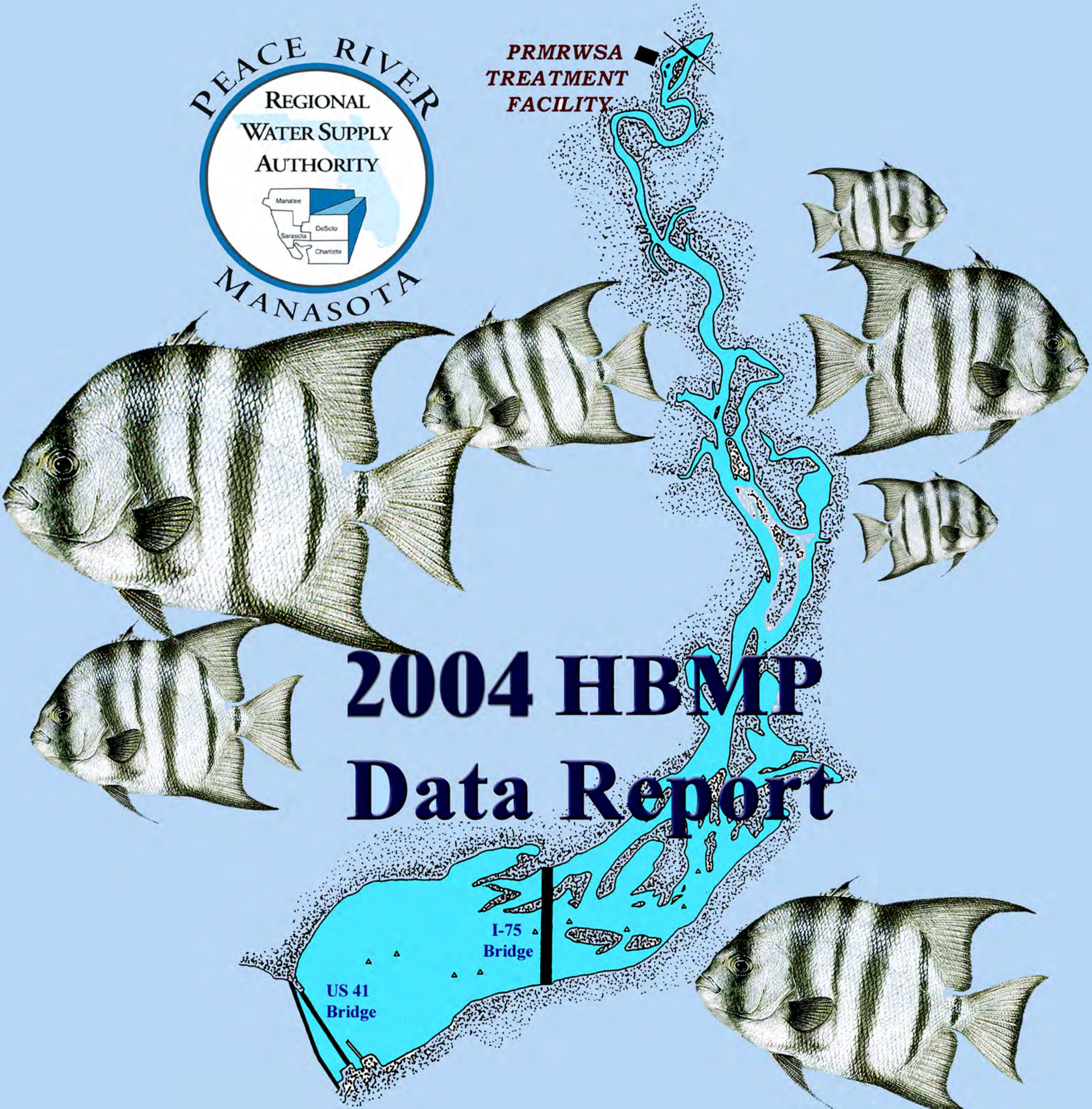
PEACE RIVER MANASOTA REGIONAL WATER SUPPLY AUTHORITY

2004 HBMP Data Report



Peace River Hydrobiological Monitoring Program 2003 Annual Data Report

Required by

Southwest Florida Water Management District
Water Use Permit 2010420.03

Prepared for

Peace River Regional Water Supply Facility

Peace River / Manasota Regional Water Supply Authority

1645 Barber Road, Suite A
Sarasota, Florida 34240

Prepared by

PBS&J
5300 West Cypress Street,Suite 300
Tampa, Florida 33607-1712

August 2004

Acknowledgments

The raw data, as well as the methods sections, presented in this report for the calendar year 2003 were provided by each of the contractors responsible for conducting specific elements of the Hydrobiological Monitoring Program.

- **EarthBalance (Florida Environmental)** – was responsible for all *in situ* water column physical measurements and the collection of water chemistry samples for both the "fixed" and "moving" station elements of the HBMP. In addition, EarthBalance staff was responsible for gathering and interpretation of all biannual HBMP Peace River vegetation monitoring.

- **U.S. Geological Survey (Tampa Office) –** was responsible for all data collected by the three tide gages and the associated measurements of surface and bottom conductivity, and provided all flow data used in this study.

  1. Peace River at Arcadia (02296750)
  2. Horse Creek near Arcadia (02297310)
  3. Joshua Creek near Nocatee (02297100)
  4. Shell Creek near Punta Gorda (02298202)

- **Peace River/Manasota Regional Water Supply Authority** – provided measurements of daily withdrawals by the facility.

- **Benchmark Laboratory –** conducted all HBMP water chemistry analyses conducted during 2003.

- **Dr. Susan Jensen** – conducted all phytoplankton taxonomic identifications.

Contents

List Of Tables

List Of Figures

1.0 Introduction/Summary

1.1 Previous Studies and Reports

On December 10, 1975, the Consumptive Use Permit #7500016 for the Peace River Regional Water Supply Facility was signed between General Development Utilities, Inc. and the Southwest Florida Water Management District (District). In conjunction with this agreement, a comprehensive Hydrobiological Monitoring Program (HBMP) was set forth to assess the responses of various physical, chemical and biological characteristics of the Charlotte Harbor Estuary to changes in Peace River flow. The program was designed to evaluate the impacts and significance of natural salinity changes on the aquatic fauna and flora in upper Charlotte Harbor, and to determine if freshwater withdrawals by the Peace River Regional Water Supply Facility could be shown to alter these patterns. The area of study is shown in **Figure 1.1**.

Between 1979 and 2003, an ongoing series of individual reports have been submitted to the District, documenting the results of the HBMP during the period from January 1976 through December 2002. These reports include summarizations (findings) of data collected during the first four years of baseline monitoring, prior to the start of freshwater withdrawals, as well as comparisons of these data to the results obtained from the HBMP during subsequent years of water treatment plant operation. The period covered within this 2003 Annual Data Report follows directly upon that contained within the preceding 2002 Annual Data Report submitted in August 2003, as well as the "Draft" 2002 Comprehensive Summary Report submitted in April 2004. This current data report includes unreported HBMP data collected over the period from January through December 2003, and represents the fourteenth year of data collection for the Peace River/Manasota Regional Water Supply Authority (Authority), the owner/operator of the Peace River Regional Water Supply Facility.

In 1976 the initial monitoring elements of the HBMP were designed to provide answers to specific questions raised by District staff during the original permitting process. These questions raised concerns regarding the potential for negative impacts that might be associated with possible salinity changes in Charlotte Harbor resulting from freshwater withdrawals. Analysis of data from pre- and post-water treatment plant operation, presented in the August 1982 Summary Report, indicated the need to revise the monitoring program. These revisions would better evaluate possible changes in the Charlotte Harbor system due to natural variations in freshwater inflows. Further modifications to the HBMP were made in 1985 and again in conjunction with the renewal of the Water Use Permit in November 1988. Under the 1988 permit, data reports were required to be submitted annually for the first through fifth years of the monitoring program. In addition, two expanded Comprehensive Summary Reports were submitted which included various comparative analyses of the data reported over the preceding periods of data. The first Comprehensive Summary Report was finalized in December 1993 and included analyses of long-term data collected between 1983 and 1991. The next Comprehensive Summary Report was filed in draft form in 1994, and as a final report in April 1995. This second Summary Report statistically summarized and evaluated the results of the HBMP elements conducted between 1976 and 1993. The report stated that, "To date, no observed short-term seasonal or long-term trends in any of the physical/chemical or biological parameters measured in this extensive investigation of the upper Charlotte Harbor Estuary have shown any influence by current water withdrawals by the Peace River Regional Water Facility."

1.2 Current Hydrobiological Monitoring Program

Based on the results of these summary reports and additional analyses requested by District staff during the permit renewal process, an expanded HBMP was approved by the District in March 1996 as a part of Water Use Permit (WUP) #2010420.03 for implementation in 1996 and subsequent years. This 20 year Water Use Permit continues to require the submission of both Annual Data Reports as well as Comprehensive Summary Documents after data collection for the 3rd and 5th years of each five-year period. Specific conditions within the permit include major expansions of both the physical and biological elements of the Hydrobiological Monitoring Program.

The analyses of long-term HBMP data provided in both the initial 2000 Interpretive Report (finalized in 2002) and the recent "Draft" 2002 Comprehensive Summary Report (submitted in April 2004) further support previous monitoring program findings regarding the potential magnitude of the changes that might be attributed directly to facility withdrawals. The primary goals and objectives of these summary documents have been to provide the District with sufficient analyses to:

- Determine key relationships between ecological characteristics and freshwater inflows, and determine whether the biological health and productivity of the estuary are showing signs of stress related to natural periods of low freshwater inflow or potential negative influences of facility withdrawals.
- Assess the presence or absence of long-term trends for important HBMP variables.
- Evaluate the overall HBMP design and make recommendations regarding implementing modifications.
- Assess the presence or absence of adverse ecological impacts and determine the influence facility withdrawals may have contributed.
- Evaluate the environmental considerations that may be associated with additional future increased withdrawals from the river and the feasibility of increased water supplies.
- Assess and evaluate the effectiveness of the withdrawal schedule for preventing adverse environmental impacts.

The overall findings of these recent summary documents submitted to the District in conjunction with the 1996 permit requirements have indicated that:

- In response to increasing potable water demands, Peace River Facility withdrawals have steadily and progressively increased since being initiated in 1980. However, the magnitude of withdrawals has remained extremely small when compared to the natural seasonal variability of rates of freshwater inflow to the estuary. Currently average yearly Peace River Facility withdrawals comprise less than 1 percent of total feshwater flow at the mouth of the Peace River.

- Since its inception in 1976, the HBMP has incorporated numerous physical, chemical, and biological study elements directed toward assessing both the overall "health of the harbor" as well as direct and indirect adverse impacts potentially associated with facility withdrawals. To date, none of these monitoring efforts have been able to detect any significant impacts associated with facility withdrawals.

- The summary results of developed statistical salinity models have indicated that, on average, the influences of facility withdrawals on the salinity structure of the Lower Peace River between the U.S. 41 Bridge and the Peace River Facility has historically resulted in maximum changes of less than 0.3 ppt.

- Statistical models were also used to predict what the potential magnitude of salinity changes might be under the maximum permitted daily withdrawals during Arcadia flows between 200 and 1,000 cfs. Model results predict that a maximum salinity change of < 0.5 ppt would occur between River Kilometers 14 and 18 when Arcadia flows range between 400 and 1000 cfs. With Arcadia flows of 200 cfs, the results predict that similar changes in salinity (< 0.5 ppt) would occur further upstream.

- The results and findings of similar statistical models developed using data from the two HBMP continuous recorders concluded that the maximum expected increases in salinity due to facility withdrawals would be difficult to actually measure within the normal daily range of tidal salinity variations during the periods when the facility is potentially having its greatest influence.

- Long-term comparisons of upstream and downstream occurrences of selected indicator plant species along the lower Peace River have indicated that the distributions of the selected indicator species have not indicated any signs of systematic progressive changes over time.

As long as salinity changes attributable to facility withdrawals remain a fraction of the normal typical range of daily (and seasonal) salinity variations along the lower Peace River/upper Charlotte Harbor HBMP study monitoring transect, no significant measurable environmental changes in the estuarine system would be expected. To date, none of the conducted HBMP data analyses have shown that facility withdrawals have had, or are expected to cause, measurable negative physical or biological adverse impacts within the lower Peace River estuarine system.

1.2.1 Ongoing HBMP Program Study Elements

An explicit element of the updated HBMP was the development of standardized station descriptors to be applied across all program elements (**Figure 1.2**). As part of the required morphometric study (see description below), the "mouth" of the Peace River was defined using USGS standardized protocols as an imaginary line extending from Punta Gorda Point to Hog

Island. **Figure 1.3** and **Table 1.1** provide a summary of the locations of all ongoing long-term fixed study elements and a cross-reference to previous station identifications. The following briefly outlines each of the current HBMP study elements.

1.2.2 Continuous Recorders

The primary goal of this element of the HBMP was to develop an extensive database of short-term (daily or more frequent) changes in surface and near-bottom salinity in the lower Peace River. These data, combined with corresponding gage height, freshwater flows and withdrawals, would then be used to develop detailed spatial and temporal relationships. A secondary goal was to assess potential long-term changes in river salinity, which might be explained by predicted increases in sea level.

In 1996 the U.S. Geological Survey (USGS) installed automated 15-minute interval water level recorders at the following two locations:

1. At Boca Grande, which is the estuary's largest opening to the Gulf of Mexico.
2. Approximately 15.5 kilometers upstream of the river's mouth at Harbour Heights. The gaging station at Harbour Heights also measures surface and bottom conductivity at 15-minute intervals.

In November 1997 a third gage was installed at approximately River Kilometer (RK) 26.7 just downstream of the Peace River Facility. This gage also measures water level as well as surface and bottom conductivity at 15-minute intervals. The relative locations of each of these three USGS gages are depicted in **Figure 5.a**.

1.2.3 Water Chemistry and Water Column Physical Profiles

There are a number of goals associated with the study elements in which physical and chemical water quality are measured. On an overall "health of the harbor" level, a primary goal is to collect sufficient long-term data to statistically describe spatial and seasonal variability in the water quality characteristics of the lower Peace River/upper Charlotte Harbor Estuary, and test for significant changes over time (trends). A second goal is to determine whether significant relationships exist between freshwater inflows and the seasonal/spatial variability of these water quality parameters. If such relationships can be shown, then the ultimate goal is to determine the potential magnitude of change that might result from permitted withdrawals, and compare such predictions with the range of observed natural variability.

Physical and chemical water quality parameters are measured within the lower Peace River/upper Charlotte Harbor Estuary under two different HBMP study elements.

1. During the first week of each month, water quality measurements (physical and chemical) are conducted at four "moving" salinity-based isohaline locations (0, 6, 12 and 20 ppt) along a river kilometer center-line running from the imaginary "mouth" of the Peace River upstream to above its junction with Horse Creek, and downstream to Boca Grande Pass. The relative monthly location of each sampling is based on the first

occurrence of these specific isohalines (± 0.5 ppt), with freshwater being defined as the first occurrence of conductivities less than 500 ms. The isohaline sampling effort is undertaken in conjunction with the long-term phytoplankton elements of the HBMP.

2. Approximately two weeks after the collection of the “moving” isohalines, water column physical profiles are conducted, near high tide, at sixteen locations along a transect running from just below the river’s mouth upstream to a point just above the Peace River Facility (see **Figure 1.3** and **Table 1.1**). In addition, chemical water quality samples are taken at five of these locations.

Both of these water quality study HBMP elements include physical *in situ* water column profile measurements of characteristic parameters (temperature, dissolved oxygen, pH, conductivity and salinity) at 0.5 meter intervals from the surface to the bottom. In addition both efforts measure the penetration of photosynthetically active radiation (PAR) to determine ambient extinction coefficients at specific sampling locations. Both studies also include the analyses of an extensive list of chemical water quality parameters (**Table 1.2**). The only difference is that at the “fixed” sampling stations both sub-surface and near-bottom samples are collected at each of the five sites, while only sub-surface water chemistry samples are taken as part of the “moving” isohaline phytoplankton production study element.

During 2003, EarthBalance, Inc. (formerly Florida Environmental) conducted all fieldwork (physical water column profile measurements and water chemistry parameter sampling) associated with both the “moving” and “fixed” station HBMP monitoring elements. Benchmark EnviroAnalytical, Inc. was responsible for conducting all 2003 water chemistry analyses.

In response to the recommendations contained within the 2000 HBMP Interpretive Report, the number of water chemistry parameters associated with both the “moving and “fixed” HBMP study elements was decreased from those originally specified in the 1996 monitoring conditions. These changes were made only after extensive consultation with both the HBMP Scientific Review Panel and District staff. As a result of this consultation, all monitoring in both January and February 2003 was conducted using the previous complete parameter list and the revised/ reduced long-term water quality sampling parameter list was implemented in March 2003 (**Table 1.2**).

The following briefly outlines the primary reasoning considered by Authority and District staff and the HBMP Scientific Review Panel for each of the six parameters deleted from the long-term water quality monitoring programs.

- **Alkalinity** – This parameter measures a unique water quality characteristic whose spatial distribution along the lower Peace River is directly related to flow. However, it was initially added to the list of water chemistry parameters collected at the “moving” stations as a backup method of calculating inorganic carbon (which was needed to calculate carbon uptake rates). By itself, alkalinity is not a key element of the HBMP estuarine Conceptual Model and was viewed as no longer serving a useful purpose now that carbon uptake rates have been deleted from the long-term HBMP study elements (see below).

- **Turbidity** – Statistical models for the lower Peace River presented in the HBMP 2000 Interpretive Report failed to demonstrate any consistent relationships of observed turbidity with season, distance, or freshwater inflows. Field observations in the lower Peace River have indicated increased turbidity resulting from factors such as: 1) flocculent organic material; 2) plankton; and 3) suspended organic sediments caused by wind stress across shallow areas. The potential for any correlation of turbidity with Peace River Facility withdrawals was viewed as extremely doubtful, and it was recommended that this parameter be deleted from the HBMP water quality monitoring programs.

- **Total Phosphorus** – The Peace River basin contains extensive natural phosphate deposits, and ambient concentrations in the lower Peace River are extremely high in comparison to estuarine systems outside of southwest Florida. There are no data to suggest that the availability of phosphorus ever limits phytoplankton primary production in the Peace River estuarine system. Ortho-phosphorus is the biologically available form and comprises over 92 percent of total measured phosphorus in the lower Peace River estuarine system. It was therefore recommended that total phosphorus be deleted from both the fixed and moving station HBMP water chemistry studies, and that ortho-phosphorus be retained in assessing the long-term "health of the harbor" and potential changes in mining practices in the watershed.

- **Inorganic Carbon** – This chemical constituent does not meet the primary key criteria of being an important component of the HBMP Conceptual Model for the lower river/upper harbor estuarine system. It was originally added to the HBMP since it was necessary to measure phytoplankton primary production carbon uptake rates. Primary production was previously dropped from the HBMP and thus measures of inorganic carbon were no longer necessary and this parameter was deleted.

- **Total Organic Carbon** – This water quality parameter measures both dissolved organic carbon as well as any particulate organic material in the water column, including both phytoplankton and zooplankton. While total organic carbon is an important component of the HBMP estuarine Conceptual Model, its relationships with flow are mediated through a variety of highly temporal pathways, obscuring any interactions with flow or withdrawals. It was therefore recommended that the measurement of total organic carbon be deleted from both the fixed and moving station HBMP water chemistry studies.

- **Dissolved Organic Carbon** – There is a considerable amount of literature and speculation concerning the potential role of dissolved organic carbon as an important component of production in estuarine systems. However, the pathways, mechanisms, and confounding influences associated with the reliance of bacterial-based food chains on estuarine dissolved organic carbon loadings are very poorly understood. While this parameter may be an important "health of the harbor" measure, the magnitudes of current permitted withdrawals are far below that which might reasonably be expected to result in measurable changes. Statistical analyses conducted as part of the 2000 HBMP Interpretive Report indicated neither a clear direct relation with flow nor any statistically significant long-term trends. It was therefore recommended that this parameter be deleted from the HBMP water chemistry list.

1.2.4 HBMP Study of Long-Term Changes in Vegetation

Identification of potential adverse effects to emergent vegetation and riverine wetlands caused by freshwater withdrawals initially requires determining the magnitude of the spatial and temporal responses of these vegetative communities to the natural variation resulting from extended periods of drought and flood. This step involves developing methodologies that allow differentiating between long-term natural changes in riverine vegetative patterns and withdrawal induced changes. The vegetative monitoring elements of the HBMP provide information for determining relationships between vegetation patterns and freshwater flows by observing the positions of the freshwater and salt-tolerant plant communities, especially in the salinity transitional zone of the river. A permanent shift of more salt-tolerant plants upriver could be an indication that withdrawals were impacting the river corridor wetlands, as long as natural variability (drought) or man-made causes could be eliminated. EarthBalance is currently conducting all vegetation elements of the HBMP studies.

Photointerpretation - This long-term element of the HBMP initially began in 1976. Initially aerial infra-red photography of the vegetative communities was taken yearly along the lower Peace River, starting at the U.S. 41 Bridge (River Kilometer 6.6) and extending upstream above the Peace River Facility to near the area where Horse Creek enters the river (river kilometer 39.5). Under the 1996 HBMP permit modifications, such aerial surveys continue to be conducted at two years intervals. All post-1996 aerial photography is taken in a corrected, GIS compatible format, thus allowing for accurate quantification of any observed changes. Photointerpretation of these images, in conjunction with field observations, will periodically be used to develop maps of the river's vegetation associations. Both qualitative and quantitative data are being used to assess potential changes associated with extended natural periods of both low and high freshwater inflows.

First and Last Occurrence of Indicator Plant Species – Since 1976, at approximately two year intervals, the first and last occurrence of a large number of indicator plant species has been recorded along the banks of the Peace River downstream of the Peace River Facility. As part of the vegetation study element of the HBMP, detailed maps using the standardized river kilometer scale are made, identifying the first and last occurrences of individual and substantial populations of key indicator species. The current permit requires a detailed photographic record be compiled in conjunction with this effort. These data are used in conjunction with the aerial photography to assess the influences of long-term natural variations in river flow.

Vegetation Transition Sites – Under the current permit, this portion of the HBMP study extends and expands the detailed monitoring begun in 1979 of plant communities along the river's banks at fixed locations. The vegetative communities at three permanent transect sites (see **Figure 1.4** and **Table 1.1**) are sampled at two-year intervals. At each monitoring location, three transects from the top of the bank to the water's edge are surveyed. The vegetation one meter to each side of the transects are identified, and the location and density recorded. These long-term data can be used to further assess the response of the riverine vegetative communities to natural variations in freshwater flows.

1.2.5 Phytoplankton Studies

Sub-surface samples are being collected in conjunction with the "moving" isohaline sampling of physical and chemical water quality characteristics described above.

Carbon Uptake – From June 1983 through December 1999, replicate (5) rates of carbon uptake were determined for each of three separate phytoplankton size fractions: 1) greater than 20 microns; 2) less than 20 microns and greater than 5 microns; and 3) those cells less than 5 microns at each of the four "moving" isohalines (0, 6, 12 and 20 ppt). Based on the extensive nature of the database gathered, further *in situ* carbon uptake measurements were deleted from the HBMP in 2000.

Chlorophyll *a* Biomass – Although direct carbon uptake measurements have been deleted from the HBMP, sub-surface samples for the measurement of chlorophyll *a* continue to be taken with regard to the estimation of phytoplankton biomass. However, as of 2002, the relative levels of chlorophyll *a* within each of three size fractions: 1) greater than 20 microns; 2) less than 20 microns and greater than 5 microns; and 3) those cells less than 5 microns, will no longer be determined.

Species Composition - Since 1989, monthly sub-surface phytoplankton samples have been collected, preserved and identified to the lowest practical taxon in conjunction with the carbon uptake measurements at each of the four isohalines. To date, the same individual (Dr. Susan Jensen) has conducted all taxonomic identifications.

1.3 Special Studies Associated with the HBMP

In addition to the current, ongoing elements of the HBMP outlined above, the revised HBMP program implemented in 1996 also required the Authority to conduct and/or contribute to a number of duration-limited studies designed to answer specific research questions. The following outlines the major goals of each of these special studies conducted within the first major review period of the current Water Use Permit. Each of these special investigations has resulted in a stand-alone report submitted to the District. Where applicable, all pertinent data collected during these specific research studies will be incorporated into other study elements of the HBMP. Comprehensive overviews and summaries of the primary conclusions from each of the major Hydrobiological Monitoring Program documents, as well as other relevant lower Peace River/upper Charlotte Harbor reports that have been prepared since the 1996 Permit renewal, were included in the recently submitted "Draft" 2002 HBMP Comprehensive Summary Report.

1.3.1 Morphometric Investigation

Conducted by PBS&J, the goal of this effort was to develop maps and tabular files indicating typical cross-sections, open-water area, water volume, shoreline length, and areas/types of adjacent wetland habitat. All such determinations and metrics were defined corresponding to 0.5-

kilometer interval segments along a developed centerline extending from the mouth of the Peace River near Punta Gorda to a point well upstream of the Peace River Facility. In addition, a summary table was developed indicating the locations of both current and previous fixed water quality and vegetation sampling locations in relation to the new centerline kilometer distance scale developed during the morphometric analysis. The results of the morphometric study were finalized and submitted to the District in January 2000 as a separate report. **Table 1.1** and **Figures 1.2 and 1.3** indicate the permanent river kilometer distances that will be used in all future HBMP documents, providing relations to both previously used USGS river miles and EQL station locations.

1.3.2 Benthic Macroinvertebrate and Mollusc Study

Mote Marine Laboratory conducted this special study element of the HBMP, and a final report was submitted in April 2002. The primary objectives of the two investigations conducted as part of this effort were to:

- Describe the distribution of major macroinvertebrate habitats and communities in the lower Peace River.

- Determine whether benthic organisms and/or their community structure can be used to assess natural variations in freshwater inflows, and measure potential influences caused by the diversions of the Peace River Facility.

The approach of these studies was to characterize the tidal area of the river downstream of the Peace River Facility based on a series of criteria, including: 1) the magnitude of tidal influence, 2) dominant shoreline habitats, and 3) observed gradients in physical and/or chemical characteristics, or other features found to be significant. Important riverine characteristics of significance to the distribution of benthic invertebrate communities would include physical/chemical parameters such as the sediment granulometry of the riverbed, as well as spatial differences with depth, salinity and dissolved oxygen.

Macroinvertebrates – The design of this sampling effort incorporated dividing the lower Peace River into four "salinity segments" based on historic gradients from data gathered as part of the HBMP.

- < 0.5 ppt
- > 0.5 & < 8 ppt
- > 8 & < 16 ppt
- > 16 ppt

Core samples, the colonization of artificial substrates, and sweep nets were used to characterize the benthic invertebrate communities from two depths: 1) the intertidal zone, and 2) from Mean Low Low Water down to a depth of 3.7 meters, within each of the four identified salinity zones.

Mollusc Study - A second corollary investigation of the distribution of benthic, hard-shell mollusc communities was undertaken. This effort examined both live and dead shells to delineate ecological zones in the estuary and attempted to relate the observed patterns to recent seasonal patterns in flows and observed variations in near-bottom salinity. This investigation incorporated intensive sampling at 0.5 km intervals along the lower river.

1.3.3 Fish Nursery Study

The University of South Florida conducted this special short-term, two-year study, which was jointly funded by the Authority and the District. The study's goal was to define seasonal and spatial patterns of fish nursery use within the lower Peace River/upper Charlotte Harbor Estuary and to determine the potential influences/relationships freshwater inflows have on such observed patterns. Stratified estimates of the relative distribution and abundance of fishes and selected invertebrate taxa were made from two randomly selected, five minute, three-step (bottom-midwater-surface) oblique tows collected during night, flood tide conditions using a weighted, flowmeter-equipped plankton net. Monthly samples were collected at seven zones within the lower Peace River. A comprehensive report summarizing the findings of this investigation was submitted in June 2002.

1.3.4 Fixed Station Salinity Modeling

A key element of the recently finalized Year Three Interpretive Report was the development of statistical models of salinity as functions of the interrelationships between freshwater inflows and location in the lower river along the developed centerline between the U.S. 41 Bridge (RK 6.8) and the Peace River Facility (RK 29.8). These models were then applied to determine:

- Historical changes in salinity predicted to have occurred downstream of the point of withdrawal as a result of actual facility freshwater withdrawals.

- Predicted potential salinity changes in the lower Peace River/upper Charlotte Harbor estuarine system that might be expected to occur under maximum freshwater withdrawals under the existing permitted withdrawal schedule.

In order to further test these results, the District contracted with the Authority to retain Janicki Environmental, Inc. to develop updated regression models to predict salinity at each of seven fixed sampling locations:

1. River Kilometer –2.4 (EQL #9)
2. River Kilometer 6.6 (EQL #10)
3. River Kilometer 10.5 (EQL #11)
4. River Kilometer 15.5 (EQL #12)
5. River Kilometer 20.1 (EQL #13)
6. River Kilometer 23.6 (EQL #14)
7. River Kilometer 25.9 (EQL #15)

Regression models for salinity were developed at each of these seven locations at a series of water column depths.

- Near the surface
- At a depth of 1.0 meters
- At a depth of 2.0 meters
- Near the bottom

A draft document of the findings of this study was submitted for review in June 2001 and finalized in March 2002.

1.4 Summary of 2003 Results

The following text and tables compare data collected during 2003 with similar average values for key parameters previously compiled during various elements of the ongoing long-term monitoring programs. Such key elements, include:

1. Peace River freshwater inflows and facility withdrawals.

2. Physical measurements such as water temperature, color and extinction coefficients.

3. Water quality characteristics such as nitrate/nitrite, ortho-phosphorus, nitrogen to phosphorus ratios, and reactive silica.

4. Biological measurements of phytoplankton biomass (chlorophyll *a*.)

In making comparisons of the 2003 data with averages of similar data collected over the preceding twenty-year period (1983-2002), it should be noted that the very wet winter/spring El Niño of 1997/1998 was followed by very dry La Niña conditions that influenced southwest Florida and the entire Peace River watershed between 1999 and mid-2002 (see **Figure 2.6**). A weaker El Niño at the end of 2002 and a wetter than average wet-season resulted in freshwater flows during 2003 being well above average.

- **Flows** – Average mean daily Peace River flow at the Arcadia gage during 2003 was 1853 cfs, which was approximately sixty percent greater than the daily mean flow during 2002, and thirteen times greater than the mean flow during 2000, which was the lowest that has occurred during the twenty-eight year period of HBMP monitoring. Overall, gaged Peace River at Arcadia freshwater inflows during 2003 were approximately double the average daily flow for the preceding long-term period 1976-2002 (see **Table 2.3**). The sum of average daily flows from the Peace River at Arcadia, Horse Creek, Joshua Creek, and Shell Creek during 2003 was roughly one hundred and ninety percent of the average daily flows for the period 1976-2002.

- **Withdrawals** – Facility withdrawals only reached levels of ten percent of the gaged Peace River at Arcadia flows (those over 130 cfs) on three percent of the days of the year. Facility withdrawals during 2003 comprised 1.41 percent of the annual Arcadia gaged flow, and 0.89 percent of the combined lower Peace River gaged flow (Peace, Arcadia, Horse Creek, Joshua Creek and Shell Creek). Due to the minimum cutoff of 130 cfs (as measured at the USGS Arcadia gage), there are often extended periods each year when the Peace River Facility does not withdraw water from the river. During 2003, the facility did not withdraw any water approximately eleven percent of the time. As indicated, maximum withdrawals increased notably during the later half of 2002 due to the recently completed facility expansion, which resulted in an increase in the Authority's ability to treat larger daily amounts of freshwater when river flows are within the existing permit schedule.

Statistical comparisons between 2003 and long-term averages for the following selected physical, chemical and biological water quality characteristics measured in conjunction with the "moving" and "fixed" HBMP study elements are presented in **Tables 3.8** and **4.5**.

- **Temperature** – Average water temperatures throughout most of the year were generally above the long-term annual averages, even though surface water temperatures during the summer months were slightly below recent years (probably reflecting increased wet-season rainfall). Water temperatures at the end of the year (November and December 2003) were much warmer than average. As in previous years, during the summer wet-season (June through October), water temperatures in the freshwater isohaline were slightly below those observed at the other three monitored salinity zones.

- **Water Color** – The average color levels throughout the estuary were markedly different than those recently observed during the preceding years of drought. Color levels were well above the long-term averages as a result of the higher than average flows during much of 2003. Comparatively, the greatest difference in color levels during 2003 when compared to the long-term averages occurred within the higher salinity reaches of the estuary.

- **Extinction Coefficient** – Comparisons among the mean 2003 extinction values indicated divergent patterns. Light extinction coefficients within the freshwater reaches of the lower river were below historical annual averages, while at the same time extinction coefficients were at or above average within the higher estuarine salinity zones. It is suggested that the higher than average flows that occurred through the first half of 2003 suppressed normal spring levels of phytoplankton production (chlorophyll *a*), resulting in lower than average measurements of extinction coefficients within the lower river.

- **Nitrite/Nitrate Nitrogen** - During 2003, the average concentrations of this major inorganic form of nitrogen were similar to the long-term averages in the lower river, and slightly above average in the higher salinity reaches of the estuary. Spatially concentrations typically decrease rapidly with increasing salinity, while temporally ambient inorganic nitrogen concentrations in the estuary usually decline to their lowest levels during the relatively drier, late spring as phytoplankton populations respond to increasing water temperatures and light, and increased primary production removed available inorganic nitrogen.

- **Ortho-phosphorus** - Average inorganic phosphorus concentrations during 2003 were generally lower than the long-term averages (1983-2002). Since ambient inorganic phosphorus concentrations are heavily influenced by the unusually "very" high natural levels found in the Peace River watershed, the observed differences in concentrations among the four monitored HBMP isohalines simply reflect conservative dilution by Gulf waters. Unlike inorganic nitrogen, observed changes in phosphorus concentrations are for the most part unaffected by biological uptake. Ambient inorganic phosphorus concentrations entering the estuary system from the Peace River watershed are typically lower during wetter periods, when a higher proportion of flow results from surface flow (rather than coming from groundwater, which is naturally richer in phosphorus). Since the late 1970s there has been a marked decline in inorganic phosphorus levels in the lower Peace River/upper Charlotte Harbor estuarine system due to declines in the combined influences of phosphate mining in the upper reaches of the basin.

- **Nitrogen to Phosphorus Atomic Ratios** – Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations show nitrogen to always be the inorganic macronutrient limiting phytoplankton production within the lower Peace River/upper Charlotte Harbor estuarine system.

- **Silica** - Concentrations during 2003 reflected a continuation of the previously noted increasing pattern of higher dissolved silica concentrations. This increasing pattern was slightly interrupted by the recent extended drought, but average reactive silica concentrations during 2003 were more than double the long-term means throughout the lower river and upper harbor.

- **Chlorophyll *a*** – The pattern of freshwater inflows during 2003 reflected the influences of the much wetter than usual 2002/2003 winter, followed by wetter than average conditions during the typically very dry spring, and a wetter than average summer wet-season. The result was both higher than average inputs of inorganic nutrients, and higher than average ambient water color (low light). This was fairly typical of relatively lower levels of phytoplankton production in the more highly color-influenced lower salinity reaches of the estuary, combined with higher than average phytoplankton production (chlorophyll *a*) within the higher salinity zones. The 2003 data indicate the occurrences of a number of instances of high phytoplankton chlorophyll *a* biomass. Corresponding species identifications found that either increases in dinoflagellates or diatoms often characterized these "blooms."

1.5 Conclusions

This document represents the seventh Annual Data Report submitted under the expanded Hydrobiological Monitoring Program (HBMP) initiated in 1996 in compliance with Water Use Permit 2010420.03. The graphical and summary analyzes presented in this document do not indicate any substantial changes, or atypical events in either the physical or biological data collected during 2003, other than those previously noted. These include:

- Higher than usual winter freshwater inflows associated with the winter 2002/2003 El Niño event.

- A wetter than average summer wet-season.

- A resumption of the previously noted long-term increase in reactive silica concentrations in the lower Peace River.

These "limited" analyzes also do not suggest that there have been any long-term changes resulting from either current or historic water withdrawals by the Peace River Regional Water Supply Facility.

1.6 Permanent Data

All historic water quality and *in situ* data collected during the fixed and moving station elements of the HBMP used in the preparation of this document are provided on the HBMP 2003 Annual Data Report CD in the directory labeled 2003 Data Sets, as either ASCII files and/or SAS format. Table 1.3 provides a summary and links to descriptions of the variables within each of the SAS data sets.

Table 1.3
Description of Data Sets

Data Set Name	Time Period	Brief Description
HBMP SAS Data Sets		
Flwd03.sd2	1931-2003	Historic daily flow data for: Peace at Arcadia; Horse Creek near Arcadia; Joshua Creek near Nocatee; and Shell Creek near Punta Gorda. Historic daily Peace River Facility withdrawals. All values in cfs.
Cmov8303.sd2	1983-2003	Water quality, and phytoplankton biomass and uptake measurements from monthly surface samples collected at each of the four moving isohalines. Relative locations reflect distances from the river mouth in kilometers.
Hymov03.sd2	1983-2003	Monthly hydrolab *in situ* water quality measurements taken at 0.5-meter intervals at each of the four moving isohalines. Relative locations reflect distances from the river mouth in kilometers.
Hyfix03.sd2	1996-2003	Monthly *in situ* hydrolab water column profile data taken at 0.5-meter intervals from fixed sample locations from near the river's mouth to just upstream of the Peace River Facility.
Cfix9603.sd2	1996-2003	Monthly surface and bottom chemical water quality samples taken at five intervals from fixed sample locations from near the river's mouth to just upstream of the Peace River Facility.
Efix9603.sd2	1996-2003	Water column extinction coefficients collected at the fixed sampling locations.
Boca03.sd2	1996-2003	Water level at 15-minute intervals from the continuous recording gage near Boca Grande.

Table 1.3
Description of Data Sets

Data Set Name	Time Period	Brief Description
HBMP SAS Data Sets		
Ph03.sd2	1996-2003	Water level and surface and bottom conductivity and temperature at 15-minute intervals from the continuous recording gage on the Peace River near Harbour Heights (River Kilometer 15.5).
pr03.sd2	1997-2003	Water level and surface and bottom conductivity and temperature at 15-minute intervals from the continuous recording gage on the Peace River near Peace River Heights (River Kilometer 26.7).
Environmental Quality Laboratory Background Data Sets		
Chall_2.sd2	1976-1990	EQL Charlotte Harbor background water chemistry data.
Hydroall.sd2	1976-1990	EQL Charlotte Harbor hydrolab water column profile data.

❖ **Note:** Click on the data set name to review a comprehensive listing of the data set contents.

1.7 Problems Encountered During 2003

Overall, very few data problems occurred during 2003, when compared to some of the difficulties that have occurred during previous years. The following outlines some of the problems and errors encountered during data collection for various elements of the HBMP monitoring program.

- **USGS Continuous Recorders** – Due to short-term instrument failures, a limited number of records for gage height, temperature and/or conductivity are unavailable for the Harbour Heights and Peace River Heights gaging sites during 2003.

2.0 Peace River Gaged Flows and Regional Water Supply Facility Withdrawals

The purpose of this section is to provide overviews of 2003 gaged river freshwater inflows to the lower Peace River estuary as well as freshwater withdrawals by Peace River Regional Water Supply Facility (PRF). This section also provides comparisons of the 2003 flow record and facility withdrawal levels with similar long-term information from the historic 1976-2003 period corresponding with HBMP monitoring.

Previously presented **Figures 1.1** and **1.2** depict the location of the Peace River Regional Water Supply Facility in relation to both the lower Peace River watershed and the lower Peace River/upper Charlotte Harbor Estuary. As indicated, the point of PRF withdrawal is located in the tidal portion of the lower river estuarine system, in a reach of the river that is characterized by brackish conditions during periods of low freshwater inflow.

2.1 2003 Peace River Flows

Daily Peace River discharges (in cubic feet per second) at the USGS gaging station at Arcadia, Florida during the reporting period, January through December 2003, are depicted in **Figure 2.1a**. As indicated, freshwater inflows during 2003 were in marked contrast with the preceding period of severe extended drought that began in 1999 and continued through early 2002. The fall of 2002 was marked by the initiation of an El Niño climatic event (the previous being in 1997/1998). The abnormally high flows observed during much of the first half of 2003 reflected the continued influences of the unusually wet winter and spring conditions associated with this El Niño event. Higher than normal freshwater flow to the lower Peace River estuarine system also occurred throughout the typical June-September summer wet-season during 2003, with unusually high flows extending well into October.

The seasonal patterns of freshwater inflows during 2003 are further graphically presented in relation to the preceding long-term historical averages (1976-2002) in **Figure 2.1b**. Statistical analyses were used to determine long-term average daily "exceedances" of the 10^{th}, 25^{th}, 50^{th} (median), 75^{th} and 90^{th} percentiles for Peace River flow using the daily Arcadia gage record. Thus, the line presented in **Figure 2.1b** for Q90 represents a level of freshwater inflow that, over the long-term 1976-2002 average, is only exceeded ten percent of the time on that particular day. This graphic clearly shows that gaged Peace River at Arcadia flows during 2003 were above the corresponding median (Q50) levels almost continually throughout the year. During January and throughout extended periods during the summer wet-season, 2003 flow levels often exceeded the statistical Q90, and were thus in the upper ten percent of flows recorded for that date over the long-term 1976-2002 period.

Table 2.1

Comparisons of Freshwater Inflows During 2003 and the Period 1976-2003

Figure	Description
Figure 2.1a	Daily Peace River flow at Arcadia (2003)
Figure 2.1b	Daily Peace River flow at Arcadia in relation to long-term statistical averages
Figure 2.2	Daily Peace River flow at Arcadia (1976-2003)
Figure 2.3	Monthly mean Peace River flow at Arcadia (1976-2003)
Figure 2.4	3-month moving average Peace River flow at Arcadia (1976-2003)
Figure 2.5	Total daily flow - Peace River + (Horse + Joshua + Shell) Creeks (2003)
Figure 2.6	Total daily flow - Peace River + (Horse + Joshua + Shell) Creeks (1976-2003)
Figure 2.7	Mean monthly flow - Peace River + (Horse + Joshua + Shell) Creeks (1976-2003)
Figure 2.8	3-month moving average flow - Peace River + (Horse + Joshua + Shell) Creeks (1976-2003)

Daily Peace River flows between 1976, the beginning of the HBMP, and 2003 are shown in **Figure 2.2**. This figure clearly shows the magnitude of the extended drought that recently occurred between 1999 and 2002, and the influences of the El Niño climatic event that began late in 2002 and extended well into 2003. The same long-term period of river flow is further presented as mean monthly values (**Figure 2.3**) and as the 3-month moving averages (**Figure 2.4**). Plots similar to those above for total gaged flow entering Charlotte Harbor from the Peace River (Peace River at Arcadia + Horse Creek + Joshua Creek + Shell Creek) are shown in Figures 2.5 through 2.8. Combined, these graphics clearly indicate the seasonal wetter than average conditions that characterized much of 2003, with higher than normal flows occurring during both the typically drier winter and spring months, and throughout the summer wet-season.

Comparison of the data displayed in **Figures 2.1b** and **2.2** shows that Peace River average daily flow at Arcadia during 2003 was approximately 217 percent of that calculated over the preceding longer 1976-2002 period. The data displayed in **Figures 2.5** and **2.6** for the sum of average daily flows from the Peace River at Arcadia, Horse Creek, Joshua Creek, and Shell Creek indicate that total freshwater inflows to the lower Peace River estuary during 2003 were roughly 197 percent of the average over the longer preceding time period of HBMP monitoring (1976-2002).

2.2 Peace River Facility Withdrawals

Daily withdrawals from the Peace River (in cubic feet per second) by the Peace River Facility during 2003 are presented in **Figure 2.9**. Two items of note are indicated in this figure. The first being that due to the minimum cutoff of 130 cfs (as measured at the USGS Arcadia gage), there are often extended periods (typically during the spring dry-season) each year when the Peace River Facility does not withdraw water from the river. The second is that, due to the unusually wet conditions and higher than average freshwater flows that occurred during 2003, the PRF was able to withdraw water from the lower Peace River many more days than during the recent severe 1999-2002 drought.

Daily withdrawals since facility startup are shown from 1980-2003 in **Figure 2.10**. This figure clearly indicates the increases in maximum withdrawals beginning in the later half of 2002 due to the recently completed facility expansion, and the Authority's increased ability to treat larger daily amounts of freshwater.

Plots of the monthly means and 3-month moving averages of withdrawals over this period are depicted in **Figures 2.11** and **2.12.** The effects on water withdrawals from the recent long-term drought and the 2002 facility expansion are clearly evident in **Figure 2.12.** Various relationships between 2003 Arcadia gaged Peace River flows and PRF withdrawals are further depicted in **Figures 2.13** through **2.16**.

Table 2.2

Comparisons of Facility Withdrawals and Freshwater Inflows During 2003 and the Period 1980-2003

Figure	Description
Figure 2.9	Daily water treatment facility withdrawals (2003)
Figure 2.10	Daily water treatment facility withdrawals (1980-2003)
Figure 2.11	Monthly mean water treatment facility withdrawals (1980-2003)
Figure 2.12	3-month moving average water treatment facility withdrawals (1980-2003)
Figure 2.13	Peace River flows at Arcadia and water treatment facility withdrawals (2003)
Figure 2.14	Peace at Arcadia + Horse + Joshua + Shell Flows and water treatment facility withdrawals (2003)
Figure 2.15	Peace River flows at Arcadia vs. water treatment facility withdrawals (2003)
Figure 2.16	Peace River flows at Arcadia vs. % water treatment facility withdrawals (2003)

Facility withdrawals from the river during 2003 reached ten percent of the preceding daily gaged Peace River at Arcadia flow only a small number of days during the year. However, as indicated in **Figure 2.16**, there were a number of times (eleven) during 2003 when withdrawals exceeded this amount. The primary reason for these discrepancies stems from the way that stage/flow data are gathered. The Authority uses "provisional" preceding day flow data from the water level recorder at the USGS gaging station on the Peace River at Arcadia. These data are obtained directly from the USGS Tampa office's Web Site. However, after the fact, the USGS checks and evaluates the data from the stage recorder and river cross section a number of times each year. Thus, the daily values used by the Authority are only "provisional" and are often changed by the USGS weeks or even months later. It is not uncommon for subsequent determinations of percent withdrawals, based on revised USGS calculations of daily flows, to sometimes indicate that daily withdrawals, based on provisional flow information, exceeded ten percent.

2.3 Summary

Annual mean Peace River flows (gaged data only) at Arcadia and the U.S. 41 Bridge are summarized since 1976, the start of the HBMP, in **Table 2.3**. Also included in this table are mean annual Peace River Facility withdrawals (since1980), and the annual percentage facility withdrawals have comprised of measured gaged flows at both Arcadia and the U.S. 41 Bridge. Average daily withdrawal for 2003 was approximately 0.89 percent of the combined average daily flows of the Peace River, Horse Creek, Joshua Creek, and Shell Creek. During the preceding period 1980-2002, average daily withdrawals were approximately 0.64 percent of the combined average daily flows of the Peace River, Horse Creek, Joshua Creek, and Shell Creek.

3.0 Phytoplankton and Water Chemistry at "Moving" Isohaline Locations

3.1 Introduction

The development of a comprehensive understanding of phytoplankton production and related community structure within the Charlotte Harbor system is fundamental in developing an understanding of the interrelated biological communities and physical processes within the estuary, including secondary production and nutrient cycling. A thorough understanding of those processes controlling phytoplankton production within Charlotte Harbor is necessary to quantify the estuary's immediate and long-term responses to various external inputs. The HBMP's ongoing, long-term investigation of production in the lower Peace River/upper Charlotte Harbor estuarine system attributable to phytoplankton assemblages meets these criteria by providing both:

- A measurement of populations and community structure that act as sensitive barometers of external change at a short (daily to weekly) temporal scale.
- Insight into basic spatial processes not only affecting water quality but having secondary widespread interrelations and effects upon other estuarine system components.

Phytoplankton production generally represents an immediately available food resource, unlike other estuarine production such as that associated with seagrass, mangrove and saltmarsh habitats, where much of the resource becomes available through secondary processes. Of the various inputs into the Charlotte Harbor estuarine system, phytoplankton production represents both the largest single component of primary production and a food source directly accessible to many filter and detrital feeding organisms. Phytoplankton production and community composition, due to the short generation times involved, have also been shown to be effective in demonstrating ephemeral, seasonal and long-term changes in water quality. Phytoplankton production represents a highly integrated estuarine component and can be used to provide information on both direct and predictive secondary impacts of external influences.

3.1.1 Current Long-Term Phytoplankton Study Elements

This report presents data collected during the twenty-first year (2003) of this unique long-term study of the relationships between phytoplankton productivity and Peace River flow into upper Charlotte Harbor. The continuation of phytoplankton studies under the 1996 SWFWMD Water Use Permit ensures development of a database sufficiently large enough to enhance the ongoing statistical evaluation of trends and develop a long-term understanding of differences in the harbor's responses to periods of both extended drought and unusually high freshwater inflows. In addition, the permit continues the collection and thorough taxonomic evaluation of the seasonal abundance and dominance of observed phytoplankton species. This portion of the study seeks to quantify the specific responses of major phytoplankton taxonomic groups to variations in the periodicity of freshwater inflow, and assess the potential influences (if any) of Peace River Facility diversions.

The current HBMP study elements of phytoplankton production in the lower river and upper harbor are designed to develop the needed long-term database necessary to evaluate both short and long-term cycles in phytoplankton production in the upper estuarine system. Statistically comparable levels of phytoplankton ^{14}C fixation rates were measured monthly at each of four salinity-based isohaline locations between June 1983 and December 1999 (following which uptake rate measurements were discontinued). Although direct *in situ* measurements of phytoplankton carbon uptake rates are no longer being measured, determinations continue to be made of phytoplankton biomass (chlorophyll *a*), population structure, related physical parameters, water column light profiles and analysis of the major chemical constituents associated with phytoplankton growth. The four sampling locations in this study represent non-fixed surface salinity zones, such that the monthly location of each isohaline is dependent upon the preceding amount of freshwater inflow from the Peace River. Table 3.1 summarizes the historical statistical distributions of these isohalines. The four salinity sampling zones are:

- Station 101 = 0 o/oo
- Station 102 = 5-7 o/oo
- Station 103 = 11-13 o/oo
- Station 104 = 20-22 o/oo

Table 3.1

Summary Statistics of the Four Isohaline Locations (Kilometers) from the Peace River’s Mouth for the Period 1983-2003

Isohaline	Minimum	Maximum	Mean	Median
0 o/oo	3.4	37.6	21.7	20.9
6 o/oo	-16.3	27.5	12.4	12.1
12 o/oo	-30.1	24.5	7.3	8.6
20 o/oo	-36.3	18.0	-0.2	2.3

To date, the most upstream occurrence of the 0 o/oo isohaline sampling location has been just over a quarter mile upstream of the point were Horse Creek joins the Peace River (June 2000). The most downstream occurrence of the 20 o/oo isohaline sampling location has been in the Gulf of Mexico just off Boca Grande (September 1988) (see **Figure 3.1**).

The relative location of each of these four isohalines during 2003 is shown in **Figure 3.2**, while long-term patterns for the period 1983-2003 are presented in **Figures 3.3** and **3.4**. The influences of the recent extended drought conditions that influenced freshwater flows in the Peace River watershed between 1999 and 2002 are noticeable in the atypical upstream movements and near historic maximum extents of all four isohalines during this extended, unusually dry period following the 1997/1988 El Niño climatic event.

Table 3.2
Comparisons of Isohaline Locations During 2003 and the Period 1983-2003

Figure	Description
Figure 3.1	Study area with most upstream and downstream locations of salinity sampling zones
Figure 3.2	Relative distance (km) from the mouth of the river (2003)
Figure 3.3	Relative distance from the mouth of the river of 0 and 6 ppt salinity sampling zones (1983-2003)
Figure 3.4	Relative distance from the mouth of the river of 12 and 20 ppt salinity sampling zones (1983-2003)
Figure 3.5	Box & whisker plots of relative distance (km) from the mouth of the river (2003 & 1983-2002)

The box and whisker plots presented in **Figure 3.5** summarize and compare the relative locations of each of the four “moving” isohaline sampling zones during both 2003 and over the preceding 1983-2002 monitoring period. The box indicates the median line (50^{th} percentile) as well as the 25^{th} and 75^{th} percentiles respectively at the bottom and top. Whisker lines then extend from the 25^{th} percentile to the 10^{th} percentile and from the 75^{th} percentile to the 90^{th} percentile. Extreme values (outside the 10^{th}-90^{th} percentiles) are represented by dots at the end of the whiskers. In Figure 3.5, the zero reference line denotes the imaginary mouth of the Peace River as defined in the previous morphometric study. The influence of the higher than average freshwater inflows during 2003 is evident in the average downstream movement of the median locations during 2003 of all four of the HBMP isohalines, in comparison to the long-term 1983-2002 period of HBMP isohaline location monitoring.

3.2 Methods for Phytoplankton Study Elements

The methodologies used to measure and evaluate the physical, chemical, and biological parameters encompassed within this investigation are outlined and described within the following sections. Environmental Quality Laboratory, Inc. (EQL) was responsible for all aspects of the “moving” station monitoring between 1983 and July 2000, after which time EarthBalance, Inc. (formerly Florida Environmental) was contracted to conduct the physical water column measurements and collection of water chemistry samples for both the “moving” isohaline and “fixed” HBMP station elements. A number of EarthBalance staff previously worked on the HBMP while with EQL and all previously used field collection procedures have been maintained.

Since the initial inception of the HBMP monitoring program in 1976, all water chemistry analyses had been conducted by Environmental Quality Laboratory, which was purchased in 2000 by ASCI, Inc. ASCI continued to conduct all HBMP chemical analyses through January 2002. However, due to concerns regarding QA/QC issues and the long-term stability of ASCI, in February 2002 the Authority changed to contract Benchmark EnviroAnalytical, Inc. located in Palmetto, Florida. Benchmark conducted all chemistry analyses during 2003. All laboratory methods previously used by EQL/ASCI have been continued by Benchmark.

3.2.1 *In Situ* Measurements of Physical Parameters

Depth, temperature, dissolved oxygen, conductivity, and pH were measured *in situ* with Hydrolab Surveyor systems. Profiles were made from the surface to the bottom in 0.5m increments at each sampling station location. Depth measurements were determined on the basis of both pre-measured marks on the unit’s cable and the unit’s depth sensor.

Pre-sampling instrument calibrations were conducted within four hours prior to use. Temperature was measured with a linear resistance thermistor, factory calibrated and accurate to within ±0.2 ^{o}C. Dissolved oxygen (DO) was measured with a temperature-compensated, passive, polarographic cell, which measures the partial pressure of oxygen as parts per million (ppm or mg/l) of oxygen, ±0.2 ppm. The probe was calibrated using the oxygen tension of water-saturated air (temperature corrected) as a standard.

The conductivity probe was calibrated against a KCl solution of known conductivity. Probe response was then tested with a solution of known low and high conductivity to ensure that the reading was within ±1.0 percent of the range selected. The probes are automatically temperature compensated to provide conductivity at 25 ^{o}C.

The Hydrolab pH probes are glass, KCl filled with silver/silver chloride reference electrodes and refillable junctions. They are automatically temperature compensated. Two buffer solutions of 7.0 and 10.0 pH (± 0.1 units) were used to calibrate the accuracy of the probe.

3.2.2 Light Profile

Light intensity profiles were utilized to gather sufficient data to calculate the water column extinction coefficient at each isohaline sampling location. A LI-COR quantum/radiometer/ photometer equipped with an underwater quantum sensor was used to measure photo-synthetically active radiation (400-700 nanometers). Light intensities (microeinsteins/m^2/sec) were measured in the air just above the water surface, again just below the surface, and at six selected depths (20, 40, 60, 80, and 100 cm). Light intensity profile data, by month, at each isohaline sampling location during 2003 are presented along with complete analyses in **Appendix B**.

3.2.3 Chlorophyll *a*

Ambient chlorophyll *a* levels are widely used to estimate phytoplankton biomass. For these investigations, chlorophyll *a* concentrations were determined spectrometrically for: 1) greater than 20 microns, 2) 5 to 20 microns, and 3) less than 5 microns size fractions, from subsurface samples collected at each of the four isohalines. Chlorophyll *a* levels were determined for each of the three size fractions, both uncorrected and corrected for pheophytin, in order to provide comparable estimates of phytoplankton biomass.

3.2.4 Water Chemistry

Surface water samples were collected for analysis at each salinity-based station in pre-labeled, one-liter polyethylene containers. The containers were rinsed with sample water, filled and immediately placed in the dark on ice until returned to the laboratory following standard chain of custody and quality assurance procedures. Specific methods of analyses are listed in **Table 3.3**.

In response to the recommendations contained within the 2000 HBMP Interpretive Report, the number of water chemistry parameters associated with both the "moving and "fixed" HBMP study elements were decreased from those originally specified in the 1996 monitoring conditions. These changes were made only after extensive consultation with both the HBMP Scientific Review Panel and District Staff. As a result of this coordination, all monitoring in both January and February 2003 was conducted using the previous complete parameter list and the revised/reduced long-term water quality sampling parameter list was implemented starting in March 2003 (**Table 1.2**).

3.2.5 Population Structure

Surface water samples were collected for taxonomic analysis at each salinity-based station in conjunction with phytoplankton biomass measurements. Samples for microscopic investigation were placed in one-liter polyethylene containers and immediately fixed with 4 ml of Lugol's solution, which is the preferred preservative for samples that may include significant numbers of flagellates. The samples were placed on ice in the dark for transportation to the lab, where they were held in a refrigerator at 4 ^{o}C until prepared for counting. Extensive work has been completed in preparing a thorough photographic taxonomic inventory of the phytoplankton taxa seasonally present at the four salinity zones. To date over 500 taxa have been identified from samples collected. Samples were prepared for observation using a Zeiss inverted microscope utilizing the following settling procedures.

1. Samples were removed from the refrigerator and gently shaken to assure resuspension of all material.
2. Randomly selected subsamples totaling 5-200 ml (depending on the concentration of the material in the samples) were withdrawn and placed in 50 ml conical glass centrifuge tubes.
3. The tubes were then spun at approximately 50 x gravity for 45 minutes. Three to four drops of iodine solution were then added at the top of the tubes, which were then allowed to stand for at least 24 hours.
4. At the end of the first settling period, the settled material in the bottom 2.5 ml and any cells adhering to the surface tension of each centrifuge tube was drawn off and placed in a 10 ml Zeiss inverted microscope settling chamber.
5. Two drops of iodine solution were again added to promote settling, and the composite samples were again allowed to stand undisturbed for 24 hours.

Once the samples were prepared, the counting chambers were placed on a Zeiss inverted microscope for phytoplankton identification. Taxonomic determinations to the lowest practical taxonomy level were conducted from random fields using a modified strip method. To determine community structure, a standardized number of cells are identified (500). The majority of the taxonomic work was conducted using a 100X objective and 16X wide field oculars. As each observation was made, assigned genus and species codes are recorded. After having recorded the taxonomic determinations of 500 cells, additional notes on each sample were compiled using a combination of low and high power objectives. Determinations of the number of cells per unit volume were conducted on the same samples using a 10X ocular grid and 100X objective. The total number of cells in randomly selected fields, taken in a modified strip method, were recorded on a data sheet and appropriate dilution calculations made.

3.2.6 Taxonomic Determinations of Phytoplankton Community Structure

The collection of monthly samples for the analysis of phytoplankton community structure was begun in 1989 in conjunction with the long-term study of physical/chemical water quality and primary production at the four monitored salinity zones. Phytoplankton community structure has long been used in other studies as a tool in assessing both temporal and long-term changes in water quality in estuarine systems. A complete presentation of all the phytoplankton taxonomic data collected during 2003, listing: 1) the taxonomic structure, 2) percent composition of the major taxonomic groups, and 3) species diversity and evenness indices, is presented by salinity zone, month and year in **Appendix D**.

Historically, microscopic surveys of phytoplankton samples collected concurrently with the chlorophyll *a* biomass estimates have generally indicated the relative dominance of the following groups.

- At the stations characterized by intermediate and higher salinities, the smallest phytoplankton size fraction (<5 microns) is often dominated by Cryptophyceae species (*Chroomanas* spp. and *Cryptomonas* spp.). Small Bacillariphyceae (*Thalossiosira* spp., *Nitzschia* spp., *Navicula* spp.) are also often significant portions of the nano-plankton components at these salinities.

- At the higher salinities, which are under greater influences from Gulf waters, chain-forming and larger diatoms frequently dominated the net-plankton size fraction. Seasonally important diatoms at these locations were *Skeletonema costatum*, *Asterionella glacialis*, *Odentella sinensis*, *Corethron criophilum*, *Coscinodiscus centralis*, and *Coscinodiscus eccentricus*, as well as species of Chaetoceros and Rizosolenia. Dinophyceae (*Ceratium* spp. and *Peridinium* spp.) were often seasonally common in the largest size fraction during the summer months at some of the higher salinity stations.

- At intermediate salinities, blooms of *Skeletonema costatum* were commonly associated with relative increases in carbon uptake and chlorophyll *a* within the largest size fraction. In certain instances, however, dinoflagellates (*Prorocentrum micans*, *P. minimum*, *Gymnodinium* spp. and *Gyrodinium* spp.) were also major components of the largest size fraction. Specifically, at 6 and 12 o/oo salinity at the mouth of the Peace River, the larger size fractions were seasonally dominated by blooms of *Gyrodinium splendens*.

- The picoplankton size fraction (< 5 microns) at the lower salinity stations often contained significant numbers of non-flagellated, smooth, circular to ovoid, green cells. Taxonomically, such cells probably include Cyanophyceae (*Synechoccus* spp., *Chroococcus* spp., *Anacystis* spp.) as well as Chlorophyceae (*Nannochloris* spp., *Chlorella* spp.). Small phytoflagellates (*Chlamydomonas* spp., *Carteria* spp., *Chroomonas* spp., *Cryptomonas* spp.) were also common components of the picoplankton at the lowest salinities. The larger size fractions in the riverine portions of the estuary are generally characterized by mixtures of Chlorophyceae (*Ankistrodesmus* spp., *Coelastrum* spp., *Crucigenia* spp., *Pediastrum* spp., *Scenedesmus* spp., *Tetraedron* spp.), Bacillariophyceae (*Cyclotella* spp., *Nitschia* spp., *Navicula* spp., *Fragillaria* spp.), and Cyanophyceae (*Anabaena* spp., *Anacystis* spp.).

The phytoplankton counts from the 2003 samples were somewhat different than those reported during the recent extended drought. During the drought the small Cyanophyceae, *Synechoccus aquaticus*, dominated many of the samples. Although these taxa had historically been present, as the extended period of drought continued, it has become increasingly dominant in the Peace River/Charlotte Harbor phytoplankton samples. However, during 2003, when freshwater inflows were generally above average, dinoflagellates (Dinophyceae) and diatoms (Bacillariophyceae) again became far more major components of the estuarine phytoplankton community structure.

3.3 Physical and Water Chemistry Data Collected in the "Moving" Isohaline Locations in Conjunction With Phytoplankton Study Elements

Water quality data collected at the four "moving" isohaline locations in conjunction with the 2003 phytoplankton HBMP study element are presented and summarized in the following Tables and Figures. **Tables 3.4** and **3.5** summarize the determinations of a number of the key physical, chemical and biological measurements. Seasonal representations of selected parameters are further graphically presented in Figures 3.6 through 3.13 (see Table 3.6). Complete *in situ* physical water column profiles at each of the four salinity zones by month are presented in **Appendix A**. Surface water chemistry results at each salinity zone during each month are presented in **Appendix C**.

Relationships of the 2003 data to those data collected during the preceding twenty years of study (1983-2002) are shown for selected physical, chemical and biological measurements in Figures 3.14 through 3.21 (see Table 3.7). Further comparisons of these parameters are presented as box and whisker plots by salinity for both 2003 and long-term data collected between 1983-2002 in Figures 3.22 through 3.29. The box and whisker plots display a detailed distribution of the data, showing the median (50th percentile) at the center of the box and the 25th and 75th percentiles at the bottom and top of the box, respectively. The whiskers are lines that extend from the 25th percentile to the 10th percentile and 75th percentile to the 90th percentile. Extreme values (outside the 10th-90th percentiles) are represented by dots at the ends of the whiskers.

Table 3.6

Summary Tables and Graphics of Key Physical and Chemical Measurements for Data Collected in 2003 at the Four Isohaline Locations

Tables	Description
Table 3.4	Physical and chemical water quality parameters
Table 3.5	Physical and chemical water quality parameters - nutrients
Figures	**Description**
Figure 3.6	2003 Temperature at salinity sampling zones
Figure 3.7	2003 Color at salinity sampling zones
Figure 3.8	2003 Extinction coefficient at salinity sampling zones
Figure 3.9	2003 Nitrite/Nitrate at salinity sampling zones
Figure 3.10	2003 Ortho-phosphorus at salinity sampling zones
Figure 3.11	2003 Atomic N/P ratio at salinity sampling zones
Figure 3.12	2003 Silica at salinity sampling zones
Figure 3.13	2003 Chlorophyll *a* (mg/m^3) at salinity sampling zones

Table 3.7

Summary Graphics of Key Physical and Chemical Measurements for Data Collected During the Period 1983-2003 at the Four Isohaline Locations

Figure	Description
Figure 3.14	1983-2003 Temperature at salinity sampling zones
Figure 3.15	1983-2003 Color at salinity sampling zones
Figure 3.16	1983-2003 Extinction coefficient at salinity sampling zones
Figure 3.17	1983-2003 Nitrite/Nitrate at salinity sampling zones
Figure 3.18	1983-2003 Ortho-phosphorus at salinity sampling zones
Figure 3.19	1983-2003 Atomic nitrogen/phosphorus ratio at salinity sampling zones
Figure 3.20	1983-2003 Silica at salinity sampling zones
Figure 3.21	1983-2003 Chlorophyll *a* (mg/m^3) at salinity sampling zones
Figure 3.22	Box and whisker plots of temperature at salinity sampling zones (2003) & (1983-2002)
Figure 3.23	Box and whisker plots of color at salinity sampling zones (2003) & (1983-2002)
Figure 3.24	Box and whisker plots of extinction coefficient at salinity sampling zones (2003) & (1983-2002)
Figure 3.25	Box and whisker plots of nitrite/nitrate at salinity sampling zones 2003) & (1983-2002)
Figure 3.26	Box and whisker plots of ortho-phosphorus at salinity sampling zones (2003) & (1983-2002)

Table 3.7

Summary Graphics of Key Physical and Chemical Measurements for Data Collected During the Period 1983-2003 at the Four Isohaline Locations

Figure	Description
Figure 3.27	Box and whisker plots of atomic N/P ratio at salinity sampling zones (2003) & (1983-2002)
Figure 3.28	Box and whisker plots of silica at salinity sampling zones (2003) & (1983-2002)
Figure 3.29	Box and whisker plots of chlorophyll *a* (mg/m^3) at salinity sampling zones (2003) & (1983-2002)

3.4 Summary

Statistical comparisons between mean 2003 values and long-term 1983-2002 averages for selected parameters are summarized in **Table 3.8.** Overall the data collected during 2003 indicate:

- **Temperature** – Average water temperatures throughout most of the year were generally above the long-term annual averages, even though surface water temperatures during the summer months were slightly below recent years (probably reflecting increased wet-season rainfall). Water temperatures at the end of the year (November and December 2003) were much warmer than average. As in previous years, during the summer wet-season (June through October), water temperatures in the freshwater isohaline were slightly below those observed at the other three monitored salinity zones.

- **Water Color** – The average color levels throughout the estuary were markedly different than those recently observed during the preceding years of drought. Color levels were well above the long-term averages within each of the four isohalines as a result of the higher than average flows during much of 2003. Comparatively, the greatest difference in color levels during 2003 when compared to the long-term averages occurred within the two higher isohalines (12 and 20 o/oo.)

- **Extinction Coefficient** – The rates of measured light attenuation at each of the four isohalines reflect both ambient color and phytoplankton biomass (chlorophyll *a*). Comparisons among the mean 2003 extinction values at the four isohalines indicated divergent patterns, even though water color throughout the estuary was higher than average during 2003 due to greater than average freshwater inflows. Light extinction coefficients at the two lower isohalines were below historical annual averages, while at the same time being at or above average at the two higher monitored salinity zones. It is possible that the higher than average flows that occurred through the first half of 2003 suppressed normal spring levels of phytoplankton production (chlorophyll *a*), resulting in lower than average measurements of extinction coefficients.

- **Nitrite/Nitrate Nitrogen** - During 2003, the average concentrations of this major inorganic form of nitrogen were similar to the long-term averages for the two lowest isohaline monitoring zones, and slightly above average at the two higher isohalines. A comparison among the isohalines indicates inorganic nitrogen concentrations in the lower Peace River/upper Charlotte Harbor Estuary are characterized by a distinct spatial gradient. Concentrations typically decrease rapidly with increasing salinity. Inorganic nitrogen levels, within the 20 o/oo isohaline, were at or near method detection limits throughout much of the year. Seasonally, ambient inorganic nitrogen concentrations in the estuary usually decline to their lowest levels during the relatively drier, late spring as phytoplankton populations respond to increasing water temperatures and light, and increased primary production removed available inorganic nitrogen.

- **Ortho-phosphorus** - Average inorganic phosphorus concentrations during 2003 were generally lower than the long-term averages (1983-2002) at the four isohalines. Since ambient inorganic phosphorus concentrations are heavily influenced by the unusually “very” high natural levels found in the Peace River watershed, the observed differences in concentrations among the four isohalines simply reflects conservative dilution by Gulf waters. Unlike inorganic nitrogen, observed changes in phosphorus concentrations are for the most part unaffected by biological uptake. Ambient inorganic phosphorus concentrations entering the estuary system from the Peace River watershed are typically lower during wetter periods, when a higher proportion of flow results from surface flow (rather than coming from groundwater, which is naturally richer in phosphorus). Since the late 1970s there has been a marked decline in inorganic phosphorus levels in the lower Peace River/upper Charlotte Harbor estuarine system due to declines in the combined influences of phosphate mining in the upper reaches of the basin.

- **Nitrogen to Phosphorus Atomic Ratios** – Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations in 2003, as indicated by the long-term averages, show nitrogen to always be the limiting macronutrient at each of the four isohalines.

- **Silica** - Concentrations during 2003 reflected a continuation of the previously noted increasing pattern of higher dissolved silica values at all of the isohalines. This increasing pattern was slightly interrupted by the recent extended drought, but as indicated in the presented figures and **Table 3.8,** average reactive silica concentrations during 2003 were more than double the long-term means within all four salinity zones.

- **Chlorophyll *a*** – The pattern of freshwater inflows during 2003 reflected the influences of the much wetter than usual 2002/2003 winter, followed by wetter than average conditions during the typically very dry spring, and a wetter than average summer wet-season. The result was both higher than average inputs of inorganic nutrients, and higher than average ambient water color (low light). This was fairly typical of relatively lower levels of phytoplankton production in the more highly colored lower salinity reaches of the estuary, combined with higher than average phytoplankton production (chlorophyll *a*) within the higher salinity zones. The 2003 data also indicate two occurrences, during March and June, when there were very high phytoplankton blooms within the 12 o/oo isohaline. These two “bloom” events were due to very high numbers of different dinoflagellates (Dinophyceae).

4.0 Water Chemistry Data Collected at "Fixed" Station Locations

4.1 Introduction

A number of the HBMP elements prior to 1996 had included collections of water quality data. However, the majority of these data were *in situ* physical measurements of water column characteristics. Such *in situ* water column profile data were collected during:

1. The monthly HBMP night trawl fish study conducted between 1976-1986.

2. The sea star and benthic invertebrate studies carried out between 1976 and 1984.

3. The long-term monthly fixed station study of water column characteristics undertaken between 1976 and 1986 at numerous fixed sites in the lower Peace River and upper Charlotte Harbor.

In addition, as discussed in **Section 3.0**, both water column profiles and surface water chemistry samples have been collected monthly since 1983 at four "moving" isohaline locations in conjunction with the ongoing HBMP study of phytoplankton estuarine production.

Under the 1996 WUP permit renewal, the monitoring program was expanded to include water chemistry data collections at five fixed sampling locations from near the mouth of the river to upstream of the Peace River Facility. In addition, *in situ* physical water column profile sampling only was initiated at ten additional "fixed" sampling locations beyond the five "fixed" water chemistry sampling locations. These new HBMP water sampling and *in situ* water column investigations were initiated using sampling sites formerly utilized (1975-1990) by General Development Corporation's Environmental Quality Laboratory (EQL) for similar long-term lower Peace River background monitoring. Beginning in 1998, an additional fixed monthly sampling site was added to correspond to the location of the third tide gage that was installed in 1997 at River Kilometer 26.7. The relative locations of these fixed sampling locations are shown in **Figure 4.1**, while **Table 4.1** provides currently used river kilometers as well as previously used EQL station numbers and USGS river mile designations.

Long-term water chemistry data were gathered by EQL between the inception of the HBMP monitoring program in 1976 and 1990 at each of the five water quality monitoring locations in conjunction with General Development Corporation's background monitoring program of the lower Peace River and Charlotte Harbor. Between 1990 and 1996, the District collected some monthly data at two of these locations (River Kilometers -2.4 and 6.6) as part of its Charlotte Harbor SWIM monitoring program, and Charlotte County also collected monthly data at these same two sites as background for the South Gulf Cove and Manchester Waterway Permit monitoring programs. As part of the 1996 expanded HBMP monitoring program, the Authority contracted the USGS to collect both the *in situ* hydrolab profile and water chemistry information at the "fixed" HBMP monitoring locations. In July 2000, EarthBalance, Inc. (formerly Florida Environmental) became responsible for all of the water chemistry and biological HBMP fieldwork. This has included the taking of physical water column measurements and the collection of water chemistry samples for both the “moving” isohaline and “fixed” HBMP station elements. ASCI (formerly EQL) conducted both the “fixed” and “moving” HBMP chemical analyses through January 2002. However, due to concerns regarding QA/QC issues and the long-term stability of ASCI, in February 2002 the Authority changed to contract Benchmark EnviroAnalytical, Inc. located in Palmetto, Florida. Benchmark conducted all the chemistry samples collected during 2003. All laboratory methods previously used by EQL/ASCI have been continued by Benchmark.

4.2 Description of Fixed Station Data Collection

The following description provides an overview and summary of the procedures and methods used during the “fixed” station elements of the HBMP.

The “fixed” station water quality monitoring project consists of two categories of data collection.

1. Monthly physical water column *in situ* water quality measurements at 16 “fixed” sampling sites. *In situ* field measurements made at all sixteen physical water column profile sites include depth, pH, temperature, dissolved oxygen, and specific conductance. Field measurements are made at 0.5 m intervals, beginning at the surface and ending near the bottom.

2. Monthly sub-surface and near-bottom chemical water quality samples collected at five locations, spaced between the river’s mouth and just upstream of the facility along the established river kilometer centerline transect.

Near-surface and near-bottom samples collected at the five monthly water quality monitoring sites are analyzed for color, turbidity, alkalinity, total nutrients (ammonia nitrogen, ammonia plus organic nitrogen, nitrate plus nitrite nitrogen, nitrite nitrogen, ortho-phosphorus, phosphorus), total organic carbon, total inorganic carbon, dissolved organic carbon, dissolved silica, dissolved chloride, total suspended solids, volatile suspended solids, salinity (estimated from specific conductance), and chlorophyll *a*. (As noted in Section 1, several of these water quality parameters were dropped from the HBMP sampling design during 2003.)

In situ field measurements made in conjunction with sampling at these water quality sites include depth, pH, temperature, dissolved oxygen, specific conductance, and light characteristics.

In response to the recommendations contained within the 2000 HBMP Interpretive Report, the number of water chemistry parameters associated with both the “moving and “fixed” HBMP study elements were decreased from those originally specified in the 1996 monitoring conditions. These changes were made only after extensive consultation with both the HBMP Scientific Review Panel and District staff. As a result of this coordination, all monitoring in both January and February 2003 was conducted using the previous complete parameter list and the revised/reduced long-term water quality sampling parameter list was implemented starting in March 2003 (**Table 1.2**).

4.3 Data Collection and Analyses

A detailed compilation of all procedures and protocols used during all elements of the HBMP has been compiled in the "Project and Quality Control Plan" submitted to the District in August 2002. All *in situ* physical water quality procedures and methods used in the "fixed" station HBMP monitoring during 2003 were analogous to previously described methods in Section 3.0 for the "moving" isohaline study elements, with the added use of a Kemmerer to collect near-bottom water samples at each of the five water quality sampling locations.

4.4 Results and Conclusions

4.4.1 Physical Water Column Characteristics (2003)

The results for the period January through December 2003 of the *in situ* hydrolab water column profiles at the sixteen fixed stations are presented in **Appendix E**. Complete analyses of the accompanying *in situ* water column light profile data are presented in detail in **Appendix F**. These data are presented graphically in Figure 4.2 through Figure 4.6 (see Table 4.2).

Table 4.2

Summary Graphics of Mean Physical Water Column *In Situ* Water Quality Measurements at the Fixed Sampling Locations During 2003

Figure	Description
Figure 4.2a	Average temperature at river kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.2b	Average temperature at river kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.2c	Average temperature at river kilometers 20.1, 21.9, 23.6 and 24.7
Figure 4.2d	Average temperature at river kilometers 25.9, 29.5, 30.4 and 32.3
Figure 4.3a	Average dissolved oxygen at river kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.3b	Average dissolved oxygen at river kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.3c	Average dissolved oxygen at river kilometers 20.1, 21.9, 23.6 and 24.7
Figure 4.3d	Average dissolved oxygen at river kilometers 25.9, 29.5, 30.4 and 32.3
Figure 4.4a	Average pH at river kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.4b	Average pH at river kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.4c	Average pH at river kilometers 20.1, 21.9, 23.6 and 24.7
Figure 4.4d	Average pH at river kilometers 25.9, 29.5, 30.4 and 32.3
Figure 4.5a	1% Light depth at river kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.5b	1% Light depth at river kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.5c	1% Light depth at river kilometers 20.1, 21.9, 23.6 and 24.7

Table 4.2

Summary Graphics of Mean Physical Water Column *In Situ* Water Quality Measurements at the Fixed Sampling Locations During 2003

Figure	Description
Figure 4.5d	1% Light depth at river kilometers 25.9, 29.5, 30.4 and 32.3
Figure 4.6a	Average specific conductance at river kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.6b	Average specific conductance at river kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.6c	Average specific conductance at river kilometers 20.1, 21.9, 23.6 and 24.7
Figure 4.6d	Average specific conductance at river kilometers 25.9, 29.5, 30.4 and 32.3

The following patterns and observations with regards to seasonal differences among the sixteen "fixed" sampling sites are shown and supported by these Figures.

- Previous results have indicated that within the downstream reaches of the river, between River Kilometers –2.4 and 10.5, the typical wet-season depression of average water column dissolved oxygen levels in response to increased wet-season flows is generally more intense and of greater duration than that observed at the upstream monitoring sites. The 2003 observations were generally consistent with the widely documented hypoxic/anoxic conditions that typically result from the extreme water column stratification that commonly occurs near the mouth of the river and upper regions of the harbor during the summer wet-season. However, as indicated, during 2003 average water column dissolved oxygen levels declined throughout the estuarine lower Peace River as flows and water temperatures increased.

- Both the timing and magnitude of the ability of light to penetrate into the water column (1 percent depth) also exhibited seasonal differences among the "fixed" monitoring sites along the HBMP lower Peace River/upper Charlotte Harbor sampling transect. In the Charlotte Harbor estuarine system, the extinction of light is mitigated in part by ambient chlorophyll concentrations (phytoplankton biomass), but primarily by flow derived water color. As expected, Figures 4a-4d indicate that water clarity is generally highest during the dry-season (April-May) reflecting reduced water color and low level nutrient inputs that would support enhanced phytoplankton production. The influences of the relatively mild 2002/2003 El Niño event and the wetter than average 2003 summer wet-season resulted in unusually high water color and depressed light depths through much of the year.

- Figures 4.6a through 4.6d clearly show the influences of the wetter than average conditions and resulting high river flows during 2003 on the temporal and spatial patterns of conductivity (salinity) throughout the lower Peace River/upper Charlotte Harbor estuarine system. These comparisons are particularly dramatic when contrasted with those previously reported during the extended long-term drought that affected southwest Florida and the Peace River basin during much of the previous three years. During the drought, very high conductivities were observed even at the most upstream sampling locations each spring. In comparison, the 2003 conductivity data clearly indicate the extent and duration of low conductivity conditions both in the river and upper harbor during both the winter El Niño event and the wetter than average 2003 summer wet-season. As the Figures indicate, high conductivity harbor waters were not observed upstream of approximately River Kilometer twenty-four throughout the entire year.

4.4.2 Chemical Water Quality Characteristics (2003)

The 2003 water chemistry data for the five “fixed” water quality stations are presented in **Appendix G**. Comparisons of surface and bottom samples for selected parameters are graphically summarized in Figure 4.7 through Figure 4.15 (see Table 4.3).

Table 4.3

Summary Graphics of Chemical Water Quality Measurements for Data Collected During 2003 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.4)

Figure	Description
Figure 4.7a	Subsurface color at fixed sampling stations (2003)
Figure 4.7b	Near bottom color at fixed sampling stations (2003)
Figure 4.8a	Subsurface total suspended solids at fixed sampling stations (2003)
Figure 4.8b	Near bottom total suspended solids at fixed sampling stations (2003)
Figure 4.9a	Subsurface nitrite/nitrate at fixed sampling stations (2003)
Figure 4.9b	Near bottom nitrite/nitrate at fixed sampling stations (2003)
Figure 4.10a	Subsurface total Kjeldahl Nitrogen at fixed sampling stations (2003)
Figure 4.10b	Near bottom total Kjeldahl Nitrogen at fixed sampling stations (2003)
Figure 4.11a	Subsurface ortho-phosphorus at fixed sampling stations (2003)
Figure 4.11b	Near bottom ortho-phosphorus at fixed sampling stations (2003)
Figure 4.12a	Subsurface silica at fixed sampling stations (2003)
Figure 4.12b	Near bottom silica at fixed sampling stations (2003)
Figure 4.13a	Subsurface chlorophyll *a* at fixed sampling stations (2003)
Figure 4.13b	Near bottom chlorophyll *a* at fixed sampling stations (2003)

These graphics indicate that, for a number of these water quality constituents, there were strong spatial and temporal seasonal differences within the areas of the lower Peace River/upper Charlotte Harbor Estuary represented by the five “fixed” water quality monitoring locations. In addition, further differences are also apparent both within and among sampling locations between sub-surface and near-bottom samples. Water color, for example, is clearly seasonally higher further upstream, while late summer water color levels near the river's mouth are often higher at the surface than near the bottom. During 2003, these differences between surface and bottom values were often not as apparent as during previous years, since the water column was often well mixed due to the periods of very high flows.

A number of the other measured water quality parameters indicated strong seasonal relationships related to annual patterns of increasing and decreasing flow, while other seasonal patterns and spatial relationships for these water quality characteristics reflect far more complex relationships.

- The highest levels of total suspended solids near the surface of the water column often occurred during the spring and fall near the mouth of the river. These seasonal patterns probably reflect both temporal and spatial plankton production patterns in the upper estuary. Correspondingly, lowest levels occurred at all sites during the summer wet-season, while the very highest measured levels were observed near the bottom of the water column during the winter and spring.

- Inorganic nitrite + nitrate nitrogen concentrations were the lowest during the peak of the spring dry-season, when high light and water temperatures resulted in increased phytoplankton production and freshwater inflows were low. The data indicated that, except during the peak of the summer wet-season when high ambient color depresses primary production throughout much of the lower river estuarine system, there is a distinct spatial gradient in inorganic nitrogen with higher levels progressively occurring upstream.

- Total Kjeldahl nitrogen concentrations were generally the highest at each of the sampling sites during the summer wet-season, reflecting the influences of increased freshwater inflows.

- Inorganic phosphorus concentrations at each monitoring location were generally similar throughout the year, with the exception of the observed spikes at the three upstream sites during November. As indicated, the most distinct pattern in inorganic phosphorus concentrations was the spatial differences among the sampling sites, with concentrations being markedly higher upstream than downstream. As previously discussed, phosphorus concentrations in the Peace River estuary follow conservative water quality constituent patterns. Inorganic phosphorus concentrations are primarily influenced by the dilution of high ambient levels in Peace River water as it is diluted by Gulf water moving up the harbor.

- The observed seasonal patterns in total organic carbon suggest responses to both light/temperature as well as increases in freshwater inflows.

- Reactive silica concentrations suggest a number of differing patterns. During the spring dry-season, the data suggest depressed concentrations near the river's mouth corresponding with periods of increased chlorophyll *a* biomass (reflecting uptake by diatoms in the phytoplankton). During this same time period, reactive silica concentrations in other areas of the lower Peace River/upper Charlotte Harbor Estuary were increasing (as water temperature increased). Then in June, with the start of the summer wet-season, ambient concentrations rapidly increased in the more saline reaches of the estuary reflecting increased freshwater inflows. However, as indicated, at the most upstream sampling locations, reactive silica concentrations increased throughout the year, continuing to reflect the recent increasing trend noted in previous HBMP reports.

- Chlorophyll *a* phytoplankton biomass patterns showed a number of seasonal peaks throughout the year that differed both seasonally and among sampling locations. However, a noted fall increase in phytoplankton biomass was observed at all of the sampling sites in October following the end of the summer wet-season. The common occurrence of such a fall phytoplankton increase has also been noted throughout the HBMP isohaline-based monitoring program (see **Section 3.0**).

4.4.3 Long-Term Physical and Chemical Water Quality Characteristics (1976-2003)

During the period 1975-1990, the Environmental Quality Laboratory (EQL) conducted an extensive, long-term monitoring program within the Charlotte Harbor estuarine system, independent of the requirements of the HBMP. These data included chemical water quality analyses of monthly surface and bottom samples, at the same locations, for many of the same parameters that were added to the HBMP permit requirements during 1996. Figures 4.16 through 4.35 (see Table 4.4) graphically compare the data, for a selected number of sub-surface and near-bottom measurements, gathered during the period 1976-1990 with those subsequently measured as part of the current HBMP effort during 1996-2003.

Table 4.4

Selected Long-Term Physical and Chemical Water Quality Data Collected During the Periods 1976-1990 and 1996-2003 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.4)

Figure	Description
Figure 4.14a	Long-term surface salinity River Kilometer –2.4
Figure 4.14b	Long-term surface salinity River Kilometer 6.6
Figure 4.14c	Long-term surface salinity River Kilometer 15.5
Figure 4.14d	Long-term surface salinity River Kilometer 23.6
Figure 4.14e	Long-term surface salinity River Kilometer 30.4
Figure 4.15a	Long-term bottom salinity River Kilometer –2.4
Figure 4.15b	Long-term bottom salinity River Kilometer 6.6
Figure 4.15c	Long-term bottom salinity River Kilometer 15.5
Figure 4.15d	Long-term bottom salinity River Kilometer 23.6
Figure 4.15e	Long-term bottom salinity River Kilometer 30.4

Table 4.4

Selected Long-Term Physical and Chemical Water Quality Data Collected During the Periods 1976-1990 and 1996-2003 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.4)

Figure	Description
Figure 4.16a	Long-term surface dissolved oxygen levels River Kilometer –2.4
Figure 4.16b	Long-term surface dissolved oxygen levels River Kilometer 6.6
Figure 4.16c	Long-term surface dissolved oxygen levels River Kilometer 15.5
Figure 4.16d	Long-term surface dissolved oxygen levels River Kilometer 23.6
Figure 4.16e	Long-term surface dissolved oxygen levels River Kilometer 30.4
Figure 4.17a	Long-term bottom dissolved oxygen levels River Kilometer –2.4
Figure 4.17b	Long-term bottom dissolved oxygen levels River Kilometer 6.6
Figure 4.17c	Long-term bottom dissolved oxygen levels River Kilometer 15.5
Figure 4.17d	Long-term bottom dissolved oxygen levels River Kilometer 23.6
Figure 4.17e	Long-term bottom dissolved oxygen levels River Kilometer 30.4
Figure 4.18a	Long-term surface water color River Kilometer –2.4
Figure 4.18b	Long-term surface water color River Kilometer 6.6
Figure 4.18c	Long-term surface water color River Kilometer 15.5
Figure 4.18d	Long-term surface water color River Kilometer 23.6
Figure 4.18e	Long-term bottom water color River Kilometer 30.4
Figure 4.19a	Long-term bottom water color River Kilometer –2.4
Figure 4.19b	Long-term bottom water color River Kilometer 6.6
Figure 4.19c	Long-term bottom water color River Kilometer 15.5
Figure 4.19d	Long-term bottom water color River Kilometer 23.6
Figure 4.19e	Long-term bottom water color River Kilometer 30.4
Figure 4.20a	Long-term surface nitrite/nitrate nitrogen River Kilometer –2.4
Figure 4.20b	surface nitrite/nitrate nitrogen River Kilometer 6.6
Figure 4.20c	Long-term surface nitrite/nitrate nitrogen River Kilometer 15.5
Figure 4.20d	Long-term surface nitrite/nitrate nitrogen River Kilometer 23.6
Figure 4.20e	Long-term surface nitrite/nitrate nitrogen River Kilometer 30.4
Figure 4.21a	Long-term bottom nitrite/nitrate nitrogen River Kilometer –2.4
Figure 4.21b	Long-term bottom nitrite/nitrate nitrogen River Kilometer 6.6
Figure 4.21c	Long-term bottom nitrite/nitrate nitrogen River Kilometer 15.5
Figure 4.21d	Long-term bottom nitrite/nitrate nitrogen River Kilometer 23.6
Figure 4.21e	Long-term bottom nitrite/nitrate nitrogen River Kilometer 30.4

Table 4.4

Selected Long-Term Physical and Chemical Water Quality Data Collected During the Periods 1976-1990 and 1996-2003 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.4)

Figure	Description
Figure 4.22a	Long-term surface total Kjeldahl Nitrogen River Kilometer –2.4
Figure 4.22b	Long-term surface total Kjeldahl Nitrogen River Kilometer 6.6
Figure 4.22c	Long-term surface total Kjeldahl Nitrogen River Kilometer 15.5
Figure 4.22d	Long-term surface total Kjeldahl Nitrogen River Kilometer 23.6
Figure 4.22e	Long-term surface total Kjeldahl Nitrogen River Kilometer 30.4
Figure 4.23a	Long-term bottom total Kjeldahl Nitrogen River Kilometer –2.4
Figure 4.23b	Long-term bottom total Kjeldahl Nitrogen River Kilometer 6.6
Figure 4.23c	Long-term bottom total Kjeldahl Nitrogen River Kilometer 15.5
Figure 4.23d	Long-term bottom total Kjeldahl Nitrogen River Kilometer 23.6
Figure 4.23e	Long-term bottom total Kjeldahl Nitrogen River Kilometer 30.4
Figure 4.24a	Long-term surface ortho-phosphorus River Kilometer –2.4
Figure 4.24b	Long-term surface ortho-phosphorus River Kilometer 6.6
Figure 4.24c	Long-term surface ortho-phosphorus River Kilometer 15.5
Figure 4.24d	Long-term surface ortho-phosphorus River Kilometer 23.6
Figure 4.24e	Long-term surface ortho-phosphorus River Kilometer 30.4
Figure 4.25a	Long-term bottom ortho-phosphorus River Kilometer –2.4
Figure 4.25b	Long-term bottom ortho-phosphorus River Kilometer 6.6
Figure 4.25c	Long-term bottom ortho-phosphorus River Kilometer 15.5
Figure 4.25d	Long-term bottom ortho-phosphorus River Kilometer 23.6
Figure 4.25e	Long-term bottom ortho-phosphorus River Kilometer 30.4
Figure 4.26a	Long-term surface silica River Kilometer –2.4
Figure 4.26b	Long-term surface silica River Kilometer 6.6
Figure 4.26c	Long-term surface silica River Kilometer 15.5
Figure 4.26d	Long-term surface silica River Kilometer 23.6
Figure 4.26e	Long-term surface silica River Kilometer 30.4
Figure 4.27a	Long-term bottom silica River Kilometer –2.4
Figure 4.27b	Long-term bottom silica River Kilometer 6.6
Figure 4.27c	Long-term bottom silica River Kilometer 15.5
Figure 4.27d	Long-term bottom silica River Kilometer 23.6
Figure 4.27e	Long-term bottom silica River Kilometer 30.4

Table 4.4

Selected Long-Term Physical and Chemical Water Quality Data Collected During the Periods 1976-1990 and 1996-2003 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.4)

Figure	Description
Figure 4.28a	Long-term surface chlorophyll *a* River Kilometer –2.4
Figure 4.28b	Long-term surface chlorophyll *a* River Kilometer 6.6
Figure 4.28c	Long-term surface chlorophyll *a* River Kilometer 15.5
Figure 4.28d	Long-term surface chlorophyll *a* River Kilometer 23.6
Figure 4.28e	Long-term surface chlorophyll *a* River Kilometer 30.4
Figure 4.29a	Long-term bottom chlorophyll *a* River Kilometer -2.4 **
Figure 4.29b	Long-term bottom chlorophyll *a* River Kilometer 6.6 **
Figure 4.29c	Long-term bottom chlorophyll *a* River Kilometer 15.5 **
Figure 4.29d	Long-term bottom chlorophyll *a* River Kilometer 23.6 **
Figure 4.29e	Long-term bottom chlorophyll *a* River Kilometer 30.4 **

❖ Note: EQL samples not analyzed for chlorophyll *a* are indicated as “Zero”
❖ Plot scales may not include unusually high “outlier” data points

These presented graphical analyzes indicate a number of interesting patterns.

- Record high surface and bottom salinities occurred at each of the five HBMP “fixed” water quality monitoring locations during the recent extended drought that began in early 2000 and extended through the first half of 2002. In 2003, by comparison, near record low salinity levels were observed both near the surface of the water column at the more downstream sampling sites.

- Salinities at the two most upstream sampling sites (River Kilometers 23.6 and 30.4) were generally higher during the recent 2000/2002 drought than during the similar extended drought that occurred in 1984 and 1985 following the 1983 El Niño.

- Near-bottom dissolved oxygen concentrations show clear seasonal cycles in response to summer wet-season freshwater inflows. Both the duration and magnitude of these periods of depressed dissolved oxygen concentrations increase towards the river’s mouth.

- Temporally, water color levels increase very quickly in response to changes in freshwater inflow. As expected, levels are spatially much higher upstream than near the mouth of the river, although very high color can reach well into the harbor during periods of high freshwater inflow such as occurred during much of 2003.

- Both inorganic nitrite + nitrate and total Kjeldahl nitrogen concentrations indicate very similar seasonal patterns and levels of annual variation over the entire twenty-eight year monitoring period. As expected, spatially inorganic nitrogen concentrations markedly increase moving upstream.

- Most of the previously reported apparent marked declines in inorganic phosphorus concentrations that have occurred in the lower Peace River/upper Charlotte Harbor Estuary took place prior to 1985. Since that time inorganic phosphorus concentrations have shown fairly consistent seasonal patterns over a comparably narrow range of variation.

- Plots of the long-term data clearly show that reactive silica concentrations have both increased and exhibit a much wider range of variation during the recent monitoring period when compared to data collected during the 1976-1990 period. Silica levels are much higher at the upstream sampling sites, and show a strong seasonal pattern in response.

- The long-term data show that there has been a marked decline in the very high chlorophyll *a* concentration “blooms” that commonly occurred during the late 70s and early 80s throughout the lower Peace River/upper Charlotte Harbor estuarine system.

Table 4.5 presents statistical summaries of mean near-surface values at each of the five “fixed” sampling locations during 2003, in comparison to previous data gathered during the six-year period 1996-2002.

5.0 Continuous Recorders

5.1 Overview

The U.S. Geological Survey (USGS) began a cooperative water quality data collection program with the Peace River/Manasota Regional Water Supply Authority (Authority) in August 1996. As part of this program, the USGS initiated continuous (15-minute intervals) monitoring of:

1. Water level, as well as surface and bottom specific conductance and temperature at Harbour Heights on the Peace River. The USGS designates this site as 02297460, and it is located at River Kilometer 15.5.

2. Water level near Boca Grande at the USGS designated site 2293332, which is located approximately near River Kilometer –31.8.

In November 1997, at the request of the Authority and USGS added a third gaging station (see **Figure 5.a**) designated by USGS as site 02297350 (Peace River Heights) located at River Kilometer 26.7. Measurements taken at this upstream location include both water level and surface and bottom specific conductance and temperature.

5.2 Field Activities at Continuous Recorder Sites

Water level is measured at each of the continuous recording sites (stations 2293332, 02297460 and 02297350) using a float sensor in a PVC stilling well (Rantz and others, 1982). Data is recorded at 15-minute intervals using a Campbell Scientific CR-10 electronic data logger. Near-surface and near-bottom specific conductance and temperature are measured in the Peace River at stations 02297460 and 02297350 using USGS combination temperature and specific conductance probes. Readings are averaged over a two-minute interval and are recorded at 15-minute intervals.

Near-surface sensors are suspended one-foot below the surface using a float in a stilling well. The near-bottom sensors are suspended about one-foot from the bottom in the same stilling well as the near-surface sensor.

Data are retrieved at approximately monthly intervals or more often as needed. Once data are retrieved, the calibration stability of the specific conductance and temperature sensors is checked using a field thermometer and specific conductance standards with values that bracket the range of expected values in the Peace River. The sensors are cleaned, inspected, and rechecked with the thermometer and specific conductance standards. If needed, the sensor readings are adjusted to the standard values. The sensors are considered calibrated if the temperature is within 0.5 °C and the specific conductance is within 5 percent of the standard values. Calibrations are recorded on calibration forms and these records are maintained by the USGS in Tampa, Florida.

5.3 Results from USGS Continuous Recorders (2003)

Summaries of the data gathered at each of the three USGS gages are presented in **Appendix I**.

Gage height, as well as surface and bottom conductivity and temperature readings collected at 15-minute intervals at Harbour Heights on the Peace River (USGS Station 02297460, River Kilometer 15.5) are presented in Figures 5.1 through 5.5. Similar plots are shown in Figures 5.6 through 5.10 for the continuous gage at Peace River Heights on the Peace River (USGS Station 02297350, River Kilometer 26.7). Gage height data are depicted in Figure 5.11 for the 15-minute interval data collected during 2003 by the USGS at the Boca Grande Station (264312082153000). These graphics are summarized in Table 5.1.

The duration and magnitude of the higher than average freshwater flows in the Peace River watershed are clearly evident by the surface and bottom conductivities observed at both Peace River gages during the winter and summer of 2003. Conductivities indicative of the upstream movement of higher conductivity harbor waters were only evident at the more upstream recording gage during the typical spring dry-season (April-May) and in the late fall (November-December).

Table 5.1
Summary Graphics of 2003 Data from USGS Continuous Recorders

Figure	Description
Figure 5.1	Gage height (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.2	Surface conductivity (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.3	Bottom conductivity (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.4	Surface temperature (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.5	Bottom temperature (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.6	Gage height (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.7	Surface conductivity (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.8	Bottom conductivity (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.9	Surface temperature (15-minute intervals) for Peace River fixed station 02297350 (River Kilometer 26.7)
Figure 5.10	Bottom temperature (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.11a	Gage height (15-minute intervals) for Boca Grande
Figure 5.11b	Gage height (15-minute intervals) for Boca Grande

Comparisons of gage heights and both surface and bottom conductivity measurements at the two Peace River gage locations, Harbour Heights (River Kilometer 15.5) and Peace River Heights (River Kilometer 26.7), are presented in Figures 5.12 through 5.23 for the first two weeks in May 2003 (dry-season) and September 2003 (wet- season). An overview of these graphics is presented in Table 5.2.

Table 5.2

Summary Graphics of Comparisons of Stage Height and Surface and Bottom Conductivity During May and September 2003 at the Continuous Recorders

Figure	Description
Figure 5.12	Surface conductivity and stage height in May - station 02297460 (River Kilometer 15.5)
Figure 5.13	Bottom conductivity and stage height in May – station 02297460 (River Kilometer 15.5)
Figure 5.14	Surface and bottom conductivity in May - station 02297460 (River Kilometer 15.5)
Figure 5.15	Surface conductivity and stage height in September -station 02297460 (River Kilometer 15.5)
Figure 5.16	Bottom conductivity and stage height in September – station 02297460 (River Kilometer 15.5)
Figure 5.17	Surface and bottom conductivity in September – station 02297460 (River Kilometer 15.5)
Figure 5.18	Surface conductivity and stage height in May - station 02297350 (River Kilometer 26.7)
Figure 5.19	Bottom conductivity and stage height in May - station 02297350 (River Kilometer 26.7)
Figure 5.20	Surface and bottom conductivity in May – station 02297350 (River Kilometer 26.7).
Figure 5.21	Surface conductivity and stage height in September - station 02297350 (River Kilometer 26.7)
Figure 5.22	Bottom conductivity and stage height in September - station 02297350 (River Kilometer 26.7)
Figure 5.23	Surface and bottom conductivity in September - station 02297350 (River Kilometer 26.7)

As indicated in comparing the series of Figures, both surface and bottom conductivities at the downstream Harbour Heights site (River Kilometer 15.5) were very strongly influences by tide when river flows were low. During May, in the dry-season, it was not uncommon for surface and bottom conductivities to vary 7000 to 13000 uS/cm (roughly 5 to 9 ppt salinity) over a tidal cycle. During September, in the wet-season, this area of the Peace River was characteristically far fresher and daily tidal influences were greatly reduced.

Upstream, the conductivity data collected during May 2003 at the continuous gage at Peace River Heights (River Kilometer 26.7) showed fresh, hard water conditions with very little tidal variations in conductivity (less than 50 uS/cm). During the wet-season (September), conductivities were extremely low and showed no variations due to normal daily tidal influences.

6.0 References

American Public Health Association, 1992, Standard methods for the examination of water and wastewater (18th edition): American Public Health Association, Washington, D.C.

Britton, L.J., and Greeson, P.E., eds., 1989, Methods for collection and analysis of aquatic biological and microbiological samples: U.S. Geological Survey Techniques of Water_Resources Investigations, Book 5, Chapter A4, 363 p.

Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water_Resources Investigations, Book 5, Chap. A1, 545 p.

Friedman, L.C., and Erdmann, D.E., 1982, Quality assurance practices for the chemical and biological analyses of water and fluvial sediments: U.S. Geological Survey Techniques of Water_Resources Investigations, Book 5, Chap. A6, 181 p.

Horowitz, A.J., Demas, C.R., Fitzgerald, K.K., Miller, T.L., and Rickert, D.A., 1994, U.S. Geological Survey protocol for the collection and processing of surface_water samples for the subsequent determination of inorganic constituents in filtered water: U.S. Geological Survey Open_File Report 94_539, 57 p.

Rantz and others, 1982a, Measurement and computation of streamflow: Volume 1. Measurement of stage and discharge: U.S. Geological Survey Water_Supply Paper 2175, p. 1_284.

Rantz and others, 1982b, Measurement and computation of streamflow: Volume 2. Computation of discharge: U.S. Geological Survey Water_Supply Paper 2175, p. 285_631.

Stanley, D.L., 1995, Standard procedures and quality_control practices for the U.S. Geological Survey National Field Quality Assurance program from 1982 through 1993: U.S. Geological Survey Open_File Report 95_317, 75 p.

Stanley, D.L., Shampine, W.J., and Schroder, L.J., 1992, Summary of the U.S. Geological Survey National Field Quality Assurance program from 1979 through 1989: U.S. Geological Survey Open_File Report 92_163, 14p.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water_Resources Investigations, Book 5, Chapter A3, 80 p.

Ward, J.R., and Harr, C.A., eds., 1990, Methods for collection and processing of surface_water and bed_material samples for physical and chemical analyses: U.S. Geological Survey Open_File Report 90_140, 71 p.