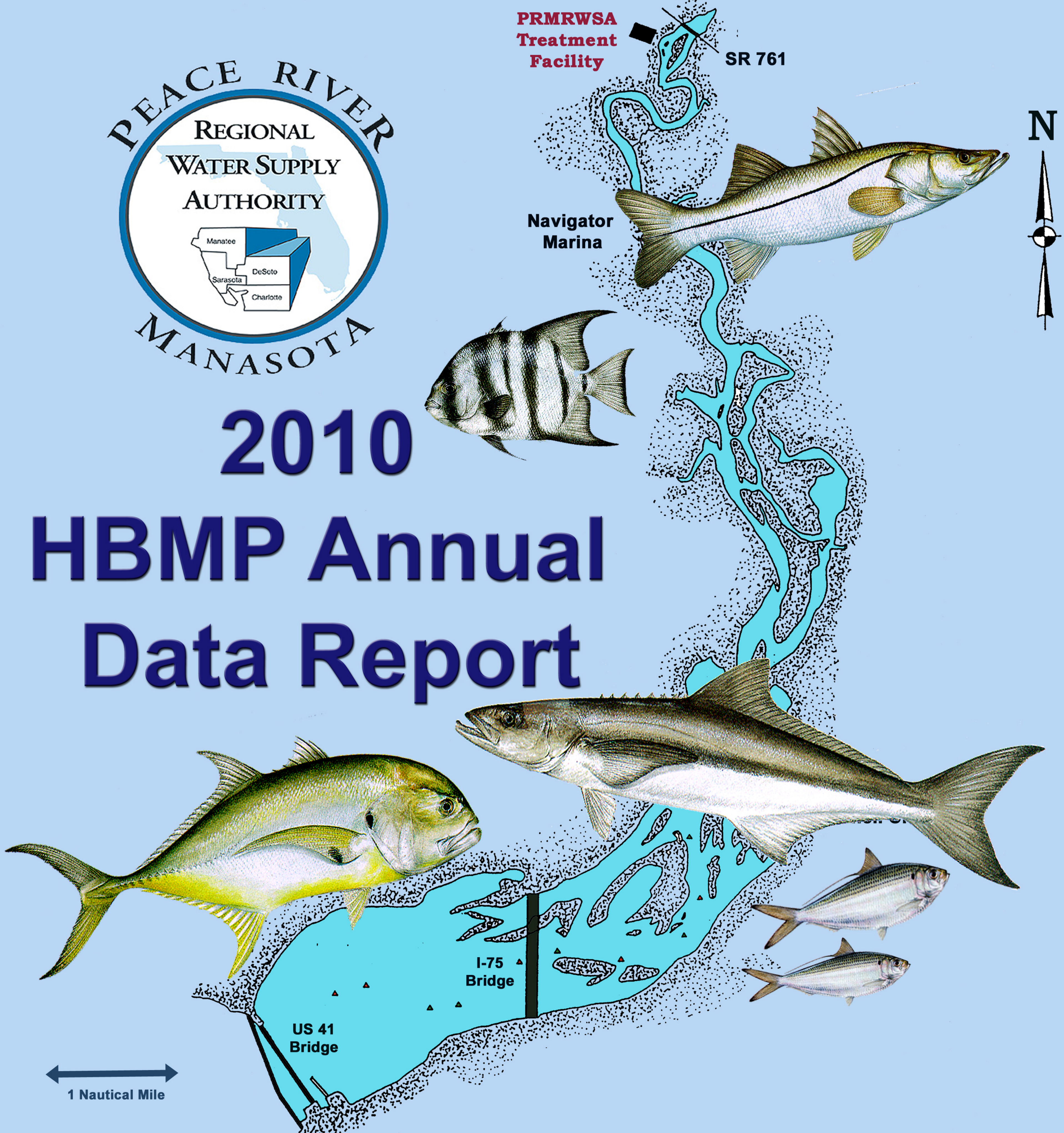
Peace River Manasota Regional Water Supply Authority

2010 HBMP Annual Data Report



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Peace River Hydrobiological Monitoring Program
2010 HBMP Annual Data Report

Required by

Southwest Florida Water Management District
Water Use Permit 20010420.0004

Prepared for

Peace River Regional Water Supply Facility

Peace River Manasota Regional Water Supply Authority

6311 Atrium Drive, Suite 100
Bradenton, Florida 34202

Prepared by

ATKINS

4030 West Boy Scout Blvd. - Suite 700
Tampa, FL 33607

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Acknowledgments

The raw data, as well as the methods sections, presented in this report for the calendar year 2010 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.

- **U.S. Geological Survey (Tampa Office) –** was responsible for all data collected at the three tide gages located in the lower Peace River that continuously collect data at 15 minute intervals. Measurements at each gaging location included measurements of: 1) surface and bottom conductivity; 2) surface and bottom water temperature; 3) and tide stage (water depth).

Lower Peace River Continuous Recorders

1. The Harbour Heights gage is designated by USGS as site 02297460, and it is located at the end of a private dock at River Kilometer 15.5.

2. The second site is designated by USGS as 02297350 and it is located on a dock near Peace River Heights. This upstream monitoring site is located at River Kilometer 26.7.

3. Recently USGS installed recorders at a third site (02297345) at the Facility's intake (RK 29.8).

Gaged Stream Flow

USGS also collects daily stream flow data at a wide number of gaging locations throughout southwest Florida. Flow data from a number of these sites are used by the HBMP program. Data for the period of record were obtained from the USGS web site: **(http://fl.water.usgs.gov/Tampa/index.html)**

1. Peace River at Bartow (02294650)
2. Peace River at Fort Meade (02294898)
3. Peace River at Zolfo Springs (02295637)
4. Peace River at Arcadia (02296750)
5. Joshua Creek at Nocatee (02297100)
6. Horse Creek near Arcadia (02297310)
7. Prairie Creek near Fort Ogden (02298123)
8. Shell Creek near Punta Gorda (02298202)
9. Myakka River near Sarasota (02298830)
10. Big Slough near North Port (02299450)

- **Atkins/ formerly PBS&J (Tampa Office) –** was responsible for all data collected at the five Authority HBMP recorders located in the lower Peace River that continuously collect data at 15-minute intervals. Measurements at each of the four surface gaging locations include surface conductivity and water temperature. Conductivity, temperature and dissolved oxygen are also monitored near the bottom of the water column at a single location.

  Authority HBMP Lower Peace River Continuous Recorders

  1. **RK 12.7 –** Near bottom conductivity, temperature and dissolved oxygen are recorded at 15-minute intervals from the HBMP continuous recorder attached to a navigation aid located on the lower Peace River downstream of Shell Creek (River Kilometer 12.9). Data collection began in May 2008 and has continued since.

  2. **RK 21.9** – Near surface conductivity and temperature are measured at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on the Peace River near Liverpool side channel (River Kilometer 21.9). Data have been collected over the 2006-2010 time interval.

  3. **RK 23.4 –** Near surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on the Peace at River Kilometer 23.4. Data were collected from 2006 until May 2008, after which monitoring at this site was suspended.

  4. **RK 24.5 –** Near surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on the Peace River just downstream of Navigator Marina (River Kilometer 24.5). Data have been collected over the 2006-2010 time interval.

  5. **RK 30.6** - Near surface conductivity and temperature are measured at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on the Peace River just upstream of the Facility (River Kilometer 30.6). Data collection began in May 2008 and is ongoing.

  6. **RK 31.7** - Near surface conductivity and temperature are measured at 15-minute intervals from the HBMP continuous recording gage attached to the old railroad trestle located on the Peace River upstream of the Facility (River Kilometer 31.7). Data collection also began in May 2008 and continues.

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

- **City of Punta Gorda** – provided measurements of daily withdrawals and data from the Shell Creek HBMP.

- **Benchmark Laboratory** – conducted all HBMP water chemistry analyses conducted during 2010.

Executive Summary

Historical Overview

On December 10, 1975, the Consumptive Use Permit #27500016 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 whether freshwater withdrawals by the Peace River Regional Water Supply Facility (Facility) could be shown to alter these patterns.

Between 1979 and 2010, 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 2009. 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 facility operation. The period covered within this *2010 HBMP Annual Data Report* follows directly upon that contained within the preceding *2009 HBMP Annual Data Report* submitted in May 2010 , as well as both the *2004 HBMP Mid-term Interpretive Report* submitted in November 2006 and the *2006 HBMP Comprehensive Summary Report* finalized in December 2009. This current data report includes HBMP data collected over the period from January through December 2010, and represents the twenty-first year of data collection for the Peace River Manasota Regional Water Supply Authority (Authority), as owner/operator of the Peace River Regional Water Supply Facility.

Although the Peace River Facility has only been operated by the Authority since 1991, the initial system was constructed by General Development Utilities and has been withdrawing water from the Peace River since 1980. The Facility's initial storage capacity was 625 million gallons in the form of an 85-acre off-stream surface reservoir. Additional storage capacity was added incrementally from 1985 through 2002 providing approximately 6300 million gallons of treated water storage in 21 Aquifer Storage and recovery wells..

The 2002 expansion also included increasing the Facility's treatment capacity from 12 mgd to 24 mgd (37.1 cfs), with raw water river diversion from the Peace River accomplished using four pumps having a combined maximum capacity of 44 mgd (68.0 cfs). These expansions enhanced the Authority's ability to withdraw raw river water from the river during periods of higher river flow that could be stored in the off-stream surface reservoir, with any excess treated water being stored in the system's ASR wells. Conversely, when water was unavailable from the Peace River due to the established low flow cutoff of 130 cfs, water could be pumped from the raw off-stream surface water reservoir to the Peace River Facility for treatment, and/or previously treated water could be recovered from the ASR well system to meet service area water supply demands.

In 2009 the Authority completed another major Facility expansion in order to meet future regional water demands. This included increasing the river pumping capacity to 90 mgd (the upper limit of the 1996 permit), and doubling the Facility's treatment capacity to 48 mgd. An additional larger regional 640-acre off-stream reservoir with a capacity of 6 billion gallons was also completed in 2009. The existing transmission piping networks will gradually be expanded in the future to optimize regional water delivery to meet future demands and to increase regional system reliability.

Summary of Previous Key HBMP Findings

The following briefly summarizes a number of the primary findings and conclusions presented in the submitted draft *2006 Comprehensive Summary Report* (named for the period through which HBMP data were analyzed), which was finalized and submitted to the District in December 2009.

Rainfall – Climate researchers have suggested that natural climate cycles or phases can persist over multiple decades. One of these cycles, the Atlantic Multidecadal Oscillation (AMO) refers to long-term cool and warm phase differences of only about 1°F (0.6°C) in the North Atlantic sea surface average temperatures. An analysis of Atlantic sea surface temperatures suggests that warm AMO phases occurred during 1869-1893, 1926-1969, and from 1995 to date, while cooler phases occurred during the 1894-1925 and 1970-1994 time periods. Climatological data indicate that differences between relatively warm and cool AMO periods affect both air temperature and rainfall patterns. Analyses presented as part of the *2006 HBMP Comprehensive Summary Report* indicated the following patterns.

- Total annual average Peace River watershed rainfall levels at the Bartow and Arcadia gages were found to be slightly higher prior to the 1960s when compared with the period from the late 1960s to the mid 1990s. The data indicate that between the mid 1990s and 2006 annual total rainfall levels had, on average, increased within these two interior Peace River watersheds.

- Annual average wet-season (June-September) rainfall in the Peace River watershed was generally higher during the 1930s through the mid-1960s when compared with the interval from the late 1960s through the early 1990s. Between 1994 and 2006 there was a notable increase in wet-season rainfall.

- No similar long-term patterns were apparent with regard to dry-season (January-May and October-December) rainfall, although periodic high annual totals were observed corresponding to El Niño events.

- The plots of yearly annual deviations from the average rainfall further supported the conclusions that total annual rainfall during the 1940s and 1950s was above the long-term average of 52 inches per year, and generally below this average during much of the 1970s and 1980s.

- Similar analyses of annual deviations conducted after dividing yearly rainfall totals into wet-season (June through September) and dry-season (October through December and

January through May) indicated slightly higher wet-season rainfall during the earlier time periods. In contrast, dry-season rainfall varied randomly around the long-term average over time.

Lower Peace River Estuarine Freshwater Inflows – The following summarizes the major findings of analyses presented in the *2006 HBMP Comprehensive Summary Report*.

- The trend analyses indicated that there had been long-term statistically significant declines in flows in the upper reaches of the watershed at both Bartow (since 1940) and Zolfo Springs (since 1934).

- U.S. Geological Survey (USGS) gaged Peace River at Arcadia flows also showed statistically significant declines in a number of flow metrics over the 75-year period of record.

- In the southern tributaries of the Peace River watershed, by comparison, it was found that flows increased over their periods of record (which have shorter records than the northern gages). Shell Creek flow data indicated statistically significant increases in the lowest flow percentiles (base flows), while there were increasing trends in Prairie Creek at all percentiles between the monthly minimum and median values, and all percentiles of flow at the Joshua Creek gage indicated increases over time.

- Even with such agriculturally augmented dry-season flows in many of the southern watershed basins, combined total gaged flows upstream of the Facility still showed statistically significant declines over the 1951 to 2006 interval for all monthly percentiles below the median flow.

- There were no statistically significant trends in flows at any of the USGS gages along the main stem of the Peace River during the analyzed period of HBMP monitoring between 1976 and 2006.

- All of the analyzed flow metrics (percentiles) at the Joshua Creek gaging location showed statistically significant increases over the 1976-2006 time interval. The results indicate the relative magnitude of agricultural development that has occurred in the Joshua Creek basin during this time interval.

- In comparison, trend test results showed that only those flows at or below the median have been augmented by agricultural development in the Horse Creek and Prairie Creek basins.

- The observed differences in trends showed all three of these southern Peace River watershed basins have seen augmented dry-season stream flows due to agricultural ground water pumping. The degree of land use and drainage changes that have occurred in the Joshua Creek watershed have also resulted in structural changes that have fundamentally altered hydrologic surface flows in the basin.

Peace River Treatment Facility Withdrawals – The following observations and conclusions were presented in the report with regard to the status, long-term patterns and trends in Facility freshwater withdrawals.

- Prior to 1988 when withdrawal quantities were not based on a percent of river flow, much larger percentages of low flows were initially taken under the District's original monthly-based withdrawal schedule.

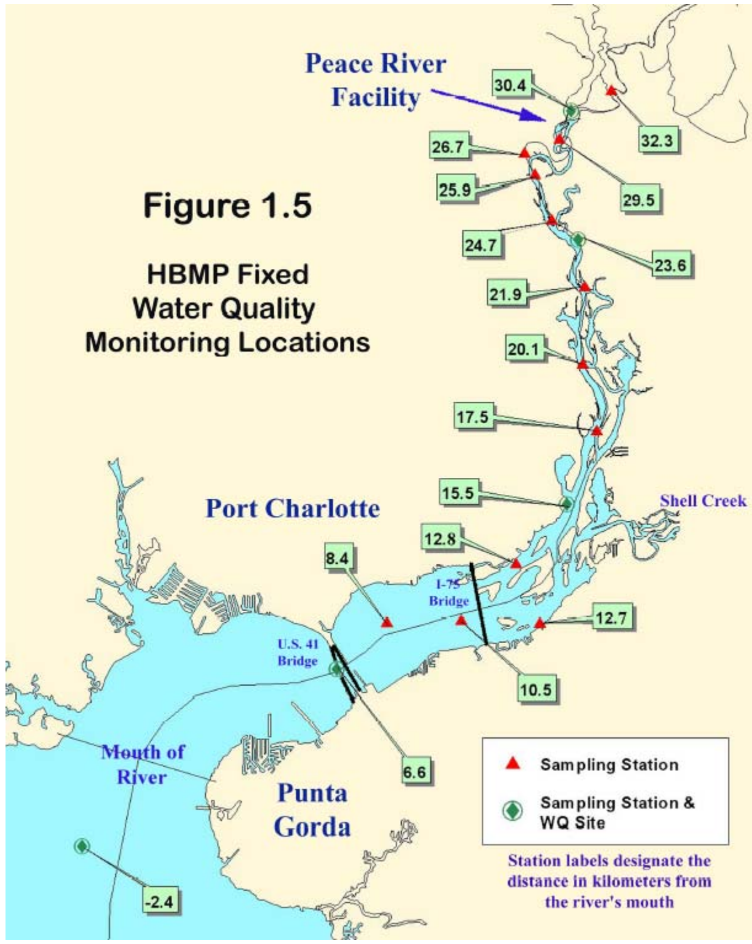
- Time-series plots plainly showed the relatively steady increases in the amounts of freshwater withdrawals by the Facility since 1980 due to increasing potable water demands. Also clearly evident was the noticeable increase in maximum Facility withdrawals following completion of the Facility's 2002 expansion, which resulted in the Authority's increased ability to treat and store larger daily amounts of freshwater.

- Comparisons indicated that other than during the warm/dry months of April and May when the Facility is often not withdrawing water from the Peace River due to the 130 cfs cutoff, Facility withdrawals have been fairly uniform throughout most of the year, differing primarily between changes in the permits and differences in Facility capacities.

- The low flow cutoffs based on flows at the USGS Peace River at Arcadia gage have often resulted in periods each year when the Facility does not withdraw water from the river. During the 2000 drought the Facility did not withdraw any water from the Peace River for a total of 248 days, and further relied solely on stored reserves another 219 days during 2001.

- Facility withdrawals have periodically exceeded the ten percent criteria since it was established in 1988. 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. Currently, these data are taken directly from the USGS Tampa office's website. However, after the fact, the USGS checks and evaluates the data from the stage recorder and validates the river cross section a number of times each year. Thus, the daily values used by the Authority are only "provisional" and are occasionally changed by the USGS weeks or months after the fact. It is not uncommon for subsequent determinations of percent withdrawals, based on revised USGS calculations of daily flows, to conclude that daily Facility withdrawals, based on provisional flow information, in fact exceeded the established ten percent criteria. Such differences also result in instances when the Authority actually takes less than the permitted ten percent. The Authority and the USGS Tampa office staff have continued to work to reduce such instances to the greatest possible extent.

Status and Trends in "Fixed" HBMP Station Water Quality Parameters – The following summarizes the primary conclusions regarding the status and trends in lower Peace River water quality presented in the *2006 HBMP Comprehensive Summary Report*. The HBMP water quality monitoring design has included the monthly collection of *in situ* physical measurements and chemical water characteristics at a number of fixed station locations (Figure 1.5 from the main report) along the lower Peace River and in upper Charlotte Harbor. These data were used to describe the present status, and statistically test for long-term changes in the water quality characteristics at these specific selected locations along the lower Peace River HBMP monitoring transect. The following summarizes the results and findings of these analyses for a number of key water quality parameters.



- **Salinity –** There is a strong, distinct spatial salinity gradient along the lower Peace River monitoring transect. The greatest annual and inter-annual variability in salinity generally occurs in the surface waters near the mouth of the river in the upper harbor where seasonal differences may reach 35 parts per thousand (or practical salinity units) between extended periods of low and high freshwater inflow. The influences of the recent high freshwater inflows during the 1997/1998 El Niño event and the extended 1999-2001 drought are evident in the time-series plots.

- **Dissolved Oxygen –** Near-bottom dissolved oxygen concentrations show clear seasonal cycles in response to higher freshwater flows during the summer wet-season. The duration and magnitude of periods of very low dissolved oxygen concentrations increase toward the river mouth as higher bottom salinities establish greater vertical stratification in the water column during high flows. Other studies have noted apparent declines in dissolved oxygen concentrations in the lower river over time, but have been unable to clearly identify any cause. The current analyses, based on a somewhat longer data set than these previous analyses, generally find similar surface and bottom annual average dissolved oxygen concentrations along the HBMP monitoring transect when comparing the 1976-1989 and 1996-2006 time periods.

- **Water Color –** Humic compounds derived from the breakdown and subsequent leaching of vegetation into surface waters are the source of the high water color that characterizes the blackwater river systems of southwest Florida. Color levels in the estuary temporally increase quickly in response to increased freshwater inflow, with very high color levels extending well into the harbor during extended periods of high freshwater flows such as occurred during the 1997/1998 El Niño or recently during the extremely high flows that occurred during 2001, 2003, 2004 and 2005. Statistical analyses indicated significant differences between the average annual surface color levels at the two most downstream monitoring locations (River Kilometer (RK) -2.3 and 6.6) between the 1976-1989 and 1996-200 sampling periods. These differences reflect the higher recent inflows of dark colored water farther down the river and into the upper harbor during the recent period of high flows.

- **Nitrite+Nitrate Nitrogen –** Concentration levels and seasonal patterns of dissolved inorganic nitrite+nitrate nitrogen differ along the lower river/upper harbor HBMP monitoring transect. The time-series plots indicate that inorganic nitrite+nitrate nitrogen levels at the most downstream fixed sampling station (located near the arbitrarily defined river mouth) are typically near or at method detection limits. Salinities are typically high in this region of the estuary and, except during periods of very high river flow, phytoplankton primary production is limited by the availability of inorganic nitrogen. Conversely, during extended periods of high freshwater river flows, surface salinities decline, bringing increased nutrient loading and higher levels of water color that limit the penetration of light into the water column and subsequently reduces phytoplankton growth and nitrogen uptake. By comparison, inorganic nitrogen levels progressively increase moving upstream along the HBMP sampling transect, as dilution by low nutrient/high salinity harbor water declines and higher water color increasingly limits phytoplankton nitrogen uptake. Only during periods of extended low freshwater flow, such as during the spring dry-season, are ambient inorganic nitrogen levels low at the upstream river sampling sites. The observed statistically significant increase in inorganic nitrogen concentrations in the upper harbor (RK -2.4) matches with the corresponding increase in water color and supports the previous observations that these increases reflect higher inflows of darker (nitrogen rich) freshwater farther downstream into the upper harbor during the recent period of characteristically higher river flows.

- **Total Kjeldahl Nitrogen –** While this gross measurement of combined inorganic ammonia and organic water column nitrogen shows distinct seasonal patterns, spatially levels at all the monitoring locations were observed to be relatively similar. Statistical tests found no significant differences when comparing the 1976-1989 and 1996-2006 time periods.

- **Ortho-Phosphorus –** Probably the most dramatic long-term change in water quality in the lower Peace River has been the marked observed statistically significant long-term decline in dissolved inorganic (and total) phosphorus concentrations. Phosphorus concentrations generally reflect both the spatial and temporal variation in Peace River freshwater inputs. The highest phosphorus concentrations are typically associated with seasonal low river flow, when the influences of ground water are more pronounced. Long-term temporal patterns indicate rapid declines in both the magnitude and variability in phosphorus levels when compared with the first six years of HBMP monitoring. Comparisons of the average annual mean phosphorus concentrations between the 1976-1989 and 1996-2006 time periods indicate a continued decline at the HBMP river stations, even though the largest changes occurred prior to 1984. Of particular note however are more recent observations, which show phosphorus levels throughout the lower Peace River/upper Charlotte Harbor Estuary have dramatically increased following Hurricanes Charley, Francis and Jeanne in August and September of 2004. The long-term data indicate that following this unusual series of events phosphorus concentrations increased throughout the system to levels not seen for over 20 years.

- **Silica –** Both the long-term time-series plots and the statistical comparisons of mean annual average reactive silica concentrations indicate that silica levels have recently dramatically increased along the entire length of the lower Peace River monitoring transect. During the most recent eleven years of HBMP monitoring, silica concentrations at all five fixed sampling sites have increased and the range of variability has increased when compared with similar data from the 1976-1989 period. It may be that the observed increases in ambient reactive silica levels in the Peace River estuarine system reflect the cumulative influences of increased ground water use and the expansion of water intense agriculture in the Peace River watershed, or it may be associated with other land use changes occurring upstream in the watershed. The Authority has collected additional dry- and wet-season data at a number of locations throughout the upper watershed in order to be able to better identify potential sources of both apparent increasing silica and phosphorus concentrations.

- **Chlorophyll *a* –** Previous studies observed marked declines in the periodic very high chlorophyll *a* concentrations or phytoplankton "blooms" that commonly occurred in the surface waters throughout the lower Peace River/upper Charlotte Harbor estuarine system during the late 1970s and early 1980s. However, current examination of the data, which extends similar analyses through 2006 indicates that since 2004 chlorophyll *a* levels in the lower river and upper harbor have uniformly shown increases to annual average levels not seen in over 20 years. Following Hurricanes Charley, Francis and Jeanne in August and September of 2004, as previously discussed, water quality data from the lower river showed marked increases in ortho-phosphorus levels that correspond with the observed increases in chlorophyll *a*. Since phosphorus levels in the lower Peace River/upper Charlotte Harbor Estuary are naturally high, and nutrient additions have shown local estuarine phytoplankton populations are seasonally nitrogen and not phosphorus limited, it is doubtful that the observed increases in phosphorus levels are directly the ultimate cause of the observed increases in chlorophyll *a* concentrations. This is probably because other water quality constituents not monitored by the HBMP, but having the same source as the observed phosphorus increases, are responsible for the observed increases in phytoplankton levels. Overall, the result of the observed historic declines, combined with the recent observed increases, is that there are no statistically significant differences in average annual seasonally weighted mean chlorophyll *a* concentrations between the 1976-1989 and 1996-2006 time intervals at any of the fixed HBMP monitoring locations. This result demonstrates the inherent difficulty in using most commonly applied statistical trend procedures when evaluating long-term changes in water quality parameters having multiple non-seasonal increasing and decreasing patterns.

Current Hydrobiological Monitoring Program

The initial monitoring elements of the HBMP were designed in 1976 to provide answers to specific questions raised by District staff during the Facility's 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. The HBMP was from its conception envisioned as a dynamic program. Modifications have been made to the program's monitoring elements throughout its history, with study elements having been added and deleted in order to enhance the overall knowledge base of the lower Peace River/upper Charlotte Harbor estuarine system. Historically, those major monitoring elements aimed at assessing direct relationships with variations in freshwater inflow have had the longest histories (vegetation and water quality). Other HBMP elements, primarily those focused on assessing indirect biological indicators, have extended over a number of years and then ended once a sufficient baseline basis of information had been accumulated.

Based on the results of the *1993* and *1995 Summary HBMP Reports* and additional analyses requested by District staff during the 1996 permit renewal process, an expanded HBMP was approved by the District in March 1996 as a part of Water Use Permit (WUP) #20010420 for implementation in 1996 and subsequent years. The Peace River Facility's 20-year Water Use Permit continues to require the submission of Annual Data Reports, as well as Mid-term and Comprehensive Summary documents respectively after data collection for the 3rd and 5th years of each five-year period. Specific conditions within the 1996 permit renewal included major expansions of both the physical and biological elements of the Hydrobiological Monitoring Program. (Note: One of the recommendations of the *2006 HBMP Comprehensive Summary Report* was to replace the current Mid-term HBMP Reports with more focused, topic specific reports. These focused reports would be designed to address specific issues and analyses suggested by the HBMP Scientific Review Panel, which has supported this recommendation to the District).

USGS Continuous Recorders – The primary goal of this HBMP study element has been to develop an extensive database of short-term changes in surface and near-bottom salinity in the lower Peace River. In 1996 the USGS installed an automated 15-minute interval water level conductivity and stage recorder approximately 15.5 kilometers upstream of the river's mouth at Harbour Heights. In November 1997 a similar Peace River Heights recorder was installed at approximately RK 26.7 just downstream of the Peace River Facility (Figure 5.1), and in December 2009 a third recorder was installed by USGS at the Facilities intake (RK 29.8). As indicated in previous HBMP annual reports, both surface and bottom conductivities at the downstream Harbour Heights site (River Kilometer 15.5) are very strongly influenced by tide (water stage) during periods when river flows are relatively low. During May 2010, in the dry-season, it was not uncommon for surface and bottom conductivities to vary 7000 to 15000 uS/cm (roughly from 4 to 9.0 psu) over a tidal cycle. During the wet-season, this lower reach of the Peace River is characteristically far fresher and daily variations in both surface and near-bottom conductivities resulting from tidal influences are greatly reduced, typically varying over a range of less than 0.2 psu.

At the more upstream continuous USGS gage at Peace River Heights (RK 26.7), the conductivity data collected in 2010 showed surface and bottom conductivities varying 200 to 2000 uS/cm (roughly from 0.1 to 1.0 psu) over a tidal cycle during the May spring dry-season. This is in direct contrast to recent drier years 2006-2009, when the data often indicated far greater (from 3.0 to 10.0 psu) daily tidal changes in salinity during the May 2005 dry-season. In comparison, during the wet season in September conductivities were low and did not show any noticeable response to daily tidal variations.

At the most upstream USGS recorder located at the Facility (RK 29.8), the 2010 data did not indicate any strong seasonal influences due to the upstream movement of tidal higher conductivity waters, which was common in this reach of the lower river during recent previous much drier years (1999-2002 and 2006-2009).

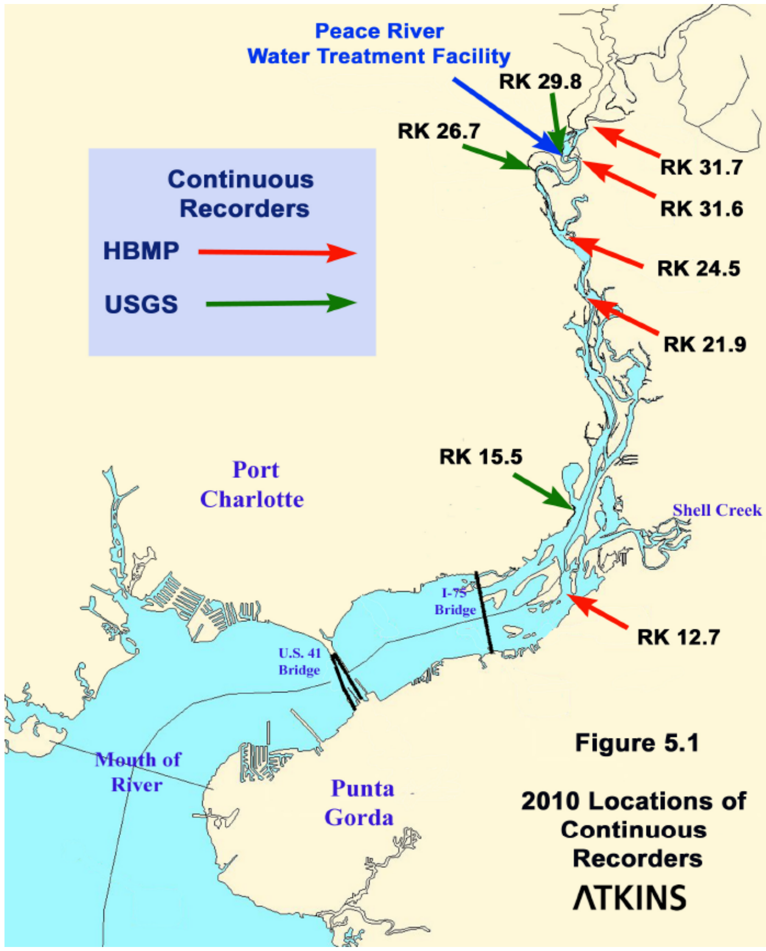


Figure 5.1

2010 Locations of Continuous Recorders

Five Additional Authority Continuous Recorders – The HBMP recorders installed during 2005 and 2008 by the Authority showed analogous patterns during 2010 to those observed at the three USGS continuous gages located downstream and upstream along the HBMP monitoring transect (Figure 5.1). As previously discussed with respect to corresponding data from the USGS continuous gages located downstream and upstream of these HBMP recorder locations, surface conductivities in the reach of the lower Peace River characterized by the two HBMP recorders between River Kilometers 21.9 and 24.5 typically show a great degree of daily tidal variability during periods of low flow and usually only very small or limited tidal salinity changes during higher flows.

Water Chemistry and Water Column Physical Profiles – The primary focus of this HBMP program element extends along the monitoring transect centerline that extends from south of the mouth of the river (which follows an imaginary line between Punta Gorda Point and Hog Island) to upstream of the Facility to where Horse Creek enters the lower Peace River. Two separate HBMP study elements incorporate both *in situ* water column profile physical measurements combined with the collection of chemical water quality sampling along the monitoring transect. Several objectives are associated with both the individual and combined findings of these water quality HBMP study elements. A principal goal of both monitoring efforts is to assess the overall "health of the estuary" by collecting sufficient long-term data to statistically describe spatial and seasonal variability of the water quality characteristics of the lower Peace River/upper Charlotte Harbor Estuary, and test for significant changes over time (trends). A further goal of these HBMP elements is to determine whether significant relationships exist between freshwater inflows and the seasonal/spatial variability of key selected water quality parameters. Where such relationships exist, a further objective then becomes to determine the potential magnitude of change that might result from both existing and projected future permitted withdrawals, and compare such predicted changes due to withdrawals with the normal ranges of observed natural seasonal and annual variability.

Similar and comparable physical and chemical water quality parameter measurements along the upper Charlotte Harbor/lower Peace River estuarine monitoring transect are collected under these 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 psu) along a river kilometer centerline 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. Historically, this isohaline sampling effort was undertaken in conjunction with other 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 "fixed" locations along a transect running from just below the river's mouth upstream to a point just above the Peace River Facility (see Figure 1.5 above). In addition, chemical water quality samples are taken at five of these locations.

Both of these water quality HBMP study 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. 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 based HBMP study element.

Summary of 2010 HBMP Study Results

The following compares data collected during 2010 with similar average values for key parameters previously compiled during various elements of the ongoing long-term monitoring programs. This summary of 2010 data includes the following key HBMP study elements.

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 2010 data with averages of similar data collected over the preceding 34-year period (1976-2009), 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 early 2002. A weaker El Niño occurred at the end of 2002, and freshwater flows during 2003, 2004 and 2005 were generally above average. Rainfall in the Peace River watershed during the recent 2006-2009 interval by comparison was well below average, while seasonal rainfall patterns during 2010 returned to more normal conditions.

- **Flows** – Average mean daily Peace River flow at the Arcadia gage during 2010 was 704 cfs, which is slightly below the 878 cfs average over the 35 years of HBMP monitoring (1976-2010). The average flow during 2010 was well above the annual average flow of 381 cfs over the preceding four-year interval between 2006 and 2009. However, it was also well below the average flow of 1538 cfs over the much wetter five-year interval between 2001 and 2005.

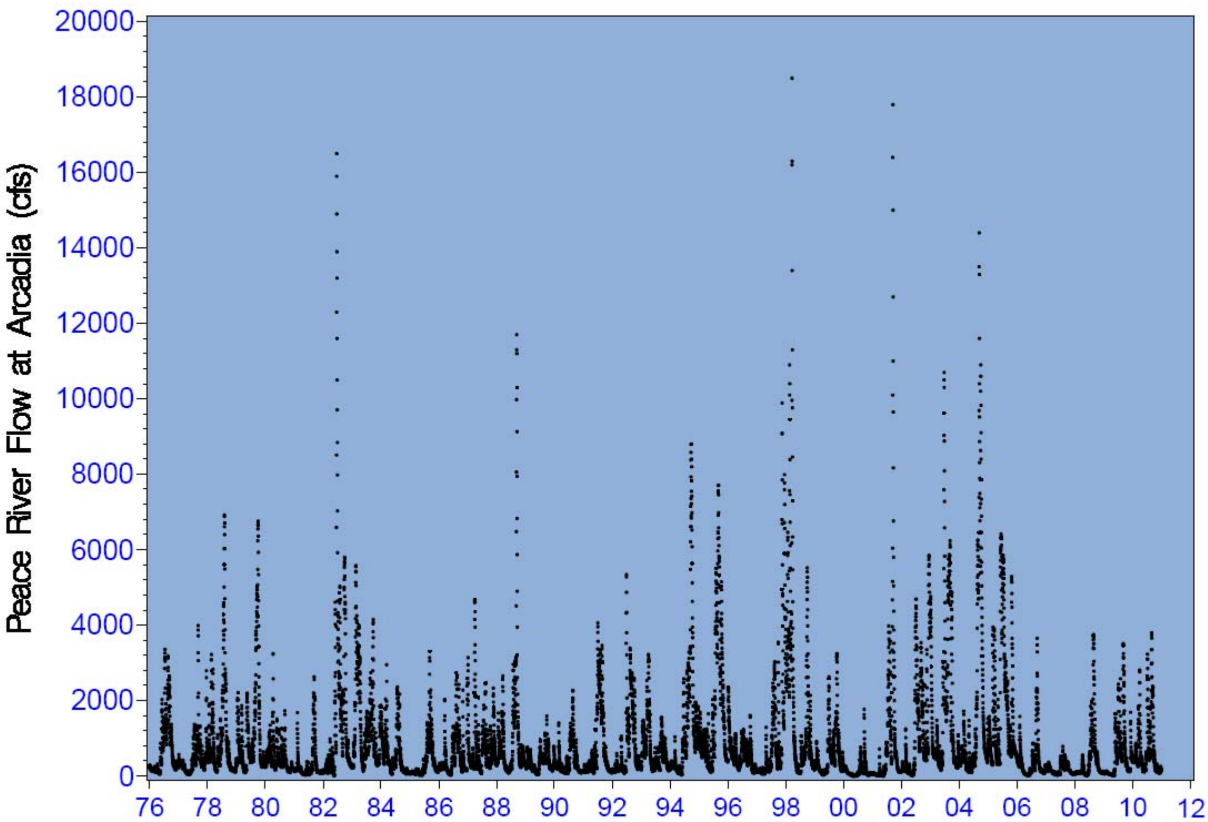


Figure 2.3 Daily Peace River flow at Arcadia (1976-2010)

Overall, annual mean flow at the USGS Peace River at Arcadia gage during 2010 was just 79.6 percent of the average daily flow over the preceding long-term 1976-2009 period. In comparison, the sum of average daily flows from the Peace River at Arcadia, Horse Creek, Joshua Creek, and Shell Creek during 2010 was roughly 85 percent of the average daily flows over the longer term 1976-2009 HBMP monitoring period.

- **Withdrawals** – Through the first two months of 2010, the Peace River Facility operated under District modifications to the Water Use Permit and Executive Orders that temporarily altered the low flow cutoff and/or temporarily increased the percent of flow that could be withdrawn from the river. During the remainder of 2010 the Facility operated under the conditions of its 1996 permit. Total Peace River Facility withdrawals during 2010 were approximately 4.7 percent of the total gaged freshwater flow measured at the USGS Arcadia gage, 3.4 percent of the upstream gaged flow at the Facility, and 2.6 percent of the combined average daily inflows upstream of the U.S. 41 Bridge. During the entire period of Peace River Facility withdrawals (1980-2010), total combined withdrawals have been approximately 1.53 percent of the corresponding gaged Peace River at Arcadia flows and 1.23 percent of the corresponding combined daily flows of the Peace River, and Horse, Joshua, and Shell Creeks. There were some days during 2010 when Peace River Facility withdrawals exceeded the seasonally designated maximum percents allowed by the permit. Such exceedances of the permitted percent withdrawals primarily result from subsequent USGS revisions of the provisional daily flow information available to the Authority at the time of actual withdrawals. Often there are extended periods each year when the Peace River Facility does not withdraw any water from the river due to either the low flow threshold and/or Facility operations. During

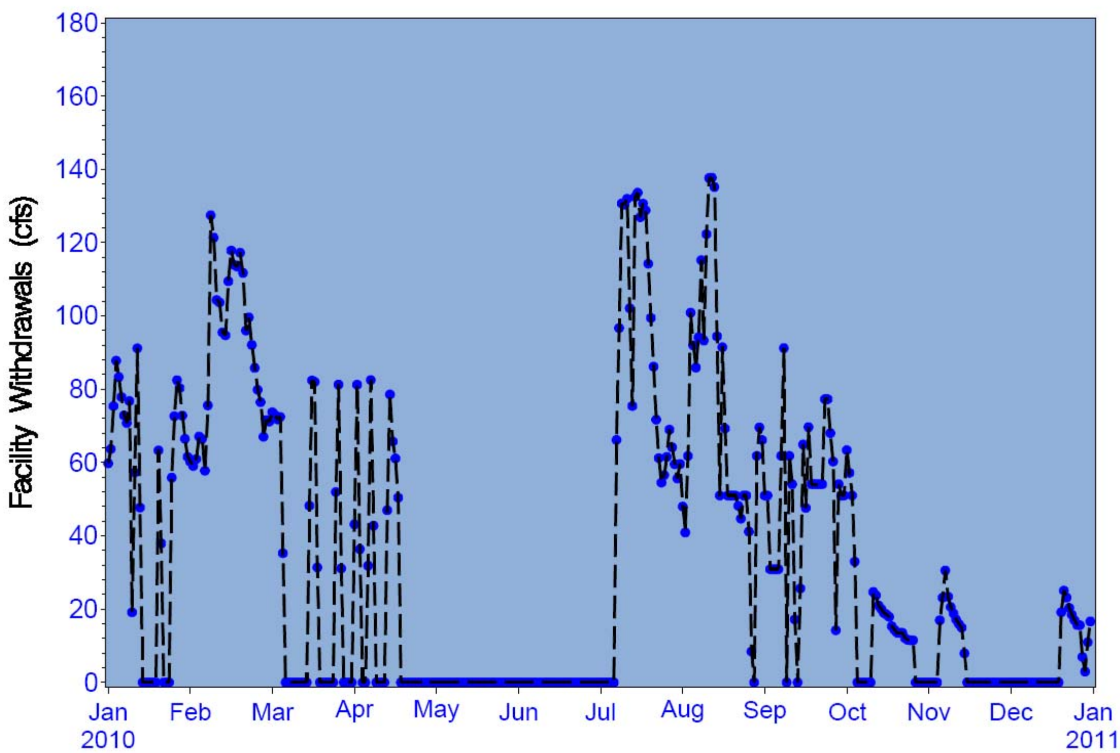


Figure 2.18 Daily water treatment facility withdrawals (2010)

2010, the facility did not withdraw any water from the river approximately 46 percent of the time. Maximum Facility withdrawals have increased both in 2002 and 2009 due to the completed Facility expansions, which have resulted in increases in the Authority's ability to divert, treat and store larger daily amounts of freshwater when river flows meet the District's threshold criteria.

- **Salinity Spatial Distribution –** Freshwater inflows to the lower Peace River during 2010 were generally higher than during the preceding 2006-2009 drought. The influences of the slightly drier than usual conditions that characterized overall 2010 flows are reflected in the seasonal and average spatial distributions of each of the four sampled moving isohalines along the HBMP monitoring transect. Overall, the relative spatial distributions of each of the isohalines during 2010 reflected slight upstream movements when compared with their previous long-term 1983-2009 averages.

The following provides comparisons between 2010 and long-term averages for the following selected physical, chemical and biological water quality characteristics.

- **Temperature** – Median annual water temperatures during 2010 at each of the four isohalines were, on average, slightly higher than corresponding values measured over the preceding 27-year period (1983-2009). However, corresponding mean annual water temperatures for the year by comparison were several degrees below their long-term averages. The much lower than average mean water temperatures during 2010 reflect unusually cold conditions at both the beginning and the end of the year, caused by a series of atypical cold fronts during both the winters of 2009 and 2010.

- **Water Color** – Seasonally water color levels during 2010 were similar or just slightly higher than average levels over the preceding long-term historic period (1983-2009). This is in direct comparison with the generally lower levels observed during the 2006-2009 drought when color levels in the lower Peace River/upper Charlotte Harbor estuarine system were well below their long-term averages within all but the highest salinity isohaline.

- **Extinction Coefficient** – The rates of measured light attenuation at each of the four HBMP isohalines reflect the interactions of both ambient color and phytoplankton biomass (chlorophyll *a*). Comparisons of mean extinction values among the four isohalines during 2010 with corresponding long-term averages show much lower levels at all but the most downstream, highest salinity level (20 psu). This result probably reflects the overall slightly lower than average annual flows that characterized 2010.

- **Nitrite+Nitrate Nitrogen** - During 2010, the average concentrations of this major inorganic form of nitrogen were generally similar to the observed long-term (1983-2009) historical annual averages. The one exception that skewed the annual 2010 averages for the upstream freshwater isohaline was the occurrence of a high value in January. The data clearly indicate that inorganic nitrogen levels were below normal in the lower Peace River/upper Charlotte Harbor estuarine system during the recent years of extended drought. Monthly comparisons among the isohalines indicate nitrite/nitrate inorganic nitrogen concentrations in the lower Peace River/upper Charlotte Harbor estuarine system are characterized by a distinct spatial gradient that shows strong responses to seasonal patterns of freshwater inflows. Concentrations typically decrease rapidly with increasing salinity, with inorganic nitrogen levels within the 20 psu isohaline often being near or at method detection limits over much of the year. Normally, estuarine inorganic nitrogen concentrations decline to their lowest levels during the relatively drier spring months. This is a result of phytoplankton populations responding to increasing water temperatures and light, and increased primary production removing available inorganic nitrogen. As a result, inorganic nitrogen levels in the lower river and upper harbor are typically at their lowest levels in the late spring, just prior to increases in summer wet-season inflows.

- **Ortho-phosphorus** - Estuarine inorganic phosphorus concentrations in the lower Peace River and upper Charlotte Harbor are heavily influenced by the characteristically "very" high natural levels found in the Peace River watershed. As a result, the observed difference in concentrations among the four isohalines primarily reflects conservative dilution by Gulf waters. Unlike inorganic nitrogen, seasonal observed changes in phosphorus concentrations in the estuary are for the most part not affected by biological uptake. Inorganic phosphorus concentrations entering the estuary system from the Peace

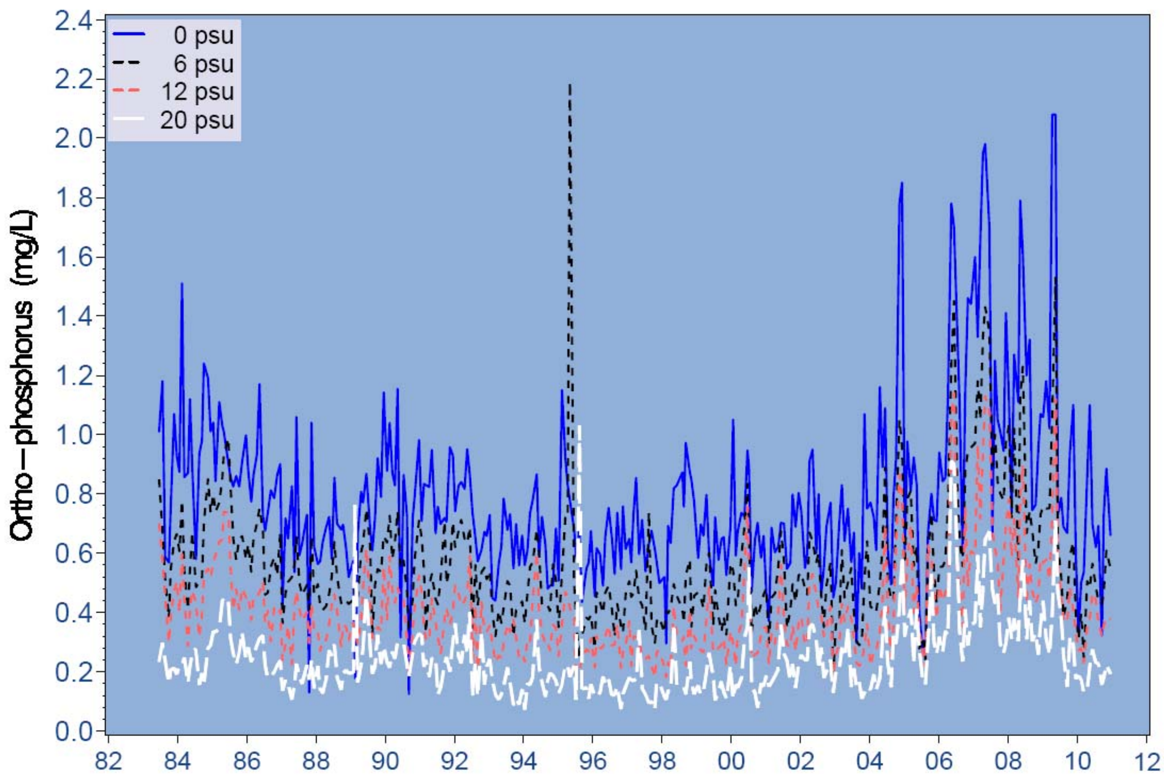


Figure 3.18 Monthly ortho-phosphorus at each isohaline based sampling zone (1983-2010)

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). Historically, since the late 1970s, there had been marked declines in inorganic phosphorus levels in the lower Peace River/upper Charlotte Harbor estuarine system due to declines in the combined influences of phosphate mining and processing in the upper reaches of the basin. However, following Hurricane Charlie and the subsequent Hurricanes Francis and Jeanne during the late summer of 2004, inorganic phosphorus concentrations have dramatically increased throughout the lower Peace River/upper Charlotte Harbor estuarine system. Ortho-phosphorus concentrations remained well above recent historic levels throughout much of 2005-2009 and have recently rapidly declined. The direct cause for the observed increased levels seems to have been related to the on-going closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin. Annual average ortho-phosphorus concentrations at each of the four isohalines were generally lower in 2010 than the corresponding long-term averages (1983-2009).

- **Nitrogen to Phosphorus Atomic Ratios** – Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations in 2010, as indicated by the long-term averages, show nitrogen to almost always be the limiting macronutrient at each of the four isohalines. The possible exception occurred during January at the freshwater location when a very high level of inorganic nitrite/nitrate nitrogen was observed.

- **Silica** – Seasonally, silica levels in the lower Peace River/upper Charlotte Harbor estuarine system typically peak following periods of high freshwater inflows. Although silica levels also seem to be positively correlated with higher water temperatures (possibly reflecting recycling from riverine/estuarine sediments), historically lower silica concentrations in higher salinity zones of the estuary often occurred during corresponding

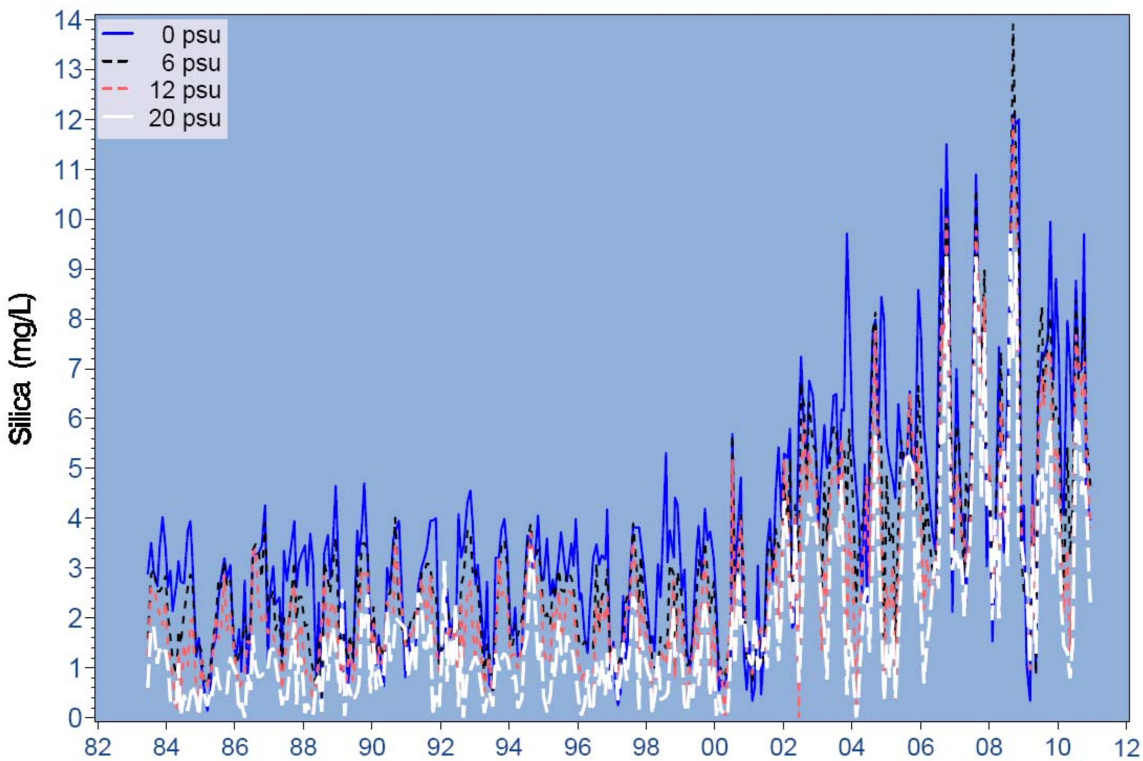


Figure 3.20 Monthly silica at each isohaline based sampling zone (1983-2010)

periods of combined low spring freshwater inflow and spring increases in phytoplankton diatom numbers. Between 1983 and the late 1990s these seasonal patterns of increasing and decreasing reactive silica concentrations remained relatively stable with no indications of any consistent systematic changes over time. However, as discussed in previous HBMP reports, silica levels started showing increasing concentrations during the late 1990s. Then, as flows declined during the extended 1999-2002 drought, silica levels also declined. However, following the return of higher than average flows during 2003-2005 measured silica levels in the estuary again began rapidly increasing. Even though flows between 2006-2008 were below normal, silica levels throughout the lower river/upper harbor estuary continued to reach historically high levels during the summer wet-seasons. As with ortho-phosphorus, the proximate cause for these increasing levels seems to be related to the on-going closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin. However, while peak levels during 2009 and 2010 were somewhat lower than during the immediate preceding years, annual average concentrations during 2010 were well above their long-term averages at each of the four moving isohaline bases monitoring locations.

- **Chlorophyll *a* –** The seasonal patterns of freshwater inflows to the estuary during 2010 were characterized by slightly drier than usual conditions when compared to the long-term average conditions. Typically, seasonal periods of increased flows produce both higher than average inputs of limiting inorganic nutrients (nitrogen), as well as higher than average levels of water color (resulting in greater light attenuation). The rapid increase in flows in July following the dry spring was accompanied by sharp increases in phytoplankton biomass at the 12 psu isohaline and a abnormally very high observed peak at the 6 psu isohaline in August. With the exception of these two unusual events, chlorophyll *a* concentrations within the Peace River/upper Charlotte Harbor estuarine salinity zones were generally similar to their preceding long-term (1983-2009) corresponding averages. As in previous years, phytoplankton levels within the intermediate (6 and 12 psu) isohalines reflected a balance between stimulation due to increased nitrogen inputs, and light inhibition resulting from higher water color. During previous years, taxonomic counts indicated that such "bloom" events within these intermediate salinity zones were often predominantly characterized by high numbers of dinoflagellates (*Dinophyceae*) or diatoms (*Bacillariophycae*).

Conclusions

This document represents the fifteenth Annual Data Report submitted under the expanded Hydrobiological Monitoring Program (HBMP) initiated in 1996 in compliance with Water Use Permit 20010420. The graphical and summary analyses presented in this document do not indicate any substantial changes, or atypical events in either the physical or biological data collected during 2010, other than those previously noted. These include:

- Freshwater inflows during 2010 were influenced by slightly drier than normal conditions, especially during the normal spring dry-season and the fall/winter periods.

- There has been a continuation, but slight decline, in the previously noted long-term increase in reactive silica concentrations noted at the lower Peace River/upper Charlotte Harbor monitoring locations.

- There are strong indications that inorganic phosphorus concentrations in the freshwater entering the estuary have increased in recent years, following decades of major declines that began in the late 1970s. However, observations during 2009 and 2010 show that levels have substantially declined again to levels near where they were prior to the observed recent increase.

- The observed recent increases in silica and phosphorus seem to have been linked to the on-going closure of phosphogypsum stack systems in the upper Peace River watershed.

The "limited" analyses presented in the *2010 HBMP Annual Data Report* do not suggest that there have been any long-term, systematic changes resulting from either current or historic water withdrawals by the Peace River Regional Water Supply Facility.

Review of Long-term Changes in Upstream Water Quality

Analyses of long-term water quality data from both the fixed and isohaline monitoring program study elements presented in this and previous HBMP reports have identified several important recent and longer term changes in water quality that have occurred upstream of the Facility that may influence both aspects of operations and/or the biological communities of the estuarine system.

- There have been long-term, progressive increases in the conductance of the water coming downstream to the Facility during the drier months of the year. This trend has further been associated with increasing volumes of water (base flow) during the normally seasonal drier time intervals. These changes over recent decades have been primarily associated with increasing land conversions from less to more intense forms of agriculture that increasingly rely on irrigation using high conductivity water pumped from the upper Floridan aquifer. Such changes are particularly apparent in the Joshua and Horse Creek basins in the southern portions of the Peace River watershed. The upstream changes in water quality (conductance, chlorides and TDS levels) originating from agricultural discharges during the dry-season have yet to be a serious hindrance to water supply operations. However, this is not to say that such changes may not become a problem in the future if the current trends in the contributing upstream basins continue.

- Silica levels in the lower Peace River/upper Charlotte Harbor estuary have been increasing over the past decade. More recently, phosphorus levels in the lower Peace River that had historically show dramatic declines during the late 1970s and 1980s had returned to levels not observed in decades. These observed changes in long-term HBMP data, combined with the Authority's watershed monitoring and the District's watershed ambient surface water quality monitoring indicate that these recent changes coincide well with the ongoing closure of phosphogypsum stacks and associated discharges in the Whidden Creek subbasin. It is therefore reasonable to assume that increases in these same parameters that predate the period of closures of the USAgriChemicals Fort Meade operations have also been related to changes in phosphate mining activities in the upper Peace River watershed.

Permanent Historic and Current HBMP Data

This Executive Summary provides a brief over view of the HBMP project and the recent findings from the 2010 annual report. The entire report, including summary graphics and tables, and all historic project water quality data are available in electronic format on a CD titled *2010 HBMP Annual Data Report*. This CD is available upon request by contacting the Southwest Florida Water Management District or the Peace River Manasota Regional Water Supply Authority. All historic water quality and *in situ* data collected during the fixed, moving station, and continuous recorder elements of the HBMP are provided on the *2010 HBMP Annual Data Report* CD in a separate directory labeled 2010 Data Sets, as files in ASCII, Excel and/or SAS formats.

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1.0 Introduction/Summary

1.1 Report Objectives

This introductory section the of *2010 HBMP Annual Data Report* summarizes and provides brief overviews of the historic background and current status of the Peace River Manasota Regional Water Supply Authority's (Authority) Hydrobiological Monitoring Program (HBMP). The following provides an overview of the major topics included in this section.

- A historical review of the Authority's Peace River Facility Water Use Permit (WUP), and the overall goals and objectives of the associated HBMP.
- An overview of major previous and current HBMP monitoring elements, as well as special HBMP studies.
- A brief summary of some of the key findings of recent previous HBMP reports and studies.
- An outline of current HBMP monitoring elements.
- Summary results of the information presented in Sections 2 through 6 of this *2010 HBMP Annual Data Report*.
- An overview of the current and historic data sets used in the analyses of 2010 HBMP data.
- A general summary of specific problems encountered by study elements during the 2010 HBMP monitoring that resulted in either missing or unusable data.

The following outlines the organization and primary objectives of each of the sections of the *2010 HBMP Annual Data Report* following this introduction and generalized summary.

- **Section 2.0 (Peace River Gaged Flows and Peace River Facility Withdrawals) –** The purpose of this section is to provide analysis and summarize 2010 gaged river freshwater inflows to the lower Peace River estuary, and compare inflows with freshwater withdrawals by the Peace River Regional Water Supply Facility (Facility). This section also presents comparisons of the 2010 flow record and facility withdrawal levels with similar long-term information over the 1976-2010 time interval, which corresponds with the historic period of HBMP monitoring.
- **Section 3.0 (Physical and Chemical Water Quality Characteristics at "Moving" Isohaline Based Locations) –** The intention of this section is to provide a brief overview of the initial objectives of the "moving" isohaline based monitoring program, describe the current sampling plan, and present both the results of data collected in 2010 as well as

summary graphical and tabular comparisons of the 2010 results with previous similar salinity based sampling HBMP data collected between 1983-2009.

- **Section 4.0 (Physical and Chemical Water Quality Characteristics at "Fixed" Lower River/Upper Harbor Monitoring Transect Locations) –** This section summarizes the objectives of the long-term "fixed" station monitoring program, describing both the historic and current sampling designs, and presents both the results of data collected in 2010 as well as summary graphical and tabular comparisons of selected 2010 water quality monitoring results with previous similar HBMP data collected between 1976-2009.

- **Section 5.0 (USGS and HBMP Continuous Recorders) –** This report section summarizes the initial principle objectives envisioned in establishing 15-minute U.S Geological Survey (USGS) continuous recorders (tide stage, and surface and bottom temperature and conductivity) at Harbour Heights (River Kilometer 15.5) and Peace River Heights (River Kilometer 26.7). Also described and summarized are the design criteria that were used in establishing additional HBMP 15-minute continuous recorders (subsurface temperature and conductivity) in December 2005 at River Kilometers (RK) 22.0, 23.4 and 24.5. The HBMP recorder at RK 23.4 was subsequently discontinued and three additional recorders were added in May 2008, based on recommendations of the HBMP Scientific Review Panel (near surface at RK 30.6 and RK 31.7, and near bottom at RK 12.7). More recently (December 2009) USGS installed a third set of near surface and near bottom recorders at the Facility's intake (RK 29.8). The results of data collected in 2010 at the eight current continuous recorder locations (three USGS and five HBMP) are presented in this section. Included are graphical and tabular results providing comparisons among the seven sites were surface salinities are measured along the lower Peace River HBMP monitoring transect, as well as with similar data collected during previous years at corresponding locations.

- **Section 6.0 (Significant Environmental Change) –** This section briefly summarizes the previously presented (*2006 HBMP Comprehensive Summary Report*) discussion of the Southwest Florida Water Management District's (District) concept of an "Adverse Impact" and compares and contrasts the HBMP working definition of "Significant Environmental Change" relative to impacts potentially associated with Facility withdrawals from the lower Peace River.

1.2 Peace River Facility Water Use Permit and Related HBMP

The Authority's Peace River Regional Water Supply Facility is located adjacent to a side-branch of the Peace River in southwest DeSoto County. Although the system has only been operated by the Authority since 1991, the Facility has been operating and withdrawing water from the Peace River since 1980. Table 1.1 summarizes differences in the Facility's withdrawal schedules associated with each of the historic modifications of the Water Use Permit's specific conditions.

- Prior to October 1988, the Facility's previous (1982) modification of the Water Use Permit had limited annual average withdrawals to 8.2 mgd (12.7 cfs), with the maximum daily withdrawal limited by the Facility's physical ability to withdraw water from the river (which was 22 mgd or 34.0 cfs). Monthly individual low flow Peace River at Arcadia cutoffs were determined based on the previous 20-years of USGS flow data. As a result, the individual monthly low flow cutoffs ranged from lows of 64.6 mgd (100 cfs) in April and May to a high of 429.2 mgd (664 cfs) in September.

- The October 1988 Water Use Permit renewal limited withdrawals to ten percent of the previous day flow as measured at the USGS Peace River at Arcadia gage, up to the limit of 34.0 cfs per day (which matched the pumping capacity of the river intake facility at the time). The low flow cutoffs during the period from 1989 to 1995 were 130 cfs during the months of June through February, and then 100 cfs during the March through May spring dry-season.

- The 20-year 1996 Water Use Permit renewal increased the low flow cutoff to 130 cfs year round, while concurrently raising the maximum withdrawal capacity to 90 mgd (139 cfs). The 1996 permit renewal retained the ten percent withdrawal limit established under the previous October 1988 permit. The Authority's intent was to increase the Facility's treatment capacity to capture a greater portion of the full permitted ten percent withdrawal under higher flow conditions, thus increasing the Facility's reliability with the ability to withdraw and store excess amounts of water above actual daily demands.

Table 1.1
Historic Summary of Facility Permits

Year	December 1975	March 1979	May 1982	October 1988	March 1996
Water Use Permit Number	27500016	27602923	202923	2010420	2010420.02
Average Permitted River Withdrawal (mgd)	5.0	5.0	8.2	10.7	32.7
Maximum Permitted River Withdrawal (mgd)	12 & 18	12 & 18	22	22	90
Diversion Schedule Low Flow Cutoff (cfs)	91 – 664*	91 – 664*	100 – 664*	100 & 130**	130**
Maximum Percent Withdrawal of River Flow (%)	5	5	n/a	10	10

* Withdrawals based on historic monthly averages

** Withdrawals based on percent of actual daily flow

Prior to 2009 the Peace River Facility had the capacity to treat up to 24 million gallons per day (mgd), and relied on four pumps with a combined maximum capacity of 44 mgd (68.0 cfs) for raw water diversions. During periods of high river flow (or periods where permitted withdrawal exceeds demand), raw river water was stored in the Facility's 0.6 billion gallon off-stream surface reservoir and any excess treated water was stored in the system's 21 aquifer storage/recovery (ASR) wells. Conversely, when water has been unavailable from the Peace River due to the established low flow 130 cfs cutoff (or when demand exceeds permitted withdrawals), water can be pumped from the raw water reservoir to the Peace River Facility for treatment, and/or previously treated water can also be recovered from the ASR well system to meet the water supply demands of the Authority's service area.

During 2009 the Authority finished implementing a series of expansions to the Peace River Facility undertaken as part of its ongoing plans to meet projected future increasing water demands caused by expected future regional growth in the member counties. These expansions included increasing the Facility's pumping capacity from the river to 90 mgd (the current permit limit) and construction that increased the Facility's treatment capacity to 48 mgd (twice the previous capacity). In addition, construction of a new regional off-stream reservoir with a capacity of approximately 6 billion gallons was completed, and additional system transmission pipe networks will be expanded to optimize water delivery throughout the region.

On December 10, 1975, the Consumptive Use Permit #27500016 for the Peace River Regional Water Supply Facility was signed between General Development Utilities, Inc. and the Southwest Florida Water Management District. In conjunction with this agreement, a comprehensive Hydrobiological Monitoring Program 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 influences 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**.

In 1976 the initial monitoring elements of the HBMP were designed in coordination with District staff to provide answers to specific questions raised during the original permitting process. These questions raised concerns regarding the potential for negative impacts potentially associated with salinity changes in the lower Peace River/upper Charlotte Harbor estuarine system resulting from freshwater withdrawals. Analysis of data from pre- and post-water treatment plant operation, presented in the August *1982 HBMP Summary Report*, indicated the need to revise the monitoring program to better evaluate changes in the Charlotte Harbor system due to both natural seasonal and longer-term variations in freshwater inflows, and relative magnitude and timing of changes due to Facility withdrawals. Further modifications and refinements to the HBMP were made in 1985 and again in conjunction with the renewal of the Water Use Permit in October 1988.

The current Water Use Permit (# 2010420) was issued by the District to the Authority in March 1996. The permit contained specific conditions for the continuation and enhancement of the Hydrobiological Monitoring Program for the lower Peace River/upper Charlotte Harbor Estuary. The HBMP study elements specified in the 1996 permit were designed to build upon and add to the HBMP monitoring activities that have been ongoing since 1975, and predate the 1980 completion and initial consumptive Facility withdrawals. The initial background and HBMP monitoring conducted prior to operations provided a basis for pre-withdrawal conditions against which later comparisons were made.

Between 1979 and 2010, 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 2010 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. Under the 1988 permit, data reports were required to be submitted annually, and two expanded Comprehensive Summary Reports were submitted that included a range of comparative analyses of the data reported over the preceding periods. 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 (finalized in April 1995), and statistically summarized and evaluated the results of the HBMP study elements conducted between 1976 and 1993.

The 1996 Water Use Permit specifies reporting requirements with respect to data collected and interpreted under the HBMP. In addition to Annual Data Reports, the Permit requires limited Mid-term Reports and much more extensive Comprehensive Summary Reports to be submitted to the District approximately after the third and fifth years of each five-year interval of the 20-year permit. Due to increased public concerns regarding long-term hydrologic alterations of freshwater flows in the Peace River watershed, the Authority has expanded the level of data analysis in all of the HBMP Reports beyond that originally envisioned during the 1996 permit renewal. The primary focus of these additional increased statistical analyses and evaluations have been specifically directed toward further assessing both the magnitude and distribution of potential impacts resulting from current and projected future Facility withdrawals under the 1996 permit. The HBMP Scientific Review Panel (Panel) also recommended a number of significant modifications and additions to the HBMP over recent years. In addition to these program modifications, the Panel has provided suggestions and asked questions about the HBMP data which have been included in recent HBMP reports.

The *2002 Peace River HBMP Comprehensive Summary Report* (named for the period through which HBMP data were analyzed) both extended previous selected analyses of study elements undertaken in conjunction with the preceding summary reports of long-term HBMP data, as well as presented new analyses of a number of program elements. The *HBMP 2004 Mid-term Interpretive Report* (submitted in November 2006 and finalized in February 2009) focused primarily on analyses of long-term changes in seasonal patterns and flows in the Peace River watershed, and provided updated summaries of both existing and future expansions, as well as future projected increases in demands. The *2006 HBMP Comprehensive Summary Report* (submitted in April 2008 and finalized in December 2009) combined, updated and extended many of the analyses of long-term HBMP data presented in previous HBMP summary reports, as well as provided new enhanced statistical modeling relative to the potential spatial and temporal magnitudes of predicted short- and long-term salinity increases due to permitted Facility freshwater withdrawals from the lower Peace River.

The period covered within this *2010 HBMP Annual Data Report* follows directly upon that contained within the preceding *2009 HBMP Annual Data Report* submitted in May 2010. This current report includes unreported HBMP data collected over the period from January through December 2010, and represents the 21st year of data collection for the Authority, as owner/operator of the Peace River Regional Water Supply Facility.

As defined by the District 1996 Water Use Permit conditions, the primary focus and overall objective of the HBMP is to assess the following key issues.

- Monitor river withdrawals from the Peace River by the Facility and evaluate gaged tributary flows from Joshua, Horse and Shell Creeks, as well as the primary Peace River flows measured at Arcadia and direct rainfall to the lower Peace River.

- Evaluate relationships between the ecology of the lower Peace River/upper Charlotte Harbor estuary and freshwater inflows.

- Monitor selected water quality and biological variables in order to determine whether the ecological characteristics of the estuary related to freshwater inflows are changing over time.

- Determine the relative degree and magnitude of effects of Peace River withdrawals by the Facility on ecological changes that may be observed in the lower Peace River/upper Charlotte Harbor estuarine system.

- Evaluate whether consumptive freshwater withdrawals significantly contribute to any adverse ecological impacts to the estuary resulting from extended periods of low freshwater inflows.

- Evaluate whether the withdrawals have had any significant effects on the ecology of the estuary, based on related information such as nutrient loadings, fish abundance, or seagrass distribution data collected as part of other studies conducted by the District or other parties.

The overall primary goal of both the historic and current HBMP study elements has been to provide the District with sufficient information to determine whether the biological communities of the lower Peace River/upper Charlotte Harbor estuarine system have been, are being, or may be adversely impacted by permitted freshwater withdrawals by the Authority's water treatment Facility. The expanding base of ecological information regarding the lower Peace River and upper Charlotte Harbor Estuary resulting from the ongoing HBMP also provides a further basis to periodically evaluate the effectiveness of the withdrawal schedule with regard to preventing significant environmental changes.

1.3 Previous HBMP Study Elements and Studies

The HBMP was not conceived to be a rigid monitoring program but rather a flexible study design that could be periodically restructured based on updated findings and identified research needs. When the first discussion began with District staff in 1975 regarding what might be included within such a monitoring effort, very little was known about either salinity/flow relationships, or the spatial/temporal distributions of other physical/chemical water quality parameters in the lower Peace River/upper Charlotte Harbor Estuary. Even less was known about the biological communities that studies in other estuarine systems had indicated could potentially be negatively affected by freshwater diversions. As a result, much of the effort under the initial HBMP study design was directed toward developing sufficient data to statistically describe the spatial distribution and seasonal variability of physical and chemical indicators within this estuarine system, and to determine potential relationships with naturally occurring variation in freshwater inflows. The initial HBMP investigations included the collection of monthly *in situ* water column profile characteristics, and surface and near-bottom water chemistry at a wide variety of sites located from upstream of the Facility to near Boca Grande Pass.

In addition, initial attempts were begun to determine if key indicator species or biological communities could be identified to assess responses to natural variations in freshwater inflows. Determining the presence of such long-term relationships was thought to be especially important because, with only a small percentage of total flow being initially diverted, the direct effects of withdrawals were projected to be extremely small in comparison to natural variation. These original HBMP elements included: 1) the initial long-term study of the seasonal pattern of juvenile fishes in the upper harbor; 2) studies of benthic indicator species; 3) the investigation of the seasonal distribution of sea stars in the harbor and lower river; and 4) the vegetation study of first and last occurrence of selected plant taxa along the lower Peace River.

In the 1980s, studies of zooplankton and phytoplankton community structure and primary production were added to the HBMP. These studies were again not intended to directly evaluate the influences of withdrawals, but rather were designed to address issues related to the “health of the estuary” and the influences of naturally occurring extended periods of drought and flood conditions on key initial components of the estuarine food-chain. The short-term benthic invertebrate study and the fish nursery investigation conducted in the late 1990s were again not designed to measure the influences of withdrawal directly, but rather were intended to investigate the response of biological communities to natural variations in freshwater inflows.

An explicit element in the District’s 1996 renewal of the Water Use Permit was the development of standardized station descriptors to be applied across all HBMP program elements. A morphometric study was undertaken of the lower river/upper harbor for the HBMP using the “mouth” of the Peace River as defined by the previous USGS standardized protocol as using an imaginary line extending from Punta Gorda Point to Hog Island. Since the morphometric study, all new and previous on-going study elements monitoring locations have been cross-referenced to this “River Kilometer” identification system.

Modifications have been made to the HBMP elements throughout its history. While the overall effort (inflation adjusted) of the monitoring program has remained relatively constant, study elements have been added and deleted in order to enhance the overall knowledge base of the lower Peace River/upper Charlotte Harbor estuarine system. Historically, those major monitoring elements aimed at assessing direct relationships with variations in freshwater inflow have had the longest histories. Other program elements, primarily those focused on assessing indirect biological indicators, have extended over a number of years and then ended once a sufficient baseline level of information had been accumulated.

The outside HBMP Scientific Review Panel implemented in conjunction with the 1996 Water Use Permit renewal has also recommended a number of changes to the monitoring program study elements. Overall the Panel has recommended that the HBMP should focus monitoring primarily on assessing long-term trends in key physical, chemical and biological characteristics directly related to the Facility’s potential influences and less on elements more directly related to the overall “health of the estuary” potentially influenced by other anthropogenic impacts.

1.4 Overview of Previous HBMP Summary Results

Expanded analyses of recent and longer-term HBMP monitoring data over the entire period–of-record (since 1976) have been conducted at three and five-year intervals as required under the 1996 Water Use Permit as part of the *2000 Mid-term Interpretive Report*, the *2002 Peace River HBMP Comprehensive Summary Report*, the *HBMP 2004 Mid-term Interpretive Report*, and the *2006 HBMP Comprehensive Summary Report*. The results of the analyses presented in this extensive series of reports further support previous monitoring program findings regarding the potential magnitude of the changes that are potentially directly attributable to facility withdrawals. These earlier findings are presented in previous Summary HBMP Reports submitted in the 1980s, 1993, 1995, and as part of the supplementary analyses requested by District staff during the 1996 permit renewal process. Combined, the primary purpose of these summary documents has been to provide the District with a sufficient history of analyses to meet the following goals and objectives.

- Assess the presence or absence of long-term trends for important HBMP variables and freshwater inflows.
- 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 adverse ecological impacts and determine the relative magnitude of influence Facility withdrawals may have contributed.
- Evaluate the environmental considerations that may be associated with projected 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. Evaluate the overall HBMP design and make recommendations regarding implementing modifications.

The overall findings of the summary HBMP reports submitted to the District in conjunction with the 1996 permit requirements have supported the following conclusions.

- There have been statistically significant declines in high, median and low flows over the long-term period of record at the USGS Peace River at Bartow and Peace River at Zolfo Springs gaging sites in the northern Peace River watershed.
- Similar trend analyses of seasonal long-term Peace River at Arcadia flows, by comparison, indicate that there have been statistically significant declines of only the lower flow percentiles.

- Low and base flows in the upper Peace River watershed have been impacted by phosphate mining, agriculture and urban anthropogenic land use changes, while observed differences in mean and median flows have primarily resulted from natural multidecadal variability in rainfall.

- Historical watershed flow data indicate higher average flows over the summer months (June-September) during both the historic warmer "wetter" Atlantic Multidecadal Oscillation (AMO) phase that occurred prior to 1969 and the more recent period since 1995, when compared with the cooler "drier" phase that persisted between 1969-1994.

- In the southern portion of the Peace River watershed, base flows have increased over periods of record in the Joshua, Horse and Shell Creek tributaries as a result of seasonal augmentation due to agricultural ground water irrigation.

- 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. Over the past 28 years, annual total Peace River Facility withdrawals have averaged approximately one percent of total freshwater flow at the river's mouth.

- 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 estuary" as well as direct and indirect adverse impacts potentially associated with facility withdrawals.

- Long-term comparisons of upstream and downstream occurrences of selected indicator plant species along the lower Peace River spanning nearly 30 years have indicated that the distributions of the selected indicator species have not systematically or progressively changed over time. Since seasonal river flows over this extended period have exhibited a great degree of natural variation including both extended dry and wet intervals, it is apparent that the observed relatively stable spatial distribution of the riparian vegetation communities along the lower Peace River are maintained by the combined influences of both seasonal variability of exposure to differing salinity regimes due to changing flows and localized physical floodplain characteristics. Thus monitoring differences in the spatial distribution of riparian vegetation along the lower river are not sensitive enough to access potential changes due to Facility freshwater withdrawals.

- 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 have historically resulted in daily changes of < 0.3 psu (practical salinity units).

    - These statistical models were also used to predict what the potential magnitude of salinity changes might be expected to occur under the maximum permitted daily withdrawals under the 1996 Water Use Permit. Modeled results predict a maximum daily salinity change of < 0.1 - 0.5 psu occurring between River Kilometers 14 and 18 when USGS gaged Peace River flow at Arcadia ranged between 400 and 1000 cfs (cubic feet per second). The modeled results predict that similar changes in salinity (< 0.1 - 0.5 psu) would occur further upstream, as flows decline to near 200 cfs, and that potential salinity changes would continue to further decrease under lower flows approaching the low flow withdrawal threshold of 130 cfs. Modeling efforts have indicated that the predicted influences of freshwater withdrawals under the Facility's existing withdrawal schedule typically impacts the daily average salinity along the lower river in the range of 0.1-0.3 psu. To date, these efforts have suggested that any Facility salinity impacts probably could not easily be detected, other than by using continuous recorders, given the normal distributions and daily tidal ranges of salinity along the lower Peace River/upper Charlotte Harbor HBMP monitoring transect. Given the far greater natural daily and seasonal ranges of salinity variation in the lower Peace River/upper Charlotte Harbor estuary and the lack of information regarding the potential consequences of such small salinity changes on tidal estuarine processes, the ecological consequences of these small but predictable changes are exceptionally difficult to evaluate and predict. Thus, while withdrawals have resulted in predictable changes in salinity, the normal daily and seasonal variability in estuarine salinity distributions indicate that the ecological changes due to Facility withdrawals do not appear to be of a magnitude likely to be easily measured directly. This suggests that evaluating and predicting the effects of withdrawals on the salinity distributions within the lower Peace River/upper Charlotte Harbor estuarine system may ultimately best be accomplished using hydrographic and statistical modeling approaches in assessing, comparing and quantifying the potential for significant adverse harm.

- Further findings based on results of the 2006/2007 series of Facility "Pump Tests" and similar statistical models developed using data from the two USGS and three HBMP continuous recorders concluded that the maximum expected increases in salinity due to facility withdrawals would be difficult to actually measure (other than by using continuous recorders) given the normal daily range of tidal salinity variations during the periods when the facility is potentially having its greatest influence.

The conclusions reached by these different modeling efforts have similarly suggested that the predicted influences of Facility freshwater withdrawals on salinity along the lower river are typically in the range of 0.1 - 0.3 psu. To date, these efforts have suggested that any Facility salinity impacts probably could not easily be detected, other than by using continuous recorders, given the normal distributions and daily tidal ranges of salinity along the lower Peace River/upper Charlotte Harbor HBMP monitoring transect. Given the far greater natural daily and seasonal ranges of salinity variation in the lower Peace River/upper Charlotte Harbor estuary and the lack of information regarding the potential consequences of salinity changes of such a small magnitude on tidal estuarine processes, the ecological consequences of these small but predictable changes are exceptionally difficult to evaluate and predict. Thus, while withdrawals have resulted in predictable changes in salinity, the normal daily and seasonal variability in estuarine salinity distributions indicate that the ecological changes due to Facility withdrawals do not appear to be of a magnitude likely to be easily measured directly. This suggests that evaluating and predicting the effects of withdrawals on the salinity distributions within the lower

Peace River/upper Charlotte Harbor estuarine system may ultimately best be accomplished using hydrographic modeling approaches in assessing, comparing and quantifying the potential for significant adverse harm.

1.5 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, 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.

1.5.1 Water Chemistry and Water Column Physical Profiles

The primary focus of this HBMP program extends along the monitoring transect centerline from River Kilometer (RK) -2.4 south of the river's mouth upstream to RK 30.8 located just above the 761 Bridge, north of the Peace River Facility (see **Figure 1.2**). Two separate HBMP study elements incorporate both *in situ* water column profile physical measurements combined with the collection of chemical water quality sampling along the monitoring transect. Several goals are associated with both the individual and combined findings of these water quality HBMP study elements. A principal goal of both monitoring efforts is to assess the overall "health of the estuary" by collecting sufficient long-term data to statistically describe spatial and seasonal variability of the water quality characteristics of the lower Peace River/upper Charlotte Harbor Estuary, and test for significant changes over time (trends). A further goal of these HBMP elements is to determine whether significant relationships exist between freshwater inflows and the seasonal/spatial variability of key selected water quality parameters. If such relationships can be shown, then the ultimate goal becomes to determine the potential magnitude of change that might result from both existing permitted withdrawals and projected future increases, and compare such predicted changes due to withdrawals with the normal ranges of observed natural seasonal and annual variability.

Similar and comparable physical and chemical water quality parameter measurements along the upper Charlotte Harbor/lower Peace River estuarine monitoring transect are collected under these 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 psu) along a river kilometer centerline 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 psu), with freshwater being defined as the first occurrence of conductivities less than 500 ms. Historically, this isohaline sampling

effort was undertaken in conjunction with other 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 "fixed" 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 HBMP study 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 based HBMP study element.

During 2010, 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 2010 water chemistry analyses.

In response to the recommendations contained within the *2000 HBMP Mid-term 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 after extensive consultation with both the HBMP Scientific Review Panel and District staff. As a result of this consultation, a revised/ reduced long-term water quality sampling list of 12 parameters was implemented in March 2003 (**Table 1.2**).

Further descriptions, as well as complete summaries of the 2010 monitoring results and historical comparisons of the "isohaline" and "fixed" location based HBMP monitoring study elements are presented respectively in **Section 3** and **Section 4** of this report.

1.5.2 USGS 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, longer-term goal was to potentially assess any systematic changes in river salinity that might be observed due to predicted decadal increases in sea level.

In 1996 the USGS installed automated 15-minute interval water level recorders at the following two locations.

1. On a dock near Boca Grande, the estuary's largest opening to the Gulf of Mexico.

2. At approximately 15.5 kilometers upstream of the river's mouth at the end of a dock in Harbour Heights. The gaging station at Harbour Heights also measures surface and bottom conductivity/temperature at 15-minute intervals.

In November 1997 a third gage was installed on a private dock at RK 26.7, approximately three kilometers downstream of the Peace River Facility, and in December 2009 USGS added another recorder at the Facility's intake (RK 29.8). These gages also measures water level as well as surface and bottom conductivity/temperature at 15-minute intervals.

Based on consultation with USGS staff, the water level recorder information from the gage at Boca Grande was discontinued at the end of 2004. The original purpose of this gage was to assess potential increase in salinity that might be naturally occurring due to projected gradual increases in sea level expected to occur over time. However, USGS staff felt that any conclusions regarding sea level rises at this site would be compromised due to the gages location near the mouth of the pass. After consultation with the Scientific Review Panel and District, Authority staff decided to delete future collection of gage height information at the Boca Grande site from the HBMP monitoring program. The relative locations of each of these USGS gages are summarized in Table 1.3 below and depicted in **Figure 5.1**.

In 2010 the Authority became aware that USGS had modified the method used to collect near surface data in January 2005 from "floating" to "fixed depth" probes while making repairs following Hurricane Charlie (August 2004). The Authority conducted a series of analyses comparing and contrasting the near surface conductivity measurements used by both methods and was unable to detect any statistically significant differences.

Table 1.3

Summary of HBMP Continuous Recorders

Gage ID, Location and Period of Monitoring	River Kilometer
RK12 (Authority) - Manatee Zone Marker near Shell Creek – May 2008 to present	RK 12.7
HH (USGS - 02297460) – Dock at Harbour Heights - Sep1996 to present	RK 15.5
RK21 (Authority) - Manatee Zone Marker near Liverpool area - Dec 2005 to present	RK 21.9
RK23 (Authority) - Manatee Zone Marker downstream of Navigator Marina - Dec 2005 to May 2008	RK 23.4
RK24 (Authority) - Manatee Zone Marker gage near Navigator Marina - Dec 2005 to present	RK 24.5
PRH (USGS - 02297350) – Dock at Peace River Heights gage – Nov 1997 to present	RK 26.7
PRP (USGS – 02297345) – Peace River at Platt (Facility) – December 2009 to present	RK 29.8
RK30 (Authority) - Manatee Zone Marker near SR 761 Bridge – May 2008 to present	RK 30.6
RK31 (Authority) - Old Railroad Bridge upstream of Facility – May 2008 to present	RK 31.7

Summary results of 2010 information for the continuous USGS recorders located at Harbour Heights (RK 15.5), Peace River Heights (RK 26.7) and the Facility (RK 29.8) are further presented in **Section 5** of this document.

1.5.3 Additional HBMP Continuous Recorders

During 2005, the Authority evaluated a number of possible alternative sites and methodologies to be utilized in the deployment of additional continuous conductivity monitoring devices downstream of the Facility. The objective was to deploy additional continuous conductivity recorders at other monitoring sites to be used as part of an expanded HBMP study element directed specifically toward measuring Facility withdrawal impacts under lower flow conditions. Analyses of conductivity data from these new monitoring locations were recently used as part of both the recent HBMP *Pump Test Study* and the *2006 HBMP Comprehensive Summary Report* to extend previous graphical and statistical results with regard to directly measuring salinity changes due to withdrawals.

The first step to deploying additional continuous recorders was to determine the potential spatial distribution of arraying such new continuous recorders downstream of the Facility in order to maximize their ability to detect salinity changes (impacts) that could be directly attributed to Facility freshwater withdrawals. Existing statistical models and graphical analyses of salinity/flow relationships were reviewed from the long-term HBMP fixed stations and USGS continuous recorders in this reach of the lower Peace River. These results were then evaluated in relationship to potential existing physical structures (docks, pilings, etc.) to which additional continuous recorders might be attached (**Table 5.3**). A series of potential new monitoring sites located between the two existing USGS continuous recorders were selected for evaluation

One option considered was to locate a third land-based gage similar in design to the two existing USGS continuous recorders on one of the single family docks located just upstream (between River Kilometers 24.5 and 25.0) of the entrance to Navigator Marina. However, a series of other potential sites existed further downstream, due to the recent placement of Manatee Speed Zone markers along the river. The Authority was able to receive permission from US Fish and Wildlife to establish continuous recorders using these markers. Three of these Manatee Speed Zone markers were chosen by the Authority for the initial deployment in December 2005 of HBMP continuous recorders measuring near surface conductivity.

Based on comments and recommendations made by members of the HBMP Scientific Review Panel at its meeting of December 2007, the Authority added two additional continuous recorders and relocated the recorder previously at RK 23.4 in May 2008. The intent of these new recorders locations was to extend upstream and downstream the area along the lower river covered by the continuous recorder array.

- A new recorder was installed downstream of the USGS Harbor Heights gage on a Peace River Manatee Zone Marker (RK 12.7) below the confluence with Shell Creek. Unlike the other HBMP recorders, this instrument was installed near the bottom of the water column (~ 1.7 meters) and measures both conductivity, temperature and dissolved oxygen levels continuously at 15-minute intervals.

- A new recorder was also installed above the USGS Peace River Heights gage on a Manatee Zone Marker (RK 30.6) just upstream of the Facility's intake near the SR 761 Bridge. This recorder measures subsurface conductivity and temperature at 15-minute intervals.

- The HBMP recorder previously located at RK 23.4 was relocated upstream to the old railroad trestle (RK 31.7) above the Facility. This recorder also measures subsurface conductivity and temperature at 15-minute intervals.

The locations of the recorders during 2010 (including the old recorder at RK 23.4) are summarized in Table 1.3 above and in **Figure 5.1**. The methodologies used for deployment of the continuous recorders are depicted in **Figure 5.8** and **Photographs 5.1** through **5.7.**

1.6 Summary of 2010 Results

The following text and tables compare data collected during 2010 with similar average values for key parameters previously compiled during various elements of the ongoing long-term monitoring programs. The following key HBMP project elements are included in this summary.

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 2010 data with averages of similar data collected over the preceding 34-year period (1976-2009), 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 early 2002 (see **Figures 2.3** and **2.4**). A weaker El Niño occurred at the end of 2002, and freshwater flows during 2003, 2004 and 2005 were generally above average. Rainfall in the Peace River watershed during the recent 2006-2009 interval by comparison was well below average, while seasonal rainfall patterns during 2010 returned to more normal conditions.

- **Flows** – Average mean daily Peace River flow at the Arcadia gage during 2010 was 704 cfs, which is slightly below the 878 cfs average over the 35 years of HBMP monitoring (1976-2010). The average flow during 2010 was well above the annual average flow of 381 cfs over the preceding four-year interval between 2006 and 2009. However, it was also well below the average flow of 1538 cfs over the much wetter five-year interval between 2001 and 2005.

Overall, annual mean flow at the USGS Peace River at Arcadia gage during 2010 was just 79.6 percent of the average daily flow over the preceding long-term 1976-2009 period (see **Table 2.9**). In comparison, the sum of average daily flows from the Peace River at Arcadia, Horse Creek, Joshua Creek, and Shell Creek during 2010 was roughly 85 percent of the average daily flows over the longer term 1976-2009 HBMP monitoring period.

- **Withdrawals –** Through the first two months of 2010, the Peace River Facility operated under District modifications to the Water Use Permit and Executive Orders that temporarily altered the low flow cutoff and/or temporarily increased the percent of flow that could be withdrawn from the river. During the remainder of 2010 the Facility operated under the conditions of its 1996 permit. Total Peace River Facility withdrawals during 2010 were approximately 4.7 percent of the total gaged freshwater flow measured at the USGS Arcadia gage, 3.4 percent of the upstream gaged flow at the Facility, and 2.6 percent of the combined average daily inflows upstream of the U.S. 41 Bridge. During the entire period of Peace River Facility withdrawals (1980-2010), total combined withdrawals have been approximately 1.53 percent of the corresponding gaged Peace River at Arcadia flows and 1.23 percent of the corresponding combined daily flows of the Peace River, and Horse, Joshua, and Shell Creeks.

  There were some days during 2010 when Peace River Facility withdrawals exceeded the seasonally designated maximum percents allowed by the permit . Such exceedances of the permitted percent withdrawals primarily result from subsequent USGS revisions of the provisional daily flow information available to the Authority at the time of actual withdrawals. Often there are extended periods each year when the Peace River Facility does not withdraw any water from the river due to either the low flow threshold and/or Facility operations. During 2010, the facility did not withdraw any water from the river approximately 46 percent of the time. Maximum Facility withdrawals have increased both in 2002 and 2009 due to the completed Facility expansions, which have resulted in increases in the Authority's ability to divert, treat and store larger daily amounts of freshwater when river flows meet the District's threshold criteria.

- **Salinity Spatial Distribution –** Freshwater inflows to the lower Peace River during 2010 were generally higher than during the preceding 2006-2009 drought (see **Section 2**). The influences of the slightly drier than usual conditions that characterized overall 2010 flows are reflected in the seasonal and average spatial distributions of each of the four sampled moving isohalines along the HBMP monitoring transect. Overall, the relative spatial distributions of each of the isohalines during 2010 reflected slight upstream movements when compared with their previous long-term 1983-2009 averages.

Comparisons of means between 2010 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 **Table 3.8** and **Table 4.4**.

- **Temperature** – Median annual water temperatures during 2010 at each of the four isohalines were, on average, slightly higher than corresponding values measured over the preceding 27-year period (1983-2009). However, corresponding mean annual water temperatures for the year by comparison were several degrees below their long-term averages. The much lower than average mean water temperatures during 2010 reflect unusually cold conditions at both the beginning and the end of the year, caused by a series of atypical cold fronts during both the winters of 2009 and 2010.

- **Water Color** – Seasonally water color levels during 2010 were similar or just slightly higher than average levels over the preceding long-term historic period (1983-2009). This is in direct comparison with the generally lower levels observed during the 2006-2009 drought when color levels in the lower Peace River/upper Charlotte Harbor estuarine system were well below their long-term averages within all but the highest salinity isohaline.

- **Extinction Coefficient** – The rates of measured light attenuation at each of the four HBMP isohalines reflect the interactions of both ambient color and phytoplankton biomass (chlorophyll *a*). Comparisons of mean extinction values among the four isohalines during 2010 with corresponding long-term averages show much lower levels at all but the most downstream, highest salinity level (20 psu). This result probably reflects the overall slightly lower than average annual flows that characterized 2010.

- **Nitrite/NitrateNitrogen** - During 2010, the average concentrations of this major inorganic form of nitrogen were generally similar to the observed long-term (1983-2009) historical annual averages. The one exception that skewed the annual 2010 averages for the upstream freshwater isohaline was the occurrence of a high value in January. The data clearly indicate that inorganic nitrogen levels were below normal in the lower Peace River/upper Charlotte Harbor estuarine system during the recent years of extended drought. Monthly comparisons among the isohalines indicate nitrite/nitrate inorganic nitrogen concentrations in the lower Peace River/upper Charlotte Harbor estuarine system are characterized by a distinct spatial gradient that shows strong responses to seasonal patterns of freshwater inflows. Concentrations typically decrease rapidly with increasing salinity, with inorganic nitrogen levels within the 20 psu isohaline often being near or at method detection limits over much of the year. Normally, estuarine inorganic nitrogen concentrations decline to their lowest levels during the relatively drier spring months. This is a result of phytoplankton populations responding to increasing water temperatures and light, and increased primary production removing available inorganic nitrogen. As a result, inorganic nitrogen levels in the lower river and upper harbor are typically at their lowest levels in the late spring, just prior to increases in summer wet-season inflows.

- **Ortho-phosphorus** - Estuarine inorganic phosphorus concentrations in the lower Peace River and upper Charlotte Harbor are heavily influenced by the characteristically "very" high natural levels found in the Peace River watershed. As a result, the observed difference in concentrations among the four isohalines primarily reflects conservative dilution by Gulf waters. Unlike inorganic nitrogen, seasonal observed changes in phosphorus concentrations in the estuary are for the most part not affected by biological uptake. 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). Historically, since the late 1970s, there had been marked declines in inorganic phosphorus levels in the lower Peace River/upper Charlotte Harbor estuarine system due to declines in the combined influences of phosphate mining and processing in the upper reaches of the basin. However, following Hurricane Charlie and the subsequent Hurricanes Francis and Jeanne during the late summer of 2004, inorganic phosphorus concentrations have dramatically increased throughout the lower Peace River/upper Charlotte Harbor estuarine system. Ortho-phosphorus concentrations remained well above recent historic levels throughout much of 2005-2009 and have recently rapidly declined. The direct cause for the observed increased levels seems to have been related to the on-going closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin (see Section 7 of the previous *2008 HBMP Data Report*). Annual average ortho-phosphorus concentrations at each of the four isohalines were generally lower in 2010 than the corresponding long-term averages (1983-2009).

- **Nitrogen to Phosphorus Atomic Ratios** – Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations in 2010, as indicated by the long-term averages, show nitrogen to almost always be the limiting macronutrient at each of the four isohalines. The possible exception occurred during January at the freshwater location when a very high level of inorganic nitrite/nitrate nitrogen was observed.

- **Silica** – Seasonally, silica levels in the lower Peace River/upper Charlotte Harbor estuarine system typically peak following periods of high freshwater inflows. Although silica levels also seem to be positively correlated with higher water temperatures (possibly reflecting recycling from riverine/estuarine sediments), historically lower silica concentrations in higher salinity zones of the estuary often occurred during corresponding periods of combined low spring freshwater inflow and spring increases in phytoplankton diatom numbers. Between 1983 and the late 1990s these seasonal patterns of increasing and decreasing reactive silica concentrations remained relatively stable with no indications of any consistent systematic changes over time. However, as discussed in previous HBMP reports, silica levels started showing increasing concentrations during the late 1990s. Then, as flows declined during the extended 1999-2002 drought, silica levels also declined. However, following the return of higher than average flows during 2003-2005 measured silica levels in the estuary again began rapidly increasing. Even though flows between 2006-2008 were below normal, silica levels throughout the lower river/upper harbor estuary continued to reach historically high levels during the summer wet-seasons. As with ortho-phosphorus, the proximate cause for these increasing levels seems to be related to the on-going closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin. However, while peak levels during 2009 and 2010 were somewhat lower than during the immediate preceding years, annual average concentrations during 2010 were well above their long-term averages at each of the four moving isohaline bases monitoring locations.

- **Chlorophyll *a*** – The seasonal patterns of freshwater inflows to the estuary during 2010 were characterized by slightly drier than usual conditions when compared to the long-term average conditions (see **Section 2**). Typically, seasonal periods of increased flows produce both higher than average inputs of limiting inorganic nutrients (nitrogen), as well as higher than average levels of water color (resulting in greater light attenuation). The rapid increase in flows in July following the dry spring was accompanied by sharp increases in phytoplankton biomass at the 12 psu isohaline and a abnormally very high observed peak at the 6 psu isohaline in August. With the exception of these two unusual events, chlorophyll *a* concentrations within the Peace River/upper Charlotte Harbor estuarine salinity zones were generally similar to their preceding long-term (1983-2009) corresponding averages. As in previous years, phytoplankton levels within the intermediate (6 and 12 psu) isohalines reflected a balance between stimulation due to increased nitrogen inputs, and light inhibition resulting from higher water color. During previous years, taxonomic counts indicated that such "bloom" events within these intermediate salinity zones were often predominantly characterized by high numbers of dinoflagellates (*Dinophyceae*) or diatoms (*Bacillariophycae*).

1.7 Conclusions

This document represents the fifteenth Annual Data Report submitted under the expanded Hydrobiological Monitoring Program (HBMP) initiated in 1996 in compliance with Water Use Permit 20010420. The graphical and summary analyses presented in this document do not indicate any substantial changes, or atypical events in either the physical or biological data collected during 2010, other than those previously noted. These include:

- Freshwater inflows during 2010 were influenced by slightly drier than normal conditions, especially during the normal spring dry-season and the fall/winter periods.

- There has been a continuation, but slight decline, in the previously noted long-term increase in reactive silica concentrations noted at the lower Peace River/upper Charlotte Harbor monitoring locations.

- There are strong indications that inorganic phosphorus concentrations in the freshwater entering the estuary have increased in recent years, following decades of major declines that began in the late 1970s. However, observations during 2009 and 2010 show that levels have substantially declined again to levels near where they were prior to the observed recent increase.

- The observed recent increases in silica and phosphorus seem to have been linked to the on-going closure of phosphogypsum stack systems in the upper Peace River watershed.

The "limited" analyses presented in the *2010 HBMP Annual Data Report* do not suggest that there have been any long-term, systematic changes resulting from either current or historic water withdrawals by the Peace River Regional Water Supply Facility.

1.8 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 *2010 HBMP Annual Data Report* CD in the directory labeled 2010 Data Sets, as files in ASCII, Excel and/or SAS formats. Table 1.3 provides a summary and links to descriptions of the variables within each of the SAS data sets.

Table 1.3
Long-term Historical HBMP Data Sets

Data Set Name	Time Period	Brief Description
HBMP SAS Data Sets		
Flwd10.sd2	1931-2010	Historic daily flow data for: Peace at Bartow, Fort Meade, Zolfo Springs and Arcadia. Daily tributary flows for: Horse Creek near Arcadia; Joshua Creek near Nocatee; Prairie Creek near Ft. Ogden; and Shell Creek near Punta Gorda. Daily flows for the Myakka River near Sarasota and Big Slough near North Port. Historic daily Peace River and Shell Creek Water Treatment Facility withdrawals. All values in cfs.
Cmov8310.sd2	1983-2010	Water quality and phytoplankton biomass measurements (1983-2010) from monthly surface samples collected at each of the four moving isohalines. Relative locations reflect distances from the river mouth in kilometers.
Hymov10.sd2	1983-2010	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.
Hyfix10.sd2	1996-2010	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 Treatment Facility.
Cfix9610.sd2	1996-2010	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 Treatment Facility.
Efix9610.sd2	1996-2010	Water column extinction coefficients collected at the fixed sampling locations.
Boca04.sd2	1996-2004	Water level at 15-minute intervals from the continuous recording gage near Boca Grande. Discontinued.
HH10.sd2	1996-2010	Water level, and surface and bottom conductivity and temperature at 15-minute intervals from the continuous recording gage on the Peace River near Harbor Heights (River Kilometer 15.5).
PRH10.sd2	1997-2010	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).
PLATT10.sd2	2009-2010	Water level, and surface and bottom conductivity and temperature at 15-minute intervals from the continuous recording gage on the Peace River at the Facility intake (River Kilometer 29.8).
RK21_10.sd2	2006-2010	Near surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on the Peace River near Liverpool side channel (River Kilometer 21.9).
RK23_10.sd2	2006-2008	Near surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on the Peace at River Kilometer 23.4. Discontinued.

Table 1.3
Long-term Historical HBMP Data Sets

Data Set Name	Time Period	Brief Description
RK24_10.sd2	2006-2010	Near surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on the Peace River just downstream of Navigator Marina (River Kilometer 24.5).
RK12_10.sd2	2008-2010	Near bottom conductivity, temperature and dissolved oxygen at 15-minute intervals from the HBMP continuous recording gage attached to a channel marker located on the Peace River just downstream of Shell Creek (River Kilometer 12.9).
RK30_10.sd2	2008-2010	Near surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on the Peace River just upstream of the Facility (River Kilometer 30.6).
RK31_10.sd2	2008-2010	Near surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the old railroad trestle located on the Peace River just upstream of the Facility (River Kilometer 31.7).
Environmental Quality Laboratory (EQL) Background Data Sets		
SAS Version 6.0.8 Data Sets		
Chall_2.sd2	1976-1990	EQL fixed station Charlotte Harbor background water chemistry data.
Hydroall.sd2	1976-1990	EQL fixed station Charlotte Harbor hydrolab water column profile data.
SAS Version 6.1.3 Data Sets		
Chem_v12.sd2	1976-1990	EQL fixed station Charlotte Harbor background water chemistry data.
Hall_v12.sd2	1976-1990	EQL fixed station Charlotte Harbor hydrolab water column profile data.

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

1.9 Problems Encountered During 2010

The following outlines the limited number of problems and errors encountered during data collection for various elements of the 2010 HBMP monitoring program. Overall, very few data collection problems and/or other data issues other than related to instrument failures were encountered during 2010.

- **USGS Continuous Recorders** – Due to short-term instrument failures, some records for gage height, temperature and/or conductivity are unavailable for the Harbour Heights (RK 15.5) and Peace River Heights (RK 26.7) gaging sites during 2010.

- **HBMP Continuous Recorders** – Also due to instrument issues, some of the data collected by the five HBMP continuous recorders were flagged as questionable, and were not used in the presented analyses. The most common instances of such occurrences (although infrequent) were related to near bottom 15-minute dissolved oxygen readings at RK 12.9.

2.0 Peace River Gaged Flows and Regional Water Supply Facility Withdrawals

The purpose of this section is to present a general overview and summarize 2010 gaged river freshwater inflows to the lower Peace River/upper Charlotte Harbor Estuary, as well as provide comparisons with the relative magnitudes of historic flows and the timing of the Authority's freshwater withdrawals. This section presents comparisons of 2010 freshwater inflows to the harbor from the lower Peace River and permitted freshwater withdrawal with similar longer-term summary information over the 1976-2010 time interval, which corresponds with the historic period of HBMP monitoring.

Previously presented **Figures 1.1** and **1.2** depict the location of the Peace River Regional Water Supply Facility (Facility) in relation to both the lower Peace River watershed and the lower Peace River/upper Charlotte Harbor Estuary. As indicated, the Peace River Facility intake withdrawal structure is located on a side channel, in the tidal portion of the lower river estuarine system. This reach of the lower tidal river is often characterized by brackish conditions during seasonal periods of low freshwater inflow (< 90 cfs as measured by the USGS Peace River at Arcadia gage). The long-term relationships between combined USGS gaged inflows upstream of the Facility (Peace River at Arcadia, Horse Creek near Arcadia and Joshua Creek at Nocatee) and subsurface and near bottom conductivities measured approximately two kilometers downstream of the Facility's river intake at the USGS continuous recorder located at River Kilometer (RK) 26.7 are shown in **Figures 5.4** and **5.5**.

Table 2.1 summarizes the series of USGS monitoring gages used by the HBMP to assess both long-term yearly and seasonal patterns of freshwater inflows to the lower Peace River/upper Charlotte Harbor estuarine system. Both historic (http://waterdata.usgs.gov/nwis) and recent/real time (http://waterdata.usgs.gov/fl/nwis/current/?type=flow) flow data collected by USGS were obtained from the USGS streamflow web sites and used to update the long-term HBMP watershed streamflow database. Since flow data are retrieved for the annual HBMP data reports during the first part of each calendar year, the flows for the last three months of the previous calendar year often represent "provisional" rather than "accepted" USGS data. In the instance of the *2010 HBMP Data Report* October through December 2010 flow data for the gages listed in Table 2.1 had not been updated by USGS to "accepted" prior to being downloaded for the report.

Table 2.1
Primary USGS Gages Used in HBMP Hydrology Analyses

USGS Gage Name	Gage Reference Number	Upstream Basin Area (Square Miles)	Period Of Record (Complete Years)
Peace River at Bartow	02294650	390	1940-2010
Peace River at Fort Meade	02294898	480	1975-2010
Peace River at Zolfo Springs	02295637	826	1934-2010
Peace River at Arcadia	02296750	1367	1932-2010
Joshua Creek at Nocatee	02297100	132	1951-2010

Table 2.1
Primary USGS Gages Used in HBMP Hydrology Analyses

USGS Gage Name	Gage Reference Number	Upstream Basin Area (Square Miles)	Period Of Record (Complete Years)
Horse Creek near Arcadia	02297310	218	1951-2010
Prairie Creek near Fort Ogden	02298123	233	1964-2010
Shell Creek near Punta Gorda	02298202	373	1966-2010
Myakka River near Sarasota	02298830	229	1937-2010
Big Slough near North Port	02299450	81	2002-2010

2.1 2010 Gaged Flows to the Lower Peace River

Daily Peace River discharges (in cubic feet per second) at the USGS gaging station at Arcadia, Florida during the January through December 2010 reporting period are depicted in **Figure 2.1**. Freshwater inflows during 2010 were characterized by much drier than normal conditions throughout the first five months of the year and during much of the fall (**Figure 2.2**), extending the drought conditions that began in 2006. While the overall seasonal pattern of gaged flow was typical of that normally observed, the actual rates of flow during the drier months of the year were below normal (**Figure 2.2**).

Much of the decline in summer flows observed during 2006, 2007 and 2008 can be directly attributed to the predominant atypical patterns of wet-season afternoon thunderstorm activity that took place throughout much of the summer during those years. Summer thunderstorms in southwest Florida normally build up in the early afternoon in the interior of the state and move toward the coast later in the afternoon. However, during the recent drought the typical afternoon thunderstorm activity often tended to build and remain along the coastline (**Map 2.1**). The result was that many of the coastal USGS stream flow gages within smaller coastal watersheds actually experienced higher flows throughout much of the year when compared to the much larger sub-basins in the interior of the Peace River watershed.

Tropical storms (Table 2.2) can have dramatic influences on rainfall/flow patterns in the Peace River watershed. The reduced influence of tropical storms on summer wet-season rainfall patterns during the recent 2006-2008 drought was far less than during the preceding, unusually active 2004-2005 hurricane seasons (**Maps 2004 and 2005**). Since 2005, only a few named tropical storms in 2006 (Ernesto), 2007 (Olga) and 2008 (Fay) have briefly influenced rainfall in the Peace River watershed (**Maps 2006, 2007 and 2008**). During both 2009 and 2010 there were no named tropical storms that directly influenced rainfall patterns in the Peace River watershed (**Maps 2009** and **2010**).

The seasonal patterns of freshwater inflows during 2010 are graphically summarized in relation to the preceding long-term historical averages (1976-2009) in **Figure 2.2**. 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 2.2** for Q90 represents a level of freshwater inflow that, over the long-term

Table 2.2
Maps Showing the Tracts of Tropical Storms/Hurricanes during HBMP Monitoring Including Cool/Dry (1975-1994) and the Recent Warm/Wet (1995-2010) Atlantic Multidecadal Oscillation Phases

1975	1976	1977	1978	1979	1980
1981	1982	1983	1984	1985	1986
1987	1988	1989	1990	1991	1992
1993	1994	1995	1996	1997	1998
1999	2000	2001	2002	2003	2004
2005	2006	2007	2008	2009	2010

1976-2009 average, is only exceeded ten percent of the time on that particular day. This graphic clearly shows that 2010 gaged Peace River at Arcadia flows during the typically dry months of March and April were substantially above corresponding median (Q50) levels, while Peace River at Arcadia flows were well below the long-term average throughout the last three months of the year. Peace River at Arcadia gaged flows were actually above the recent historic long-term averages during much of the summer wet-season period. Plots of gaged and total upstream flows for both 2010 and the long-term period of HBMP monitoring (1976-2010) are presented in Table 2.3 for selected locations, as well as for the entire upper harbor.

Table 2.3
Freshwater Inflows During 2010 and the Period 1976-2010

Figure	Description
Figure 2.1	Daily Peace River flow at Arcadia (2010)
Figure 2.2	Daily 2010 River flow at Arcadia in relation to long-term daily statistical averages
Figure 2.3	Daily Peace River flow at Arcadia (1976-2010)
Figure 2.4	Monthly mean Peace River flow at Arcadia (1976-2010)
Figure 2.5	3-Month moving average Peace River flow at Arcadia (1976-2010)
Figure 2.6	Total daily flow - Peace River + (Horse + Joshua) Creeks (2010)
Figure 2.7	Total daily flow - Peace River + (Horse + Joshua) Creeks (1976-2010)
Figure 2.8	Mean monthly flow - Peace River + (Horse + Joshua) Creeks (1976-2010)
Figure 2.9	3-Month moving average flow - Peace River + (Horse + Joshua) Creeks (1976-2010)
Figure 2.10	Total daily flow - Peace River + (Horse + Joshua + Shell) Creeks (2010)
Figure 2.11	Total daily flow - Peace River + (Horse + Joshua + Shell) Creeks (1976-2010)
Figure 2.12	Mean monthly flow - Peace River + (Horse + Joshua + Shell) Creeks (1976-2010)
Figure 2.13	3-Month moving average flow - Peace River + (Horse + Joshua + Shell) Creeks (1976-2010)
Figure 2.14	Total daily gaged flow – (Peace + Myakka) Rivers + (Horse + Joshua + Shell) Creeks (2010)
Figure 2.15	Total daily gaged flow - (Peace + Myakka) Rivers + (Horse + Joshua + Shell) Creeks (1976-2010)

Table 2.3
Freshwater Inflows During 2010 and the Period 1976-2010

Figure	Description
Figure 2.16	Mean monthly gaged flow - (Peace + Myakka) Rivers + (Horse + Joshua + Shell) Creeks (1976-2010)
Figure 2.17	3-Month moving average gaged flow - (Peace + Myakka) Rivers + (Horse + Joshua + Shell) Creeks (1976-2010)

Daily Peace River at Arcadia gage flows between 1976 (the beginning of the HBMP) and the most recent year (2010) are shown in **Figure 2.3**. This figure clearly shows the magnitude of the extended drought that occurred between 1999 and 2002, the higher than average flows that immediately followed during 2003, 2004 and 2005, as well as the very dry conditions that extended from 2006 through the first half of 2009. The figure clearly shows the magnitude of the drought during 2007, which was characterized by a lack of wet-season flows beyond anything observed since the beginning (1976) of HBMP monitoring.

Peace River at Arcadia gaged flows over the same long-term period are further depicted as mean monthly values in **Figure 2.4** and again based on 3-month moving averages in **Figure 2.5**. Analogous graphical plots for both 2010 and the 1976-2010 interval are presented in **Figures 2.6** through **2.9** for the total gaged flow upstream of the Peace River Treatment Facility (Peace River at Arcadia + Horse and Joshua Creeks). Similar plots are further shown in **Figures 2.10** through **2.13** for the total gaged lower Peace River flow at the U.S. 41 Bridge (Peace River at Arcadia + Horse, Joshua and Shell Creeks). **Figures 2.14** through **2.17** show comparative plots of daily, mean monthly, and 3-month moving average total gaged freshwater inflows to upper Charlotte Harbor by including Myakka River flows. (However, it should be noted that the USGS Myakka River near Sarasota gaging location does not include runoff from a substantial portion of the lower Myakka River watershed.) Combined, these graphics again clearly indicate the historically dry conditions that have characterized much of the past five years (2006-2010).

Comparison of the data displayed in **Figures 2.2** and **2.3** shows that Peace River average daily flow at Arcadia during 2010 was approximately 79.6 percent of that calculated over the preceding longer 1976-2009 period. The data displayed in **Figures 2.6** and **2.7** for the sum of average daily flows upstream of the Peace River Facility indicate that they were roughly 85.0 percent of the average over the longer preceding time period of HBMP monitoring (1976-2009). In comparison, **Figures 2.10** and **2.11** show that the addition of Shell Creek flows resulted in the total freshwater inflows of the lower Peace River to the estuary during 2010 was approximately 83.5 percent of the longer 1976-2009 term average.

Table 2.4 provides comparisons of the relative contributions of each of the downstream USGS gages on the major tributaries to the lower Peace River over both the recent historic period (1976-2009) and the current reporting year (2010). Relative percentages are provided both upstream of the Peace River Facility and at the U.S. 41 Bridge (downstream of the river's confluence with Shell Creek). These summary results clearly show that during 2010, flows in each of the USGS gaged watersheds contributing to lower Peace River freshwater inputs to upper Charlotte Harbor were relatively similar to their long-term averages (with the 2010 percent contribution of Peace at Arcadia being slightly below and Joshua Creek being slightly above the long-term average.). This indicates that the low periods of rainfall (and flows) experienced during the drier intervals during 2010 generally occurred throughout the watershed and were not primary isolated to the interior as during the previous periods of drought.

Table 2.4
Comparisons of Relative Contributions of Gaged Flows Over Recent Historic (1976-2009) and the Current Period (2010)

Time Period	Percent of Total Gaged Flow at Facility			Percent of Total Gaged Flow at U.S. 41 Bridge			
	Peace at Arcadia	Horse Creek	Joshua Creek	Peace at Arcadia	Horse Creek	Joshua Creek	Shell Creek
1976-2009	75.5	15.3	9.1	58.2	11.8	7.0	22.9
2010	70.8	15.3	13.9	55.6	12.1	11.0	21.2

2.2 Peace River Facility Withdrawals

Due to extended drought conditions during 2006 and concern about the upcoming 2007 dry season, the Authority asked and received permission from the District in December 2006 to reduce the low flow Peace River at Arcadia withdrawal threshold from 130 cfs to 90 cfs until the end of the drought using the 1996 permit's 10 percent criteria. However, due to the unexpected historic low Peace River flows during the summer of 2007, the District issued an additional series of Executive Orders that temporarily modified the Authority's Peace River Facility withdrawal schedule (Table 2.5). The series of District Executive Orders modified the withdrawal schedule to include withdrawals based on the total gaged flows upstream of the Facility (Peace River at Arcadia, plus Horse Creek near Arcadia and Joshua Creek near Nocatee), modifications of the low flow threshold, and increases in the allowable percent withdrawals.

The Executive Orders were initially based on the draft criteria presented in the District's proposed Minimum Flow and Level (MFL) for the lower Peace River (Table 2.6). The draft Lower Peace River MFL, for example, proposed that during seasonal Block 2 (October 27 to April 19) the maximum permitted withdrawals should be 14 percent of all flows between 90 and 330 cfs based on the combined gaged flows upstream of the Facility. Maximum withdrawals could then increase to 21 percent of the combined gaged flows above the long-term historic median flow of 330 cfs during the Block 2 time interval.

In April 2010 the District revised the proposed MFL's by modifying the maximum withdrawals allowable, after evaluating comments received on the initial draft report covering both the lower Peace River and Shell Creek MFLs. The District's revised MFL for the lower Peace River eliminated the criteria of adjusting withdrawals based on whether flows were above or below the calculated seasonal mean, added a 625 cfs upper threshold prior to changing the allowable percent withdrawal to both Blocks II and III, and delayed a final proposed Shell Creek MFL. In August 2010 the District approved and implemented the final MFL for the lower Peace River (Table 2.7).

Table 2.5
Modifications to the Normal 1996 Permitted Withdrawal Schedule

Event	Effective Dates	Low Flow Threshold	Gages Used	Percent Withdrawal
Temporary WUP	12/1/06 to 8/12/07	90 cfs	Peace River at Arcadia	10%
Executive Order	8/13/07 to 8/29/07	130 cfs	Three gages upstream of the Facility	12%
Executive Order	8/30/07 – 10/31/07	90 cfs	Three gages upstream of the Facility	12%
Executive Order*	11/1/07 – 4/19/08	90 cfs	Three gages upstream of the Facility	14% to 330 cfs 21% above 330 cfs
Executive Order*	4/20/08 – 6/25/08	90 cfs	Three gages upstream of the Facility	10% to 221 cfs 26% above 221 cfs
Executive Order*	6/26/08 – 10/26/08	90 cfs	Three gages upstream of the Facility	12% to 1370 cfs 15% above 1370 cfs
Executive Order*	10/23/08 -7/15/09	90 cfs	Three gages upstream of the Facility	**4/20-6/25** 10% to 221 cfs 26% above 221 cfs **6/26-10/26** 12% to 1370 cfs 15% above1370 cfs **10/27-4/19** 14% to 330 cfs 15% above 330 cfs
Executive Order**	7/16/09 –March 2010	Same as above but increases maximum withdrawal from 90 to 120 mgd		
4/30/10 – Executive Orders ended and withdrawals returned to the original permit conditions				

* Note 1: The temp WUP was extended each month by the governing board until the first Executive Order was approved

** Note 2: Variable percent withdrawal based on District proposed MFL criteria

Table 2.6
Initial Daft District Proposed Lower Peace River Withdrawals
(based on combined USGS gaged flow at three upstream gages)

Block	Mean Flow	Allowable Percent Reduction if Flow:	
		Below the Median	Above the Median
Block 1 (April 20th – June 25th)	221	10	26
Block 2 (October 27th – April 19th)	330	14	21
Block 3 (June 26th – October 26th)	1370	12	15

Table 2.7
Final Adopted District Lower Peace River Withdrawals
(based on combined USGS gaged flow at three upstream gages)

Block	Allowable Percent Reduction in Flow	
Block 1 (April 20th – June 25th)	16%	
Block 2 (October 27th – April 19th)	16% if flow < 625 cfs	29% if flow > 625 cfs
Block 3 (June 26th – October 26th)	16% if flow < 625 cfs	38% if flow > 625 cfs

The temporary modifications to the Facility's 1996 Water Use Permit were in direct response to the severity of the 2006/2009 drought and were not a permanent change to the Authority's 1996 permitted 10 percent withdrawal based solely on Peace River at Arcadia gaged flows. However, the District adopted a final MFL for the lower Peace River based on the combined flows of the three upstream gages and the Authority completed construction of the new 6 billion gallon reservoir during 2009. The Authority has therefore requested a revised withdrawal schedule based on the District's adopted MFL in order to provide for increased utilization of its increased off-stream storage and improve reliability for the same 32.7 mgd average day delivery of water permitted in the Facilities existing 1996 District permit.

Daily freshwater withdrawals (in cubic feet per second) by the Peace River Facility during 2010 are shown in **Figure 2.18**. Several items of note are depicted in this figure. The first being that, even with the temporary modifications of withdrawal schedule (Table 2.5), there were extended periods when the Peace River Facility did not withdraw water from the river. During 2010, the Facility did not withdraw water from the river (except for a few brief periods) from early March through the first part of July. Even with the District's temporary withdrawal schedule modifications, the Peace River Facility did not withdraw water from the river 46.9 percent (167 days) of the time during 2010. Reasons for the Facility not withdrawing water on a given day or time interval can be:

- Upstream USGS gaged stream flows are below the designated low flow threshold for freshwater withdrawals
- Poor water quality (conductivity, taste/odor)
- Facility maintenance
- Insufficient storage capacity (full existing storage system) even with the 2009 completion of the new 6 billion gallon reservoir

Daily withdrawals since Facility startup are shown from 1980-2010 in **Figure 2.19**. This figure clearly indicates the increase in maximum withdrawals beginning in the later half of 2002 following the Facility's previous recent expansion, which increased the Peace River Treatment Facility's physical ability to divert, treat and store larger daily amounts of freshwater. During 2009 the Authority finished implementing the most recent series of expansions to the Peace River Facility, which were undertaken as part of ongoing plans to meet projected future increasing water demands expected due to projected future regional growth in the member counties. These expansions included increasing the Facility's pumping capacity from the river from 44 mgd to 90 mgd (the current permit limit) and construction that increased the Facility's treatment capacity to 48 mgd (twice the previous capacity), and construction of a new regional off-stream reservoir with a capacity of approximately 6 billion gallons.

Additional figures depicting Peace River Facility withdrawals in relation to different combinations of total gaged flows are presented in Table 2.8.

Table 2.8

Peace River Water Treatment Facility Withdrawals and Freshwater Inflows During 2010 and the Period 1980-2010

Figure	Description
Figure 2.18	Daily water treatment facility withdrawals (2010)
Figure 2.19	Daily water treatment facility withdrawals (1980-2010)
Figure 2.20	Monthly mean water treatment facility withdrawals (1980-2010)
Figure 2.21	3-month moving average water treatment facility withdrawals (1980-2010)
Figure 2.22	Daily Peace River flows at Arcadia and water treatment facility withdrawals (2010)
Figure 2.23	Daily total gaged flow at the Facility (Peace River at Arcadia + Horse + Joshua Creeks) and water treatment facility withdrawals (2010)
Figure 2.24	Daily total gaged flow at river's mouth (Peace River at Arcadia + Horse + Joshua + Shell Creek) and water treatment facility withdrawals (2010)
Figure 2.25	Peace River flows at Arcadia vs. water treatment facility withdrawals (2010)
Figure 2.26	2010 water treatment facility withdrawals as percent of combined USGS upstream gaged flows

Plots of the monthly means and 3-month moving averages of withdrawals over the 1980-2010 period are depicted in **Figures 2.20** and **2.21.** The effects of the 1999-2001 long-term drought on Facility water withdrawals, the higher than average flows in 2003-2005, the very dry conditions since 2006, as well as the Facility's increased treatment capacity following the 2002 and 2009 expansions are clearly evident in these two figures**.** Seasonal relationships between 2010 Peace River total gaged inflows (at Arcadia, the Facility and U.S. 41 Bridge) and Peace River Facility withdrawals are further depicted in **Figures 2.22** through **2.24**.

Figure 2.26 shows Facility withdrawals from the river during 2010 relative to the percent of preceding daily gaged Peace River at Arcadia flow. Due to the drought conditions during 2006-2009 the District issued Executive Orders (Table 2.5) that both altered the percent of flow available for withdrawal and changed the amount of river flow to also include gaged daily inflows from both Horse and Joshua Creeks.

Figure 2.26 indicates that Facility withdrawals at times exceeded the 1996 established 10 percent withdrawal criteria, either due to the District's drought related Executive Orders, or due to how USGS reports flow data. Historically, discrepancies have often stemmed from the way that stage/flow data are reported. The Facility uses "provisional" preceding day flow data from the water level recorders at the USGS gaging station at each of the locations. Such "provisional" real-time data are obtained directly from the USGS Tampa office's Web Site a number of times each day by the Authority. This is accomplished in order to determine an accurate working estimate of the preceding daily stream flow on which to establish the Facility's current day's withdrawal schedule. However, after the fact, the USGS checks and evaluates the data from both the gage recorders and periodic river cross section measurements collected a number of times each year. Based on such quality assurance checks the USGS may make revisions to the real-time information before establishing finalized daily flow estimates for the preceding water year. Thus, the daily values used by the Facility are only "provisional" and can and are often changed as a result of ongoing USGS data quality assurance procedures weeks or even months later. Experience has shown that adjustments of provisional gaged data are often frequent for extended periods of low flow. It is therefore not uncommon for subsequent determinations of percent withdrawals, based on the finalized, revised USGS calculations of the initial "provisional" daily flows, to sometimes indicate that daily withdrawals, based on initial real-time flow information, exceeded the District's permitted maximum 10 percent. Under low flow conditions, such as occurred throughout much of 2010, even small adjustments between USGS provisional and finalized flow estimates can result in fairly large changes in the relative percent of flow.

2.3 Comparisons of Peace River Facility and Shell Creek Facility Withdrawals

There are two public suppliers that withdraw potable water from the lower Peace River system. As previously described, the Authority's Peace River Regional Water Supply Facility withdraws water from the intake withdrawal structure located on a side channel, in the tidal portion of the lower river estuarine system. Water is stored untreated in the Facility's off-stream reservoirs, or treated water can be stored in the Authority's series of Aquifer Storage Recovery (ASR) wells. Under normal conditions, the Facility's existing 1996 permit has a 130 cfs low flow threshold for withdrawals based on the upstream USGS Arcadia gage. Withdrawals above the 130 cfs threshold are limited to 10 percent of the preceding days flow, with a 90 mgd maximum daily cap under the 1996 District WUP (water use permit).

The older City of Punta Gorda Facility utilizes an in-stream reservoir constructed in the tidal portion of Shell Creek, just below the confluences of Shell and Prairie Creeks. Unlike the Peace River Facility's flow based permit structure, the current 20-year Shell Creek permit issued in September 2007 allows an annual average of 8.008 mgd, with a maximum monthly cap of 11.728 mgd.

Figures 2.27 and **2.28** provide comparisons of both the 2010 and recent historic withdrawal patterns of the two facilities. **Figure 2.29** provides an indication of both the magnitude and timing of the total withdrawals by the two facilities that occurred in the lower Peace River estuarine system during 2010 in relation to total gaged flows for the major tributaries.

Table 2.10

Comparisons of Peace River Water Treatment Facility and Shell Creek Facility Withdrawals with Freshwater Inflows during 2010 and the Period 1980-2010

Figure	Description
Figure 2.27	Daily Peace River and Shell Creek water treatment facility withdrawals (2010)
Figure 2.28	Daily Peace River and Shell Creek water treatment facility withdrawals (1980-2010)
Figure 2.29	Daily total gaged flow at river's mouth (Peace River at Arcadia + Horse + Joshua + Shell Creek) and total water treatment facility withdrawals (2010)

2.4 Summary

Annual mean Peace River flows based on: 1) the Peace River at Arcadia gage; 2) total gaged flow upstream of the Peace River Facility; and 3) total gaged flow upstream of the U.S. 41 Bridge since 1976 (the start of the HBMP) are summarized in **Table 2.9**. The Table also includes mean annual Facility lower Peace River withdrawals (since 1980) and City of Punta Gorda Shell Creek withdrawals. The annual percentages that Peace River Facility withdrawals have comprised of gaged Peace River flows measured at Arcadia, the Facility and the U.S. 41 Bridge are also included. Finally the table indicates the percent of annual total flow to the upper harbor utilized by both the Peace River and City of Punta Gorda facilities.

Total Peace River Facility withdrawals during 2010 were approximately 4.7 percent of the total gaged freshwater flow measured at the USGS Arcadia gage, 3.4 percent of the upstream gaged flow at the Facility, and 2.6 percent of the combined average daily inflows upstream of the U.S. 41 Bridge. During the entire period of Peace River Facility withdrawals (1980-2010), total combined withdrawals have been approximately 1.53 percent of the corresponding gaged Peace River at Arcadia flows and 1.23 percent of the corresponding combined daily flows of the Peace River, and Horse, Joshua, and Shell Creeks.

3.0 Physical and Chemical Water Quality Characteristics at "Moving" Isohaline Based Locations

3.1 Introduction

An early objective of the Peace River HBMP was the development of a comprehensive understanding of phytoplankton production and related community structure within the Charlotte Harbor estuarine system. Development of a conceptual understanding of the temporal and spatial relationships between freshwater inflows and phytoplankton production was established as a fundamental goal towards developing an overall understanding of other key interrelated biological communities and physical processes within the estuary, including secondary production and nutrient cycling. Components of the long-term HBMP "isohaline" salinity based monitoring study element were designed in part to develop a greater understanding of the interactions of seasonal freshwater inflows and the temporal and spatial responses of phytoplankton production in the lower Peace River/upper Harbor estuarine system. Specific goals of these studies included determining both the immediate and long-term phytoplankton responses to freshwater inputs, including both nutrient loadings (nitrogen) and increased water color (light availability). The HBMP's historic, long-term phytoplankton investigations in the lower Peace River/upper Charlotte Harbor estuarine system provided:

- Measurements of populations and community structure acting as barometers of changes over both short (daily to weekly) and longer (seasonal) temporal scales.

- Insight into basic spatial/temporal processes affected by water quality and having secondary widespread interrelations and effects upon other estuarine food-web 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.

3.2 Historical Long-Term Phytoplankton Study Elements

Since its inception in the early 1980s, this element of the HBMP has incorporated a number of long-term monitoring studies designed to answer specific questions with regard to spatial and temporal patterns in phytoplankton production, community structure and biomass. The objectives of these HBMP studies have been to develop sufficient information to evaluate trends and establish a long-term understanding of differences in the response in the lower Peace River/upper Charlotte Harbor estuarine system to periods of both extended drought as well as unusually high freshwater inflows.

Phytoplankton Primary Production – Statistically comparable levels of phytoplankton ^{14}C fixation rates were measured monthly at each of the four salinity-based isohaline locations between June 1983 and December 1999. In addition to overall estimates of phytoplankton production, carbon uptake rates were determined for three separate size fractions: 1) greater than 20 microns; 2) 5 to 20 microns; and 3) less than 5 microns. The results of this long-term HBMP study clearly showed the quick response of phytoplankton production to brief pulses of relatively nitrogen rich freshwater into the estuary during the early spring. These results further supported the extreme importance to other components of the estuarine food-web of early spring/summer flows to the estuary during the start of the typical summer wet-season.

Phytoplankton Taxonomic Identification – A second element of the HBMP phytoplankton study, conducted monthly between 1989 and 2004, sought to quantify the specific responses of major phytoplankton taxonomic groups to variations in the periodicity of freshwater inflow. The developed monthly phytoplankton taxonomic information included: 1) raw counts of the relative taxonomic structure; 2) percent composition of key major taxonomic groups; and 3) summary species diversity and evenness index estimates. The results of these microscopic phytoplankton surveys generally indicated the relative dominance of the following groups.

- Among samples collected at intermediate and higher salinities, the smallest phytoplankton size fraction (<5 microns) was often observed to be dominated by Cryptophyceae species (*Chroomanas* spp. and *Cryptomonas* spp.). Small Bacillariphyceae (*Thalossiosira* spp., *Nitzschia* spp., *Navicula* spp.) were also often observed to comprise significant portions of the nano-plankton components at these salinities.

- At the very highest salinities, influenced by 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 during the summer months.

- At intermediate salinities, blooms of *Skeletonema costatum* were commonly associated with relative increases in carbon uptake and chlorophyll *a* within the largest size fraction. However, seasonally, dinoflagellates (*Prorocentrum micans*, *P. minimum*, *Gymnodinium* spp. and *Gyrodinium* spp.) were also major components of the largest phytoplankton size fraction. Specifically, at 6 and 12 o/oo salinity at the mouth of the Peace River, during the typical spring increase in phytoplankton population 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 included 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 within the lower salinity areas. The larger size fractions in the riverine portions of the estuary were found to be 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.).

Phytoplankton Biomass Estimates – Although direct *in situ* measurements of carbon uptake rates and enumerations of phytoplankton taxonomic structure are no longer conducted, the HBMP isohaline-based monitoring study element continues to collect monthly information of phytoplankton biomass (chlorophyll *a*) in relation to seasonal and flow related variations in physical parameters, water column light profiles, and the major chemical constituents associated with phytoplankton growth. This report presents data collected during the twenty-eighth year (2010) of this unique long-term study of the relationships between phytoplankton productivity and Peace River flow into upper Charlotte Harbor.

3.3 Overview of “Isohaline” Based Monitoring Methods

The following briefly outlines and summarizes the methodologies used to measure and evaluate the physical, chemical, and biological parameters of this study element. Environmental Quality Laboratory, Inc. (EQL) was responsible for all aspects of the HBMP “moving” isohaline based 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 EQL, which was purchased in 2000 by ASCI, Inc. ASCI continued to conduct all HBMP chemical analyses through January 2002. However, due to issues regarding QA/QC and the long-term stability of ASCI, in February 2002 the Peace River Manasota Water Supply Authority (Authority) changed the chemistry contract to Benchmark EnviroAnalytical, Inc. located in Palmetto, Florida. All laboratory methods previously used by EQL/ASCI have been continued by Benchmark, who conducted all HBMP chemistry analyses during 2010.

The four isohaline-based monthly sampling locations in this HBMP study element represent non-fixed surface salinity zones, such that the monthly location of each isohaline is dependent upon both tide stage and the preceding amount of freshwater inflow from the Peace River. Table 3.1 summarizes the historical statistical distribution of these isohaline locations. The four salinity sampling zones are:

- Station 101 = 0 psu (practical salinity units)

- Station 102 = 5-7 psu
- Station 103 = 11-13 psu
- Station 104 = 20-22 psu

Table 3.1
Summary Statistics of the Four Isohaline Locations (Kilometers) from the Peace River's Mouth for the Period 1983-2010

Isohaline	Minimum (Downstream)	Maximum (Upstream)	Mean	Median
0 psu	0.6	37.6	22.8	22.1
6 psu	-16.3	28.3	13.1	12.9
12 psu	-30.1	25.0	8.2	9.4
20 psu	-36.3	21.0	1.0	4.1

Note: HBMP reports previous to 2006 used the units "o/oo". However, since 2006 equivalent practical salinity units (psu) have been used, which distinguishes salinity determined by field *in situ* conductivity rather than laboratory wet chemistry.

The Peace River Water Treatment Facility is located at approximately River Kilometer 29.8. To date, the most upstream occurrence of the 0 psu isohaline sampling location has been just over a quarter mile upstream of the point were Horse Creek joins the Peace River (during June 2000). (This upstream location also represents the practical upper end of the HBMP monitoring transect, since during low flows limestone outcroppings prevent further upstream monitoring by boat.) The most downstream occurrence of the 20 psu 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 2010 is shown in **Figure 3.2**, while long-term patterns for the period 1983-2010 are presented in **Figures 3.3** and **3.4**. The affects of the extended drought conditions that influenced freshwater flows in the Peace River watershed between both 1999-2001 and 2006-2009 are noticeable in the atypical upstream movements and near historic maximum extents of all four isohalines during these extended, unusually dry periods. Following the end of the extended 1999-2001 drought, the seasonal variability of the relative locations of each of these four measured isohalines returned to cyclical patterns similar to those previously observed during more normal annual hydrologic conditions. However, in response to the very dry conditions that characterized 2006, 2007, 2008 and much of 2009, the relative spatial distribution of the four moving isohalines returned to patterns similar to those observed during the previous extended drought (1999-2001).

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 2010 and over the preceding 1983-2009 monitoring period. As shown in **Diagram 3.1**, 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. The statistical mean is indicated by a colored dot within the box. In **Figure 3.5**, the zero reference line denotes the imaginary mouth of the Peace River as defined in the previous morphometric study (see **Figure 1.2**). The return to more normal freshwater inflows during 2010 are evident in the seasonal pattern of the locations of all four of the HBMP isohalines when compare to the longer-term 1983-2009 preceding period of historic HBMP isohaline based monitoring.

Table 3.2
Isohaline Locations During 2010 and the Period 1983-2010

Figure	Description
Figure 3.1	Study area with most upstream and downstream locations of 0 & 20 isohaline sampling locations
Figure 3.2	Relative distance (km) from the mouth of the river (2010)
Figure 3.3	Relative distance from the mouth of the river of 0 and 6 psu salinity sampling zones (1983-2010)
Figure 3.4	Relative distance from the mouth of the river of 12 and 20 psu salinity sampling zones (1983-2010)
Figure 3.5	Box & whisker plots of relative distance (km) from the mouth of the river

3.3.1 *In Situ* Measurements of Physical Parameters

Depth, temperature, dissolved oxygen, conductivity, and pH were measured *in situ* with Hydrolab Surveyor (or YSI) 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 pre-measured marks on the unit's cable and/or 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.

3.3.2 Light Profile

Light intensity profiles were utilized to gather sufficient data to calculate the water column extinction coefficient at each isohaline sampling location. A LiCore™ 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).

3.3.3 Water Chemistry

Surface water samples were collected for analysis at each salinity-based station in pre-labeled, polyethylene containers. The containers were rinsed with sample water, filled, preserved and immediately placed in the dark on ice until transferred to Benchmark EnviroAnalytical, Inc. following standard chain of custody and Florida Department of Environmental Protection (FDEP) quality assurance procedures. Specific methods of analyses used by the laboratory are listed in **Table 3.3**.

In response to the recommendations contained within the *1998 HBMP Mid-term Interpretive Report* and the *2002 Peace River Comprehensive Summary Report*, the number of water chemistry parameters associated with both the "moving" and "fixed" HBMP study elements was decreased from those originally specified (17 parameters) in the 1996 WUP 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 during 2010 was conducted using the revised/reduced long-term water quality sampling parameter list (12 parameters) implemented starting in March 2003 (**Table 1.2**).

3.4 Physical and Water Chemistry Data Collected in the "Moving" Isohaline Locations

Water quality data collected during 2010 at the four "moving" isohaline, salinity-based locations are presented and summarized in the following Tables and Figures. **Tables 3.4** and **3.5** summarize the determinations of 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).

Relationships of the 2010 data to those data collected during the preceding 27 years of study (1983-2009) 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 2010 and long-term data collected between 1983-2009 in **Figures 3.22** through **3.29**. As previously disused, the box and whisker plots display a detailed distribution of the data as depicted in **Diagram 3.1**, showing the median (50^{th} percentile) at the center of the box and the 25^{th} and 75^{th} percentiles at the bottom and top of the box, respectively. The statistical means are shown as dots within each box. The whiskers are lines that extend from the 25^{th} percentile to the 10^{th} percentile and 75^{th} percentile to the 90^{th} percentile. Extreme values (outside the 10^{th}-90^{th} 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 2010 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
Figure 3.6	Monthly temperature at salinity sampling zones – 2010
Figure 3.7	Monthly color at salinity sampling zones – 2010
Figure 3.8	Monthly extinction coefficient at salinity sampling zones – 2010
Figure 3.9	Monthly nitrite/nitrate at salinity sampling zones – 2010
Figure 3.10	Monthly ortho-phosphorus at salinity sampling zones – 2010
Figure 3.11	Monthly atomic N/P ratio at salinity sampling zones – 2010
Figure 3.12	Monthly silica at salinity sampling zones – 2010
Figure 3.13	Monthly chlorophyll *a* at salinity sampling zones - 2010

Table 3.7
Summary Graphics of Key Physical and Chemical Measurements for Data Collected During the Period 1983-2010 at the Four Isohaline Locations

Figure	Description
Figure 3.14	Monthly temperature at salinity sampling zones (1983-2010)
Figure 3.15	Monthly color at salinity sampling zones (1983-2010)
Figure 3.16	Monthly extinction coefficient at salinity sampling zones (1983-2010)
Figure 3.17	Monthly nitrite/nitrate at salinity sampling zones (1983-2010)
Figure 3.18	Monthly ortho-phosphorus at salinity sampling zones (1983-2010)
Figure 3.19	Monthly atomic nitrogen/phosphorus ratio at salinity sampling zones (1983-2010)
Figure 3.20	Monthly silica at salinity sampling zones (1983-2010)
Figure 3.21	Monthly chlorophyll *a* at salinity sampling zones (1983-2010)
Figure 3.22	Box and whisker plots of temperature at salinity sampling zones (2010) & (1983-2009)
Figure 3.23	Box and whisker plots of color at salinity sampling zones (2010) & (1983-2009)
Figure 3.24	Box and whisker plots of extinction coefficient at salinity sampling zones (2010) & (1983-2009)
Figure 3.25	Box and whisker plots of nitrite/nitrate at salinity sampling zones (2010) & (1983-2009)
Figure 3.26	Box and whisker plots of ortho-phosphorus at salinity sampling zones (2010) & (1983-2009)
Figure 3.27	Box and whisker plots of atomic N/P ratio at salinity sampling zones (2010) & (1983-2008)
Figure 3.28	Box and whisker plots of silica at salinity sampling zones (2010) & (1983-2009)
Figure 3.29	Box and whisker plots of chlorophyll *a* at salinity sampling zones (2010) & (1983-2009)

3.5 Summary

Statistical comparisons between mean 2010 values and long-term 1983-2009 averages for selected measurements and parameters are summarized in **Table 3.8.** The following summarizes comparisons of the findings from the 2010 data with those previously collected as part of the long-term isohaline-based HBMP water quality monitoring program element.

- **Salinity Spatial Distribution –** Freshwater inflows to the lower Peace River during 2010 were generally higher than during the preceding 2006-2009 drought (see **Section 2**). The influences of the slightly drier than usual conditions that characterized overall 2010 flows are reflected in the seasonal and average spatial distributions of each of the four sampled moving isohalines along the HBMP monitoring transect as seen in **Figure 3.5** and **Table 3.8**. Overall, the relative spatial distributions of each of the isohalines during 2010 reflected slight upstream movements when compared with their previous long-term 1983-2009 averages.

- **Temperature –** Median annual water temperatures (as seen in **Figure 3.22)** during 2010 at each of the four isohalines were, on average, slightly higher than corresponding values measured over the preceding 27-year period (1983-2009). However, as indicated, corresponding mean annual water temperatures for the year by comparison were several degrees below their long-term averages (**Table 3.8**). As **Figure 3.14** indicates, the much lower than average mean water temperatures during 2010 reflect unusually cold conditions at both the beginning and the end of the year, caused by a series of atypical cold fronts during both the winters of 2009 and 2010.

- **Water Color –** Seasonally water color levels during 2010 (**Figure 3.15**) were similar or just slightly higher (**Figure 3.23** and **Table 3.8**) than average levels over the preceding long-term historic period (1983-2009). This is in direct comparison with the generally lower levels observed during the 2006-2009 drought when color levels in the lower Peace River/upper Charlotte Harbor estuarine system were well below their long-term averages within all but the highest salinity isohaline.

- **Extinction Coefficient –** The rates of measured light attenuation at each of the four HBMP isohalines reflect the interactions of both ambient color and phytoplankton biomass (chlorophyll *a*). Comparisons of mean extinction values among the four isohalines during 2010 with corresponding long-term averages (**Figure 3.24** and **Table 3.8**) show much lower levels at all but the most downstream, highest salinity level (20 psu). This result probably reflects the overall slightly lower than average annual flows that characterized 2010.

- **Nitrite/Nitrate Nitrogen** - During 2010, the average concentrations of this major inorganic form of nitrogen were generally similar to the observed long-term (1983-2009) historical annual averages (**Figure 3.25** and **Table 3.8**). The one exception that skewed the annual 2010 averages for the upstream freshwater isohaline was the occurrence of a high value in January. The data clearly indicate that inorganic nitrogen levels were below normal in the lower Peace River/upper Charlotte Harbor estuarine system during the recent years of extended drought (**Figure 3.17**). Monthly comparisons among the isohalines indicate nitrite/nitrate inorganic nitrogen concentrations in the lower Peace River/upper Charlotte Harbor estuarine system are characterized by a distinct spatial gradient that shows strong responses to seasonal patterns of freshwater inflows (**Figures 3.9** and **3.25**). Concentrations typically decrease rapidly with increasing salinity, with inorganic nitrogen levels within the 20 psu isohaline often being near or at method detection limits over much of the year. Normally, estuarine inorganic nitrogen concentrations decline to their lowest levels during the relatively drier spring months as phytoplankton populations respond to increasing water temperatures and light, and increased primary production removes available inorganic nitrogen. As a result, inorganic nitrogen levels in the lower river and upper harbor are typically at their lowest levels in the late spring, just prior to increases in summer wet-season inflows.

- **Ortho-phosphorus** - Estuarine inorganic phosphorus concentrations in the lower Peace River and upper Charlotte Harbor are heavily influenced by the characteristically "very" high natural levels found in the Peace River watershed. As a result, the observed difference in concentrations among the four isohalines primarily reflects conservative dilution by Gulf waters. Unlike inorganic nitrogen, seasonal observed changes in phosphorus concentrations in the estuary are for the most part unaffected by biological uptake. 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). Historically, since the late 1970s, there had been marked declines in inorganic phosphorus levels in the lower Peace River/upper Charlotte Harbor estuarine system due to declines in the combined influences of phosphate mining and processing in the upper reaches of the basin. However, following Hurricane Charlie and the subsequent Hurricanes Francis and Jeanne during the late summer of 2004, inorganic phosphorus concentrations have dramatically increased throughout the lower Peace River/upper Charlotte Harbor estuarine system. Ortho-phosphorus concentrations remained well above recent historic levels throughout much of 2005-2009 and have recently rapidly declined (**Figure 3.18**). The direct cause for the observed increased levels seems to have been related to the on-going closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin (see Section 7 of the previous *2008 HBMP Data Report*). Annual average ortho-phosphorus concentrations at each of the four isohalines were generally lower in 2010 than the corresponding long-term averages (1983-2009).

- **Nitrogen to Phosphorus Atomic Ratios** – Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations in 2010, as indicated by the long-term averages, show nitrogen to almost always be the limiting macronutrient at each of the four isohalines (**Figure 3.19**). The possible exception occurred during January at the freshwater location when a very high level of inorganic nitrite/nitrate nitrogen was observed (**Figures 3.11** and **3.27**).

- **Silica** – Seasonally, silica levels in the lower Peace River/upper Charlotte Harbor estuarine system typically peak following periods of high freshwater inflows. Although silica levels also seem to be positively correlated with higher water temperatures (possibly reflecting recycling from riverine/estuarine sediments), historically lower silica concentrations in higher salinity zones of the estuary often occurred during corresponding periods of combined low spring freshwater inflow and spring increases in phytoplankton diatom numbers. Between 1983 and the late 1990s these seasonal patterns of increasing and decreasing reactive silica concentrations remained relatively stable with no indications of any consistent systematic changes over time. However, as discussed in previous HBMP reports, silica levels started showing increasing concentrations during the late 1990s (**Figure 3.20**). Then, as flows declined during the extended 1999-2002 drought, silica levels also declined. However, following the return of higher than average flows during 2003-2005 measured silica levels in the estuary again began rapidly increasing. Even though flows between 2006-2008 were below normal, silica levels throughout the lower river/upper harbor estuary continued to reach historically high levels during the summer wet-seasons. As with ortho-phosphorus, the proximate cause for these increasing levels seems to be related to the on-going closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin. However, while peak levels during 2009 and 2010 were somewhat lower than during the immediate preceding years, annual average concentrations during 2010 were well above their long-term averages at each of the four moving isohaline bases monitoring locations (**Figure 3.28** and **Table 3.8**).

- **Chlorophyll *a* –** The seasonal patterns of freshwater inflows to the estuary during 2010 were characterized by slightly drier than usual conditions when compared to the long-term average conditions (see **Section 2**). Typically, seasonal periods of increased flows produce both higher than average inputs of limiting inorganic nutrients (nitrogen), as well as higher than average levels of water color (resulting in greater light attenuation). The rapid increase in flows in July following the dry spring was accompanied by sharp increases in phytoplankton biomass at the 12 psu isohaline (**Figure 3.13b**) and a abnormally very high observed peak at the 6 psu isohaline in August. With the exception of these two unusual events chlorophyll *a* concentrations within the Peace River/upper Charlotte Harbor estuarine salinity zones were generally similar to their preceding long-term (1983-2009) corresponding averages (**Figure 3.29a**). As in previous years, phytoplankton levels within the intermediate (6 and 12 psu) isohalines reflected a balance between stimulation due to increased nitrogen inputs, and light inhibition resulting from higher water color. During previous years, taxonomic counts indicated that such "bloom" events within these intermediate salinity zones were often predominantly characterized by high numbers of dinoflagellates (*Dinophyceae*) or diatoms (*Bacillariophycae*).

4.0 Water Chemistry Data Collected at "Fixed" Station Locations

4.1 Introduction

A number of the HBMP study elements conducted prior to 1996 included the collection of water quality data. The majority of these data, however, were limited to *in situ* measurements of water column physical characteristics. The following lists historic HBMP study elements that included the collection of such *in situ* water column profile data.

1. The monthly HBMP night trawl fish study that was conducted in the upper harbor between 1976-1986.

2. The sea star and benthic invertebrate studies carried out in the harbor and lower river between 1976 and 1984.

3. The long-term, monthly fixed station HBMP study of water column characteristics that was undertaken between 1976 and 1986 at a number of fixed sampling sites in the lower Peace River and Charlotte Harbor.

Prior to 1996, the only HBMP study that included chemical water quality monitoring was the monthly "moving" isohaline monitoring at four locations (see **Section 3**). This ongoing study that began in 1983 includes monthly water column profiles and surface water chemistry samples taken in conjunction with the HBMP study elements of phytoplankton estuarine production.

Under the 1996 Water Use Permit (WUP) renewal, the HBMP monitoring program was expanded to include the collection of monthly water chemistry data at an additional five "fixed" sampling sites spatially distributed along the HBMP monitoring transect from downstream near the mouth of the river to upstream of the Peace River Regional Water Supply Facility (Facility). In addition to these 5 water chemistry locations, the sampling of *in situ* physical water column profile data was also initiated at ten additional "fixed" sampling locations. These new HBMP water chemistry 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/upper Charlotte Harbor background monitoring. An additional fixed monthly sampling site was added in 1998 to correspond to the location of the third USGS recorder installed in 1997 at River Kilometer (RK) 26.7. The relative locations of these "fixed" sampling locations are shown in **Figure 4.1**, while **Table 4.1** provides both currently used HBMP river kilometers, as well as previously used EQL station numbers and USGS river mile designations.

Long-term water chemistry data were collected by EQL between the inception of the HBMP monitoring program in 1976 and 1990 at each of the five current HBMP 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 field collection of all of the water chemistry and biological HBMP fieldwork. This has included taking physical water column measurements and the collection of water chemistry samples for both the "moving" isohaline (**Section 3**) and "fixed" HBMP station elements. ASCI, Inc. conducted both the "fixed" and "moving" HBMP chemical analyses between the sale of EQL in 1998 and January 2002. However, due to concerns regarding QA/QC issues and the long-term stability of ASCI, in February 2002 the Authority changed all HBMP water chemistry analyses to Benchmark EnviroAnalytical, Inc. located in Palmetto, Florida. Benchmark continued to conduct all the chemistry analyses of samples collected during 2010, and 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 (**Figure 4.1**).

1. The first consists of 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, specific conductance, and light characteristics. Field measurements are made at 0.5 m intervals, beginning at the surface and ending near the bottom of the water column. Depths are determined based on pre-labeled marks on the units cable combined with direct sonde pressure based readings.

2. The second type of data collection consists of 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.

Between 1996 and 2003, near-surface and near-bottom samples collected at the five monthly water quality monitoring sites were 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* (see **Table 1.2**)

In response to the recommendations contained within both the *1998 HBMP Mid-term Interpretive Report* and the *2002 Peace River Comprehensive Summary Report* the number of water chemistry parameters associated with 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. Based on the result of this coordination, the revised/reduced long-term water quality sampling parameter list was implemented starting in March 2003 (**Table 1.2**).

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

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 locations during 2010 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

The following summarizes some of the key seasonal and historical patterns observed from the “fixed” station monitoring data both recently during 2010 and over the long-term 1976-2010 interval.

4.4.1 Physical Water Column Characteristics (2010)

The results for the *in situ* hydrolab water column profiles for the period January through December 2010 at the sixteen fixed stations are contained in the appropriate summary data sets summarized in Table 1.3 (see **Section 1**). These monthly data are presented graphically in **Figure 4.2** through **Figure 4.6** (Table 4.2).

Table 4.2
Summary Graphics of Mean Monthly Physical Water Column *In Situ* Water Quality Measurements at the Fixed Sampling Locations During 2010

Figure	Description
Figure 4.2a	2010 Mean monthly temperature at River Kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.2b	2010 Mean monthly temperature at River Kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.2c	2010 Mean monthly temperature at River Kilometers 20.1, 21.9, 23.6 and 24.7
Figure 4.2d	2010 Mean monthly temperature at River Kilometers 25.9, 29.5, 30.7 and 32.3
Figure 4.3a	2010 Mean monthly dissolved oxygen at River Kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.3b	2010 Mean monthly dissolved oxygen at River Kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.3c	2010 Mean monthly dissolved oxygen at River Kilometers 20.1, 21.9, 23.6 and 24.7

Table 4.2
Summary Graphics of Mean Monthly Physical Water Column *In Situ* Water Quality Measurements at the Fixed Sampling Locations During 2010

Figure	Description
Figure 4.3d	2010 Mean monthly dissolved oxygen at River Kilometers 25.9, 29.5, 30.7 and 32.3
Figure 4.4a	2010 Mean monthly pH at River Kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.4b	2010 Mean monthly pH at River Kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.4c	2010 Mean monthly pH at River Kilometers 20.1, 21.9, 23.6 and 24.7
Figure 4.4d	2010 Mean monthly pH at River Kilometers 25.9, 29.5, 30.7and 32.3
Figure 4.5a	2010 Monthly 1% light depth at River Kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.5b	2010 Monthly 1% light depth at River Kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.5c	2010 Monthly 1% light depth at River Kilometers 20.1, 21.9, 23.6 and 24.7
Figure 4.5d	2010 Monthly 1% light depth at River Kilometers 25.9, 29.5, 30.7and 32.3
Figure 4.6a	2010 Mean monthly specific conductance at River Kilometers –2.4, 6.6, 8.4 and 10.5
Figure 4.6b	2010 Mean monthly specific conductance at River Kilometers 12.7, 12.8, 15.5 and 17.5
Figure 4.6c	2010 Mean monthly specific conductance at River Kilometers 20.1, 21.9, 23.6 and 24.7
Figure 4.6d	2010 Mean monthly specific conductance at River Kilometers 25.9, 29.5, 30.7and 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.

- **Water Temperature** – As expected water temperatures show a strong seasonal pattern with the highest annual values being observed at all of the monitoring sites during July 2010. Historically the annual peak in water temperatures in the estuary usually varies between July and August depending on annual variations in cloud cover and differences in seasonal rainfall patterns. The 2010 data clearly shows the lower than normal cold conditions during both February and December associated with unusually strong winter cold fronts both early and at the end of the year.

- **Dissolved Oxygen** – Previous results have indicated that within the downstream reaches of the river between River Kilometers -2.4 and 10.5, there is typically a wet-season depression of average water column dissolved oxygen levels in response to increased wet-season flows. This seasonal pattern typifies the widely documented hypoxic/anoxic conditions that typically occur in upper Charlotte Harbor as a result of the extreme water column stratification that commonly occurs near the mouth of the river and upper regions of the harbor during the summer. This typical observed seasonal depression of average water column dissolved oxygen concentrations in this reach of the lower river is generally more intense and of greater duration than that observed at the more upstream monitoring sites. During 2010 (as typically observed in previous years) average water column dissolved oxygen levels generally declined as water temperatures increased, reaching their lowest levels during summer wet-season between July and September throughout both the lower river and upper harbor as both water temperatures and flows increased. The 2010 summer, wet-season column profile data indicated the return of normal hypoxic/anoxic bottom dissolved oxygen levels in the upper harbor that had been reduced during the extended 2006-2009 drought. This strongly suggests that the flows that occurred during the summer of 2010 were of sufficient duration and intensity to induce the level of water column stratification necessary to cause the development of extremely low, widespread near-bottom dissolved oxygen levels in upper Charlotte Harbor (see **Figures 4.18a** and **4.18b**). The HBMP water column profile data measured since 2004 have not indicated any lingering influences from the historically massive, wide spread depression of dissolved oxygen levels that occurred throughout the entire water column in the Charlotte Harbor Estuary following Hurricane Charlie in August 2004.

- **Light Extinction –** The 2010 HBMP data indicate that both the timing and magnitude of the ability of light to penetrate into the water column (1 percent depth) exhibit both strong temporal (seasonal) and spatial differences among the “fixed” monitoring sites along the HBMP lower Peace River/upper Charlotte Harbor sampling transect. In many other estuarine systems, the extinction of light is often highly influenced by ambient chlorophyll *a* concentrations (phytoplankton biomass). However, due to the “black water” characteristics of freshwater flows from the Peace River watershed into the harbor, light extinction in the lower Peace River/upper Charlotte Harbor estuarine system is primarily mediated by water color. **Figures 4.5a** through **4.5d** indicate that water clarity during 2010 (as in previous years) was the greatest in the lower river and especially in the upper harbor during both the typical spring dry-season and other periods of lower flows (see **Figure 2.1**). The influences of the relatively low levels of highly colored freshwater flows during May and at the end of the year during 2010 are clearly evident in comparing the one percent light depths observed at the more downstream lower river/upper harbor monitoring locations with the summer wet-season months.

- **Conductivity/Salinity –** **Figures 4.6a** through **4.6d** clearly show the influences of drier intervals during 2010 on the temporal and spatial patterns of conductivity (salinity) throughout the lower Peace River/upper Charlotte Harbor estuarine system. Comparisons of seasonal and spatial patterns during 2010 are particularly dramatic when contrasted with those over the recent drier than average four-year period between 2006-2009. During this 2010, higher conductivity harbor waters were rarely observed upstream of approximately RK 26.0 throughout the entire year. However, during the spring dry-season and late fall of the four-year interval between 2006 and 2009, brackish conditions in the lower river often extended upstream even beyond the Peace River Facility intake. Such relatively high salinity conditions in the lower river also seasonally occurred during the previous extended drought that affected southwest Florida and the Peace River basin during much of the 1999-2001 period (see **Table 2.9**). During these years, very high conductivities have been observed even at the most upstream sampling locations during extended periods of low freshwater inflows.

4.4.2 Chemical Water Quality Characteristics (2010)

The 2010 water chemistry data for the five "fixed" water quality stations are contained in the appropriate summary data sets and summarized in **Table 1.3** (see **Section 1**). Comparisons of surface and bottom samples for selected parameters are graphically summarized in **Figure 4.7** through **Figure 4.13** (Table 4.3).

Table 4.3
Summary Graphics of Chemical Water Quality Measurements for Monthly Data Collected During 2010 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.7)

Figure	Description
Figure 4.7a	Monthly surface color at fixed sampling stations (2010)
Figure 4.7b	Monthly bottom color at fixed sampling stations (2010)
Figure 4.8a	Monthly surface total suspended solids at fixed sampling stations (2010)
Figure 4.8b	Monthly bottom total suspended solids at fixed sampling stations (2010)
Figure 4.9a	Monthly surface nitrite/nitrate at fixed sampling stations (2010)
Figure 4.9b	Monthly bottom nitrite/nitrate at fixed sampling stations (2010)
Figure 4.10a	Monthly surface total Kjeldahl nitrogen at fixed sampling stations (2010)
Figure 4.10b	Monthly bottom total Kjeldahl nitrogen at fixed sampling stations (2010)
Figure 4.11a	Monthly surface ortho-phosphorus at fixed sampling stations (2010)
Figure 4.11b	Monthly bottom ortho-phosphorus at fixed sampling stations (2010)
Figure 4.12a	Monthly surface silica at fixed sampling stations (2010)
Figure 4.12b	Monthly bottom silica at fixed sampling stations (2010)
Figure 4.13a	Monthly surface chlorophyll *a* at fixed sampling stations (2010)
Figure 4.13b	Monthly bottom chlorophyll *a* at fixed sampling stations (2010)

These graphics indicate that, for a number of water quality constituents, there are strong spatial and temporal seasonal differences within the reaches of the lower Peace River/upper Charlotte Harbor estuary represented by the five "fixed" water quality monitoring locations. Further spatial and temporal differences are also apparent both within and among sampling locations between sub-surface and near-bottom samples. Water color, for example, clearly indicates a distinct seasonal pattern, with levels increasing first upstream and then progressively downstream at the end of the typical spring dry-season (**Figures 4.7a** and **4.7b**). Water color levels downstream, nearer the river's mouth, are often higher at the surface than near the bottom indicating distinct stratification between more colored, lower density surface freshwater inflows and higher salinity bottom waters.

A number of other measured water quality parameters also show distinct seasonal relationships relative to the typical annual patterns of seasonal increasing and decreasing freshwater inflows.

However, in other instance, the seasonal patterns and spatial relationships of some water quality characteristics reflect far more complex relationships.

- **Total Suspended Solids –** 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 and often are observed to coincide with increased chlorophyll *a* concentrations. Correspondingly, lowest surface levels often occur in the lower river and upper harbor during the summer wet-season. As expected, the very highest measured levels are typically observed near the bottom of the water column. The spatial and temporal patterns in total suspended solids occurring in 2010 generally followed these normal patterns (**Figures 4.8a** and **4.8b**).

- **Inorganic Nitrite+Nitrate Nitrogen –** In the Charlotte Harbor estuarine system inorganic nitrite+nitrate nitrogen concentrations are typically the lowest during the peak of the spring dry-season, when high light and water temperatures result in increased phytoplankton production and freshwater inflows are low. Concentrations rapidly increase in the lower salinity reaches of the estuary with higher flows as nitrogen is carried from the watershed and increasing color reduces light penetration of the water column and limits phytoplankton growth. The data typically indicates a distinct spatial gradient within the lower river/upper harbor estuarine system with higher levels of inorganic nitrogen progressively occurring upstream. During 2010 inorganic nitrogen concentrations downstream in upper Charlotte Harbor were low or at near detection limits during the spring dry-season (May). Overall, nitrite+nitrate nitrogen levels in 2010 were similar with the longer-term averages at each of the five fixed station locations (**Table 4.4**).

- **Total Kjeldahl Nitrogen –** Typically, total Kjeldahl nitrogen concentrations in the lower Peace River/upper Charlotte Harbor estuarine system are generally the highest during the summer wet-season, reflecting the influences of increased freshwater inflows (**Figure 4.10a**). In the preceding four drought years (2006-2009), total Kjeldahl nitrogen levels at the more downstream monitoring sites were notably lower during the drier months when compared to normally wetter time intervals. Overall, during 2010 the annual average Kjeldahl concentrations at each of the five monitoring locations were very similar to their historic long-term averages (**Table 4.4**)

- **Ortho-Phosphorus –** As previously discussed (see **Section 3**), inorganic phosphorus concentrations in the Peace River Estuary follow patterns typical of conservative water quality constituents. Estuarine phosphorus concentrations are primarily influenced by dilution of high ambient levels in Peace River freshwater by saline Gulf water moving up the harbor. Thus the HBMP monitoring data typically indicate distinct spatial patterns in inorganic phosphorus concentrations among the sampling sites, with concentrations being markedly higher upstream than downstream (**Figure 4.11a**). Following Hurricane Charlie in August 2004 (and the subsequent Hurricanes Frances and Jeanne storms in September 2004), the data indicated that there were atypical marked increases in inorganic phosphorus levels associated with high levels of hurricane related flows from the Peace

River watershed. During the wetter than average conditions in 2005, inorganic phosphorus patterns in the lower river/upper harbor estuarine system returned to more typical seasonal patterns. However, during the dry conditions that characterized the 2006-2008 time period, phosphorus concentrations in the lower river/upper harbor estuarine system returned to higher levels not seen in over two decades. Phosphorus concentrations then began to decline during 2009 and continued declining during 2010 (**Figure 4.25e**). As previously discussed in **Section 3**, the direct cause for these increased levels seems to have been related to discharges of waters during the on-going closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin (see Section 7 of the *2008 HBMP Annual Data Report*).

- **Silica** – Annual reactive silica concentrations in the Peace River Estuary characteristically indicate a number of differing temporal and spatial patterns. Typically, during the spring dry-season silica levels are annually the lowest throughout the lower Peace River/upper Charlotte Harbor estuarine system corresponding to depressed flow inputs and periods of increased chlorophyll *a* biomass (potentially reflecting uptake by diatoms in the phytoplankton). Then usually during May and June, as water temperatures increase and the start of the summer wet-season begins, concentrations often rapidly increased throughout the estuary (**Figure 4.12a**). However, reactive silica concentrations during 2010 continued to reflect the recently observed pattern of increased levels noted in previous HBMP reports, with peak silica levels near seasonally historically high levels. Again, the increasing silica levels seem to have been associated with the on-going closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin.

- **Chlorophyll *a*** –Phytoplankton biomass (chlorophyll *a*) patterns in the lower Peace River/upper Charlotte Harbor Estuary are normally characterized by several seasonal peaks throughout the year that differed both seasonally and spatially among the HBMP “fixed” sampling locations. Typically chlorophyll *a* phytoplankton biomass in the lower Peace River/upper Charlotte Harbor Estuary show distinct increases both during the spring with increasing light and water temperatures and during the late fall after wet-season flows have increased nitrogen levels and associated high color levels begin to decline (**Figure 4.13a**). However, the occurrences of spring phytoplankton increases is often muted during drought conditions such as those that characterized the 2006-2009 time interval. The common occurrences of such spring and fall phytoplankton increases have often been noted in conjunction with the HBMP isohaline-based monitoring program (**Section 3.0**). Chlorophyll *a* increases (blooms) during 2010 were influenced by both the dry spring, as well as the high flows during the summer wet-season that resulted in phytoplankton “blooms” stimulated by nitrogen inputs in both the higher and intermediate salinity reaches of the lower river/upper harbor estuary. It should be noted that the chlorophyll *a* peaks observed by the “fixed” station monitoring during 2010 were much lower than those observed by the “moving’ isohaline based monitoring, which is conducted approximately two weeks earlier each month (see chlorophyll *a* results in **Section 3**). This suggests that either the observed phytoplankton blooms are either spatially or temporally limited (or possibly both).

4.4.3 Long-Term Physical and Chemical Water Quality Characteristics (1976-2010)

EQL conducted an extensive, long-term water quality monitoring program between 1976 and 1990 within both the lower Peace River and the Charlotte Harbor estuarine system, independent of the requirements of the HBMP. This program served as part of an overall regional background water quality assessment undertaken for the General Development Corporation. 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 4.14** through **4.**30 (Table 4.5) graphically compare the historical EQL estuarine data, for a selected number of surface and bottom measurements, gathered during the 1976-1990 period with those subsequently measured as part of the current HBMP effort during the more recent 1996-2010 time interval.

Table 4.5
Selected Long-Term Physical and Chemical Water Quality Data Collected Monthly During the Periods 1976-1990 and 1996-2010 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.7)

Figure	Description
Figure 4.14a	Monthly long-term surface temperature River Kilometer –2.4
Figure 4.14b	Monthly long-term surface temperature River Kilometer 6.6
Figure 4.14c	Monthly long-term surface temperature River Kilometer 15.5
Figure 4.14d	Monthly long-term surface temperature River Kilometer 23.6
Figure 4.14e	Monthly long-term surface temperature River Kilometer 30.7
Figure 4.15a	Monthly long-term surface salinity River Kilometer –2.4
Figure 4.15b	Monthly long-term surface salinity River Kilometer 6.6
Figure 4.15c	Monthly long-term surface salinity River Kilometer 15.5
Figure 4.15d	Monthly long-term surface salinity River Kilometer 23.6
Figure 4.15e	Monthly long-term surface salinity River Kilometer 30.7
Figure 4.16a	Monthly long-term bottom salinity River Kilometer –2.4
Figure 4.16b	Monthly long-term bottom salinity River Kilometer 6.6
Figure 4.16c	Monthly long-term bottom salinity River Kilometer 15.5
Figure 4.16d	Monthly long-term bottom salinity River Kilometer 23.6
Figure 4.16e	Monthly long-term bottom salinity River Kilometer 30.7
Figure 4.17a	Monthly long-term surface dissolved oxygen levels River Kilometer –2.4
Figure 4.17b	Monthly long-term surface dissolved oxygen levels River Kilometer 6.6
Figure 4.17c	Monthly long-term surface dissolved oxygen levels River Kilometer 15.5
Figure 4.17d	Monthly long-term surface dissolved oxygen levels River Kilometer 23.6
Figure 4.17e	Monthly long-term surface dissolved oxygen levels River Kilometer 30.7

Table 4.5
Selected Long-Term Physical and Chemical Water Quality Data Collected Monthly During the Periods 1976-1990 and 1996-2010 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.7)

Figure	Description
Figure 4.18a	Monthly long-term bottom dissolved oxygen levels River Kilometer –2.4
Figure 4.18b	Monthly long-term bottom dissolved oxygen levels River Kilometer 6.6
Figure 4.18c	Monthly long-term bottom dissolved oxygen levels River Kilometer 15.5
Figure 4.18d	Monthly long-term bottom dissolved oxygen levels River Kilometer 23.6
Figure 4.18e	Monthly long-term bottom dissolved oxygen levels River Kilometer 30.7
Figure 4.19a	Monthly long-term surface water color River Kilometer –2.4
Figure 4.19b	Monthly long-term surface water color River Kilometer 6.6
Figure 4.19c	Monthly long-term surface water color River Kilometer 15.5
Figure 4.19d	Monthly long-term surface water color River Kilometer 23.6
Figure 4.19e	Monthly long-term surface water color River Kilometer 30.7
Figure 4.20a	Monthly long-term bottom water color River Kilometer –2.4
Figure 4.20b	Monthly long-term bottom water color River Kilometer 6.6
Figure 4.20c	Monthly long-term bottom water color River Kilometer 15.5
Figure 4.20d	Monthly long-term bottom water color River Kilometer 23.6
Figure 4.20e	Monthly long-term bottom water color River Kilometer 30.7
Figure 4.21a	Monthly long-term surface nitrite/nitrate nitrogen River Kilometer –2.4
Figure 4.21b	Monthly long-term surface nitrite/nitrate nitrogen River Kilometer 6.6
Figure 4.21c	Monthly long-term surface nitrite/nitrate nitrogen River Kilometer 15.5
Figure 4.21d	Monthly long-term surface nitrite/nitrate nitrogen River Kilometer 23.6
Figure 4.21e	Monthly long-term surface nitrite/nitrate nitrogen River Kilometer 30.7
Figure 4.22a	Monthly long-term bottom nitrite/nitrate nitrogen River Kilometer –2.4
Figure 4.22b	Monthly long-term bottom nitrite/nitrate nitrogen River Kilometer 6.6
Figure 4.22c	Monthly long-term bottom nitrite/nitrate nitrogen River Kilometer 15.5
Figure 4.22d	Monthly long-term bottom nitrite/nitrate nitrogen River Kilometer 23.6
Figure 4.22e	Monthly long-term bottom nitrite/nitrate nitrogen River Kilometer 30.7
Figure 4.23a	Monthly long-term surface total Kjeldahl nitrogen River Kilometer –2.4
Figure 4.23b	Monthly long-term surface total Kjeldahl nitrogen River Kilometer 6.6
Figure 4.23c	Monthly long-term surface total Kjeldahl nitrogen River Kilometer 15.5
Figure 4.23d	Monthly long-term surface total Kjeldahl nitrogen River Kilometer 23.6
Figure 4.23e	Monthly long-term surface total Kjeldahl nitrogen River Kilometer 30.7

Table 4.5
Selected Long-Term Physical and Chemical Water Quality Data Collected Monthly During the Periods 1976-1990 and 1996-2010 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.7)

Figure	Description
Figure 4.24a	Monthly long-term bottom total Kjeldahl nitrogen River Kilometer –2.4
Figure 4.24b	Monthly long-term bottom total Kjeldahl nitrogen River Kilometer 6.6
Figure 4.24c	Monthly long-term bottom total Kjeldahl nitrogen River Kilometer 15.5
Figure 4.24d	Monthly long-term bottom total Kjeldahl nitrogen River Kilometer 23.6
Figure 4.24e	Monthly long-term bottom total Kjeldahl nitrogen River Kilometer 30.7
Figure 4.25a	Monthly long-term surface ortho-phosphorus River Kilometer –2.4
Figure 4.25b	Monthly long-term surface ortho-phosphorus River Kilometer 6.6
Figure 4.25c	Monthly long-term surface ortho-phosphorus River Kilometer 15.5
Figure 4.25d	Monthly long-term surface ortho-phosphorus River Kilometer 23.6
Figure 4.25e	Monthly long-term surface ortho-phosphorus River Kilometer 30.7
Figure 4.26a	Monthly long-term bottom ortho-phosphorus River Kilometer –2.4
Figure 4.26b	Monthly long-term bottom ortho-phosphorus River Kilometer 6.6
Figure 4.26c	Monthly long-term bottom ortho-phosphorus River Kilometer 15.5
Figure 4.26d	Monthly long-term bottom ortho-phosphorus River Kilometer 23.6
Figure 4.26e	Monthly long-term bottom ortho-phosphorus River Kilometer 30.7
Figure 4.27a	Monthly long-term surface silica River Kilometer –2.4
Figure 4.27b	Monthly long-term surface silica River Kilometer 6.6
Figure 4.27c	Monthly long-term surface silica River Kilometer 15.5
Figure 4.27d	Monthly long-term surface silica River Kilometer 23.6
Figure 4.27e	Monthly long-term surface silica River Kilometer 30.7
Figure 4.28a	Monthly long-term bottom silica River Kilometer –2.4
Figure 4.28b	Monthly long-term bottom silica River Kilometer 6.6
Figure 4.28c	Monthly long-term bottom silica River Kilometer 15.5
Figure 4.28d	Monthly long-term bottom silica River Kilometer 23.6
Figure 4.28e	Monthly long-term bottom silica River Kilometer 30.7
Figure 4.29a	Monthly long-term surface chlorophyll *a* River Kilometer –2.4
Figure 4.29b	Monthly long-term surface chlorophyll *a* River Kilometer 6.6
Figure 4.29c	Monthly long-term surface chlorophyll *a* River Kilometer 15.5
Figure 4.29d	Monthly long-term surface chlorophyll *a* River Kilometer 23.6
Figure 4.29e	Monthly long-term surface chlorophyll *a* River Kilometer 30.7

Table 4.5
Selected Long-Term Physical and Chemical Water Quality Data Collected Monthly During the Periods 1976-1990 and 1996-2010 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6 and 30.7)

Figure	Description
Figure 4.30a	Monthly long-term bottom chlorophyll *a* River Kilometer -2.4 **
Figure 4.30b	Monthly long-term bottom chlorophyll *a* River Kilometer 6.6 **
Figure 4.30c	Monthly long-term bottom chlorophyll *a* River Kilometer 15.5 **
Figure 4.30d	Monthly long-term bottom chlorophyll *a* River Kilometer 23.6 **
Figure 4.30e	Monthly long-term bottom chlorophyll *a* River Kilometer 30.7 **

* Note: EQL samples not analyzed for chlorophyll *a* are indicated as "Zero"

** Plots scale may not include unusually high "outlier" data points

These presented graphical analyses indicate the occurrence of a number of interesting patterns relative to long-term temporal and spatial water quality patterns within the lower Peace River/upper Charlotte Harbor estuarine system. The following summarizes several of the key observations that can be made from the presented plots of these long-term estuarine water quality data.

- **Temperature** – Long-term plots of surface water temperatures indicate that the annual observed summer estuarine highs have generally been fairly consistent over the HBMP monitoring period (1976-2010), with the annual high temperatures in the more highly colored upstream reaches of the river being slightly higher than corresponding values in the harbor (**Figures 4.14a** through **4.14e**). By comparison, annual low surface water temperatures show a great deal of variation. Noticeably, the data indicate extended periods with relatively warm winter temperatures, such as between 1985-1990 and 2004-2008.

- **Salinity** – Record high surface and bottom salinities occurred at each of the five HBMP "fixed" water quality monitoring locations during the extended drought that began in 1999 and extended through the first half of 2001. Then during the relatively high flow summer wet-seasons that occurred between 2003 and 2005, near record low salinity levels were observed both near the surface and bottom of the water column, at the more downstream sampling sites. The four most recent years (2006-2009) were again characterized by extremely dry conditions in the Peace River watershed, which again resulted in much higher than usual seasonal salinities both in the lower Peace River and upper Charlotte Harbor (**Figures 4.15a** through **4.15e**). Salinities throughout the estuary were somewhat higher during both the 1999-2001 and 2006-2009 droughts than during the similar extended series of droughts following the 1983 El Niño (**Figure 4.15a**).

- **Dissolved Oxygen** – 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 (**Figures 4.18a** through **4.18e**). These figures show that the widespread occurrences of very low near-bottom dissolved oxygen levels (including both hypoxic and anoxic conditions) over large reaches of the lower river and upper harbor are greatly reduced during periods of extended drought. The highly unusual period of widespread hypoxic/anoxic conditions that immediately followed Hurricane Charlie in August 2004 is evident from both the subsurface and near-bottom measurements taken throughout the lower river and upper harbor. Dissolved oxygen levels recovered relatively quickly following this rare event, with little indication of any lingering influences.

- **Water Color** – Temporally, water color levels increase very quickly in response to changes in freshwater inflows. As expected, color 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 (**Figures 4.19a** through **4.19e**).

- **Nitrogen** – Both inorganic nitrite+nitrate nitrogen (**Figures 4.21a** through **4.21e**) and total Kjeldahl nitrogen concentrations have indicated very similar seasonal patterns and levels of annual variation over the entire 35-year monitoring period. Spatially inorganic nitrogen concentrations markedly increase moving upstream. Peaks in total Kjeldahl nitrogen levels at the upstream sampling locations were clearly evident following Hurricane Charlie in August 2004. During the recent years of drought, total Kjeldahl nitrogen concentrations within the lower reaches of the Peace River and upper Charlotte Harbor (**Figures 4.23a** through **4.23e**) declined in response to seasonally lower than average freshwater inflows.

- **Phosphorus** - 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 had shown fairly consistent seasonal patterns over a comparably narrow range of variation (excluding a few periodic data points). However, following the end of the 1999-2002 drought, the data indicated that phosphorus levels at the upper freshwater HBMP "fixed" monitoring station locations increased to levels not seen for over 20 years, with the sharpest rise following Hurricane Charlie (**Figure 4.25e**). In approximately 2008 the data began to indicate declining levels, which by 2010 had returned to near those seen earlier in the decade. Upstream sampling by the Authority (see Section 7 of the previous *2008 HBMP Annual Data Report*) has linked the recent pattern of increased phosphorus levels with the discharges associated with on-going closure of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin.

- **Silica** – Plots of the long-term data clearly show that reactive silica concentrations have increased and exhibited a much wider range of variation during the recent 1996-2010 HBMP monitoring period when compared to older EQL background monitoring data collected during the 1976-1990 period (**Figure 4.27e)**. Silica levels are much higher at the upstream sampling sites, and show a strong seasonal pattern of increases associated with periods of higher freshwater inflows. There are indications that in part some of the observed increases may also be associated with upstream phosphate mining activities such as on-going closure of the Ft. Meade Facility. However, the observed increase in silica concentrations at both the “moving” (see **Section 3**) and “fixed” HBMP stations began much earlier than the recent increase in phosphorus levels, and hasn’t shown a corresponding rapid decrease.

- **Chlorophyll** – The long-term data show that high chlorophyll *a* concentrations or “blooms” commonly occurred during the late 1970s and early 1980s throughout the lower Peace River/upper Charlotte Harbor estuarine system. During the drier period of the later 1980s and early 1990s the frequency of such events declined. However, as flows have generally increased again over the past decade (even with the recent droughts) so have the occurrences of periodic spikes (**Figures 4.29a** through **4.29e**) in phytoplankton biomass (chlorophyll *a*).

5.0 USGS and HBMP Continuous Recorders

5.1 Introduction and Overview

During the 1996 permit renewal, the need was identified to begin collecting salinity data at fixed points along the HBMP monitoring transect at much greater frequencies than the ongoing monthly monitoring. The availability of such data would allow the development of statistical and/or mechanistic models that would allow increased accuracy in assessing the relative magnitudes of short-term salinity changes. These salinity changes are expected to result from the interactions of seasonally varying Facility withdrawals with natural variations in flows and tides. The initial 15-minute recorder locations were established by USGS under an ongoing contract with the Authority. Responding to comments and recommendations of the HBMP Scientific Review Panel, the Authority subsequently deployed addition continuous salinity recorders in December of 2005 and again in May 2008. In December 2009, USGS installed near surface and near bottom continuous recorders immediately adjacent to the Facility's river intake structure. This provided the Authority the ability to assess river conductance both downstream and at the Facility in real time. The relative locations during 2010 of the recorder array along the lower Peace River HBMP monitoring transect are depicted in **Figure 5.1** and further summarized in Table 5.1.

Table 5.1

Summary of HBMP Continuous Recorders on the Peace River

Gage ID, Location and Period of Monitoring	River Kilometer
RK12 (Authority) - Manatee Zone Marker near Shell Creek – May 2008 to present	RK 12.7
HH (USGS - 02297460) – Dock at Harbour Heights - Sep1996 to present	RK 15.5
RK21 (Authority) - Manatee Zone Marker near Liverpool area - Dec 2005 to present	RK 21.9
RK23 (Authority) - Manatee Zone Marker downstream of Navigator Marina - Dec 2005 to May 2008	RK 23.4
RK24 (Authority) - Manatee Zone Marker gage near Navigator Marina - Dec 2005 to present	RK 24.5
PRH (USGS - 02297350) – Dock at Peace River Heights gage – Nov 1997 to present	RK 26.7
PRP (USGS – 02297345) – Peace River at Platt (Facility) – December 2009 to present	RK 29.8
RK30 (Authority) - Manatee Zone Marker near SR 761 Bridge – May 2008 to present	RK 30.6
RK31 (Authority) - Old Railroad Bridge upstream of Facility – May 2008 to present	RK 31.7

5.1.1 USGS Recorders

The USGS began a cooperative water quality data collection program with the Authority in August 1996. An initial USGS continuous recorder (15-minute intervals) was installed later that month in the lower Peace River (**Figure 5.1**) at the end of an exiting private dock at Harbour Heights (RK 15.5). This USGS gaging site (02297460) monitors water level, surface and bottom specific conductance, and temperature.

The following month (September 1996) USGS installed an additional 15-minute recorder, which measured only water level at a site adjacent to Boca Grande. This site was located approximately near River Kilometer –31.8, and designated by USGS as 02293332. Tide stage data were collected by USGS for the Authority at this location between 1996 and 2004. The original purpose of this gage was to assess potential gradual increases in sea level. This rise in sea level was expected to occur over time and required monitoring in order to account for natural increases in salinity that might be occurring in the lower Peace River estuary. However, USGS staff at a later date felt that any conclusions regarding sea level rises at this site would be compromised due to the gage's location near the mouth of the Boca Grande Pass. The Authority (after consultation with the Scientific Review Panel and District staff) therefore decided to delete the continued collection of water level information at this site at the end of 2004.

The USGS added a second continuous conductivity recorder in the lower Peace River at the request of the Authority in November 1997 further upstream (RK 26.7) on a private dock near Peace River Heights (**Figure 5.1**). This USGS site (02297350) also measures water level, surface and bottom specific conductance, and corresponding temperatures at 15-minute intervals. Recently, in December 2009, USGS installed near surface and near bottom recorders (02297345) at the Facility's intake (RK 29.8).

Water level measurements at the two original USGS recording sites were initially made utilizing a floating sensor in a PVC stilling well and a fixed sensor near the bottom of the water column. USGS combination temperature and specific conductance probes measure near-surface and near-bottom specific conductance and temperature. Readings are electronically averaged over two-minute intervals and recorded at 15-minute intervals using a Campbell Scientific CR-10 electronic data logger. Data are retrieved and the sensors recalibrated at approximately monthly intervals.

The near-surface sensors at the two original gaging sites were initially suspended one-foot below the surface using a float, while the near-bottom sensors were suspended about one-foot from the bottom in the same stilling well. However, following damage caused by Hurricane Charlie (August 2004), the Harbour Heights gage (02297460) was rebuilt on January 11, 2005. The upper sensor was set at a fixed depth (0.40 ft below NGVD 1929) below the water surface to measure the near-surface specific conductance and temperature and the lower sensor was fixed (3.5 ft below NGVD 1929) near the bottom. The sensors were subsequently lowered to a new elevation on Nov 21, 2006. The upper sensor was set at a fixed depth (1.40 below NGVD 1929) and the lower sensor was set at (4.4 ft below NGVD 1929) near the bottom. The Peace River Heights gage was also rebuilt at this time (January 6-7, 2005). The top sensor was set to a fixed elevation approximately 1.3 ft below NGVD 1929 and the bottom sensor at approximately 3.8 ft. below NGVD 1929.

In 2009, using both the extensive data collected before and after these changes, as well as corresponding field measurements made during the monthly "fixed" station monitoring, the Authority completed a series of statistical comparisons to determine if these changes in depth resulted in meaningful systematic differences in the measured data. The results of these analyses concluded that no such changes could be detected.

The USGS continuous recorders located at the Facility's river intake structure were install in December 2009. The bottom YSI-600R water quality sensor is located inside 3 inch diameter pipe attached to the stilling well to record near bottom (approximately 12.8 ft below NAVD 88). The top YSI-600R water quality sensor is located in a 2 ft section of 3 inch diameter PVC pipe attached to a float. This floating sonde system is attached to two guide cables that are fastened to both a bracket at the top of a 16 inch aluminum stilling well and to two eyebolts in the bottom. The float keeps the water quality sensor approximately 1.5 ft. from the water surface at all gage heights.

The particular locations of the USGS recorders on existing docks and structures were established in part due to the USGS's need to be able to have land-based access for the ease of routine maintenance and the downloading of data. The influences of tide, wind and antecedent flow conditions can individually and in combination result in extremely wide ranges of observed variation in daily averaged conductivity measurements. **Figures 5.2** and **5.3** indicate the high degree of variability in conductivity that occurs at the Harbour Heights gage located at RK 15.5 relative to corresponding total upstream USGS gaged flows (Peace River at Arcadia, plus Horse Creek near Arcadia, and Joshua Creek at Nocatee). The influences of these confounding affects of wind and tide, by comparison, are noticeably less at the more upstream USGS Peace River Heights gaging site located at RK 26.7 (**Figures 5.4** and 5.5).

Table 5.2
Average Daily Conductivity at the Three USGS Continuous Recorders Versus Combined Upstream Gaged Peace River Flow
(Peace River at Arcadia + Horse and Joshua Creeks)

USGS Gage / River Kilometer	Subsurface Conductivity	Near-Bottom Conductivity
Harbour Heights (RK 15.5)	**Figure 5.2**	**Figure 5.3**
Peace River Heights (RK 26.7)	**Figure 5.4**	**Figure 5.5**
Peace River at Platt (RK 29.8)	**Figure 5.6***	**Figure 5.7***

* Figures are based on a single year of data collection

The 1996 renewal of the Facility's Water Use Permit set a threshold of 130 cfs (for all 12 months) at the USGS Peace River at Arcadia gage for the start of freshwater withdrawals. **Section 2.2** and **Table 2.5** summarize the temporary changes made to the withdrawal schedule during 2010 due to the severity of the 2006-2009 drought. However, as shown in Table 5.2, conductivity (salinity) levels are often extremely low in the upstream reach of the river (RK 26.7) monitored by the Peace River Heights USGS recorder (**Figure 5.1**). Often this area downstream of the Facility is characterized by freshwater conditions when Peace River at Arcadia flows are 130 cfs or greater. Thus, while the physical location of this upstream continuous recorder is appropriate to detect potential long-term systematic shifts in the freshwater/saltwater interface during low levels of freshwater inflow, it is extremely doubtful whether the direct influences of the Facility withdrawals can typically be measured at this upstream location when flows are near or above 130 cfs. The installing of the new USGS recorder at the intake structure (RK 29.8) will provide the Authority with a far clearer view of seasonal tidal influences combined with the upstream movement of higher salinity waters on withdrawals under low flow conditions (**Figures 5.6** and **5.7**).

5.1.2 Authority HBMP Recorders

The *2002 HBMP Comprehensive Report* (finalized in September 2004) recommended that an additional series of continuous conductivity gages be established by the Authority downstream of the USGS Peace River Heights recorder location. The primary objective of installing an additional series of HBMP continuous conductivity recorders, when combined with the existing long-term USGS sites, was to obtain greater resolution of the direct relationships among freshwater flow, stage height, and conductivity downstream of the Facility during periods of withdrawals. The addition of these gages was specifically designed to determine potential salinity changes during Facility withdrawals within the reach of the river characterized by the movement of the freshwater/saltwater interface at flows immediately above (or below) the 130 cfs threshold. The primary objective of the selected locations of these additional gages was, therefore, to assure and enhance the monitoring program's ability to directly measure salinity changes due to Facility withdrawals under lower flow conditions.

A number of possible alternative sites and deployment methodologies were evaluated by the Authority to assure that these monitoring objectives were met by the additional HBMP continuous conductivity recorders. The first step in deploying these instruments was to determine the potential spatial distribution of arraying the recorders downstream of the Facility. Again, the primary objective was to spatially maximize the new recorders' ability to detect salinity changes (impacts) that could be directly attributed to Facility freshwater withdrawals. Existing statistical models and graphical analyses of salinity/flow relationships were reviewed from the long-term HBMP fixed stations and USGS continuous recorders along the lower Peace River HBMP monitoring transect. These results were next evaluated in relation to potential existing physical structures (docks, pilings, etc.) to which additional continuous recorders might be attached (**Table 5.3**). A series of potential new monitoring sites located between the two existing USGS continuous recorders were selected and evaluated. The recent placement of a large number of Manatee Speed Zone markers along the lower river provided a series of spatially distributed potential sites downstream of the Facility. The Authority received permission from US Fish and Wildlife to establish continuous recorders using these markers. Three of these Manatee Speed Zone markers were chosen by the Authority for the initial deployment in December 2005 of HBMP continuous recorders measuring near surface conductivity (**Figure 5.1**).

- **RK 21.9** –The Manatee Speed Zone Marker located on the Peace River near the Liverpool side channel.
- **RK 23.4** – The Manatee Speed Zone Marker located on the Peace River downstream of Navigator Marina.
- **RK 24.5** – The Manatee Speed Zone Marker located on the Peace River just across from Navigator Marina (RK 24.5).

Based on comments and recommendations made by members of the HBMP Scientific Review Panel at its December 2007 meeting, the Authority added three additional continuous recorder locations in May 2008 by relocating the recorder previously at RK 23.4 to RK 31.7 and adding new recorders at RK 12.7 and RK 30.6 to extend upstream and downstream the area along the lower river covered by the continuous recorder array.

- **RK 12.7 –** A recorder was installed downstream of the USGS Harbour Heights gage on a Peace River Manatee Zone Marker (RK 12.7) below the confluence with Shell Creek. Unlike the other HBMP recorders, this instrument was installed near the bottom of the water column (~1.7 meters) and measures conductivity, temperature and dissolved oxygen levels continuously at 15-minute intervals.

- **RK 30.6 –** A recorder was also installed above the USGS Peace River Heights gage on a Manatee Zone Marker (RK 30.6) just upstream of the Facility's intake near the SR 761 Bridge. This recorder measures subsurface conductivity and temperature at 15-minute intervals.

- **RK 31.7** - The HBMP recorder previously located at RK 23.4 was relocated upstream to the old railroad trestle (RK 31.7) above the Facility. This recorder also measures subsurface conductivity and temperature at 15-minute intervals.

The locations of the recorders during 2010 (excluding the discontinued recorder at RK 23.4) are summarized in Table 5.1 above and are shown in **Figure 5.1**.

The methodologies used for deployment of the continuous recorders are depicted in **Figure 5.8** and **Photographs 5.1** through **5.7**.

- **Figure 5.8** – This diagram shows the method used to attach the PVC stilling well to the deep side of the selected Manatee Speed Zone Markers, using a series of stainless steel clamps.

- **Photo 5.1** – The photograph shows actually strapping the PVC stilling well to the inside of one of the Manatee Speed Zone Markers.

- **Photo 5.2** – The method used to attach the YSI conductivity/temperature sonde to the bullet floats is shown in this photograph. The size of the bullet floats was selected based on the weight of the sonde, and the diameter of the stilling well. Unlike the USGS continuous recorders, these YSI units have been deployed to measure conductivity and temperature only just below the surface. The Manatee Speed Zone Markers are located in relatively shallow depths along the sides of the main river channel. These locations are therefore not well suited for measuring differences between surface and bottom values.

- **Photo 5.3** – This photograph shows the YSI conductivity/temperature sonde attached to two bullet floats being readied for placement in the stilling well.

- **Photo 5.4** – This photograph shows the stilling well (with the locking cap) as seen from the river.

- **Photo 5.5** – This photograph shows deployment of the YSI meter near the bottom of the water column at RK 12.7 to measure conductivity, temperature and dissolved oxygen.

- **Photo 5.6** – This photograph shows the stilling well (with the locking cap) attached to the Manatee Speed Zone marker at RK 30.6 just upstream of the Facility and immediately downstream of the SR 761.

- **Photo 5.7** – This last photograph shows the most upstream continuous recorder stilling well (with the locking cap) attached to the old railroad trestle at RK 31.7.

Data from these recorders are retrieved at approximately monthly intervals (or more often as needed). A complete cleaned, calibrated and checked replacement set of sondes are typically deployed each month. However, if this is not possible, then the data are retrieved, the stabilities of the specific conductance and temperature sensors are checked, and the conductivity probes are cleaned and recalibrated. The factory calibrated temperature is checked against a second instrument, while specific conductance is calibrated against standards with values that bracket the range of expected values in the Peace River. The sensors are considered calibrated if the temperature is within 0.2 °C and specific conductance is within five percent of the standard values.

5.2 Results from USGS Continuous Recorders (2010)

All current (2010) and historical data gathered at the three USGS continuous recording conductivity gages located at Harbour Heights (02297460), Peace River Heights (02297350) and the Peace River at Platt (02297345), as well as historical information for the stage level gage near Boca Grande (2293332) are contained in the appropriate summary data sets summarized in **Table 1.3** (see **Section 1**).

Gage height, as well as surface and bottom conductivity and temperature readings collected in 2010 at 15-minute intervals at Harbour Heights on the Peace River (USGS Station 02297460, RK 15.5) are presented in **Figures 5.9** through **5.13**. Similar plots are shown in **Figures 5.14** through **5.18** for the continuous gage at Peace River Heights on the Peace River (USGS Station 02297350, River Kilometer 26.7), and for the gage at the Facility (USGS Station 02297345, River Kilometer 29.8) in **Figures 5.19** through **5.23** . These graphics are summarized in Table 5.4.

The magnitude and duration of influences of low freshwater inflows from the Peace River watershed on the upstream movement of higher salinity harbor waters are clearly evident by the surface and bottom conductivities observed at both the Harbour Heights (RK 15.5) and Peace River Heights (RK 26.7) gages. Conductivities at the more upstream Peace River Heights recording gage indicate the extent and duration of the upstream movement of higher conductivity harbor waters during 2010. Higher conductivity harbor water (2,000–8,000 uS/cm) extended upstream into this characteristically freshwater reach of the lower river during May through June and then again from the end of October through December during 2010. This is in direct contrast to the preceding much wetter 2003-2005 time interval when conductivities at the Peace River Heights gage exceeded 1000 uS/cm for only a few days each year.

Table 5.4
Summary Graphics of 2010 Data from USGS Continuous Recorders

Figure	Description
Figure 5.9	2010 Gage height (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.10	2010 Surface conductivity (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.11	2010 Bottom conductivity (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.12	2010 Surface temperature (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.13	2010 Bottom temperature (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.14	2010 Gage height (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.15	2010 Surface conductivity (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.16	2010 Bottom conductivity (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.17	2010 Surface temperature (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.18	2010 Bottom temperature (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.19	2010 Gage height (15-minute intervals) for Peace River fixed station at Peace River at Platt (Facility) – USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.20	2010 Surface conductivity (15-minute intervals) for Peace River fixed station at Peace River at Platt (Facility) – USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.21	2010 Bottom conductivity (15-minute intervals) for Peace River fixed station at Peace River at Platt (Facility) – USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.22	2010 Surface temperature (15-minute intervals) for Peace River fixed station at Peace River at Platt (Facility) – USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.23	2010 Bottom temperature (15-minute intervals) for Peace River fixed station at Peace River at Platt (Facility) – USGS Gage 02297345 (River Kilometer 29.8)

Comparisons of gage heights and both surface and bottom conductivity measurements at the three Peace River USGS gage locations, Harbour Heights (RK 15.5), Peace River Heights (RK 26.7) and at the Facility Intake (RK 29.8) are presented in **Figures 5.17** through **5.28** for the last two weeks in May 2010 (dry-season) and first two weeks of September 2010 (wet-season). These intervals were selected as representative of some of the dry-season and wet-season flows during 2010 . An overview of these graphics is presented in Table 5.5.

Table 5.5
Summary Graphics of Comparisons of Stage Height and Surface and Bottom Conductivity During May and September 2010 at the USGS Continuous Recorders

Figure	Description
Figure 5.24	Surface conductivity and stage height in May – USGS gage 02297460 (River Kilometer 15.5)
Figure 5.25	Bottom conductivity and stage height in May – USGS gage 02297460 (River Kilometer 15.5)
Figure 5.26	Surface and bottom conductivity in May - USGS gage 02297460 (River Kilometer 15.5)
Figure 5.27	Surface conductivity and stage height in September - USGS gage 02297460 (River Kilometer 15.5)
Figure 5.28	Bottom conductivity and stage height in September – USGS gage 02297460 (River Kilometer 15.5)
Figure 5.29	Surface and bottom conductivity in September – USGS gage 02297460 (River Kilometer 15.5)
Figure 5.30	Surface conductivity and stage height in May - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.31	Bottom conductivity and stage height in May - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.32	Surface and bottom conductivity in May – USGS gage 02297350 (River Kilometer 26.7)
Figure 5.33	Surface conductivity and stage height in September - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.34	Bottom conductivity and stage height in September - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.35	Surface and bottom conductivity in September - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.36	Surface conductivity and stage height in May - USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.37	Bottom conductivity and stage height in May - USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.38	Surface and bottom conductivity in May – USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.39	Surface conductivity and stage height in September - USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.40	Bottom conductivity and stage height in September - USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.41	Surface and bottom conductivity in September - USGS Gage 02297345 (River Kilometer 29.8)

As indicated in previous HBMP annual reports, **Figures 5.24** and **5.25** show that both surface and bottom conductivities at the downstream Harbour Heights site (RK 15.5) are very strongly influenced by tide (water stage) during periods when river flows are relatively low. During May, in the dry-season, it was not uncommon for surface and bottom conductivities to vary 7000 to 15000 uS/cm (roughly from 4 to 9.0 psu) over a tidal cycle. During September, in the wet-season, this lower reach of the Peace River is characteristically far fresher and daily variations in both surface and near bottom conductivities resulting from tidal influences are greatly reduced, often varying over a range of less than 0.2 psu. However, even during relatively wet periods, **Figures 5.27** and **5.28** show the marked influences that strong, sustained southerly winds can have on salinity in this reach of the lower Peace River.

At the more upstream continuous USGS gage at Peace River Heights (RK 26.7), the conductivity data collected in 2010 (**Figures 5.23** and **5.24)** showed surface and bottom conductivities varying 200 to 2000 uS/cm (roughly from 0.1 to 1.0 psu) over a tidal cycle during the May spring dry-season. This is in direct contrast to recent wetter years such as 2005, when corresponding May data indicate only small, infrequent differences in conductivity (usually less than 100 uS/cm) resulting from tidal variations. Another example is during the much drier period in May 2009 when measured tidal variations in conductivity at this location were observed ranging 9000 to 15000 uS/cm. During the wet-season in September 2010, conductivities at this upstream USGS gaging site were low, and did not show any noticeable response to daily tidal variations (**Figures 5.33** and **5.34)**.

At the most upstream USGS recorder (02297345) located at River Kilometer 29.8, the data do not indicate any influence of the upstream movement of tidal higher conductivity waters during either of the two time periods (May and September 2010) that was shown for the other two downstream USGS gaging locations.

5.3 Results from HBMP Continuous Recorders (2010)

All data to date for the six HBMP continuous (15-minute interval) conductivity gages at River Kilometers 12.7, 21.9, 23.4 (through May 2008), 24.5, 30.6 and 31.7 are contained in the appropriate summary data sets summarized in **Table 1.3** (see **Section 1**).

Conductivity readings (and dissolved oxygen at RK 12.7) collected in 2010 at 15-minute intervals at the HBMP continuous recorder sites (Table 5.1 above) are presented in **Figures 5.42** through **5.46**. More detailed graphics of this 15-minute data are also presented over two week intervals during both periods of spring dry-season low flow at the end of May (**Figures 5.47** through **5.51**) and summer wet-season high flow over the first two weeks of September (**Figures 5.41** through **5.45**). The single graphics of the 15-minute and daily average conductivities provide direct comparisons of the spatial differences among reaches of the lower river characterized by each of the recorder locations during both the May dry-season (**Figures 5.39** and **5.40)** and the September wet-season (**Figures 5.54** and **5.58**). The various graphics presented summarizing and contrasting the 2010 results for the Authority's HBMP continuous recorders are shown in Table 5.6.

As previously discussed with respect to corresponding data from the USGS continuous gages located downstream and upstream of these HBMP recorder locations, surface conductivities typically show a great degree of daily tidal variability during periods of low flow, in comparison to usually much smaller (or limited) tidal salinity changes during intervals of higher freshwater inflows.

Table 5.6
2010 Authority's HBMP Continuous Recorder Results

Location	Jan-Dec 2010	May 2010	September 2010	Comparison of Five Sites May 2010		Comparison of Five Sites September 2010	
				15-Minute	Daily Average	15-Minute	Daily Average
RK 12.7	Figure 5.42	Figure5.47	Figure 5.54	Figure 5.52	Figure 5.53	Figure 5.59	Figure 5.60
RK 21.9	Figure 5.43	Figure5.48	Figure 5.55				
RK 24.5	Figure 5.44	Figure 5.49	Figure 5.56				
RK 30.6	Figure 5.45	Figure 5.50	Figure 5.57				
RK 31.7	Figure 5.46	Figure 5.51	Figure 5.58				

5.4 Summary Comparisons among USGS and HBMP Continuous Recorders

The seasonal and daily ranges of variation in near surface salinities at the HBMP continuous recorders are statistically summarized and compared with similar data from the two USGS recorders over the past five years in Tables 5.7 (2006), 5.8 (2007), 5.9 (2008), 5.10 (2009) and 5.10 (2010). It should be noted that comparisons for RK 12.7 are not included since that HBMP gage measures only near bottom conductivities.

Of particular interest in comparing the data from the continuous recorders among the past five years is to compare annual differences in various reaches of the lower river in mean, median and maximum differences in salinities recorded on a daily basis at each of the monitoring locations. It should be noted that the actual observed changes are of a far greater magnitude than those predicted by the developed HBMP statistical models due to Facility withdrawals acting alone (approximately 0.1 to 0.5 psu depending on flow and location).

Table 5.7
Seasonal and Daily Ranges of Surface Salinity at the Two USGS and Three Authority HBMP Continuous Recorders during 2006

Location	Annual Salinity Statistics				Daily Change (Δ) in Salinity			
	Mean Salinity (psu)	Median Salinity (psu)	Minimum Salinity (psu)	Maximum Salinity (psu)	Mean Salinity Change (psu)	Median Salinity Change (psu)	Minimum Salinity Change (psu)	Maximum Salinity Change (psu)
USGS RK 15.5 Harbour Heights	8.1	7.6	0.1	24.7	6.0	6.0	0	14.3
HBMP RK 21.9	2.7	0.9	0.1	18.6	3.4	3.1	0	13.7
HBMP RK 23.4	2.0	0.5	0.1	18.3	3.1	2.3	0	14.1
HBMP RK 24.5	1.6	0.4	0.1	16.5	2.8	1.9	0	13.3
USGS RK 26.7 Peace River Heights	1.1	0.3	0.1	14.1	1.6	1.0	0	10.4

Table 5.8
Seasonal and Daily Ranges of Surface Salinity at the Two USGS and Three Authority HBMP Continuous Recorders during 2007

Location	Annual Salinity Statistics				Daily Change (Δ) in Salinity			
	Mean Salinity (psu)	Median Salinity (psu)	Minimum Salinity (psu)	Maximum Salinity (psu)	Mean Salinity Change (psu)	Median Salinity Change (psu)	Minimum Salinity Change (psu)	Maximum Salinity Change (psu)
USGS RK 15.5 Harbour Heights	13.1	13.6	0.5	30.6	13.0	8.0	2.3	15.8
HBMP RK 21.9	5.1	4.0	0.2	23.3	5.8	5.0	0.1	17.7
HBMP RK 23.4	3.9	2.6	0.2	25.1	5.0	3.7	0.0	21.5
HBMP RK 24.5	3.1	1.5	0.2	23.8	4.5	3.0	0.0	20.8
USGS RK 26.7 Peace River Heights	1.7	0.5	0.2	22.2	2.8	1.5	0.0	20.5

Table 5.9
Seasonal and Daily Ranges of Surface Salinity at the Two USGS and Two Ongoing Authority HBMP Continuous Recorders during 2008

Location	Annual Salinity Statistics				Daily Change (Δ) in Salinity			
	Mean Salinity (psu)	Median Salinity (psu)	Minimum Salinity (psu)	Maximum Salinity (psu)	Mean Salinity Change (psu)	Median Salinity Change (psu)	Minimum Salinity Change (psu)	Maximum Salinity Change (psu)
USGS RK 15.5 Harbour Heights	11.7	13.7	0.1	27.5	7.0	11.7	0.1	18.8
HBMP RK 21.9	4.6	4.0	0.1	19.0	4.3	5.1	0	13.4
HBMP RK 24.5	3.0	1.8	0.1	16.5	2.8	4.2	0	13.7
USGS RK 26.7 Peace River Heights	1.7	0.6	0.1	13.7	2.9	1.5	0	11.4

Table 5.10
Seasonal and Daily Ranges of Surface Salinity at the Two USGS and Four Ongoing Authority HBMP Continuous Recorders during 2009

Location	Annual Salinity Statistics				Daily Change (Δ) in Salinity			
	Mean Salinity (psu)	Median Salinity (psu)	Minimum Salinity (psu)	Maximum Salinity (psu)	Mean Salinity Change (psu)	Median Salinity Change (psu)	Minimum Salinity Change (psu)	Maximum Salinity Change (psu)
USGS RK 15.5 Harbour Heights	9.9	7.0	0.1	29.6	10.1	9.9	0.15	25.8
HBMP RK 21.9	4.8	1.4	0.1	23.6	4.8	4.7	0.0	13.4
HBMP RK 24.5	3.1	0.4	0.1	21.5	3.1	3.9	0.0	13.9
USGS RK 26.7 Peace River Heights	2.0	0.3	0.1	18.8	2.0	1.9	0.0	12.9
HBMP RK 30.6	0.7	0.3	0.1	8.4	0.7	0.6	0.0	5.5
HBMP RK 31.7	0.6	0.3	0.1	6.8	0.6	0.5	0.0	5.9

Table 5.11
Seasonal and Daily Ranges of Surface Salinity at the Three USGS and Four Ongoing Authority HBMP Continuous Recorders during 2010

Location	Annual Salinity Statistics				Daily Change (Δ) in Salinity			
	Mean Salinity (psu)	Median Salinity (psu)	Minimum Salinity (psu)	Maximum Salinity (psu)	Mean Salinity Change (psu)	Median Salinity Change (psu)	Minimum Salinity Change (psu)	Maximum Salinity Change (psu)
USGS RK 15.5 Harbour Heights	4.6	3.0	0.1	19.5	4.5	4.3	0.0	15.9
HBMP RK 21.9	1.0	0.3	0.1	11.5	0.9	0.9	0.0	9.8
HBMP RK 24.5	0.5	0.3	0.1	7.8	0.5	0.4	0.0	7.1
USGS RK 26.7 Peace River Heights	0.3	0.2	0.1	4.9	0.3	0.3	0.0	4.5
USGS RK29.8 at Facility	0.2	0.2	0.1	0.4	0.2	0.2	0.0	0.1
HBMP RK 30.6	0.2	0.2	0.1	0.7	0.2	0.2	0.0	0.3
HBMP RK 31.7	0.2	0.2	0.1	0.5	0.2	0.2	0.0	0.1

Peace River watershed flows from 2006 through the 2009 dry-season were unusually low (except for brief periods when tropical storms influenced summer rainfalls in the Peace River watershed). This is especially apparent, when making comparisons with the extended high seasonal flows that characterized much of the preceding three-year period between 2003 and

2005 (**Figure 2.7**). Thus, comparisons of the annual and daily statistical summary salinity values presented in these tables further emphasize just how extremely dry conditions were between 2006 and the summer of 2009. Not only were mean and median salinities measurably higher at each of the recorder locations over the 2007-2009 period when compared with 2006 and 2010, but there were large differences in both the maximum recorded levels and observed ranges of daily tidal variability. **Figures 5.61**, **5.62**, **5.63**, **5.64** and **5.65**. further graphically depict the spatial and temporal salinity differences between the past five years along the lower Peace River.

Table 5.12
Annual Spatial Variability in Salinity as Measured Along the Monitoring Transect by both the USGS and HBMP Continuous Recorders

Graphic and Year		
Figure 5.61 (2006)	Figure 5.62 (2007)	Figure 5.63 (2008)
Figure 5.64 (2009)	Figure 5.65 (2010)	

As these summary statistics indicate, salinities (conductivity) naturally vary over fairly broad ranges under low flow conditions in the reach of the river downstream of the Peace River Facility. Historical and recent statistical models presented in the *2007 "Pump Test" Findings* and the *2006 HBMP Comprehensive Summary Report* have indicated that potential daily average salinity changes due to Facility freshwater withdrawals (specified under the 1996 permit) are estimated (modeled) to be in the range of 0.1-0.5 psu in the reach of the lower river characterized by the continuous recorders. As long as the withdrawal schedule limits potential daily average changes to this range, salinity changes due to Facility withdrawals are expected to be small and difficult to directly measure.

6.0 Significant Environmental Change

Since its inception, the Hydrobiological Monitoring Program (HBMP) has incorporated numerous study elements directed toward assessing both the overall "health of the estuary" as well as impacts potentially associated with Facility withdrawals. An approach for determining whether permitted surface withdrawals have or are causing adverse environmental changes in the estuary utilizing HBMP data was proposed in the *2002 HBMP Comprehensive Summary Report* and further refined in the recent *2006 HBMP Comprehensive Summary Report*. This section briefly summarizes the hierarchy of management actions proposed to be implemented in response to detected changes that could forewarn of potential future changes that would constitute an adverse change.

6.1 Regulatory Basis of Review

The Southwest Florida Water Management District's (District) *Basis of Review* has established a specific series of performance standards for water use permits associated with withdrawals from natural surface waterbodies, such as the Peace River.

- *Flow rates shall not deviate from the normal rate and range of fluctuation to the extent that water quality, vegetation, and animal populations are adversely impacted in streams and estuaries.*

- *Flow rates shall not be reduced from the existing level of flow to the extent that salinity distributions in tidal streams and estuaries are significantly altered as a result of withdrawals.*

- *Flow rates shall not deviate from the normal rate and range of fluctuation to the extent that recreational use or aesthetic qualities of the water resource are adversely impacted.*

From a technical standpoint, adverse environmental impact can be defined using a wide range of metrics that quantify deviations from the pre-withdrawal salinity patterns, including changes in water quality conditions/characteristics that might be expected to significantly alter the spatial and/or temporal distribution and abundance of biological communities. The Peace River HBMP Scientific Review Panel (Panel) was established primarily to assist the District and Peace River Manasota Regional Water Supply Authority (Authority) staff in assessing the continued technical efficacy and ability of the HBMP to detect potential adverse impacts caused by the Facility, and secondarily to assist in the interpretation of analysis of HBMP data.

6.2 Resource Management Goals and Relevant Hydrobiological Indicators

In issuing the Peace River Facility's Water Use Permit, the District has identified the primary resources of interest, as well as resource management and protection goals, for the lower Peace River and upper Charlotte Harbor estuarine system.

- Protect the extent, distribution, and diversity of physical and biological habitats in the lower Peace River and upper Charlotte Harbor.

- Protect the abundance of fish and invertebrate species of sport and commercial importance in the lower Peace River and upper Charlotte Harbor.
- Protect the estuarine fish nursery function in the lower Peace River and upper Charlotte Harbor.
- Protect the spatial and temporal distributions of organisms that are important food sources for fish in the lower Peace River.
- Protect seasonal patterns of nutrient delivery to the estuary so that trophic interactions are maintained in the lower Peace River and the four goals above are met.
- Protect seasonal patterns of organic matter delivery to the estuary so that trophic interactions are maintained in the lower Peace River and Goals 1 through 4 are met.
- Protect the temporal and spatial characteristics of salinity distributions in the estuary so that Goals 1 through 4 are met.
- Protect dissolved oxygen concentrations in the estuary so that Goals 1 through 4 are met.
- Protect the abundance of any rare, threatened or endangered species that use the lower Peace River or upper Charlotte Harbor.
- Protect suitable habitats and water quality for fish and wildlife that are not of sport or commercial importance.

6.3 Rationale for Defining Significant Environmental Change

Inherent in the District's rules is the recognition that surface water withdrawals are linked to changes in salinity, and potentially associated with alterations of water quality characteristics, habitats and biological communities. Freshwater withdrawals have a direct and instantaneous physical affect on salinity, while the effects of freshwater withdrawals on other water quality constituents, and biological communities in particular, are typically indirect and more complex (**Figure 6.1**). Such indirect impacts are mediated by physical and chemical processes, and are typically manifested on slower time scales (i.e. weeks, months, or seasons).

District staff, with assistance from the HBMP Scientific Review Panel (Panel), is responsible for evaluating the interpretation of data collected from the HBMP and other sources to determine whether the timing and magnitude of the permitted Facility surface water withdrawals have or might be expected to cause harm to the lower Peace River/upper Charlotte Harbor estuarine systems. The term *adverse impact*, which is included in the Authority's Water Use Permit, has a distinct legal meaning in the context of water use permitting. The HBMP Scientific Review Panel expressed a concern that delaying action until this regulatory threshold had been crossed limited the ability to avoid perceived potential impacts. Therefore, based on consultation with the HBMP Panel and District staff, the 2002 and 2006 *HBMP Peace River Comprehensive Summary Reports* proposed that the less restrictive term *significant environmental change* be used by the Authority as a lower threshold criterion for assessing the findings of the HBMP.

The following definition of *significant environmental change* has been revised slightly from that originally proposed to include not only differences from the pre-withdrawal condition (before 1980), but also to incorporate comparisons between more recent periods and conditions under differing permitted withdrawals.

Significant Environmental Change

> ***A detected change, supported by statistical inference or a preponderance of evidence, in the normal or previous abundance, distribution, species composition, or species richness of biological communities of interest in the lower Peace River and upper Charlotte Harbor that is directly attributable to reductions in freshwater inflows caused by permitted surface water withdrawals.***

Conditions meeting the working definition of *significant environmental change* stated above could be measured and described in many different ways. Some simple examples are described below.

1. **Significant environmental changes in lower river/upper harbor habitats** - this would include measurable spatial and temporal changes in the natural variability of the salinity structure of characteristic fixed and/or dynamic estuarine components of sufficient magnitude to alter effected biological communities.

2. **Change in species richness or community balance** - numerous measures and indices exist to describe species richness, community balance, and biodiversity (e.g. Shannon-Weaver index) for various biotic indicators.

3. **Dislocation of an indicator species' distribution -** the "center of abundance" statistic and observed first and last occurrences have been used in the HBMP with respect to the distribution of larval and juvenile fish, benthos, and vegetation. A change in this statistic would likely be considered a significant environmental change

4. **Elimination or reduced abundance of a "desirable" indicator species -** the elimination, or a significant reduction in the abundance, of a desirable (e.g. economically or ecologically important) indicator species would likely be considered a significant environmental change.

5. **Introduction or increased abundance of an "undesirable" indicator species** - the converse of the above described scenario, the introduction, or a significant increase in the abundance, of an "undesirable" (e.g. non-native or nuisance) indicator species within a reporting unit would also likely be considered a significant environmental change.

Using this framework for identifying whether a significant environmental change has occurred, a series of hierarchy of management responses can be developed and structured according to various potential criteria and outcome objectives.

6.4 Authority's Management Response Plan (MRP) to a Potential Observed Significant Environmental Change

Waiting until an adverse environmental impact has occurred to initiate appropriate management actions or remedial measures reduces the opportunity to adequately protect resources that may be at risk. Therefore, the Authority has adopted a MRP that is a proactive approach to protecting the resources of concern in the lower Peace River estuarine system.

The plan recommends that salinity deviations be used as the initial primary indicator of significant environmental change that could lead to potential adverse environmental impacts. In addition, salinity deviations will be used as the triggering mechanism for a range of management responses aimed at reversing or minimizing the change to prevent potential adverse environmental impacts. Salinity deviations from the target distribution (**Figure 6.2**) will be evaluated in terms of magnitude, spatial extent, and/or temporal duration to develop a decision tree that is linked to various management actions (**Figure 6.3**). Using this approach, the intensity and urgency of the management response would be appropriately linked to the degree of the observed salinity deviations.

Initial management actions would focus on determining whether the observed deviation is in fact real and not a measurement error or an artifact of the sampling design. If the change is determined to be real, the next series of management actions will focus on better understanding and describing the change, and determining potential cause and affect relationships. Finally, the most intense management actions may involve regulatory actions resulting in remediation. A hierarchy of management actions, contained in the Authority's MRP is listed sequentially in order of increasing intensity and urgency below.

1. **Data QA/QC Audit** - This action would involve the performance of an intense QA/QC audit to determine if the detected change was the result of laboratory, data entry, or sampling errors.

2. **Data Comparison (Correlates)** - This action would involve a review of data correlates to determine if there is more than one line of evidence reflecting the detected change.

3. **Scientific Review Panel Meeting** - If Steps 1 and 2 indicate that the detected change is not due to quality control problems, and is reflected in multiple lines of evidence, the next step would be to convene a special meeting of the Panel. The purpose of the meeting would be to determine a possible modified course of action to refine the understanding of the magnitude and extent of the detected change. The Panel could recommend additional data analyses, or a redirected and focused sampling effort to better elucidate the detected change. Recommendations of the Panel would be subject to further review and approval by District staff.

4. **Redirected Sampling Effort** - This action would involve conducting more focused supplemental sampling in the affected river segments with the objective of gaining a better understanding of the detected change. This action would determine if detection of the change is repeatable under a more focused sampling program. In some instance,

District staff could recommend proceeding directly to Step 5 without conducting any redirected or additional sampling.

5. **Determination of Significant Environmental Change** - Based on the findings of Steps 1 through 4, the next step would be to reconvene the Panel with the objective of evaluating whether the detected change is substantial enough to potentially constitute an adverse environmental change. A determination of significant environmental change would be made via a consensus of professional opinion by District staff and the Panel members in consideration of technical and scientific factors. Following this determination, the Authority's Board would be briefed on the findings and recommendations of District staff and the Panel.

6. **Regulatory Summit Meeting –** If District staff and the Panel conclude that a significant environmental change has occurred, the next step would be to convene a meeting with all applicable regulatory agencies to determine the appropriate regulatory course of action. Actions could include deferral to the Water Management District Governing Board, or more immediate regulatory actions such as temporary modification of the withdrawal schedule. If more substantial regulatory actions such as permanent modifications to the withdrawal schedule were determined to be appropriate, recommendations would be made to the District Governing Board for formal action.

7. **District Governing Board Hearing** - This step would involve the presentation of data and other evidence indicating the occurrence of significant environmental change to the District Governing Board. The formal determination of adverse impact from a regulatory and legal standpoint would be made by the District Governing Board. If it is determined that the detected change constitutes an adverse environmental impact, then the Governing Board could require appropriate remediation and or mitigation.

8. **Remediation** - The requirement of appropriate remedial measures by the District Governing Board could include such actions as modifications to the permitted withdrawal schedule. Modifications to the withdrawal schedule could include provisional or temporary reductions in withdrawal rates, or modifications to the schedules with greater withdrawals occurring during high flows and lesser withdrawals during low flows.

In the implementation of the sequence of management responses described above, the primary objective is the prevention of any adverse impacts. However, the intensity of the management response should not be the only criteria considered. The detection of any hydrobiological change must always be framed within the degree of certainty that the detected change is real, and not solely due to chance. Therefore, the intensity of the management response should be tied not only to the magnitude or severity of the hydrobiological change, but also to the degree of certainty that the detected change is real, and whether it is caused by Authority withdrawals. Table 6.1 below presents a conceptual matrix approach that integrates the magnitude of the detected change and the probability that the change is due to chance alone (e.g. alpha).

Table 6.1
Conceptual Decision Matrix For Determining An Appropriate Management Response To Detected Hydrobiological Change

Probability of Making a Type I Error	Magnitude of Detected Hydrobiological Change		
Alpha	**Small**	**Moderate**	**Large**
0.20	Data Comparison	Scientific Review Panel Meeting	Redirected Sampling
0.10	Scientific Review Panel Meeting	Redirected Sampling	Determination of Significant Change
0.05	Redirected Sampling	Determination of Significant Change	Regulatory Summit Meeting

As shown in Table 6.1, the intensity of the selected management response is a function of both factors. If the detected change is relatively large, but the degree of certainty is low (e.g. high alpha) then a less intense management response would be appropriate. If, on the other hand, the detected change is considered to be moderate, but the degree of certainty is high (e.g. low alpha), then a more intense management response would be indicated. The application of this approach would obviously vary with the specific hydrobiological changes and statistical measures of certainty involved. The approach of the selected management response would also depend on whether the observed change was found to be attributable directly to Facility withdrawals or potentially to anthropogenic upstream activities.

6.5 Assessment of Permitted Withdrawals

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 estuary" as well as direct and indirect adverse impacts potentially associated with Facility withdrawals. The slightly lower than average flows observed during 2010 resulted in upstream shifts in a number of water quality characteristics when compared to the longer-term, historic HBMP information. In other instances, constituents such as silica and ortho-phosphorus have shown progressive, systematic changes over time (trends) as documented in **Sections 3** and **4**. However, as documented in Chapter 7 of the previous *2008 HBMP Annual Data Report* these trends have been shown to be associated with other changes in the watershed and not related to Facility withdrawals.

The analyses and evaluations of the 2010 HBMP data presented in Sections 2 through 5 neither indicated any potential "Significant Environmental Changes," nor were any changes observed that required administrative action as per the Authority's Management Response Plan.

7.0 Assessment of Upstream Changes in Water Quality

Since its inception, the Hydrobiological Monitoring Program (HBMP) has incorporated numerous study elements directed toward both assessing the magnitude of changes resulting from freshwater withdrawals relative to the downstream physical estuarine environment and biological communities of the lower Peace River/upper Charlotte. The HBMP has further sought to determine seasonal and longer term changes in flows and other parameters, such as water quality, that relate to changes in the upstream watershed and the overall "health of the estuary". Analyses of long-term water quality data from both the fixed and isohaline monitoring program study elements presented in this and previous HBMP reports have identified several important recent and longer term changes in water quality that have occurred upstream of the Facility that may influence both aspects of operations and/or the biological communities of the estuarine system. These distinct observed changes in water quality include the following trends.

- There have been long-term, progressive increases in the conductance of the water coming downstream to the Facility during the drier months of the year. This trend has further been associated with increasing volumes of water (base flow) during the normally seasonal drier time intervals.

- Seasonally, silica levels in the lower Peace River/upper Charlotte Harbor estuary have been progressively increasing at a rapid rate over the past decade. More recently, phosphorus levels in the lower Peace River that had historically shown dramatic declines during the late 1970s and 1980s have returned to levels not observed in decades.

The following summarizes the findings of previous analyses. A series of updated comprehensive analyses will be conducted in the upcoming Year-Five *2011 HBMP Comprehensive Summary Report*.

7.1 Increasing Conductance in the Lower Peace River

The recently completed *Peace River Cumulative Impact Study* (PBS&J 2007) identified anthropogenically related trends of increasing specific conductance within some of the major tributaries to the lower Peace River. These changes over recent decades have been primarily associated with increasing land conversions from less to more intense forms of agriculture that increasingly rely on irrigation using higher conductivity water pumped from the upper Floridan aquifer. The *2006 HBMP Comprehensive Summary Report* evaluated patterns and historical trends in specific conductance and associated water quality characteristics measured at the Peace River at Arcadia gage, within both the upstream Joshua and Horse Creek tributaries and at the fixed HBMP long-term monitoring site located at River Kilometer (RK) 30.7 located immediately upstream of the Peace River Facility.

7.1.1 Peace River at Arcadia

The Peace River at Arcadia USGS gage (2296750) has the longest flow historic record (1931–present) of any of the gages in the Peace River watershed. It is also the most downstream gage located along the main stem of the river and includes flows not only from the immediate basin, but also from the upstream Bartow and Zolfo Springs watershed basins, as well as the Payne and Charlie Creek tributary basins. Historic loss of flows from springs and seeps have been one of the factors that have affected base flow to the upper portion of the Peace River. Base flows in both the upper and middle Peace River have also been affected by changes in discharges and drainage alterations associated with urbanization, phosphate mining, and more intense forms of agriculture. Specific conductance values historically measured by USGS and more recently by the District at the Peace River at Arcadia gage site have ranged from a low of only 22 uS/cm (July 1966) to a high of 645 uS/cm (June 2000). Seasonally the highest mean and median specific conductance values occur in May following the typically spring dry-season, while the lowest mean and median levels are observed in August during the summer wet-season. The analyses of long-term data presented in the *2006 HBMP Comprehensive Summary Report* clearly indicate that both specific conductance and chloride concentrations have both increased over time during periods of low flow. These data indicate that the largest increases occurred from the 1960s to the early 1980s. The observed patterns of water quality changes at the Arcadia gage clearly indicate seasonal contributions of higher conductivity ground water into the middle portions of the Peace River.

7.1.2 Joshua Creek at Nocatee

The Joshua Creek begins in northeastern DeSoto County and flows southwest to where it joins the Peace River downstream of the Peace River at Arcadia gage at a point slightly upstream from Nocatee in central DeSoto County. Land use in this basin has historically changed from predominantly native habitats and unimproved pasture in the 1940s to extensive areas of improved pasture and more intense forms of agriculture such as citrus and row crops by the late 1990s. Approximately three quarters of the land use in the Joshua Creek basin by 1999 was in agricultural uses, with 29 percent of the basin being utilized for citrus production (PBS&J 2007). These alterations to more intense forms of agriculture are reflected in the historic changes in the water chemistry of Joshua Creek, which over recent decades has seen large increases in concentrations of both specific conductance and total dissolved solids. These changes are associated with the increasing surface drainage of agricultural discharges of high conductivity ground water pumped from the upper Floridan aquifer for irrigation and ultimately flow into Joshua Creek. The augmentation of base flow resulting from agricultural discharges is particularly apparent during naturally occurring seasonal low flow periods, when irrigation is vital to agriculture. Time-series plots of specific conductance clearly indicate that specific conductance has been increasing in Joshua Creek over time *Peace River Cumulative Impact Study* (PBS&J 2007) and *2008 HBMP Data Report*. The available data indicate that water quality in Joshua Creek has undergone substantial chemical changes over time. These changes in conductivity and related water quality parameters stem from agricultural irrigation practices throughout the basin and have recently been particularly prevalent during drought conditions.

The *Shell Creek and Prairie Creek Watersheds Management Plan* (SWFWMD 2004) addressed such water quality changes in Joshua Creek, acknowledging that pumping highly mineralized water from the upper Floridan aquifer for agricultural irrigation is the primary contributing factor to the observed water quality degradation in Joshua Creek. The District's watershed management plan proposed basin conductivity target levels corresponding with the state standards for Class I waters should not to be exceeded at any time by 2014. While progress has been made reducing levels below those observed during the 1999-2001 drought, dry-season levels remain well above historic levels.

7.1.3 Horse Creek near Arcadia

Over portions of the south Horse Creek basin, the head of the intermediate aquifer is often higher than that of the surficial aquifer, resulting in intermediate aquifer ground water moving upward into the surficial aquifer and then discharging into the creek (PBS&J 2007). In other portions of the basin, ground water use has historically reduced the potentiometeric surface of the lower aquifers and much of Horse Creek base flow is seasonally, predominantly influenced by agricultural ground water discharges. There have been a number of land use changes in the Horse Creek basin that have influenced basin flows. Phosphate mining has moved south from the Payne Creek basin and continues to expand into the adjoining northern areas of the Horse Creek basin. Agriculture and urban development have both at the same time expanded in the more southern portions of the basin. Agriculture in 1999 accounted for just under half of the Horse Creek basin's land use, with ten percent being in intense forms of agriculture (citrus and row crops).

Specific conductance levels are generally the highest in the southern part of the basin during the seasonal dry spring and other periods of low flow, such as during the recent extended periods of drought (1999-2001 and 2006-2009). Again, the data indicate that specific conductance and chloride levels in southern Horse Creek have been increasing primarily due to augmented base flow by surface discharges of highly mineralized deep aquifer ground water due to agriculture irrigation. Specific conductance concentrations during dry periods exceed the protective levels set forth by the District in the *Shell Creek and Prairie Creek Watersheds Management Plan*.

7.1.4 Peace River Kilometer 30.7

Monthly samples have been taken as part of the fixed station HBMP water quality monitoring program just upstream of the Peace River Facility at RK 30.7 (old EQL Station 18). Monthly monitoring began in 1976, ceased in 1990, and then resumed in 1996 as part of both the HBMP fixed and moving station water quality monitoring in conjunction with the renewal of the Facility's 1996 water use permit. The data from this location has been of special interest due to its proximity to the Facility and thus the sampling frequency was therefore increased in 1996 to twice monthly.

When the Peace River at Arcadia flows are low (90-110 cfs) over an extended period of time, the reach of the lower Peace River near the Facility is often tidally subject to intrusions of brackish waters. However, beyond such low flow occurrences, the primary seasonal influences on specific conductance (and other associated water quality parameters) measured immediately upstream of the Facility are constituents contained in combined flows moving downstream from the Peace River at Arcadia, Joshua Creek at Nocatee, and Horse Creek near Arcadia stations.

Analyses of dry-season specific conductance and chloride concentrations at RK 30.7 conducted as part of the *2006 HBMP Comprehensive Summary Report* clearly show that measured levels immediately upstream of the Facility have been increasing over time (after having excluded the upstream movement of higher saline harbor waters). At the same time, the relative annual contributions of the upstream gages to flows at the Facility indicate that over time the proportion from the Peace River at Arcadia station has been decreasing, while the relative contributions from Horse and Joshua Creeks have been increasing. The increasing relative proportion of flows during dry periods has resulted from a decoupling of rainfall and basin flow due to agricultural augmentation of flow.

The upstream changes in water quality (conductance, chlorides and TDS levels) originating from agricultural discharges during the dry-season have yet to be a serious hindrance to water supply. However, this is not to say that such changes may not become a problem in the future if the current trends in the contributing upstream basins continue. Reducing agricultural ground water pumping in these upstream basins would effectively decrease the potential for such impact to Facility operations. It would, however, also substantially reduce the total dry-season flows to the Facility. To a great extent the historic declines in base flow due to the anthropogenic losses of spring flows in the upper Peace River watershed have subsequently been replaced by agricultural discharges in the southern watershed basins. Future reductions of these artificially augmented flows without corresponding restoration of upper watershed base flows may have the unintended consequence of shifting the salt wedge further upriver and increasing the frequency of time during which the Facility is unable to withdraw during the dry season and put a higher premium on storing water during the wet-season.

7.2 Changes in Phosphorus and Silica in the Lower Peace River

Seasonal silica levels in the lower Peace River and upper Charlotte Harbor have been progressively increasing over the past decade. Further, in recent years, phosphorus levels in the lower Peace River that had historically shown dramatic declines during the late 1970s and 1980s had returned to levels not observed in decades. The notable changes in these two characteristic water quality parameters have been highlighted in HBMP reports going back over a number of years, and are readily apparent in time-series data plotted over the period-of-record from both the monitoring program's isohaline (**Figures 3.18** and **3.20**) and fixed station (**Figures 4.25e** and **4.27e**) elements.

A number of alternative potential explanations had been suggested as potential causes for these observed water quality changes, but ultimately neither Authority nor District staffs had been able to attribute such water quality changes to specific activities in the upstream watershed. The Authority therefore decided to independently collect water quality samples to determine if these observed changes might be linked to specific regions (or basins) of Peace River watershed and if so, could these changes be further linked to recent or on-going changes in land use and/or specific types of anthropogenic activities. This exploratory monitoring was undertaken using a flexible sampling strategy designed to help define potential upstream sources of the observed changes in water quality. Ultimately, samples were collected an analyzed for a number of water quality parameters from ten different watershed sites upstream of the Facility (**Figure 7.1)**.

- Peace River at Highway 98 (Fort Meade)
- Bowlegs Creek at Highway 657
- Whidden Creek at Highway 17
- Peace River at County Line Road
- Peace River at Highway 636

- Peace River at Highway 64
- Peace River at Highway 70
- Joshua Creek at Highway 17
- Horse Creek at Highway 769
- Peace River at SR 761

Water quality samples were collected from differing groups of sites over the period between 2007 and 2010 to help specifically define potential sources and identify seasonal differences (**Table 7.1**).

June 2007 – samples were collected at the end of the wet-season under low flow conditions from an array of eight locations distributed over the Peace River watershed to determine if a potential region or areas might be identified as the source(s) of the increasing high levels of silica and phosphorus. The results (**Table 7.1** – notably high values are indicated in red) clearly indicates that there was a distinct source of water characterized by high levels of conductivity, calcium, potassium, phosphorus and silica somewhere between the two upstream Peace River sites at Highway 98 in Fort Meade and further downstream at County Line Road. (The results also showed high conductivity levels within Joshua Creek, but not high levels of phosphorus or silica).

July 2007 – this follow-up sampling, undertaken under considerably wetter conditions, was specifically designed to determine if the source of the high levels of phosphorus and silica observed the month before between the Peace River Fort Meade and County Line locations could be better defined, and might be originating in either the Whidden or Bowlegs Creek subbasins (both of which are characterized by extensive areas of phosphate mining). The results (**Table 7.1**) clearly showed that the source of high phosphorus and silica was located in the Whidden Creek basin.

April 2008 – samples were collected at all ten monitoring sites during the spring dry-season. The results again identified Whidden Creek as a source of water characterized by high conductivity, calcium, potassium, phosphorus and silica. During this one sampling event high levels of silica were also observed upstream both in the Pace River at Fort Meade and coming from the Bowlegs Creek basin. In the southern portion of the watershed high conductivity levels were observed in both Joshua and Horse Creek basins.

May 2008 – a second set of dry-season sampling was conducted the following month in May 2008, again using the array of ten Peace River Watershed sites. The results (**Table 7.1**) were similar to those observed during the previous month, with the notable exceptions that high silica levels were not observed at either the Peace River at Fort Meade or Bowlegs Creek sites.

October and November 2008 – samples were collected just from the Whidden Creek sampling site. As in the previous sampling events, high levels of conductivity, calcium, potassium, phosphorus and silica continued to be observed in the water entering the upper Peace River from Whidden Creek.

April 2009 – this set of samples was collected from all ten watershed locations and as in previous years the results show high level of conductivity, calcium, potassium, phosphorus and silica coming from Whidden Creek, and high levels of conductivity in both Joshua and Horse Creeks.

June 2010 – these samples were also collected from all ten watershed locations and as in previous years the results show high level of conductivity, calcium, potassium, phosphorus and silica coming from Whidden Creek, while conductivity levels in both Joshua and Horse Creeks were below those observed during previous years.

Using the gathered data, Authority staff met with District and Florida Department of Environmental Protection (DEP) staff in September 2008 to discuss the monitoring results and express potential concerns. The majority of land uses and water use permits in the Whidden Creek basin are associated with phosphate mining activities (**Figure 7.2**) with there being very few other land uses such as agriculture occurring in areas adjacent to the creek. Currently there are four existing NPDES permits associated with Mosaic's mining operations located upstream of the Whidden Creek monitoring site.

Communication with staff at the FDEP Bureau of Mines and Minerals revealed that the USAgriChemicals Fort Meade operations is currently conducting shut-down operations under a DEP consent order (# 06-1506), which allows closure of the two existing phosphogypsum stacks (No. 1 and No. 2 in **Figure 7.2** and **Figures 7.3a** and **7.3b**), with the associated discharge of treated water from these two stacks being directly to Whidden Creek. The closures of the stacks and Whidden Creek discharges began in November 2005. The consent order initially set a maximum conductivity of discharge at 3000 us/cm. This level was reduced in November 2007 to 2500 us/cm, and was expected to be further reduced again in late 2008. It was initially projected that the closure procedures would continue through 2010, with most of the discharge of process water to the creek stopping in 2009. However, even after the closures of the two phosphogypsum stacks are completed, the stacks will continue to create some lower volume waste water consisting primarily of rainwater and some seepage from the stacks that will enter the storm water system.

During stack closure, process water is treated, blended with Upper Floridan aquifer ground water and continually discharged to Whidden Creek (approx. 5-7 mgd, which will be reduced toward the final year of closure). The treatment system for the process water consists of pumping process water at a pH of approximately 1.0 su to a stack cell and adding lime to achieve a pH of 4.0 su. The goal is to precipitate metals, fluoride and radiological chemicals that then remain within the cell after the stack is closed. The process water is then pumped into another cell and additional lime is added to achieve a pH of 11.0 su and where phosphate is settled and ammonia is released to the atmosphere. The process water is then again pumped to another cell where the pH is reduced back to 7.0 su, blended with surface and/or ground water (depending on season and availability of surface water) before being discharged to Whidden Creek.

In addition to the Whidden Creek operations, the Mosaic Company's Bartow operations also located in the Peace River watershed has phosphogypsum stack operations. This facility has two (north and south) stacks. The south stack is still in operation and receives new process water daily, while the north stack has started closure under a normal permit. Since the phosphate facility is still in operation, the system looses water which requires process water from the north stack to be recycled to a regional pond. However, if rainfall events cause high system water levels, then treated water may be discharged to the Six Mile Creek.

In addition, DEP allowed an emergency discharge of stack water to the Peace River for all mines from September 2004 through the spring of the spring of 2005, due to the unusual passage of three hurricanes (see **Section 2**) through the watershed over a short period of time during the summer of 2004. This step was necessary in order to reduce water inventory on the stacks and reduce the risk of failures due to the hurricane events.

The observed changes and increasing trends in water quality noted by the Authority's HBMP and watershed monitoring, as well as the District's watershed ambient surface water quality monitoring program (see Section 7 in the *2008 HBMP Data Report*) appear to coincide well with the mine closure discharge activities. Whidden Creek is the second mine closure in the Peace River Basin since 1996. DEP has agreed to provide the Authority with a copy of the current Whidden Creek consent order, to keep the Authority appraised of the ongoing progress on the stack closures, and keep them informed of future further closures occurring in the Peace River Watershed.

7.3 Summary

- There have been long-term, progressive increases in the conductance of the water coming downstream to the Facility during the drier months of the year. This trend has further been associated with increasing volumes of water (base flow) during the normally seasonal drier time intervals. These changes over recent decades have been primarily associated with increasing land conversions from less to more intense forms of agriculture that increasingly rely on irrigation using high conductivity water pumped from the upper Floridan aquifer. Such changes are particularly apparent in the Joshua and Horse Creek basins in the southern portions of the Peace River watershed. The upstream changes in water quality (conductance, chlorides and TDS levels) originating from agricultural discharges during the dry-season have yet to be a serious hindrance to water supply operations. However, this is not to say that such changes may not become a problem in the future if the current trends in the contributing upstream basins continue.

- Silica levels in the lower Peace River/upper Charlotte Harbor estuary have been increasing over the past decade. More recently, phosphorus levels in the lower Peace River that had historically show dramatic declines during the late 1970s and 1980s had returned to levels not observed in decades. These observed changes in long-term HBMP data, combined with the Authority's watershed monitoring and the District's watershed ambient surface water quality monitoring indicate that these recent changes coincide well with the ongoing closure of phosphogypsum stacks and associated discharges in the Whidden Creek subbasin. It is therefore reasonable to assume that increases in these same parameters that predate the period of closures of the USAgriChemicals Fort Meade operations have also been related to changes in phosphate mining activities in the upper Peace River watershed.

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2010 HBMP Tables

This section contains tables not included directly in the text for each section

- **Section 1 – Introduction / Summary**
- **Section 2 – Peace River Gaged Flows and Regional Water Supply Facility Withdrawals**
- **Section 3 – *In Situ* Physical Measurements, Water Chemistry and Phytoplankton Biomass at "Moving Isohaline Locations**
- **Section 4 – Water Chemistry Data Collected At "Fixed" Station Locations**
- **Section 5 – USGS and HBMP Continuous Recorders**
- **Section 7 – Assessment of Upstream Changes in Water Quality**

Table 1.1
HBMP Fixed Sampling Locations

USGS River Mile	USGS Location Number	Previous EQL Station Number	Additional Sampling	New River Kilometer designation based on Morphometric Study
Current *In Situ* Water Column Profile Sampling Locations				
CH6	265355082075500	9	Water Quality	**-2.4**
RM3.95	265640082033500	10	Water Quality	**6.6**
RM4.88	265724082024400	21		**8.4**
RM6.25	265727082012800	11		**10.5**
RM8.61	265711081595500	Shell Creek 9 (92)		**12.7**
RM8.6B	265819082003200	22		**12.8**
RM10.2	2297460	12	Water Quality/Tide Gage/Conductivity	**15.5**
RM11.2	270022081591000	23		**17.5**
RM 12.55	270124081592500	13		**20.1**
RM13.95	270235081592400	24		**21.9**
RM14.82	270318081593100	14	Water Quality	**23.6**
RM15.45	270337081595800	25		**24.7**
RM16.29	270418082001600	15		**25.9**
N/A	2297350	N/A	Tide Gage/ Conductivity	**26.7**
RM18.25	270451081595100	17		**29.5**
RM18.95	2297330	18	Water Quality	**30.7**
RM19.5	270537081585800	19		**32.3**
Previous Vegetation Transect Locations				
N/A	N/A	I		**15.6**
N/A	N/A	II		**22.3**
N/A	N/A	III		**20.4**
Previous EQL Water Column and Chemistry Sampling Sites				
N/A	N/A	16		**27.1**
N/A	N/A	20		**34.1**

Table 1.2
HBMP Chemical Water Quality Parameters

Ongoing Long-term Analytes	Benchmark, Inc. 2010 Detection Limits (MDL)
Salinity	0.1 psu
Chloride	0.35 mg/l
Color	2 pcu
Silica	0.044 mg/l
Iron	29 ug/l
Ortho-Phosphorus	0.002 mg/l
Nitrate + Nitrite Nitrogen	0.004 mg/l
Ammonia/Ammonium Nitrogen	0.005 mg/l
Total Kjeldahl Nitrogen	0.05 mg/l
Total Nitrogen	0.05 mg/l
Suspended Solids	0.57 mg/l
Volatile Solids	1.4 mg/l
Chlorophyll *a*	3.46 ug/l
Analytes Deleted Starting March 2003	
Alkalinity	
Turbidity	
Total Phosphorus	
Inorganic Carbon	
Total Organic Carbon	
Dissolved Organic Carbon	

Table 2.9
Long-Term Yearly Mean Measurements of Peace River Flows and Facility Withdrawals during HBMP Monitoring Period

Year	Annual Mean Peace River Total Gaged Flow (cfs) at:			Annual Mean Withdrawals (cfs)		Peace River Facility Withdrawals as Percentages of Total Gaged Flows at:			Total of Authority and City of Punta Gorda Withdrawals as Percent of Total Gaged Flow as US 41 Bridge
	Arcadia	Peace River Facility	US 41 Bridge	Peace River Facility	City of Punta Gorda from Shell Creek	Arcadia	Facility	US 41 Bridge	
1976	703.3	784.2	960.8	No Withdrawals	2.5	No Withdrawals			0.3
1977	478.7	588.0	732.0		3.0				0.4
1978	997.3	1254.6	1525.8		3.0				0.2
1979	1171.5	1532.7	2080.5		3.2				0.2
1980	495.2	578.2	726.3	3.9	3.4	0.7	0.6	0.5	0.9
1981	288.4	442.3	629.7	5.1	3.7	1.8	1.2	0.8	1.4
1982	1610.5	2141.9	2746.9	5.9	3.9	0.4	0.3	0.2	0.4
1983	1371.4	1778.7	2319.9	5.1	3.8	0.4	0.3	0.2	0.4
1984	567.0	742.9	1102.7	4.1	4.2	0.7	0.6	0.4	0.8
1985	369.0	510.6	680.8	7.2	3.9	2.0	1.4	1.1	1.6
1986	549.0	781.3	1013.7	7.5	3.8	1.4	1.0	0.7	1.1
1987	802.8	1095.5	1357.8	7.6	3.8	1.0	0.7	0.6	0.8
1988	1054.1	1425.2	1738.4	9.5	5.0	0.9	0.7	0.6	0.8
1989	373.6	481.9	699.0	9.6	5.2	2.6	2.0	1.4	2.1
1990	402.4	544.5	741.4	8.7	5.3	2.2	1.6	1.2	1.9
1991	771.2	1063.7	1567.6	10.4	4.7	1.4	1.0	0.7	1.0
1992	784.6	1143.0	1543.7	9.4	5.0	1.2	0.8	0.6	0.9
1993	698.5	903.1	1249.3	12.0	4.9	1.7	1.3	1.0	1.4
1994	1365.9	1788.6	2259.0	11.7	5.0	0.9	0.7	0.5	0.7
1995	1708.1	2250.4	3071.6	12.2	4.9	0.7	0.5	0.4	0.6
1996	598.2	725.6	928.8	12.5	5.2	2.1	1.7	1.3	1.9
1997	1059.9	1439.0	1777.6	12.1	5.0	1.1	0.8	0.7	1.0
1998	1916.0	2459.9	2921.3	15.4	5.1	0.8	0.6	0.5	0.7
1999	565.9	782.7	1144.5	12.8	5.5	2.3	1.7	1.2	1.7
2000	138.7	220.8	335.3	5.7	6.1	4.1	2.6	1.7	3.5

Table 2.9
Long-Term Yearly Mean Measurements of Peace River Flows and Facility Withdrawals during HBMP Monitoring Period

Year	Annual Mean Peace River Total Gaged Flow (cfs) at:			Annual Mean Withdrawals (cfs)		Peace River Facility Withdrawals as Percentages of Total Gaged Flows at:			Total of Authority and City of Punta Gorda Withdrawals as Percent of Total Gaged Flow as US 41 Bridge
	Arcadia	Peace River Facility	US 41 Bridge	Peace River Facility	City of Punta Gorda from Shell Creek	Arcadia	Facility	US 41 Bridge	
2001	1038.4	1442.0	1936.9	7.9	6.1	0.8	0.6	0.4	0.7
2002	1191.8	1635.8	2202.6	22.8	6.5	1.9	1.4	1.0	1.3
2003	1856.3	2454.3	2921.9	26.1	6.8	1.4	1.1	0.9	1.1
2004	1746.5	2363.3	2788.1	24.2	6.9	1.4	1.0	0.9	1.1
2005	1859.9	2338.7	2955.2	29.1	6.9	1.6	1.2	1.0	1.2
2006	375.6	538.2	818.4	18.4	7.5	4.9	3.4	2.2	3.2
2007	173.1	237.6	353.2	11.2	5.0	6.5	4.7	3.2	4.6
2008	430.8	594.8	830.4	15.4	6.6	3.6	2.6	1.9	2.7
2009	544.8	727.0	990.1	43.6	6.9	8.0	6.0	4.4	5.1
2010	703.8	994.8	1268.0	33.3	7.1	4.7	3.4	2.6	3.2

Table 3.3
Water Chemistry Methods used during Isohaline Based "Moving" Station HBMP Monitoring Study Element

Parameter	Method	Detection Limit
Color	EPA 110.2	2.0 Co_Pt Units
Chloride	EPA 325.2	0.4 mg/l
Total Suspended Solids	EPA 160.2	0.6 mg/L
Volatile Suspended Solids	EPA 160.4	1.4 mg/L
NO2+NO3 Nitrogen	EPA 353.2	0.004 mg/l
NH3+NH4 Nitrogen	EPA 350.1	0.005 mg/l
Total Kjeldahl	EPA 351.2	0.05 mg/l
Ortho-Phosphorus	EPA 365.2	0.002 mg/l
Silica	EPA 370.1	0.04 mg/l
Iron	EPA 236.1	0.03 mg/l
Chlorophyll *a*	Flurometeric SM 10200H.3 Spectrophotometric SM10200H.2	0.25 ug/l 3.4 ug/l

Table 3.4
2010 Physical and Chemical Water Quality Parameters

Month	Sample Location	Temperature (C)	Color (CPU)	Light Extinction Coefficient (K)	Iron (mg/l)	Silica (mg/l)
Jan	0 psu	9.6	120	1.5	0.26	7.20
Jan	6 psu	10.9	100	1.8	0.27	5.99
Jan	12 psu	11.5	100	1.6	0.22	5.15
Jan	20 psu	10.9	60	1.2	0.16	3.84
Feb	0 psu	15.5	140	2.2	0.32	4.48
Feb	6 psu	16.1	100	1.8	0.39	3.73
Feb	12 psu	15.7	60	1.8	0.19	2.89
Feb	20 psu	15.2	50	1.5	0.14	2.14
Mar	0 psu	17.4	80	1.3	0.24	4.07
Mar	6 psu	16.1	100	1.4	0.28	2.58
Mar	12 psu	16.3	80	1.4	0.16	2.09
Mar	20 psu	15.5	40	0.9	0.09	1.44
Apr	0 psu	23.5	200	3.1	0.72	7.96
Apr	6 psu	22.4	200	1.9	0.78	5.42
Apr	12 psu	22.4	140	2.4	0.48	3.39
Apr	20 psu	22.5	60	1.4	0.15	1.3
May	0 psu	28.8	120	1.5	0.3	7.17
May	6 psu	27.9	120	2.1	0.45	3.26
May	12 psu	27.2	100	1.7	0.35	1.33
May	20 psu	27.5	60	1.1	0.09	0.80

Table 3.4
2010 Physical and Chemical Water Quality Parameters

Month	Sample Location	Temperature (C)	Color (CPU)	Light Extinction Coefficient (K)	Iron (mg/l)	Silica (mg/l)
Jun	0 psu	31.4	160	2.2	0.35	5.75
Jun	6 psu	30.5	80	1.5	0.18	4.19
Jun	12 psu	30.3	60	1.1	0.09	2.53
Jun	20 psu	30.4	40	1.1	0.09	1.46
Jul	0 psu	31.1	300	3	0.79	8.76
Jul	6 psu	31.3	250	3.2	0.52	8.37
Jul	12 psu	30.9	150	2.5	0.34	7.67
Jul	20 psu	30.3	80	1.8	0.14	6.04
Aug	0 psu	28.3	200	2.8	0.49	6.91
Aug	6 psu	28.8	300	3	0.27	6.79
Aug	12 psu	28.9	100	1.9	0.33	7.17
Aug	20 psu	29.4	80	2.5	0.17	5.87
Sep	0 psu	30.1	250	2.8	0.6	6.99
Sep	6 psu	30.9	200	2.4	0.47	7.18
Sep	12 psu	29.6	120	1.9	0.32	6.47
Sep	20 psu	30.0	60	1	0.08	4.48
Oct	0 psu	24.7	150	2.2	0.36	9.70
Oct	6 psu	23.9	150	2.5	0.41	8.03
Oct	12 psu	23.5	100	2.1	0.25	7.12
Oct	20 psu	24.0	80	1.7	0.15	5.09

Table 3.4
2010 Physical and Chemical Water Quality Parameters

Month	Sample Location	Temperature (C)	Color (CPU)	Light Extinction Coefficient (K)	Iron (mg/l)	Silica (mg/l)
Nov	0 psu	25.7	55	1.4	0.14	4.49
Nov	6 psu	26.6	90	2.2	0.31	5.68
Nov	12 psu	26.4	70	1.9	0.19	5.33
Nov	20 psu	25.7	45	2	0.18	4.35
Dec	0 psu	11.5	50	1.5	0.09	3.97
Dec	6 psu	13.2	70	1.8	0.15	4.64
Dec	12 psu	13.3	70	1.8	0.15	4.64
Dec	20 psu	12.9	70	1.9	0.17	3.80

Table 3.5
2010 Physical and Chemical Water Quality Parameters - Nutrients

Month	Sample Location	Ammonia / Ammonium (mg/l)	Nitrite + Nitrate Nitrogen (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Ortho-phosphorus (mg/l)	Available N/P Atomic Ratio	Chlorophyll *a* (mg/l)
Jan	0 psu	0.096	2.29	0.94	0.333	16.4	3.5
Jan	6 psu	0.082	0.459	0.8	0.311	4.0	5.0
Jan	12 psu	0.135	0.309	0.68	0.272	3.7	3.5
Jan	20 psu	0.053	0.152	0.57	0.186	2.5	3.5
Feb	0 psu	0.095	0.457	1.09	0.501	2.5	3.5
Feb	6 psu	0.310	0.334	1.03	0.396	3.7	5.0
Feb	12 psu	0.29	0.224	0.84	0.28	4.2	7.0
Feb	20 psu	0.048	0.115	0.77	0.172	2.2	8.6
Mar	0 psu	0.042	0.519	0.73	0.536	2.4	3.5
Mar	6 psu	0.026	0.098	0.88	0.247	1.1	10.6
Mar	12 psu	0.061	0.068	0.72	0.23	1.3	7.7
Mar	20 psu	0.032	0.007	0.53	0.13	0.7	4.7
Apr	0 psu	0.086	0.368	1.22	0.856	1.2	3.5
Apr	6 psu	0.088	0.250	1.19	0.506	1.5	5.6
Apr	12 psu	0.078	0.161	1.01	0.349	1.6	8.6
Apr	20 psu	0.151	0.042	0.68	0.146	3.0	11.3
May	0 psu	0.076	0.370	1.08	1.100	0.9	8.3
May	6 psu	0.047	0.004	1.12	0.483	0.2	31.7
May	12 psu	0.170	0.007	0.95	0.381	1.1	21.3
May	20 psu	0.104	0.016	0.88	0.219	1.3	13.8

Table 3.5
2010 Physical and Chemical Water Quality Parameters - Nutrients

Month	Sample Location	Ammonia / Ammonium (mg/l)	Nitrite + Nitrate Nitrogen (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Ortho-phosphorus (mg/l)	Available N/P Atomic Ratio	Chlorophyll a (mg/l)
Jun	0 psu	0.053	0.296	1.14	0.698	1.1	18.1
Jun	6 psu	0.028	0.044	1.03	0.565	0.3	11.4
Jun	12 psu	0.038	0.017	0.87	0.465	0.3	12.7
Jun	20 psu	0.014	0.007	0.75	0.274	0.2	9.4
Jul	0 psu	0.12	0.111	1.59	0.62	0.9	3.5
Jul	6 psu	0.085	0.082	1.38	0.487	0.8	3.5
Jul	12 psu	0.065	0.054	1.83	0.441	0.6	128.0
Jul	20 psu	0.036	0.02	0.83	0.23	0.6	14.6
Aug	0 psu	0.091	0.220	1.06	0.692	1.0	3.5
Aug	6 psu	0.263	0.137	10.70	0.439	2.1	992.0
Aug	12 psu	0.239	0.081	1.04	0.363	2.0	27.3
Aug	20 psu	0.038	0.006	1.01	0.228	0.4	62.3
Sep	0 psu	0.088	0.120	1.26	0.323	1.5	3.5
Sep	6 psu	0.092	0.115	1.12	0.429	1.1	3.8
Sep	12 psu	0.059	0.071	0.99	0.32	0.9	12.0
Sep	20 psu	0.04	0.01	0.6	0.157	0.7	6.5
Oct	0 psu	0.043	0.394	0.98	0.727	1.4	7.5
Oct	6 psu	0.069	0.167	1.28	0.469	1.2	33.0
Oct	12 psu	0.049	0.070	1.06	0.353	0.8	18.7
Oct	20 psu	0.026	0.005	1.22	0.180	0.4	40.4

Table 3.5
2010 Physical and Chemical Water Quality Parameters - Nutrients

Month	Sample Location	Ammonia / Ammonium (mg/l)	Nitrite + Nitrate Nitrogen (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Ortho-phosphorus (mg/l)	Available N/P Atomic Ratio	Chlorophyll *a* (mg/l)
Nov	0 psu	0.023	0.282	0.73	0.885	0.8	22.0
Nov	6 psu	0.094	0.019	1.15	0.609	0.4	40.0
Nov	12 psu	0.072	0.029	0.97	0.383	0.6	15.5
Nov	20 psu	0.04	0.016	0.73	0.222	0.6	8.1
Dec	0 psu	0.026	0.687	0.57	0.661	2.5	3.5
Dec	6 psu	0.057	0.214	1.10	0.549	1.1	29.8
Dec	12 psu	0.057	0.214	1.10	0.549	1.1	36.1
Dec	20 psu	0.077	0.092	1.16	0.375	1.0	12.2

Table 3.8
Mean Near Surface Values for Key Physical, Chemical and Biological Measurements by Isohaline

Isohaline	River Kilometer	Temperature (^{0}C)	COLOR (Co_Pt units)	Nitrite + Nitrate Nitrogen (mg/l)	Ortho – Phosphorus (mg/l)	Atomic Nitrogen to Phosphorus Ratio	Silica (mg/l)	Extinction Coefficient (K)	Chlorophyll *a* (ug/l)
Summary of data from current year – 2010									
0 (psu) Salinity	25.5	23.1	152	0.510	0.661	1.2	6.45	2.1	7.0
6 (psu) Salinity	13.7	22.5	141	0.164	0.465	0.6	5.42	2.1	92.4
12 (psu) Salinity	9.5	23.0	96	0.099	0.351	0.7	4.58	1.9	24.9
20 (psu) Salinity	2.2	22.9	59	0.034	0.195	0.5	3.25	1.5	16.3
Summary of data from preceding period 1983-2009									
0 (psu) Salinity	22.7	25.0	145	0.448	0.801	0.7	3.56	2.8	10.0
6 (psu) Salinity	13.1	25.3	121	0.200	0.573	0.5	3.13	2.5	23.0
12 (psu) Salinity	8.3	25.1	93	0.097	0.413	0.4	2.55	2.1	27.3
20 (psu) Salinity	1.4	24.8	57	0.036	0.248	0.4	1.76	1.5	16.0

Table 4.1
HBMP Fixed Sampling Locations

USGS River Mile	USGS Location Number	Previous EQL Station Number	Additional Sampling	New River Kilometer designation based on Morphometric Study
Current *In Situ* Water Column Profile Sampling Locations				
CH6	265355082075500	9	Water Quality	**-2.4**
RM3.95	265640082033500	10	Water Quality	**6.6**
RM4.88	265724082024400	21		**8.4**
RM6.25	265727082012800	11		**10.5**
RM8.61	265711081595500	Shell Creek 9 (92)		**12.7**
RM8.6B	265819082003200	22		**12.8**
RM10.2	2297460	12	Water Quality/Tide Gage/Conductivity	**15.5**
RM11.2	270022081591000	23		**17.5**
RM 12.55	270124081592500	13		**20.1**
RM13.95	270235081592400	24		**21.9**
RM14.82	270318081593100	14	Water Quality	**23.6**
RM15.45	270337081595800	25		**24.7**
RM16.29	270418082001600	15		**25.9**
N/A	2297350	N/A	Tide Gage/ Conductivity	**26.7**
RM18.25	270451081595100	17		**29.5**
RM18.95	2297330	18	Water Quality	**30.7**
RM19.5	270537081585800	19		**32.3**
Previous EQL Water Column and Chemistry Sampling Sites				
N/A	N/A	16		**27.1**
N/A	N/A	20		**34.1**

Table 4.4
Mean Near Surface Values for Key Physical, Chemical and Biological Measurements at Fixed Sampling Sites

River Kilometer	Color (Co_Pt Units)	Iron (mg/L)	Nitrite+Nitrate Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Ortho-phosphorus (mg/L)	Silica (mg/L)	Chlorophyll *a* (ug/L)
Summary of data from current year – 2010							
-2.4	48	0.08	0.017	0.64	0.12	2.5	13.8
6.6	79	0.19	0.080	0.97	0.25	3.8	33.0
15.5	132	0.33	0.222	1.03	0.5	5.2	11.2
23.6	135	0.29	0.414	1.08	0.62	6.1	13.5
30.7	133	0.32	0.481	0.99	0.63	6.3	6.8
Summary of data from preceding period 1996-2009							
-2.4	54	0.24	0.033	0.63	0.19	2.2	15.8
6.6	89	0.30	0.078	0.77	0.31	3.1	14.1
15.5	139	0.35	0.202	1.07	0.58	4.7	26.6
23.6	149	0.35	0.363	1.01	0.78	5.4	15.4
30.7	148	0.34	0.433	1.02	0.85	5.4	13.0

Table 5.3
Existing and Potential Locations for Additional Continuous Recorder Deployments

ID	Name	Location	# pilings	Depth 1 (feet)	Depth 2 (feet)	Channel Depth (feet)	Latitude		Longitude		Channel Position
RM 31.7	**Broken railroad trestle bridge**	Upstream of intake	Multiple	6.0		16.4	27	5.37	81	58.84	side
RM 30.1	**MZ**	Just downstream of SR 776 bridge	2	5.5		7.2	27	5.30	81	59.68	Side
USGS3	**USGS Platt Recording Gage**	At the Facility intake		T & B			27	5.20	81	59.97	
USGS2	**USGS Peace River Heights Recording Gage**	Campground (Dock)		T & B			27	4.629	82	0.432	
MZ-1	MZ above Navigator	Between Navigator & campground	2	3.0	3.2		27	4.204	82	0.203	side
Dock 1	Dock (Alderon)	Upstream of Navigator	multiple	9.6			27	3.781	82	0.098	side
Dock 2	Dock (south of Alderon)	Upstream of Navigator	multiple	10.5			27	3.78	82	0.095	side
RM 21.9	**MZ (South of Navigator)**		2	3.5	3.4	7.9	27	2.58	81	59.36	side
RM 23.4	**MZ below Navigator ****	Downstream of Navigator	2	3.0	3.0	11.0	27	3.247	81	59.48	side
RM 24.5	**MZ across from Navigator**	Across from Navigator	2	4.0	4.0	7.5	27	3.65	81	59.96	side
MZ-5	**MZ mid Liverpool**	Mid Liverpool mid channel	2	4.3	4.4	4.4	27	2.069	81	59.49	side
R/G-A	Red/Green Marker A	South tip Island 33	1	8.2		16	27	1.975	81	59.52	side
R-14	Red Marker 14	South tip Liverpool	1	4.0		12.4	27	1.896	81	59.47	side
MZ-6	MZ South tip Liverpool	South tip Liverpool	2	3.2	3.2	12.4	27	1.884	81	59.44	side
R-12	Red Marker 12	South tip Liverpool	1	8.1		11.6	27	1.815	81	59.45	side
G-11	Green Marker 11		1	7.6		8.0	27	1.443	81	59.41	side
Dock 3	Dock just below Marker 11	West bank below Marker 11	multiple	6.0		8.0	27	1.36	81	59.44	center
R-10	Red Marker 10	Above upper power lines	1	8.2		10.0	27	1.09	81	59.12	side
G-9	Green Marker 9	Below upper power lines	1	5.2		19.0	27	0.58	81	59.03	side
G-7	Green Marker 7		1	6.7		8.0	27	0.371	81	59.21	side
G-5	Green Marker 5		1	8.3		8.3	27	0.216	81	59.3	mid
R-4	Red Marker 4	Above lower power lines	1	6.4		7.0	27	0.036	81	59.32	side
R-2	Red Marker 2	Below lower power lines	1	10.3		14.0	26	59.8	81	59.35	side

Table 5.3
Existing and Potential Locations for Additional Continuous Recorder Deployments

MZ7	MZ adjacent to Red Marker 2	Below lower power lines	2	9.4	9.4	14.0	26	59.8	81	59.34	side
USGS1	**USGS Harbor Heights Recording Gage**	At end of dock		T & B			26	59.25	81	59.58	
RM 12.6	**MZ**	North of I-75 bridge)	2	7.9		12.1	26	57.707	81	59.96	Side

*** Note**: MZ denotes Manatee zone US Fish & Wildlife markers; R denotes "red" channel navigational markers that are identified by their number; G denotes "green" channel navigational markers that are identified by their number. The three USGS continuous recorder sites (bold red) and the four HBMP sites (bold green) are highlighted.

** HBMP continuous recorder at RK 23.4 was discontinued.

Table 7.1
Authority Peace River Watershed Special Data Collection Results

Station_ID	Conductivity us/cm	pH su	TDS mg/l	Sulfate Mg/l	Calcium mg/l	Magnesium mg/l	Potassium mg/l	Ortho-phosphorous mg/l	Total Phosphorous mg/l	Silica mg/l
6/12/2007										
Peace River Hwy 98 Fort Meade	254.8	6.91	-	-	22.3	14.2	3.2	0.761	0.849	3.4
Peace River County Line Road	**1878.0**	8.00	-	-	**55.3**	19.7	**44.0**	**4.510**	**4.690**	**22.7**
Peace River Hwy 636	1215.0	7.84	-	-	52.2	22.3	25.1	3.360	3.820	12.1
Peace River Hwy 64	1024.0	7.95	-	-	49.1	22.6	21.1	3.010	3.340	11.5
Peace River Hwy 70	883.4	7.47	-	-	46.0	22.4	21.2	2.310	2.540	7.7
Joshua Creek Hwy 17	**1152.0**	7.96	-	-	**96.9**	31.0	12.9	0.233	0.254	7.7
Horse Creek Hwy 769	659.4	7.11	-	-	69.1	27.4	13.3	0.638	0.764	5.9
Peace River Hwy 761	1379.0	7.31	-	-	56.6	31.3	18.4	1.370	1.480	5.7
7/23/2007										
Peace River Hwy 98 Fort Meade	305.9	6.92	-	-	26.3	18.1	4.2	0.458	0.528	2.7
Hwy 657 at Bowlegs Creek	322.6	7.28	-	-	29.1	18.6	2.1	0.420	0.471	4.6
Hwy 17 at Whidden Creek	**1780.0**	7.38	-	-	**67.3**	22.3	**43.2**	**7.300**	**8.990**	**24.5**
Peace River County Line Road	1735.0	7.78	-	-	60.6	21.8	40.3	5.670	8.770	19.9
4/7/2008										
Peace River Hwy 98 Fort Meade	316.9	6.53	-	-	26.2	15.1	3.7	0.780	1.350	**10.2**
Bowlegs Creek at Hwy 657	239.8	6.51	-	-	16.1	11.1	4.7	0.599	0.754	**11.2**
Whidden Creek at Hwy 17	**1773.0**	6.80	-	-	**49.7**	17.6	**28.6**	**1.320**	**4.090**	**9.2**
Peace River County Line Road	973.4	6.99	-	-	34.2	16.0	14.7	1.030	1.940	11.8
Peace River Hwy 636	741.8	7.11	-	-	26.7	18.5	13.1	0.867	1.350	8.3
Peace River Hwy 64	677.6	7.25	-	-	35.4	17.8	12.4	0.842	1.260	8.9
Peace River Hwy 70	662.4	6.92	-	-	36.5	17.9	14.2	0.713	0.853	6.3
Joshua Creek Hwy 17	**1030.0**	7.05	-	-	**74.7**	**27.6**	15.3	0.144	0.210	6.6

Table 7.1
Authority Peace River Watershed Special Data Collection Results

Station_ID	Conductivity us/cm	pH su	TDS mg/l	Sulfate Mg/l	Calcium mg/l	Magnesium mg/l	Potassium mg/l	Ortho-phosphorous mg/l	Total Phosphorous mg/l	Silica mg/l
Horse Creek Hwy 769	**920.3**	6.91	-	-	**89.1**	**36.0**	10.8	0.365	0.462	5.0
Peace River Hwy 761	813.0	7.11	-	-	45.1	20.4	13.0	0.707	0.850	3.9
5/7/2008										
Peace River Hwy 98 Fort Meade	499.0	7.08	-	-	40.0	23.4	4.0	1.500	1.770	3.3
Bowlegs Creek at Hwy 657	198.2	6.63	-	-	16.6	13.7	2.7	0.011	0.230	0.6
Whidden Creek at Hwy 17	**2398.0**	7.21	-	-	**77.1**	23.9	**60.0**	**3.940**	**4.730**	**23.0**
Peace River County Line Road	1905.0	8.02	-	-	68.2	23.8	46.1	3.680	4.180	14.2
Peace River Hwy 636	1503.0	8.53	-	-	59.8	24.3	34.5	2.400	2.700	9.0
Peace River Hwy 64	1405.0	8.44	-	-	54.8	22.9	32.4	2.100	2.350	7.9
Peace River Hwy 70	881.9	7.70	-	-	50.4	22.0	17.1	1.710	1.920	5.0
Joshua Creek Hwy 17	**1071.0**	7.69	-	-	**88.5**	31.4	10.0	0.028	0.247	2.9
Horse Creek Hwy 769	649.9	7.03	-	-	**77.2**	27.1	5.4	0.484	0.711	4.1
Peace River Hwy 761	1275.0	7.13	-	-	49.8	31.6	16.2	1.370	1.590	6.6
10/8/2008										
Whidden Creek at Hwy 17	**2264.0**	7.16	**1236.0**	**722.0**	**74.0**	30.9	**42.4**	**3.100**	**3.200**	**22.9**
11/6/2008										
Whidden Creek at Hwy 17	**2292.0**	7.15	**1352.0**	**780.0**	**75.3**	21.7	**47.1**	**3.900**	**3.900**	**27.3**
3/4/2009										
Peace River Hwy 98 Fort Meade	458.9	8.42	252.0	56.00	34.5	21.3	3.9	0.800	0.900	1.1
Bowlegs Creek at Hwy 657	232.4	8.23	168.0	21.00	16.6	11.9	6.9	0.100	0.500	0.8
Whidden Creek at Hwy 17	**1818.0**	7.53	**1380.0**	**788.0**	**65.5**	22.5	**46.2**	**5.400**	**5.800**	**28.9**

Table 7.1
Authority Peace River Watershed Special Data Collection Results

Station_ID	Conductivity us/cm	pH su	TDS mg/l	Sulfate Mg/l	Calcium mg/l	Magnesium mg/l	Potassium mg/l	Ortho-phosphorous mg/l	Total Phosphorous mg/l	Silica mg/l
Peace River County Line Road	1818.0	8.54	1156.0	660.0	62.9	19.1	36.0	4.900	5.300	16.0
Peace River Hwy 636	1371.0	8.88	848.0	455.0	54.9	20.3	28.2	3.100	3.400	5.9
Peace River Hwy 64	1421.0	8.64	808.0	440.0	51.0	20.8	24.9	1.700	1.700	3.5
Peace River Hwy 70	1324.0	8.42	608.0	303.0	56.6	24.9	17.4	1.500	1.600	1.7
Joshua Creek Hwy 17	**1458.0**	8.12	764.0	179.0	101.0	35.3	11.0	0.100	0.100	0.9
Horse Creek Hwy 769	**1211.0**	8.41	468.0	178.0	74.0	27.0	7.3	0.400	0.400	1.2
Peace River Hwy 761	1112.0	8.20	584.0	243.0	63.2	25.5	14.8	1.100	1.200	0.9
6/2/2010										
Peace River Hwy 98 Fort Meade	334.1	7.96	196.0	48.3	24.80	11.70	4.39	0.90	1.17	5.57
Bowlegs Creek at Hwy 657	189.6	7.40	124.0	18.6	11.30	10.10	4.26	0.06	0.11	1.62
Whidden Creek at Hwy 17	**1832.0**	7.69	**1308.0**	**789.0**	**79.90**	22.40	**44.30**	**2.30**	**2.35**	**19.30**
Peace River County Line Road	997.2	7.93	628.0	319.0	56.90	22.70	14.90	1.46	1.54	6.75
Peace River Hwy 636	916.3	7.87	532.0	271.0	53.70	22.80	11.90	1.35	1.47	5.37
Peace River Hwy 64	793.0	8.23	528.0	260.0	54.30	22.50	11.10	1.28	1.31	5.34
Peace River Hwy 70	477.7	7.70	324.0	141.0	**70.30**	16.70	9.17	0.75	0.85	5.75
Joshua Creek Hwy 17	695.2	8.21	468.0	103.0	54.40	22.30	11.50	0.17	0.25	7.36
Horse Creek Hwy 769	416.2	7.55	300.0	118.0	36.20	16.00	5.26	0.39	0.45	6.71
Peace River Hwy 761	542.6	7.64	372.0	143.0	45.10	17.90	8.78	0.65	0.74	5.30

* Values of note are highlighted in red