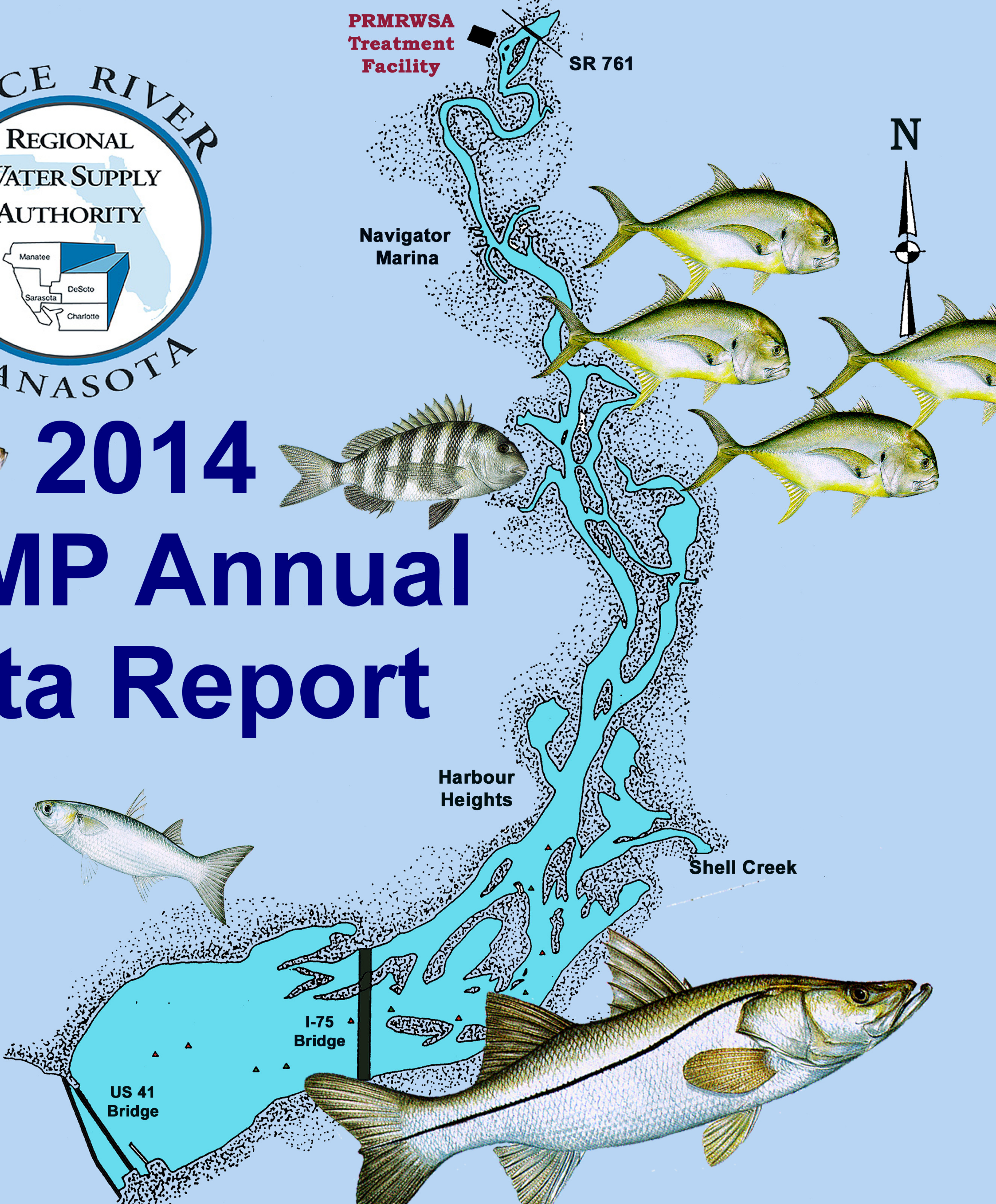
PEACE RIVER MANASOTA REGIONAL WATER SUPPLY AUTHORITY

2014 HBMP Annual Data Report



Peace River Hydrobiological Monitoring Program
2014 HBMP Annual Data Report

Required by

Southwest Florida Water Management District
Water Use Permit 20010420.008

Prepared for

Peace River Regional Water Supply Facility

Peace River Manasota Regional Water Supply Authority

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Acknowledgments

The raw data, as well as the methods sections, presented in this report for the calendar year 2013 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. More recently the USGS installed third recorder site designated as Peace River at Platt (02297345) located 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 (Tampa Office) –** was responsible during 2013 for all eight Authority HBMP recorders located in the lower Peace River that continuously collect data at 15-minute intervals. Measurements at each of these eight surface recorder locations include surface conductivity and water temperature. Subsurface dissolved oxygen is further monitored at 15-minute intervals at RK 12.7 in conjunction with the measurements of conductivity and temperature.

Eight 2013 Ongoing Authority HBMP Lower Peace River Continuous Recorders

1. **RK 9.2 –** Near surface conductivity and temperature are measured at 15-minute intervals from the HBMP continuous recording gage attached to a navigation marker located between the I75 and U.S.41 Bridges. Data collection began in June 2011 and is continuing.

2. **RK 12.7 (surface) –** Near surface conductivity, temperature and dissolved oxygen are recorded at 15-minute intervals from the HBMP continuous recorder attached to a Manatee Speed Zone Sign located on the lower Peace River downstream of Shell Creek (River Kilometer 12.9). Data collection began in June 2011 and continues.

3. **RK 18.5 –** Near surface conductivity, temperature and dissolved oxygen are recorded at 15-minute intervals from the HBMP continuous recorder attached to navigational aid located near the power line crossing. Data collection began in June 2011 and continues.

4. **RK 18.7 (Hunter Creek) –** Near surface conductivity, temperature and dissolved oxygen are recorded at 15-minute intervals from the HBMP continuous recorder attached to Manatee Speed Zone Sign located near the power line crossing near Jim Long Lake. Data collection began in June 2011 and continues.

5. **RK 20.8 –** Near surface conductivity, temperature and dissolved oxygen are recorded at 15-minute intervals from the HBMP continuous recorder attached to navigational aid located just downstream on an island. Data collection began in June 2011 and continues.

6. **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 at this site since 2006.

7. **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 at this site since 2006.

8. **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.

Three Previous Authority HBMP Lower Peace River Continuous Recorders

1. **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.

2. **RK 12.7 (bottom)** – Near bottom conductivity, temperature and dissolved oxygen were recorded at 15-minute intervals from the HBMP continuous recorder attached to a Manatee Speed Zone Sign located on the lower Peace River downstream of Shell Creek (River Kilometer 12.9). Data collection began in May 2008 and continued until June 2011 when the instruments were moved to record near surface measurements.

3. **RK 30.6** - Near surface conductivity and temperature were 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 was discontinued in June 2011.

- **Peace River/Manasota Regional Water Supply Authority** – provided measurements of daily withdrawals by the facility, as well as data collected as part of an ongoing upstream watershed background monitoring effort.

- **City of Punta Gorda** – provided measurements of daily withdrawals and data from the Shell Creek HBMP, as well as all historical data collected as part of their HBMP.

- **Benchmark Laboratory –** conducted all HBMP water chemistry analyses conducted during 2013.

Karen Burnett of EarthBalance initiated the development of this report and along with Sam Stone of the Peace River Manasota Water Supply Authority provided helpful comments of this report.

Lastly, a special acknowledgement is extended to Ralph Montgomery who for many years led the efforts of many in the pursuit of the understanding of the Peace River and its amazing complexities. He left us far too early but his memory will not be lost.

Executive Summary

Historical Overview

On December 10, 1975, 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 2013, an ongoing series of reports have been submitted to the District, documenting the results of the HBMP during the period from January 1976 through December 2013. These reports include summarizations (findings) of data collected during the first four years of baseline monitoring, prior to the start of Facility freshwater withdrawals, as well as comparisons of historic data to the results obtained from the HBMP during subsequent years of water treatment facility operation. The period covered within this *2014 HBMP Annual Data Report* follows directly upon that contained within the preceding *2013 HBMP Annual Data Report* finalized in August 2014, as well as the *2011 HBMP Comprehensive Summary Report* finalized in December 2013. This current data report includes HBMP data collected over the period from January through December 2014, and represents the 24th year of data collection for the Peace River Manasota Regional Water Supply Authority (Authority), as owner/operator of the Facility.

The Facility has been operated by the Authority since 1991. However, the initial system was constructed by General Development Utilities and has been withdrawing water from the Peace River since 1980. The Facility's initial river water 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 6.300 million gallons of treated water storage in 21 Aquifer Storage and Recovery (ASR) wells.

A major expansion in 2002 included increasing the Facility's treatment capacity from 12 mgd to 24 mgd (37.1 cfs), with raw river water diversion from the Peace River accomplished using four pumps having a combined maximum capacity of 44 mgd (68.0 cfs). Combined, the 2002 Facility expansions enhanced the Authority's ability to withdraw raw river water during periods of higher river flows for storage in the off-stream surface reservoir. Any excess treated water could also be stored in the system's underground ASR well system. Conversely, when water was unavailable from the Peace River as seasonal lower flows dropped below 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 alternatively previously treated water could be recovered from the ASR well system to meet service area water supply demands.

In 2009, the Authority completed its most recent major Facility expansion, which was undertaken in order to meet projected 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 much larger regional 640-acre off-stream reservoir (with a capacity of 6 billion gallons) was also completed in 2009. Subsequently, the pumping capacity of diversions from the river was re-rated to 120 mgd.

A revised withdrawal schedule (Table 1) based on the District's adopted MFL was issued by the District to the Authority on April 26, 2011. This permit modification maintained the original 32.7 mgd yearly average, with a maximum monthly allowed average of 38.1 mgd. The permitted maximum daily diversions from the river were increased under the District Water Use Permit from 90 mgd to 120 mgd, in order to allow the Authority greater flexibility in utilizing the upgraded withdrawal structure on the river and further provide greater overall system reliability. Previous to implementation of the April 2011 revised withdrawal schedule, daily Facility's river withdrawals were based on the preceding daily average flow measured at the USGS Arcadia gage. The District's revised permitted withdrawal schedule utilizes the previous day's combined flow based on the readings from three USGS gages upstream of the Facility located on the Peace River at Arcadia, Horse Creek near Arcadia, and Joshua Creek at Nocatee. The low flow cutoff for Facility withdrawals however remained the same as previously permitted at 130 cfs, but was also changed to reflect the combined flow of the three upstream gages.

Table 1
April 2011 Revised Authority Lower Peace River Withdrawal Schedule
(based on combined USGS gaged flow at three upstream gages)

Block	Allowable Percent Reduction in Flow	
Block 1 (April 20th – June 25th)	16% if flow is above 130 cfs	
Block 2 (October 27th – April 19th)	16% if flow is > 130 cfs	28% if flow > 625 cfs
Block 3 (June 26th – October 26th)	16% if flow is > 130 cfs	28% if flow > 625 cfs

Two additional modifications were made to the Facility's water use permit in 2011. The first occurred in October 2011 and made small adjustments in the allowable annual average withdrawal increasing it from 32.7 mgd to 32.855 mgd. This permit modification also increased the allowable monthly maximum from 38.1 mgd to 38.3 mgd. Both modifications increased system reliability. The final permit modification occurred in November 2011 and didn't change any of the permit conditions other than changing the expiration date of the 1996 Water Use Permit from 2016 to 2037, in order to conform to the length of the Facility's existing bonds and to conform to new District rules allowing longer-term permits.

Future Authority plans include gradually expanding the existing regional transmission piping network to optimize water delivery, meet future projected demands, and increase overall regional system reliability. Recent projected regional water supply demands have declined over earlier estimates made during the rapid period of growth during the previous decade. As such, the Authority continues to annually update projected demand estimates provided by regional governments.

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 lower Peace River/upper Charlotte Harbor estuary resulting from Facility 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 estuarine system. Historically, those major monitoring elements aimed at assessing direct relationships with temporal 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 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 the Water Use Permit (WUP) #20010420 for implementation in 1996 and subsequent years. The Peace River Facility's Water Use Permit initially required 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 further 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 the replacement of the 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 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 River Kilometer (RK) 26.7 just downstream of the Facility (Figure 5.1), and in December 2009, a third recorder was installed by USGS at the Facility's intake (RK 29.8). As indicated in previous HBMP annual reports, 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. In the dry season, it is not uncommon for surface and bottom conductivities to vary 4,000 to 10,000 uS/cm (roughly from 2 to 5.5 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, often 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 have shown surface and bottom conductivities varying 2,000-12,000 uS/cm (roughly from 1.0 to 6.9 psu) over a tidal cycle during the May spring dry season. During May 2014, conditions were not as dry as during the previous 2006-2009 period and surface and bottom conductivities were observed to vary only 2,000 to 8,000 uS/cm (roughly from 1.0 to 4.4 psu) over a tidal cycle. This is in direct contrast to less frequent wetter May conditions (such as occurred during 2005), when corresponding May data indicated only small, infrequent differences in conductivity (usually less than 100 uS/cm) resulting from daily tidal variations. During the wet season in September 2014, conductivities at this upstream USGS gaging site were low, and did not noticeably respond to daily tidal variations.

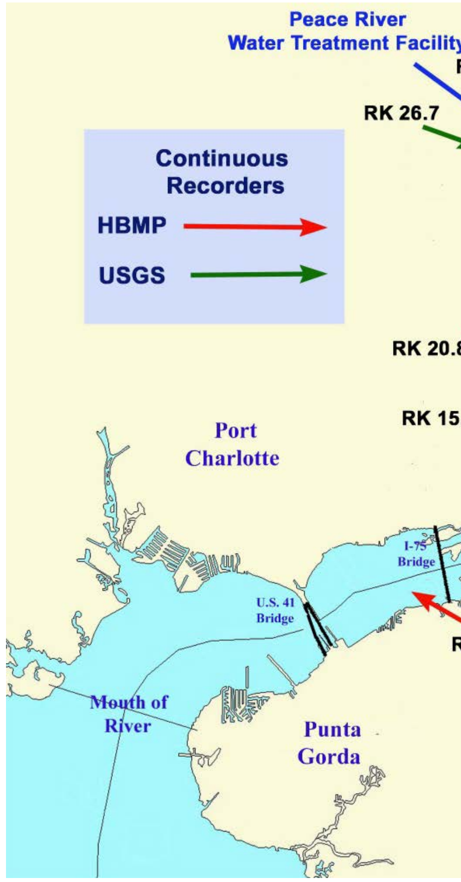


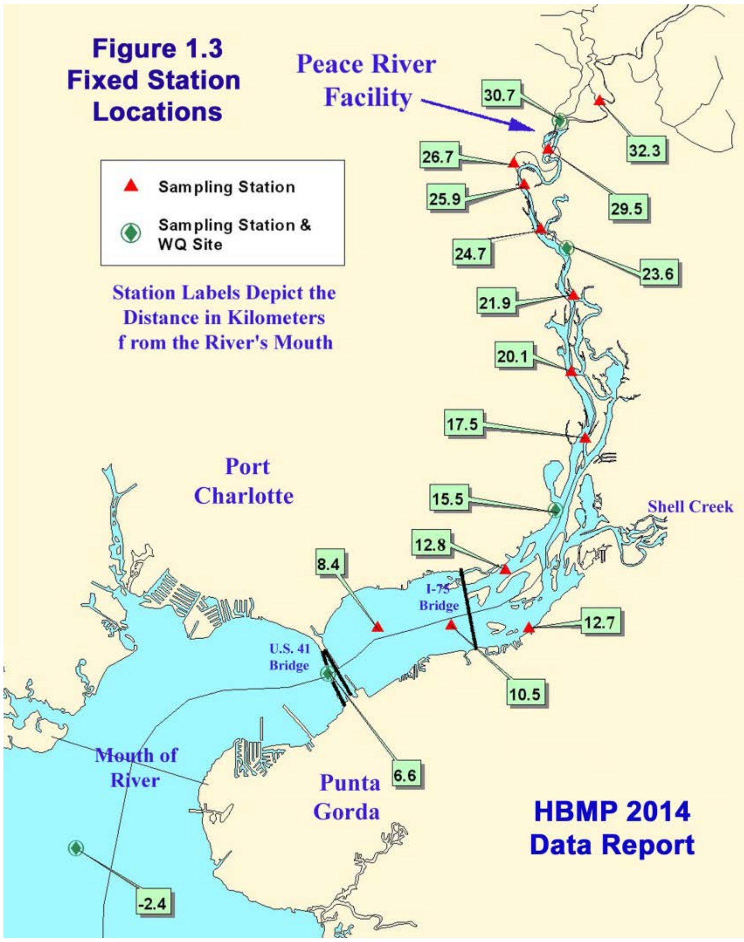
Figure 5.1

2014 Locations of Continuous Recorders

At the most upstream Platt USGS recorder located at the Facility intake (RK 29.8), data collected in May 2014 showed little daily variations in conductivity in response to tides. This is in direct contrast to May 2012 when much drier conditions resulted in tidal conductivity changes in the range of 4,000 to 8,000 us/cm (approximately 2.0 to 4.5 psu). As expected, under the higher summer wet season flows in September, there was no indication of tidal influences on measured conductivities.

Additional Authority Continuous Recorders – The HBMP recorders located along the HBMP monitoring transect (Figure 5.1) and installed during 2005, 2008, and 2011 by the Authority spatially showed analogous patterns during 2014 to those described for the recorders at the three USGS continuous monitoring sites. Spatially, daily and longer term temporal changes in surface conductivities (salinity) at the HBMP recorder locations typically showed a far greater degree of daily tidal variability during periods of low flow, in comparison to usually much smaller (and spatially limited) tidal changes observed during intervals of higher freshwater upstream inflows.

Water Chemistry and Water Column Physical Profiles – This HBMP program element is primarily spatially focused along the HBMP monitoring transect centerline, which extends from south of the mouth of the river (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 sampling both *in situ* water column profile physical measurements combined with the determination of chemical water quality characteristics along the HBMP monitoring transect. Several objectives are associated with both the individual and



combined findings of these water quality monitoring 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/timing of change that might result from both existing and projected future permitted Facility withdrawals. The potential for impacts can then be accessed through comparing predicted changes due to withdrawals with the normal ranges of observed natural seasonal and annual variability.

Standardized, 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 ums. Historically, this isohaline sampling effort was undertaken in conjunction with other long-term phytoplankton elements of the HBMP. In addition a surface water sample is also collected at RK 30.7 (historic Station 18).

2. Approximately two weeks after the collection of the "moving" isohalines, water column physical profiles are conducted, near high tide, at 16 "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 above). In addition, chemical water quality samples are taken at five of these locations (including RK 30.7).

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 each sampling locations. Both studies also include the analyses of an extensive list of chemical water quality parameters. The only difference being 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 2014 HBMP Study Results

The following compares data collected during 2014 with similar average values for key parameters previously compiled in conjunction with elements of the ongoing long-term monitoring programs. This summary includes comparisons of:

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 2014 data with similar data collected over the preceding 38-year period (1976-2013), it should be noted that rainfall/flow have annually varied considerably during the recent historic period.

- 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 (with the later two years characterized by a number of tropical depressions/hurricanes during the summer wet season).

- Rainfall in the Peace River watershed during the recent 2006-2009 interval by comparison was well below the historic long-term average.

- More recent seasonal rainfall patterns during both 2010 and 2013 were near or above normal, while the drier seasons of 2011 and 2012 were well below normal.

Flows – Average mean daily Peace River flow of the three combined gages upstream of the Facility during 2014 was 875.3 cfs, which was below the 1,143.8 cfs average over the 39 years of HBMP monitoring (1976-2014). In comparison, the average flow during 2014 was well above the annual average flow of 524 cfs over the four-year interval between 2006 and 2009. However, it was also well below the average flow of 2,046 cfs over the much wetter five-year interval between 2001 and 2005. Overall, annual mean flow upstream of the Facility during 2014 was 76 percent of the average daily flow over the preceding long-term 1976-2013 period.

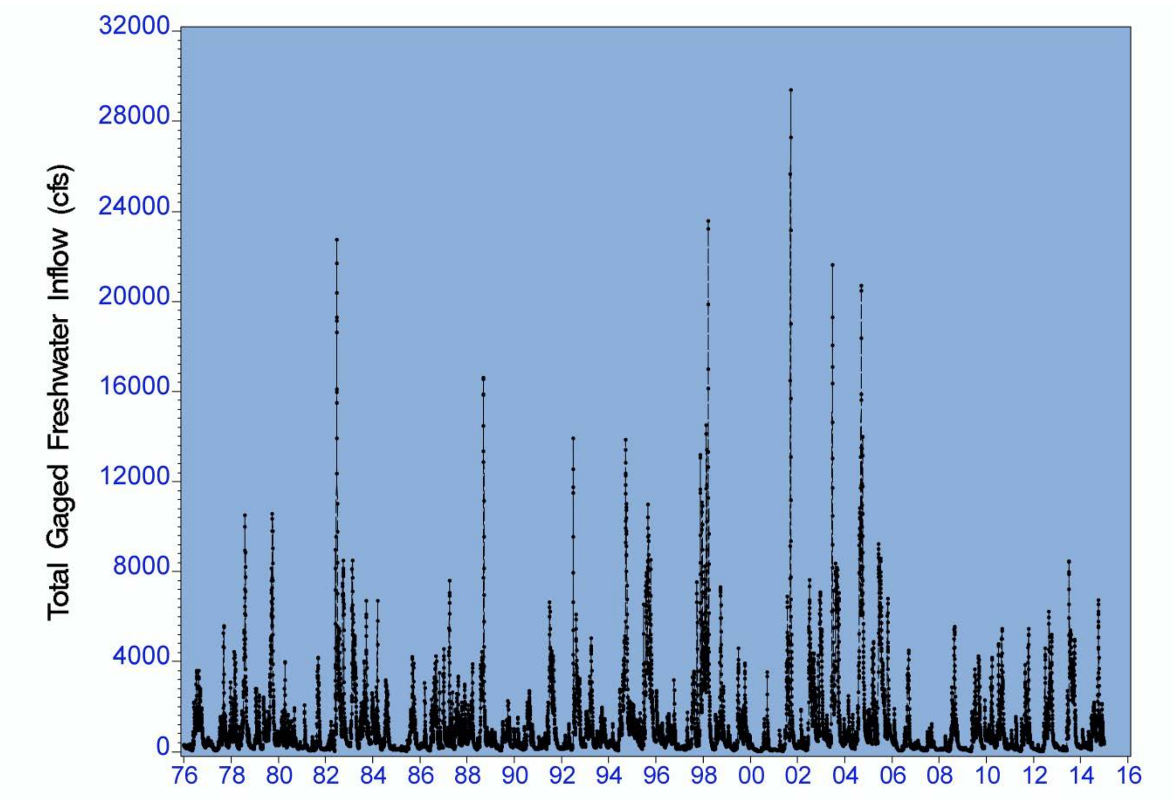


Figure 2.4 Total daily gaged flow at Facility - Peace River at Arcadia + Horse and Joshua Creeks (1976-2014)

Withdrawals – Total Peace River Facility withdrawals during 2014 were approximately 6.5 percent of the total gaged freshwater flow measured at the USGS Arcadia gage, 5.4 percent of the upstream gaged flow at the Facility, and 4.6 percent of the combined average daily inflows upstream of the U.S. 41 Bridge. During the entire period of Peace River Facility withdrawals (1980-2014), total combined withdrawals have been approximately 1.98 percent of the corresponding gaged Peace River at Arcadia flows, 1.48 percent of total gaged flow upstream of the Facility, and only 1.1 percent of the combined daily freshwater flows of the Peace River, and Horse, Joshua, and Shell Creeks.

There were a number days during 2014 when the Facility withdrawals exceeded the seasonally designated maximum percents allowed by the April 2011 revised permit withdrawal schedule. 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 Facility does not withdraw any water from the river due to either the low flow threshold and/or Facility operations. During 2014, the facility did not withdraw any water from the river on 60 days or approximately 16 percent of the time. Maximum daily Facility withdrawals increased both in 2002 and 2009 due to completed Facility expansions. These expansions resulted in the Authority's increased ability to divert, treat, and store larger daily amounts of freshwater when river flows were greater than the District's 130 cfs threshold criteria. The 2011 revised withdrawal schedule further increased the amounts of water the Facility was able to take from the river, especially under periods of higher flows.

Water Temperature – Monthly mean water column temperatures in 2014 followed the strong seasonal pattern typically observed in south Florida. Often, the highest water temperatures in the more upstream, shallower, freshwater reaches of the estuary reach their highest levels in May and then remain similar up until August. By comparison, average water column temperatures in the downstream areas, more influenced by the harbor, often don't reach their highest annual values until July. During 2014, the highest average water column temperatures occurred throughout the lower river/upper harbor estuary during June. Historically, the annual peak in water temperatures in the estuary varies between June and August depending on annual variations in cloud cover and differences in seasonal rainfall patterns. The 2014 data clearly show relatively normal cold conditions during at both the start and end of the year associated with typical winter cold fronts.

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 (DO) 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 DO 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 2014 (as typically observed in previous years), average water column DO levels generally declined as water temperatures increased, reaching their lowest levels during the summer wet season between June and September throughout both the lower river and upper harbor as both water temperatures and flows increased. The 2014 summer, wet season column profile data (as has occurred since 2010) indicated the return of normal hypoxic/anoxic dissolved oxygen levels in the upper harbor. Such normal summer/high flow low DO levels did not occur (or were far less in magnitude/duration) during the extended 2006-2009 drought. This indicated that the flows that occurred during the summer of 2014 were again of sufficient duration and intensity to induce the level of water column stratification necessary to cause the development of extremely low, widespread near-bottom DO levels in upper Charlotte Harbor. The HBMP water column profile data measured since 2004 have not indicated any lingering influences from the historically massive, widespread depression of DO levels that occurred throughout the entire water column in the Charlotte Harbor Estuary following Hurricane Charley in August 2004.

Light Extinction – The 2014 HBMP data indicate that both the timing and magnitude of the ability of light to penetrate into the water column (1 percent depth) exhibits 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, light extinction in the lower Peace River/upper Charlotte Harbor estuarine system is often primarily mediated by water color due to the "black water" characteristics of freshwater inflows from the Peace River watershed. Water clarity during 2014 (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. The influences of the dry first five months followed by typical summer wet season rainfall conditions are clearly evident in comparing the 1 percent light depths observed between the more downstream lower river/upper harbor monitoring locations with the upstream characteristically freshwater reaches of the lower river.

Conductivity/Salinity – Seasonally spatial conductivity patterns in the tidal lower Peace River during the very dry first five months of 2014 were similar with previous spring dry season and late fall conditions over much of the previous decade, when brackish conditions in the lower river extended upstream even beyond the Peace River Facility intake. Such relatively high salinity conditions in the lower river were especially noticeable during the extended droughts that affected southwest Florida and the Peace River basin during much of the 1999-2001 and 2006-2009 periods. During these years, very high conductivities were observed even at the most upstream sampling locations during the extended periods of low freshwater inflows.

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 indicate a distinct spatial gradient within the lower river/upper harbor estuarine system with higher levels of inorganic nitrogen progressively occurring upstream. During 2014, inorganic nitrogen concentrations were low or at near-detection limits during the extended spring/early summer dry season (April/May). Overall, nitrite+nitrate nitrogen levels in 2014 were similar with the longer-term averages at each of the five fixed stations.

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. In the four drought years of 2006 to 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 2014, the annual average Kjeldahl concentrations at each of the five monitoring locations were very similar to their historic long-term averages.

Ortho-Phosphorus – Inorganic phosphorus concentrations in the Peace River Estuary follow patterns typical of conservative water quality constituents (reflecting dilution rather than biological uptake). 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. Following Hurricane Charley in August 2004 (and the subsequent Hurricanes Frances and Jeanne 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 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 have continued to decline to previous observed lower levels. Seasonally, inorganic ortho-phosphorus in 2014 at the five fixed monitoring sites was similar to levels observed prior to the recent observed increase. The direct cause for the increased levels seems to have been related to the discharges of water during the closure of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin.

Silica – Historically, annual reactive silica concentrations in the Peace River Estuary characteristically have indicated a number of differing temporal and spatial patterns. During the spring dry season, silica levels were normally at their annual lowest concentrations 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 increased and the start of the summer wet season began, concentrations characteristically rapidly increased throughout the estuary. However, reactive silica concentrations during 2014 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 closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin. However, unlike phosphorus concentrations, silica levels have continued to be near historic high seasonal levels through much of the estuary.

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 shows 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. However, the occurrences of spring phytoplankton increases are 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. Chlorophyll *a* increases (blooms) during 2014 were influenced by both the seasonally low streamflow during the first five months of the year, 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.

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 increased 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 had returned to levels not observed in decades, before more recently again declining to previous lower levels. 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 previous closure of phosphogypsum stacks and associated discharges in the Whidden Creek subbasin.

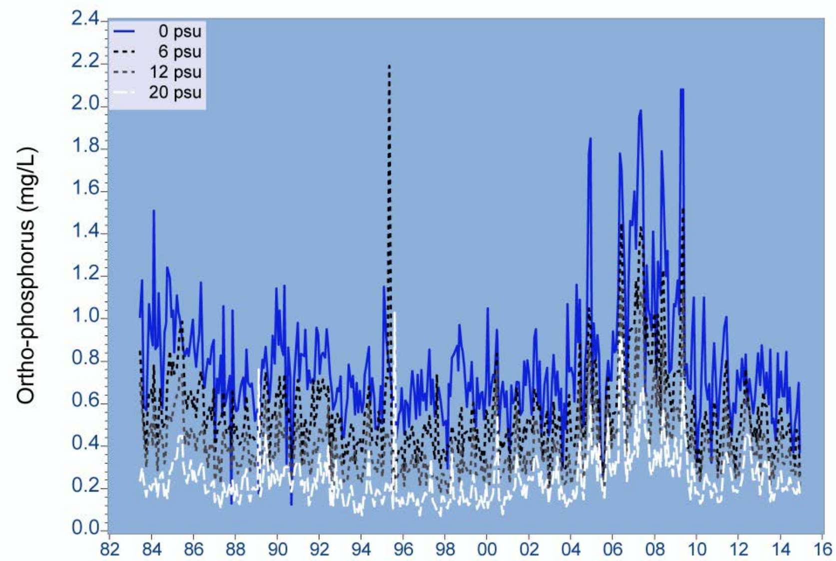


Figure 3.18 Monthly ortho-phosphorus at each isohaline based sampling zone (1983-2014)

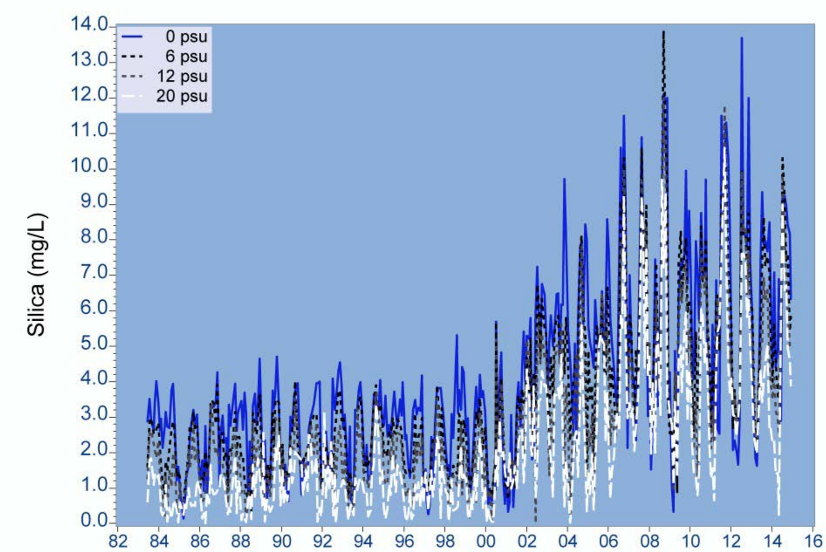


Figure 3.20 Monthly silica at each isohaline based sampling zone (1983-2014)

Conclusions

This document represents the 19th 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 2014, other than those previously noted. These include:

- Freshwater inflows during 2014 were influenced by relatively average conditions during the typical summer wet season.

- The previously noted long-term increase in reactive silica concentrations noted at the lower Peace River/upper Charlotte Harbor monitoring locations indicated some decline during 2014.

- Inorganic phosphorus concentrations in the freshwater entering the estuary had increased in recent years, following decades of major declines that began in the late 1970s. However, observations since 2009 have shown 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 previous closure of phosphogypsum stack systems in the Whidden Creek basin, located in the upper Peace River watershed.

The “limited” analyses presented in the *2014 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.

Permanent Historic and Current HBMP Data

This Executive Summary provides a brief overview of the HBMP project and the recent findings from the 2014 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 *2014 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 *2014 HBMP Annual Data Report* CD in a separate directory labeled 2014 Data Sets, as files in SAS format.

Contents

1 Introduction/Summary

1.1 Report Objectives

This introductory section of the 2014 *HBMP Annual Data Report* summarizes and provides a brief overview 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 7 of this *2014 HBMP Annual Data Report*.
- An overview of the current and historic data sets used in the analyses of 2014 HBMP data.
- A general summary of specific problems encountered by study elements during the 2014 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 *2014 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 an analysis and summarize 2014 gaged river freshwater inflows to the lower Peace River estuary, and compare estuarine inflows with freshwater river withdrawals by the Peace River Regional Water Supply Facility (Facility). This section also compares 2014 flows and Facility withdrawal with analogous long-term metrics over the entire historic 1976-2014 time interval, which corresponds with the 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 established in 1983, and describe the current elements of the isohaline based sampling plan. Summary graphical and tabular comparisons are presented comparing and contrasting the

data collected during 2014 with previous salinity (isohaline) based HBMP sampling program data historically collected between 1983 and 2014.

- **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 original HBMP long-term "fixed" station monitoring program initially established in 1976. This section describes both the historic and current sampling designs of the HBMP fixed station monitoring. Information is also presented relative to the results of the "fixed" station data collected during 2014. In addition, the section also presents summary graphical and tabular comparisons of selected 2014 water quality monitoring results with previous similar HBMP data collected over the preceding 1976-2013 time interval.

- **Section 5.0 (USGS and HBMP Continuous Recorders) –** This section of the *2014 HBMP Data Report* summarizes the initial principal objectives envisioned in establishing 15-minute U.S Geological Survey (USGS) continuous recorders (tide stage, and surface and bottom temperature and conductivity) at two locations along the lower Peace River (Harbour Heights and Peace River Heights) in the late 1990s. Also described and summarized are the design criteria that were later used, based on recommendations of the HBMP Scientific Review Panel, in initially establishing three additional Authority 15-minute continuous recorders (subsurface temperature and conductivity) recorders along the HBMP monitoring transect in December 2005. Two similar Authority recorders were further added in May 2008, and more recently three additional Authority recorders were deployed at the end of June 2011. In December 2009, USGS installed its third pair of near surface and near bottom continuous recorders immediately adjacent to the Facility's river intake structure. The results of data collected in 2014 by the current array of USGS and Authority HBMP continuous recorders along the lower river are presented in this section. Included are graphical and tabular results that provide comparisons of range of surface salinities measured along the lower Peace River HBMP monitoring transect. Comparisons are further provided depicting the annual range of variation observed in similar data collected during previous years at corresponding locations.

- **Section 6.0 (*In Situ* Chlorophyll Monitoring) –** Based on the recommendation of the HBMP Scientific Review Panel, and following consultation with District staff, the Authority implemented a new HBMP study element beginning in April 2013. This new HBMP study element employs an *in situ* fluorometer chlorophyll *a* methodology in order to provide the type of enhanced spatial intense information needed to accurately define on a monthly basis both the magnitude and spatial extent of variations in chlorophyll *a* patterns within the lower Peace River/upper Charlotte Harbor Estuary.

- **Section 7.0 (Significant Environmental Change) –** This section of the report briefly summarizes the discussion presented in previous HBMP Summary and Data Reports 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.

- **Section 8.0 (Assessment of Upstream Changes in Water Quality)** – This section briefly summarizes key findings from previous analyses of observed changes in water quality characteristics in the Peace River watershed upstream of the Facility. A comprehensive analysis of Peace River watershed data was presented in Chapter 5 of the *2011 HBMP Comprehensive Summary Report* submitted to the District and HBMP Scientific Review Panel members in 2013. As part of the upcoming Authority Water Supply Plan, the long-term water quality information for the upstream Peace River watershed was updated through the end of 2014. The updated graphical results for previously identified key upstream subbasins are presented in this section.

1.2 Overview of the History of Peace River Facility and Facility Water Use Permit

The Authority's Peace River Regional Water Supply Facility is located adjacent to a side-branch of the Peace River in southwest DeSoto County. Originally permitted, constructed, and operated by General Development Utilities, and later owned and operated by the Authority (since 1991), the Facility has been operating and withdrawing water from the Peace River since 1980. Table 1.1 (below) summarizes changes in the Facility's withdrawal schedules associated with each of the historic modifications of the Facility's Water Use Permit's (WUP) specific conditions prior to the most recent 2011 modifications (Table 1.2). The following briefly summarizes the historical major changes in the Facility's permitted water withdrawal schedules.

- The Facility's 1982 modification of the WUP changed the previous limited annual average withdrawals from 5.0 mgd to 8.2 mgd (12.7 cfs), with the maximum daily withdrawal from 18 mgd to 22 mgd, which was 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 was determined based on the previous 20 years of USGS flow data. As a result, the individual monthly low flow cutoffs changed from a previous range of 91 to 664 cfs to a new range with a low of 64.6 mgd (100 cfs) in April and May to a high of 429.2 mgd (664 cfs) in September.

- In October 1988, the 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.

- In April 2011, the Authority's withdrawal schedule was revised, following the District's adoption of Minimum Flow and Level (MFL) criteria for the lower Peace River. This change provides approximately the same annual total quantities of water with a higher rate of reliability, by greater utilization of higher summer wet-season flows through making use of the Facility's 2009 major expansions of both river intake and off-stream storage capacities.

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 based on the preceding daily flow at the USGS at Arcadia gage

Table 1.2

April 2011 Revised Authority Lower Peace River Withdrawal Schedule (based on combined flow of the Peace River at Arcadia, and the Horse and Joshua Creek USGS Gages)

Block	Allowable Percent Reduction in Flow	
Block 1 (April 20th – June 25th)	16% above 130 cfs	
Block 2 (October 27th – April 19th)	16% if flow > 130 cfs and < 625 cfs	28% if flow > 625 cfs
Block 3 (June 26th – October 26th)	16% if flow > 130 cfs and < 625 cfs	28% if flow > 625 cfs

Prior to 2009, the Peace River Facility had the capacity to treat up to 24 mgd and relied on four river pumps with a combined maximum capacity of 44 mgd (68.0 cfs) for raw river water diversions. During periods of high river flow (or periods when permitted withdrawal exceeded demands), 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 was unavailable from the Peace River due to the established low flow 130 cfs cutoff (or when demand exceeds permitted withdrawals), water was pumped from the raw water reservoir to the Peace River Facility for treatment, and/or previously treated water was 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 resulting from expected future regional growth in the member counties. These expansions included increasing the Facility's river pumping capacity from 44 to 90 mgd (the 1996 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. The pumping capacity from the river was later re-rated to 120 mgd. Current planning includes additions and expansions to the system transmission pipe networks to expand and optimize water delivery throughout the four county service region.

1.2.1 Facility Water Use Permit Related HBMP Program

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 (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 influences and significance of natural seasonal and annual salinity changes on the aquatic fauna and flora in the lower river/upper harbor estuary, and to determine if freshwater withdrawals by the Peace River Regional Water Supply Facility could be shown to potentially significantly alter these natural 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. Revisions to the HBMP monitoring elements were implemented to assess natural seasonal and longer-term variations in freshwater inflows, relative to the magnitude and timing of expected salinity changes due to Facility withdrawals. Further modifications and refinements to the HBMP study elements were made in 1985, 1988, and then again in 1996 in conjunction with the renewal of the Facility's Water Use Permit.

The current Water Use Permit (# 20010420) was issued by the District to the Authority in March 1996. The permit contained specific conditions for the continuation and enhancement of the lower Peace River/upper Charlotte Harbor estuary Hydrobiological Monitoring Program. The HBMP study elements specified in the 1996 permit renewal were designed to build upon and add to the HBMP monitoring activities initiated in 1975. The initial background HBMP monitoring conducted prior to construction completion and the Facility's initial river withdrawals was undertaken to provide a basis for pre-withdrawal conditions against which later comparisons could be made.

Between 1979 and 2014, 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 2013. 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, which was filed in draft form in 1994 (finalized in April 1995), 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 required 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 has 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 that 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* 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* 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 recently completed *2011 HBMP Comprehensive Summary Report* again provides an extensive update and analyses of each of the ongoing HBMP study elements, refinement and expansion of statistically based salinity modeling, a comprehensive historical summary of upstream watershed water quality changes, and analyses of the effectiveness of the Facility's withdrawal schedule in limiting the potential impacts of withdrawals on the downstream estuarine system.

The period covered within this *2014 HBMP Annual Data Report* follows directly upon that contained within the preceding *2013 HBMP Annual Data Report* submitted in August 2014. This current report includes unreported HBMP data collected over the period from January through December 2014, and represents the 25th year of data collection for the Authority, as owner/operator of the Peace River Regional Water Supply Facility.

As defined by the District's 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 in flow. Included in these original HBMP elements were the following investigations.

- An initial long-term study of the seasonal pattern of juvenile fishes in the upper harbor
- Studies of benthic indicator species
- An investigation of the seasonal distribution of star fish (sea star) *Luidia clathrata* in the harbor and lower river
- A series of long-term vegetation studies along the lower Peace River
  1. Periodic infrared aerials
  2. The first and last occurrence of selected plant taxa
  3. Riparian vegetation along transects at fixed locations

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 components of the estuarine food-chain. A focused shorter-term benthic invertebrate study and a separate fish nursery investigation were both conducted in the late 1990s. Again, these investigations were 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 spatial location descriptors subsequently 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 element's 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.

An outside HBMP Scientific Review Panel was implemented in conjunction with the 1996 Water Use Permit renewal to periodically review HBMP findings, and make recommendations relative to the ongoing study elements, methods of data analyses, and conclusions. The Panel has recommended a number of changes to the monitoring program study elements. Largely, the Panel has recommended that the primary focus of HBMP monitoring should be on assessing long-term trends in key physical, chemical, and biological characteristics that can be directly linked to the Facility's potential influences, and apply less effort on elements more directly related to the overall "health of the estuary", which are potentially influenced to a much greater extent by other anthropogenic impacts.

1.4 Overview of Results Presented in Previous Comprehensive Summary HBMP Reports

Expanded analyses of recent and longer-term HBMP monitoring data over the entire period-of-record (since 1976) have been conducted as required under the 1996 Water Use Permit as part of the following documents.

- *2000 Mid-term Interpretive Report*
- *2002 Peace River HBMP Comprehensive Summary Report*
- *HBMP 2004 Mid-term Interpretive Report*
- *2006 HBMP Comprehensive Summary Report*
- *2011 HBMP Comprehensive Summary Report*

The results of the analyses presented in this extensive series of reports further support previous monitoring program findings and conclusions regarding the relatively small magnitude of additional change to the much greater natural range of temporal and spatial estuarine variation that are potentially directly attributable to facility withdrawals. Similar earlier findings were presented in the 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 general conclusions.

- There have been statistically significant declines in high, median, and low flows over the long-term period of record at the USGS 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 slightly higher average flows over the summer months (June-September) during 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 stream flow augmentation due to agricultural groundwater 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. Since the initiation of Facility withdrawals in 1980, annual total Peace River Facility withdrawals have ranged approximately from 0.2 to 5.8 percent (**Table 2.6**) of total freshwater flow at the river's mouth. The higher percentages reflecting the combined influences of Facility expansions, combined with periods of lower flow.

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

- Previous statistical salinity models under the 1996 withdrawal schedule (and before) indicated that 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 had historically resulted in daily changes of 0.1-0.5 psu (practical salinity units) downstream of the Facility along the HBMP monitoring transect. Updated modeling presented in the *2011 HBMP Comprehensive Summary Report* indicated average (mean) changes in salinity downstream of the Facility were < 0.4 psuThe updated models indicated that the largest expected salinity changes will occur downstream in the normally higher brackish lower river reaches of the river during the summer wet season.

- The modeling results indicated that at least half the time Facility withdrawals have limited (if any) influence on the salinities for several reasons. First, the Facility does not affect salinity during the period of time when gage flows at Peace River at Arcadia are below the District's low flow cutoff threshold. Upstream flows can be below the 130 cfs threshold over extended intervals each year. Conversely, also when flows are high enough that a particular reach of the river is always characterized by freshwater conditions, Facility withdrawals can not affect salinity in that portion of the lower river. A somewhat less intuitive finding of the series of “pump tests” was the observation that Facility withdrawals, even during low to moderate flows, primarily only resulted in higher observed salinities during incoming tides. Withdrawals seemed to have very little directly measurable influence on salinities during the outgoing and low phases of the daily tidal cycle. Since the presented summary statistics were based on hourly estimates (versus daily estimates), it is therefore not surprising that more than half the observations did not predict any differences in salinities with and without withdrawals.

- Similar statistical analyses of the relative movement of the monitored isohalines presented in the *2011 HBMP Comprehensive Summary Report* indicated that the expected maximum change due to withdrawals has increased from 0.1-0.5 kilometers under the 1996 withdrawals schedule to 1.1-1.4 kilometers in 2011 under the current revised, MFL based withdrawal schedule. Again, the largest expected seasonal changes in the movement of the isohalines were projected to occur during the summer months under higher flow conditions.

The results of statistical models presented in this report predict commensurate increases in salinity changes and the movement of isohaline locations resulting from increased Facility withdrawals. While the annual averages (mean and median) of projected changes due to actual Facility withdrawals would still remain difficult to measure directly, the modeled estimated largest annual changes in these indicators have increased to detectable levels. However, these estimated maximum changes due to actual Facility withdrawals continue to remain small in comparison to the relative far greater magnitude of typical naturally occurring daily, seasonal, and annual variations. The Facility’s modified withdrawal schedule by design directs the largest volumes of diverted river water to occur during the summer wet season. During the summer wet season, salinities and isohaline locations are naturally experiencing a high natural degree of variation in response to increasing freshwater inflows when expected impacts to the downstream estuary from greater withdrawals would be less.

1.5 2014 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 1.3** 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 element of the lower Peace River/upper Charlotte Harbor HBMP program extends along the monitoring transect centerline from River Kilometer (RK) -2.4 south of the river's mouth upstream to RK 30.7 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 any future modifications, 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 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 event 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 us. 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 16 "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 1.3**). 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 1.4**). 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 2014, EarthBalance Corporation (formerly Florida Environmental, Inc.) 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 2014 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 were 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 1.4**).

Further descriptions, as well as complete summaries of the 2014 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, could then be used to develop detailed spatial and temporal statistical 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 3 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 measure 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 the 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 1.5** 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 Charley (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.

Summary results of 2014 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

In 2005, based on recommendations by the Scientific Review Panel and approval by District staff, 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. An objective of the Panel and resulting recommendation was to deploy additional continuous conductivity recorders at other monitoring sites spatially along the lower river as part of an expanded HBMP study element. This expanded element would re-direct portions of the monitoring efforts to specifically measure salinity changes due to Facility withdrawals under lower flow conditions. Analyses of conductivity data from these new monitoring locations were used as part of the HBMP *Pump Test Study* and the *2006 and 2011 HBMP Comprehensive Summary Reports* to extend previous graphical and statistical results with regard to directly measuring and modeling salinity changes due to withdrawals.

The first step to deploying these additional continuous recorders was to determine the potential spatial distribution for 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 along 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. A series of potential new monitoring sites located between the two existing USGS continuous recorders were then selected for evaluation

One option considered was to locate land-based gages similar in design to the existing USGS continuous recorders. However, a much broader series of other potential sites exist due to the recent placement of Manatee Speed Zone markers and the expansion of navigation markers along the lower river. The Authority was able to receive permission from U.S. Fish and Wildlife Service and U.S. Coast Guard to establish continuous recorders using these markers. Three 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 in 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 recorder 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 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.

- 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 Peace River Scientific Review Panel met again in December 2010 and recommended the deployment of an additional continuous recorder between the I-75 and U.S. 41 Bridges. The Panel further recommended that several new recorders be located between the USGS Harbour Heights gage and the HBMP gage near the Liverpool area in order to better define the relationships between salinity and flow in that reach of the lower River and within the Hunter Creek side channel. The following changes and additions to the HBMP continuous recorder array were made in June 2011.

- The exiting recorder located just downstream of the SR 761 Bridge was discontinued since USGS had installed the Platt gaging location just downstream at the Facility's intake (RK29.8).

- A new 15-minute interval subsurface conductivity and temperature recorder was located on a navigation marker at RK 9.2 between the I-75 and U.S. 41 Bridges.

- The recorder at RK 12.7 (which also measures dissolved oxygen) was moved from the bottom of the water column to the surface so that its values would be comparable with those at the other HBMP recorder sites.

- A recorder measuring subsurface conductivity and temperature at 15-minute intervals was attached to a channel marker at RK 18.5 near the Power Line Crossing.

- A subsurface conductivity and temperature recorder was located on the river's large Hunter Creek side channel near the connection to Jim Long Lake. Located on a Manatee Zone marker (approximately RK 18.7), the objective of this site was to both determine if higher salinity water was moving upstream on this side channel and the potential influences of ungaged freshwater inflows to this region of the lower river.

- A 15-minute subsurface conductivity and temperature recorder was located on the navigation channel marker at RK 20.8 just downstream of an island in the lower river.

The locations of the recorders during 2014 are summarized in **Table 1.5** and **Figure 5.1**. The methodologies used for deployment of the continuous recorders are depicted in **Figure 5.8** and **Photographs 5.1** through **5.11.**

1.5.4 Spatial *In Situ* Chlorophyll Monitoring along the HBMP Transect

Based on the recommendation of the HBMP Scientific Review Panel, and following consultation with District staff, the Authority implemented a new HBMP study element beginning in April 2014. This new HBMP study element employs *in situ* fluorometer chlorophyll *a* methodology in order to provide the type of enhanced spatial intense information needed to accurately define on a monthly basis both the magnitude and spatial extent of variations in chlorophyll *a* patterns within the lower Peace River/upper Charlotte Harbor Estuary. Accurate spatial determinations of the relative intensity and location of monthly chlorophyll *a* maxima patterns are expected to provide additional information regarding the known seasonal interactions between changes in freshwater flow (relative to additions of both nutrients and color) in relation to the seasonal movement of important estuarine zones of primary (and secondary) production.

The results of this new HBMP element are expected to help to determine the magnitude of both temporal and spatial variability of peak zones of high phytoplankton productivity in the lower river/upper harbor system. Ultimately, such determination of the seasonal influences of changes in river flow will be used to assess any potential impacts of Facility withdrawals on estuarine production under the exiting established MFL criteria. An analysis of the utility of this new HBMP study element, and recommendations for its future continuance, are expected to be made following at least two years of data gathering, and then potentially at specific intervals as part of future major summary monitoring program reports.

1.6 Summary of 2014 Results

The following text and tables compare data collected during 2014 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 2014 data with averages of similar data collected over the preceding 38-year period (1976-2013), 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 2.4**). 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 since then have returned to more normal conditions. However, as has been common in a number of recent years, dry season rainfall during portions of the first five months of 2014 was again below normal (**Figure 2.3b**).

- **Flows –** Average mean daily Peace River flow of the three combined gages upstream of the Facility during 2014 was 875.3 cfs, which is below the 1,143.8 cfs average over the 38 years of HBMP monitoring (1976-2014). In comparison, the average flow during 2014 was well above the annual average flow of 524 cfs over the four-year interval between 2006 and 2009. However, it was also well below the average flow of 2,046 cfs over the much wetter five-year interval between 2001 and 2005.

  Overall, annual mean flow upstream of the Facility during 2014 was 116.8 percent of the average daily flow over the preceding long-term 1976-2013 period (see **Table 2.6**).

- **Withdrawals –** Total Peace River Facility withdrawals during 2014 were approximately 6.5 percent of the total gaged freshwater flow measured at the USGS Arcadia gage, 5.4 percent of the upstream gaged flow at the Facility, and 4.6 percent of the combined average daily inflows upstream of the U.S. 41 Bridge. During the entire period of Peace River Facility withdrawals (1980-2014), total combined withdrawals have been approximately 1.98 percent of the corresponding gaged Peace River at Arcadia flows, 1.48 percent of total gaged flow upstream of the Facility, and only 1.1 percent of the combined daily freshwater flows of the Peace River, and Horse, Joshua, and Shell Creeks.

  There were a number of days during 2014 when Peace River Facility withdrawals exceeded the seasonally designated maximum percents allowed by the April 2011 revised permit withdrawal schedule. 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 2014, the facility did not withdraw any water from the river on 60 days or approximately 16 percent of the time. Maximum daily Facility withdrawals increased both in 2002 and 2009 due to the completed Facility expansions, which 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. The 2011 revised withdrawals schedule further increased the amounts of water the Facility was able to take from the river, especially under periods of higher flows.

- **Salinity Spatial Distribution –** Freshwater inflows to the lower Peace River during 2014 were above their recent historic long-term average (1976-2013) and much higher than during the recent severe 2006-2009 drought. However, during portions of the characteristically dry first part of the year, gaged inflows upstream of the Peace River Facility were still often below normal (see **Section 2**). The influences of the drier than usual conditions during the first part of the year and the relatively wet summer months that characterized 2014 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 2014 overall reflected slight downstream movements when compared with their previous long-term 1983-2013 averages.

Comparisons of means between 2014 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 2014 at each of the four isohaline stations were, on average, slightly higher than corresponding values measured over the preceding 30-year period (1983-2013). However, corresponding mean annual 2014 water temperatures for the year by comparison were generally similar with their long-term averages. Unusually colder than normal seasonal winter water temperatures were observed early in 2010 and 2011 as well as 2014. The seasonal annual low water temperatures during these three most recent years were in fact, three of the four coldest observed over the 30 years of monitoring at the four isohaline locations.

- **Water Color –** In comparison to seasonal averages over the preceding long-term historic period (1983-2013), water color levels during 2014 were higher than the long-term average at each of the four isohaline stations. This is in direct comparison with the generally lower levels observed during the 2006-2009 extended 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. During 2014, flows upstream of the Facility were approximately 14 percent below the longer 1976-2013 average. Including corresponding Shell Creek flows, which enter the lower Peace River further downstream nearer higher salinity harbor waters, the combined gaged flow was approximately 26 percent higher than average. These differences in regional rainfall/flows are expressed in the observed spatial differences in seasonal water color among the isohalines.

- **Extinction Coefficient –** The rates of measured water column 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 2014 with corresponding long-term averages show lower levels at all four isohaline stations. As previously noted, freshwater inflows and resulting water color levels in the lower river/upper harbor estuary during the wet season were generally above normal. However, the 2014 data indicate that measured extinction coefficients at each of the four isohalines were somewhat below normal. This result probably reflects the combined influences of often somewhat drier than usual conditions during first part of the year, as well as lower than usual measured concentrations of chlorophyll *a* (phytoplankton biomass) measured seasonally during periods of 2014.

- **Nitrite/Nitrate Nitrogen –** During 2014, the average concentrations of this major inorganic form of nitrogen were below the previously observed longer term (1983-2013) historical annual averages at the two upstream isohalines (0 and 6 psu), while being nearer historic long-term averages at the two more estuarine isohalines (12 and 20 psu). Long-term plots of nitrite/nitrate concentrations clearly indicate that inorganic nitrogen levels were well below normal throughout the lower Peace River/upper Charlotte Harbor estuarine system during the recent years of extended drought. Seasonally, monthly comparisons among the isohalines indicate that 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 annual 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 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 rainfall runoff/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 Charley (and subsequent Hurricanes Frances and Jeanne) during the late summer of 2004, inorganic phosphorus concentrations 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 begun rapidly declining again. The direct cause for the observed increased levels seems to have been related to the recent closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin. Annual average ortho-phosphorus concentrations at each of the two downstream isohalines (12 and 20 psu) were somewhat lower in 2014 than the corresponding long-term averages (1983-2013).

- **Nitrogen to Phosphorus Atomic Ratios** – Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations in 2014, as indicated by the long-term averages, show nitrogen to almost always be the limiting macronutrient at each of the four isohalines.

- **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 over the 2006-2009 interval 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 ongoing 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, levels again increased in 2011. Annual average concentrations during 2014 were again well above their long-term averages at each of the four moving isohaline based monitoring locations.

- **Chlorophyll *a*** – The seasonal patterns of freshwater inflows to the estuary during 2014 were characterized by seasonally dry conditions during the first five months of the year 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 2014 HBMP data indicate there were increases in phytoplankton biomass within the 6 and 12 psu isohalines during both the spring and fall seasons. Another phytoplankton "bloom" occurred at these same isohaline stations followed at the end of the summer wet season with declining water color and increasing residence time. Within these intermediate (6 and 12 psu) isohalines, phytoplankton biomass (chlorophyll *a*) seasonally typically reflects a balance between stimulation due to increased nitrogen inputs, changes in residence time, 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*). Overall, chlorophyll *a* concentrations within the Peace River/upper Charlotte Harbor estuarine salinity zones during 2014 were generally below their preceding long-term (1983-2013) averages.

1.7 Conclusions

This document represents the 18th 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 2014, other than those previously noted. These include:

- Freshwater inflows during 2014 were influenced by seasonally wetter than normal conditions during the normal summer wet-season.
- During 2014, the data indicated a slight decline in the previously noted increase in reactive silica concentrations that have been noted at the lower Peace River/upper Charlotte Harbor HBMP monitoring locations. In part, some of the previously observed increase may have been related to discharges during the closure of the Whidden Creek phosphyogypsum stacks. However, levels have not declined as quickly as the corresponding decrease was observed in phosphorus levels following closure of the stacks.
- 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 since 2009 have shown that levels have substantially declined again to levels near where they were prior to the observed recent increases occurring over the 2004-2008 period.
- The observed recent increases in silica and phosphorus seem to have been linked to the recent closure of phosphogypsum stack systems in the Whidden Creek basin in the upper Peace River watershed.

The “limited” analyses presented in the *2014 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 *2014 HBMP Annual Data Report* CD in the directory labeled 2014 Data Sets, as files in ASCII, Excel, and/or SAS formats. Table 1.6 provides a summary and links to descriptions of the variables within each of the SAS data sets.

Table 1.6
Long-term Historical HBMP Data Sets

Data Set Name	Time Period	Brief Description
HBMP SAS Data Sets		
Flow and Withdrawal Data for the Period-of-Record		
Flwd14_HBMP (sas7bdat)	1931-2014	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.
In Situ and Water Chemistry from "Moving" and "Fixed" HBMP Monitoring Elements		
Cmov8314 (sas7bdat)	1983-2014	Water quality and phytoplankton biomass measurements from monthly surface samples collected at each of the four moving isohalines. Relative locations reflect distances from the river mouth in kilometers.
Hymov2014 (sas7bdat)	1983-2014	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.
Hyfix2014 (sas7bdat)	1996-2014	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.
Cfix9614 (sas7bdat)	1996-2014	Monthly surface and bottom chemical water quality samples taken at five different river kilometer intervals from fixed sample locations from near the river's mouth to just upstream of the Treatment Facility.
Efix9614 (sas7bdat)	1996-2014	Water column extinction coefficients collected at the fixed sampling locations.
USGS Continuous Recorder Data		
Boca04 (sas7bdat)	1996-2004	Water level at 15-minute intervals from the continuous recording gage near Boca Grande. Discontinued.
HH14 (sas7bdat)	1996-2014	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).
PRH14 (sas7bdat)	1997-2014	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).
PLATT14 (sas7bdat)	2009-2014	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).
Ongoing HBMP Continuous Recorder Data		
RK09_14 (sas7bdat)	2011-2014	Near surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to a channel marker located on the Peace River between the I-75 and U.S. 41 Bridges (River Kilometer 9.2).
RK12_14 (sas7bdat)	2011-2014	Near surface conductivity, temperature, and dissolved oxygen at 15-minute intervals from the HBMP continuous recording gage attached to a Manatee marker located on the Peace River just downstream of Shell Creek (River

Table 1.6
Long-term Historical HBMP Data Sets

Data Set Name	Time Period	Brief Description
		Kilometer 12.7).
RK18_14.sd2 (sas7bdat)	2011-2014	Near-surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to channel marker near the power line crossing (River Kilometer 18.5).
RK18_HC_14 (sas7bdat)	2011-2014	Near-surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the Manatee Speed Zone Sign located on Hunter Creek near Jim Long Lake (River Kilometer 18.7).
RK20_14 (sas7bdat)	2011-2014	Near-surface conductivity and temperature at 15-minute intervals from the HBMP continuous recording gage attached to the channel marker located on the Peace River located just downstream of the island (River Kilometer 20.8).
RK21_14 (sas7bdat)	2006-2014	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).
RK24_14 (sas7bdat)	2006-2014	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).
RK31_14 (sas7bdat)	2008-2014	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).
Previous HBMP Continuous Recorder Data		
RK23_08 (sas7bdat)	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.
RK12_bot_11 (sas7bdat)	2008-2011	Near-bottom conductivity, temperature and dissolved oxygen at 15-minute intervals from the HBMP continuous recording gage attached to Manatee marker located on the Peace River just downstream of Shell Creek (River Kilometer 12.7). Discontinued.
RK30_11 (sas7bdat)	2008-2011	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). Discontinued June 2011.
Environmental Quality Laboratory (EQL) Background Data Sets		
SAS Version 6.0.8 Data Sets		
Chall_2 (sas7bdat)	1976-1990	EQL fixed station Charlotte Harbor background water chemistry data.
Hydroall (sas7bdat)	1976-1990	EQL fixed station Charlotte Harbor hydrolab water column profile data.
SAS Version 6.1.3 Data Sets		
Chem_v12 (sas7bdat)	1976-1990	EQL fixed station Charlotte Harbor background water chemistry data.
Hall_v12 (sas7bdat)	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 2014

The following outlines the limited number of problems and errors encountered during data collection for various elements of the 2014 HBMP monitoring program. Overall, very few data collection problems and/or other data issues other than related to instrument failures were encountered during 2014.

- **USGS Continuous Recorders –** In previous years, due to short-term instrument failures, some records for gage height, temperature, and/or conductivity were unavailable for the Harbour Heights (RK 15.5), Peace River Heights (RK 26.7), and Platt (RK 29.8) gaging sites. In 2014, there were few, if any, missing observations for the three gaging sites.

- **HBMP Continuous Recorders –** As a result of instrument issues, some of the data collected by the 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 readings at the more downstream recorder locations due to the relatively greater observed level of bio-fouling at these characteristically higher salinity monitoring sites. In 2014, new copper screening to surround the probes became available from YSI, which has reduced the instances of missing data due to bio-fouling.

- **Location of 0 psu Isohaline –** As a result of a change in field personnel at EarthBalance®, there was an issue relative to how the location of the 0 psu was identified. How this has influenced some of the identifications of the river kilometer location of 0 psu isohaline during parts of 2014 is being evaluated. If necessary, such river kilometer information for a limited number of sampling events will be identified as missing in the future.

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 2014 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 at the Peace River Facility. This section compares freshwater inflows to the lower river and upper harbor and permitted freshwater withdrawals during 2014, with similar longer-term summary information over the 1976-2013 (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 estuarine system. As indicated, the Peace River Facility intake withdrawal structure is located on a side channel, in the tidal portion of the lower river. This reach of the lower tidal river is often seasonally characterized by brackish conditions during periods of low freshwater inflow (approximately < 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 over the 2010 to 2014 time interval by the USGS continuous recorder (Peace River at Platt - 02297345) at the Facility's river intake (RK 26.7) are shown in **Figures 5.4** and **5.5**. (The relationships between gaged river flow and conductivity at all three USGS and eight HBMP continuous recorders located along the HBMP monitoring transect are presented in **Chapter 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. USGS flow data are retrieved for the annual HBMP data reports during the first part of each calendar year. USGS reports daily "provisional" flows on their web sites based on actual gage readings. However, these "provisional" flows are further updated to "accepted" based on actual periodic field measurements and cross-section adjustments (see Figure 2.1). USGS operates around "water years" running from October through September. Thus, flows for the last three months of each previous calendar year often represent "provisional" rather than "accepted" USGS data. In the instance of the *2014 HBMP Data Report*, some of the flow data over the October through December 2014 period for the gages listed in Table 2.1 had not been finalized by USGS to "accepted" prior to being downloaded for this 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	1940-2014
Peace River at Fort Meade	02294898	480	1975-2014
Peace River at Zolfo Springs	02295637	826	1934-2014
Peace River at Arcadia	02296750	1367	1932-2014
Joshua Creek at Nocatee	02297100	132	1951-2014
Horse Creek near Arcadia	02297310	218	1951-2014
Prairie Creek near Fort Ogden	02298123	233	1964-2014
Shell Creek near Punta Gorda	02298202	373	1966-2014
Myakka River near Sarasota	02298830	229	1937-2014
Big Slough near North Port	02299450	81	2002-2014

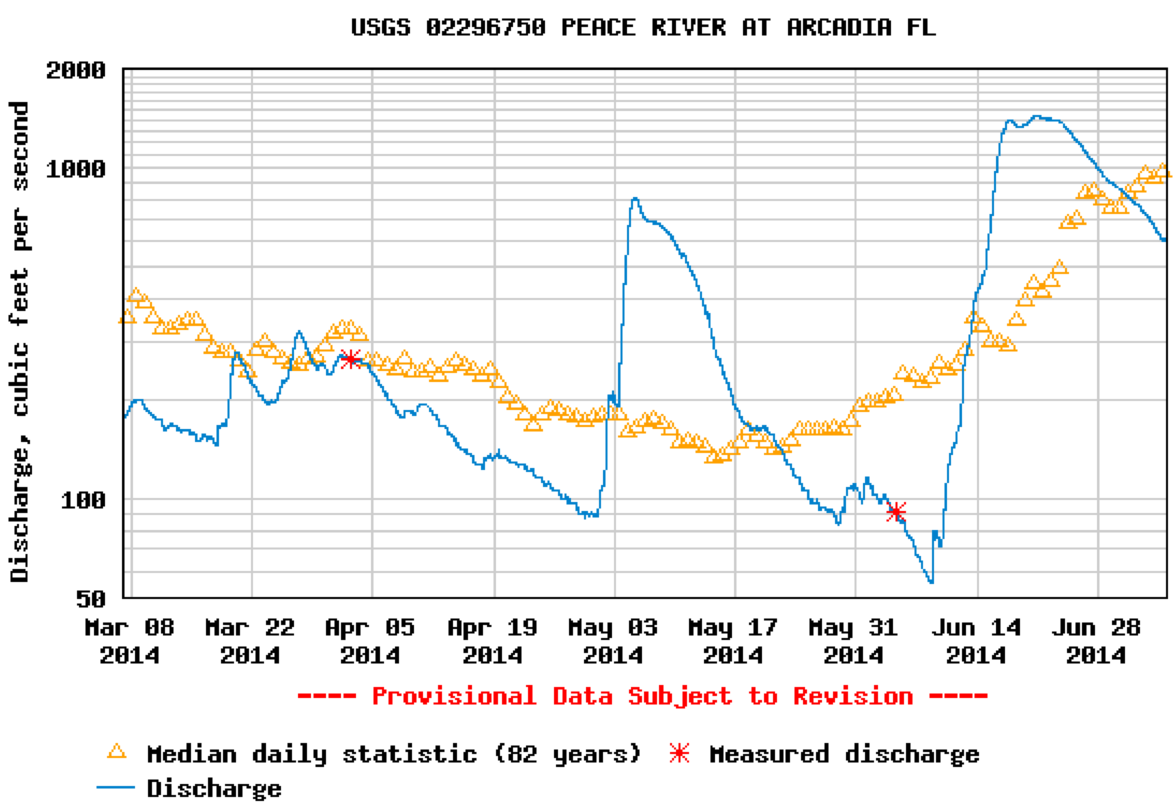


Figure 2.1 – Example of USGS periodic measurements of actual discharge used to calibrate and convert daily measured "provisional" to "accepted flows" (copied from USGS Web Site for the Peace River at Arcadia gage).

2.1 2014 Gaged Flows to the Lower Peace River

Daily combined Peace River discharges (in cubic feet per second) for the USGS gaging stations upstream of the Facility during the January through December 2014 reporting period are depicted in **Figure 2.2**. Freshwater inflows during 2014 were characterized by relatively average flows (**Figure 2.3b**). Brief periods of higher than normal flows occurred during early October (**Figure 2.3a**). Overall flows in 2014 were far more normal than the extended preceding period of drier than usual conditions that began in 2006 (**Figure 2.4)**. In fact, the annual mean combined gaged flow upstream of the Facility in 2014 of 875 cfs was slightly below the recent historical long-term (1976-2014) average of 1,143 cfs (**Table 2.2**).

Some of the decline in summer flows observed during the recent extended period of drought can be directly attributed to the occurrence of atypical patterns of wet season afternoon thunderstorm activity throughout portions of the summer during those years. Summer thunderstorms in southwest Florida normally build up along the eastern coastline and in the interior region of the state in the early afternoon and move toward the west coast later in the afternoon. However, during the recent period, the typical afternoon thunderstorm activity often tended to build and remain along the western coastline. The result was that many of the coastal USGS stream flow gages within smaller coastal watersheds actually experienced higher flows throughout much of the drought years when compared to the much larger sub-basins in the interior of the Peace River watershed.

Tropical storms (Table 2.3) can have a dramatic influence on rainfall/flow patterns in the Peace River watershed. The reduced influence of tropical storms has reduced summer wet-season rainfall during the recent extended (2006-2011) drought conditions (Figure 2.6). This drier than average period, characterized by reduced tropical storm activity, is in direct contrast with the preceding 2004-2005 interval of unusual tropical storm activity (**Maps 2004 and 2005**). During the past eight years, only tropical storms Ernesto (2006), Olga (2007), and Fay (2008) have briefly influenced rainfall in the Peace River watershed (**Maps 2006, 2007 and 2008**). Since 2008, no named tropical storms have directly influenced regional rainfall patterns (**Maps 2009, 2010**, **2011**, **2012**, **2013**, and **2014**).

The seasonal patterns of freshwater inflows during 2014 are graphically summarized in relation to the preceding long-term historical averages (1976-2014) in **Figures 2.3a** and **2.3b**. These flow duration graphics indicate the 7-day average combined flow upstream of the Facility during 2014 in relation to the long-term (1976-2014) daily statistical distributions of the average 7-day combined flow of the Peace River at Arcadia, Horse Creek near Arcadia, and Joshua Creek at Nocatee USGS gages. Statistical analyses were used to determine long-term, averages of the 10^{th}, 25^{th}, 75^{th} and 90^{th} percentiles for the combined gaged Peace River flow upstream of the Facility. Thus, the pink shaded area in **Figure 2.3b** represents the long-term (1976-2014) difference the lowest (Q100) and 10^{th} percentile (Q90) of flow calculated for each particular day of the year.

Table 2.3
Maps Showing the Tracks of Tropical Storms/Hurricanes during HBMP Monitoring Period

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
2011	2012	2013	2014		

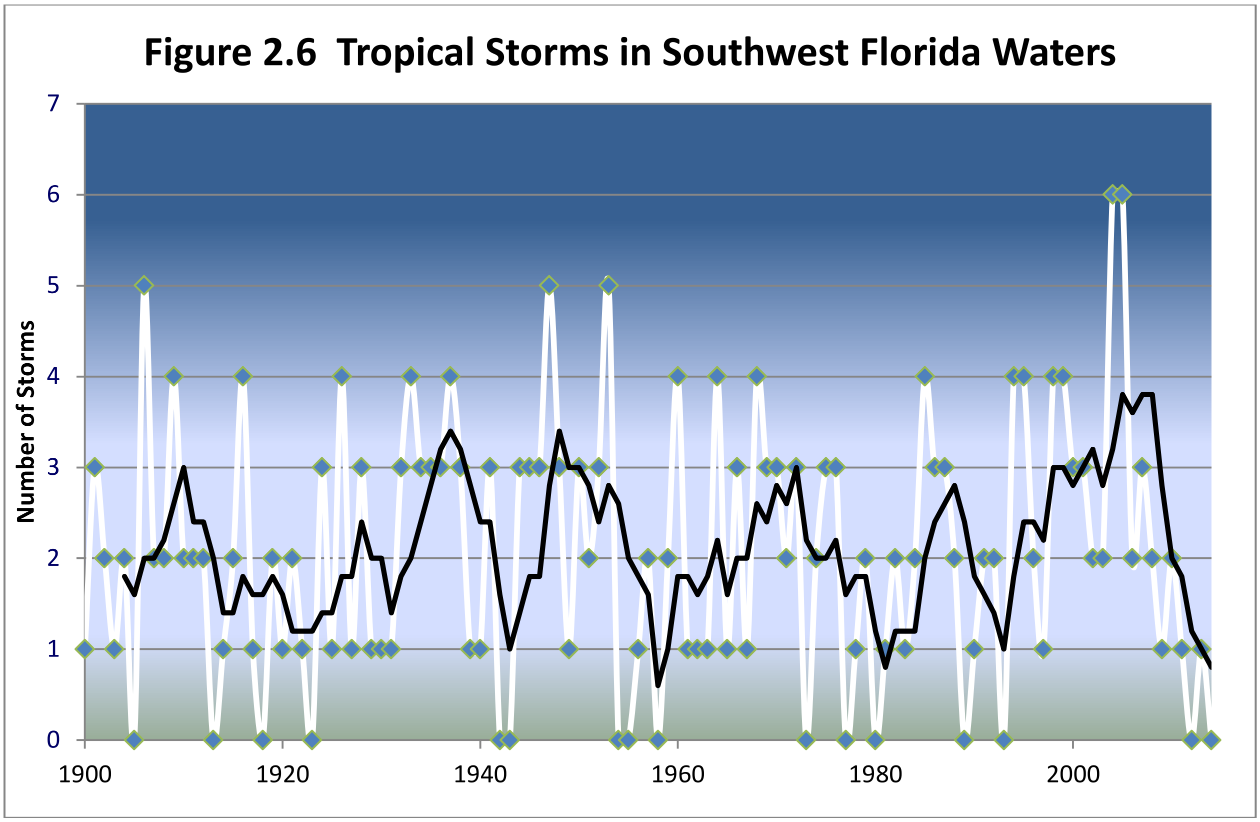


Figure 2.6 Long-term number and moving average (black line) of the number of tropical storms influencing southwest Florida.

Figures 2.3a and **2.3b** clearly show that 2014 gaged Peace River flows during the typically drier months between January and May were near normal. Plots of USGS gaged flows during 2014 and over the longer term period of HBMP monitoring (1976-2014), both for the Peace River at Arcadia and the combined gaged flows upstream of the Facility, are presented in Table 2.4. Also included are figures showing 2014 and long-term USGS gaged flows for the lower Peace River (adding the flow for Shell Creek near Punta Gorda), as well as for the entire upper harbor (further including the addition of Myakka River and Big Slough USGS gaged flows).

Table 2.4
Freshwater Inflows During 2014 and the Period 1976-2014

Figure	Description
Figure 2.2	Total daily flow at the Facility- Arcadia + (Horse + Joshua) Creeks (2014)
Figure 2.3a	Comparisons of 7-day average 2014 flow upstream of the Facility to long-term (1976-2014) percentiles
Figure 2.3b	Log scale comparisons of 7-day average 2014 flow upstream of the Facility to 1976-2014 percentiles
Figure 2.4	Total daily flow at the Facility - Arcadia + (Horse + Joshua) Creeks (1976-2014)
Figure 2.7	Mean monthly flow at the Facility - Arcadia + (Horse + Joshua) Creeks (1976-2014)
Figure 2.8	3-Month moving average flow at the Facility - Arcadia + (Horse + Joshua) Creeks (1976-2014)
Figure 2.9	Total daily flow of Lower Peace River - Arcadia + (Horse + Joshua + Shell) Creeks (2014)
Figure 2.10	Total daily flow of Lower Peace River - Arcadia + (Horse + Joshua + Shell) Creeks (1976-2014)
Figure 2.11	Mean monthly flow of Lower Peace River - Arcadia + (Horse + Joshua + Shell) Creeks (1976-2014)
Figure 2.12	3-Month moving average flow of Lower Peace River - Arcadia + (Horse + Joshua + Shell) Creeks (1976-2014)
Figure 2.13	Total daily gaged flow to Upper Harbor – (Lower Peace + Myakka) Rivers (2014)
Figure 2.14	Total daily gaged flow to Upper Harbor - (Lower Peace + Myakka) Rivers (1976-2014)
Figure 2.15	Mean monthly gaged flow to Upper Harbor - (Lower Peace + Myakka) Rivers (1976-2014)
Figure 2.16	3-Month moving average gaged flow to Upper Harbor - (Lower Peace + Myakka) Rivers (1976-2014)

Daily combined gaged flows upstream of the Facility over the 1976-2014 HBMP monitoring interval are shown in **Figure 2.4**. 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.

Combined gaged flows upstream of the Facility (Peace River at Arcadia + Horse and Joshua Creeks) over the same long-term period are further depicted as mean monthly values in **Figure 2.7** and again based on 3-month moving averages in **Figure 2.8**. Analogous graphical plots for both 2014 and the 1976-2014 interval are presented in **Figures 2.9** through **2.12** for the total gaged lower Peace River flow at the U.S. 41 Bridge (Peace River at Arcadia + Horse, Joshua, and Shell Creeks). **Figures 2.13** through **2.16** 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. USGS gaged flows for Big Slough date back only to June of 2001 and were included in the 2014 figure, but not in the plots of long-term flows) Combined, these graphics again clearly indicate the historically dry conditions that have characterized much of the preceding seven years (2006-2012).

Comparison of the data displayed in **Figures 2.4** and **2.7** indicate that combined gaged flow upstream of the Facility during 2014 was approximately 76 percent of that calculated over the longer 1976-2014 HBMP monitoring period. The data displayed in **Figures 2.9** and **2.10** for the sum of average daily flows upstream of the Peace River Facility plus that of Shell Creek was roughly 132.6 percent of the average over the longer preceding history of HBMP monitoring (1976-2014).

Table 2.5 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 (1976-2014) and the current reporting year (2014). 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 show that during 2014, the relative percent contribution of freshwater flows from the Peace at Arcadia flow were above average while the relative contributions from the Horse Creek USGS gaged watershed and Joshua Creek were below average. The contribution of the Peace at Arcadia flows to freshwater inputs to upper Charlotte Harbor at the U.S. 41 Bridge was slightly higher as well as those from Shell Creek when compared to the long-term average. In comparison, the relative percent contribution of Joshua and Horse Creeks was slightly lower than their longer term averages. This indicates that during intervals of 2014, the interior Peace River watershed was relatively wetter than the more coastal subbasins. This difference between interior and coastal rainfall patterns is not unusual.

Table 2.5
Comparisons of Relative Contributions of Gaged Flows Over Recent Historic (1976-2014) and the Current Period (2014)

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
1976-2014	75.1	15.2	9.6	57.6	11.7	7.3	23.4
2014	82.4	11.4	6.2	60.7	8.4	4.6	26.3

2.2 Peace River Facility Withdrawals

As a result of the extended drought conditions during 2006 and concern about the upcoming 2007 dry season (**Figure 2.4**), the Authority asked and received permission from the Southwest Florida Water Management District (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 while still 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. The series of District Executive Orders issued by the District in response to the severity of the extended drought 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). These executive orders also modified the low flow threshold, and increased the allowable percent withdrawals all based on the District's initial draft proposed Lower Peace River MFL. The relatively recent historic contributions (since 1976) of the USGS gaged freshwater sources to the lower Peace River, both upstream of the Facility and at the U.S. 41 Bridge (which further includes flows from Shell Creek) are presented in **Table 2.2**.

The series of District 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 2.7). The District's initial draft MFL for the lower Peace River proposed that during seasonal Block 2 (October 27 to April 19) the maximum permitted Facility 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, after evaluating comments received on the initial draft report covering both the lower Peace River and Shell Creek MFLs, the District revised its initial draft proposed MFLs (Table 2.8) by modifying the maximum withdrawals allowable. The District's revised MFL for

Table 2.7
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				
Revised Permit	4/27/11 - Present	130 cfs	Three gages upstream of the Facility	**Block I**

Table 2.7
Modifications to the Normal 1996 Permitted Withdrawal Schedule

Withdrawal Schedule Based on Adopted MFL				Apr 20th Jun 25th - 16% **Block II** Oct 27th – Apr 19th 16% if flow < 625 cfs 28% if flow > 625 cfs **Block III** Jun 26th – Oct 26th 16% if flow < 625 cfs 28% if flow > 625 cfs

* 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 2.8
Initial Daft District Proposed Lower Peace River MFL Schedule
(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 I (April 20th – June 25th)	221	10	26
Block II (October 27th – April 19th)	330	14	21
Block III (June 26th – October 26th)	1370	12	15

the lower Peace River eliminated the criteria of adjusting withdrawals based on whether flows were above or below the calculated seasonal mean. The District's revised MFLs instead added a 625 cfs upper threshold prior to changing the allowable percent withdrawal to both Blocks II and III, and delayed determination of a final Shell Creek MFL. In August 2010, the District approved and implemented the final MFL for the lower Peace River (Table 2.9).

Table 2.9
Final Adopted District Lower Peace River MFL Schedule
(based on combined USGS gaged flow at three upstream gages)

Block	Allowable Percent Reduction in Flow	
Block I (April 20th – June 25th)	16%	
Block II (October 27th – April 19th)	16% if flow < 625 cfs	29% if flow > 625 cfs
Block III (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 presented in Table 2.7 were in direct response to the severity of the 2006/2009 drought. These modifications were not permanent changes to the Authority's 1996 permitted 10 percent withdrawal of river flow based solely on Peace River at Arcadia gaged flows. In 2009, the Authority completed construction of the new 6 billion gallon reservoir, and expansion of maximum pumping capacity of the intake structure on the Peace River. Following the District's 2010 adoption of a final MFL for the lower Peace River, based on the combined flows of the three gaged flows upstream of the Facility (Table 2.9), the Authority requested a revised withdrawal schedule based on the District's adopted MFL. The Authority's goal in making this application was to provide for increased utilization of its recently increased off-stream storage system during higher river flows, in order to improve system reliability for the same 32.7 mgd average day delivery of water permitted in the Facilities 1996 District permit conditions.

A revised withdrawal schedule (Table 2.10) based on the District's adopted MFL was issued by the District to the Authority on April 26, 2011, and was implemented the following day. This permit modification maintained the original 32.7 mgd yearly average withdrawal and the maximum monthly allowed withdrawal average of 38.1mgd. The maximum daily diversions from the river were increased from 90 mgd to 120 mgd, in order to allow greater flexibility with the Authority's recent Facility upgrades. While the District's adopted MFL allows seasonal maximum withdrawals of 16%, (Block 1), 29% (Block 2), and 38% (Block 3), the Authority requested and received maximum withdrawals of 16% (Block 1) and 28% (Blocks 2 and 3) in the permitted diversion schedule. Daily Facility withdrawals had previously been based on the preceding daily average flow measured at only the USGS Arcadia gage. The new District permitted withdrawal schedule (following the final established MFL) instead utilizes the previous day's combined flow based on the readings from three gages upstream of the Facility located on the Peace River at Arcadia (USGS 02297310), Horse Creek (USGS 02297310), and Joshua Creek (USGS 02297100). The low flow cutoff for Facility withdrawals remained the same as previously permitted at 130 cfs, but was also changed to reflect the combined flow of the three upstream gages.

Table 2.10
April 2011 Revised Authority Lower Peace River Withdrawal Schedule
(based on combined USGS gaged flow at three upstream gages)

Block	Allowable Percent Reduction in Flow	
Block 1 (April 20th – June 25th)	16% if flow is above 130 cfs	
Block 2 (October 27th – April 19th)	16% if flow is > 130 cfs	28% if flow > 625 cfs
Block 3 (June 26th – October 26th)	16% if flow is > 130 cfs	28% if flow > 625 cfs

Two additional modifications were made to the Facility's water use permit in 2011. The first occurred in October 2011 and made a small adjustment in the allowable annual average withdrawal increasing it from 32.7 mgd to 32.855 mgd. This permit modification also increased the allowable monthly maximum from 38.1 mgd to 38.3 mgd. The next permit modification occurred in November 2011 and didn't change any of the permit conditions other than change the expiration date of the current water use permit from 2016 to 2037, in order to conform to the length of the Facility's existing bonds and to conform to new District rules allowing longer term water use permits.

Even with the District's revision of the withdrawal schedule based on the established MFL for the lower river, there continues to be a large number of days each year when the Peace River Facility does not withdraw water from the river. During 2014, the Facility didn't withdraw water from the river 16.4 percent (60 days) of the time. Reasons for the Facility not withdrawing water on a given day or time interval can be due to:

- The total USGS gaged stream flows upstream of the Facility being below the designated low flow threshold of 130 cfs for freshwater withdrawals
- Poor water quality from either upstream or downstream (conductivity, taste/odor)
- Facility maintenance
- Insufficient storage capacity (full existing storage system) even with the 2009 completion of the new 6 billion gallon reservoir
- Implementation of the HBMP river pump test (paired similar tide days with pumps on one of the paired days and pumps off one of the paired days)

Daily withdrawals since Facility startup are shown from 1980-2014 in **Figure 2.18**. This figure clearly indicates the increase in maximum withdrawals beginning in the later half of 2002 following the Facility's previous 2002 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 completed 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 120 mgd 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 2.11.

Table 2.11
Peace River Water Treatment Facility Withdrawals and Freshwater Inflows During 2014 and the Period 1980-2014

Figure	Description
Figure 2.17	Daily water treatment facility withdrawals (2014)
Figure 2.18	Daily water treatment facility withdrawals (1980-2014)
Figure 2.19	Monthly mean water treatment facility withdrawals (1980-2014)
Figure 2.20	3-month moving average water treatment facility withdrawals (1980-2014)
Figure 2.21	Daily total gaged flow at the Facility (Peace River at Arcadia + Horse + Joshua Creeks) and water treatment facility withdrawals (2014)
Figure 2.22	Daily total gaged flow at river's mouth (Peace River at Arcadia + Horse + Joshua + Shell Creek) and water treatment facility withdrawals (2014)

Table 2.11

Peace River Water Treatment Facility Withdrawals and Freshwater Inflows During 2014 and the Period 1980-2014

Figure	Description
Figure 2.23	Peace River flows at Facility vs. water treatment facility withdrawals (2014)
Figure 2.24	2014 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 1980-2014 period are depicted in **Figures 2.19** and **2.20.** 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 2014 Peace River total gaged inflows (at the Facility and U.S. 41 Bridge) and Peace River Facility withdrawals are further depicted in **Figures 2.21** and **2.22**.

Figure 2.23 shows the relationship between combined freshwater inflow at the three USGS gages upstream of the Facility and the actual amounts of water withdrawn, while **Figure 2.24** shows Facility withdrawals during 2014 relative to the percent of preceding daily combined Peace River upstream gaged flow. Both of these graphics utilize different colors to depict potential differences among the withdrawal schedule's seasonal blocks (see Table 2.10 above).

Figure 2.24 indicates that Facility withdrawals at times exceeded the percent withdrawal criteria set forth in the 2011 revised permit schedule (the shown horizontal lines indicate the 16 and 28 percent withdrawals, while the vertical line represents the 625 cfs flow required where the maximum percent of flow allowed to be withdrawn changes under the withdrawal schedule). Historically, discrepancies have often stemmed from the way that stage/flow data are reported. The Facility uses "provisional" preceding day flow data for gaged flow based on the water level recorders at the USGS gaging station at each of the three upstream locations. Such "provisional" real-time data are obtained directly from the USGS Web Site a number of times each day by the Authority. This is accomplished in order to determine an accurate working estimate of the current daily stream flow on which to establish the Facility's subsequent 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 frequently occur, especially during 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 amounts under the permit withdrawal schedule. Under lower flow conditions, such as occurred throughout much of early part of 2014, even small adjustments between USGS "provisional" and finalized "accepted" 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

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 (Table 2-12).

Figures 2.25 and **2.26** provide comparisons of both the 2014 and recent historic withdrawal patterns of the two facilities. **Figure 2.27** 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 2014 in relation to total gaged flows for the major tributaries.

Table 2.12
Comparisons of Peace River Water Treatment Facility and Shell Creek Facility Withdrawals with Freshwater Inflows during 2014 and the Period 1980-2014

Figure	Description
Figure 2.25	Daily Peace River and Shell Creek water treatment facility withdrawals (2014)
Figure 2.26	Daily Peace River and Shell Creek water treatment facility withdrawals (1980-2014)
Figure 2.27	Daily total gaged flow at river's mouth (Peace River at Arcadia + Horse + Joshua + Shell Creek) and total water treatment facility withdrawals (2014)
Figure 2.28	Number of days annually without water treatment facility (PRF) withdrawals (1980-2014)

Figure 2.28 depicts the number of days annually between 1980 and 2014 that the Peace River Facility hasn't withdrawn water from the river. As previously stated, the most common reason for no withdrawals being taken from the river is that the total USGS gaged stream flows upstream of the Facility is below the permitted flow threshold for freshwater withdrawal. During periods of lower freshwater flow, periods of poorer river water quality (conductivity or chlorophyll blooms) also cause the Facility to limit freshwater withdrawals and rely on previous storage. Figure 2.29a indicates the percent of days each year since 1951 that flows upstream of the Facility have been less than 200 cfs. As this figure indicates, the frequency of such events has increased since 2000. An alternative analysis of the same information is presented in Figure 2.29b. This figure depicts periods (intervals) since 1951 when the combined upstream flow above the Facility has historically been less than 200 cfs. The blue bars depict periods when the combined upstream flow above the Facility has historically been less than 200 cfs. Conversely, intervals characterized by lack of bars indicate wetter time intervals. This graphic indicates that not only has the frequency of low flow events increased but generally the duration of such events has also increased.

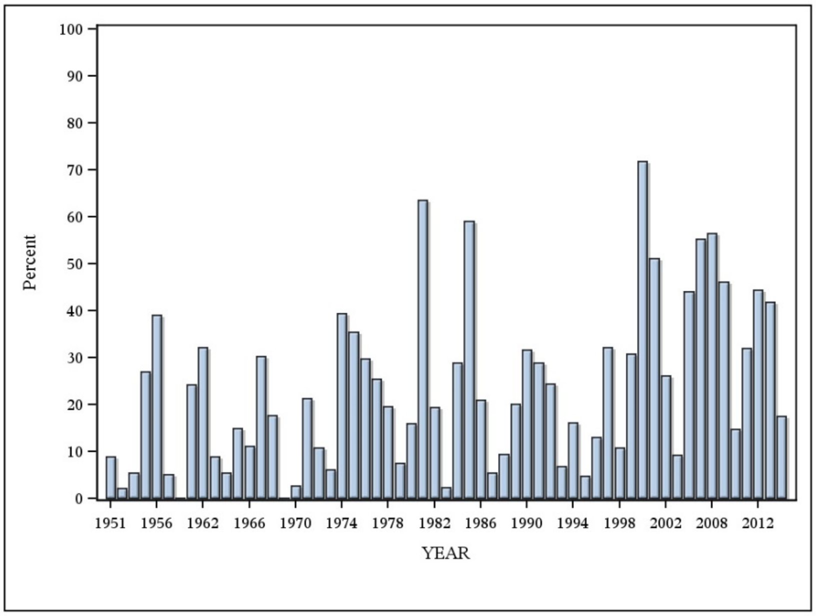


Figure 2.29a Indicates the percent of days each year since 1951 that flows upstream of the Facility have been less than 200 cfs. (The year 1951 represents the first year of complete flow records for all three of the USGS gages upstream of the Facility.)

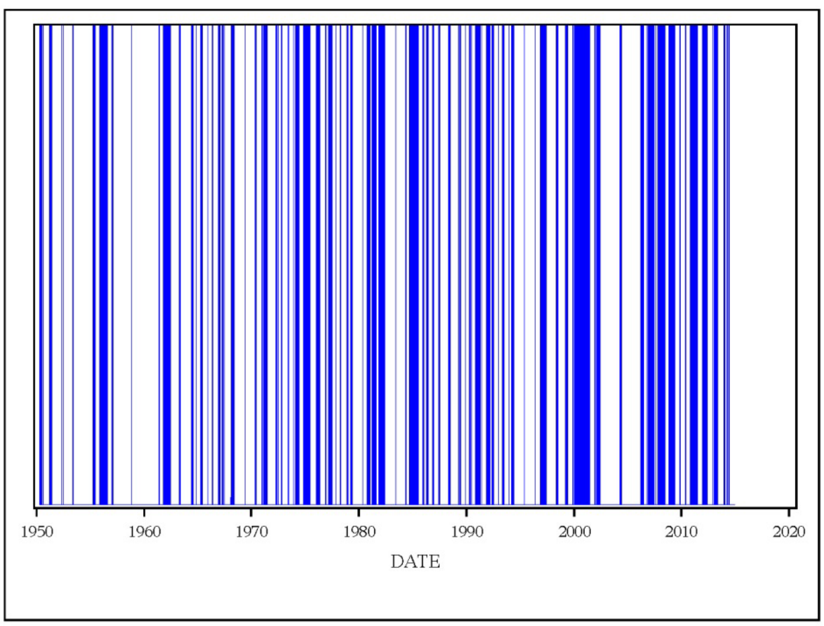


Figure 2.29b Blue bars depict periods when the combined upstream flow above the Facility has historically been less than 200 cfs. Conversely, intervals characterized by lack of bars indicate wetter time intervals.

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 2.2**. 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 Authority's Peace River Facility and City of Punta Gorda Facility.

Total Peace River Facility withdrawals during 2014 were approximately 6.5 percent of the total gaged freshwater flow measured at the USGS Arcadia gage, 5.4 percent of the upstream gaged flow at the Facility, and 4.0 percent of the combined average daily inflows upstream of the U.S. 41 Bridge. During the entire period of Peace River Facility withdrawals (1980-2014), total combined withdrawals have been approximately 2.0 percent of the corresponding gaged Peace River at Arcadia flows, 1.5 percent of total gaged flow upstream of the Facility, and only 1.1 percent of the combined daily freshwater flows of the Peace River and Horse, Joshua, and Shell Creeks.

The following from the USGS web site describes the level of error inherent in the USGS gage data used in assessing the potential impacts of the Facility's freshwater withdrawals from the lower Peace River.

Individual discharge measurements seldom are better than 2 percent. Stage discharge relations commonly have slopes of about 3 on logarithmic plots in which discharge is plotted as a function of effective stage (gage height minus offset, where offset commonly is approximately equal to gage height of zero flow). This implies that a 1 percent error in the effective stage input to the rating would translate into a 3 percent error in the computed discharge.

Figures 2.23 and **2.24,** and **Table 2.12** show how the Authority's Peace River Facility utilizing a withdrawal schedule based on a percent of the proceeding day's freshwater inflow, combined with sufficient off-stream storage (reservoirs and ASR wells), has allowed the Authority to withdraw sufficient water to meet regional demands while minimizing potential environmental impacts. This treatment and storage system allows the safe withdrawal of river water by following and accounting for the natural high seasonal variability of rainfall and flow patterns in the Peace River Watershed.

Table 2.12

Statistical Comparisons of Peace River Water Treatment Facility Withdrawals and Combined Upstream Gaged Inflows (cfs) during 2014 and the Period 1980-2014

Year / Measurement	Mean	Standard Deviation	Minimum	Maximum
2014				
Upstream gaged flow (cfs)	875	1,053	88	6,739
Facility withdrawal (cfs)	47	39	0	166
1980-2014				
Upstream gaged flow (cfs)	1,156	1,946	13	29,380
Facility withdrawal (cfs)	17	26	0	170

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. A specific goal of the HBMP isohaline based monitoring element has included determining immediate and long-term phytoplankton responses to freshwater inputs, including both nutrient loadings (nitrogen) and increased water color (which influences light availability). The HBMP's historic, long-term phytoplankton investigations in the lower Peace River/upper Charlotte Harbor estuarine system have provided:

- Measurements of populations/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 that have secondary widespread interrelations and effects upon other estuarine food-web components.

Phytoplankton production generally represents an immediately available food resource. This is in contrast with some other sources of estuarine production such as that associated with seagrass, mangrove, and saltmarsh habitats, where much of the resource becomes available through extended secondary processes and nutrient recycling. 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 30th year (2014) 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 Corporation (formerly Florida Environmental, Inc.) has continued to be contracted to conduct the physical water column measurements and collection of water chemistry samples for both the “moving” isohaline and “fixed” HBMP station elements. Initially, a number of EarthBalance® staff had previously worked on the HBMP while with EQL, thus helping to maintain previously used field collection procedures.

Since the inception of the HBMP monitoring program in 1976, all water chemistry analyses were initially conducted by EQL, which was subsequently purchased in 2000 by ASCI, Inc. ASCI continued to conduct all HBMP chemical analyses through January 2002. However, in February 2002, due to issues regarding the long-term stability of ASCI, the chemistry work was changed to Benchmark EnviroAnalytical, Inc. located in Palmetto, Florida. All laboratory methods previously used by EQL/ASCI were continued by Benchmark, who conducted all HBMP chemistry analyses during 2014.

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 1983-2014

Isohaline	Furthest River Kilometer Downstream	Furthest River Kilometer Upstream	Mean	Median
0 psu	0.6	37.6	23.5	23.7
6 psu	-16.3	30.2	13.5	13.3
12 psu	-30.1	26.3	8.5	9.5
20 psu	-36.3	22.4	1.7	4.9

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 the number of limestone outcroppings effectively prevents further upstream monitoring by boat.) Table 3.2 lists the figures showing the isohaline locations during 2014 and the period 1983-2014. 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 2014 is shown in **Figure 3.2**, while long-term patterns for the period 1983-2014 are presented in **Figures 3.3** and **3.4**. The effects of the extended drought conditions that influenced freshwater flows in the Peace River watershed between 1999-2001 and again over the 2006-2009 interval 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 2014 and over the preceding 1983-2013 monitoring period. As shown in **Diagram 3.1**, the box indicates the median line (50th percentile) as well as the 25th and 75th percentiles respectively at the bottom and top. Whisker lines then extend from the 25th percentile to the 10th percentile and from the 75th percentile to the 90th percentile. Extreme values (outside the 10th-90th 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 slightly drier than normal freshwater inflows during 2014 (see **Section 2**) are evident in the seasonal pattern of the locations of all four of the HBMP isohalines when compared to the longer-term 1983-2013 preceding period of historic HBMP isohaline based monitoring.

Table 3.2
Isohaline Locations During 2014 and the Period 1983-2014

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) of isohaline sampling locations from the mouth of the river (2014)
Figure 3.3	Relative distance from the mouth of the river of 0 and 6 psu salinity sampling zones (1983-2014)
Figure 3.4	Relative distance from the mouth of the river of 12 and 20 psu salinity sampling zones (1983-2014)
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 pH probes are typically 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 photosynthetically 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 2014 was conducted using the revised/reduced long-term water quality sampling parameter list (12 parameters) implemented starting in March 2003 (**Table 1.4**).

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

Water quality data collected during 2014 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 2014 data to those data collected during the preceding 30 years of study (1983-2013) 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 2014 and preceding longer term data collected between 1983-2013 in **Figures 3.22** through **3.29**. As previously discussed, the box and whisker plots display a detailed distribution of the data as depicted in **Diagram 3.1**, showing the median (50th percentile) at the center of the box and the 25th and 75th percentiles at the bottom and top of the box, respectively. The statistical means are shown as dots within each box. The whiskers are lines that extend from the 25th percentile to the 10th percentile and 75th percentile to the 90th

percentile. Extreme values (outside the 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 2014 at the Four Isohaline Locations

Tables	Description
Table 3.4	2014 Physical and chemical water quality parameters
Table 3.5	2014 Physical and chemical water quality parameters - nutrients
Figure 3.6	Monthly temperature at salinity sampling zones – 2014
Figure 3.7	Monthly color at salinity sampling zones – 2014
Figure 3.8	Monthly extinction coefficient at salinity sampling zones – 2014
Figure 3.9	Monthly nitrite/nitrate at salinity sampling zones – 2014
Figure 3.10	Monthly ortho-phosphorus at salinity sampling zones – 2014
Figure 3.11	Monthly atomic N/P ratio at salinity sampling zones – 2014
Figure 3.12	Monthly silica at salinity sampling zones – 2014
Figure 3.13	Monthly chlorophyll *a* at salinity sampling zones – 2014

Table 3.7
Summary Graphics of Key Physical and Chemical Measurements for Data Collected During the Period 1983-2014 at the Four Isohaline Locations

Figure	Description
Figure 3.14	Monthly temperature at salinity sampling zones (1983-2014)
Figure 3.15	Monthly color at salinity sampling zones (1983-2014)
Figure 3.16	Monthly extinction coefficient at salinity sampling zones (1983-2014)
Figure 3.17	Monthly nitrite/nitrate at salinity sampling zones (1983-2014)
Figure 3.18	Monthly ortho-phosphorus at salinity sampling zones (1983-2014)
Figure 3.19	Monthly atomic nitrogen/phosphorus ratio at salinity sampling zones (1983-2014)
Figure 3.20	Monthly silica at salinity sampling zones (1983-2014)
Figure 3.21	Monthly chlorophyll *a* at salinity sampling zones (1983-2014)
Figure 3.22	Box and whisker plots of temperature at salinity sampling zones (2014) & (1983-2013)
Figure 3.23	Box and whisker plots of color at salinity sampling zones (2014) & (1983-2013)
Figure 3.24	Box and whisker plots of extinction coefficient at salinity sampling zones (2014) & (1983-2013)
Figure 3.25	Box and whisker plots of nitrite/nitrate at salinity sampling zones (2014) & (1983-2013)
Figure 3.26	Box and whisker plots of ortho-phosphorus at salinity sampling zones (2014) & (1983-2013)
Figure 3.27	Box and whisker plots of atomic N/P ratio at salinity sampling zones (2014) & (1983-2013)
Figure 3.28	Box and whisker plots of silica at salinity sampling zones (2014) & (1983-2013)
Figure 3.29	Box and whisker plots of chlorophyll *a* at salinity sampling zones (2014) & (1983-2013)

3.5 Summary

Statistical comparisons between mean 2014 values and long-term 1983-2013 averages for selected *in situ* measurements and water quality parameters are summarized in **Table 3.8.** The following summarizes comparisons of the findings from the 2014 data with those previously collected as part of the long-term isohaline-based HBMP water quality monitoring program element.

- **Salinity Spatial Distribution** – Overall, freshwater inflows to the lower Peace River during 2014 were higher than during the recent years (2006-2009) of severe drought. During the first five months of the year, the combined gaged flows upstream of the Facility during 2014 were near their characteristic longer term seasonal averages (**Figure 2.3b**). The influences of the usual dry-season conditions that characterized the first part of the year are reflected in the seasonal and average spatial distributions of each of the four sampled moving isohalines (**Figures 3.4** and **Figure 3.5**) along the HBMP monitoring transect, and as seen in **Figure 3.5** and **Table 3.8**. Overall, the relative spatial distributions of each of the isohalines during 2014 reflected slight upstream movements when compared with their previous long-term 1983-2013 averages.

- **Temperature** – Mean annual water temperatures during 2014 at each of the four isohalines were, on average, similar to corresponding values measured over the preceding 30-year period (1983-2013). The unusually colder than normal seasonal winter water temperatures observed early in 2010, 2011, and 2012 did not occur in 2014. The seasonal annual low water temperatures during the three preceding years were in fact, three of the four coldest observed over the 30-years of monitoring at the four isohaline locations.

- **Water Color –** In comparison to seasonal averages over the preceding long-term historic period (1983-2013), water color levels during 2014 (**Figure 3.15**) were similar to the long-term average at each of the four isohalines (**Figure 3.23** and **Table 3.8**). This is in direct comparison with the generally lower levels observed during the 2006-2009 extended 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. During 2014, flows upstream of the Facility were approximately 17 percent above the longer 1976-2014 average. Including corresponding Shell Creek flows, which enter the lower Peace River further downstream nearer higher salinity harbor waters, the combined gaged flow was approximately 32 percent higher than average. These differences in regional rainfall/flows are expressed in the observed spatial differences in seasonal water color among the isohalines.

- **Extinction Coefficient –** The rates of measured water column 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 2014 with corresponding long-term averages (**Figure 3.24** and **Table 3.8**) show lower levels at all four isohalines. As previously noted, freshwater inflows and resulting water color levels in the lower river/upper harbor estuary during the wet-season of 2014 were generally above normal. However, the 2014 data indicate that measured extinction coefficients at each of the four isohalines were annually below normal. This result probably reflects the combined influences of often somewhat drier than usual conditions during the first part of the year, as well as lower than usual measured concentrations of chlorophyll *a* (phytoplankton biomass) measured seasonally during periods of 2014.

- **Nitrite/Nitrate Nitrogen** – During 2014, the average concentration of this major inorganic form of nitrogen was below the previously observed longer term (1983-2013) historical annual averages (**Figure 3.25** and **Table 3.8**) at the two upstream isohalines (0 and 6 psu), while being nearly normal at the two more estuarine isohalines (12 and 20 pus). Long-term plots (**Figure 3.17**) clearly indicate that inorganic nitrogen levels were well below normal throughout the lower Peace River/upper Charlotte Harbor estuarine system during the recent years of extended drought. Seasonally, 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 annual 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 rainfall runoff/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 Charley (and subsequent Hurricanes Frances and Jeanne) during the late summer of 2004, inorganic phosphorus concentrations 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 begun rapidly declining again (**Figure 3.18**). The direct cause for the observed increased levels seems to have been related to the recent closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin (see Section 5 of the recent *2011 Comprehensive Summary Report*). Annual average ortho-phosphorus concentrations at each the two downstream isohalines (20 psu) was somewhat higher in 2014 than the corresponding long-term averages (1983-2013).

- **Nitrogen to Phosphorus Atomic Ratios** – Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations in 2014, and as indicated by the longer term averages at each of the four isohalines, show nitrogen to almost always be the limiting macronutrient (**Figure 3.19** and **Table 3.8**).

- **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 over the 2006-2009 interval 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, levels again increased in 2011. Annual average concentrations during 2014 were again well above their long-term averages at each of the four moving isohaline based monitoring locations (**Figure 3.28** and **Table 3.8**).

- **Chlorophyll *a*** – The seasonal patterns of freshwater inflows to the estuary during 2014 were characterized by seasonally dry conditions during the first five months of the year 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 2014 HBMP data indicate there were increases in phytoplankton biomass within the 6 and 12 psu isohalines during both the spring and fall (**Figure 3.13**). Another phytoplankton “bloom” occurred at these same isohalines followed at the end of the summer wet-season with declining water color and increasing residence time. Within these intermediate (6 and 12 psu) isohalines phytoplankton biomass (chlorophyll *a*) seasonal typically reflects a balance between stimulation due to increased nitrogen inputs, changes in residence time, 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*).

Overall, chlorophyll *a* concentrations within the Peace River/upper Charlotte Harbor estuarine salinity zones during 2014 were generally below their preceding long-term (1983-2013) averages (**Table 3.8**).

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 done 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 element that included chemical water quality monitoring was the monthly "moving" isohaline monitoring at four locations along the HBMP monitoring transect. This ongoing study, initially began in 1983 to assess estuarine phytoplankton production (see **Section 3**), includes monthly *in situ* physical water column profile measurements and surface water chemistry samples taken in conjunction with the "moving" isohaline HBMP study element.

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 five 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 4.1a**, while **Table 4.1b** 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 at each of the five current HBMP water quality monitoring locations by EQL, in conjunction with General Development Corporation's background monitoring program of the lower Peace River and Charlotte Harbor, between the inception of the HBMP monitoring program in 1976 and 1990. During the interval from 1990 to 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 Surface Water Improvement and Management (SWIM) monitoring program. Charlotte County also collected monthly data at these same two sites as background information for Florida DEP/U.S. Army Corps mandated 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 new “fixed” HBMP monitoring locations. Since July 2000, EarthBalance Corporation (formerly Florida Environmental, Inc.) has been responsible for both the “fixed” and “moving” (**Section 3**) field monitoring, including taking physical water column measurements and the collection of water chemistry samples. ASCI, Inc. analyzed both the “fixed” and “moving” HBMP chemical samples between the sale of EQL in 1998 and January 2002. However, due to concerns regarding the long-term stability of ASCI, all HBMP water chemistry analyses were changed to Benchmark EnviroAnalytical, Inc. located in Palmetto, Florida in February 2002. Benchmark has continued to conduct all the chemistry analyses of samples collected through 2014, 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 4.1a**).

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 16 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 unit’s cable and/or 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 (**Figure 4.1b**).

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 1.4**)

In response to 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 1.4**).

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 was 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 2014 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 2014 and over the long-term 1976-2014 interval.

4.4.1 Physical Water Column Characteristics (2014)

The results for the *in situ* hydrolab water column profiles for the period January through December 2014 at the 16 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 2014

Figure	Description
Figure 4.2a	2014 Mean monthly temperature at River Kilometers –2.4, 6.6, 8.4, and 10.5
Figure 4.2b	2014 Mean monthly temperature at River Kilometers 12.7, 12.8, 15.5, and 17.5
Figure 4.2c	2014 Mean monthly temperature at River Kilometers 20.1, 21.9, 23.6, and 24.7
Figure 4.2d	2014 Mean monthly temperature at River Kilometers 25.9, 29.5, 30.7, and 32.3
Figure 4.3a	2014 Mean monthly dissolved oxygen at River Kilometers –2.4, 6.6, 8.4, and 10.5

Table 4.2
Summary Graphics of Mean Monthly Physical Water Column *In Situ* Water Quality Measurements at the Fixed Sampling Locations During 2014

Figure	Description
Figure 4.3b	2014 Mean monthly dissolved oxygen at River Kilometers 12.7, 12.8, 15.5, and 17.5
Figure 4.3c	2014 Mean monthly dissolved oxygen at River Kilometers 20.1, 21.9, 23.6, and 24.7
Figure 4.3d	2014 Mean monthly dissolved oxygen at River Kilometers 25.9, 29.5, 30.7, and 32.3
Figure 4.4a	2014 Mean monthly pH at River Kilometers –2.4, 6.6, 8.4, and 10.5
Figure 4.4b	2014 Mean monthly pH at River Kilometers 12.7, 12.8, 15.5, and 17.5
Figure 4.4c	2014 Mean monthly pH at River Kilometers 20.1, 21.9, 23.6, and 24.7
Figure 4.4d	2014 Mean monthly pH at River Kilometers 25.9, 29.5, 30.7, and 32.3
Figure 4.5a	2014 Monthly 1% light depth at River Kilometers –2.4, 6.6, 8.4, and 10.5
Figure 4.5b	2014 Monthly 1% light depth at River Kilometers 12.7, 12.8, 15.5, and 17.5
Figure 4.5c	2014 Monthly 1% light depth at River Kilometers 20.1, 21.9, 23.6, and 24.7
Figure 4.5d	2014 Monthly 1% light depth at River Kilometers 25.9, 29.5, 30.7, and 32.3
Figure 4.6a	2014 Mean monthly specific conductance at River Kilometers –2.4, 6.6, 8.4, and 10.5
Figure 4.6b	2014 Mean monthly specific conductance at River Kilometers 12.7, 12.8, 15.5, and 17.5
Figure 4.6c	2014 Mean monthly specific conductance at River Kilometers 20.1, 21.9, 23.6, and 24.7
Figure 4.6d	2014 Mean monthly specific conductance at River Kilometers 25.9, 29.5, 30.7, and 32.3

The following patterns and observations with regards to seasonal differences among the 16 "fixed" sampling sites are shown and supported by these figures.

- **Water Temperature –** Monthly mean water column temperatures in 2014 followed the strong seasonal pattern typically observed in south Florida. Often, the highest water temperatures are found in the more upstream, shallower, freshwater reaches of the estuary and reach their highest levels in May and then remain similar up until August. By comparison, average water column temperatures in the downstream areas are more influenced by the harbor and often don't reach their highest annual values until July. During 2014, the highest average water column temperatures occurred throughout the lower river/upper harbor estuary during June. Historically the annual peak in water temperatures in the estuary varies between June and August depending on annual variations in cloud cover and differences in seasonal rainfall patterns. The 2014 data further clearly shows relatively normal cold conditions during both the start of the year and December associated with typical winter cold fronts.

- **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 (DO) 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 high summer wet season. 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 2014 (as typically observed in previous years), average water column dissolved oxygen levels generally declined as water temperatures increased, resulting in DO levels reaching their lowest levels during summer wet season between June and September throughout both the lower river and upper harbor as both water temperatures and flows increased. The 2014 summer, wet season column profile data (as has occurred since 2010) indicated the return of normal hypoxic/anoxic dissolved oxygen levels in the upper harbor. Such normal summer/high flow low DO levels did not occur (or were far less in magnitude/duration) during the extended 2006-2009 drought. This indicates that the flows that occurred during the summer of 2014 were again 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 Charley in August 2004.

- **pH –** During 2014 as in previous years, pH values periodically show marked declines during periods of increased, lower pH summer freshwater inflows. Lower pH values indicate increased surface flows relative to groundwater influences. Surface flows from heavily vegetated upland/wetland areas are responsible for the characteristic "black water" wet-season inflows, which are high in humic acids. These surface water flow influences will decline and pH levels will increase as water flow moves downstream toward the mediating effects of higher pH, high salinity harbor waters.

- **Light Extinction –** The 2014 HBMP data indicate that both the timing and magnitude of the ability of light to penetrate into the water column (1 percent depth) exhibits 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, light extinction in the lower Peace River/upper Charlotte Harbor estuarine system is often primarily mediated by existing water color due to the "black water" characteristics of freshwater inflows from the Peace River watershed. **Figures 4.5a** through **4.5d** indicate that water clarity during 2014 (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 2.2**). The influences of the dry first five months followed by typical summer wet-season rainfall conditions are clearly evident in comparing the one percent light depths observed between the more downstream lower river/upper harbor monitoring locations with the upstream characteristically freshwater reaches of the lower river.

- **Conductivity/Salinity – Figures 4.6a** through **4.6d** clearly show the influences of both the wetter and drier intervals during 2014 on the temporal and spatial patterns of conductivity (salinity) throughout the lower Peace River/upper Charlotte Harbor estuarine system. Seasonally spatial conductivity patterns in the tidal lower Peace River during the very dry first five months of 2014 were similar with previous spring dry seasons and late fall conditions over much of the previous decade, when low river flow conditions allowed brackish conditions in the lower river to often extended upstream even beyond the Peace River Facility intake. Such relatively high salinity conditions in the lower river were especially noticeable during the extended droughts that affected southwest Florida and the Peace River basin during much of the 1999-2001 and 2006-2009 periods (see **Table 2.6**). During these years, very high conductivities were observed even at the most upstream sampling locations during the extended periods of low freshwater inflows.

4.4.2 Chemical Water Quality Characteristics (2014)

The 2014 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 2014 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 (2014)
Figure 4.7b	Monthly bottom color at fixed sampling stations (2014)
Figure 4.8a	Monthly surface total suspended solids at fixed sampling stations (2014)
Figure 4.8b	Monthly bottom total suspended solids at fixed sampling stations (2014)
Figure 4.9a	Monthly surface nitrite/nitrate at fixed sampling stations (2014)
Figure 4.9b	Monthly bottom nitrite/nitrate at fixed sampling stations (2014)
Figure 4.10a	Monthly surface total Kjeldahl nitrogen at fixed sampling stations (2014)
Figure 4.10b	Monthly bottom total Kjeldahl nitrogen at fixed sampling stations (2014)
Figure 4.11a	Monthly surface ortho-phosphorus at fixed sampling stations (2014)
Figure 4.11b	Monthly bottom ortho-phosphorus at fixed sampling stations (2014)
Figure 4.12a	Monthly surface silica at fixed sampling stations (2014)
Figure 4.12b	Monthly bottom silica at fixed sampling stations (2014)
Figure 4.13a	Monthly surface chlorophyll *a* at fixed sampling stations (2014)
Figure 4.13b	Monthly bottom chlorophyll *a* at fixed sampling stations (2014)

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 beginning of the typical summer wet 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 instances, 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 2014 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 indicate a distinct spatial gradient within the lower river/upper harbor estuarine system with higher levels of inorganic nitrogen progressively occurring upstream (**Figures 4.9a** and **4.9b**). During 2014, inorganic nitrogen concentrations were low or at near-detection limits during the extended spring/early summer dry season (April/May). Overall, nitrite+nitrate nitrogen levels in 2014 were lower than or similar to 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 four drought years of 2006 to 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 2014, the annual average

Kjeldahl concentrations were very similar to the historic long-term averages. Only the upper Harbor station (RK -2.4) showed higher concentrations in 2014 (**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 (reflecting dilution rather than biological uptake). 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 Charley 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 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 have continued to decline to previous observed lower levels (**Figure 4.25e**). Seasonally, inorganic ortho-phosphorus in 2014 at the five fixed monitoring sites was similar to levels observed prior to the recent observed increase. As previously discussed in **Section 3**, the direct cause for the increased levels seems to have been related to the discharges of water during the closure of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin (see **Section 7**).

- **Silica** – Historically, annual reactive silica concentrations in the Peace River Estuary characteristically have indicated a number of differing temporal and spatial patterns. During the spring dry season, silica levels were normally at their annual lowest concentrations 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 increased and the start of the summer wet-season began, concentrations characteristically rapidly increased throughout the estuary (**Figure 4.12a**). However, reactive silica concentrations during 2014 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 closing of the Ft. Meade phosphogypsum stack system in the upstream Whidden Creek subbasin. However, unlike phosphorus concentrations, silica levels have continued to be near historic high seasonal levels through much of the estuary.

- **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 shows 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 are 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 2014 were influenced by both the seasonally low streamflow during the first five months of the year (**Section 2.0**), 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.

4.4.3 Long-Term Physical and Chemical Water Quality Characteristics (1976-2014)

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 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 1996-2014 time interval.

Table 4.5
Selected Long-Term Physical and Chemical Water Quality Data Collected Monthly During the Periods 1976-1990 and 1996-2014 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

Table 4.5
Selected Long-Term Physical and Chemical Water Quality Data Collected Monthly During the Periods 1976-1990 and 1996-2014 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6, and 30.7)

Figure	Description
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
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

Table 4.5
Selected Long-Term Physical and Chemical Water Quality Data Collected Monthly During the Periods 1976-1990 and 1996-2014 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6, and 30.7)

Figure	Description
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
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

Table 4.5
Selected Long-Term Physical and Chemical Water Quality Data Collected Monthly During the Periods 1976-1990 and 1996-2014 at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6, and 30.7)

Figure	Description
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
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 (1976-2014), 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** – Very 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 seasonal low salinity levels were observed both near the surface and bottom of the water column, at the more downstream sampling sites. More recently, the four years of drought (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 downstream 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 Charley in August 2004 is evident from both subsequent subsurface and near-bottom measurements taken throughout the lower river/upper harbor estuarine system. 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, observed water color levels are spatially markedly 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 38-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 Charley in August 2004. During the recent years of drought (2006-2009), 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 then, 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 1999-2001 drought, the data showed phosphorus levels at the upper freshwater HBMP "fixed" monitoring station locations increasing to levels not seen for over 20 years, with the sharpest rise following Hurricane Charley (**Figure 4.25e**). In approximately 2008, the data began to indicate declining levels. Since 2010 and continuing through 2014 measured levels have returned to near those seen a decade before. Upstream sampling by the Authority (see **Section 8**) has linked the recent pattern of increased phosphorus levels with the discharges associated with the then 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 1996-2014 HBMP monitoring period when compared to older EQL background monitoring data collected during the 1976-1990 period (**Figures 4.28a through 4.28e)**. 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*).

4.4.4 Statistical Comparisons of Physical and Chemical Water Quality Characteristics during 2014 with Comparable Longer-Term Data (1996-2013)

Comparative statistical relationships between the most recent 2014 surface water quality data collected at the five “fixed” monitoring sites along the HBMP monitoring transect (**Figure 4.1**) and analogous information collected during the preceding 18 years of study (1996-2013) are shown for selected physical, chemical and biological measurements in **Figures 4.31** through **4.41** (see Table 4.6). Comparisons are presented as box and whisker plots and as previously discussed , the box and whisker plots display statistical distributions of the data (**Diagram 3.1)** showing the means, medians (50^{th} percentile), the 25^{th} and 75^{th} percentiles, with whisker lines extending to the 10^{th} and 90^{th} percentiles. Extreme values (outside the 10^{th}-90^{th} percentiles) are represented by dots at the ends of the whiskers.

Table 4.6
Summary Box and Whisker Graphics of Physical/Chemical Water Quality Parameters Comparing Data Collected in 2014 with that over the 1996-2012 Time Interval at the Fixed Sampling Locations (River Kilometers –2.4, 6.6, 15.5, 23.6, and 30.7)

Figure	Description
Figure 4.31	Box and whisker plots of surface temperature at fixed sampling sites
Figure 4.32	Box and whisker plots of surface salinity at fixed sampling sites
Figure 4.33	Box and whisker plots of surface pH at fixed sampling sites
Figure 4.34	Box and whisker plots of surface dissolved oxygen at fixed sampling sites
Figure 4.35	Box and whisker plots of extinction coefficient at fixed sampling sites
Figure 4.36	Box and whisker plots of surface color at fixed sampling sites
Figure 4.37	Box and whisker plots of surface nitrite/nitrate at fixed sampling sites
Figure 4.38	Box and whisker plots of surface total Kjeldahl Nitrogen at fixed sampling sites
Figure 4.39	Box and whisker plots of surface ortho-phosphorus at fixed sampling sites
Figure 4.40	Box and whisker plots of surface silica at fixed sampling sites
Figure 4.41a	Box and whisker plots of surface chlorophyll a (ug/L) at fixed sampling sites
Figure 4.41b	Box and whisker plots of surface chlorophyll a (ug/L) at fixed sampling sites

The following briefly describes both observed temporal and spatial patterns apparent in this series of figures.

- **Temperature** – Mean surface water temperatures at each of the five “fixed” monitoring sites were warmer in 2014 than the averages for the preceding 17 years. The figure also indicates that water temperatures at the two sites in the harbor downstream of the U.S. 41 Bridge are generally slightly lower than at the three more riverine sampling locations. These spatial differences probably result from the combined greater exposure of the estuarine waters to cold fronts during winter months, and the greater heating of highly colored upstream river water during the summer months.

- **Salinity** – The figure clearly shows the strong gradient in surface salinities along the HBMP monitoring transect, as well as the higher salinities during 2014 (especially at the three most downstream sampling sites) caused by the somewhat lower than average dry-season flows during the first part of the year (**Section 2**).

- **pH** – Measured surface levels during 2014 at two upstream monitoring locations along the HBMP monitoring transect were elevated in comparison to the statistical distributions of values over the longer-term 1996-2013 interval. This result probably reflects the influences of higher than average salinities seasonally during the first five months of 2014, since more marine waters characteristically have somewhat higher pH levels than freshwater inputs to the estuary.

- **Dissolved Oxygen –** Mean and median annual measured surface dissolved oxygen levels among the five sampling sites were generally slightly lower when compared with similar statistical metrics over the preceding 17 year interval. The previous occurrences of both very high and very low values apparent in longer-term data were not observed during 2014.

- **Light Extinction Coefficient –** As previously described, measured water column extinction coefficients primarily reflect the combined influences of water color, chlorophyll *a* (phytoplankton) and turbidity (also often heavily influenced by plankton). The presented figure indicates generally lower than average extinction coefficients (clearer water) during 2014 at the two more downstream sampling sites, reflecting the much lower than normal freshwater flows that characterized the first five months of the year. The seasonal ranges of measured values in 2014 were generally similar to those observed at each of the locations over the longer-term.

- **Water Color –** Since water color is often the primary factor influencing the extinction of light in the water column within the lower Peace River/upper Charlotte Harbor estuarine system, the spatial and temporal patterns depicted for water color closely follow those described for measured extinction coefficients. The higher than usual water color at the two most downstream upper harbor sites again reflects the somewhat higher than normal flows during the summer wet season.

- **Nitrite+Nitrate Nitrogen –** This major nutrient is often the limiting factor to phytoplankton growth in the lower river/upper harbor estuarine system, and shows both strong seasonal variability as well as a well-defined spatial patterns among the HBMP sampling sites. Measured levels are often near or at detection limits at the more downstream monitoring locations during the spring dry season, prior to the beginning of the characteristic summer wet season, when freshwater inflows delivers inputs of nutrients (and color) from the watershed. The spatial pattern of measured concentrations during 2014 along the HBMP was typical of those measured over the previous 1996-2013 time interval.

- **Total Kjeldahl Nitrogen** (TKN) **–** The spatial pattern of TKN among the five monitoring sites along the HBMP transect in 2014 was very similar to that for water color, with higher levels than average at the more downstream sampling sites due to high summer wet-season inflows. Spatially, levels are generally similar at the three sites upstream of the U.S. 41 Bridge, and progressively decrease further downstream into the upper harbor.

- **Ortho-phosphorus –** Measured concentrations along the HBMP monitoring transect during 2014 were somewhat lower than the longer-term averages, which were heavily influenced by the recently observed high levels associated with the previously discussed closure of the Ft. Meade Whidden Creek phosphogypsum stack. The spatial distribution reflects simple dilution by saline water from the most upstream site to the most downstream monitoring location in the upper harbor.

- **Silica –** As previously discussed, silica levels over recent years in the lower Peace River have been much higher than historically observed. While concentrations of ortho-phosphorus, which also recently dramatically increased, have declined over the past several years, silica levels have remained relatively high. The annual average silica levels in 2014 were appreciably higher in the four upstream sampling sites than those observed in the earlier period.

- **Chlorophyll *a* –** The spatial distribution of measured chlorophyll *a* phytoplankton biomass along the HBMP sampling transect during 2014 did not exhibit periodic extremely high spikes (blooms) in phytoplankton biomass. Such events have often been observed to occur in the region between Harbour Heights and near the U.S. 41 Bridge. This region of the lower river is commonly characterized by intermediate salinities, where freshwater with higher nutrients from the watershed mix with nutrient poor (nitrogen) higher salinity harbor water, naturally stimulating “blooms” of phytoplankton production at the base of the estuarine food-chain. The fact that the statistical means at each of the five monitoring locations is greater than the calculated medians reflects the influences of periodic unusually, higher than average measured values have on the statistical distributions of the data. During 2014, the overall measured levels of chlorophyll *a* were slightly lower than the preceding 1996-2013 average, reflecting the higher than typical summer freshwater inflows and corresponding overall increased water color, and decreased residence time.

5.0 USGS and HBMP Continuous Recorders

5.1 Introduction and Overview

During the 1996 permit renewal, a need was identified to begin collecting salinity data at fixed points along the HBMP monitoring transect at a much greater frequency than that being obtained by the ongoing monthly “fixed” and “moving” isohaline based monitoring study elements. The availability of such temporally intense data collected over an extended period, encompassing a wide variety of flows under differing tidal conditions was expected to provide the needed information for the development of more accurate statistical and/or mechanistic models. The development of such models would allow increased accuracy in assessing the relative magnitudes of short and longer-term salinity changes due to permitted Facility withdrawals. Both the magnitude and spatial duration of salinity changes along the HBMP monitoring transect resulting from Facility freshwater withdrawals are expected to be influenced by the interactions, and combined influences, of seasonally varying natural variations in flows and tides. Two initial 15-minute recorder locations were established by USGS under an ongoing contract with the Authority. Responding to comments and recommendations from the HBMP Scientific Review Panel, the Authority itself subsequently deployed three additional continuous salinity recorders in December of 2005. This was followed by two additional recorders added in May 2008, and most recently three more recorders were added at the end of June 2011. In December 2009, USGS installed a third pair of near-surface/near-bottom continuous recorders immediately adjacent to the Facility’s river intake structure. This third USGS recorder provides the Authority the ability to assess river conductance both downstream and at the Facility in real time. The relative locations during 2014 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 Historic and Current HBMP Continuous Recorders along the lower Peace River

Gage ID, Location, and Period of Monitoring	River Kilometer
RK09 (Authority) – Navigation Marker south of I75 Bridge – Jun 2011 to present	RK 09.2
RK12 (Authority) - Manatee Zone Marker near Shell Creek (near bottom) – May 2008 to Jun 2011	RK 12.7
RK12 (Authority) - Manatee Zone Marker near Shell Creek (surface) – Jun 2011 to present	RK 12.7
HH (USGS - 02297460) – Dock at Harbour Heights - Sep1996 to present	RK 15.5
RK18 (Authority) – Channel Marker in Area of Power Lines – June 2011 to present	RK 18.5
RK18_HC (Authority) - Manatee Zone Marker on Hunter Creek - Jun 2011 to present	RK 18.7
RK20 (Authority) – Channel Marker downstream of Island – June 2011 to present	RK 20.8
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

Table 5.1

Summary of Historic and Current HBMP Continuous Recorders along the lower Peace River

Gage ID, Location, and Period of Monitoring	River Kilometer
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 June 2011	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 existing private dock at Harbour Heights (RK 15.5). This USGS gaging site (02297460) monitors water level and both surface and bottom specific conductance, as well as water temperatures.

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. Such a rise in sea level was expected to occur over time and monitoring was established 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. More 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 1 -foot below the surface using a float, while the near-bottom sensors were suspended about 1 foot from the bottom in the same stilling well. However, following damage caused by Hurricane Charley (August 2004), the Harbour Heights gage (02297460) was rebuilt on January 11, 2005. The upper sensor was set at a fixed depth (0.40 foot below NGVD 1929) below the water surface to measure the near-surface specific conductance and temperature and the lower sensor was fixed (3.5 feet 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 feet below NGVD 1929) and the lower sensor was set at (4.4 feet 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 feet below NGVD 1929 and the bottom sensor at approximately 3.8 feet 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 installed 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-foot 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 feet from the water surface at all gage heights.

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 five years of data collection

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 effects 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**) and the Platt gaging site located at RK 29.8 (**Figures 5.6** and **5.7**).

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 2.7** summarize the temporary changes made to the withdrawal schedule due to the severity of the recent period of extended drought. However, as shown in Table 5.2, conductivity (salinity) levels are often extremely low in the upstream reach of the river monitored by the Peace River Heights (RK 26.7) and Platt USGS (RK 29.8) recorders (**Figure 5.1**). Often the reach of the river at and immediately downstream of the Facility monitored by these two gages is characterized by freshwater conditions when Peace River at Arcadia flows are 130 cfs or greater. Thus, while the physical location of these upstream continuous recorders 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 these upstream locations when flows are near or above 130 cfs withdrawal threshold. However, the installation of the new USGS recorder at the intake structure (RK 29.8) has provided the Authority with a far clearer view of seasonal tidal influences combined with the upstream movement of higher salinity waters 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 overall goal of the selected locations for 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. In addition to the existing navigational (red and green) markers along the lower Peace River, the U.S. Fish and Wildlife Service (USFWS) has placed a large number of Manatee Speed Zone markers along the lower river. Combined, these structures provide a series of spatially distributed potential sites for the placement of recorders downstream of the Facility. The Authority has received permission from both USFWS and U.S. Coast Guard 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 measured 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 Peace River Scientific Review Panel met again in December 2010 and recommended the addition of an additional continuous recorder downstream of the I-75 Bridge, and that several new recorders be located between USGS Harbour Heights gage and the HBMP gage near the Liverpool area in order to better define the relationships between salinity and flow in that reach of the lower River. The following changes and additions to the HBMP continuous recorder array were made in June 2011.

- **RK 30.6 –** This recorder located just downstream of the SR 761 Bridge was discontinued since USGS had installed a third gaging location at the Facility intake (RK 29.8) immediately downstream.

- **RK 09.2 –** A new recorder was located on a navigation marker between the I-75 and U.S. 41 Bridges. This recorder also measures subsurface conductivity and temperature at 15-minute intervals.

- **RK 12.7 –** This recorder (which also measures dissolved oxygen) was moved from the bottom of the water column to the surface so that its values would be comparable with those at the other HBMP recorder sites.

- **RK 18.5 –** A recorder measuring subsurface conductivity and temperature at 15-minute intervals was attached to a channel marker near the Power Line Crossing.

- **RK 18**.7 **HC –** A new subsurface conductivity and temperature recorder was located on the river's large Hunter Creek side channel near the connection to Jim Long Lake. Located on a Manatee Zone marker, the objective of this side channel site was to both determine if higher salinity water was moving upstream and potential influences of ungaged freshwater inflows to this region of the lower river.

- **RK 20.8 –** This recorder was located on the navigation channel marker just downstream of Island Thirty-Three (odd name) in the lower river. The recorder measures subsurface conductivity and temperature at 15-minute intervals.

The following series of graphics indicate the changes in the spatial distribution of USGS recorders over time.

- **2005** – Through 2005, the recorder array consisted of just the two USGS recorders, the first installed in 1996 and the second in 1997.

- **2006** – The number/location of sites following the addition of the three new HBMP continuous recorders in December 2005 are shown.

- **2008 –** This graphic indicates the changes/expansion made to the HBMP records in May 2008.

- **2010 –** A third USGS recorder was added in December 2009.

- **2011** – This graphics depicted the most recent series of changes made to the HBMP recorder locations.

The locations of the recorders during 2014 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 **5.11**.

- **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 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** – the YSI conductivity/temperature sonde is shown attached to two bullet floats being readied for placement in the stilling well.

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

- **Photo 5.5** – indicates how the YSI meter was previously deployed near the bottom of the water column at RK 12.7 to measure conductivity, temperature, and dissolved oxygen.

- **Photo 5.6** – 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** – the most upstream continuous recorder stilling well (with the locking cap) is shown attached to the old railroad trestle at RK 31.7.

- **Photo 5.8** – shows installation of the stilling well on the channel marker for the continuous recorder just downstream of Island Thirty-Three at RK 20.8.

- **Photo 5.9** – shows installing new stilling well for the continuous recorder at RK 18.7 on Hunter Creek near Jim Long Lake.

- **Photo 5.10** – deployment of the sonde on channel marker located at RK 18.5 is shown.

- **Photo 5.11** – this last photograph shows the amount of fouling that can occur on a sonde deployed for a month.

Data from these recorders are retrieved at approximately monthly intervals (or more often as needed during very dry periods when fouling becomes an issue at the more downstream sampling sites). A complete cleaned, calibrated, and checked replacement set of sondes is 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 (2014)

All current (2014) 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 1.5** (see **Section 1**).

Gage height, as well as surface and bottom conductivity and temperature readings collected in 2014 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 5.3.**

The magnitude and duration of influence by 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 the Harbour Heights (RK 15.5), Peace River Heights (RK 26.7), and Platt (RK 29.8) USGS gages. Conductivities at the more upstream Peace River Heights recording gage indicates the extent and duration of the upstream movement of higher conductivity harbor waters during the first five months of 2014. Higher conductivity harbor water (5,000–15,000 uS/cm) extended upstream into the characteristically freshwater reach of the lower river at Peace River Heights over extended time intervals during 2014. This is in direct contrast to the much wetter 2003-2005 time interval when conductivities at the Peace River Heights gage exceeded 1,000 uS/cm for only a few days each year. During the very dry period from April through May 2014, high conductivity water (1,000–2,000 uS/cm) reached the Facility Intake (**Figures 5.20** and **5.21)**, which was lower than similar spring conditions during the recent 2006-2009 drought.

The influence of relatively higher summer flows during 2014 is apparent in the observed relatively smaller daily changes in stage height at the upstream USGS gages (**Figures 5.9**, **5.14** and **5.19**) in direct response to increased flows.

Table 5.3
Summary Graphics of 2014 Data from USGS Continuous Recorders

Figure	Description
Figure 5.9	2014 Gage height (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.10	2014 Surface conductivity (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.11	2014 Bottom conductivity (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.12	2014 Surface temperature (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.13	2014 Bottom temperature (15-minute intervals) for Peace River fixed station at Harbour Heights – USGS Gage 02297460 (River Kilometer 15.5)
Figure 5.14	2014 Gage height (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.15	2014 Surface conductivity (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.16	2014 Bottom conductivity (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.17	2014 Surface temperature (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.18	2014 Bottom temperature (15-minute intervals) for Peace River fixed station at Peace River Heights – USGS Gage 02297350 (River Kilometer 26.7)
Figure 5.19	2014 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	2014 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	2014 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	2014 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	2014 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 the Facility Intake (RK 29.8), are presented in **Figures 5.24** through **5.41** for the last two weeks in May 2014 (dry season) and first two weeks of September 2014 (wet season). These intervals were selected as representative of some of the more typical dry-season and wet-season flows during 2014. An overview of these graphics is presented in Table 5.4.

Table 5.4
Summary Graphics of Comparisons of Stage Height and Surface and Bottom Conductivity During May and September 2014 at the USGS Continuous Recorders

Figure	Description
Figure 5.24	Surface conductivity and stage height in May at Harbour Heights – USGS gage 02297460 (River Kilometer 15.5)
Figure 5.25	Bottom conductivity and stage height in May at Harbour Heights– USGS gage 02297460 (River Kilometer 15.5)
Figure 5.26	Surface and bottom conductivity in May at Harbour Heights - USGS gage 02297460 (River Kilometer 15.5)
Figure 5.27	Surface conductivity and stage height in September at Harbour Heights - USGS gage 02297460 (River Kilometer 15.5)
Figure 5.28	Bottom conductivity and stage height in September at Harbour Heights – USGS gage 02297460 (River Kilometer 15.5)
Figure 5.29	Surface and bottom conductivity in September at Harbour Heights – USGS gage 02297460 (River Kilometer 15.5)
Figure 5.30	Surface conductivity and stage height in May at Peace River Heights - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.31	Bottom conductivity and stage height in May at Peace River Heights - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.32	Surface and bottom conductivity in May at Peace River Heights – USGS gage 02297350 (River Kilometer 26.7)
Figure 5.33	Surface conductivity and stage height in September at Peace River Heights - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.34	Bottom conductivity and stage height in September at Peace River Heights - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.35	Surface and bottom conductivity in September at Peace River Heights - USGS gage 02297350 (River Kilometer 26.7)
Figure 5.36	Surface conductivity and stage height in May at Platt (Facility) - USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.37	Bottom conductivity and stage height in May at Platt (Facility) - USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.38	Surface and bottom conductivity in May at Platt (Facility) – USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.39	Surface conductivity and stage height in September at Platt (Facility) - USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.40	Bottom conductivity and stage height in September at Platt (Facility) - USGS Gage 02297345 (River Kilometer 29.8)
Figure 5.41	Surface and bottom conductivity in September at Platt (Facility) - 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 2014, in the dry season, it was not uncommon for surface and bottom conductivities to vary 5,000 to 10,000 uS/cm (roughly from 2 to 5.5 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 2014 (**Figures 5.30** and **5.31)** showed surface and bottom conductivities varying 2,000 to 7,000 uS/cm (roughly from 2 to 3.5 psu) over a tidal cycle during the May spring dry season. The May 2014 results at the Peace River Heights gage were less than those observed during many previous drier spring periods, when measured tidal variations in conductivity at this location were observed ranging 9,000 to 15,000 uS/cm. Again, this contrasts to 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. During the wet season in September 2014, 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 Platt USGS recorder (02297345) located at the Facility intake (RK 29.8), data collected in May 2014 showed little daily variations in conductivity (**Figures 5.36** and **5.37**) in response to tides. This is in direct contrast to May 2012 when much drier conditions resulted in tidal conductivity changes in the range of 4,000 to 8,000 uS/cm (approximately 2.0 to 4.5 psu). As expected, under the higher summer wet-season flows in September, there was no indication of tidal influences on measured conductivities (**Figures 5.39** and **5.40**).

5.3 Results from HBMP Continuous Recorders (2014)

All data to date for the HBMP continuous (15-minute interval) conductivity/temperature gages at each of the following sites and corresponding intervals are contained in the appropriate summary data sets summarized in **Table 1.3** (see **Section 1**). Since July 2011, the HBMP continuous recorder array (**Figure 5.1**) has included a total of eight ongoing monitoring locations.

1. RK 9.2 – June 2011 to present
2. RK 12 .7 (subsurface) including dissolved oxygen – Jun 2011 to present
3. RK 18.5 – June 2011 to present
4. RK 18.7 (Hunter Creek) – Jun 2011 to present
5. RK 20.8 – June 2011 to present
6. RK 21.9 – Dec 2005 to present
7. RK 24.5 – Dec 2005 to present
8. RK 31.7– May 2008 to present

Conductivity readings (and dissolved oxygen at RK 12.7) collected in 2014 at 15-minute intervals at the current eight ongoing HBMP continuous recorder sites are presented in **Figures 5.42** through **5.49**. 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 5.50** through **5.59**) and during summer wet season high flow over the first two weeks of September (**Figures 5.60** through **5.69**). 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 5.58** and **5.59)** and the September wet season (**Figures 5.68** and **5.69**). The various graphics presented summarizing and contrasting the 2014 results for the Authority's HBMP continuous recorders are shown in Table 5.5.

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 (and spatially limited) tidal salinity changes during intervals of higher freshwater inflows.

Table 5.5
2014 Authority's HBMP Continuous Recorder Results

<table>
<tr><th rowspan="2">Location</th><th rowspan="2">Jan-Dec 2014</th><th rowspan="2">May 2014</th><th rowspan="2">September 2014</th><th colspan="2">Comparisons among Sites May 2014</th><th colspan="2">Comparison among Sites September 2014</th></tr>
<tr><th>15-Minute</th><th>Daily Average</th><th>15-Minute</th><th>Daily Average</th></tr>
<tr><td>RK 9.2</td><td>Figure 5.42</td><td>Figure 5.50</td><td>Figure 5.60</td><td rowspan="8">Figure 5.58</td><td rowspan="8">Figure 5.59</td><td rowspan="8">Figure 5.68</td><td rowspan="8">Figure 5.69</td></tr>
<tr><td>RK 12.7 (surface)</td><td>Figure 5.43</td><td>Figure 5.51 (Missing Data)</td><td>Figure 5.61</td></tr>
<tr><td>RK 18.5</td><td>Figure 5.44</td><td>Figure 5.52</td><td>Figure 5.62</td></tr>
<tr><td>RK 18.7 (Hunter Creek)</td><td>Figure 5.45</td><td>Figure 5.53</td><td>Figure 5.63</td></tr>
<tr><td>RK 20.8</td><td>Figure 5.46</td><td>Figure 5.54</td><td>Figure 5.64</td></tr>
<tr><td>RK 21.9</td><td>Figure 5.47</td><td>Figure 5.55</td><td>Figure 5.65</td></tr>
<tr><td>RK 24.5</td><td>Figure 5.48</td><td>Figure 5.56</td><td>Figure 5.66</td></tr>
<tr><td>RK 31.7</td><td>Figure 5.49</td><td>Figure 5.57</td><td>Figure 5.67</td></tr>
</table>

5.4 Summary Comparisons among USGS and HBMP Continuous Recorders

The seasonal and daily ranges of variation in near surface salinities (only sites with a complete year of data were included) at the HBMP and USGS continuous recorders are statistically summarized, compared and contrasted over the past eight years in the following series of tables.

- **Tables 5.6** (2006)
- **Tables 5.7** (2007)
- **Tables 5.8** (2008)
- **Tables 5.9** (2009)
- **Tables 5.10** (2010)
- **Tables 5.11** (2011)
- **Tables 5.12** (2012)
- **Tables 5.13** (2013)
- **Tables 5.14** (2014)

Of particular interest in comparing the data from the continuous recorders among the past eight 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 daily and seasonal changes in salinity are of a far greater magnitude than those predicted by the HBMP statistical models developed in the *2008* and *2011 HBMP Comprehensive Summary Reports*.

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 other years, but there were large differences in both the maximum recorded levels and observed ranges of daily tidal variability. The figures presented in **Table 5.15** further graphically depict the spatial and temporal salinity differences at the USGS and HBMP recorders over the past seven years along the lower Peace River monitoring transect.

Table 5.15
Annual Spatial Variability in Salinity as Measured Along the Monitoring Transect by both the USGS and HBMP Continuous Recorders

Graphic and Year		
Figure 5.70 (2006)	Figure 5.71(2007)	Figure 5.72 (2008)
Figure 5.73 (2009)	Figure 5.74 (2010)	Figure 5.75 (2011)
Figure 5.76 (2012)	Figure 5.76 (2013)	Figure 5.76 (2014)

Historically, estimated salinity changes due to Facility withdrawals have been such that they would have been difficult to physically measure given the far greater magnitudes of daily, seasonal, and annual naturally occurring variation. The Facility however has undergone major recent expansions (in 2002 and 2009), which have substantially increased its ability to withdraw, store, and treat water from the river while increasing overall reliability. In 2010, the District completed a review and adopted a final MFL for the lower Peace River, and the Authority's withdrawal schedule was subsequently modified in 2011. This modification seasonally increased the maximum allowed withdrawal percentages. The results of statistical models presented in the *2011 HBMP Comprehensive Summary Report* predicted commensurate increases in salinity changes and the movement of isohaline locations resulting from recent increased Facility withdrawals. Annual averages (mean and median) of projected salinity changes due to Facility withdrawals would however still remain difficult to be measured directly, and remain small in comparison to the relative far greater magnitudes of typical naturally occurring seasonal and annual variations shown in these figures.

6.0 HBMP In Situ Chlorophyll Transect Monitoring

6.1 Assessment of Chlorophyll (Phytoplankton Biomass) Maxima along the HBMP Monitoring Transect – Introduction and Overview

The current monthly "fixed" and "moving" HBMP water quality study elements (described in **Sections 3** and **4**) include sampling of chlorophyll *a* levels along the HBMP monitoring transect at widely spaced discrete sampling locations. As a common photosynthetic pigment among major primary producers, chlorophyll *a* levels are often used as a relative estimate of phytoplankton biomass in both freshwater and estuarine systems. Spatial and temporal variability of phytoplankton chlorophyll *a* concentrations are widely applied in estuarine ecology as a relative indicator of overall integrated levels of primary production. As a measure of phytoplankton biomass, chlorophyll *a* has a number of distinct advantages.

- Measured values can often be qualitatively coupled to important physical and chemical water quality characteristics.
- Measurements integrate phytoplankton cell types, sizes, and growth stages, and to some degree the relative overall cell health/viability.
- Applied methods of measurement are relatively simple, direct, and far less costly when compared to alternatives such as the microscopic identification of individual phytoplankton taxa and/or direct measures of carbon fixation.

The development of a comprehensive understanding of phytoplankton production (biomass) is a fundamental component in developing an integrated conceptual understanding of the interrelated physical/chemical systems and biological processes within the lower Peace River estuarine system as shown in conceptual Figure 6.1 (developed by Dr. Ernst Peebles).

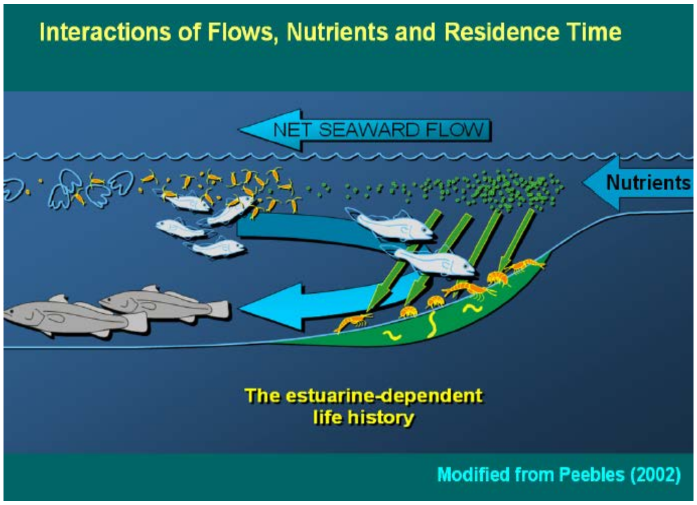


Figure 6.1 Importance of the Location of Estuarine Chlorophyll Maxima.

Phytoplankton production represents a large, immediately available food resource directly accessible to many estuarine grazing, filter/detrital feeding organisms. Phytoplankton production represents a basic, integrated estuarine food-web component that can be directly influenced by variations in freshwater inflows. As a result of the very short generation times involved (hours/days), when compared with many other potential biological indicators, phytoplankton production has the potential to be more directly quantitatively linked to changes in estuarine freshwater inflows. The observed numbers and spatial distributions of other potential biological estuarine indicators are often subject to the confounding additional influences associated with longer generation times, more intricate life-cycles, and the increasing complexity of predatory/prey interactions with each additional trophic level.

It should be noted that even though widely used as a standard relative measure, chlorophyll *a* concentration can still inherently be an imperfect absolute measure of phytoplankton biomass, since cellular pigment contents are influenced both by relative phytoplankton community structure and a wide array of commonly variable ambient physical (water color, shading, temperature) and chemical (nutrients) environmental conditions.

Advances in fluorescence technology have resulted in the recent capability of semi-quantitatively measuring *in situ* phytoplankton chlorophyll *a* and other accessory pigment estimates, without having to employ extensive filtering and expensive laboratory chemical extraction and analyses. *In situ* fluorometer chlorophyll *a* measurement procedures also present the potential utility of near-real-time data acquisition in synoptically identifying spatial phytoplankton biomass patterns along the lower river/upper harbor salinity gradient. The accuracy of such *in situ* measurements can be greatly enhanced through employing pre- and post-sampling fluorometer calibrations and comparisons to field measurements with “reference” values obtained utilizing standard laboratory (extraction) procedures.

Both the “fixed” and “moving” HBMP study elements have previously indicated the existence of seasonally-variable chlorophyll *a* maxima along the lower Peace River/upper Charlotte Harbor monitoring transect. Based on the recommendation of the HBMP Scientific Review Panel, and following consultation with District staff, the Authority implemented a new HBMP study element beginning in April 2013. This new HBMP study element employs *in situ* fluorometer chlorophyll *a* methodology in order to provide the type of enhanced spatial intense information needed to accurately define on a monthly basis both the magnitude and spatial extent of variations in chlorophyll *a* patterns within the lower Peace River/upper Charlotte Harbor Estuary. Accurate spatial determinations of the relative intensity and location of monthly chlorophyll *a* maxima patterns are expected to provide additional information regarding the known seasonal interactions between changes in freshwater flow (relative to additions of both nutrients and color) in relation to the seasonal movement of important estuarine zones of primary (and secondary) production.

The resulting high resolution data obtained from the new monthly in situ transect monitoring are graphically analyzed using standardized GIS Kriging procedures. Future analyses of the relative weighted centers of abundance will be determined using standard GIS Spatial Analyst methodologies. Calculated metrics of observed spatial patterns will then be statistically seasonally analyzed relative to natural variations in flow and measured water quality parameters obtained from other HBMP study elements.

The results of this new HBMP element are expected to help determine the magnitude of both temporal and spatial variability of peak zones of high productivity in the lower river/upper harbor system. Ultimately, such determination of the seasonal influences of changes in river flow will be used to assess any potential influences of Facility withdrawals on estuarine production under the existing established MFL criteria. The information may further be applied to assess (and potentially refine) the existing and future spatial locations of the HBMP continuous recorder array (see **Section 5**). An analysis of the utility of this new HBMP study element, and recommendations for its future continuance, are expected to be made following at least two years of data gathering, and then potentially at specific intervals as part of future major summary monitoring program reports.

6.2 Sampling Methodology

The following briefly summarize the basic approach that is currently being applied during the monthly collection of spatially intense *in situ* information on chlorophyll (and other parameters) along the HBMP monitoring transect.

- Using maps, landmarks, and GPS coordinates, the sampling boat travels along a predefined course from the mouth of the river (RK 0) to above (~ RK 32) the uppermost HBMP continuous HBMP conductivity recorder located on the river at the old railroad crossing. A sampling speed of approximately 8 kilometers/hr is maintained using GPS tracking.

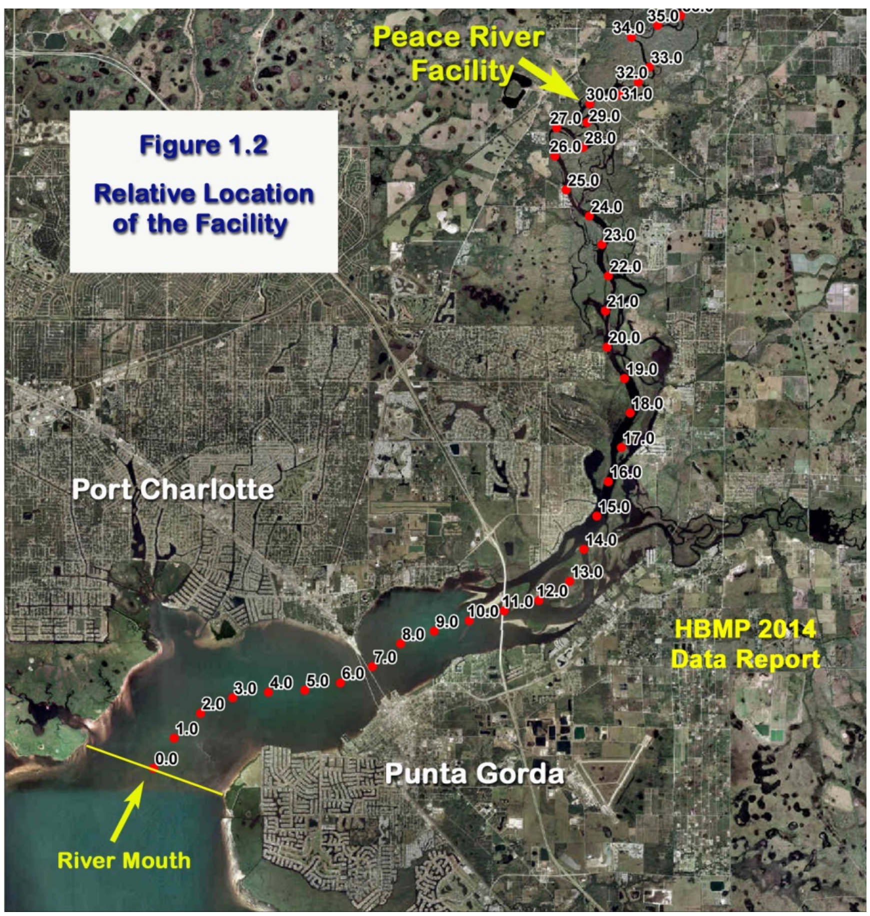


Figure 6.2 HBMP monitoring transect (copied from Section 1).

- A pair of peristaltic pumps and intake tubes mounted on a bracket over the front/side of the boat is utilized to provide for the continuous, uniform collection of subsurface water (0.2-0.5 meters). The flow rate is periodically checked and calibrated throughout the sampling run to assure consistent movement of water through the sampling chamber.

- The collected subsurface water is pumped through a blackened, flow-through chamber housing, which supports two YSI sondes with associated standard and optical sensors.

- The first YSI sonde is equipped with probes measuring standard parameters:
  1. Conductance
  2. Temperature
  3. pH

  The second YSI sonde is equipped with optical sensors that measure:
  1. 440-500 nm – Colored dissolved organic matter (fluorometric)
  2. 565-610 nm – Phycoerithrin (fluorometric)
  3. 600-700 nm – Phycocyanin (fluorometric),
  4. 650-700 nm – Chlorophyll *a* (fluorometric),
  5. 830-890 nm – Turbidity (fluorometric)

- A pair of data loggers is used to integrate GPS data with both sets of sonde measurements, which are automatically combined with GPS coordinates and recorded at short intervals of 1-2 minutes (depending on measured flow rates through the chamber).

- To the greatest extent possible, data collections are standardized within a defined temporal period relative to mid-daylight in order to normalize known daily variations in apparent chlorophyll *a* levels.

- Water grab samples (10-20 per transect) are collected and analyzed for water color and chlorophyll. These samples are collected spatially along the transect as needed emphasizing both observed changes in optical readings and observed changes in collected physical water quality information. The objective is to provide laboratory estimates for comparison over as great a range of variability as possible.

- The statistical relationships (multivariate regression) are conducted following each sampling run comparing collected fluorometric measurements with laboratory color/chlorophyll results from the periodic field sampling. Chlorophyll concentrations along the entire transect length are then estimated based on the resulting statistical analyses of *in situ* fluorometric measurements against corresponding field grab samples.

- Every attempt is made to coordinate the *in situ* transect chlorophyll sampling with the monthly "fixed" station sampling being conducted by EarthBalance® (see **Figure 4.1b**). It is ultimately expected that the monthly corresponding "fixed" station monitoring data with be combined and statistically compared with the optical *in-situ* data for future analyses.

The following series of figures further depict the physical set-up of the utilized *in situ* monitoring equipment.

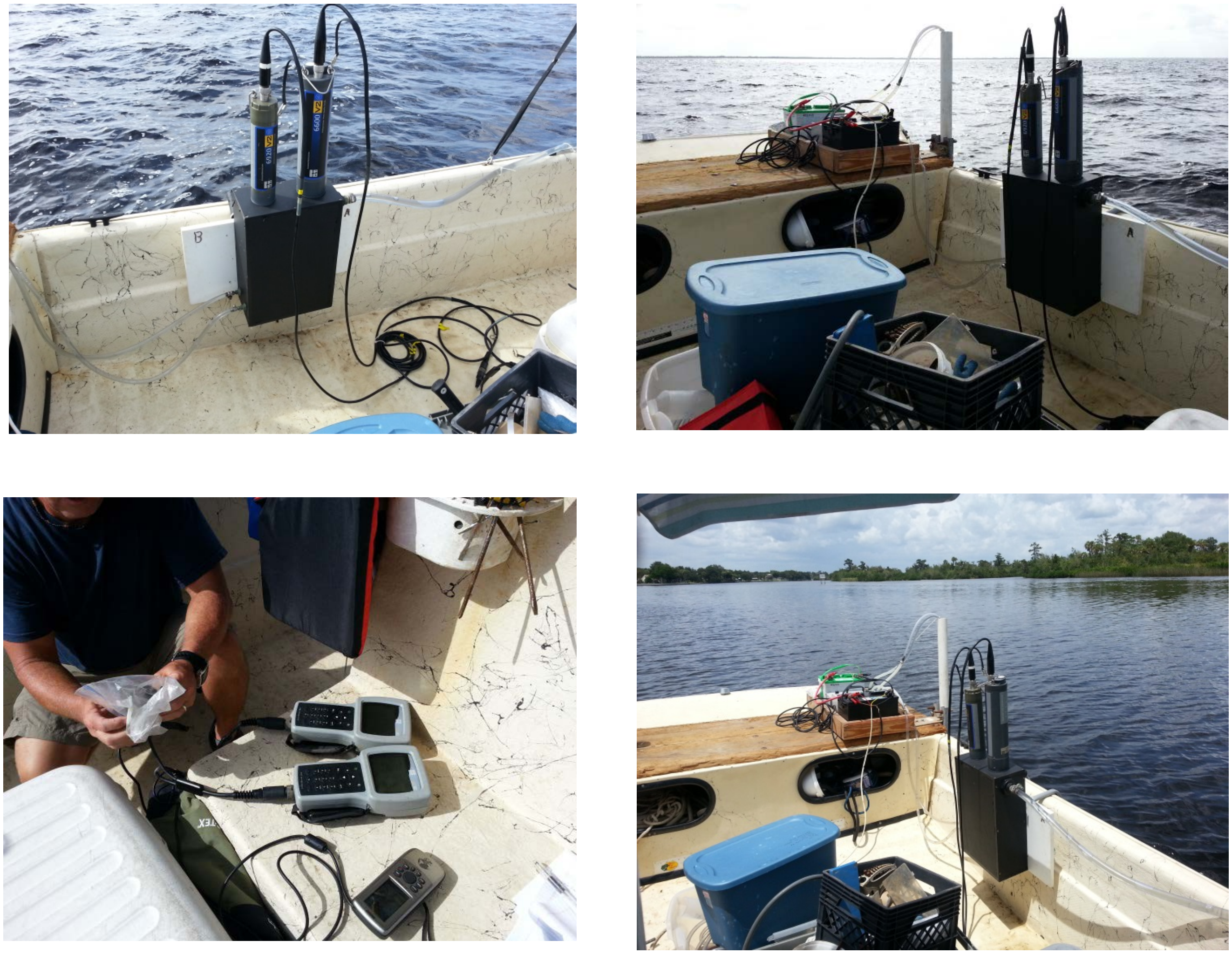


Figure 6.3 Photographs showing: the blackened, flow-through chamber housing with the pair of YSI optical and standard sondes; the pair of peristaltic pumps and intake tubes mounted on a bracket over the front/side of the boat; and the pair of data loggers integrated with a GPS unit to simultaneously record *in situ* measurements and spatial coordinates.

6.3 2014 Sampling Results

The initial monthly transect study results from data collected during 2014 are graphically presented in Table 6.1. Transect results are presented showing the spatial distribution of salinity, water color, and chlorophyll *a* along the approximate 32- kilometer length of the HBMP monitoring transect, starting near the mouth of the river (RK 0) and moving upstream to the old railroad bridge crossing (RK 31.7) upstream of the Authority's Treatment Facility.

The data for each month for these three parameters are presented using two differing methods of scaling. First, the measurements are shown scaled indicative of the range of values measured along the monitoring transect during each specific month. Alternatively, the same information is also presented using scaling based on the historic calculated ranges of data that have been seasonally observed for each of these water quality characteristics within the lower river/upper harbor estuary during long-term HBMP monitoring.

Table 6.1 2014 Sampling Results from *In Situ* HBMP Chlorophyll Transects

Month	Salinity		Chlorophyll *a*		Water Color	
	Variable Scale	Fixed Scale	Variable Scale	Fixed Scale	Variable Scale	Fixed Scale
January	Figure 6.4	Figure 6.16	Figure 6.28	Figure 6.40	Figure 6.52	Figure 6.64
February	Figure 6.5	Figure 6.17	Figure 6.29	Figure 6.41	Figure 6.53	Figure 6.65
March	Figure 6.6	Figure 6.18	Figure 6.30	Figure 6.42	Figure 6.54	Figure 6.66
April	Figure 6.7	Figure 6.19	Figure 6.31	Figure 6.43	Figure 6.55	Figure 6.67
May	Figure 6.8	Figure 6.20	Figure 6.32	Figure 6.44	Figure 6.56	Figure 6.68
June	Figure 6.9	Figure 6.21	Figure 6.33	Figure 6.45	Figure 6.57	Figure 6.69
July	Figure 6.10	Figure 6.22	Figure 6.34	Figure 6.46	Figure 6.58	Figure 6.70
August	Figure 6.11	Figure 6.23	Figure 6.35	Figure 6.47	Figure 6.59	Figure 6.71
September	Figure 6.12	Figure 6.24	Figure 6.36	Figure 6.48	Figure 6.60	Figure 6.72
October	Figure 6.13	Figure 6.25	Figure 6.37	Figure 6.49	Figure 6.61	Figure 6.73
November	Figure 6.14	Figure 6.26	Figure 6.38	Figure 6.50	Figure 6.62	Figure 6.74
December	Figure 6.15	Figure 6.27	Figure 6.39	Figure 6.51	Figure 6.63	Figure 6.75

These presented fine-scale graphical results clearly indicate the highly seasonal nature, and degree of small scale variation, that seasonally characterizes the spatial distributions of these estuarine water quality characteristics, which respond to natural variations in magnitude/duration of upstream freshwater inflows. Ultimately, this information is expected to be utilized towards the modeling of chlorophyll levels (and the location of maxima) relative to seasonal/annual variability in watershed inflows, and other water quality parameters measured as part of the other HBMP study elements.

7.0 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 determining impacts potentially associated with the Facility's withdrawals. **Figure 7.1** depicts a basic, simplified conceptual estuarine model of the primary mechanisms through which freshwater withdrawals potentially may impact the lower river/upper harbor resources, and which served as the basis for the initial development of the HBMP. None of the extensive HBMP analyses done to date have indicated changes resulting from either current or historic water withdrawals by the Facility nor have the Facility withdrawals been of significant magnitude relative to the far greater natural degree of variation to have affected the long-term physical, chemical, or biological characteristics of the lower Peace River/upper Charlotte Harbor estuarine system.

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 is summarized in this section. A more detailed conceptual model (**Figure 7.2**) relative to the pathways through which Facility withdrawals pose potential impacts to estuarine resources was developed as requested by the HBMP Scientific Review Panel as part of the 2002 HBMP summary report. Since that time, similar conceptual riverine/estuarine models have likewise been developed by the St. Johns Water Management District (**Figure 7.3**) and Tampa Bay Water (**Figure 7.4**) toward assessing potable surface water withdrawals.

This section further recounts and details the hierarchy of management actions proposed under the HBMP to be implemented in response to detected changes that could forewarn of potential future impacts of sufficient magnitude that they would constitute an "adverse change".

7.1 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, seasonal water quality conditions, and/or the distribution and abundance of key biological communities that are sensitive to environmental change. The Peace River HBMP Scientific Review Panel (Panel) has been established primarily to assist the District and the 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.

7.2 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. The following summarizes the District's stated goals and objectives in establishing the lower Peace River/upper Charlotte Harbor Hydrobiolgoical Monitoring Program.

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

2. Protect the abundance of fish and invertebrate species of sport and commercial importance in the lower Peace River and upper Charlotte Harbor.

3. Protect the estuarine fish nursery function in the lower Peace River and upper Charlotte Harbor.

4. Protect the spatial and temporal distributions of organisms that are important food sources for fish in the lower Peace River.

5. Protect seasonal patterns of nutrient delivery to the estuary so that trophic interactions are maintained in the lower Peace River and Goals 1 through 4 are met.

6. 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.

7. Protect the temporal and spatial characteristics of salinity distributions in the estuary so that Goals 1 through 4 are met.

8. Protect dissolved oxygen concentrations in the estuary so that Goals 1 through 4 are met.

9. Protect the abundance of any rare, threatened, or endangered species that use the lower Peace River or upper Charlotte Harbor.

10. Protect suitable habitats and water quality for fish and wildlife that are not of sport or commercial importance.

7.3 Rationale for Defining Significant Environmental Change

Inherent in the District rules is the recognition that surface water withdrawals are linked to potential changes in salinity, associated changes in water quality constituents (through either changes in loadings and/or dilution), and ultimately the biological communities of the lower river/upper harbor estuarine system. Freshwater withdrawals have a direct and instantaneous physical effect on salinity, while the effects of freshwater withdrawals on other water quality constituents, and biological communities in particular, are typically indirect and more complex (**Figures 7.2**). 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, is responsible for the interpretation of data collected from the HBMP and other sources to determine if the permitted Facility surface water withdrawals have caused, or have a high potential of causing, 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 Scientific Review Panel and District staff, the *2002 Peace River Comprehensive Summary Report* 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 so that it includes 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.

- **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 affected biological communities.

- **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.

- **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.

- **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.

- **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 hierarchy of management responses can be developed and structured according to various potential criteria and outcome objectives.

7.4 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 primary indicator of significant environmental change that could lead to potential adverse environmental impact. 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 impact. Salinity deviations from the target distribution (**Figure 7.5**) 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 7.6**). 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 will focus on determining if 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 effect relationships. Finally, the most intense management actions may involve regulatory enforcement actions as well as remediation and mitigation. 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 problems, data entry errors, violation of sampling protocols, etc.

2. **Data Comparison (Correlates)** - This action would involve a review of data correlates (e.g., specific conductance is a correlate to salinity) 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 review the findings of Steps 1 and 2, and to determine a possible modified course of action to refine the understanding of the magnitude and extent of the detected change. If deemed appropriate, 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. The additional data collected from this effort could then be subjected to Steps 1 and 2 above if deemed appropriate. This action would determine if detection of the change is repeatable under a more focused sampling program. Although this step could be valuable, it may not be necessary for a redirected sampling effort to be conducted for all hydrobiological changes detected by the HBMP. For some hydrobiological changes, 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. This step would involve a detailed assessment of the data analyses conducted in Steps 1 through 4 to ascertain whether conditions consistent with the working definition of significant environmental change presented above have been met. A formal 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 only. Following this determination, the Peace River Manasota Regional Water Supply Authority Board would be briefed on the findings and recommendations of District staff and the Panel.

6. **Regulatory Summit Meeting** - If, after the completion of Step 5, 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 and affected parties to

determine the appropriate regulatory course of action. At a minimum, the regulatory agencies represented would include the District and FDEP, however, depending on the environmental changes involved, other state and federal agencies may be involved (e.g., Florida Fish and Wildlife Conservation Commission; U.S. Fish and Wildlife Service). Actions by the group in attendance would include revisiting Steps 1, 2 and 4 above. If after reviewing the presented evidence the group (via a consensus of professional opinion) formally determines that significant environmental change has occurred, then the group must decide on the urgency or type of regulatory actions required. Further actions could include deferral to the Water Management District Governing Board, or immediate enforcement of regulatory actions such as temporary modification of the withdrawal schedule. If more substantial regulatory actions such as permanent modifications to the withdrawal schedule and/or mitigation were determined to be appropriate, preparations would be made for presenting recommendations 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 permanent 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 such that greater withdrawals would occur during high flows, but lesser withdrawals would occur during low flows. In the event that the permitted withdrawals resulted in irreversible significant harm to resources of concern, mitigation could be required.

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 7.1 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 7.1
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 7.1 , 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.

7.5 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. To date, none of the extensive analyses that have been conducted in conjunction with these long-term monitoring program elements, and reported in numerous previous HBMP documents submitted to the District, have found or suggest any significant long-term physical, chemical, or biological changes in the lower Peace River/upper Charlotte Harbor estuarine system resulting from either current or historic water withdrawals by the Facility. The data and analyses presented in this 2014 HBMP Annual Report continue to support this overall conclusion.

7.6 Summary

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 Report*. This chapter 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.

7.6.1 Regulatory Basis of Review

The District's *Basis of Review* has established a specific series of performance standards for water use permits associated with withdrawals from natural surface waterbodies.

- *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.*

An adverse environmental impact can be defined from a technical standpoint using a wide range of metrics that quantify deviations from the pre-withdrawal salinity patterns, water quality conditions, and the distribution and abundance of biological communities. The Peace River HBMP Scientific Review Panel (Panel) has been established primarily to assist District and 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.

Inherent in the District rules is the recognition that surface water withdrawals are linked to potential changes in salinity, associated water quality constituents, and biological communities. Freshwater withdrawals have a direct and instantaneous physical effect on salinity, while the effects of freshwater withdrawals on other water quality constituents, and biological communities in particular, are typically indirect and more complex. Such indirect impacts are mediated by physical and chemical processes, and are typically manifested on slower time scales (weeks, months, or seasons).

Since the term *adverse impact* has distinct legal meaning in the context of water use permitting, it was proposed that this term be replaced by *significant environmental change* with respect to the role of the District staff and the HBMP Scientific Review Panel, and be used as the established criteria for assessing the findings of the HBMP.

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.*

7.6.2 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. The Authority has therefore 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 primary indicator of significant environmental change that could lead to potential adverse environmental impact. In addition, salinity deviations would be used as the trigger mechanism for a range of management responses aimed at reversing or minimizing the change to prevent potential adverse environmental impact. Salinity deviations from the target distribution will be evaluated in terms of magnitude, spatial extent, and/or temporal duration to develop a decision tree that is linked to alternative management actions.

The objective of implementing a management response is the prevention of an "adverse impact". 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.

If the detected change is relatively large, but the degree of certainty is low, 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, then a more intense management response would be indicated. 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.

8.0 Assessment of Upstream Changes in Water Quality

Since its inception, the Hydrobiological Monitoring Program (HBMP) has incorporated numerous study elements directed toward assessing the magnitude of changes resulting from permitted freshwater withdrawals on both the physical/chemical characteristic, as well as biological communities within the downstream estuarine environment of the lower Peace River/upper Charlotte Harbor. The HBMP has sought to determine seasonal and longer term changes in flows and other parameters, such as water quality, relative to ongoing land use changes in the upstream watershed and the overall "health" of the downstream 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 Facility operations and/or the biological communities of the estuarine system. These distinct observed patterns in water quality include the following changes.

- 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 at a number of USGS subbasin Peace River watershed gaging sites. Both of these changes have been linked (PBS&J 2007, Atkins 2013) to increased agricultural discharges of higher conductivity groundwater during typically seasonally drier periods.

- Seasonally, silica levels in the lower Peace River/upper Charlotte Harbor estuary progressively increased at a rapid rate over the past decade, but have shown some decline of late. More recently, 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, before declining again to more typical previous levels over the past four years.

The following briefly summarizes several key findings from previous analyses of observed changes in water quality characteristics in the Peace River watershed. A comprehensive series of analyses of Peace River watershed water quality information was undertaken as part of the Year-Five *2011 HBMP Comprehensive Summary Report* finalized in 2013. More recently, the water quality information for the Peace River Watershed long-term monitoring sites (USGS/SWFWMD/FDEP/Authority) was updated through 2013 as part of the Authority's ongoing Water Supply Study. The graphics presented in Table 8.1 come from the draft Water Supply Plan to be submitted to the District at the end of 2014, and summarize the historic patterns of changes in key water quality characteristics that have historically occurred upstream of the Facility.

Table 8.1 - Time-Series Plots of Major Water Quality Characteristics in the Upstream Peace River Watershed

Parameter	Whidden Creek near Fort Meade	Peace River at Arcadia	Joshua Creek at Nocatee	Horse Creek near Arcadia
Conductivity	Figure 8.1	Figure 8.19	Figure 8.38	Figure 8.56
Color	Figure 8.2	Figure 8.20	Figure 8.39	Figure 8.57
Total Alkalinity	Figure 8.3	Figure 8.21	Figure 8.40	Figure 8.58
Total Dissolved Solids	Figure 8.4	Figure 8.22	Figure 8.41	Figure 8.59
Nitrite+Nitrate Nitrogen	Figure 8.5	Figure 8.23	Figure 8.42	Figure 8.60
Total Kjeldahl Nitrogen	Figure 8.6	Figure 8.24	Figure 8.43	Figure 8.61
Total Nitrogen	Figure 8.7	Figure 8.25	Figure 8.44	Figure 8.62
Total Phosphorus	Figure 8.8	Figure 8.26	Figure 8.45	Figure 8.63
Orthophosphate	Figure 8.9	Figure 8.27	Figure 8.46	Figure 8.64
Chlorophyll *a*	Figure 8.10	Figure 8.28	Figure 8.47	Figure 8.65
Calcium	Figure 8.11	Figure 8.29	Figure 8.48	Figure 8.66
Magnesium	Figure 8.12	Figure 8.30	Figure 8.49	Figure 8.67
Sodium	Figure 8.13	Figure 8.31	Figure 8.50	Figure 8.68
Potassium	Figure 8.14	Figure 8.32	Figure 8.51	Figure 8.69
Chloride	Figure 8.15	Figure 8.33	Figure 8.52	Figure 8.70
Sulfate	Figure 8.16	Figure 8.34	Figure 8.53	Figure 8.71
Fluoride	Figure 8.17	Figure 8.35	Figure 8.54	Figure 8.72
Iron	Figure 8.18	Figure 8.36	NA	Figure 8.73
Strontium	NA	Figure 8.37	Figure 8.55	Figure 8.74

8.1 Increasing Conductance in the Lower Peace River

The *Peace River Cumulative Impact Study* (PBS&J 2007) and *2011 HBMP Comprehensive Summary Report* (Atkins 2013) have identified anthropogenically related trends of increasing specific conductance within a number of the major upstream watershed tributaries to the lower Peace River. The observed changes in the lower portions of the Peace River watershed over recent decades have been primarily associated with increasing land conversions from less to more intense forms of agriculture, which increasingly relies on irrigation using higher conductivity ground water pumped from the upper Floridan aquifer. Both the *2006* and *2011 HBMP Comprehensive Summary Reports* 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's intake.

8.1.1 Peace River at Arcadia

The Peace River at Arcadia USGS gage (2296750) has the longest historic flow 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, Whidden and Charlie Creek tributary basins. Historic loss of flows from springs and seeps has been one of the factors that has 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 low levels measured in the 1960s to a high of nearly 1,400 uS/cm in 2011. Seasonally, the highest mean and median specific conductance values typically occur in May toward the end of the normal spring dry season, while the lowest mean and median levels are often observed toward the end the summer wet season. The analyses of long-term data presented in the *2011 HBMP Comprehensive Summary Report* clearly indicate that both specific conductance (see Fig. 8.19) and chloride concentrations have both increased over time during periods of lower flows. The observed patterns of water quality changes at the Arcadia gage clearly indicate seasonal contributions of higher conductivity groundwater into the middle portions of the Peace River. The largest increases in conductance occurred during the recent years of drought following the unusually high 2004-2005 flows. The more recent unusually high levels can be traced back to the closure of the phosphogypsum stacks in the Whidden Creek subbasin (see below).

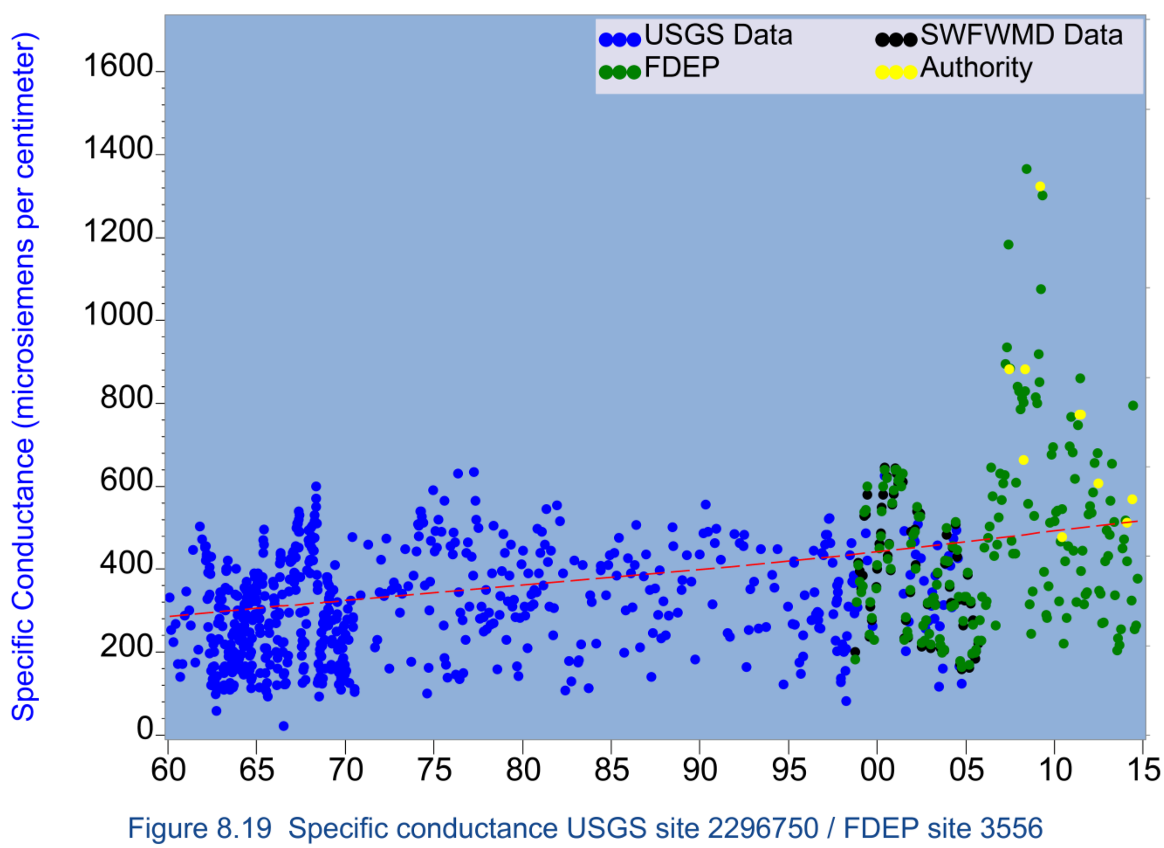


Figure 8.19 Specific conductance USGS site 2296750 / FDEP site 3556
Peace River at Arcadia - Peace River at Arcadia basin

2014 HBMP Data Report

8.1.2 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 (see **Fig. 8.38**) and total dissolved solids. These changes have been associated with increasing surface drainage of agricultural discharges of high conductivity groundwater pumped from the upper Floridan aquifer for irrigation, much of which ultimately flows 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. 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.

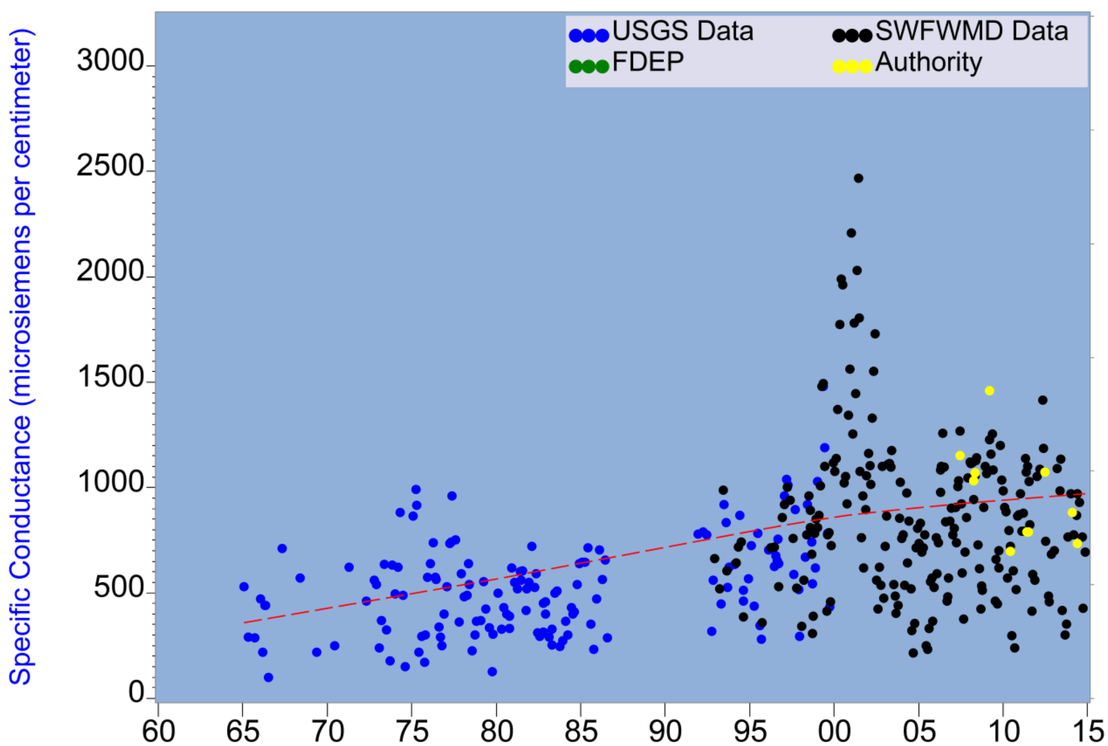


Figure 8.38 Specific conductance USGS site 2297100 / District site 24431
Joshua Creek at Nocatee - Joshua Creek basin

The *Shell Creek and Prairie Creek Watersheds Management Plan* (SWFWMD 2004) addressed such water quality changes in Joshua Creek, acknowledging that the pumping of highly mineralized water from the upper Floridan aquifer for agricultural irrigation had been the primary contributing factor to the observed water quality degradation in Joshua Creek. The District's watershed management plan proposed that 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 (see above graphic) in reducing levels below those observed during the 1999-2001 drought, dry-season levels remain well above historic levels. Recently, FDEP extended the time-line to meet management plan goals by another five years.

8.1.3 Horse Creek near Arcadia

Over portions of the southern Horse Creek basin, the head of the intermediate aquifer is often higher than that of the surficial aquifer, resulting in intermediate aquifer groundwater 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 potentiometric 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 farther south from

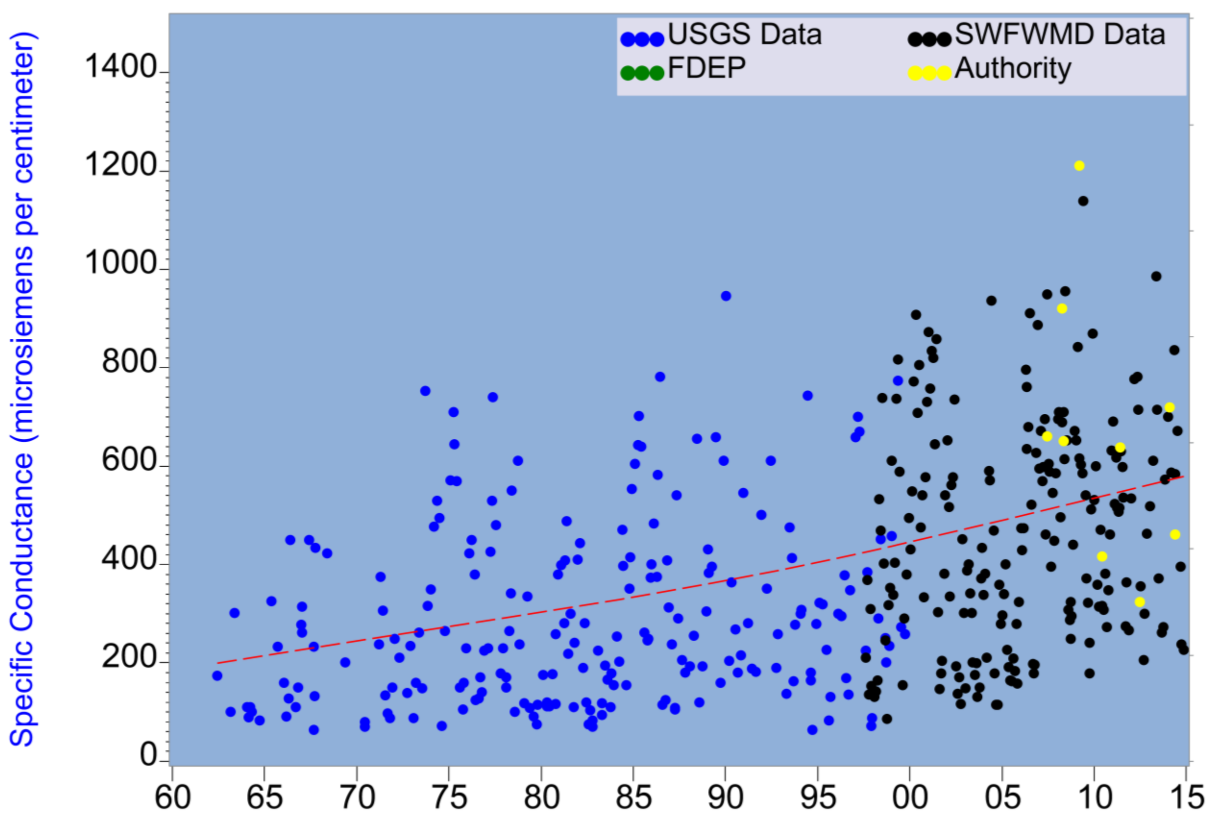


Figure 8.56 Specific conductance USGS site 2297310 / District site 24049
Horse Creek near Arcadia - Horse Creek basin

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 (see above figure) indicate that specific conductance and chloride levels in southern Horse Creek have been increasing. This is primarily due to augmented base flow by surface discharges of highly mineralized deep aquifer ground water from 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*.

8.1.4 Peace River Kilometer 30.7

Monthly samples have, and continue to be, 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 monitoring Station 18). Monthly sampling at this "fixed" sampling site 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 have been of special interest due to its near upstream proximity to the Facility and thus the sampling frequency was increased in 1996 to twice monthly (by adding sample collection at RK 30.7 to the monthly "moving" HBMP sampling.) Table 8.2 below provides statistical summaries of data collection between 1976-1990 in comparison to similar data from the more recent 1996-2014 time interval. In order to eliminate potential upstream influences of higher salinity estuarine waters, only samples collected when the preceding 7-day average flow exceeded 130 cfs were used in Table 8.2. The second half of the table provides links to long-term plots for each parameter over time. The presented graphics include both monthly measured values as well as a fitted, smoothed line, which was calculated using the Statistical Analysis Software (SAS) cubic spline method.

Table 8.2 Statistical Summaries for Sampling Upstream of the Facility (RK 30.7) for Historic 1976-1990 and more Recent 1996-2014 Time Intervals

Parameter	Mean	Median	Minimum	Maximum	# Samples
Statistical Summary 1976-1990					
Temperature (^{o}C)	24.6	25.8	12.0	32.0	181
Dissolved Oxygen (mg/l)	7.0	7.1	2.8	13.0	181
pH	7.3	7.3	5.9	9.4	181
Salinity (psu)	0.1	0.1	0	1.8	179
Conductivity (µS/cm)	375	400	100	3500	179
Total Dissolved Solids (mg/l)	264	242	99	3390	159
Chloride (mg/l)	23.3	22.2	3.5	126.0	167
Alkalinity-CaCO3 (mg/l)	51.7	51.6	14.4	88.8	161
Hardness-CaCO3 (mg/l)	126.0	126.0	25.5	215.0	152

Table 8.2 Statistical Summaries for Sampling Upstream of the Facility (RK 30.7) for Historic 1976-1990 and more Recent 1996-2014 Time Intervals

Parameter	Mean	Median	Minimum	Maximum	# Samples
Color (CPU)	153	138	22	410	173
Turbidity (NTU)	4.55	3.25	0.85	37.00	172
Ammonia/Ammonium (mg/l)	0.060	0.050	0.001	0.376	130
Nitrite/Nitrate (mg/l)	0.639	0.562	0.001	2.110	173
Total Kjeldahl Nitrogen (mg/l)	1.20	1.10	0.40	3.35	116
Total Nitrogen (mg/l)	1.880	1.778	0.861	3.421	116
Orthophosphorus (mg/l)	1.392	1.035	0.458	4.130	172
Total Phosphorus (mg/l)	1.586	1.215	0.476	4.680	172
Silica (mg/l)	2.75	2.82	0.20	5.87	173
Total Organic Carbon (mg/l)	29.69	29.95	4.21	59.90	160
Chlorophyll *a* (ug/l)	10.0	3.0	0.1	156.0	174
Iron (mg/l)	0.27	0.26	0	0.75	68
Sulfate (mg/l)	66	62	8	156	168
Fluoride (mg/l)	0.90	0.86	0.15	2.56	171

Parameter	Mean	Median	Minimum	Maximum	# Samples	Figure
Statistical Summary 1996-2014						
Temperature (^{o}C)	25.0	26.1	9.4	34.3	352	Figure 8.75
Dissolved Oxygen (mg/l)	6.6	6.4	0.4	16.9	350	Figure 8.76
pH	7.4	7.4	6.0	9.0	348	Figure 8.77
Salinity (psu)	0.2	0.2	0.0	1.1	348	Figure 8.78
Conductivity (µS/cm)	464	437	86	2114	352	Figure 8.79
Total Dissolved Solids (mg/l)	325	318	124	1024	76	Figure 8.80
Chloride (mg/l)	36.0	31.6	0.4	407.0	317	Figure 8.81
Alkalinity-CaCO3 (mg/l)	62.6	61.3	0.6	120.0	162	Figure 8.82
Hardness-CaCO3 (mg/l)	NA	NA	NA	NA	0	Figure 8.83
Color (CPU)	173	160	30	600	315	Figure 8.84
Turbidity (NTU)	3.4	2.8	0.5	18.0	85	Figure 8.85
Ammonia/Ammonium (mg/l)	0.1	0.0	0.0	0.6	315	Figure 8.86
Nitrite/Nitrate (mg/l)	0.5	0.4	0.0	3.3	315	Figure 8.87
Total Kjeldahl Nitrogen (mg/l)	1.1	1.1	0.5	2.8	313	Figure 8.88
Total Nitrogen (mg/l)	1.6	1.5	0.6	4.2	312	Figure 8.89
Orthophosphorus (mg/l)	0.8	0.7	0.0	2.1	319	Figure 8.90
Total Phosphorus (mg/l)	0.8	0.8	0.4	1.4	164	Figure 8.91
Silica (mg/l)	6.5	6.6	0.2	13.5	319	Figure 8.92
Total Organic Carbon (mg/l)	19.8	17.8	1.0	45.5	91	Figure 8.93
Chlorophyll *a* (ug/l)	10.8	5.9	0.1	110.0	309	Figure 8.94
Iron (mg/l)	0.4	0.4	0.0	1.2	275	Figure 8.95
Sulfate (mg/l)	92	89	22	278	76	Figure 8.96
Fluoride (mg/l)	0.6	0.5	0.0	1.3	76	Figure 8.97

When the Peace River flows are low over an extended period of time, the reach of the lower Peace River near the Facility is tidally subject to intrusions of brackish waters from the harbor (see discussion in **Section 5**). However, beyond periods of 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 (see Table 8.1 above).

Dry-season conductance (**Figure 8.79** below), as well as total dissolved solid, chloride, alkalinity, and sulfate concentrations at RK 30.7 clearly show (Table 8.2) 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 groundwater

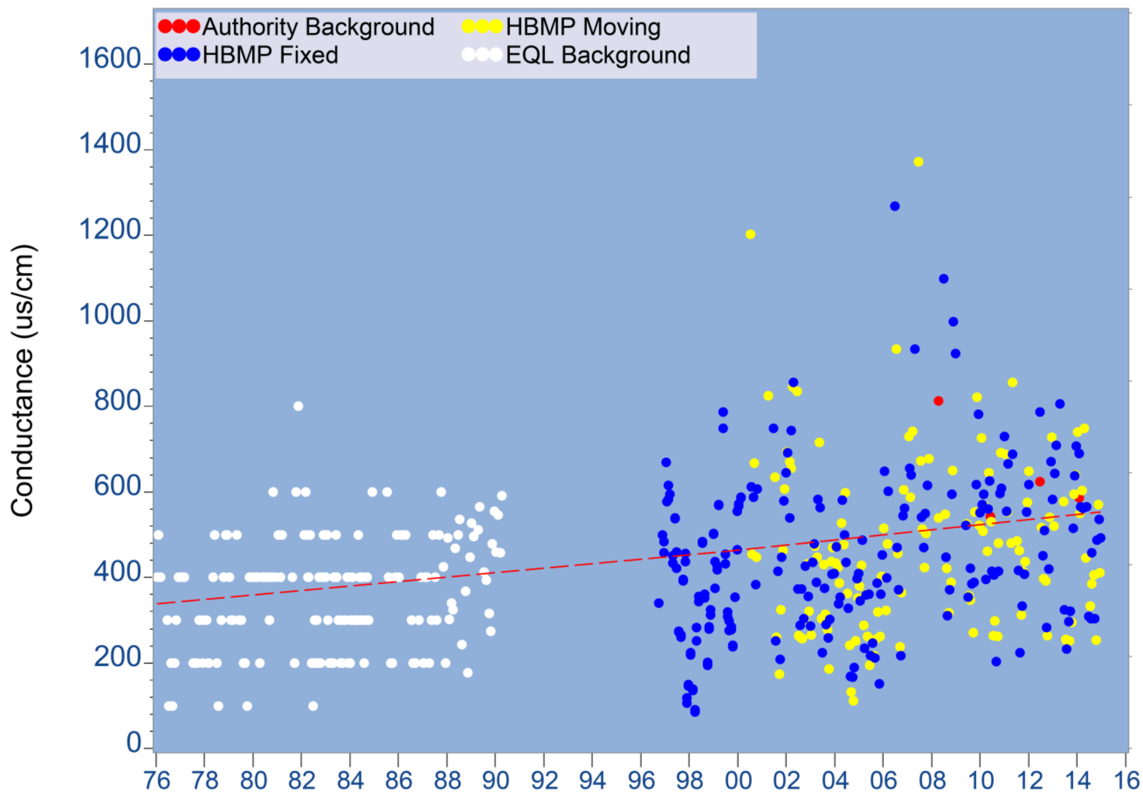


Figure 8.79 Monthly long-term surface conductivity at river kilometer 30.7 (S.R. 761)

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 upstream of 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, when combined with projected future sea level rise, 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 river water during the dry season and put a higher premium on storing water during the wet season.

8.2 Changes in Phosphorus and Silica in the Lower Peace River

Seasonal silica levels in the lower Peace River and upper Charlotte Harbor have progressively increased 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 recently returned to levels not observed in decades, before declining again over the past four years. 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 and analyzed for a number of water quality parameters from ten different watershed sites upstream of the Facility (**Figure 8.98)**.

- 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 2012 to help specifically define potential sources and identify seasonal differences (**Table 8.3**).

June 2007 – samples were collected at the end of the dry 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 observed increasing high levels of silica and phosphorus. The results (**Table 8.3**– notably high values are indicated in bold/red) clearly indicate 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 8.3**) 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 levels of conductivity, calcium, potassium, phosphorus, and silica. During this one sampling event high levels of silica were also observed upstream both in the Peace 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 8.3**) 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, total dissolved solids, sulfate, 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 levels of conductivity, total dissolved solids, sulfate, calcium, potassium, phosphorus, and silica coming from Whidden Creek, and high levels of conductivity in both Joshua and Horse Creeks.

June 2010 – samples were again collected from all ten watershed locations and as in previous years the results show high levels 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.

June 2011 – these samples were collected toward the end of the dry season from all ten watershed locations, and as in previous years water coming from Whidden Creek continued to indicate similar, continuing high levels of conductivity, total dissolved solids, sulfate, calcium, potassium, phosphorus and silica, while measured conductivity in Joshua Creek was below the higher levels observed during some of the previous years

June 2012 – samples were again collected near the end of the dry season from all ten watershed locations, and the Whidden Creek data continued to indicate continuing high levels of conductivity, total dissolved solids, sulfate, calcium, potassium, phosphorus, and silica. The silica concentration of 42.3 mg/l was much higher than any of the previous measured levels. Conductivity in Joshua Creek was again high, while the level in Horse Creek was below levels observed during several previous years

2013 – samples were scheduled for collection in late May 2013 but sudden increases in rainfall and subsequent increases in river flow caused the scheduled sample collection effort to be canceled and rescheduled for 2014.

January 2014 – As seen earlier high TDS and sulfate values were observed in Whidden Creek .

May 2014 – High conductivity and nutrients in Whidden Creek . High TDS and sulfate in several Peace River sites below the confluence with Whidden Creek.

Using some of the initial gathered data, Authority staff met with District and Florida Department of Environmental Protection (FDEP) 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 8.99**) with there being very few other land uses (such as agriculture) occurring in areas adjacent to the creek. 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 US Agri-Chemicals Fort Meade operations were in the process of conducting shut-down operations under a FDEP consent order (# 06-1506), which allows closure of the two existing phosphogypsum stacks (No. 1 and No. 2 in **Figure 8.99**, **8.100** and **8.101**), with the associated discharge of treated water from these two stacks having been directed to Whidden Creek. The closure of the stacks and Whidden Creek discharges began in November 2005. The consent order initially set a maximum conductivity for discharge water at 3,000 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. **Figure 8.102** shows a current aerial of the two closed phosphogypsum stack in the Whidden Creek basin.

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

Although the closure process on the US Agri-Chemicals site continued somewhat beyond the original 2009 completion date, the closure has been completed. During the process FDEP issued another consent order modification that continues the allowable conductivity discharge at 2,200 uS/cm. However, even following closure, the two phosphogypsum stacks will continue to create some lower volume of waste water consisting primarily of rainwater and some seepage from the stacks entering the storm water system and flowing through Whidden Creek to the Peace River.

The observed decline in ortho-phosphorus concentrations in the lower Peace River suggests that while observed concentrations (**Table 8.3**) of many chemical water quality characteristics in Whidden Creek remain high, the volumes of discharge have declined during the stack closure process. This has been reflected in the observed decline in downstream phosphorus concentrations over the past four years.

In addition to the Whidden Creek operations, the Mosaic Company's Bartow operations also located in the Peace River watershed have 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 Six Mile Creek.

In addition, FDEP allowed an emergency discharge of stack water to the Peace River for all mines from September 2004 through 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 5 in the *2011 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/future Whidden Creek consent orders, as well as keep the Authority appraised of the ongoing progress of current and future stack closures occurring in the Peace River Watershed.

8.3 Summary

- There have been long-term, progressive increases in parameters such as conductance, chlorides, total dissolved solids, alkalinity, and sulfates in 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, which 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 these water quality characteristics originating from agricultural discharges during the dry-season have yet to be a serious hindrance to Peace River Facility 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 these contributing upstream basins continue.

- Silica levels in the lower Peace River/upper Charlotte Harbor estuary have increased 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 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 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 US Agri-Chemicals Fort Meade closure operations, may also have been related to changes in phosphate mining activities in the upper Peace River watershed.

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