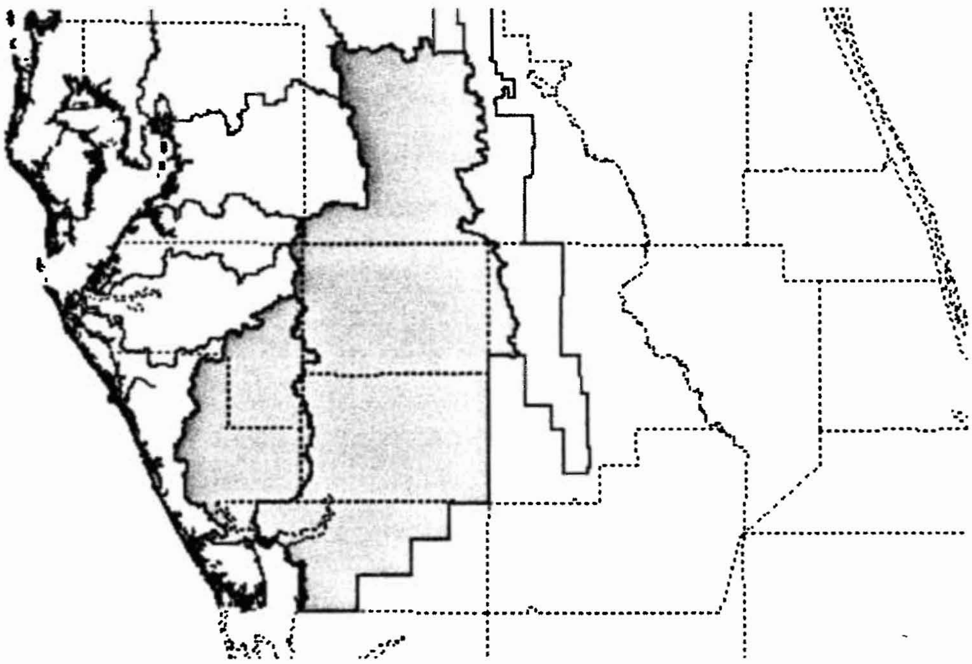
Background Information on
Watershed Management Issues
in the Peace and Myakka River Basins



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## 1.0 Introduction

### 1.1 Background

The field of environmental resource management is going through a time of fundamental change. For much of the 20th century environmental resources were viewed as commodities, and public and private organizations spent large sums on projects designed to control and develop those resources for economic purposes. The last several decades, however, have brought greater emphasis on environmental quality and integrated resource management.

In the case of water and watershed resources, projects undertaken in the first half of the century typically focused on the construction of water control infrastructure: dams, reservoirs, pump stations, canals, and the like. In recent decades the U.S. Congress—through the federal Clean Water Act of 1972 and related legislation—has called for a change in focus, emphasizing the restoration and maintenance of the physical, chemical and biological quality of the nation's waters as a priority national goal.

The National Research Council (NRC 1999) has provided an overview of some of the challenges and opportunities raised by this change in national priorities:

> "The new goal will not likely be achieved through the construction of additional control works, more regulations, or more money. Rather, the new ethic of sustaining economic prosperity while preserving environmental quality will require management approaches that integrate human and natural systems.... Watershed-based approaches offer a promising way to achieve this integration."

> "Improving the interface between science and policy and between scientists and politicians remains one of the major challenges to watershed management. It is difficult enough to manage land and water resources at small spatial and short temporal scales, but to formulate management plans for larger, longer scales often requires complex systems of governance and complex science. It is common to hear scientists complaining that their voices are being ignored by policymakers."

> "Watersheds have taken on increasing importance in establishing a context for federal, state and local policy. Some objectives are directly related to water, including water supply management, flood control, water quality protection, sediment control, fisheries conservation, navigation, and hydroelectric generation. Others are related but less focused on water, including maintenance of biological diversity, wildlife management, and general environmental preservation. Broader goals like recreation and economic development are also sometimes cast as watershed issues."

"The purpose of watershed management is to make practical choices from a full range of options that incorporate relevant economic, social, political, and ethical considerations. Such decision making requires choosing between tradeoffs, but informed decisions can only be made when the tradeoffs are clearly specified. An accurate accounting of relevant alternatives and their tradeoffs requires the systematic observation and analysis provided by science. However, selection of particular options is often driven by values, and these may be in conflict (e.g., economic efficiency versus ethical considerations). To ensure that watershed management decisions are broadly understood and considered legitimate, all interested parties must participate in choosing between tradeoffs. Thus, effective watershed management must be based on a planning process that integrates both scientific analysis and public participation."

"Differing levels of government have varying financial, technical, and political capabilities with respect to watershed management. The scale of the organizational capabilities and responsibilities must match the scale of the problem. Although some caution is necessary to avoid taking these observations too strictly, the committee offers the following thoughts about the relative roles of federal, state, local, and regional levels of decision making in a watershed context:

- local organizations are best positioned to take primary responsibility for staffing, planning, and implementing projects and, in particular, for facilitating public involvement,

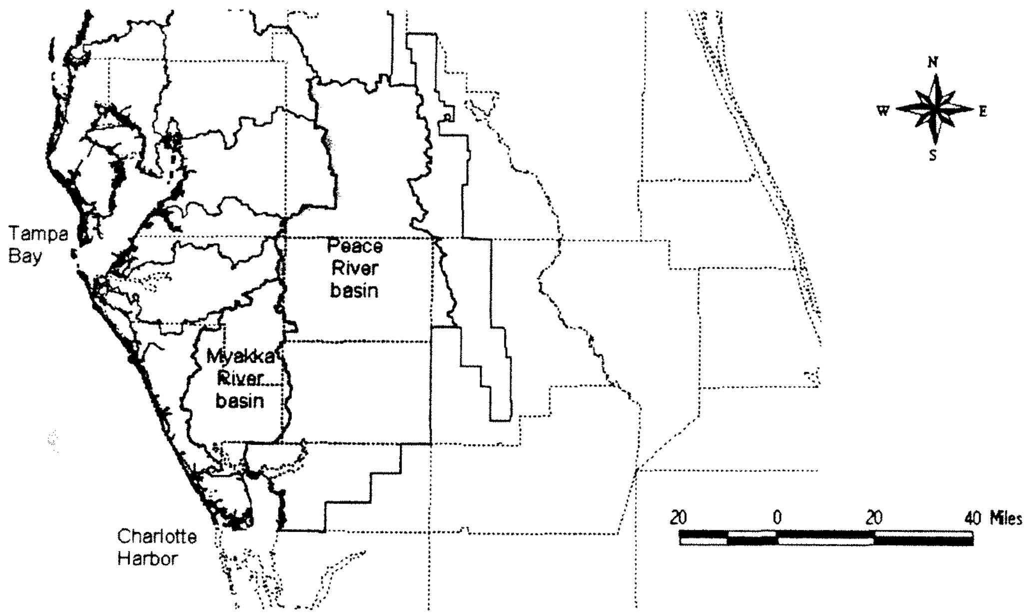
- state governments are best positioned to facilitate coordination, research, and technical assistance...

- the federal government and its agencies are best positioned ...for supporting research, providing technical assistance, and providing financial support to state and local entities."

Fortunately, a number of local, state, and federal agencies are already involved in active watershed-based management programs in the Charlotte Harbor area. These include the Charlotte Harbor National Estuary Program (CHNEP), the Southwest Florida Water Management District's Surface Water Improvement and Management (SWIM) and Comprehensive Watershed Management (CWM) programs, and the Florida Department of Environmental Protection (FDEP) Ecosystem Team Permitting initiative. These programs have generated a great deal of scientific information and have begun distributing that information to watershed residents. Future watershed management projects will have the opportunity to work cooperatively with these existing programs, helping build on the accomplishments that have already been made.

## 1.2 Objectives

The purpose of this report is to give a brief overview of some key resource management issues in the Peace and Myakka river basins. (The location of the project area is shown in the map below.) The report is intended to be a tool for local citizens and elected officials, providing information that is technically sound but written with a minimum of jargon and organized in a way that makes it accessible to non-technical readers.



### 1.3 Watershed Management Strategy

The National Research Council (NRC 1999) recommended that watershed management programs be based on the following strategy:

1. identify the watershed's priority problems, and select specific, quantifiable objectives for their resolution;

2. define the appropriate temporal and spatial scales for addressing the priority problems;

3. identify all relevant stakeholders, and provide each an opportunity to participate in the decision making process;

4. identify tradeoffs among the alternative solutions;

5. identify shared values guiding the selection of alternatives; and

6. select and implement the best management actions to balance among tradeoffs.

This report addresses portions of steps 1 and 2 of the NRC's recommended strategy, and includes suggestions for the organization of a community-based watershed management program to address steps 3 through 6.

### 1.4 Issues, Indicators and Human Activities

The report gives background information on four issues that have been identified as priorities by one or more of the existing watershed management programs:

- habitat loss and fragmentation;
- hydrologic alterations;
- nutrient enrichment of surface waters; and
- pathogens and toxins

A future document will propose a series of indicators, measurable physical attributes that can be monitored to assess environmental conditions and track the effectiveness of watershed management projects.

Other than noting them in passing, this report does not attempt to address the wide range of human activities that can affect the proposed issues and indicators. Management projects in the Peace and Myakka river basins will be dealing with a wide variety of human activities and their impacts, and doing so effectively will involve a number of social, political and economic considerations that are beyond the scope of this project.

## 2.0 Habitat Loss and Fragmentation

### 2.1 Background

When natural areas are converted to agricultural, industrial and urban land uses, the total acreage of habitat available for native plants and animals is reduced and those habitats become increasingly fragmented. In extensively developed watersheds the remaining natural areas often become isolated habitat "islands" separated by an inhospitable "sea" of roads, parking lots, and residential and commercial developments.

These changes reduce the size and increase the fragmentation of plant and animal populations. They can also reduce the genetic diversity and increase the likelihood of extinction of rare species. In the Peace and Myakka river basins several agencies have recommended the creation of a regional habitat network—a system of "core" habitat preserves connected by "wildlife corridors"—to help mitigate these ecological impacts. Examples of potential habitat networks for the Peace and Myakka basins are included in CWM plans that are currently available from the Southwest Florida Water Management District (SWFWMD 1999a,b). In the proposed habitat networks, "core" areas are typically large publicly-owned preserves—such as Myakka River State Park—while "corridors" contain a mix of public and privately-owned parcels that may provide widely varying degrees of long-term habitat protection.

In addition to potential effects on regional biodiversity, the alteration of natural habitats for human use can also impact regional hydrology and water quality. Development tends to increase the amount of "impervious surface" (such as paved roads, sidewalks, parking lots and roofs) in a watershed. This causes hydrologic changes such as increased rates and volumes of stormwater runoff and reduced levels of ground water recharge. The larger volumes of stormwater discharged from developed areas, and the higher concentrations of nutrients and other pollutants typically present in that runoff, often cause water quality to decline in a watershed as development proceeds (Schueler 1996).

Because wetland areas provide both wildlife habitat and hydrologic benefits, fragmentation and loss of wetlands are issues of particular concern to watershed managers. In Florida a large percentage of native plant and animal species are thought to rely on wetland habitats during some portion of their life cycle. Over the past several decades an estimated 51 percent of the state's herbaceous wetland acreage and 17 percent of its forested wetland acreage have been lost as a result of human activities (Fernald and Purdum 1998). Floodplains and other wetlands provide natural storage areas for stormwater runoff, and poorly planned development that encroaches into these storage areas can increase the frequency or intensity of flooding in upstream and downstream sites. In addition, once development is allowed to encroach into a floodplain—an area that, by definition, experiences frequent flooding—local governments and their taxpayers sometimes incur substantial costs in subsequent efforts to protect buildings, roads and other infrastructure from flood-related damage.

## 2.2 Land Use Changes in the Peace River Basin

The Peace River CWM team (SWFWMD 1999a) has provided a recent summary of habitat alteration in the basin. The following summary was extracted, with minor wording changes, from the CWM report:

> Based on the overall extent and nature of its physical alteration, the Peace River watershed is one of the most altered in Florida. A watershed-wide analysis of land use and land cover, based on 1995 data, indicates that over 60 percent of the total land area has been converted from its pre-alteration natural land cover...The primary sources of conversion, listed in descending order of total lands converted, have been: agricultural development (680,000 acres, or 40 percent of the watershed); "structural" development for residential, commercial and industrial purposes (194,000 acres, or 12.0 percent of the watershed); and "extractive" uses (126,000 acres, or 8.0 percent of the watershed), which have consisted primarily of phosphate mining in the upper watershed.
>
> Most of the "structural" development has taken place in the urbanized population centers. The largest of these are the cities of Lakeland, Bartow, and Winter Haven at the northern end of the watershed and unincorporated Port Charlotte at the southern end. Other population centers, situated along the middle reaches of the Peace River, include Fort Meade, Zolfo Springs, Bowling Green, Wauchula, and Arcadia.
>
> The nature and extent of land alteration varies somewhat among the watershed's sub-basins. Some of the larger sub-basins still support substantial areas of natural land cover. Approximately 52 percent of the Shell Creek/Prairie Creek sub-basin, which at nearly 276,000 acres is the largest in the watershed, still supports natural vegetation. This percentage is exceeded only by the Horse Creek sub-basin, which supports natural vegetation over approximately 53 percent of its total land area.
>
> Other large sub-basins with relatively high proportions of natural land cover include the main stem of the Peace River (46 percent), Charlie Creek (38 percent), Peace Creek Canal (36 percent) and Saddle Creek/Lake Hancock (33 percent). These stand in contrast to more highly-altered sub-basins, including Whidden Creek (4 percent natural land cover), "Mined Area" (4 percent), Sink Branch (11 percent), Bear Branch (12 percent), Hog Branch (15 percent), Thompson Branch (18 percent), and Max Branch (19 percent).
>
> Much of the remaining natural land cover in the basin occurs as small, disjunct patches scattered across a highly modified landscape, or as narrow threads of

floodplain forest lining the creeks and other small drainage features that discharge to the Peace River.

The difficult challenge of maintaining a network of representative, sustainable natural areas within the watershed is exacerbated by a relative absence of protected conservation lands. Among Florida counties, Hardee and DeSoto have the smallest percentage of their lands in protected conservation status. The vast majority of conservation lands in Polk County lie outside the Peace River basin. The state-owned Babcock/Cecil Webb Wildlife Management Area, a portion of which lies in the Peace River basin, accounts for 70 percent of all conservation lands currently present in the basin.

The Peace River CWM team also estimated historic land cover in the watershed, using existing soil survey maps, in order to assess cumulative land alteration patterns in the basin. By comparing the existing (1995) and estimated pre-development acreages of various land cover categories, quantitative estimates of acreage changes were calculated. The table below summarizes these results. It is apparent that upland scrub habitat s, which were not particularly widespread in the watershed prior to development, have experienced the greatest percent reduction. Pine flatwoods and herbaceous wetlands, historically the two most widespread habitat types, have also been greatly reduced, with only 30 percent and 42 percent of their pre-development acreages remaining (SWFMWD 1999a).

**Estimated changes in land cover in the Peace River basin**
(source: SWFWMD 1999a)

| Land Cover Category | Current Area (acres) | Area Lost (acres) | Area Remaining (% of pre-development acreage) |
|---|---|---|---|
| Disturbed | 320,000 | n/a | n/a |
| Agricultural | 680,000 | n/a | n/a |
| Herbaceous wetland | 110,000 | 111,090 | 42% |
| Forested wetland | 145,000 | 29,000 | 81% |
| Pine flatwoods | 307,500 | 535,750 | 30.9% |
| Upland scrub | 6,200 | 109,100 | 5.3% |
| Upland hardwoods | 4,300 | 37,900 | 9.5% |
| Saltmarsh | 2,800 | 195 | 91% |
| Mangrove | 8,200 | 1,820 | 62.6% |
| Open water | 62,500 | +8,070 | 117.7% |

## 2.3 Land Use Changes in the Myakka River Basin

Land use patterns in this basin were summarized recently in the Myakka River Wild and Scenic Management Plan (Hunter Services, Inc. 1990). The following summary was taken from that report:

> Land use in the watershed is predominantly rural, with the principal exceptions being portions of the City of North Port and several estate-style residential subdivisions. Except for these areas, development has largely been limited to agricultural activities and drainage alterations designed to facilitate agriculture.
>
> The watershed has historically developed through the establishment of small towns located along primary highways and rail lines. These towns include Myakka Head on State Road 64, Verna, Parmalee, Myakka City, and Edgeville along State Road 70; and North Port on U.S. Highway 41. Except for North Port these communities provide limited services and are relatively stable or have declined in population. Only North Port has experienced the sort of rapid growth seen in other urban coastal areas of Southwest Florida.
>
> The main agricultural activity in the watershed is cattle grazing on rangeland, unimproved pasture, and improved pasture. These activities occur throughout the watershed on ranches ranging in size from less than 100 acres to several thousand acres. Row crop, field crop and citrus production also occur in the watershed, and are being forced eastward into the watershed as urban and suburban development intensify along the coast to the west.
>
> Except for areas that have been subdivided for residential or ranchette uses, most of the watershed in under large tract ownership. Ownership patterns vary and include phosphate mining interests (in the northern and eastern portions of the watershed), agricultural interests elsewhere, and publicly-held lands in the vicinity of Myakka River State Park.

## 3.0 Hydrologic Alterations

## 3.1 Background

The living resources of the Peace and Myakka river basins are adapted to natural fluctuations in the timing, location, and quantity of freshwater flows. Man-induced alterations of these hydrologic characteristics can impact living resources, as demonstrated recently by large-scale tree mortality in Flatford Swamp and adjacent portions of the upper Myakka River basin (Coastal Environmental, Inc. 1995, 1998; PBS&J, Inc. 1999).

Development of a watershed often changes a number of its hydrologic characteristics. Relationships between some of the more critical changes, from a watershed manager's point of view, are described in the following table:

**Hydrologic impacts of development**
(source: Schueler 1996)

| Typical post-development changes | Causes |
|---|---|
| Increased rates and volumes of stormwater runoff to surface water bodies | Increased watershed "imperviousness" (area covered by pavement, roofs, and other impervious surfaces); straightening and hardening of stream channels |
| Reduced recharge of ground water aquifers | Increased watershed imperviousness; straightening and hardening of stream channels |
| Reduced ground water levels and reduced discharge from springs | Reduced ground water recharge; increased withdrawals for agricultural, municipal and industrial uses |
| Altered water levels and flows in non-tidal wetlands, streams and rivers | Increased rates and volumes of stormwater runoff to surface water bodies; construction of dams, locks and weirs; reduced ground water levels and spring discharges |
| Alterations in the location, volume and timing of fresh water inflows to tidal reaches of streams and rivers | Increased rates and volumes of stormwater runoff to surface water bodies; altered water levels and flows in wetlands, streams and rivers |
| In tidal reaches of streams and rivers, changes in the location and extent of ecologically-important low salinity zones | Alterations in the location, volume and timing of fresh water inflows |

### 3.2 Hydrologic Changes in the Peace River Basin

Human activities in the Peace River basin have been primarily associated with phosphate mining and agricultural and urban development. These have caused substantial alterations in watershed hydrology.

#### 3.2.1 Aquifer Levels

In the northern portion of the basin, the surface of the Upper Floridan Aquifer—the ground water aquifer that provides the majority of the region's water supply—dropped more than 20 feet between 1961 and 1980 (Fernald and Purdum 1998). This decline has been attributed to a combination of reduced rainfall and increased withdrawals of ground water for mining, agriculture, and municipal uses (Hammett 1987). Springs that obtain their flow from the Floridan Aquifer can be impacted by such hydrologic changes. Kissengen Spring near Bartow, for example, which contributed flows of approximately 20 million gallons per day to the river prior to the 1930's, began declining in 1934 and stopped flowing during the early 1950's (Hammett 1987).

Aquifer levels have rebounded to some degree in recent years, although they remain substantially below pre-development levels (SWFWMD 1999a).

#### 3.2.2. River Flow

Significant declines in flow have also been documented on the main stem of the Peace River in recent decades, with the greatest declines observed in the river's upper reaches near Bartow and Zolfo Springs (Hammett 1987; SWFWMD 1999a). Not coincidentally, this is also the area in which the largest declines in the Upper Floridan Aquifer have been observed. On the river's main stem the most severe flow declines apparently occurred during the 1960's (Hammett 1987), and flows appear to have leveled off since that time (SWFWMD 1999a). When the particularly rainy El Nino years of 1997-1998 are included in the analysis, increasing flow trends are evident at some sites during the years 1970 through 1998 (CHEC 1999).

Sinkholes are present in the river channel and floodplain between Bartow and Fort Meade, and during much of the dry season the river loses flow to the underlying aquifer at these points (Lewelling et al. 1997). During some particularly dry periods in recent years, observers have reported the complete loss of above-ground flow to these sinkholes, leaving portions of the river bed completely dry in this area until the return of the rainy season.

#### 3.2.3 Mining Impacts

Phosphate mining has caused the most extensive hydrologic alterations in the upper Peace River basin, changing surface topography and drainage patterns and altering rates of ground water discharge and recharge in the river and numerous tributaries. As of 1993, approximately 218,229 acres of land had been mined in the west-central

Florida phosphate district, an area that includes portions of the Peace, Myakka, Manatee, Little Manatee, Alafia and Hillsborough River basins. At that time the phosphate industry owned and had received regulatory approval to mine approximately 119,000 acres in the region. An additional 104,000 acres of phosphate reserves were owned by the industry and potentially available for mining, contingent on regulatory approval (Lewelling and Wylie 1993).

A summary of the mining process was given by Lewelling and Wylie (1993):

> "Initial site preparation for open-pit mining of phosphate deposits involves the removal of all vegetation. Typically, a deep trench is cut along the perimeter of the planned mine site to drain the surficial aquifer system, thus lowering the water table. The overburden, consisting of undifferentiated deposits ranging in thickness from 20 to 50 ft, is removed and cast into a previously mined-out cut to be reclaimed later. The exposed matrix layer of sand, clay and phosphate ore, ranging in thickness from 5 to 10 ft, is stripped away and placed into a containment pit where high-pressure hoses inject water to create a slurry. The slurry is then pumped through a pipeline network to the beneficiation plant where the three major components of the matrix—phosphate ore, sand, and clay—are separated. The phosphate ore is sent offsite to the chemical plant for processing, and the sand and clay waste materials are later returned either to the mine pits or to the clay settling ponds during reclamation."

The primary phosphate-bearing geological deposit in the area is the Bone Valley Member of the Hawthorne Group, which is made up of beds of sand and clay deposited during the Miocene period 10 to 25 million years before the present (Randazo and Jones 1997). The phosphate-rich Bone Valley clay beds form part of the upper confining unit of the intermediate aquifer, which lies between the surficial aquifer system and the Floridan aquifer system in this portion of the state. Mining of these clay beds produces a direct hydrologic connection between the surficial and intermediate aquifer systems (Lewelling and Wylie 1993).

Prior to the 1970's much of the mined land in the upper Peace River basin was abandoned as the mining expanded into adjacent areas (Lewelling and Wylie 1993). This unreclaimed mined land is generally characterized by long, narrow water bodies bordered by spoil piles. In 1975 the Florida Legislature mandated that all lands mined after July 1 of that year must be reclaimed, following a reclamation plan approved by state and local agencies.

Reclamation methods vary between sites, but usually involve filling mined areas with a combination of the soil, sand and clay that remains following mining and ore-processing operations. The filled areas are then revegetated with wetland or upland plant species. A primary objective of the reclamation effort is to ensure that there is no degradation of the quality of ground water or surface waters that receive runoff from the reclaimed lands (Lewelling and Wylie 1993). Regulations require that that stormwater runoff from mined lands not exceed the runoff of the premined land for rainfall events with recurrance intervals of 25 years or less.

The most common reclamation method makes use of the large volume of clay that is available following the processing of phosphate ore. An elevated dike is constructed at the perimeter of the mined-out area to form an impoundment. The clay is pumped in from the beneficiation plant in the form of a slurry, which is allowed to settle and consolidate. The consolidation process typically requires several decades, after which the reclaimed "clay settling area" is regraded and planted to pasture (Lewelling and Wylie 1993).

A comprehensive assessment of the effects of mining on the hydrology of the Peace River basin has not yet been performed (SWFWMD 1999a).

### 3.2.4 Other hydrologic impacts

In addition to mining, channelization of streams and wetlands and installation of a variety of water control structures have affected surface drainage patterns in the Peace River basin. The Peace Creek Canal was constructed in the early 20th century, with undocumented effects on river flow. Saddle Creek has been channelized upstream and downstream from Lake Hancock. Manmade weirs and other control structures have been installed for water management purposes on Lake Hancock and several lakes within the Winter Haven Chain. Shell Creek is dammed, the impoundment created upstream from the dam providing potable water supplies for the City of Punta Gorda.

Although streamflow declined in the lower Peace River (south of Zolfo Springs) between the 1960's and early 1980's, these declines were much smaller than those observed in the upper basin (Hammett 1987). The differences between the two portions of the watershed appear due to a combination of geologic and development-related factors (Lewelling et al. 1997). In the lower basin thick layers of clay and clayey sand lie on top of the Upper Floridan Aquifer, helping to buffer surface streams from the effects of reduced ground water levels. In addition, agriculture rather than phosphate mining has been the primary human activity in the lower basin, which has not yet undergone the hydrologic alterations associated with extensive mining. In the lower basin, runoff of agricultural irrigation water appears to be supplementing dry season flows in some streams (e.g., Joshua Creek), perhaps helping to alleviate the effects of reduced flows from the upper basin (SWFWMD 1999a).

### 3.2.5 Establishment of Minimum Flows

Florida Statutes (Section 373, F.S.) require each of the state's water management district to establish "minimum flows" for the rivers within its jurisdiction. The statute defines these minimum flows as "the limit at which withdrawals are significantly harmful to the water resources or ecology of the area."

The draft Peace River CWM plan (SWFWMD 1999a) indicates that minimum flows for the upper Peace River were established in 1999, and will be set for the middle segment of the river in 2004.

From a legal perspective, the water management district has taken the position that *de facto* minimum flows for the lower river have already been established through its issuance of a long-term water use permit to the Peace River/Manasota Regional Water Supply Authority. This legal interpretation has been questioned by some citizens groups, who argue that in this case the water use permitting process addressed *maximum permitted withdrawals* but did not define the river's *minimum flow* in the sense the term is used in Section 373 of Florida Statutes.

## 3.3 Hydrologic Changes in the Myakka River Basin

In striking contrast to the Peace River, where human activities have primarily caused reductions in water levels and flows, hydrologic trends in the Myakka River basin have been in the opposite direction.

### 3.3.1 Tree Mortality and Wetland Hydroperiods

Beginning in the mid-1990's, the SWFWMD began receiving reports of apparently abnormal levels of tree mortality in the Flatford Swamp, located in the upper Myakka River basin (SWFWMD 1999b). Similar reports also arrived from the Crowley Nature Preserve and Myakka River State Park. The estimated size of the affected area increased from 825 acres in 1995 to 3,740 acres in 1998, and included portions of the Flatford Swamp, upper Coker Creek and Ogleby Creek, Myakka River State Park, Owen Creek, Tatum Sawgrass, and Crowley Nature Center (PBS&J, Inc. 1999). The most strongly affected tree species include red maple, black gum, pop ash, and carolina willow (Coastal Environmental, Inc. 1998).

Subsequent investigations have indicated that the primary cause of the tree die-off is hydrologic stress (PBS&J, Inc. 1999). The water table in the affected area is apparently reaching higher levels, and remaining above the land surface for a longer portion of the year, than it did historically (SWFWMD 1999b). Rainfall did not appear to show an increasing trend during the period (Coastal Environmental, Inc. 1998). Water quality analyses have pointed to runoff of agricultural irrigation water as the most likely cause of the observed hydrologic changes (SWFWMD 1999b).

### 3.3.2 Other hydrologic impacts

Hunter Services, Inc. (1990) gave the following summary of other hydrologic modifications in the Myakka River basin:

> "Numerous drainage modifications...have been instituted for the conversion of lands to agricultural uses and for the control of flooding. The Tatum Sawgrass marsh was diked in 1974. Tatum Sawgrass is extremely important as a holding

basin during periods of heavy rainfall... The results of the Tatum Sawgrass diking have been to reduce the storage capacity of the marsh and to increase the potential for downstream flooding by diverting water away from the marsh. As a result of the dike system, flood-peak discharges and flood heights having recurrence intervals of up to 25 years are increased, approximately 1,200 additional acres along the Myakka River may be flooded during 2-year flood conditions, a 19-percent increase in flood-peak discharge at the County Road 780 bridge may occur, and an 0.8 foot increase in flood height can result (Hammett et al. 1978)."

"Drainage modifications made to Clay Gully divert water from the Myakka River. During low flow, most of the surface water goes directly to Upper Myakka Lake bypassing Tatum Sawgrass. This diversion of water has accelerated vegetation changes in the bypassed section of the river which may stay dry for nearly half the year."

"In the 1930's and 1940's, an earthen dike was constructed to separate Upper Myakka Lake from Vanderipe Slough and to divert the flow of Howard Creek into Upper Myakka Lake. These modifications were for the purpose of converting land near Vanderipe Slough into pasture land."

"A privately constructed dam, Down's Dam, approximately 0.5 mile below the Myakka River State Park's south boundary can retain up to 4 feet of water behind the structure during the dry season. As a result, the dam alters water levels upstream from their natural levels. The dam may also act as an obstacle to upstream movement of fish such as mullet, tarpon and snook. These species may be found in Lower Myakka Lake following prolonged periods of high water. The degree of impact of the dam is relatively unknown, but may be a negative influence on the Myakka River system."

"South of the Myakka River State Park, Deer Prairie Slough has been subjected to channelization and increased upland drainage. At the southern border of the park, a dike has been constructed in the slough to compensate for the effects of channelization. A weir also exists towards the downstream end of Deer Prairie Slough."

"Myakkahatchee Creek drains flat, swampy lowlands generally less than 30 feet above mean sea level in the southeastern portion of the Myakka River watershed, and serves as the primary source of drinking water for residents of North Port and a large portion of Port Charlotte. It has experienced channelization within the main stem, and extensive stormwater/flood control canals have been excavated within the City of North Port. A large east-west canal, R-36, along the northern boundary of North Port, intercepts the natural drainage flow towards the south, and also has some cross connections to Deer Prairie Slough and the Carlton Reserve."

"Within the lower watershed, a diversion channel (Curry Creek) connects the Myakka River with Roberts Bay on the Gulf of Mexico. It was created to relieve flooding on the Myakka River by diverting water to the Curry Creek system. The canal may be tidally affected for more than 5 miles upstream from the Venice by-way, may flow in either a westerly or easterly direction, and may divert up to 10 percent of the Myakka River water into Roberts Bay at high flow (Hammett et al. 1978)."

In recent years the Charlotte Harbor National Estuary Program and state and local government agencies have begun assessing the feasibility of potential restoration projects in several of these hydrologically-impacted areas.

## 4.0 Nutrient Enrichment of Surface Waters

Nutrients such as nitrogen and phosphorus—the major ingredients in the fertilizers we put on our lawns—also have a fertilizing effect on lakes, streams, and estuaries. Although beneficial in small amounts, nutrients become pollutants when present in excess.

"Eutrophication" is the term used by watershed managers to describe the changes in water chemistry and ecological structure that occur in surface water bodies receiving excessive nutrient s. These changes, which are currently among the most widespread water quality problems affecting Florida waters, include:

- increased rates of biological production, and increased quantities of algae or rooted aquatic plants;
- increased deposition of decaying organic material to the sediment zone (with associated increases in sediment oxygen demand);
- reduced water clarity, due to increased concentrations of algae and more frequent resuspension of unconsolidated bottom sediments; and
- changes in the composition of plant and animal communities, with increased abundance of species that are more tolerant of nutrient-enriched conditions

In addition to esthetic and ecological impacts, excessive nutrient inputs can also affect human uses of surface water bodies. Nuisance algae blooms, for example, often cause taste and odor problems in potable water supplies. When blooms collapse, and the algal cells die and decompose, the decomposition process can consume much of the available dissolved oxygen, causing stress or mortality in economically important fish and shellfish species. Blooms of certain species of blue-green algae can produce toxins that are harmful to wildlife, livestock, and humans (Carmichael 1994, King 2000).

The Peace and Myakka river basins are naturally fertile areas. Both basins have a subtropical climate with a long growing season, receive abundant rainfall in most years, and contain geological deposits that hold large amounts of phosphate. Research studies suggest that many lakes and streams in the area are naturally "eutrophic" and have exhibited high rates of biological productivity for the past century or more (Odum 1953, Canfield and Hoyer 1988, Brenner et al. 1993). These naturally eutrophic waterbodies have the potential to become "hypereutrophic"—with undesirably high levels of biological productivity—if human activities cause nutrient levels to become excessively high.

Several historically eutrophic lakes located in the headwaters of the Peace River basin, including Lake Parker, Lake Hancock and Banana Lake, appear to have shifted to hypereutrophic productivity levels in recent decades as a result of additional, manmade nutrient inputs (e.g., Brenner et al. 1993).

### 4.1 Water Quality Index (WQI)

The State of Florida has developed a stream water quality index (WQI) based on observed concentrations of several indicators, including nutrients, water clarity, dissolved oxygen, and oxygen demanding substances (Hand et al. 1994, 1996). Data collected from 2,000 monitoring stations were used to determine the percentile distribution of each indicator on a statewide basis.

The index is calculated using these percentiles: for example, a site whose annual average nitrogen concentration is 1.2 milligrams per liter (the statewide median value) would receive an index score of 50 for that indicator. The indicator scores are averaged to give an overall WQI score for a given monitoring station. State guidelines suggest that WQI values of 0-44 indicate "good," 45-60 indicate "fair," and >60 indicate "poor" water quality conditions in Florida streams.

Hand et al. (1996) give the following summary of the WQI: "The Florida Water Quality Index has several advantages over previous measures. First, since it is based on the percentile distribution of Florida stream data, it is tailored to Florida. Second, the index uses the most important measures of water quality in Florida: clarity, dissolved oxygen, oxygen-demanding substances, nutrients, bacteria, and biological diversity. Third, it is simple to understand and calculate and does not require a mainframe computer or any complex data transformations or averaging schemes. Finally, the index nicely identifies areas of good, fair, and poor water quality that correspond to professional and public opinion."

An application of the WQI approach to the Peace and Myakka river basins is shown in the following table, based on water quality data collected by a multi-agency monitoring program during the years 1997-1999 (CHEC 1999).

In recognition of the naturally-elevated phosphate concentrations that can occur in these basins, the average WQI values shown in the table below were calculated in two ways — one including and the other omitting the observed phosphorus concentrations. Based on these data the Saddle Creek at Structure P-11 station, which is located

**Water Quality Index (WQI) Scores for monitoring stations in the Peace and Myakka River basins, 1997-1999**
(Source: CHEC 1999)

| STATION | Turbidity | Total Suspended Solids | Total Organic Carbon | Total Nitrogen | Total Phosphorus | Avg. WQI (incl. TP) | Avg. WQI (w/o TP) | Water Quality Summary |
|---|---|---|---|---|---|---|---|---|
| Peace Creek Canal near Wahneta | 58 | 48 | 72 | 74 | 79 | 64 | 59 | fair to poor |
| Saddle Creek at Structure P-11 | >95 | >95 | 75 | >95 | 78 | 87 | 90 | poor |
| Peace River at Bartow | 75 | 87 | 67 | 82 | 94 | 81 | 76 | poor |
| Peace River at Ft. Meade | 59 | 66 | 54 | 75 | 90 | 67 | 60 | poor |
| Peace River at Zolfo Springs | 52 | 52 | 53 | 71 | 94 | 63 | 52 | fair to poor |
| Peace River at Arcadia | 51 | 53 | 56 | 69 | 90 | 64 | 57 | fair to poor |
| Charlie Creek near Gardner | 27 | 28 | 74 | 63 | 83 | 55 | 48 | fair |
| Horse Creek near Myakka Head | 17 | 11 | 71 | 41 | 79 | 44 | 33 | good |
| Horse Creek near Arcadia | 19 | 23 | 65 | 56 | 80 | 47 | 35 | good to fair |
| Shell Creek near Punta Gorda | 17 | 11 | 62 | 50 | 59 | 37 | 30 | good |
| Myakka River at Myakka City | 7 | 3 | 70 | -- | 74 | 38 | 27 | good |
| Myakka River near Sarasota | 15 | 8 | 74 | 58 | 78 | 44 | 32 | good |
| Deer Prairie Slough near North Port | 54 | 15 | 72 | -- | 70 | 53 | 47 | fair |
| Big Slough Canal near Myakka City | 49 | 28 | 73 | -- | 76 | 57 | 50 | fair |
| Big Slough Canal near North Port | 41 | 32 | 61 | -- | 75 | 55 | 48 | fair |

immediately downstream from Lake Hancock, has the poorest water quality of the 15 sites monitored, falling in the 75 th to 90th percentiles of Florida streams for all indicators assessed. Several sites—primarily located in the northern portion of the Peace River basin—exhibited WQI values >60, indicative of "poor" water quality conditions. Four sites (Horse Creek near Myakka Head, Shell Creek near Punta Gorda, Myakka River at Myakka City, and Myakka River near Sarasota) exhibited WQI values that would be characterized as "good" (average WQI < 45) based on the State classification system. The remaining sites showed intermediate values.

Because they are based on only two years of monitoring data, these results represent a relatively short-term "snapshot" of water quality conditions in the Peace and Myakka river basins. In general, though, they appear consistent with previous water quality information collected from the basin (e.g., Fraser 1991; Hand et al. 1994, 1996; Lowrey et al.1990).

## 5.0 Pathogens and Toxins

Pathogens—disease-causing bacteria, viruses and other microbes—can be present in water and sediments for natural reasons or because of contamination by inadequately treated animal or human wastes. Toxic materials—including metals, pesticides and other synthetic organic chemicals—are usually associated with manmade sources of contamination.

### 5.1 Bacteriological Indicators

Natural water bodies such as lakes, rivers and bays contain a wide variety of bacteria, viruses and other microbes, some of which can cause disease. With increasing demands on water resources, the potential for contamination of surface and ground water by pathogenic microorganisms has the potential to increase (APHA 1989). Outbreaks of waterborne diseases have not been completely eliminated. Pathogenic bacteria that can by transmitted by water or wastewater include *Salmonella*, *Shigella*, *Campylobacter*, pathogenic *E. coli*, and *Vibrio cholerae* (the cause of cholera), among others. Viral diseases associated with body contact or ingestion of untreated recreational waters include hepatitis A, Coxsackie A and B, adenovirus types 3 and 4, and a variety of gastroenteritis viruses (APHA 1989).

Most natural water bodies are not routinely monitored for pathogenic microbes. The cost of such testing would be quite high, and standardized methods for detecting some pathogens have not yet been developed. Historically, swimming beaches and other recreational water bodies have been monitored for fecal coliform bacteria, indicator organisms that are present in the feces of warm-blooded animals. Fecal coliforms are not necessarily pathogenic, but experience has shown that their presence in a water body can be used to indicate its likely sanitary quality. Examination of water bodies for specific pathogens is usually undertaken only during special studies or investigations of waterborne illnesses.

Although generally adequate from a public health perspective, the use of indicator organisms such as fecal coliforms to estimate the sanitary quality of natural water bodies can be misleading in some cases. High levels of fecal coliforms may be found at times in waters contaminated by animal wastes that carry little or no health risks for humans. Conversely, pathogenic bacteria, viruses and protozoa may at times be present in waters in which few or no fecal coliforms are found. These limitations must be kept in mind when interpreting reported coliform counts (APHA 1989).

Work is currently underway to develop cost-effective tests that more accurately estimate the public health risks associated with specific pathogens in natural water bodies. Until the appropriate tests are developed and widely applied, however, fecal coliform counts will probably remain the most widely used estimators of sanitary quality.

In the Peace and Myakka river basins a number of lakes, streams, and river segments contain elevated levels of coliform bacteria. In 1998, FDEP and U.S. EPA published a list of "impaired waters" in the two basins — surface water bodies that did not currently meet federal and state water quality standards and appeared to need increased management attention in order to do so. Nineteen water bodies in the Peace River basin and four water bodies in the Myakka River basin were included on the list because of elevated coliform levels. These water bodies, and the complete lists of "impaired waters" in the two basins, are summarized in Appendix A.

### 5.2 Waterborne Toxins

#### 5.2.1 Mercury

High concentrations of mercury in largemouth bass and other game fish were first documented in Florida in the 1980s. In recent decades fish consumption advisories have been issued for bass, gar, bowfin and several estuarine and marine species. On a statewide basis the situation is most pronounced in the Everglades and Water Conservation Areas 2A and 3, where no consumption of bass, gar and bowfin is recommended (Fernald and Purdum 1998). Fish consumption advisories for mercury have also been issued for the Peace and Myakka Rivers, and have played a role in the inclusion of these rivers on the state and federal "impaired waters" list (Appendix A).

Mercury released from natural and manmade sources can travel long distances in the atmosphere before being re-deposited on the earth's surface. As a result, it is unlikely that management actions taken solely within the Peace and Myakka river basins would have significant effects on the mercury levels occurring in fish caught in those basins. Management of elevated mercury in fish and other wildlife appears to be an issue that will require coordinated long-term action at the state, national and (perhaps) international levels.

### 5.2.2 Pesticides

Pesticides are not widely monitored in surface waters in the Peace and Myakka river basins, and we have not located any monitoring data indicating that toxic levels of pesticides are present in water bodies within the area. However, a recent federal study (NOAA 1992) suggests that greater attention to this issue may be warranted.

The NOAA (1992) study examined agricultural pesticide use in coastal watersheds throughout the United States during the year 1987. The Gulf of Mexico region ranked highest in the nation in estimated application rates of the more hazardous insecticides, fungicides, and herbicides examined (19.4 million pounds per year). Among Gulf of Mexico watersheds, the Charlotte Harbor drainage basin was estimated to receive the third highest application rates of these chemicals (2.6 million pounds per year). Four compounds (endosulfan, chlorothalonil, chlorpyrifos, and trifluralin) accounted for about 60 percent of the hazard-adjusted pesticide applications in the Gulf of Mexico region. Endosulfan used on tomatoes in the Charlotte Harbor and Tampa Bay watersheds accounted for almost 70 percent of the hazard-adjusted applications in those basins (NOAA 1989). Chlorpyrifos, used for insect control on citrus, was also a substantial contributor to the hazard-adjusted application rate estimated for the Charlotte Harbor watershed (NOAA 1989).

### 5.2.3 Cyanobacterial Toxins

Cyanobacteria — commonly known as blue-green algae — are among Earth's most ancient organisms. They are more closely related to bacteria than to algae, and their fossilized remains have been found in rocks more than three billion years old (Charmichael 1994). The following discussion of potential cyanobacterial toxicity in the Peace River basin was taken from a recent article published by the Charlotte Harbor NEP (King 2000):

> "Within the last few decades, the size, frequency and duration of cyanobacteria blooms may be increasing in Florida lakes, streams, and estuaries. Toxin producing species of cyanobacteria have recently been reported in several freshwater lakes that are part of the Peace River headwaters. *Cylindrospermopsis raciborskii*, an exotic species from Australia, has been identified in Lake Marianna which is part of the Winter Haven Chain of Lakes."
>
> "A recently recognized problem associated with the cyanobacteria is that they are known to produce toxins, including neurotoxins, hepatotoxins, and shellfish toxins. Animals, including humans, can be affected by ingestion or recreational contact with the toxins. Drinking water supplies can contain cyanobacteria or the toxins, and the toxins can pass through the facilities' treatment systems. Presently, there have been no documented cases of human illnesses due to the toxins in Florida. With increasing instances of the frequency and persistance of the blooms along with an increase on withdrawing surface water for drinking water, human health may be at risk."

"The Florida Harmful Algal Bloom (HAB) Task Force has been formed to investigate these concerns with funding provided to conduct a statewide survey to detect cyanobacteria and their toxins. Toxic species have been found throughout Florida, including Florida Bay."

### 5.3 Sediment Toxicity

In recent decades, the role of sediment quality in determining the health of aquatic ecosystems has become more clearly understood (MacDonald 1995). Following their release into aquatic environments, many pollutants adhere to particulate matter that becomes incorporated into bottom sediments. Several classes of toxic substances have been found in aquatic sediments, including trace metals (such as cadmium, copper, chromium, lead, mercury, and zinc), organochlorine pesticides (such as DDT and its derivatives), and variety of other synthetic organic chemicals. At elevated concentrations, sediment-associated contaminants have been linked to a number of adverse effects on organisms living in and on those sediments. If contamination levels are sufficiently high, the sediments may be acutely or chronically toxic to the organisms that attempt to live there. In addition, many of the contaminants that accumulate in sediments also accumulate in the tissues of fish and shellfish. At elevated levels these tissue-borne contaminants may represent significant hazards to humans and wildlife that consume aquatic organisms. The potential accumulation of toxic substances in aquatic sediments is thus an issue for concern for environmental managers in many parts of the country (MacDonald 1995).

Sediment quality has not received a great deal of study in the Peace and Myakka River basins. The most recent report we have found was prepared by Schropp (1998), using funds provided by the SWFWMD's Charlotte Harbor SWIM program. The report focused on the Charlotte Harbor estuary, but contains information on the lower reaches of the Peace and Myakka rivers as well.

The overall conclusion of the Schropp (1998) study is that Charlotte Harbor is relatively free of toxic sediment contaminants. Evidence of contamination was found primarily in nearshore areas close to likely sources of pollution. This is in contrast to some other large estuaries in southern Florida — such as Tampa Bay and Biscayne Bay — where sediment contaminants are more widespread and are present in higher concentrations.

Schropp (1998) examined seven data sets that had been collected between the years 1965 and 1989. Three of the data sets included information on concentrations of trace metals — arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. The majority of Charlotte Harbor sediments, even those near developed areas, showed no significant metal enrichment. Most of the metal-enriched sediments came from the upper Charlotte Harbor area, in or near marinas. Where metal enrichment was found, the metal concentrations were usually below the "threshold effects level" or TEL (the level below which adverse biological effects are rarely observed). Arsenic and copper concentrations exceeded the TEL at one Charlotte Harbor station located in a marina.

In the lower Peace River, mercury concentrations at two stations exceeded the TEL. At four stations sampled in the lower Myakka River, no metals concentrations exceeded the TEL.

Evidence of contamination by petroleum discharges was found at a number of stations in the lower Peace River, particularly in the vicinity of marinas and residential canals in the Port Charlotte and Punta Gorda areas (Schropp 1998). In general, though, hydrocarbon concentrations reported in Charlotte Harbor were similar to those observed in unpolluted sections of Tampa Bay.

Chlorinated pesticides and PCBs were not found in substantial quantities in the tested Charlotte Harbor sediments. A NOAA study reported trace amounts of one pesticide (alpha-chlordane) and trace amounts of PCBs at three stations sampled in 1985. The concentrations measured were all below the TELs for those chemicals (Schropp 1998).

## 6.0 Watershed Management and the TMDL Process

On a nationwide basis, about 40 percent of U.S. water bodies — which include about 5 million acres of lakes and 300,000 miles of river and bay shorelines — do not currently meet state water quality standards or federal criteria (U.S. EPA 2000).

Under Section 303(d) of the 1972 Clean Water Act each state is required to identify and list the "impaired" water bodies within its jurisdiction. The Act defines an "impaired" water body as one that is not expected to meet standards even after all point sources of pollution have installed the minimum levels of pollution control technology required by local, state or federal regulations. The law requires each state to establish a priority ranking of its impaired waters (known as a "state 303(d) list"), which must be updated by the state and approved by EPA every two years. The most recent lists of impaired waters in the Peace and Myakka river basins, which were prepared by the State of Florida in 1998, are shown in Appendix A. (Additional information on the states' "impaired waters" lists is available on the EPA web site, at http://www.epa.gov/owow/tmdl.)

The Clean Water Act also requires the state or EPA to identify the pollutants that are preventing its impaired waters from meeting water quality standards, and to develop "total maximum daily loads" (TMDLs) for those pollutants. The TMDL for a particular pollutant, such as nitrogen or phosphorus, identifies the maximum amount of the pollutant a water body can receive and still meet water quality standards. It thus gives the state a legal basis for establishing additional water quality-based controls on pollutant discharges to its impaired waters (U.S. EPA 2000).

Although TMDLs have been required by the Clean Water Act since 1972, until recently this portion of the Act was not vigorously implemented by EPA or the states. In response, citizens organizations have brought legal actions against EPA to force the agency and the states to enforce section 303(d). As a result of those legal actions, EPA is currently under court orders or consent decrees in many states to ensure that TMDLs are established, either by the state or by EPA (U.S. EPA 2000).

The Florida Legislature addressed these issues in its 1999 session, enacting the Florida Watershed Restoration Act (Chapter 99-223, Laws of Florida). The Act identifies the Florida Department of Environmental Protection (FDEP) as the state's lead agency for TMDL development, and gives the Florida Department of Agriculture and Consumer Services (FDACS) authority to develop best management practices for agricultural pollution sources.

In accordance with the Florida Watershed Restoration Act, FDEP has developed a five-year watershed-based process (summarized in the table below) to prepare basin management plans and TMDLs for Florida's impaired waters. In the Peace and Myakka river basins, FDEP plans to begin work on Phase 1 of the five-year process in July, 2003 (Livingston 1999).

The situation in the Myakka River basin is complicated because this basin was specifically addressed in one of the TMDL-related legal actions mentioned earlier. Although FDEP is not scheduled to begin work on its Myakka River basin management plan until 2003, discussions with EPA and FDEP staff indicate that work on a legally-mandated Myakka River TMDL is currently underway.

**FDEP's five-phase program for basin management and TMDL development. (Source: Livingston 1999)**

| Phase | Schedule | Activities |
|---|---|---|
| Phase 1. Initial basin assessment | Years 1-2 | • Identify stakeholders<br>• Build basin team<br>• Prepare draft status report<br>• Prepare basin assessment:<br>I. Identify and prioritize management goals<br>II. Inventory existing and proposed management activities<br>III. Develop plan of study<br>IV. Hold public meetings<br>V. Environmental education |
| Phase 2. Coordinated monitoring | Years 1-3 | Carry out strategic monitoring to collect necessary data |
| Phase 3. Data analysis and TMDL development | Years 2-4 | • Compile and evaluate data; incorporate findings in status report<br>• Complete TMDLs and source water assessments |
| Phase 4. Management Action Plan | Years 4-5 | • Finalize management goals and objectives<br>• Develop draft action plan<br>• Identify monitoring and management partnerships |
| Phase 5. Implementation | Years 5+ | • Implement action plan |

## 7.0 Recommendations for Community-Based Watershed Management

Phase 1 of the State of Florida's five-year basin management process in the Peace and Myakka river basins will have the following objectives (Livingston 1999):

- establish the general ecological health of the basins and the water quality of their individual water bodies;
- identify water bodies that may require restoration, protection, and/or TMDL development;
- identify water bodies where further study is needed, because of water quality problems or lack of data;
- identify sources of pollution; and
- develop consensus-based management goals and objectives.

Fortunately, as noted earlier, a number of local, state, and federal agencies are already conducting watershed-based management programs in the two basins. These include the Charlotte Harbor National Estuary Program, the Southwest Florida Water Management District's Surface Water Improvement and Management (SWIM) and Comprehensive Watershed Management (CWM) programs, and the FDEP Ecosystem Team Permitting initiative. The existing programs have generated substantial amounts of technical information on the two basins, and have begun distributing that information to basin residents.

If a community-based watershed management program—working cooperatively with the existing groups and focusing specifically on the Peace and Myakka river basins—could be set up during 2001, it appears that much of the state's proposed Phase 1 basin management work could be completed before the year 2003. The state has limited resources available for basin management, and is currently struggling to find adequate resources to address critical management issues in the Kissimmee River valley, Lake Okeechobee, the Everglades, Florida Bay, and elsewhere. The existence of a community-based management program in the Peace and Myakka river basins would benefit the state by allowing it to focus additional resources on these critical areas. It would benefit the existing local programs by giving them a clear role as stakeholders in the basin management process.

A community-based basin management program could be structured in a number of different ways. The EPA's National Estuary Program, which is organized around a watershed-based "management conference" made up of local, state and federal agency representatives, non-governmental organizations, the private sector, interested citizens, and elected officials, offers one potential model. Because the Charlotte Harbor National Estuary Program already exists, and includes the Peace and Myakka river basins within its project area, the simplest approach for these basins may be to work within or in cooperation with the existing NEP management structure. We recommend that the Charlotte Harbor Fund explore these options with the Management and Policy Committees of the Charlotte Harbor NEP, with NEP staff, and with other potential participants to identify an appropriate organizational structure.

As noted earlier in this report, the National Research Council (NRC 1999) has recommended that watershed management be based on the following strategy:

1. identify the watershed's priority problems, and select specific, quantifiable objectives for their resolution;

2. define the appropriate temporal and spatial scales for addressing the priority problems;

3. identify all relevant stakeholders, and provide each an opportunity to participate in the decision making process;

4. identify tradeoffs among the alternative solutions;

5. identify shared values guiding the selection of alternatives; and

6. select and implement the best management actions to balance among tradeoffs.

If all participants agreed to follow it, this strategy could perhaps serve as the organizing paradigm for a community-based management initiative in the Peace and Myakka river basins.

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## Appendix A

## Lists of "Impaired Waters" in the Peace and Myakka River Basins. (Source: U.S. EPA)

### I. Peace River basin

| Name of impaired water body | Cause(s) of impairment |
|---|---|
| L. Smart | nutrients, un-ionized ammonia, dissolved oxygen (DO) |
| L. Haines | coliforms, nutrients, DO |
| L. Alfred | nutrients, DO |
| Saddle Creek | coliforms, nutrients, DO |
| Crystal Lake | nutrients, un-ionized ammonia, DO |
| L. Parker | nutrients |
| L. Tenoroc | DO |
| L. Bonny | nutrients |
| L. Lena | nutrients |
| L. Lena Run | coliforms, nutrients, total suspended solids, turbidity, DO |
| L. Arianna | nutrients |
| L. Lulu Outlet | nutrients, DO |
| L. Eloise | nutrients |
| L. Shipp | nutrients, DO |
| L. May | nutrients |
| L. Howard | nutrients |

**Peace River basin (cont.)**

| Name of impaired water body | Cause(s) of impairment |
|---|---|
| L. Cannon | coliforms, nutrients, DO |
| L. Mirror | nutrients |
| L. Jessie | nutrients |
| Peace Creek Drainage Canal | coliforms, biochemical oxygen demand, fish consumption advisory (mercury), total suspended solids, turbidity, DO |
| Banana Lake Canal | fluoride, nutrients, un-ionized ammonia, DO |
| Wahneta Farms Drainage Canal | coliforms, nutrients, turbidity, DO |
| Peace Creek Tributary Canal | coliforms, nutrients, turbidity, DO |
| L. Effie Outlet | nutrients |
| Peace River above Joshua Creek | fish consumption advisory (mercury), nutrients, total suspended solids, DO |
| Peace River above Charlie Creek | fish consumption advisory (mercury), nutrients, total suspended solids, turbidity, coliforms |
| Peace River above Oak Creek | fish consumption advisory (mercury), nutrients, total suspended solids, turbidity |
| Peace River above Payne Creek | fish consumption advisory (mercury), nutrients, coliforms, DO |
| Peace River above Bowlegs Creek | fish consumption advisory (mercury), nutrients, total suspended solids, turbidity, coliforms, BOD, DO |

**Peace River basin (cont.)**

| Name of impaired water body | Cause(s) of impairment |
|---|---|
| Whidden Creek | DO, total suspended solids, turbidity, nutrients |
| Saddle Creek below L. Hancock | coliforms, nutrients, total suspended solids, turbidity, un-ionized ammonia, DO |
| L. Hancock | nutrients, un-ionized ammonia, DO |
| West Wales Drainage Canal | nutrients, turbidity, DO |
| Payne Creek | nutrients, DO, coliforms |
| Little Charlie Creek | nutrients, coliforms |
| Horse Creek above Peace River | coliforms, biochemical oxygen demand, nutrients, DO |
| Thompson Branch | nutrients, coliforms |
| Alligator Branch | coliforms, nutrients, DO |
| Limestone Creek | coliforms, nutrients, total suspended solids, DO |
| Brandy Branch | nutrients |
| Bear Branch | nutrients, DO |
| Prairie Creek | nutrients, turbidity, DO |
| Myrtle Slough | biochemical oxygen demand, coliforms, nutrients, DO |
| Hawthorne Creek | nutrients, coliforms |
| Peace River, mid-estuary | fish consumption advisory (mercury), nutrients, DO |
| Peace River, lower estuary | fish consumption advisory (mercury), nutrients, DO |

## II. Myakka River Basin

| Name of impaired water body | Cause(s) of impairment |
|---|---|
| Owen Creek | coliforms, nutrients, total suspended solids, turbidity, DO |
| Mud Lake Slough | coliforms, nutrients, total suspended solids, turbidity, DO |
| Big Slough Canal | coliforms, nutrients, DO |
| Myakka River | fish consumption advisory (mercury), coliforms, nutrients, total suspended solids, DO |
| Upper Lake Myakka | impaired biological community |
| Deer Prairie Slough | biochemical oxygen demand, nutrients, DO |