

Dissolved Oxygen Concentrations and Relationships in Waters of the Loxahatchee River near Riverbend Park

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November, 1995

Introduction

The Loxahatchee River was once fed by a system of natural wetlands that existed west and south of the present course of the river. Under the historic conditions, a vast quantity of water was stored in the wetlands and transported to the river channel by creeks and other tributaries . The volumes delivered varied seasonally, but a constant flow was maintained in all but the most severe of drought conditions and, the quality of water remained pristine in the absence of pollution sources.

Numerous modifications have occurred within the watershed over the past half century and the quantity and quality of the waters delivered to the Loxahatchee River have changed as a result. Channelization, competing demands for water and the introduction of agriculture and rural habitation within portions of the historic wetlands have served to reduce the water availability, severely adjust hydroperiods and negatively impact the quality of surface waters.

The purpose of this report is two-fold. The first section will review several environmental observations that suggest water quality degradation in the tributaries and upper reaches of the northwest fork of the Loxahatchee River. The final two sections of the report will describe the methodology employed in a recent dissolved oxygen monitoring project and discuss the results and apparent relationships in various surface waters of the study area.

Observed Water Quality Problems

In the early 1990's, the findings of several investigations pointed to a significant escalation of water quality degradation in the area of the river near Riverbend Park. Observations of increased aquatic weed growth, a declining index of water quality, reduced levels of dissolved oxygen and decreased biological productivity each raised concern. When viewed in combination, this concern became quite serious and the technical community set out to better identify and isolate the causes of the observed problems. Summaries of the major issues and the corresponding investigations are presented in the following paragraphs.

The Florida Department of Environmental Protection (DEP) has, as one of its duties, the regulation of aquatic weeds. In early 1995, the agency began a study of the aquatic weeds found in the headwaters portion of the river within and above Riverbend Park. The investigation was in response to numerous observations, in late 1994 and early 1995, of large quantities of aquatic vegetation floating downstream and causing unwanted physical, chemical and biological problems in the area of the Park and downstream within the river corridor. While the vegetation and the periodic high flows, resultant from events such as tropical storm Gordon, were easily observed, the precise origin of the weeds was less well defined. The ongoing DEP study is intended to provide information to better understand the problem and design a management strategy to correct and confine future problems. In defining the problem, it is anticipated that specific upstream sources and reasons for the abundance of plant growth will be identified. The report is anticipated for an early 1996 release.

Water quality analyses have been conducted in the Loxahatchee watershed for the past twenty-five years and the results of these tests were recently consolidated in the EPA STORET database. In the early 1990's, the State of Florida developed a series of indices that can be used in expressing water quality and comparing the conditions of water throughout the state. One such index is called the Florida Water Quality Index and combines such water quality characteristics as clarity, organic load, oxygen, nutrients, bacteria and biological integrity into one comprehensive expression. The Loxahatchee River District has worked in cooperation with the state DEP to place water quality information on the database and to devise a formula for the proper development of this index. Figure #1 takes the water quality data from sampling stations upstream of Riverbend Park and expresses it in index form over time. The declining nature of this composite index is of serious concern. Although the evaluation does not specifically pinpoint the type of water quality problem, nor its source or severity, it does clearly identify a problem of declining water quality.

Research on the aquatic macroinvertebrates of the Loxahatchee River has been ongoing for the past 15 years. The Florida Department of Environmental Protection and the Loxahatchee River District have coordinated efforts in this work. It was only recently, however, that the results of these investigations were combined, analyzed and compared against some newly developed indices for biological measurement. When the comparisons were complete, they showed a decline in the number and diversity of small animals that live in the water near Riverbend Park. Figure #2 gives a graphic representation of this decline by combining several indexes and expressing the results as a percent of optimal conditions. In the early 1980's, the macroinvertebrates present in this reach of the river were indicative of a very healthy environment. By the early 1990's, something had modified that environment and the animals showed some degree of stress. While the comparison does not clearly define the magnitude of the problem nor show specifically why it is occurring, it strongly suggests that a problem exists.

One very important indicator of water quality and environmental health is dissolved oxygen (D.O.). A sufficient supply of oxygen dissolved in the water is just as important to aquatic organisms as is the atmospheric oxygen for terrestrial animals. The level of D.O. in this section of the river has been measured fairly frequently for nearly 25 years. When this historic data is placed in a common database, the EPA STORET system, and compared against time, it becomes clear that the concentration of D.O. in the waters flowing in the river is decreasing over time. Figure #3 shows this effect.

On the premise that D.O. is a related and important factor in each of the observed environmental problems, it became evident that a more complete knowledge of D.O. in this reach of the river was needed.

Dissolved Oxygen Investigation - Design

In 1995, the Loxahatchee River District undertook an evaluation of dissolved oxygen in the area of Riverbend Park and tributary upstream waters. The objective of the study was to frequently measure the D.O. levels within the study area, identify the source and location of low D.O. waters and understand certain cause and effect relationships.

The study area is identified in Figure #4. For the purpose of simplification, the area is divided into four general subareas including the river corridor downstream of Indiantown Road, the river/C-14 channel from Indiantown Road upstream to the G-92 structure, the lateral canal network draining the Jupiter Farms community and the C-18 Canal. Drainage is from the Jupiter Farms community and the C-18 Canal (when the culvert structure is open) into the C-14 Canal, then to the river corridor within Riverbend Park and finally under the Indiantown Road bridge to the historic channel and floodplain of the Loxahatchee River. Additional information regarding the hydrologic relationships of these water bodies is given in the following paragraphs.

The C-18 is normally maintained at a higher elevation than the C-14 which allows water to flow by gravity through a gated culvert structure designated G-92. The hydrologic contribution from the C-18 varies widely from 0 c.f.s. when the culvert is closed to several hundred c.f.s. which can represent nearly all of the flow to the downstream river corridor.

The drainage network within the Jupiter Farms area consists primarily of seven lateral canals, flowing from west to east, and draining an area of approximately 14 square miles. Other than culverts, no internal structures are in place to contain runoff water and each canal flows into the north-south oriented C-14 canal/river channel. The southern two canals enter the C-14 at a point south of the G-92 structure, the middle two join the C-14 between the G-92 structure and the southern boundary of Riverbend park and the northern three lateral canals flow into the channel of the upper Loxahatchee River as it flows through the Park. Flows from these canals can also vary, ranging from reverse flow or no flow during drought conditions to several hundred c.f.s. following rainfall events.

The natural corridor of the Loxahatchee River at and below the Indiantown Road bridge is also important hydrologically. The bridge structure and the meandering nature of the river each serve to constrict flow and, at flow rates above 300 or 400 c.f.s. water tends to back up. Also, the Lainhart dam is located about 1/4 mile north of the bridge and serves as a control weir for the entire drainage basin.

The study was designed to provide extensive measurements of dissolved oxygen levels at several points within the area. The specific monitoring points are identified on Figure #4 and are described as follows.

Station #82 - Located in the C-18 canal upstream of the G-92 structure. The data from this station represent the concentrations of D.O. in waters contributed from the C-18

Station #92 - Located in the C-14 canal downstream of the G-92 structure. This station was established to measure the D.O. levels after the mixing of waters from the C-18 with those from the southern portion of the Jupiter Farms drainage network.

Station #94 - Located in Lateral canal #4 of the Jupiter Farms drainage network some 100 meters upstream of where it enters the C-14 canal. The data from this station are representative of D.O. levels from several of the lateral canals.

Station #96 - Located in Lateral canal #2 of the Jupiter Farms drainage network and placed approximately 400 meters upstream of where it enters the channel of the Loxahatchee River. This station was also established to obtain data representative of the drainage network within the Jupiter Farms area.

Station #69 - Located in the Loxahatchee River at the Indiantown Road bridge. This station is downstream of all other stations and was established to measure D.O. after the mixing of waters from all upstream sources.

Past studies of dissolved oxygen have been grab samples normally taken in daylight hours. This 'snapshot' look at conditions has its value but is limited when trying to fully understand environmental parameters such as the levels of dissolved oxygen. The reason is that D.O. levels can change substantially throughout the day. For example, when the sun is shining and photosynthetic activity by the aquatic plants is producing maximum amounts of oxygen, the D.O. levels recorded will likely be within acceptable ranges. However, when the sun goes down, those same plants which were making oxygen now cease production and must start consuming oxygen along with the animals present in the aquatic environment. If this combined consumption is large, then the D.O. levels can fall to unacceptable levels in the early morning hours before the sun comes back up. This diurnal swing in D.O. is very important but has not been well documented in the Loxahatchee watershed.

This study was benefited by the availability and use of several continuous monitoring devices called 'datasounde' units or probes. In effect, these units are waterproof computers that, once placed at the monitoring site, collect and record data every 30 minutes. Therefore, 48 D.O. readings were obtained each day at each site. This capability resulted in a substantially greater quantity of information and presented a much more accurate picture of conditions than previously had been available.

The monitoring program was set up to conduct two separate test runs of about ten days each. The first was conducted in January/February of 1995 and the second in June of 1995. It should be noted that the hydrologic conditions present during the two test runs were quite different. In January and February, the water was at a high stand. The canal and river system had been flushed in November of 1994 due to tropical storm Gordon and continued to have good flow. The second run was conducted after a prolonged period of little rain and the water level in the canals was much lower.

During each run, the continuous monitoring devices were placed at various monitoring sites for five days, then moved to the other sites for five additional days. The data, that included temperature, conductivity and pH as well as dissolved oxygen, were then downloaded into computers. The following section presents the information produced by the monitoring program.

Dissolved Oxygen Investigation - Results.

It is important to note that the results of this study are based on a substantially larger set of data than had previously been available. Earlier investigations of the concentrations of dissolved oxygen in the freshwater reaches of the river may have been supported by several samples per month or as many as several dozen samples over the course of a year. This analysis, supported by state of the art equipment, generated over 1,500 dissolved oxygen readings for each of the two sample periods. It should also be noted that this report is not intended to pinpoint the source of D.O. problems. Surface water runoff,

groundwater flow, the growth and decay of vegetation, temperature, cloud cover and many other factors have been shown to influence the level of D.O. in surface waters.

The concentrations of dissolved oxygen in the surface waters during late January and early February of 1995 are shown on Figure #5. Although usually a dry time of the year, above average rainfall in the preceding months made this sampling event representative of wet or above average flow conditions. The six lines shown on the graphic can best be discussed in sets of two.

- ❖ Data for Station #69A and #69B, shown in orange and magenta, are from the same location but taken about one week apart with Station #69A representing the early part of the study period and Station #69B providing data for the later portion. The stage and flow at this location remained fairly constant throughout the study period. The D.O. concentrations from this site, which has the combined flows from all upstream sources, were very similar for both sample runs, fluctuated between 5 mg/l and 6 mg/l and showed minimal diurnal swings.
- ❖ The light and dark blue lines display data from the C-18 canal upstream of the G-92 structure and the C-14 canal after the mixing of waters from the G-92 discharge and the southern portion of the Jupiter Farms drainage network. The concentration of D.O. was consistently good with levels of 7 mg/l to 8 mg/l and no significant daily changes. Hydrologic measurements were not undertaken, but visual observations indicated that the majority of flow during the sampling period was from the C-18 canal through the G-92 structure.
- ❖ Lateral canals #2 and #4 were sampled and the results are shown in light green, Station #96 and dark green, Station #94, respectively. Significant diurnal variations in D.O. were recorded at Station #96 with daytime measurements reaching 8 mg/l or 9 mg/l and nighttime readings at 2 mg/l or 3 mg/l. The water at station #94 on lateral canal #4 was essentially devoid of oxygen. This condition is believed to be resultant from the demands of an extremely large deposit of organic material present at the site. Dense stands of floating aquatic vegetation were present near the site and were potentially the source of much of the organic material. Follow up field analyses of D.O. using conventional meters was undertaken after the study period and confirmed the anoxic conditions in much of the water column. Minimal concentrations of D.O., less than 1 mg/l, were recorded in the upper foot or two of the canal.

The dry condition sampling run was conducted in early June of 1995 and employed a similar methodology. With water temperature several degrees higher and the river stage significantly lower than in the earlier test runs, lower levels of D.O. were expected. The results are shown on figure #6 and discussed below.

- ❖ Data for Station # 69A and Station #69B, orange and magenta lines, show D.O. concentrations ranging, due to diurnal fluctuations, from daylight concentrations at

or above 4 mg/l to nighttime concentrations between 2 mg/l and 4 mg/l. These observed variations are greater and the D.O. levels are significantly lower than the results of the wet condition sampling.

- ❖ The upstream station in the C-18 canal, Station #82, shown by the light blue line, and the station in the C-14 canal, Station #92, shown in dark blue, continued to show acceptable levels of D.O. but expressed a greater diurnal shift than was observed in February. The observed dip in D.O. levels for the final two days of the run is believed to have been caused by extensive cloud cover which was not present in the early part of the sampling run.

- ❖ The concentration of D.O. in the water of the lateral canals was similar to the conditions observed in February. Specifically, Station #96 in lateral canal #2, shown in light green on the chart, showed extreme diurnal variations with concentrations fluctuating from 1 mg/l to 8 mg/l. The D.O. at Station #94 in lateral canal #4, shown in dark green, was minimal with only 1 mg/l or 2 mg/l present. The low water flows observed in this test run had allowed the organic materials to settle into an approximate three foot muck layer with clearer water above. The sampling device was placed in the zone above the muck and was able to record the low D.O. concentrations.

Water quality standards for the state of Florida call for a minimum of 4 mg/l D.O. in surface waters to maintain a healthy and viable ecosystem. Research has shown that aquatic animals begin to show stress at D.O. levels between 2 mg/l and 4 mg/l, dependent upon the organism involved. And, waters that have D.O. concentrations below 2 mg/l for several hours at a time will not support a diversity of fauna, rather will provide habitat only for a limited number of pollution tolerant species.

The study clearly shows that the two major sources of flow to the Loxahatchee River exhibit different levels of D.O. Water from the C-18 canal appears to have acceptable levels of D.O. under both flow conditions analyzed. Conversely, the water from lateral canals in the Jupiter Farms community consistently shows low levels of D.O., often below standards and, under certain observed conditions, at levels not conducive to the support of most animal life. Additionally, under various flow conditions, the low D.O. waters from the tributary canals adversely impact the concentrations of D.O. in the river at Riverbend Park; at times, to an extent that the D.O. in the Loxahatchee River is reduced to unacceptable levels.

The findings of this study support the concerns of declining water quality expressed earlier in this report. The trend of decreasing concentrations of D.O. at Station #69, the loss of biological diversity at the same location and the decline in overall water quality for the upper reach of the Loxahatchee River will likely all continue unless changes in the management of this water system are developed and implemented.

Figure #1: Composite index number for select Monitoring Stations above Riverbend Park

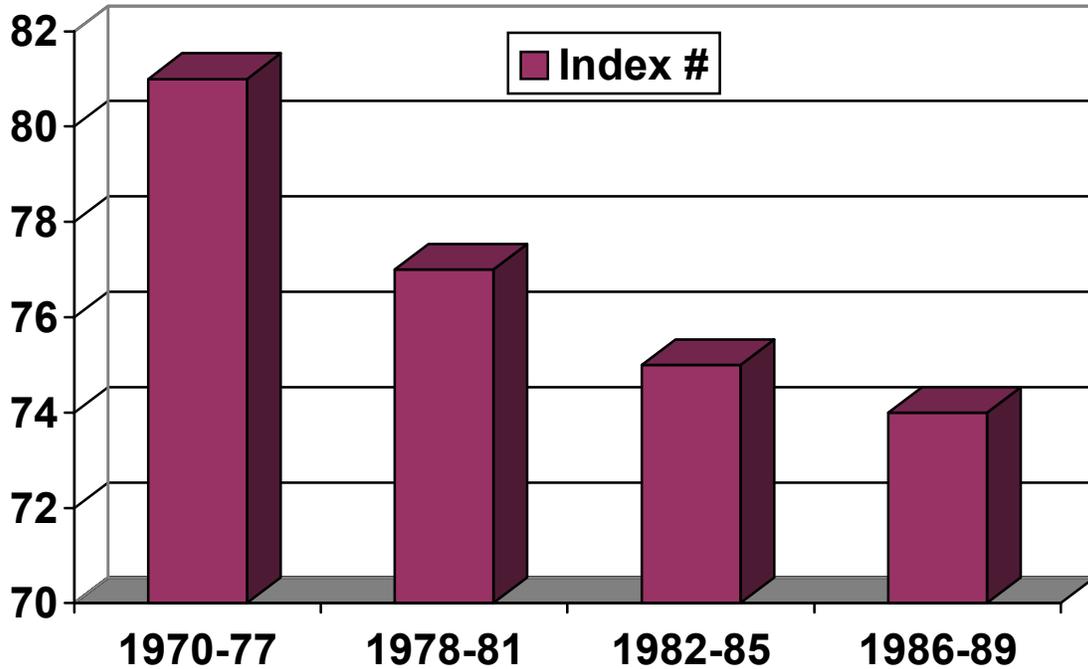


Figure #2: Composite biological index for the Loxahatchee River near Indiantown Road (Station #69)

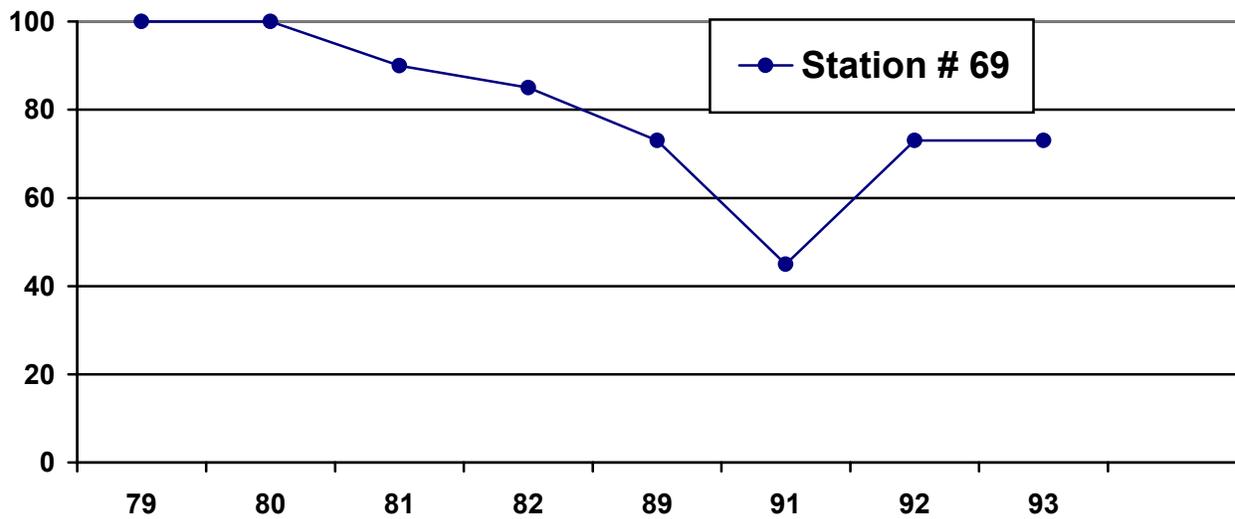
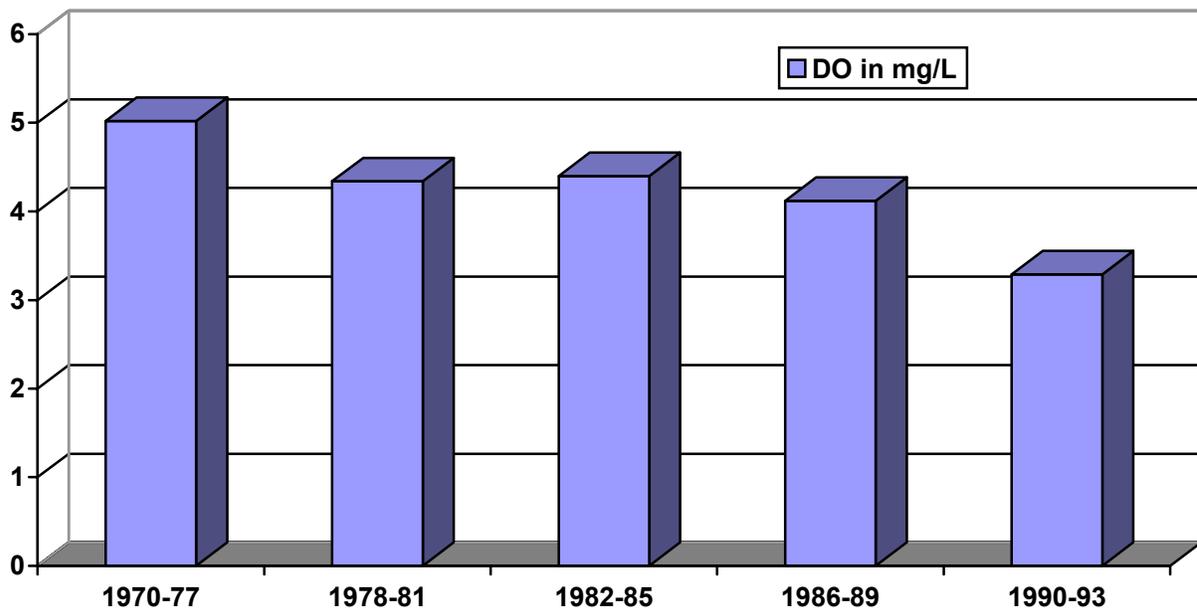


Figure #3: Dissolved oxygen levels in the Loxahatchee River near Indiantown Road bridge (Station #69)



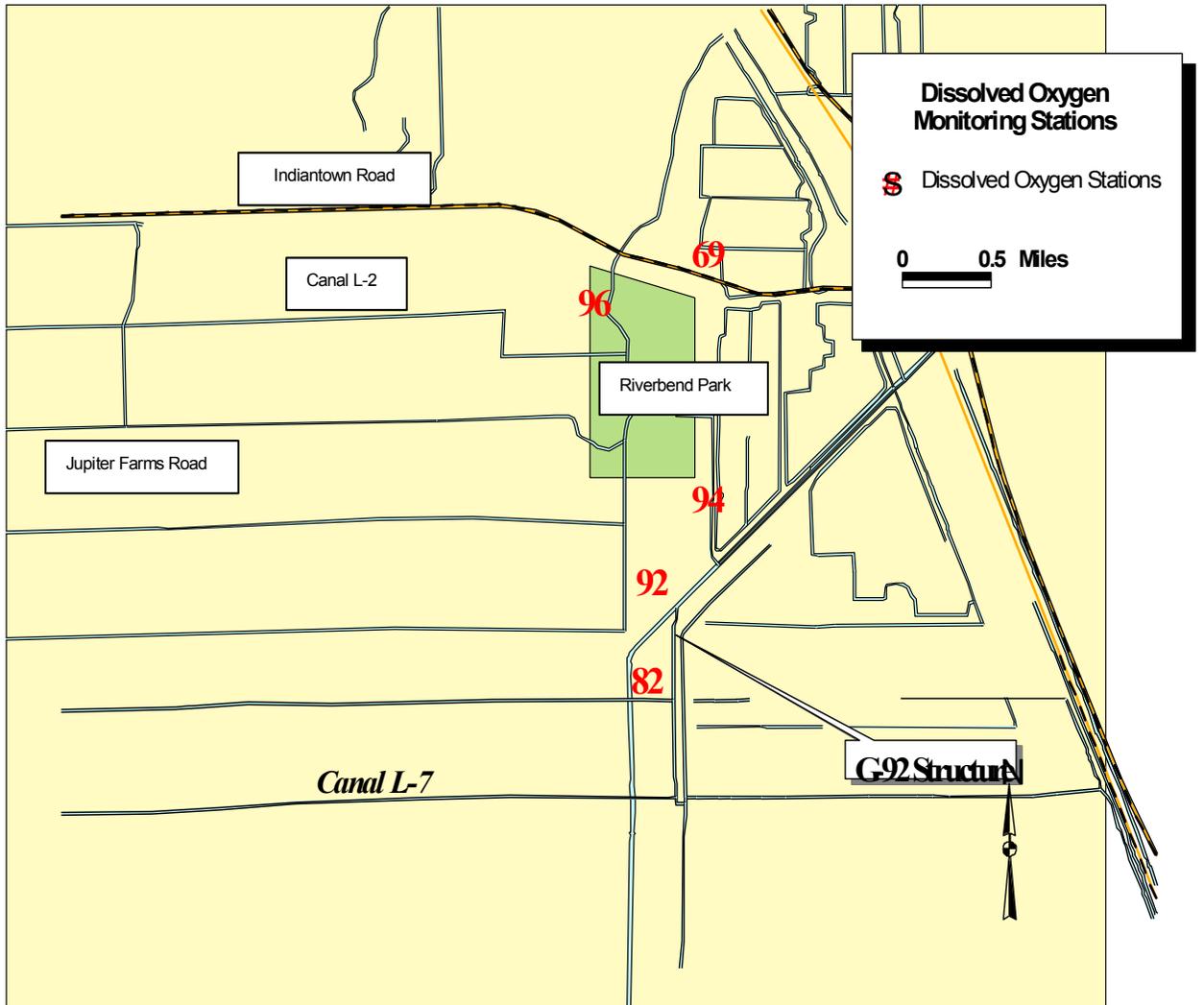


FIGURE # 4 : STUDY AREA MAP AND MONITORING STATIONS

