	Manatee Pocket				•	•		•			•	4

Source: Trocine and Trefry, 1993

1 = See Figure 5-2 for definition of background level
2 = Dot represents presence of above-average concentrations of that metal

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over 0.2 ppm at that time, with the highest levels in the Canaveral Barge Canal (1.3 ppm), Port Canaveral (1.1 ppm), and in upper Turkey Creek and Taylor Creek (0.7 ppm). The vertical profile of values in the sediments of Manatee Pocket indicates that the concentration has been decreasing in mucks accumulated since about the 1970s. However, the 1983 survey (Trefry, et al., 1983) found maximum values of 0.203 ppm in the Lagoon system sediments, whereas Trocine and Trefry (1993) found values as high as 0.749 ppm. This difference in concentrations may indicate some increase in Hg accumulation in recent years.

Copper

The report by Trocine and Trefry (1993) also summarizes the occurrence of copper in the muck sediments. With the exception of 9 sites, copper concentrations are generally within the 95% prediction interval range defined by FDER (now FDEP) as normal for unimpacted sediments. The 7 sites with elevated Hg also have relatively high Cu concentrations. In addition, relatively high copper values were obtained from sediments taken in Port Canaveral in Brevard County (Station 500), near Taylor Creek in St. Lucie County (Station 1102), and in the vicinity of Vero Beach in Indian River County (Station 1003). Trocine and Trefry (1993) indicate that the primary source of copper is from boat bottom anti-fouling paint. The copper enters the sediment as particles from chipping and scraping boat hulls as they are serviced or as a result of sediment particle adsorption of dissolved copper leached from boat bottoms. The high copper values generally are associated with places in the Lagoon where marine or industrial activities are concentrated. Trocine and Trefry (1993) reported that at least 75% of the Cu in the system is retained within the creeks, creek mouths, and their associated harbors.

Data from the FDER 1983-84 study indicated highest copper concentrations in the sediments at Port Canaveral (103 ppm), the Canaveral Barge Canal (49 ppm), in the Indian River Lagoon at Titusville (39 ppm), and in Taylor Creek (36 ppm). Copper levels in upper Turkey Creek sediments have been reported as high as 559 ppm (Zediker, 1982; Glascock, 1987).

Lead

Figure 7-2 also shows the lead sampling results of Trocine and Trefry (1993). All surficial sediment values were within or below the FDEP guidelines for normal unimpacted sediments. Trocine and Trefry used the average crustal abundance method to identify relatively high sediment lead values as occurring in Melbourne and Eau Gallie Harbors (Stations 603 and 703) and near Turkey Creek (Stations 804 and 807).

The Canaveral Barge Canal, Port Canaveral, Banana River, and Taylor Creek all were found to have higher (>30 ppm) lead levels in the FDER surveys in 1983-1984. The most likely source of the lead is through airborne transport from the burning of gasoline and other fossil fuels.

Zinc

Trocine and Trefry (1993) also measured sediment zinc concentrations (Figure 7-2). Although most of the values were within the FDEP guidelines for natural sediment, there were nine sites where the concentrations were above the 95% prediction interval. Like lead, 7 of these sites corresponded to places where high copper values were measured. The zinc contamination was highest in the main basins of the harbors and freshwater tributaries to the Lagoon (Stations 603, 703, 804), Manatee Pocket (Stations 1202-1204), and Port Canaveral and the south Banana River (Stations 500 and 503). Again, Port Canaveral, the Canaveral Barge Canal, and Taylor Creek were areas of highest concentration in the 1983-1984 FDER survey, with a maximum concentration of over 240 ppm found at Port Canaveral. High concentrations were also recorded from upper Turkey Creek in the 1980s (Zediker, 1982; Glascock, 1987). The principal sources of zinc include a variety of urban and residential sources including wastewater and stormwater runoff.

Other Metals

Figures 7-2 and 7-3 show the Trocine and Trefry (1993) system-wide survey values for the metals chromium (Cr), cadmium (Cd), silver (Ag), iron (Fe), and aluminum (Al). All of the values are roughly within the range of values from natural unimpacted areas.

A study by Sleister (1989) in Mosquito Lagoon showed heavy metal enrichment of sediments at three freshwater discharge points at the Canal Street and Gabordy canals in New Smyrna Beach and the Florida Shores canal in Edgewater. Each of these had Cu, Pb, and Zn levels elevated above background. The highest concentrations in the Canal Street outfall were in samples taken closest to the discharge point. Levels in the Gabordy and Florida Shores canals were generally lower than at Canal Street, but Pb and Zn concentrations were still above background levels. In general, Hg concentrations in all of these Mosquito Lagoon samples were 6 times higher than values (0.06 ppm) previously measured by FDER (Sleister, 1989).

The 1987 Trefry, et al. study indicated that, of the areas that were studied, levels of Hg, Cu, Pb, and Fe were all highest in the Melbourne area (Segments 1C and 2), less in the Sebastian area (Segment 3), and least near Ft. Pierce (Segment 4). Aluminum concentrations were relatively unchanged throughout these areas, The resulting ratios to Al indicate that metals are increased over natural levels in the Melbourne area in particular.

7.2 TRANSPORT OF SEDIMENTS

The physical transport of sediments is also a consideration in assessing the overall quality of the Indian River Lagoon system sedimentary environment. As described above, contaminated particles can be transported to the Lagoon in the muck from sources in the freshwater creeks. Another aspect of sedimentation is shoaling which can directly impact navigation. Shoaling of the Lagoon, especially near the inlets, has the effect of further reducing circulation which alters the rate at which the nutrient and contaminant loads are transferred from their sources to the ocean.

The wide-spread general distribution of muck deposits over the entire Lagoon (Figure 7-1) suggests broad scale source, transport, and sink actions. For example, the largest cluster of muck deposits is in the relatively tideless sub-regime of the North and North Central Indian River Lagoon (Segments 1C and 2) where freshwater inputs are less than in the South Indian River Lagoon (Segment 4). Other areas of substantial deposit occur between Sebastian River and Sebastian Inlet, and in the thick deposits in Manatee Pocket. The muck deposits of the southern Indian River Lagoon, between the Ft. Pierce and St. Lucie Inlets, appear to be smaller and more scattered than elsewhere in the Lagoon.

Trefry, et al. (1989) implicate land runoff as the source of the organic material in the muck in two ways. First, organic detritus from the land contributes directly to these deposits. Secondly, nutrients in runoff may stimulate planktonic plant and algae production in the Lagoon, which in turn can contribute a significant load of dead organic material to the sediments. High runoff events may sweep the muck sediments from the tributary creeks to the Lagoon. In the "tideless" sub-regime there is seldom the combination of wave and current conditions that is necessary to re-entrain the muck sediments from sheltered places within the ICWW and near the causeways. Therefore, the muck tends to build up in these areas in Segments 1C and 2.

The deposit of muck in the ICWW between Sebastian River and Sebastian Inlet is probably a more dynamic and transient feature than the muck deposits further north in the Lagoon. Tidal currents are relatively strong in this area of the Lagoon so re-entrainment of the muck may occur episodically when these currents combine with storm discharges and waves. However, water quality data indicate that the Sebastian River is a probable source of these sediments, constantly replenishing them at a rate sufficient to replace the amounts transported to the Atlantic Ocean through the inlet. The Atlantic Ocean may be the ultimate sink for sediment lost through Sebastian Inlet. Sediment deposition and transport within this reach should be further examined with computer models, field measurements, or both.

A vigorous tidal regime may be responsible for the pattern of smaller, more scattered muck deposits in the South Indian River Lagoon (Segment 4) . These may even be ephemeral in nature, at least at some of the locations. However, the large permanent muck deposit of Manatee Pocket appears to have developed because several creeks feed into its protected area (Trefry, et al., 1990). This muck deposit does not extend out into the St. Lucie Estuary beyond the mouth of Manatee Pocket. However, some muck may bypass or work through the protected area of the pocket and be swept out the inlet when it encounters the more vigorous current regime of the St. Lucie Estuary. At the present time, there are no measurements or model results to further explore the possibility of muck dispersal beyond the limits of the known deposits in this area.

In addition to the muck and chemical contamination, the re-entrainment, transport, and deposition of sands and silts near the inlets also bring about physical alterations that are considered impacts. Problems include the direct changes caused by shoal building within the

Lagoon inside of the inlets and the secondary effects that this shoal building has on restricting tidal circulation within the Lagoon. The inlets in the barrier island chain of the Indian River Lagoon complex form break points in the open ocean littoral sand transport system. All along the ocean beaches of the barrier islands, the waves move sand longshore, primarily in the surf zone. Since the barrier islands end at inlets, the sand moving along the island then interacts with the tidal flows going in and out of the inlets.

Many barrier island inlets in other estuaries are bypassing-type inlets. This means that a large amount of the sand transported in the surf zone process ultimately makes its way across the inlet and resumes its longshore transport along the next island in the chain. However, as described in the Physical Features Technical Report, most of the inlets connecting the Indian River Lagoon system to the ocean allow sand to be carried into the inlet where it encounters more sheltered conditions and is deposited as one or a series of shoals. These shoals that form within the inlet are called the flood tide delta because the deposits form from sand brought through the inlet by the flood tide currents. Navigational problems are caused by sand build-up in channels.

All of the inlets of the Indian River Lagoon have shoaling problems, but there is a large variation in the degree of severity. The St. Lucie Inlet in particular has an ongoing problem with sand buildup within the Lagoon. Each year about 7,000 yd^3 (5,400 m^3) of sand sediments are deposited in a shoal within the inlet, with another 43,000 yd^3 (33,000 m^3) deposited in the Sailfish Point Navigation Channel, and 32,000 yd^3 (24,000 m^3) deposited in the flood tide shoals within the inlet (ATM 1993). The inlet management plan currently on file calls for improvements to the jetties, the north sedimentation basin and the dredging program in an attempt to reduce these shoaling rates and improve navigational conditions.

The Ft. Pierce Inlet is maintained by the U.S. Army Corps of Engineers and has been dredged 34 times since 1935. The current Federal project includes an entrance channel that is 350 ft (100 m) wide and 27 ft (8 m) deep. A new project that was authorized in 1988 awaits the outcome of a re-evaluation study (Coastal Planning and Engineering, Inc. 1993). In addition to sedimentation in the entrance channel, there is ongoing shoal building on the flood tide delta.

The Sebastian Inlet is relatively shallow. Sedimentation management plans include maintenance of a depression within the inlet designed to act as a sand trap. The comprehensive management plan for the Sebastian Inlet calls for maintenance dredging of this sand trap every two years with the expectation that this will prevent substantial long-term build up of sediment within the inlet (Coastal Technology Corporation, 1988).

Ponce de Leon Inlet is also a shallow inlet used primarily by vessels that draw less than 4 ft. Until jetties were constructed in the late 1960s, the inlet and its shoals migrated alternately north and south. There is a long-term trend toward sedimentation on the ebb tide shoals outside of this inlet (Taylor Engineering, Inc., 1993).

All of these inlets now have comprehensive management plans. These plans contain provisions for environmental monitoring to assure that the maintenance of the inlets does not adversely effect the surrounding environment. However, the plans do not have provisions for conducting this monitoring over large areas within the Lagoon and they do not have provisions for evaluating the role of the inlets in maintaining the natural salinity regime within the Lagoon. Shoaling and episodic maintenance dredging can have large scale effects but to an unknown degree. From the evaluation of the available information, it appears that the current management protocol of considering the inlets from strictly navigational perspective could cause charges to tidal circulation patterns in the Indian River Lagoon system.

8.0 DISCUSSION OF QUALITY RESULTS

8.1 GENERAL WATER QUALITY

The SWIM Program has targeted the following 12 priority problem areas of the Lagoon (shown below with segment locations as used in this study) as focus areas because of water or sediment quality issues (SJRWMD and SFWMD, 1993):

- Mosquito Lagoon (Segment 1A)
- Titusville vicinity (Segment 1C)
- Cocoa/Rockledge and South Banana River (Segments 1B and 1C)
- Eau Gallie River watershed (Segment 2)
- Crane Creek watershed (Segment 2)
- Turkey Creek watershed (Segment 2)
- Sebastian River watershed (Segment 3)
- Lagoon segment between Melbourne and Sebastian (Segment 2)
- Vero Beach vicinity (Segment 3)
- Moores Creek/Virginia Avenue Canal (Ft. Pierce) (Segment 4)
- Five and Ten Mile Creeks within the St. Lucie River Watershed (Segment 4)
- Manatee Pocket within the St. Lucie River watershed (Segment 4)

Data has not been available to evaluate water quality areas within the St. Lucie River watershed, but available water and sediment quality data for the other focus areas tend to confirm the presence of at least one water quality related problem in each area, with the possible exception of Mosquito Lagoon. The most recently available data (through 1991) indicates that overall water quality in Mosquito Lagoon (Segment 1A) appears to be generally good. However, there does appear to be some elevation of turbidity, color, TSS, and chlorophyll *a* in the northern portion near the urbanized area of Edgewater in particular. Secchi disk depths are reduced in this vicinity indicating a potential for reduced light penetration. In addition, elevated heavy metals concentrations have been reported (Sleister, 1989) in some drainage outfalls in this area. Bacterial contamination was not reviewed in this study due to lack of sufficient data in the SWIM data base, but septic tanks have been reported as a potential problem in the Florida Shores/Edgewater area (Loadings Assessment Technical Report) and bacterial contamination has affected shellfishing waters in Mosquito Lagoon (SJRWMD and SFWMD, 1993).

The SWIM data appear to be generally consistent with earlier limited data for Segment 1A (Windsor and Steward, 1987) and with the longer-term WQA averages. Although Mosquito Lagoon has been described as a fairly "natural" part of the system, total nitrogen and TKN in the wet season in the area studied appear to be at the upper limits of values found throughout the entire Indian River Lagoon complex in the SWIM data set. Turbidity, color, TSS, DO, and TP all appear to be within the low to moderate range for the complex as a whole. At the current time, it therefore appears that elevated nitrogen levels, bacterial contamination, and trace metals contamination may be the primary concerns for this segment. The Loadings Assessment Technical Report has indicated that stormwater runoff and potential OSDS seepage from the Florida Shores/Edgewater area may be sources of nitrogen and bacteria for Segment 1A.

In the vicinity of Titusville (Segment 1C), the SWIM water quality data indicates that TP is relatively close to the Lagoon-wide average, but TKN is at the high end of the range. Chlorophyll *a* levels are also near the upper end of the range and exceed the 15 μg/L level that has been identified in one study as a potential target maximum level for support of a healthy seagrass community (Funderburk, et al., 1991). Metals contamination, particularly copper levels in the water column and in tissues of hard clams, also has been identified as a possible area of concern for this portion of Segment 1C.

The Cocoa/Rockledge area of Indian River Lagoon (Segment 1C) and the south Banana River (Segment 1B) have been indicated by the data in this report to have several water and sediment quality problems. One of the primary concerns for both of these areas is the high levels of metals in water, tissues, and sediments, although only copper appears to be exceeding state water quality standards. The Cocoa/Rockledge portion of Segment 1C is an area with substantially above average TKN and TN, and slightly elevated TP levels. Chlorophyll *a* levels are among the highest in the complex.

Total Kjeldahl nitrogen is above the Lagoon-wide average condition throughout Banana River (Segment 1B) and TP at the south end of Banana River is well above the average condition.

Turbidity and TSS levels in Banana River do not appear to be elevated, but very high chlorophyll *a* levels are found in the south half of Segment 1B. Levels of all water quality parameters examined for Sykes Creek and Newfound Harbor are similar to those in the southern Banana River. There is some indication that TP concentrations in Sykes Creek, Newfound Harbor, and the south Banana River have decreased, possibly by as much as 50%, since the 1980-1985 period. However, TN, TKN, and chlorophyll *a* concentrations have probably remained unchanged and may have increased.

In Segment 2, SWIM data from stations in the Lagoon near the mouths of the Eau Gallie River and Crane Creek indicate that higher TP, TKN, TN, and chlorophyll *a* levels are found near their discharge points. Salinity in the Lagoon near these two tributaries is also substantially lower than in most of the Lagoon. SWIM data from stations in Crane Creek and the Eau Gallie River also indicate that these two tributaries have TP and chlorophyll *a* concentrations about twice as high as in most other tributaries to the Lagoon. Nitrogen levels are near the upper end of the range for tributaries. Thus it appears that these two tributaries may currently influence Lagoon water quality in Segment 2.

Data from Windsor and Steward (1987) indicates that very high chlorophyll *a* values were present in Crane Creek (8 - 34 μg/L) and the Eau Gallie River (49 - 78 μg/L) in the 1980 to 1985 period, and that a decline has occurred since that time. Tributary TN and TP were also reported to be several times higher than levels in the Lagoon. Comparison of recent TP levels to Windsor and Steward's data indicates a substantial decline in average TP concentration has occurred since 1985 in Crane Creek (from 0.6 - 1.0 mg/L to 0.1 - 0.8 mg/L) and the Eau Gallie River (from 0.3 - 0.4 to 0.1 - 0.2 mg/L). A similar decrease in TN has occurred in Crane Creek (2.4 - 4.2 to 0.7 - 2.2), although TN concentrations apparently have not changed much in the Eau Gallie River. The harbors at the mouths of these tributaries also have shown elevated levels of several metals in water, sediments, and tissues.

Total Kjeldahl nitrogen and TN in Turkey Creek and the Sebastian River (Segments 2 and 3) are somewhat higher than the Lagoon average, but are substantially lower than those reported for Crane Creek and the Eau Gallie River by Windsor and Steward (1987). The 1989-1991 levels are similar to those reported by Windsor and Steward (1987) for the 1980 to 1985 period. Although there is little data, it appears that levels have remained constant over time. Total phosphorous levels in Turkey Creek are elevated by a factor of about 2, compared to the Lagoon. However TP levels in Crane Creek, the Eau Gallie River, and the Sebastian River are from 2 to 4 times higher than concentrations in the Lagoon. The TP concentrations in the Sebastian River, along with those of the Vero Canals, are much higher than elsewhere in the system. Phosphorous levels in Sebastian River appear to be a major water quality problem source for Segment 3 of the Lagoon, and a comparison of data to that of Windsor and Steward (1987) indicates that levels may have increased since the early 1980s.

The primary difference in water quality in the portion of the Lagoon between Melbourne and Sebastian (Segments 2 and 3) is the low salinities encountered. Some individual readings in the SWIM data set have indicated salinities below 15 ppt in this reach of the Lagoon. The Loadings Assessment Technical Report discusses the effects of the large freshwater discharges from Turkey Creek, Crane Creek and other tributaries in Segment 2.

The Vero Beach vicinity of the Lagoon (Segment 3) is characterized by an abnormally high TP concentration, over twice as high as elsewhere in the complex, although this high level does not appear to have resulted in increased phytoplankton concentrations as indicated by the chlorophyll *a* data. The Vero North, Vero Main, and Vero South Canals, in addition to Sebastian River, all have TP levels elevated to 4 to 8 times the average level in the Lagoon, indicating that these four tributaries are responsible for the high TP levels in the Lagoon in this area. Color, turbidity, and TSS have all been high in these canals at times.

Data is still very limited for assessing the effect of tributaries in the South Indian River Lagoon (Segment 4). The extensive system of SWIM water quality monitoring stations in the Lagoon will provide a good means for assessing future conditions, but no strong patterns appear to exist in the existing water quality data, and SWIM data is not yet available for the tributaries. The SWIM water quality data for Segment 4 does not appear to indicate substantial deviation from average conditions in the Moore's Creek area of Ft. Pierce, although some elevated chlorophyll *a* levels may occur in this vicinity. Data from earlier studies (Hand, et al., 1986) has indicated some elevated metals concentrations in Taylor Creek, but not to a high degree.

Manatee Pocket in the St. Lucie Estuary (Segment 4) has shown substantial accumulations of muck sediments with some trace metals contamination. These sediments appear to contain some of the highest levels of Hg, Cu, Cr, and Zn in the system. Although these levels are elevated, their level of impact is not known. These mucks may however, be a source of organic particulate matter and turbidity for the Lagoon. The muck substrate also may be a less suitable substrate for benthic organisms than other substrate types.

With the possible exception of the Moore's Creek area (Segment 4), this water and sediment characterization of the Lagoon appears to support the selection of the SWIM priority problem areas. Elevated nutrient, turbidity, chlorophyll *a*, and color values, as well as levels of metals in sediments, water, and marine organisms appear to be the primary water quality parameters of concern. Nitrogen appears to be relatively high in Banana River (Segment 1B), the northern part of Mosquito Lagoon (Segment 1A), and Indian River Lagoon north of Sebastian (Segments 1C and 2) whereas high phosphorous levels are concentrated in Segment 3 near the Sebastian River and the Vero North, Main, and South Canals. Bacterial contamination is also a major area of concern. Actual impacts of these levels have not necessarily been demonstrated in all of these areas, and additional data will be needed to establish trends and link impacts to specific causes.

No other areas appear to be pose major water quality concerns at this time. Overall conditions in the Hobe Sound/Jupiter area, which has not been evaluated prior to this study, appear to be good. There may be a slight tendency to higher wet season nutrient levels in this area, but levels are still within or below the average range for the complex.

Another potential problem may be the high color and fairly high nutrient levels of Turnbull Creek and Big Flounder Creek in the northern end of Segment 1C in the Indian River Lagoon. This portion of the Lagoon has good water quality, but a highly colored discharge of Turnbull Creek has been reported to have resulted in a large seagrass decline in 1991 in this area (Historical Imagery Technical Report).

8.2 TRACE METALS IN THE INDIAN RIVER LAGOON SYSTEM

Although metals levels several times the estimated background condition have been found in the water column of the Lagoon in some scattered locations, even these highest concentrations are generally below the maximums allowed by state water quality standards (Section 17-302, F.A.C., for all metals except copper which has been reported at concentrations nearly double the state standard near the Eau Gallie Harbor and at marinas in Segment 2 (Hand and Paulic, 1992).

Areas with elevated metals concentrations in the water column in large part coincide with areas of elevated concentrations in sediments. Several studies (Trefry, et al., 1987, 1990a; Hand and Paulic, 1992; Trocine and Trefry, 1993) have indicated that the areas with consistently high sediment and water column levels of several metals include the harbors at Melbourne and Eau Gallie and the southern part of Banana River near Patrick Air Force Base. Other areas in which elevated levels of some metals are found include the Indian River Lagoon between Titusville and Cocoa and near Vero Beach, Port Canaveral, Manatee Pocket, and in several tributaries such as Turkey Creek, Crane Creek, and Taylor Creek.

Elevated levels of metals in the tissues of marine organisms have been found at several of these locations, including the south Banana River, Melbourne and Eau Gallie Harbors, and the Indian River Lagoon between Titusville and Cocoa. All of these areas are areas with elevated water column and/or sediment concentrations. Of these, the area between Titusville and Cocoa may pose the most immediate problem because this is near commercial hard clam harvesting areas (Body C) and because the copper levels found (Trocine and Trefry, 1993) in some clams in this area may be near reported lethal levels for clams. Copper appears to be the only metal which may be a significant concern in water, sediments, or organisms on other than a localized basis. However, there is currently not enough data on metals to adequately evaluate trends over time or to determine if levels in the system are generally increasing or decreasing.

9.0 RECOMMENDATIONS AND PRIORITY ISSUES

The experiences in developing this water quality assessment and the results of the assessment have lead to numerous recommendations concerning the water quality monitoring program and the current water and sediment quality of the Lagoon. This section provides recommendations for implementation in the water quality monitoring network and for future studies and management actions for the Lagoon.

Recommendations Concerning Water Quality Monitoring in the Lagoon

- Great difficulty was experienced in working with the SWIM data set and trying to present data from this set in a manner that conveys meaningful information, while maintaining accuracy without misrepresentation. One of the primary reasons for this difficulty is the unevenness of the coverage of the data set and the many gaps in the data. Even with the implementation of the SWIM network, significant problems remain in comparing data from different stations and sources. Gaps in temporal coverage, differing periods of record, and truncating of the periods of record make it difficult to compare averages or construct meaningful time series analyses. Differing monitoring frequencies (i.e., quarterly vs monthly) or different periods (i.e. December vs January for quarterly monitoring) can result in over-weighting certain values. In some cases, this can result in a time series presentation where one month may be represented by only one aberrant station, thus presenting a totally misleading picture of trends. The level of effort required to determine what can be presented and justified; how best to present it and then to manipulate data to a point where the comparisons can be made; or to provide detail on all the details, exceptions, and "caveats"can be enormous for an area the size of the Lagoon with the current incomplete state of the data base. Therefore, we strongly feel that it is imperative that efforts continue to standardize sampling intervals and dates throughout the Lagoon, and to insure that this date is entered into the data base in an expeditious and accurate fashion.

- A large number of data gaps existed in the current SWIM water quality data set at the time of this study. These gaps have included key stations that were missing (i.e., Sykes Creek and the St. Lucie River), sequential data gaps at some stations, and missing parameters. Efforts should continue to verify this data and input it to the data base.

- Another data gap in the SWIM data set is the lack of any sediment or tissue sampling data, particularly in respect to metals and organic compounds. Existing data from Florida Institute of Technology and the Florida Department of Environmental Protection, as well as any other existing or future sources, should be added to the data set. Locations of stations should also be well documented.

- Some data gaps appear to have resulted from data which was eliminated due to quality assurance problems. Some of the problems appear to have been errors of transferring data from one format to another or from one agency to another. Additional data verification beyond that allowed by current resources is recommended to recover valuable data.

- Some older data may be limited in value for several reasons, including improper sample preparation and unsuitably high instrument detection limits for several parameters such as metals and organic compounds. In order for future studies of these parameters to be of value, care should be exercised in maintaining quality assurance in both sampling and analysis.

- All of the parameters evaluated in Section 5.0 are felt to be valuable for tracking the state of the Lagoon and should be maintained in the monitoring network. In addition, inclusion of routine BOD and bacteriological monitoring may be of value. Water temperature may also be useful.

- Although TN and TP are useful and readily obtained indicators of the overall nutrient content of a system, dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP) have been found to be nutrient parameters most utilized by phytoplankton and most indicative of phytoplankton dynamics and the controlling factors in an estuary (Funderburk, et al., 1991). It is recommended that if chlorophyll *a* data indicate a potential phytoplankton overabundance problem (levels greater than 15 to 20 mg/L), DIP and DIN should be added to the parameter list.

- Quarterly data may be suitable for some parameters. However, greater temporal resolution and a larger universe of sampling points is desirable. Perhaps sampling intervals could be standardized at two month intervals to provide a balance between the increased cost-efficiencies of longer intervals with the resolution of monthly programs.

- It was not possible to perform a total data validation within the constraints of this project, which had to assume that SJRWMD and IRLNEP had accomplished the validation. However, while not knowing the full provenance of the data, it appears that spatial differences appear on a regular basis between adjacent stations which are monitored by different agencies. This raises a question as to whether the differences represent true ambient water quality changes or are a result of differences in sampling or analytical methods. It is recommended that occasional duplicate samples collected by agencies also be sent to laboratories used by other agencies as a confirmation of analytical comparability.

- The SWIM water quality data set appears to show some differences between nearby stations that may be related to factors such as depth, distance from shore, location, and substrate type. For future use of the data set, it would be advantageous to maintain a central station inventory describing the exact location and physical conditions of each station in a readily retrievable and usable format.

- The location and intensity of the stations of the water quality network appear to be adequate for Lagoon-wide and local analysis, if the data collected are comparable and complete.

- Significant data gaps may occur for major tributaries such as those in Segment 4. Although data has been gathered in these areas, either the availability may be limited or quality control problems may limit utility of the existing data.

Implications from Results of Water Quality Assessment

- No major specific sources of high nitrogen are apparent from the water quality data throughout much of the North Indian River Lagoon and Mosquito Lagoon, yet TKN and TN levels are high in several reaches. Stormwater non-point source modelling studies (Loadings Assessment Technical Report) indicate that non-point runoff sources may be important contributors of TN. Septic (OSDS) systems also may be important sources. These possible sources should be studied in more detail, especially in areas where non-point loads are projected to increase.

- The North Indian River Lagoon (Segment 1C), Banana River (Segment 1B), and Mosquito Lagoon (Segment 1A) all appear to have elevated nitrogen levels, particularly organic-based TKN. In some areas of these segments, chlorophyll *a* levels seem to follow similar patterns, but this does not appear to be consistent throughout these segments. It is recommended that additional analysis be done on the relation between chlorophyll *a* and nitrogen with statistical correlations to the extent possible from the data set in order to gain better understanding of the factors controlling phytoplankton abundance in these areas.

- Although most parameters do not appear to be elevated in the north Banana River, the portion of Banana River south of Cocoa Beach has elevated concentrations of nutrients and metals and potentially troublesome levels of chlorophyll *a*. Since it appears that this segment does not flush readily (Physical Features Technical Report), source reduction strategies may be necessary to produce improvements in water quality.

- Metals contamination may not be a significant problem throughout most of the Indian River Lagoon complex. However, the status of metals should be periodically re-evaluated because of the potentially high impacts of elevated levels. In particular, it may be advisable to monitor both water column and tissue contents in the shellfishing waters of the Titusville/Cocoa/Rockledge area of Segment 1C.

- Concentrations of several contaminants have been reported as highest in Crane Creek and the Eau Gallie River. Water quality data from stations in the Lagoon near these tributaries indicate that some impacts from these tributaries occur in mid-Lagoon. There is a need to continue updating existing information on these tributaries, since they may impact water quality of the Lagoon inordinately in respect to their flow rates.

- Concentrations of most contaminants are thought to be lower in Turkey Creek than in Crane Creek and the Eau Gallie River, but flow rates are greater. Thus contaminant inputs from Turkey Creek may be more difficult to control because a larger volume of water (Loadings Assessment Technical Report) may have to be treated to remove the same mass of contaminants from the Lagoon. An evaluation of the relative effectiveness of source controls in these three sub-basins should be considered prior to implementation of control measures.

- The Sebastian River and the Vero North, Main, and South Canals appear to be significant sources of TP for Segment 3 in the vicinity of Vero Beach. Control of TP inputs from these drainages would seem to be indicated.

- Although TP is much higher than the Lagoon-wide norm in much of Segment 3, the average chlorophyll *a* levels do not seem to indicate increased phytoplankton growth in response to the TP enrichment. Thus the extent of impact of TP is not readily apparent. Since the Loadings Assessment Technical Report projects substantially increased TP loadings in this segment by 2010, the mechanisms governing the response of the systems of this segment of the Lagoon to nutrient enrichment should be examined further. It is not known whether increased TP loading will impact the systems or at what level it may occur. It is also possible that nitrogen remains the limiting nutrient factor controlling processes such as phytoplankton response. Consequently, small increases in nitrogen could lead to large increases in phytoplankton growth as long as TP levels remain high. These mechanisms should be better understood in order to implement the most effective management actions.

- The SWIM water quality data set indicates that water quality parameters around the inlets are generally typical of open ocean ranges and can be considered "good". This observation supports the hypothesis that the flushing and tidal exchange through the inlets may enhance water quality and should be encouraged.

- The SWIM water quality data indicate that the water quality impacts of large flows from the St. Lucie Estuary appear to be restricted to a fairly limited area adjacent to the Inlet. Modelling studies should be initiated to evaluate the significance of the St. Lucie flows on water quality of the Lagoon.

- The water quality data indicate that the principal areas currently requiring corrective or management measures include:

    - Segment 2, North Central Indian River Lagoon, between Sebastian River and the Eau Gallie River due to salinity variations, elevated metals concentrations around the harbors and river mouths, and elevated nutrient and chlorophyll *a* levels near Crane Creek and the Eau Gallie River,

    - Segment 1C, North Indian River Lagoon in the Titusville, Cocoa, and Rockledge areas where high chlorophyll *a*, TP, and TKN concentrations are present and where metals and bacteria have been indicated as potential problems for the shellfish industry.

    - Segment 1B, in the south end of Banana River, with moderately high nutrient and very high chlorophyll *a* levels, as well as contamination from several metals.

- Areas which appear to have the potential for developing problems in the future which should be addressed by management plans include:

  - Segment 1A, the portion of Mosquito Lagoon from Edgewater to about Haulover Canal, where relatively high nitrogen levels occur and where other studies have indicated potential for bacterial and metals contamination from stormwater runoff and OSDS.

  - Segment 3, the South Central Indian River from Sebastian to south of Vero Beach where substantially elevated levels of TP occur and where high TP levels are present in each of the main tributaries.

10.0
SUMMARY OF QUALITY RESULTS

10.1 WATER QUALITY

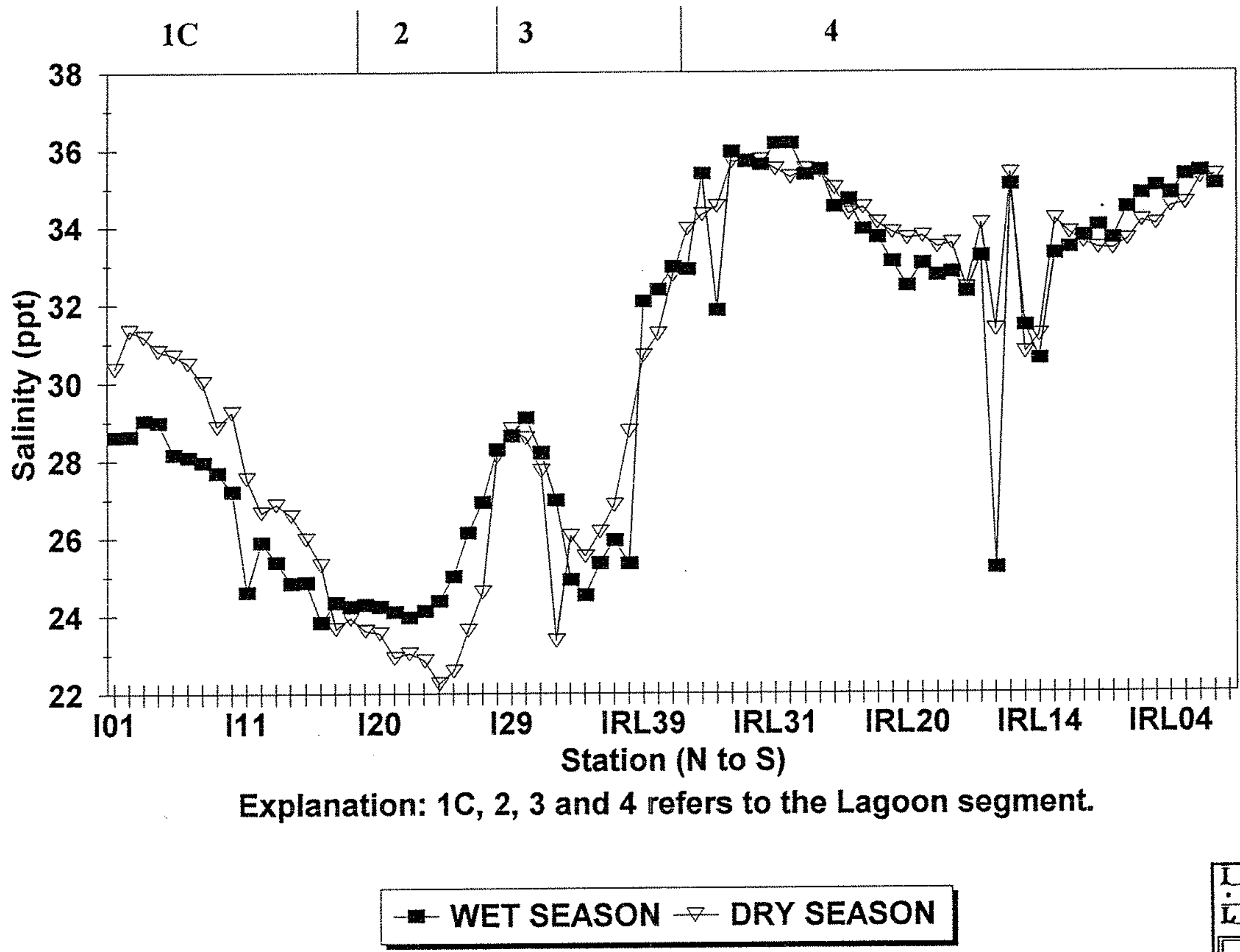
A review of water quality data confirms that water quality differences exist throughout the Indian River Lagoon complex and its tributaries. The results of Section 5.1 for the four individual segments (Segments 1C, 2, 3, 4) of the Indian River Lagoon proper have been combined graphically in Figures 10-1 to 10-10 for an overview of Lagoon-wide patterns of water quality conditions. These figures show the system variations from north to south for the following indicator parameters: salinity, TKN, TN, TP, DO, chlorophyll *a*, TSS, color, Secchi disk depth, and turbidity. Figures 10-1 to 10-10 also indicate the difference in concentration for each of the parameters for wet and dry seasons for the system area. Table 10-1 summarizes the water quality statistics by segment for the system. The wet and dry season means and standard deviations for each station are shown in Appendices A and B.

When the water quality of all six segments is compared, the following general statements can be made:

- Salinity is highest in the south end in Segment 4 (South Indian River Lagoon) (Figure 10-1).

- In the Banana River (Segment 1B), average salinity values are relatively low with a gradient from north to south. An increase in salinity in May, June, and July shows a response to evaporation from the large surface area (Figure 5-6).

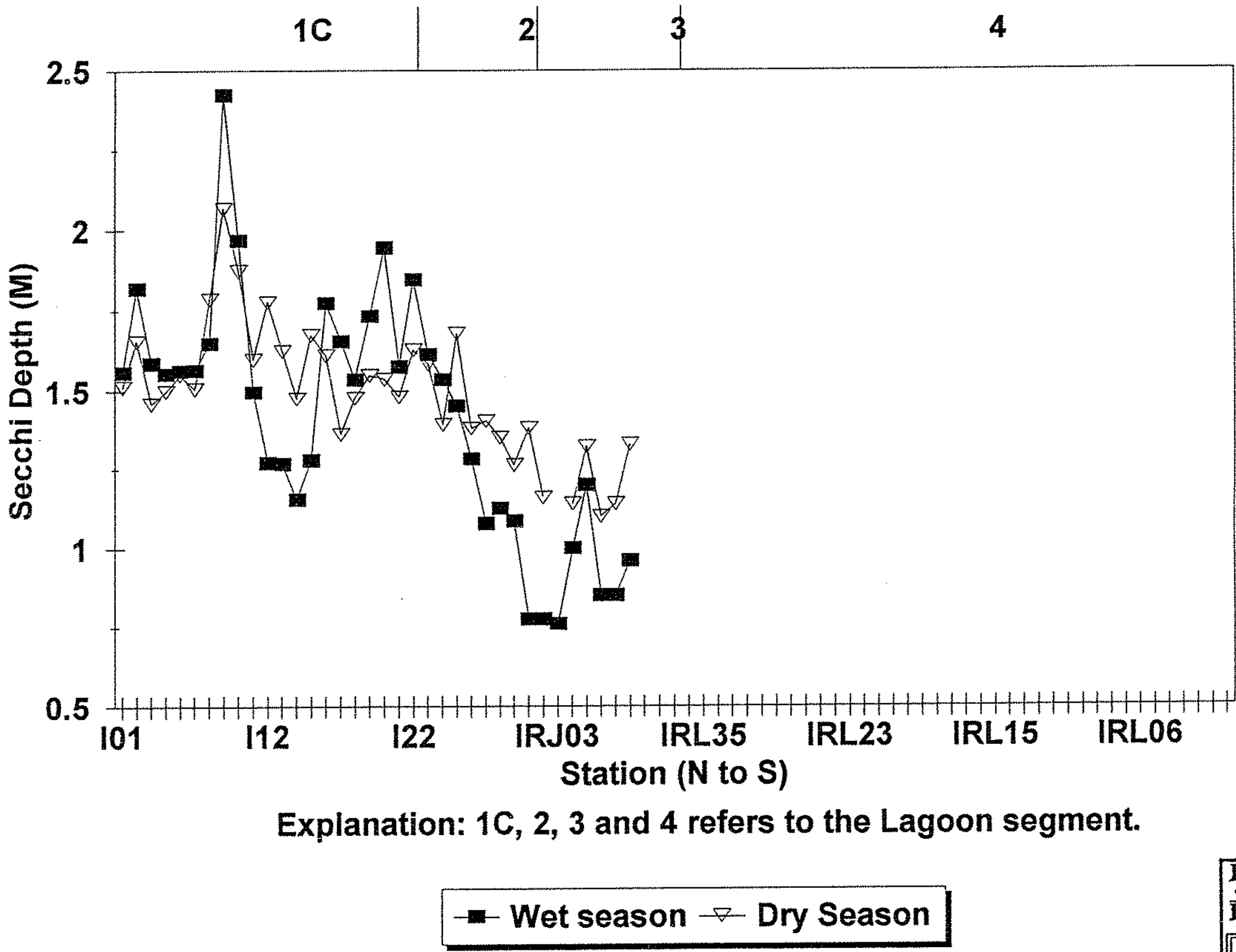
- Seasonal salinity differences are present in the northern part of the complex, but are not as pronounced in the southern half.



Explanation: 1C, 2, 3 and 4 refers to the Lagoon segment.

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 10-1 AVERAGE SALINITY CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysis	DRAWING NO.: DATE:	FIGURE 10-2 AVERAGE SECCHI DISK DEPTHS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

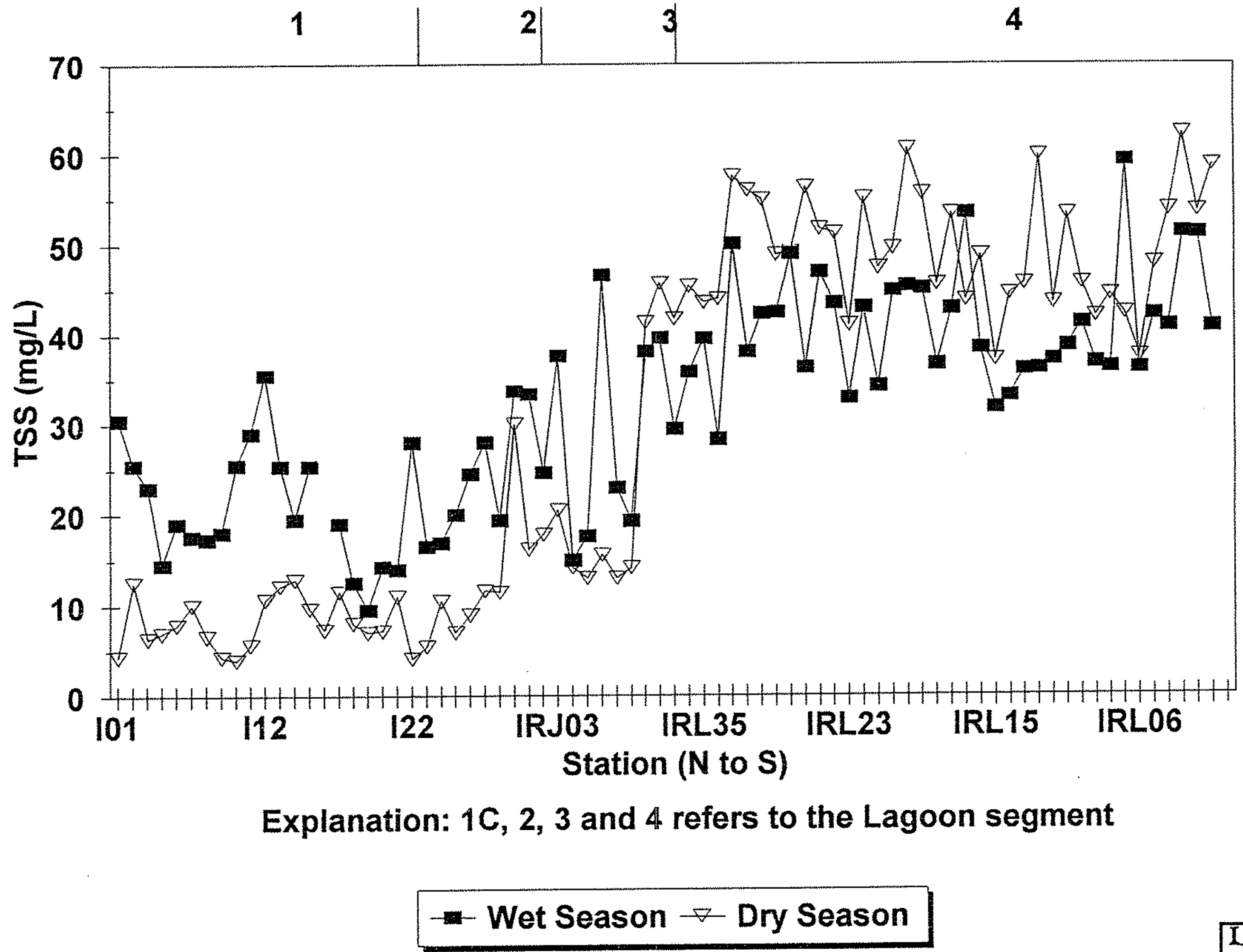


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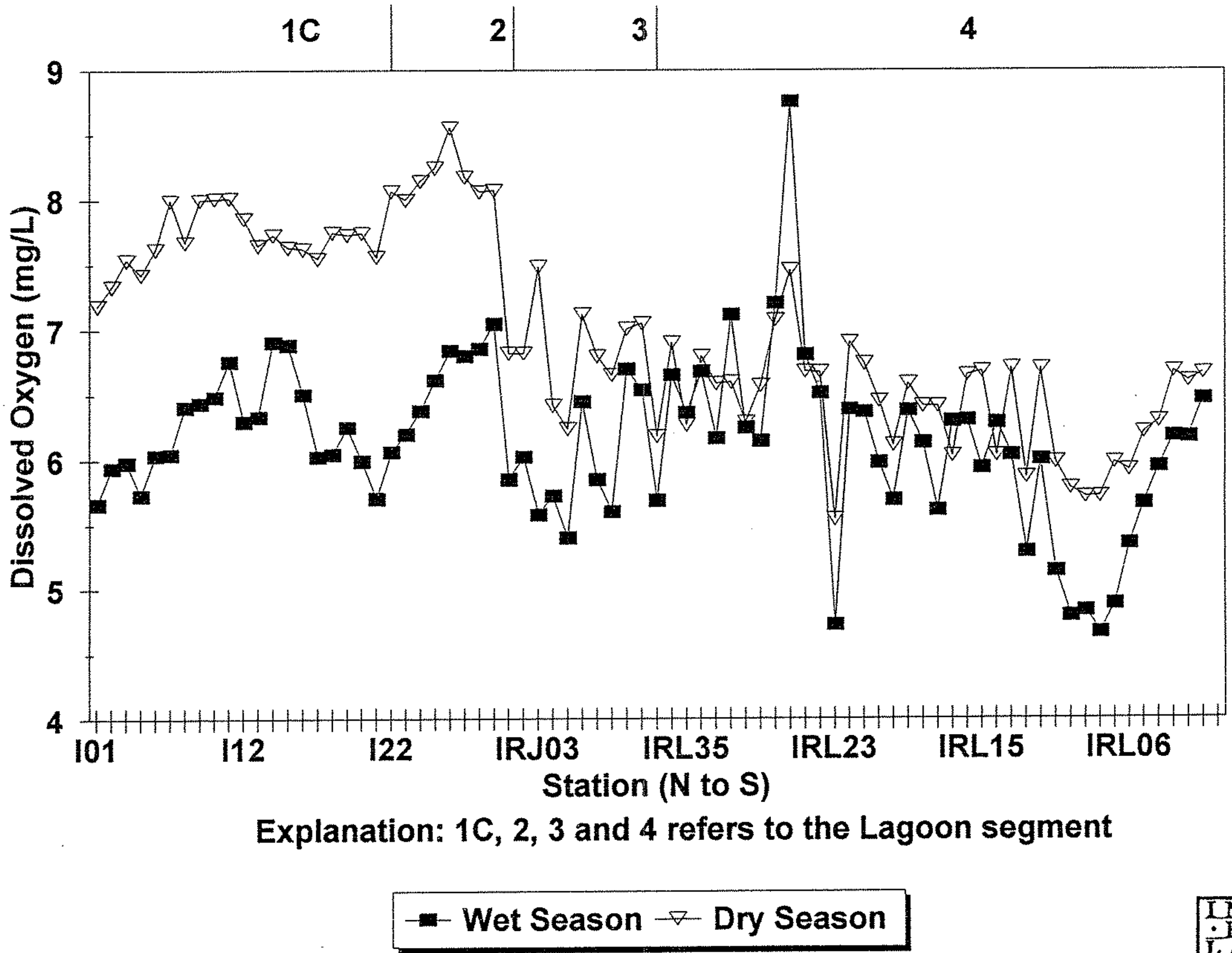
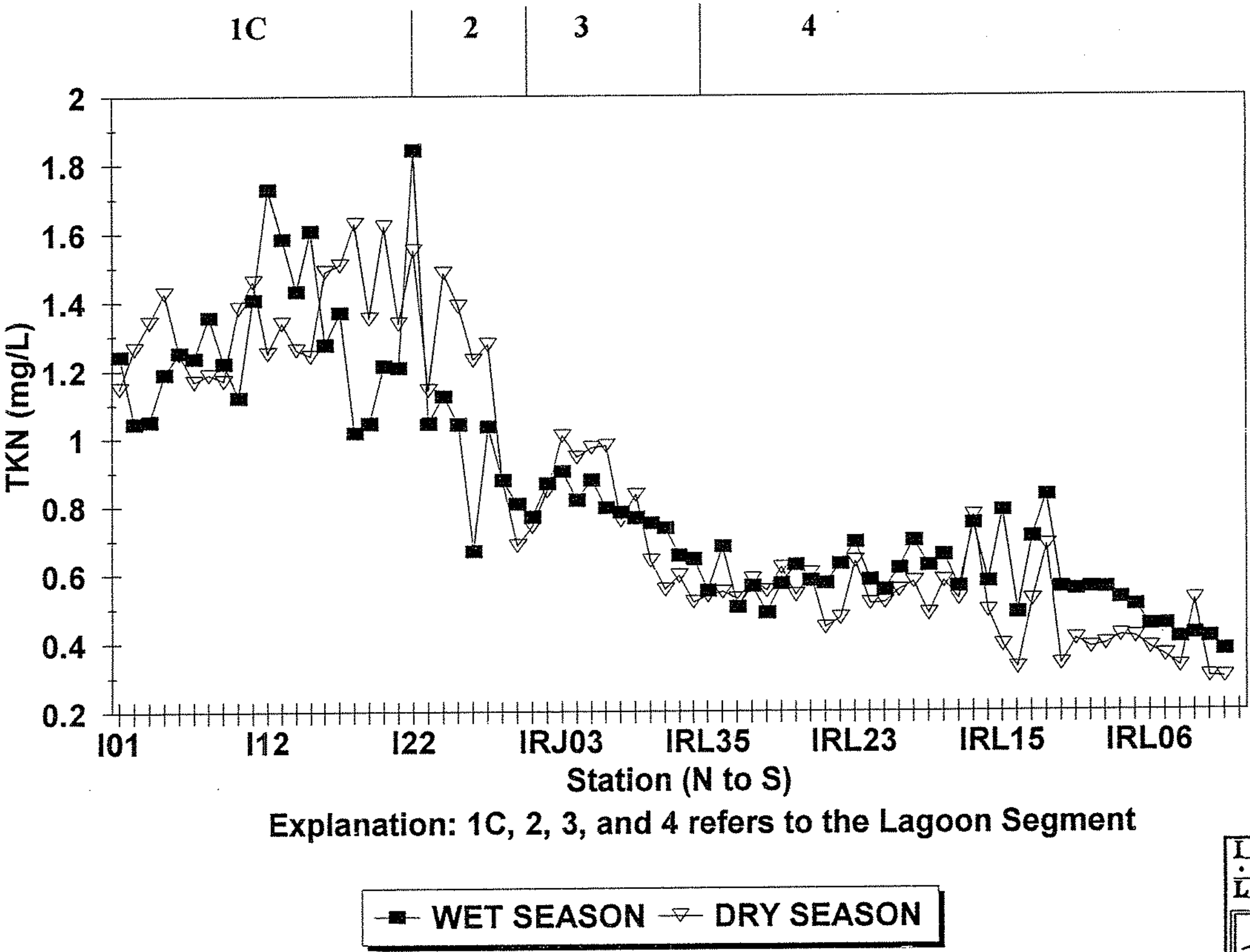
FIGURE 10-3 AVERAGE TOTAL SUSPENDED SOLIDS CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 10-4 AVERAGE DISSOLVED OXYGEN CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



• Woodward-Clyde Consultants
• Marshall McCully & Associates
• Natural Systems Analysts

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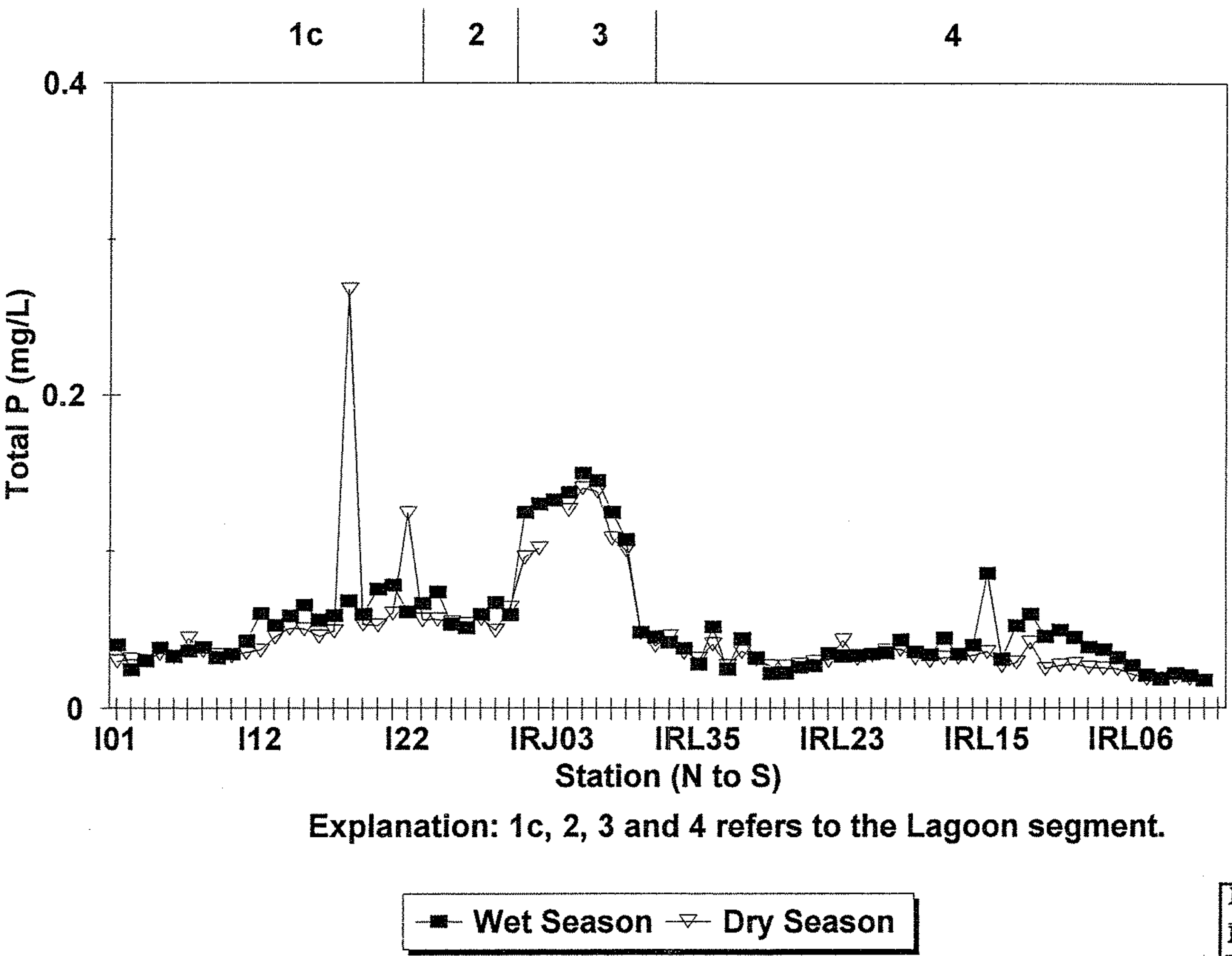
FIGURE 10-5 AVERAGE TKN CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



• Woodward–Clyde Consultants
• Marshall McCully & Associates
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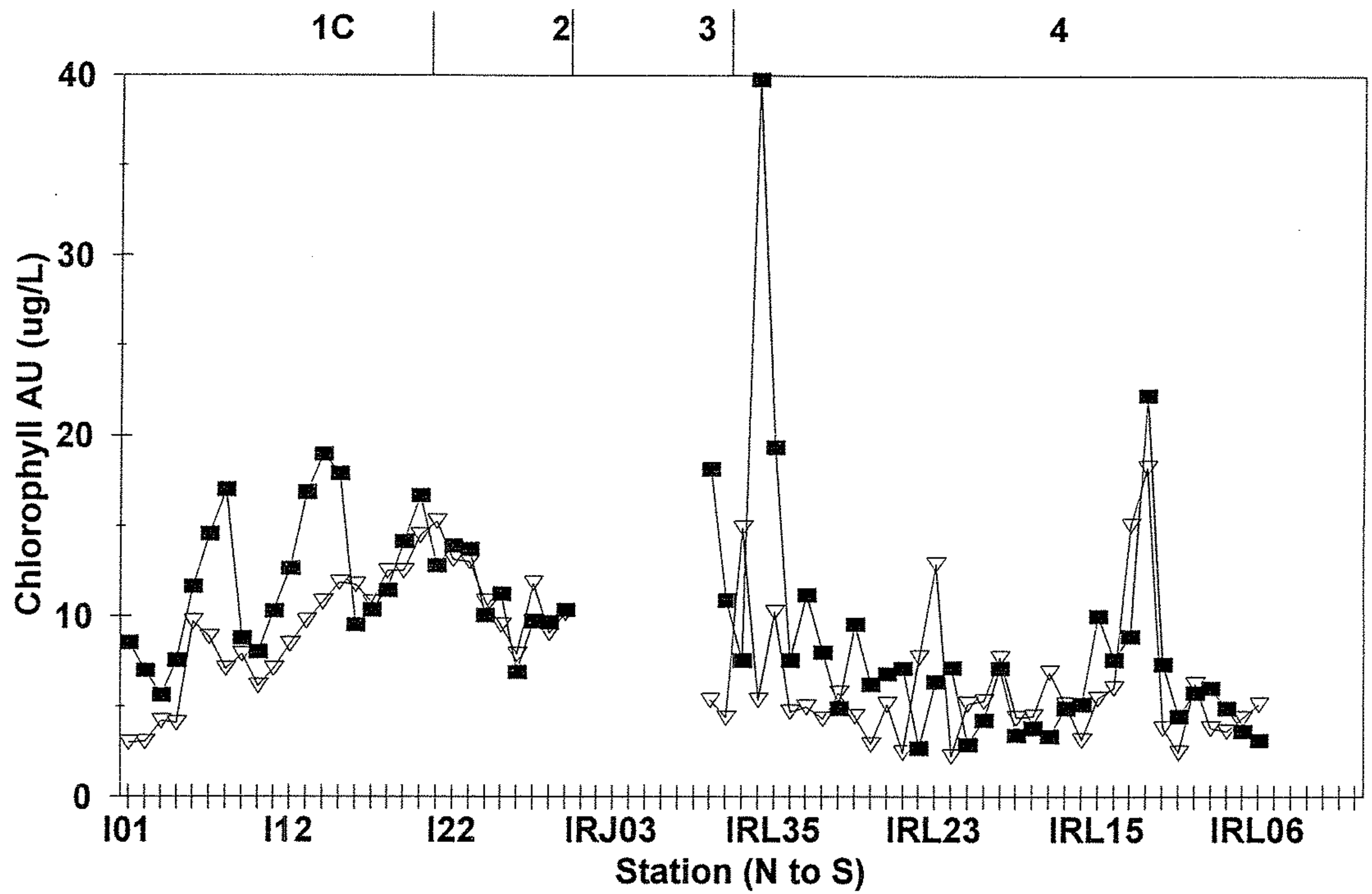
FIGURE 10-6 AVERAGE TOTAL PHOSPHORUS CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



Explanation: 1C, 2, 3 and 4 refers to the Lagoon segment.

Wet Season — Dry Season

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FIGURE 10-7 AVERAGE CHLOROPHYLL *a* (UNCORRECTED) CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

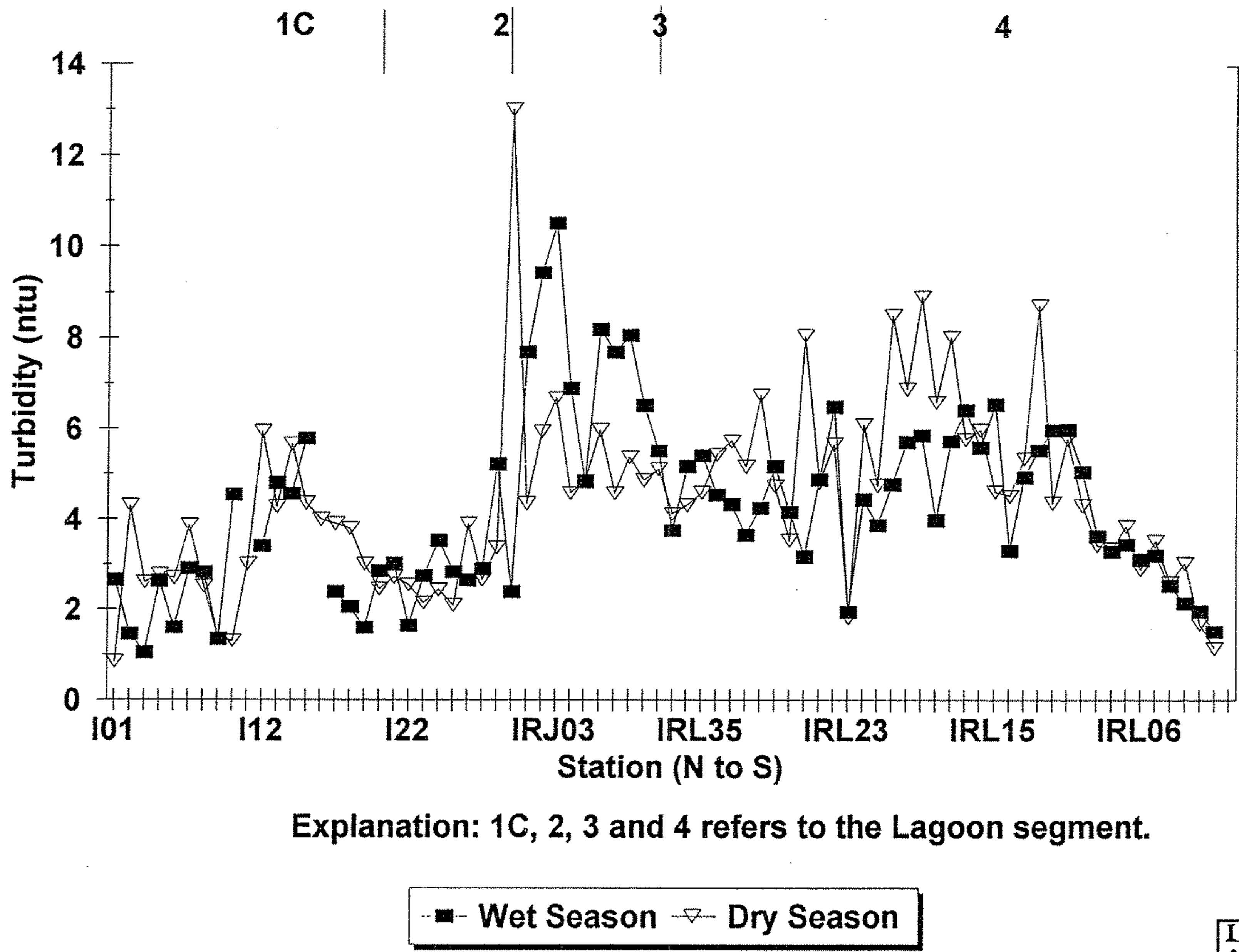

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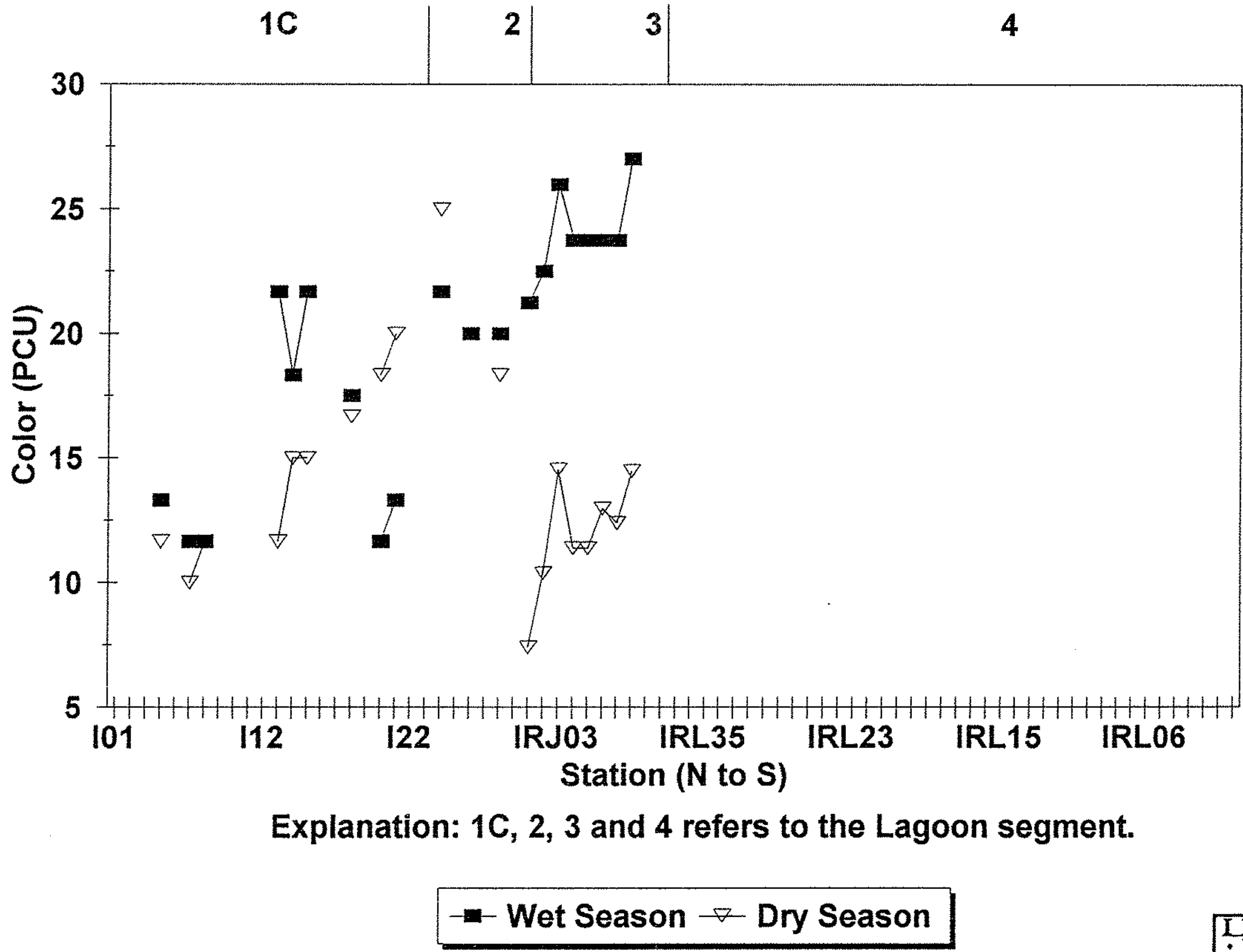
FIGURE 10-8 AVERAGE TURBIDITY CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



• Woodward–Clyde Consultants
• Marshall McCully & Associates
• Natural Systems Analysts

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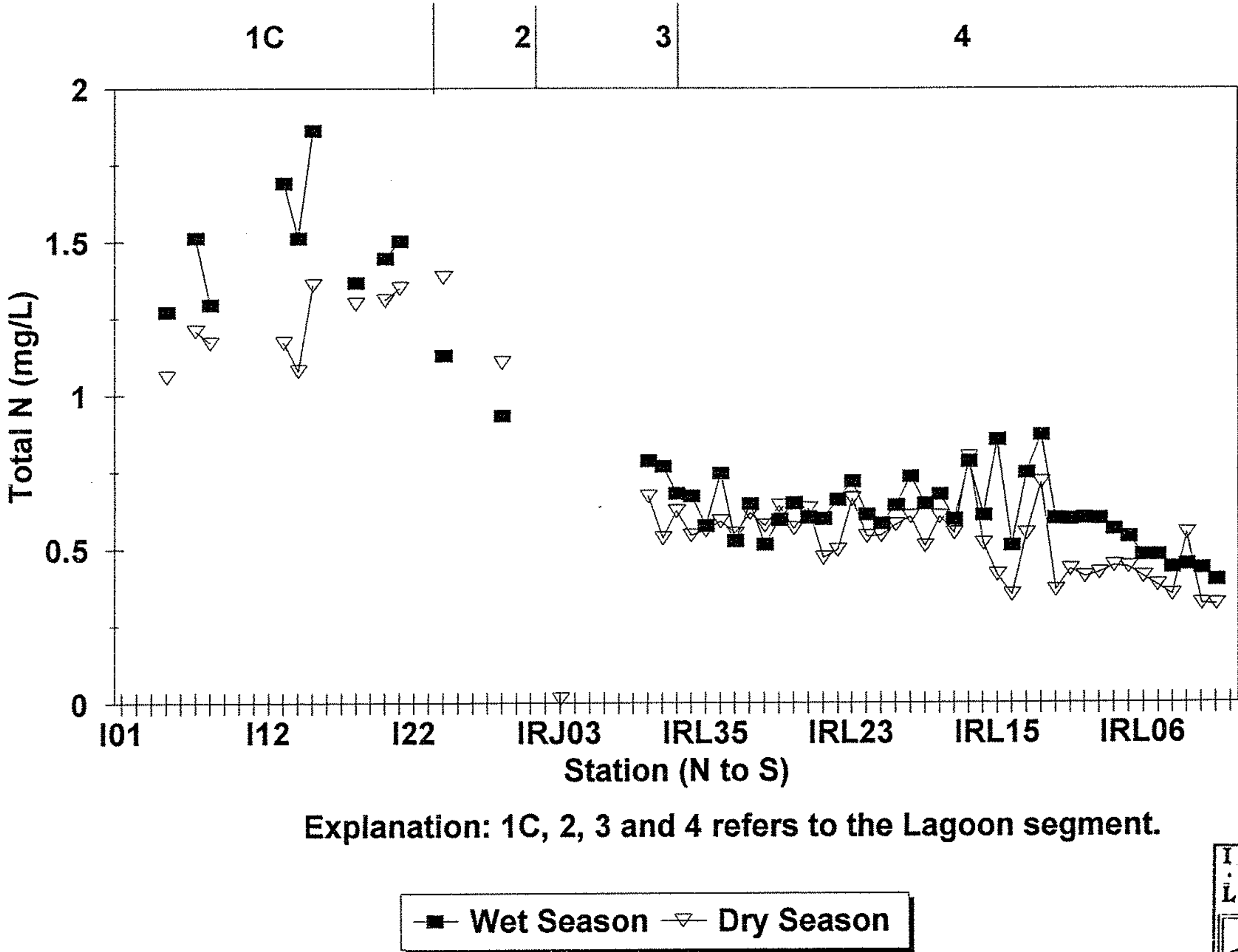
FIGURE 10-9 AVERAGE COLOR CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



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DATE: 6-27-94

FIGURE 10-10 AVERAGE TOTAL NITROGEN CONCENTRATIONS FOR THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

TABLE 10-1

WATER QUALITY STATISTICS BY SEGMENT FOR THE INDIAN RIVER LAGOON SYSTEM

STATISTICAL PARAMETERS	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL *a* (µg/L)	TKN (mg/L)
SEGMENT 1A - MOSQUITO LAGOON										
Number of Samples	834	831	808	754	342	752	202	341	717 (C)	780
Maximum Concentration	9.6	41	3	16	20	100	0.43	3.8	25.6 (C)	3.78
Minimum Concentration	3.2	14.1	0.1	1.2	0	1	0.015	0.06	0.06 (C)	0.04
Average Concentration	6.6	32.1	1.07	6.56	11.0	18.4	0.089	0.99	6.90 (C)	1.08
Standard Deviation	1.15	4.43	0.41	2.96	4.38	15.1	0.082	0.06	4.34 (C)	0.50
SEGMENT 1B - BANANA RIVER										
Number of Samples	513	523	523	122	0	121	234	0	222 (U)	236
Maximum Concentration	12.3	34.5	2.7	10.5	—	85	0.19	—	69.2 (U)	2.45
Minimum Concentration	2.93	15.3	0.4	0.1	—	0.1	0.01	—	1 (U)	0.13
Average Concentration	6.61	24.6	1.27	4.15	—	22.6	0.05	—	12.3 (U)	1.37
Standard Deviation	1.56	3.10	0.42	1.99	—	16.9	0.03	—	10.2 (U)	0.44
SEGMENT 1C - NORTH INDIAN RIVER LAGOON										
Number of Samples	764	765	766	136	46	142	297	58	267 (U)	297
Maximum Concentration	14.7	40	3.66	13	35	57	0.14	2.74	62.7 (U)	3.8
Minimum Concentration	0.4	10	0.3	0.3	5	3.7	0.005	0.55	0.58 (U)	0.05
Average Concentration	6.99	27.1	1.62	3.35	14.8	14.4	0.04	1.35	10.7 (U)	1.31
Standard Deviation	1.44	5.06	0.53	2.14	6.05	11.2	0.02	0.39	9.00 (U)	0.47
SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON										
Number of Samples	312	328	324	57	19	58	127	18	114	126
Maximum Concentration	14.7	37	4.11	7.7	40	45	0.61	1.86	30.6	3.2
Minimum Concentration	2.8	10	0.2	1	10	3.3	0.03	0.59	0.59	0.05
Average Concentration	7.33	24.5	1.47	3.17	19.7	14.3	0.06	1.23	11.4	1.15
Standard Deviation	1.57	4.88	0.54	1.63	6.56	9.5	0.05	0.31	6.05	0.46

TABLE 10-1

WATER QUALITY STATISTICS BY SEGMENT FOR THE INDIAN RIVER LAGOON SYSTEM, Continued

STATISTICAL PARAMETERS	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL *a* (μg/L)	TKN (mg/L)
SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON										
Number of Samples	117	118	118	63	77	69	89	1	76 (C)	90
Maximum Concentration	12	37	2.44	13.6	40	67	0.22	0.013	28.4 (C)	1.43
Minimum Concentration	4	8.26	0.6	2.1	4.9	6	0.02	0.013	1.1 (C)	0.47
Average Concentration	6.78	27.2	1.11	6.47	17.4	20.7	0.11	0.013	7.37 (C)	0.84
Standard Deviation	1.37	4.54	0.35	2.89	9.04	13.2	0.04	—	6.18 (C)	0.21
SEGMENT 4 - SOUTH INDIAN RIVER LAGOON										
Number of Samples	941	582	0	975	0	975	975	975	138 (U)	974
Maximum Concentration	14.2	40	—	39	—	176	0.18	2.52	76.5 (U)	2.37
Minimum Concentration	2.3	10.2	—	0.34	—	1	0.004	0.02	1.3 (U)	0.02
Average Concentration	6.26	33.8	—	4.75	—	44.7	0.034	0.57	7.26 (U)	0.55
Standard Deviation	1.13	3.32	—	3.17	—	32.1	0.02	0.28	8.14 (U)	0.27

U = Uncorrected Chlorophyll *a*
C = Corrected Chlorophyll *a*

- The greatest Secchi disk depths are recorded in the North Indian River Lagoon segment (Segment 1C) (Figure 10-2). Secchi disk depth is lower in the wet season in Mosquito Lagoon in inverse fashion to color, turbidity, and chlorophyll *a* concentrations. No patterns are discernable from data in the other segments. However, no Secchi desk depths are available for the South Indian River Lagoon segment.

- The highest values for TSS occur in the South Indian River Lagoon segment (Segment 4) (Figure 10-3).

- In general, DO decreases for all segments during the wet season. However, the amount of oxygen that can be dissolve in water decreases with increasing temperature and is also a function of salinity. Therefore, no observations other than this general finding are presented.

- The South Indian River Lagoon (Segment 4) has the lowest TKN values (Figure 10-5). TKN is highest in the southern Banana River (Figure 5-5).

- The South Indian River Lagoon (Segment 4) has the lowest and the least variable TP, while the South Central Indian River Lagoon (Segment 3) generally has the highest TP values (Figure 10-6).

- Chlorophyll *a* values generally indicate a wet season increase for all segments (Figures 5-2, 5-5, 10-7). Highest levels occur in south Banana River (Segment 1B), and near Titusville and Cocoa/Rockledge (Segment 1C).

- Turbidity is lowest in the North Central Indian River Lagoon (Segment 2). Mosquito Lagoon (Segment 1A) and the South Central Indian River Lagoon (Segment 3) values are relatively high (Figures 5-2, 10-8).

- Color data is sparse for the Lagoon-wide data set. No conclusions have been drawn (Figure 10-9).

- Total nitrogen data is sparse in all segments except in the south basin (Segment 4). From the limited data available, it appears that values are higher in the northern segments and lowest in the South Indian River Lagoon (Segment 4) (Figure 10-10).

- The most samples analyzed for the indicator parameters were from the South Indian River Lagoon (Segment 4) which also has the highest number of stations. The lowest number of samples analyzed was from the South Central Indian River Lagoon (Segment 3) which also has the least number of stations (Table 10-1).

- Because of the variability of water quality from each Lagoon tributary, it is difficult to make any general conclusions. However, the following observations are indicated: color values are an order of magnitude higher in the tributaries than in the open water of the Lagoon; TP and TKN are present in the tributaries in higher concentrations than the open waters; dissolved oxygen is lower in Segment 1C and 2 tributaries than in the open waters of the Lagoon; and salinity appears to be lower in tributaries of segment 1C and 3 than open Lagoon values.

- Trace metal concentrations for water (Cd, Cu, and Pb) from the Indian River Lagoon reflect both natural and anthropogenic inputs.

- Metal contamination has been identified mostly in tributaries and sheltered harbors along the Lagoon, including areas in the Titusville and Cocoa/Rockledge areas, south Banana River, Eau Gallie Harbor, Melbourne Harbor, Turkey Creek, Taylor Creek, and Manatee Pocket.

- Dissolved Cu concentrations in harbors at concentration up to 13 times background levels appear to be related to leaching of antifouling paints applied to marine craft.

In Mosquito Lagoon, the southern watershed is relatively undeveloped compared to the other five basins. Water quality, expected to be good to very good, was confirmed by the data.

In Mosquito Lagoon, a strong but apparently natural wet season/dry season response was seen for many parameters.

Similar "good" water quality conditions occur in the northern reaches of the North Indian River Lagoon (Segment 1C). However, the impact of urban land use can be seen near Titusville. Wet season TKN values are greater than dry season values indicating stormwater sources. Chlorophyll *a* values increase dramatically at locations adjacent to Titusville, especially near the wastewater treatment plant outfalls. Chlorophyll *a* concentrations decrease and dry season TKN values again become greater than wet season concentrations in the relatively short stretch between Titusville and Rockledge. At Cocoa and Rockledge increased wet season TKN values and elevated chlorophyll *a* concentrations may be associated with discharge from two municipal wastewater treatment plants.

In Banana River (Segment 1B), there is a decrease in salinity from north to south. Total phosphorous also increases steadily from north to south. TKN becomes greater during the dry season. Chlorophyll *a* increases significantly in the Banana River south of Cocoa Beach near Patrick Air Force Base during both seasons. The urbanized areas of Merritt Island, City of Cape Canaveral, the City of Cocoa Beach, and Patrick Air Force Base may contribute nutrients from wastewater treatment plants and urban runoff that also have resulted in the increased phytoplankton productivity in this area of the Lagoon.

The widely fluctuating short-term salinity variations of the freshwater discharges from the extended watershed cannot be clearly seen from the salinity data set for the North Central Indian River Lagoon basin (Segment 2). The quarterly sampling regime may have regularly missed the storm events that may reduce the salinity in this segment for long periods of time. Tidal mixing due to the proximity of Sebastian Inlet is evident, particularly south of Melbourne. This is reflected in the increase in salinity at southern stations.

In South Central Indian River Lagoon basin (Segment 3), the effect of the Sebastian River and the Indian River Farms Water Control District discharges are obvious. A large volume of freshwater flows into the Lagoon from the Sebastian River even though the discharges from C-54 are controlled. Fellsmere Canal, however, is uncontrolled and discharges flows from Fellsmere Farms continuously, as does the discharge from the Sebastian River Water Control District through the South Prong. As a result, average salinity values in the database did not exceed 30.0 ppt even near Sebastian Inlet and dropped to about 26.0 ppt near the Vero North, Main, and South canals outfalls. This part of the Lagoon has reduced surface area so evaporation is reduced as well. By contrast, in the Mosquito Lagoon with a large surface area and associated high rate of evaporation, salinity values remained high during the wet season. Another good example of the effect of the freshwater discharge into Segment 3 is color. Wet season color values were higher than dry season values by a factor of 3, and were high during the wet season for all stations, north to south. This indicates that the entire Segment 3 of the Lagoon is affected by the discharges from the Sebastian River and Indian River Farms Water Control District.

By contrast, in Segment 4 (South Indian River Lagoon), salinity values remain high throughout most of the segment, dropping only at the discharge points of the Belcher Canal (C-25), and the St. Lucie River. The volume of discharge from both of these drainage systems is very high, higher than the Sebastian River discharge. However, unlike discharges into the North Central and South Central segments, there are physical features in Segment 4 that may prevent mixing of the St. Lucie River and Belcher Canal discharges with Lagoon waters. Ft. Pierce inlet is directly across the Lagoon from the Belcher Canal. The shipping channel is deep and there are causeways on each side of the flow path from the canal to Ft. Pierce Inlet. At the St. Lucie Estuary mouth, some circulation and mixing may occur in the Lagoon north of the estuary mouth, but they are limited by the shoaling at the inlet and by the Stuart causeway. The chlorophyll *a*, TP, and TKN data show rapid changes over short distances from the inlets and illustrate the reduced mixing effect.

The water quality data is summarized in the following observations:

- Bi-monthly sampling should be considered a minimum regime because a mixture of quarterly and monthly data makes analysis difficult.

- Mosquito Lagoon (Segment 1A) and the Indian River Lagoon north of Titusville (Segment 1C) are the areas with the best water quality.

- The Banana River (Segment 1B), being practically a closed system, is impacted by point and non-point urban sources and the lack of tidal mixing.

- The North Indian River Lagoon (Segment 1C), from Titusville south, exhibits impacts from point and non-point urban sources, which are exacerbated by the lack of tidal or wind mixing.

- The North Central Indian River Lagoon (Segment 2) shows a strong wet season response to freshwater discharges, with the lowest salinity values of the Lagoon system.

- The South Central Indian River Lagoon (Segment 3), because discharge volumes are high and flushing through Sebastian Inlet is ineffective, experiences lowered salinity values year-round, with color being very high during the wet season.

- In the South Indian River Lagoon segment, the physical impediments to circulation from dredged channels, causeways, and marshlands appear to direct the high volume freshwater flows from Belcher Canal and the St. Lucie Estuary through the Ft. Pierce and St. Lucie Inlets with little mixing into the Lagoon. This bypassing of freshwater directly to the ocean keeps salinities in a reasonable range for the estuarine habitat. The impact of the high freshwater discharge through the inlets on reef and other near-coastal ocean habitats is unknown.

- Most tributaries are nutrient rich, with relatively low dissolved oxygen concentrations. Tributaries may not meet the 17-302 DO standard (5.0 mg/L) during the wet season.

10.2 ORGANISMS

Concentrations of cadmium, chromium, copper, iron, mercury, lead, and zinc found in Indian River Lagoon clams reflect both natural and anthropogenic inputs to the system. In most cases concentrations of Cd, Cu, Hg, and Zn in clam samples are greater than those from sediment samples taken in the same area. Bioaccumulation for these metals appears to be occurring from particulate and dissolved sources throughout the Lagoon (Trocine and Trefry, 1993). Lagoon-wide results indicate that the maximum concentrations for Cd, Hg, and Pb are up to 10 times greater than minimum levels. For Zn, there is a difference of greater than 50 times. These differences indicate that certain areas of the Lagoon system have been more impacted than others.

Data is still too limited to identify definitive trends. However, available data indicates that elevated levels of several metals are present in organisms in the south Banana River near Patrick Air Force Base, in Eau Gallie Harbor near Melbourne, in Port Canaveral, and in the Titusville to Cocoa area. The Titusville-Cocoa area is significant because of commercial shellfish harvesting waters in the vicinity. In some cases near Cocoa, the Cu levels found in clams appear to be near reported potentially lethal levels for clams. However, particularly elevated Cu levels in the water column have not been reported for this specific area of the Lagoon, so specific sources and mechanisms of uptake are unclear. A focus on selected areas identified in the clam research studies in the Toxic Substances Survey coupled with investigation of water and sediment quality may identify causes for differences.

10.3 SEDIMENTS

The sediment quality of most of the open water areas of the Indian River Lagoon is good. Levels of metals in sediments of the Indian River Lagoon complex are generally within FDEP estimated normal background levels for estuaries. Metals contamination appears to be associated only with the muck deposits that occur in about 10% of the Lagoon area. These deposits tend to be found in the sheltered mouths of the tributary creeks, in the deeper parts of the ICWW, and in sheltered pockets along the shoreline such as corners where causeways intersect the shoreline.

Elevated levels of copper, mercury, lead, and zinc have been noted at several localized areas where muck deposits are found. The largest of these muck deposits is in Manatee Pocket. The Melbourne and Eau Gallie Harbors in the Melbourne area are locations in which elevated levels of five or more different metals have been found. Other locations of commonly elevated metals include Manatee Pocket, the southern end of Banana River in the vicinity of Patrick Air Force Base, and around the mouths of Crane Creek and Turkey Creek. Some elevated copper levels have also been found in Taylor Creek near Ft. Pierce and in the Lagoon in the vicinity of Vero Beach.

In addition to the chemical contamination in sediments, sediment build-up inside the Lagoon adjacent to the inlets has been identified as a physical problem. These deposits interfere with navigation and change the tidal regime within large parts of the Lagoon. Integration of inlet management and assessment of effects of inlet maintenance operations on the circulation and water quality within the Lagoon may be a valuable aspect of the Indian River Lagoon management plan.

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Appendix A

MOSQUITO LAGOON (SEGMENT 1A) DRY SEASON AND WET SEASON SAMPLE AVERAGES
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
V01	5.97	33.50	1.12	6.96	11.00	18.44	0.06	1.26	7.50		1.17
V02	5.92	33.45	1.06	7.25	10.71	23.31	0.06	1.27	8.06		1.19
V03	5.74	33.61	0.98	8.11	11.71	23.50	0.08	1.25	9.40		1.22
V04	5.79	33.75	1.01	7.39	11.14	22.56	0.07	1.45	8.74		1.29
V05	5.64	33.77	0.93	8.02	12.14	23.89	0.07	1.41	9.90		1.30
V06	6.14	33.53	0.84	9.04	11.43	27.06	0.09	1.29	10.79		1.28
V07	6.07	33.85	0.73	9.31	11.50	26.75	0.09	1.42	11.04		1.29
V08	6.21	33.86	0.88	8.34	11.14	23.97	0.08	1.28	10.52		1.29
V09	5.95	34.33	0.71	9.50	13.43	29.36	0.08	1.40	10.81		1.41
V10	6.04	33.75	0.86	9.14	12.43	28.61	0.06	1.50	11.82		1.39
V11	5.26	33.72	0.75	9.96	13.71	25.97	0.07	1.38	10.53		1.49
V12	5.69	33.60	0.77	9.19	14.00	27.18	0.08	1.25	10.50		1.40
V13	6.16	33.92	0.78	9.84	12.57	25.00	0.07	1.37	10.12		1.37
V14	6.15	33.18	0.85	8.24	13.00	25.82	0.07	1.33	10.77		1.41
V15	5.43	33.35	0.88	8.45	12.00	25.00	0.06	1.37	8.45		1.39
V16	5.36	33.10	0.94	6.96	12.86	22.95	0.06	1.30	7.37		1.35
V17	5.59	33.33	0.75	7.97	12.57	22.00	0.06	1.26	8.45		1.42
V18	5.77	33.44	1.01	7.70	12.14	22.42	0.06	1.32	8.56		1.41
V20	6.19	33.34	1.09	6.28	11.14	15.13	0.06	1.31	6.83		1.48
ML01	5.63	30.85	1.27	3.71		31.25	0.04			8.03	1.09
ML02	5.84	27.21	1.23	3.31		42.80	0.04			6.84	1.22

MOSQUITO LAGOON (SEGMENT 1A) DRY SEASON AND WET SEASON SAMPLE AVERAGES
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
V01	7.01	32.58	1.52	4.84	7.00	14.43	0.10	0.62	4.57		0.70
V02	7.01	32.61	1.48	4.95	8.18	14.80	0.09	0.59	4.79		0.70
V03	7.06	32.41	1.32	5.03	9.45	13.58	0.09	0.64	5.03		0.72
V04	7.07	32.45	1.37	5.06	10.00	12.60	0.11	0.70	4.45		0.74
V05	7.11	32.36	1.31	5.10	10.00	13.20	0.11	0.73	4.87		0.79
V06	7.41	32.43	1.27	5.56	10.09	12.20	0.09	0.81	5.44		0.83
V07	7.49	32.23	1.07	5.33	10.73	11.80	0.09	0.76	5.69		0.80
V08	7.30	32.22	1.22	4.95	10.09	12.05	0.09	0.77	5.70		0.81
V09	7.47	32.43	0.82	5.04	10.27	11.60	0.09	0.71	4.78		0.78
V10	7.22	31.92	1.18	5.24	12.00	12.93	0.10	0.69	5.42		0.78
V11	7.19	32.57	0.98	5.88	10.73	12.80	0.09	1.07	3.11		1.02
V12	7.29	32.59	1.01	5.13	11.77	11.55	0.10	0.76	4.02		0.85
V13	7.47	31.95	1.05	5.27	11.82	12.70	0.07	0.75	4.53		0.83
V14	7.28	31.91	1.18	4.76	11.36	10.83	0.08	0.99	4.40		1.00
V15	6.91	31.97	1.16	5.18	11.09	11.88	0.08	0.84	3.89		0.90
V16	6.92	32.02	1.21	4.65	10.36	10.80	0.07	0.79	3.51		0.87
V17	7.22	32.10	0.78	5.04	11.18	11.68	0.07	0.79	3.50		0.84
V18	7.22	32.17	1.30	5.38	10.18	11.93	0.07	0.88	3.90		0.92
V20	7.40	32.27	1.43	4.76	9.73	10.70	0.13	0.87	3.11		0.96
ML01	7.26	31.22	1.70	3.08		14.70	0.04			5.31	1.09
ML02	7.24	19.53	1.10	7.41		35.00	0.04			6.43	1.02

BANANA RIVER LAGOON (SEGMENT 1B) DRY SEASON AND WET SEASON SAMPLE AVERAGES
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
B01	7.42	25.54	1.44	3.15		23.70	0.03			5.19	1.29
B02	7.48	25.55	1.52	4.28		20.30	0.03			4.35	1.31
B03	7.35	24.84	1.31	3.80		15.50	0.04			6.76	1.44
B04	7.63	24.94	1.30	6.10		13.08	0.04			7.76	1.38
B05	7.27	24.14	1.31	3.78		19.65	0.05			8.90	1.36
B06	7.66	23.53	1.13	5.61		20.25	0.05			15.74	1.42
B07	8.02	23.24	1.19	5.05		18.39	0.06			14.57	1.33
B08	7.80	23.62	1.30	4.90		35.60	0.06			13.52	1.35
B09	7.72	23.24	1.31	2.88		14.35	0.06			11.34	1.38
B10	7.20	22.96	1.25	4.43		22.35	0.07			14.30	1.39

BANANA RIVER LAGOON (SEGMENT 1B) DRY SEASON AND WET SEASON SAMPLE AVERAGES
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
B01	5.45	27.51	1.14	3.88		29.20	0.04			6.32	1.55
B02	5.55	26.85	1.40	3.22		35.40	0.05			7.26	1.48
B03	5.69	25.39	1.40	4.17		21.26	0.05			11.50	1.66
B04	6.07	25.78	1.20	4.18		28.56	0.05			10.75	1.46
B05	5.47	24.95	1.14	4.78		26.48	0.05			11.92	1.50
B06	5.88	24.20	1.23	3.84		23.28	0.06			17.82	1.20
B07	5.70	24.07	1.22	3.73		20.52	0.07			17.11	1.19
B08	6.26	24.15	1.31	3.56		18.62	0.07			18.44	1.23
B09	5.96	23.81	1.24	3.57		26.98	0.08			14.79	1.34
B10	5.43	23.18	1.08	4.82		29.74	0.09			24.16	1.23

NORTH INDIAN RIVER LAGOON (SEGMENT 1C) DRY SEASON AND WET SEASON SAMPLE AVERAGES
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I01	5.66	28.61	1.56	2.65		30.50	0.04			8.55	1.24
I02	5.94	28.62	1.82	1.45		25.50	0.02			7.00	1.05
I03	5.98	29.03	1.59	1.05		23.00	0.03			5.61	1.05
I04	5.73	28.99	1.55	2.63	13.33	14.54	0.04	1.27		7.55	1.19
I05	6.04	28.16	1.56	1.60		19.00	0.03			11.65	1.25
I06	6.05	28.09	1.56	2.91	11.67	17.60	0.04	1.52		14.59	1.24
I07	6.41	27.96	1.65	2.83	11.67	17.31	0.04	1.30		17.02	1.36
I08	6.44	27.69	2.42	1.35		18.00	0.03			8.78	1.22
I09	6.49	27.22	1.97	4.55		25.50	0.04			8.03	1.12
I11	6.76	24.62	1.49			29.00	0.04			10.30	1.41
I12	6.30	25.90	1.27	3.40		35.50	0.06			12.67	1.73
I13	6.33	25.38	1.27	4.80	21.67	25.35	0.05	1.69		16.87	1.58
I14	6.91	24.84	1.15	4.57	18.33	19.50	0.06	1.51		18.97	1.43
I15	6.88	24.87	1.28	5.80	21.67	25.39	0.07	1.86		17.90	1.61
I16	6.51	23.83	1.77				0.06			9.53	1.28
I17	6.03	24.34	1.65	2.40		19.00	0.06			10.38	1.37
I18	6.04	24.25	1.54	2.07	17.50	12.50	0.07	1.37		11.43	1.02
I19	6.25	24.29	1.73	1.60		9.50	0.06			14.16	1.05
I20	5.99	24.25	1.95	2.86	11.67	14.29	0.08	1.45		16.70	1.21

NORTH INDIAN RIVER LAGOON (SEGMENT 1C) DRY SEASON AND WET SEASON SAMPLE AVERAGES
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I01	7.19	30.37	1.51	0.85		4.35	0.03			2.99	1.15
I02	7.34	31.33	1.65	4.30		12.50	0.03			3.03	1.26
I03	7.54	31.18	1.46	2.60		6.35	0.03			4.19	1.34
I04	7.42	30.82	1.50	2.78	11.67	6.95	0.04	1.06		4.06	1.43
I05	7.62	30.70	1.55	2.70		7.85	0.03			9.72	1.25
I06	8.00	30.49	1.50	3.87	10.00	9.97	0.04	1.21		8.84	1.17
I07	7.67	30.01	1.79	2.52	11.67	6.60	0.04	1.17		7.09	1.19
I08	8.00	28.88	2.07	1.35		4.30	0.03			7.88	1.17
I09	8.01	29.25	1.87	1.30		4.00	0.03			6.12	1.38
I11	8.01	27.55	1.60	3.00		5.65	0.04			7.07	1.46
I12	7.85	26.66	1.78	5.95		10.65	0.04			8.46	1.25
I13	7.65	26.88	1.62	4.28	11.67	12.12	0.05	1.17		9.75	1.34
I14	7.73	26.59	1.47	5.67	15.00	12.83	0.05	1.08		10.80	1.26
I15	7.63	25.99	1.67	4.36	15.00	9.60	0.05	1.36		11.85	1.24
I16	7.62	25.31	1.61	4.00		7.30	0.05			11.73	1.49
I17	7.55	23.66	1.36	3.90		11.50	0.05			10.76	1.51
I18	7.75	23.94	1.48	3.80	16.67	7.98		1.30		12.51	1.63
I19	7.73	23.62	1.55	3.00		7.00	0.05			12.51	1.35
I20	7.74	23.55	1.54	2.46	18.33	7.18	0.05	1.31		14.50	1.62

NORTH CENTRAL INDIAN RIVER LAGOON (SEGMENT 2) DRY SEASON AND WET SEASON SAMPLE AVERAGES
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I21	5.70	24.11	1.57	3.01	13.33	13.96	0.08	1.50		12.83	1.21
I22	6.06	23.97	1.85	1.65		28.00	0.06			13.93	1.84
I23	6.20	24.13	1.61	2.75		16.50	0.07			13.74	1.05
I24	6.38	24.39	1.54	3.53	21.67	16.87	0.07	1.13		10.08	1.12
I25	6.62	25.01	1.45	2.83		20.00	0.05			11.25	1.04
I26	6.84	26.14	1.28	2.65	20.00	24.50	0.05			6.91	0.67
I27	6.80	26.94	1.08	2.90		28.00	0.06			9.74	1.03
I28	6.86	28.28	1.13	5.22	20.00	19.37	0.07	0.93		9.69	0.88

NORTH CENTRAL INDIAN RIVER LAGOON (SEGMENT 2) DRY SEASON AND WET SEASON SAMPLE AVERAGES
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I21	7.56	22.93	1.48	2.72	20.00	10.93	0.06	1.35		15.25	1.34
I22	8.07	23.04	1.63	2.55		4.15	0.12			13.15	1.55
I23	8.00	22.84	1.58	2.15		5.50	0.06			13.01	1.14
I24	8.14	22.26	1.39	2.44	25.00	10.48	0.06	1.39		10.83	1.49
I25	8.24	22.58	1.68	2.10		7.00	0.05			9.50	1.39
I26	8.56	23.63	1.38	3.90		8.90	0.05			7.90	1.23
I27	8.18	24.62	1.40	2.67		11.60	0.06			11.83	1.27
I28	8.06	28.11	1.35	3.37	18.33	11.43	0.05	1.11		9.06	0.88

SOUTH CENTRAL INDIAN RIVER LAGOON (SEGMENT 3) DRY SEASON AND WET SEASON SAMPLE AVERAGES

DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I29	7.04	28.63	1.08	2.40		33.67	0.06			10.36	0.81
IRJ01	5.85	29.10	0.78	7.70	21.25	33.33	0.13		11.17		0.77
IRJ02	6.03	28.20	0.78	9.43	22.50	24.67	0.13		11.74		0.87
IRJ03	5.58	26.98	0.76	10.53	26.00	37.67	0.13		11.65		0.90
IRJ04	5.73	24.93	1.00	6.90	23.75	15.00	0.14		8.54		0.82
IRJ05	5.40	24.53	1.20	4.83	23.75	17.67	0.15		11.53		0.88
IRJ07	6.45	25.35	0.85	8.20	23.75	46.67	0.15		9.04		0.80
IRJ08	5.85	25.95	0.85	7.70	23.75	23.00	0.13		7.14		0.78
IRJ09	5.60	25.34	0.96	8.08	27.00	19.33	0.11		9.80		0.77

SOUTH CENTRAL INDIAN RIVER LAGOON (SEGMENT 3) DRY SEASON AND WET SEASON SAMPLE AVERAGES

WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I29	8.07	28.81	1.26	13.00		30.00	0.06			10.19	0.68
IRJ01	6.82	28.58	1.38	4.35	7.40	16.20	0.10		3.54		0.74
IRJ02	6.82	27.74	1.16	5.95	10.40	17.80	0.10		6.06		0.84
IRJ03	7.49	23.35		6.68	14.56	20.50		0.01	8.04		1.01
IRJ04	6.42	26.06	1.14	4.58	11.40	14.20	0.13		4.28		0.94
IRJ05	6.24	25.52	1.32	4.85	11.40	13.00	0.14		4.55		0.97
IRJ07	7.12	26.16	1.10	5.98	13.00	15.60	0.14		4.54		0.98
IRJ08	6.80	26.86	1.14	4.58	12.40	13.00	0.11		2.92		0.76
IRJ09	6.66	28.75	1.33	5.38	14.50	14.20	0.10		5.94		0.83

SOUTH INDIAN RIVER LAGOON (SEGMENT 4) DRY SEASON AND WET SEASON SAMPLE AVERAGES
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
IRL39	6.70	32.07		6.52		38.15	0.05	0.79		18.15	0.75
IRL38	6.54	32.37		5.52		39.69	0.05	0.77		10.90	0.73
IRL37	5.69	32.95		3.75		29.46	0.04	0.68		7.55	0.65
IRL36	6.65	32.90		5.18		35.83	0.04	0.67			0.64
IRL35	6.36	35.37		5.42		39.62	0.03	0.57		19.35	0.55
IRL34	6.68	31.85		4.55		28.31	0.05	0.75		7.55	0.68
IRL30	6.17	35.93		4.34		50.15	0.03	0.53		11.20	0.50
IRL32	7.12	35.69		3.65		38.08	0.04	0.65		8.00	0.57
IRL33	6.25	35.60		4.26		42.38	0.03	0.51		4.90	0.49
IRL31	6.14	36.14		5.18		42.50	0.02	0.59		9.55	0.57
IRL29	7.21	36.14		4.17		49.00	0.02	0.65		6.20	0.63
IRL28	8.76	35.34		3.18		36.31	0.03	0.60		6.80	0.58
IRL40	6.81	35.48		4.88		47.00	0.03	0.60		7.10	0.57
IRL27	6.52	34.52		6.50		43.50	0.04	0.66		2.70	0.63
IRL23	4.73	34.70		1.96		32.92	0.03	0.72		6.35	0.69
IRL26	6.39	33.93		4.45		43.08	0.03	0.61		7.15	0.58
IRL22	6.37	33.71		3.87		34.27	0.04	0.58		2.90	0.56
IRL21	5.98	33.09		4.78		44.92	0.04	0.64		4.25	0.62
IRL20	5.69	32.46		5.72		45.45	0.04	0.74		7.10	0.70
IRL24	6.38	33.03		5.87		45.15	0.04	0.65		3.40	0.62
IRL25	6.13	32.73		3.98		36.69	0.03	0.68		3.80	0.66
IRL19	5.61	32.80		5.74		42.92	0.04	0.60		3.35	0.56
IRL18	6.30	32.31		6.43		53.46	0.03	0.78		4.90	0.75
IRL17	6.31	33.22		5.61		38.46	0.04	0.61		5.10	0.58
IRL15	5.94	25.21		6.56		31.77	0.09	0.85		10.05	0.79
IRL16	6.29	35.08		3.30		33.15	0.03	0.51		7.60	0.49
IRL13	6.04	31.44		4.94		36.08	0.05	0.75		8.90	0.71
IRL14	5.29	30.58		5.54		36.23	0.06	0.87		22.25	0.83
IRL12	6.01	33.29		5.99		37.23	0.05	0.60		7.35	0.56
IRL11	5.14	33.44		6.00		38.77	0.05	0.60		4.45	0.56
IRL10	4.79	33.74		5.06		41.31	0.05	0.60		5.75	0.56
IRL09	4.84	34.01		3.64		36.85	0.04	0.60		6.00	0.56
IRL08	4.67	33.66		3.29		36.31	0.04	0.56		4.90	0.53
IRL07	4.89	34.47		3.45		59.31	0.03	0.54		3.60	0.51
IRL06	5.35	34.83		3.11		36.23	0.03	0.48		3.15	0.45
IRL05	5.66	35.02		3.20		42.18	0.02	0.48			0.45
IRL04	5.95	34.86		2.54		40.91	0.02	0.44			0.41
IRL03	6.18	35.31		2.15		51.27	0.02	0.45			0.42
IRL02	6.18	35.41		1.98		51.18	0.02	0.44			0.41
IRL01	6.47	35.07		1.52		40.82	0.02	0.40			0.38

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SOUTH INDIAN RIVER LAGOON (SEGMENT 4) DRY SEASON AND WET SEASON SAMPLE AVERAGES
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
IRL39	7.01	30.68		4.87		41.33	0.05	0.67		5.35	0.64
IRL38	7.05	31.24		5.12		45.75	0.04	0.53		4.35	0.55
IRL37	6.18	32.75		4.13		41.75	0.05	0.62		14.95	0.60
IRL36	6.90	33.94		4.32		45.42	0.04	0.54		5.35	0.52
IRL35	6.27	34.31		4.60		43.58	0.03	0.56		10.25	0.54
IRL34	6.80	34.53		5.44		44.00	0.04	0.59		4.70	0.55
IRL30	6.59	35.68		5.74		57.58	0.03	0.55		4.95	0.53
IRL32	6.60	35.70		5.17		56.00	0.04	0.62		4.30	0.59
IRL33	6.29	35.72		6.75		55.00	0.03	0.58		5.75	0.55
IRL31	6.58	35.49		4.74		48.92	0.03	0.64		4.45	0.62
IRL29	7.08	35.28		3.54		49.17	0.03	0.56		2.90	0.54
IRL28	7.46	35.49		8.07		56.33	0.03	0.63		5.10	0.60
IRL40	6.68	35.43		4.83		51.75	0.03	0.47		2.45	0.44
IRL27	6.68	34.99		5.68		51.25	0.03	0.50		7.75	0.47
IRL23	5.54	34.33		1.83		41.08	0.04	0.66		12.90	0.64
IRL26	6.91	34.49		6.11		55.17	0.03	0.54		2.25	0.51
IRL22	6.74	34.09		4.76		47.42	0.03	0.54		5.15	0.52
IRL21	6.46	33.84		8.52		49.58	0.04	0.58		5.30	0.55
IRL20	6.12	33.68		6.90		60.58	0.04	0.60		7.70	0.58
IRL24	6.59	33.74		8.93		55.67	0.03	0.51		4.35	0.48
IRL25	6.42	33.45		6.61		45.58	0.03	0.60		4.45	0.58
IRL19	6.41	33.55		8.05		53.42	0.03	0.55		6.90	0.53
IRL18	6.03	32.40		5.78		43.83	0.03	0.80		5.10	0.77
IRL17	6.66	34.06		5.99		48.83	0.03	0.51		3.15	0.49
IRL15	6.69	31.33		4.62		37.17	0.04	0.41		5.45	0.39
IRL16	6.04	35.36		4.53		44.50	0.03	0.35		6.00	0.33
IRL13	6.71	30.74		5.36		45.67	0.03	0.55		15.10	0.52
IRL14	5.87	31.19		8.74		59.83	0.04	0.71		18.25	0.68
IRL12	6.71	34.18		4.38		43.50	0.03	0.36		3.80	0.34
IRL11	5.99	33.81		5.79		53.33	0.03	0.43		2.45	0.41
IRL10	5.78	33.57		4.32		45.75	0.03	0.41		6.25	0.38
IRL09	5.71	33.41		3.43		42.00	0.03	0.42		3.80	0.39
IRL08	5.72	33.40		3.36		44.42	0.03	0.45		3.60	0.42
IRL07	5.98	33.63		3.86		42.33	0.02	0.44		4.35	0.41
IRL06	5.92	34.13		2.90		37.58	0.02	0.41		5.10	0.38
IRL05	6.21	34.04		3.53		47.90	0.02	0.38			0.36
IRL04	6.30	34.51		2.61		53.80	0.02	0.35			0.33
IRL03	6.68	34.57		3.04		62.30	0.02	0.55			0.52
IRL02	6.61	35.23		1.70		53.60	0.02	0.32			0.30
IRL01	6.67	35.28		1.14		58.80	0.02	0.32			0.30

Appendix B

MOSQUITO LAGOON (SEGMENT 1A) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
V1	0.58	3.32	0.50	2.66	4.43	14.41	0.12	0.24	2.67		0.27
V2	0.61	3.05	0.40	1.73	4.47	11.29	0.10	0.44	3.01		0.38
V3	0.79	2.84	0.31	1.50	4.52	10.66	0.10	0.35	2.43		0.31
V4	0.81	2.80	0.34	2.19	5.66	7.59	0.11	0.38	2.92		0.32
V5	0.89	2.73	0.32	2.13	4.92	8.00	0.13	0.40	2.54		0.37
V6	0.92	2.67	0.29	1.98	5.09	7.92	0.11	0.52	2.63		0.43
V7	0.79	2.74	0.22	2.01	5.69	7.04	0.11	0.38	2.68		0.34
V8	0.91	3.12	0.23	1.51	4.99	6.48	0.10	0.41	3.09		0.34
V9	1.09	2.61	0.28	2.02	5.68	8.02	0.11	0.42	3.09		0.36
V10	0.91	3.29	0.30	1.47	5.64	8.31	0.09	0.30	2.55		0.32
V11	0.96	2.85	0.27	2.80	5.26	8.65	0.09	1.00	3.02		0.75
V12	0.88	2.74	0.18	2.14	5.79	6.57	0.15	0.37	3.38		0.38
V13	1.06	3.37	0.31	1.95	4.40	7.95	0.08	0.45	2.24		0.40
V14	1.03	3.53	0.28	1.68	4.43	5.23	0.10	0.86	2.56		0.66
V15	0.90	3.50	0.30	1.69	3.75	5.95	0.10	0.49	2.60		0.45
V16	1.08	3.43	0.43	1.28	3.90	5.13	0.09	0.40	1.96		0.40
V17	0.94	3.49	0.18	2.27	4.60	7.82	0.08	0.57	2.41		0.49
V18	1.00	3.74	0.38	2.87	3.52	6.51	0.09	0.52	2.97		0.44
V19	0.93	4.15	0.44	2.78	2.15	7.32	0.07	0.51	2.28		0.46

MOSQUITO LAGOON (SEGMENT 1A) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
V1	0.92	3.69	0.40	3.02	4.28	17.23	0.03	0.56	4.61		0.40
V2	0.89	3.62	0.33	3.04	4.27	20.29	0.01	0.56	4.61		0.38
V3	0.80	3.82	0.29	2.73	3.90	19.36	0.03	0.56	4.45		0.37
V4	0.80	3.84	0.30	2.07	3.98	17.30	0.01	0.71	3.49		0.43
V5	0.77	3.89	0.25	2.33	4.88	20.57	0.01	0.66	4.51		0.50
V6	0.94	4.04	0.19	2.92	3.78	19.30	0.11	0.65	3.58		0.43
V7	0.86	3.97	0.24	2.69	3.40	18.28	0.02	0.54	4.27		0.39
V8	0.87	4.02	0.21	2.85	3.98	15.30	0.09	0.57	3.99		0.39
V9	0.97	3.81	0.22	2.85	3.99	22.83	0.00	0.60	5.47		0.42
V10	0.85	4.28	0.18	2.57	2.51	16.58	0.01	0.71	4.54		0.47
V11	0.92	4.06	0.22	3.43	4.89	17.39	0.04	0.69	6.26		0.46
V12	0.82	4.00	0.17	2.50	3.70	17.47	0.03	0.62	3.84		0.46
V13	0.93	4.15	0.16	3.51	2.51	14.28	0.01	0.67	3.95		0.48
V14	0.83	4.10	0.19	2.15	3.65	18.71	0.02	0.63	3.67		0.45
V15	0.89	3.74	0.21	2.47	3.83	17.82	0.01	0.75	4.02		0.49
V16	0.83	4.23	0.23	1.97	2.67	15.98	0.01	0.60	2.85		0.40
V17	0.70	3.98	0.14	2.41	2.51	17.28	0.01	0.54	3.87		0.45
V18	0.72	3.94	0.33	2.95	2.27	17.69	0.01	0.71	3.06		0.47
V19	0.95	3.61	0.33	2.57	3.53	10.75	0.01	0.68	2.63		0.46

BANANA RIVER LAGOON (SEGMENT 1B) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
B01	1.09	2.47	0.48	2.50		21.58	0.01			2.99	0.35
B02	0.90	2.30	0.49	4.09		18.44	0.01			3.48	0.46
B03	1.10	2.30	0.40	1.08		11.68	0.01			3.89	0.40
B04	1.27	2.21	0.37	3.91		16.02	0.02			4.55	0.30
B05	1.74	5.01	0.43	3.32		17.17	0.01			7.35	0.47
B06	1.90	4.27	0.42	1.65		13.05	0.02			9.17	0.59
B07	1.36	2.58	0.42	2.39		16.71	0.02			11.87	0.41
B08	1.16	2.71	0.38	2.83		38.38	0.01			10.25	0.48
B09	1.40	2.52	0.37	1.39		13.23	0.02			8.90	0.42
B10	1.15	2.33	0.42	1.88		15.82	0.01			9.90	0.52

BANANA RIVER LAGOON (SEGMENT 1B) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
B01	0.62	2.81	0.30	0.56		14.65	0.02			3.78	0.16
B02	0.93	2.89	0.63	1.01		21.62	0.03			5.08	0.23
B03	1.01	2.92	0.36	1.40		14.77	0.03			6.62	0.36
B04	1.20	3.14	0.49	1.69		19.35	0.03			9.71	0.45
B05	1.06	3.08	0.35	1.99		18.21	0.03			4.81	0.33
B06	0.91	3.05	0.39	1.11		15.32	0.03			22.42	0.29
B07	1.20	3.48	0.36	1.49		11.89	0.04			7.81	0.39
B08	1.17	3.74	0.43	0.73		15.01	0.02			11.46	0.27
B09	0.92	3.65	0.42	1.71		22.10	0.03			5.80	0.40
B10	0.98	4.18	0.36	2.55		7.77	0.03			7.74	0.30

NORTH INDIAN RIVER LAGOON (SEGMENT 1C) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I01	1.10	5.31	0.30	0.07		0.92	0.01			0.68	0.37
I02	1.09	5.34	0.58	0.42		2.12	0.02			1.98	0.37
I3	0.93	4.33	0.39	0.85		2.33	0.01			0.76	0.50
I4	1.28	4.60	0.45	1.81	2.89	3.13	0.02	0.25		0.88	1.04
I5	1.04	4.38	0.48	1.56		3.04	0.02			6.50	0.82
I6	1.01	4.85	0.44	2.90		4.70	0.02	0.41		4.53	0.31
I7	1.15	4.46	0.43	0.63	2.89	1.65	0.01	0.45		1.59	0.36
I8	0.88	4.45	0.59	0.07			0.01			5.32	0.58
I9	1.31	4.37	0.44				0.01			2.79	0.33
I11	1.53	3.40	0.40	0.28		0.92	0.01			1.23	0.46
I12	1.54	3.43	0.46	3.61		6.15	0.02			4.73	0.55
I13	1.74	3.13	0.50	2.57	2.89	8.31	0.02	0.43		3.68	0.52
I14	1.87	3.22	0.56	3.89	5.00	7.56	0.02	0.46		5.62	0.63
I15	1.91	2.72	0.80	2.28	7.07	4.04	0.02	0.30		6.80	0.34
I16	1.05	2.66	0.69	0.57		1.41	0.02			5.87	0.37
I17	1.16	1.91	0.51			6.36	0.01			7.32	0.39
I18	1.17	2.27	0.53	1.23	2.89	2.79	0.65	0.15		8.73	0.45
I19	1.42	2.14	0.45	0.28			0.01			7.59	0.43
I20	1.08	2.15	0.42	0.36	2.89	1.89	0.01	0.09		8.90	0.47

NORTH INDIAN RIVER LAGOON (SEGMENT 1C) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I01	1.72	9.89	0.48	1.66		17.67	0.02			9.78	0.50
I02	1.32	8.15	0.45	0.37		7.92	0.01			1.75	0.45
I3	1.18	6.49	0.28	0.07		4.24	0.01			1.94	0.20
I4	1.19	8.37	0.47	1.77		12.67	0.02			4.69	0.43
I5	1.56	7.28	0.40	0.22		15.44	0.02			5.87	0.39
I6	1.53	7.44	0.39	1.54		9.32	0.01			10.33	0.53
I7	1.45	6.99	0.55	1.17		13.20	0.02			14.05	0.55
I8	1.46	6.59	0.62	0.76		12.32	0.02			5.46	0.38
I9	1.38	6.49	0.52	3.07		20.93	0.02			3.71	0.37
I11	1.69	6.40	0.46	95.91		10.09	0.01			8.45	0.39
I12	1.46	5.96	0.39	53.43		14.68	0.02			8.56	0.68
I13	2.10	5.55	0.42	18.43		13.72	0.02			11.67	0.39
I14	1.53	5.29	0.31	5.55		13.34	0.02			17.68	0.83
I15	1.44	3.46	0.66	3.12	2.89	17.35	0.02	0.58		19.10	0.55
I16	1.70	5.76	0.78	3.09		28.04	0.02			21.18	0.69
I17	1.44	5.06	0.58	0.50		7.95	0.02			6.16	0.34
I18	1.46	5.60	0.44	1.08		7.80	0.03			4.84	0.30
I19	1.75	5.72	0.67	0.31		4.61	0.02			9.82	0.40
I20	1.30	4.28	0.74	2.39	7.64	9.72	0.04	0.45		18.10	0.30

NORTH CENTRAL INDIAN RIVER LAGOON (SEGMENT 2) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I21	8.10	21.83	1.00								
I22	1.18	1.96	0.43	0.41	5.00	7.03	0.14	0.08		6.68	0.33
I23	1.53	4.06	0.54	1.10		1.38	0.14			5.76	0.50
I24	1.63	4.24	0.68	1.24		4.75	0.02			6.41	0.65
I25	1.77	4.47	0.70	1.23		3.99	0.01			6.22	0.71
I26	1.96	4.89	0.55	1.64		2.98	0.01			4.31	0.49
I27	1.89	5.29	0.43	1.63		6.68	0.02			4.58	0.44
I28	1.66	5.34	0.36	1.54		6.69	0.02			5.27	0.48

NORTH CENTRAL INDIAN RIVER LAGOON (SEGMENT 2) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I21	0.84	4.77	0.64	1.80	5.77	6.32	0.04	0.32		7.99	0.41
I22	1.08	5.12	0.82	0.21		24.04	0.02			6.59	2.28
I23	1.42	5.13	0.54	1.77		3.54	0.02			4.90	0.23
I24	1.22	5.71	0.57	2.07	5.77	8.06	0.03	0.31		6.51	0.38
I25	1.29	6.05	0.46	1.37		12.29	0.01			6.76	0.45
I26	1.41	6.39	0.46	1.63		20.51	0.01			6.23	0.42
I27	1.19	6.43	0.31				0.01			2.50	0.40
I28	1.28	5.39	0.31	2.08	0.00	11.55	0.02	0.28		5.09	0.33

SOUTH CENTRAL INDIAN RIVER LAGOON (SEGMENT 3) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I29	1.39	4.30	0.38				0.04			7.32	0.24
IRJ01	0.82	6.74	0.33				0.04			8.85	0.21
IRJ02	0.54	2.21	0.24	2.08	4.56	10.50	0.04		1.67		0.09
IRJ03	2.05	7.18	0.42	3.35	8.56	10.77	0.04		5.33		0.25
IRJ04	0.26	2.62	0.17	1.02	4.98	7.46	0.03		0.61		0.17
IRJ05	0.29	3.15	0.24	1.22	3.51	6.44	0.03		1.99		0.21
IRJ07	0.77	3.27	0.35	1.94	2.74	5.68	0.04		1.36		0.21
IRJ08	0.83	3.82	0.34	1.71	3.71	5.43	0.03		1.13		0.11
IRJ09	0.73	2.90	0.40	2.09	8.22	11.28	0.02		6.26		0.18

SOUTH CENTRAL INDIAN RIVER LAGOON (SEGMENT 3) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
I29	1.20	5.01	0.29	0.14		9.61	0.02			6.36	0.22
IRJ01	0.91	4.13	0.13	1.59	8.54	17.90	0.03		6.01		0.20
IRJ02	1.02	4.60	0.10	2.75	6.45	6.51	0.04		9.21		0.23
IRJ03	1.20	4.46	0.15	2.65	9.62	25.40	0.05		10.33		0.36
IRJ04	1.47	5.41	0.48	1.71	11.09	5.00	0.04		7.37		0.25
IRJ05	0.92	5.14	0.42	1.79	11.09	10.97	0.05		9.58		0.22
IRJ07	1.28	5.60	0.13	3.73	8.54	9.02	0.05		7.55		0.25
IRJ08	1.84	5.46	0.17	3.25	4.79	19.16	0.03		4.87		0.15
IRJ09	0.98	5.46	0.33	3.05	8.37	13.05	0.03		9.09		0.19

SOUTH INDIAN RIVER LAGOON (SEGMENT 4) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
DRY SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
IRL39	1.00	3.63		1.47		30.00	0.02	0.16		1.91	0.15
IRL38	1.18	3.68		2.21		31.79	0.03	0.21		0.21	0.13
IRL37	0.65	3.24		1.71		29.05	0.02	0.22		1.90	0.23
IRL36	1.01	3.90		2.04		28.67	0.02	0.35		2.47	0.36
IRL35	0.67	2.94		1.48		32.43	0.02	0.21		3.18	0.22
IRL34	1.23	2.95		2.62		29.66	0.02	0.35		2.83	0.33
IRL30	1.01	1.95		3.03		29.97	0.02	0.24		0.78	0.24
IRL32	0.49	1.86		2.88		31.46	0.04	0.54		0.14	0.55
IRL33	0.81	1.95		3.58		32.82	0.02	0.28		1.20	0.28
IRL31	0.77	2.09		1.72		28.92	0.02	0.29		1.91	0.30
IRL29	0.80	2.08		2.17		31.98	0.02	0.26		0.99	0.26
IRL28	0.75	2.00		3.76		32.70	0.01	0.21		2.83	0.22
IRL40	0.81	2.31		3.15		30.06	0.02	0.16		1.63	0.16
IRL27	0.76	2.35		3.79		31.52	0.02	0.14		4.74	0.14
IRL23	1.02	2.43		0.51		29.68	0.03	0.18		1.84	0.18
IRL26	0.63	2.15		4.73		25.79	0.02	0.15		0.64	0.16
IRL22	0.58	1.84		3.35		28.42	0.02	0.12		3.46	0.12
IRL21	0.80	1.99		9.74		34.46	0.02	0.13		1.27	0.14
IRL20	0.67	1.89		2.36		33.58	0.02	0.13		0.14	0.13
IRL24	0.76	1.87		4.37		32.12	0.02	0.09		0.78	0.09
IRL25	0.85	1.94		4.66		26.67	0.01	0.23		4.45	0.23
IRL19	0.63	2.01		4.23		32.28	0.02	0.17		1.56	0.17
IRL18	0.78	2.75		4.52		30.41	0.02	0.37		0.28	0.37
IRL17	0.63	2.31		3.04		26.96	0.02	0.19		0.64	0.19
IRL15	0.81	3.20		1.91		24.28	0.01	0.25		3.04	0.26
IRL16	0.75	1.31		1.84		31.84	0.01	0.17		2.26	0.17
IRL13	0.81	2.27		1.78		31.31	0.01	0.19		4.38	0.19
IRL14	0.89	2.23		4.26		46.75	0.01	0.17		1.60	0.16
IRL12	0.82	1.72		1.71		34.39	0.01	0.15		0.99	0.17
IRL11	0.79	2.04		2.53		32.54	0.01	0.25		1.63	0.25
IRL10	0.80	2.35		1.20		31.51	0.01	0.23		2.47	0.23
IRL09	0.85	2.65		0.97		30.48	0.01	0.20		0.99	0.20
IRL08	0.82	2.38		1.05		30.97	0.01	0.19		1.27	0.19
IRL07	0.90	2.13		1.45		30.53	0.01	0.13		0.78	0.13
IRL06	0.63	2.06		1.18		25.53	0.01	0.20		1.56	0.20
IRL05	0.36	0.82		1.17		27.66	0.01	0.15			0.16
IRL04	0.35	0.85		0.80		32.10	0.01	0.19			0.20
IRL03	0.41	0.67		1.03		38.36	0.01	0.64			0.65
IRL02	0.31	0.97		0.43		30.06	0.01	0.17			0.18
IRL01	0.47	0.97		0.58		26.17	0.01	0.18			0.19

SOUTH INDIAN RIVER LAGOON (SEGMENT 4) DRY SEASON AND WET SEASON SAMPLE STANDARD DEVIATIONS
WET SEASON

LOCATION	DO (mg/L)	SALINITY (ppt)	SECCHI DISK DEPTH (m)	TURBIDITY (NTU)	COLOR (PCU)	TSS (mg/L)	TOTAL P (mg/L)	TOTAL N (mg/L)	CHLOROPHYLL a C (µg/L)	CHLOROPHYLL a U (µg/L)	TKN (mg/L)
IRL39	0.92	4.70		4.26		27.16	0.03	0.41			0.39
IRL38	1.89	11.31		2.91		24.66	0.03	0.33		6.93	0.32
IRL37	5.10	23.20		3.90		9.00	0.04	0.51			0.50
IRL36	0.49	3.55		3.83		27.43	0.02	0.32			0.31
IRL35	0.97	3.76		1.70		29.34	0.01	0.22			0.22
IRL34	1.30	4.28		1.23		20.99	0.03	0.41		5.02	0.36
IRL30	0.74	3.06		1.38		38.95	0.01	0.26		8.34	0.26
IRL32	1.31	3.11		1.59		30.49	0.04	0.46		3.82	0.45
IRL33	0.79	2.76		1.06		28.90	0.01	0.21		3.82	0.21
IRL31	0.70	3.26		2.49		30.98	0.01	0.12		6.01	0.12
IRL29	1.14	4.03		2.57		47.16	0.01	0.15		6.93	0.15
IRL28	2.39	3.83		1.67		37.60	0.02	0.10		6.79	0.11
IRL40	0.73	3.31		2.99		38.57	0.02	0.15		4.38	0.16
IRL27	1.07	3.92		2.37		36.02	0.02	0.31			0.29
IRL23	0.94	4.42		1.03		30.94	0.02	0.21		0.21	0.21
IRL26	0.86	3.78		2.94		33.14	0.02	0.24		6.86	0.24
IRL22	0.78	3.86		1.89		32.53	0.02	0.16		0.99	0.17
IRL21	0.92	3.75		1.64		35.42	0.02	0.19		0.92	0.19
IRL20	0.83	4.07		2.12		35.58	0.02	0.24			0.24
IRL24	2.15	11.65		2.75		23.85	0.01	0.26			0.26
IRL25	2.12	3.81		2.90		30.77	0.02	0.23		1.56	0.24
IRL19	0.60	3.88		3.13		33.35	0.02	0.28		0.92	0.28
IRL18	1.41	3.32		8.41		40.57	0.02	0.36		3.11	0.35
IRL17	0.57	3.13		2.56		34.25	0.02	0.25		0.28	0.25
IRL15	0.60	6.71		3.16		27.81	0.05	0.54		3.46	0.51
IRL16	1.23	2.36		0.90		28.96	0.01	0.24		5.66	0.25
IRL13	1.25	2.22		1.89		37.28	0.03	0.35		0.00	0.35
IRL14	2.48	5.61		2.09		31.03	0.03	0.34		3.18	0.33
IRL12	0.91	3.21		2.21		25.95	0.02	0.33		3.46	0.32
IRL11	0.89	4.35		3.16		30.15	0.03	0.24		1.20	0.23
IRL10	0.80	4.29		2.85		32.26	0.03	0.20		0.64	0.19
IRL09	0.73	4.31		2.05		37.47	0.02	0.27		0.28	0.26
IRL08	0.81	4.37		1.93		36.11	0.02	0.25		0.00	0.25
IRL07	0.95	3.59		1.78		41.58	0.02	0.23		0.00	0.22
IRL06	0.71	3.20		1.19		28.15	0.01	0.20		1.91	0.20
IRL05	0.89	2.61		1.19		30.79	0.01	0.22			0.23
IRL04	0.81	2.12		0.92		37.63	0.01	0.21			0.22
IRL03	0.76	1.05		1.43		42.94	0.01	0.20			0.20
IRL02	0.95	0.76		0.95		37.76	0.01	0.22			0.23
IRL01	0.81	1.58		1.28		46.11	0.01	0.18			0.18