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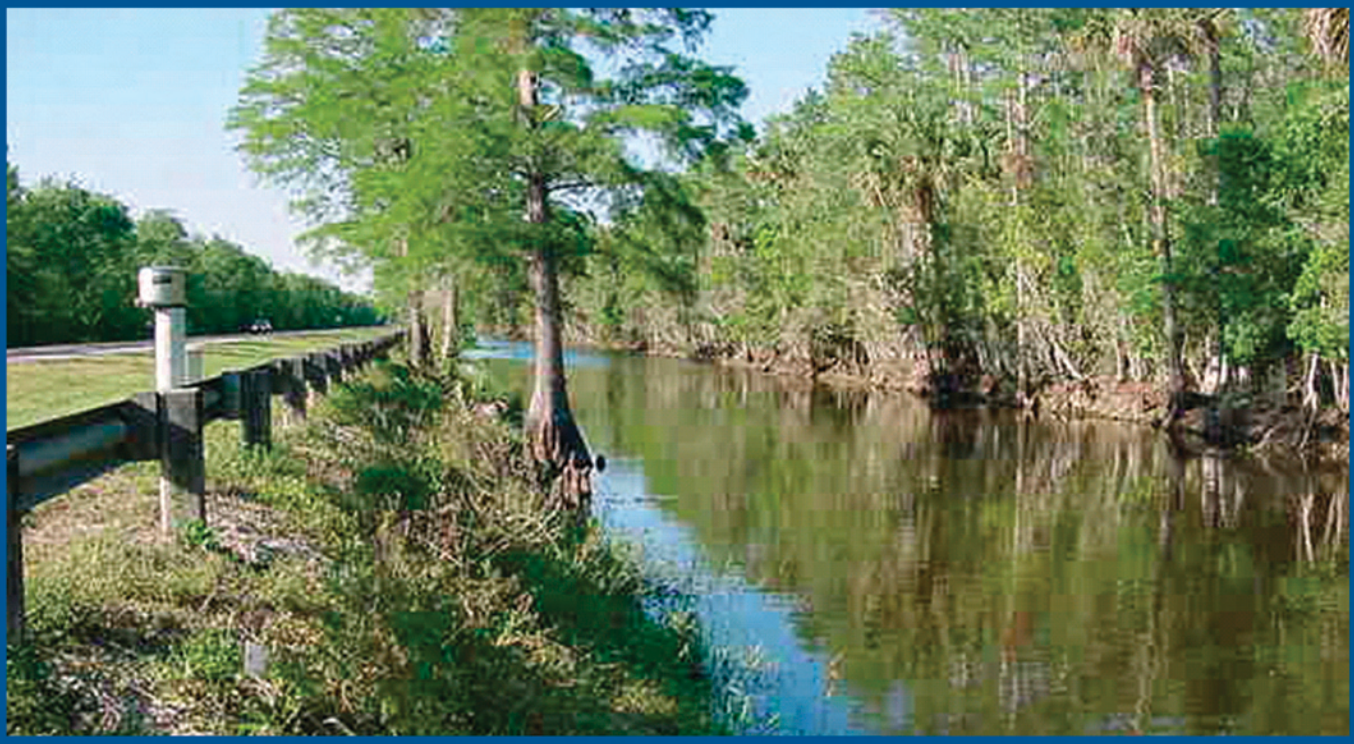
Reconnaissance of Hydrology and Environmental Conditions in Central Big Cypress Basin



Final Report
February 15, 2006
CN040927-WO01

South Florida Water Management District

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RECONNAISSANCE OF HYDROLOGY AND ENVIRONMENTAL CONDITIONS IN CENTRAL BIG CYPRESS BASIN

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Acknowledgements

The Reconnaissance of Hydrology and Environmental Conditions in Central Big Cypress Basin was prepared by Metcalf & Eddy, Inc. for the South Florida Water Management District. Carla N. Palmer, P.E., Stormwater Management Division Director for the South Florida Water Management District, provided programmatic oversight and guidance and co-edited the report. Liz Abbott, PMP, lead project manager for the South Florida Water Management District, managed and co-edited the project. Special thanks to Scott Legg of Atlas Management, Inc. working for the South Florida Water Management District, Tim Lieberman, Ananta Nath, P.E., Tim Howard, Mike Duever, Steve Sentes, of the South Florida Water Management District, Ellen Lindblad of CREW, Rhonda Watkins of Collier County, Robert Sobczak of the United States National Park Service, and Daryl Thomas of the United States Fish and Wildlife Service for providing guidance and assistance with references for the report. Additional reviews, discussions, and advice were generously offered by the Project Technical Team.

The Metcalf & Eddy project team was directed by Alejandro Toro, P.E. The lead author and project manager was Robert Singer, Ph.D. Additional writing and field support were conducted by Peter Verbanac. Nellie Morales, Ph.D. authored part of the document, and editorial comments were made by Michelle Pearcy and Betsy Shreve-Gibb, AICP. Jonathan Thompson provided graphics input to the report. The Metcalf & Eddy team was supplemented with three subcontractors: ES Consultants (land use), CRJ & Associates (hydrology), and Precision Engineering (GIS).

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1.1 Introduction

1.1.1 Purpose

The purpose of this project is to conduct a reconnaissance and assessment of the hydrologic and environmental conditions of an area in the central Big Cypress Basin that includes the Barron River Canal, Bear Slough, Okaloacoochee Slough, the Camp Keais Strand, and several other small sub-basins. These four basins, including their tributaries, have been identified as the primary focus in the study area. However, it is recognized that many sub-basin boundaries are interconnected and may fluctuate based on local conditions such as season, rainfall, and localized drainage operations. An aspect of the analysis will be to define some of the parameters or circumstances when flows or conditions are changed or variant.

The assessment includes an analysis and identification of problems that present and future conditions may have on: water quality; environmental restoration; planning for future changes; the benefits to estuaries and aquifers that capturing and storing water may provide; distributed flows versus point discharges; and flood control. In addition, this effort will identify opportunities within the project study area to protect and restore wetlands, protect wildlife, re-establish flow-ways, and control invasive vegetation. The analysis will be used as a tool to provide information to decision makers to help achieve the greatest return to the management of the resources when projects or changes are contemplated.

1.1.2 Project Scope

The project scope was to collect, review, consolidate, analyze, and interpret the many sources of environmental information available for the project study area in order to identify current and potential future environmental problems and to recommend strategies that will help resolve problems. Five specific areas of reconnaissance and assessment were addressed. These are:

- Identification and delineation of Basin Boundaries and Sub-basins
- Land Use and Hydrology
- Environmental Assessment
- Water Quality Assessment and Monitoring Plan
- Problem Identification Report.

The scope of this project was to identify and summarize the existing literature and studies available in the project area. Site visits were conducted to familiarize the project team with specific issues and areas that were called to their attention by the Project Technical Team.

1.1.3 Project Organization

Sections two through six of this report each represented a separate draft deliverable. This Final Report is a compilation of the separate sections. A Project Technical Team composed of agency representatives and non-governmental agencies was convened to review each draft deliverable. The following agencies were represented on the Project Technical Team:

- South Florida Water Management District (Project Sponsor)
- Collier County
- Corkscrew Regional Ecosystem Watershed / Land & Water Trust
- Florida Department of Environmental Protection
- Florida Division of Forestry
- Florida Fish & Wildlife Conservation Commission
- South Florida Water Management District (Project Sponsor)
- U.S. Fish and Wildlife Service
- U.S. National Park Service

Meetings of the Project Technical Team were held to discuss the draft sections, and this final report represents to the extent feasible a consensus of the Project Technical Team. Recommendations are made based on information reviewed and is not meant for use in detailed engineering design where site specific conditions may vary from the generalized information found herein.

1.1.4 Sources of Information

This report is a review of existing information. Current sources that have undergone thorough review were used preferentially and are listed in the References section. In addition to published reports, many reports and documents were reviewed from internet-based sources. These are also referenced and cited in the text.

The Project Technical Team provided a wealth of information from their personal experiences of working in and around the project study area. When information is presented that is based on personal or anecdotal information it is attributed to the source.

Except as noted, the base maps and GIS-based data were obtained from the South Florida Water Management District Big Cypress Basin office.

1.1.5 Project Study Area

The project study area is shown in Figure 2.1 and described in detail in Section 2. This area includes much of rural Collier County and the southern portions of Hendry and Lee Counties. The project study area encompasses 954 square miles and is comprised of a

variegated terrain of diverse habitats, and terrains including natural features such as swamps, marshes, wetlands, flatwood hammocks and estuaries, and man-made features such as urbanized areas, roads and canal networks. It excludes areas that have been the subject of other extensive reviews, such as the Estero Bay area and the Golden Gate Estates, although these areas are considered in this report because they either influence or are influenced by the drainage areas included in the project study area.

1.2 Watershed Boundaries and Sub-basins

The majority of the 609,956-acre project study area has not been directly impacted by urbanized development; however, other land uses such as agricultural land use, which typically introduces dirt roads and man-made ditches, have altered the historical flow patterns, and ultimately affected wetland habitat. These alterations have converted the historical surface sheet flows to channelized flows. Watershed boundaries are difficult to ascertain because of the very low topographic gradients. Furthermore, flows can vary in direction depending on the water levels from previous rainstorms. Nonetheless, four major sub-basins, Estero Bay, Trafford, East Collier, and West Collier were identified and shown in Figure 2.1. These sub-basins were further sub-divided into 60 minor sub-basins. Specific areas of concern in the Bear Slough Area, Camp Keais Strand, and the basins surrounding the Corkscrew Sanctuary are described.

1.3 Land Use and Hydrology

The land use and hydrology section of the report describes existing land uses and future (2025) land uses. A series of maps (Figure 3.1a-c and Figure 3.2a-c) show the overall project study area and details of four areas that are subject to rapid and intense development: Immokalee, Ave Maria College development, and the Northern Golden Gate Estates.

The principal change in land use projected for the project study area is the conversion of approximately 22,000 acres of agricultural land into residential uses by the year 2025. This change is focused primarily in the areas mentioned above. The impact of this change in land use on hydrology will be minimized by adherence to regulatory requirements that require the detention and treatment of storm flows on site for development.

1.4 Environmental Assessment

The purpose of this section is to inventory the important natural resources in the project study area and to determine the vulnerability of the resources to development. An environmental assessment matrix-based tool developed by the District in cooperation with other agencies is presented in Section 3. The tool is used to: 1) identify the effects of proposed land use activities; 2) identify the location of planned urban development and restoration activities; 3) determine the ecological significance of those activities; 4) prioritize areas where restoration efforts need to focus; and 5) provide

recommendations for future land use considerations within the purview of the present short and long range land use plans and regulations.

Environmental resources may be impacted by changes in drainage patterns, land use changes, alteration of natural fire regimes, introduction of exotic species, loss of wildlife corridors, and introduction of human activities that affect wildlife. Restoration efforts should be focused on:

- Protection, buffering, and management of existing public lands
- Restoration of degraded habitat, and minimization of further habitat loss
- Protection of primary flowway corridors from further development to minimize needs for additional drainage projects
- Protection of habitat loss by severe fires
- Restoration of more natural distribution, timing and quantities of fresh water into the coastal estuaries
- Improvement of aquifer recharge
- Improvement to water quality by addressing point source and non-point source discharges through the adoption of best management practices
- Protection of ground water from pollutant loading, saltwater intrusion

1.5 Water Quality Assessment and Monitoring Plan

The water quality assessment and monitoring section of the report describes the existing water quality monitoring efforts, locates the stations on Figure 5.1, and describes potential gaps in the data collection efforts. Interagency cooperation and the sharing of data bases via web-based publishing of data have resulted in a thorough network of sampling and the widespread availability of data.

The most thorough effort at identifying data gaps is the Southwest Florida Feasibility Study. This effort is based on sub-basin delineations that in some cases are too large to identify specific areas that have water quality problems within the Central BCB study area. Comparisons of the sub-basins used by the Feasibility Study with those used by the SFWMD are displayed in Figure 5.2. Also, in some cases the source of a water quality problem may be a natural process, such as the flow of low oxygen groundwater into surface waters in the southern parts of the East and West Collier sub-basins.

Future development will provide a monitoring challenge, and several areas adjacent to the areas subject to development described in Section 3 of the report were identified as possible locations for additional monitoring stations. The stage and flow of surface water beneath the I-75 and US 41 east-west corridors were also described.

1.6 Problem Identification Report

The last section of the report summarizes the hydrological and environmental problems in the project study area. The types of problems, the cause of the problems, and the generic methods of addressing each type of problem are described. The section lists

the planned restoration efforts in Table 6.1 and displays the locations of these restoration projects in Figure 6.1.

The restoration projects that are in planning or underway are designed to resolve the following problems:

1 Restore the historic sheet flow hydrology.

2 To manage growth, existing County-level Master Plans and the Collier County Transfer of Development Rights program (See Section 3.6) should be enforced via zoning and land use approvals to cluster development in upland areas near existing development or via the conversion of agricultural land.

3 Continue to pursue an aggressive plan for public acquisition and management of conservation lands to expand upon the existing preserves, to protect the watersheds of the preserves, and to buffer the borders of the preserves from further development.

4 Planned restoration projects should be funded and expedited.

Prioritization of projects is difficult, because all the projects that have been reviewed have significant merit. However, if funding limits require difficult choices, the following priorities are recommended:

1 Land Acquisition and Management. Land values in South Florida have historically increased faster than the inflation rate, so a purchase of land now will save future dollars, and once land is developed it becomes virtually impossible to acquire for conservation.

2 Hydrological Restoration Projects. The entire regional plan requires active efforts to alter hydrological flow patterns.

3 Research and Studies. Ongoing research, and particularly the performance evaluation of the restoration projects is important, but adequate information is available now to initiate the land acquisitions and restoration projects that are given higher priority status. There is a need for development of sub-regional hydrologic models of the major flowways (Okaloacoochee Slough, Barron River Canal, Camp Keais, etc.) that are likely to be influenced by future growth and development.

2. WATERSHED BOUNDARIES AND SUB-BASINS

2.1 Introduction

The reconnaissance project study area is located in the central portion of the Big Cypress Basin, a vast and important system to the western Everglades. The project study area encompasses portions of three counties – Lee, Collier, and Hendry – but is located primarily within Collier County. The project study area encompasses 954 square miles and is comprised of diverse habitats, and terrains including natural features such as swamps, marshes, wetlands, flatwoods, and estuaries, and man-made features such as urbanized areas and canal networks. Descriptions of the natural resources and land use may be found in Sections 3 and 4, respectively.

In terms of the impact of land use by humans, the majority of the project study area has not been directly impacted by urbanized development; however, other land uses such as agriculture which typically introduces dirt roads and man-made ditches, have altered the historical flow patterns, and ultimately affected wetland habitat. Surface water in the basin is almost entirely comprised of freshwater except for a one to two-mile wide zone off the coast *(*DHI*,* 2001*).* Approximately 50% of the project study area is comprised of wetland forest (DHI, 2001).

The overall purpose of the reconnaissance of hydrology and environmental conditions in the central portion of the Big Cypress Basin is to implement an assessment in the area that includes the Barron River Canal, Bear Slough, Okaloacoochee Slough, the Camp Keais Strand, and several other sub-basins. However, the purpose of this task is to depict the interconnectedness of sub-basins; it is understood that flow may fluctuate based on local conditions such as season, rainfall and South Florida Water Management District/Big Cypress Basin operations. This chapter will review the sources of information that have been used to describe water flows in the study area. It will provide an overview of normal water flow directions in the project study area as well as describe the sub-basins inside the project study area. It will also describe flows under atypical flow regimes and point out areas where flow directions are intermittent or unknown. It will assess areas where the hydrological conditions can lead to land use problems and where hydrological conditions have altered or could alter natural areas.

The project study area is not historically a distinct watershed; for example, the Central Big Cypress Basin received additional inflow from northern systems, such as the Kissimmee River and Lake Okeechobee (Cuevas, 2000) prior to flow alterations conducted at a regional level by the Central and Southern Florida (C&SF) Project, initiated in 1948 for flood control and water supply purposes. The northern and western portions of the project study area exchange flows from drainages outside of the study area. Since other areas hydrologically affect the project study area, the actual watershed, in the technical sense of an area bounded by topography that drains in opposite directions, must be considered as part of a much larger hydrological system. This is important to note since, due to the slowly increasing water levels in the wetlands,

the response of the entire hydrological system will affect critical flood levels and flows (DHI, 2001). The project study area, in terms of its hydrology, can be influenced from outside affects (i.e., heavy rainfall to the north, increased discharges from developments and agriculture into and passing through the area). In addition, the area has been identified as having two generalized directions of flow – westward for portions of Trafford and Estero Bay major sub-basins, and southward for the East Collier and West Collier major sub-basins (Interagency Project Technical Team, 2005). However, the central and southern portions of the project study area are hydrologically contained and function as a single watershed with drainage to the south.

The identification of water flow and sub-basins, both major and minor (Figure 2.1), will provide an overview of how rainfall runoff travels within the project study area. Such information can assist in identifying areas that receive either too much or too little water. This information can also be used as a planning tool to provide assistance in retaining water flows within the Big Cypress Preserve Area in order to maintain adequate hydration of the wetland with fresh water and avoid canal discharge directly into coastal waters. In addition, this overview of flow patterns and sub-basins can be used as a planning tool for future development in providing an understanding of where runoff flows and assist in identifying areas that are prone to excessive drainage or flooding.

2. 2 Methods

DATA COLLECTION AND REVIEW:
A considerable portion of the level of effort for this task, *Watershed Boundaries and Sub-Basins*, is gathering and making assessments of existing information (model reports, maps, study reports). Much of the information collected for this task was made available both electronically and in hard copy from the Big Cypress Basin Library located in Naples, Florida, and through contact with various members of the Project Technical Team – primarily Water Management District staff.

INSTITUTIONAL KNOWLEDGE AND MEETINGS WITH KEY STAFF AND PROJECT TECHNICAL TEAM MEMBERS:
In addition to reviewing reports, meetings were conducted with South Florida Water Management District staff and other members of the Project Technical Team. Institutional knowledge of South Florida Water Management District staff regarding flow regimes and overall hydrologic conditions in the Big Cypress Basin in general, and the project study area in particular was invaluable to this effort. In addition to an overall history of how the existing four major sub-basins were derived, staff directed the Consultant to information; other sources of information included reports from other agencies, interviews with knowledgeable individuals, and field reconnaissance visits with property owners (See Reference Section).

FIELD VISITS:
The purpose of field visits was to ground truth areas where drainage basin delineation is problematic, or areas of concern expressed. Field visits included consultations with local residents as well as observations of indicators of flow, including channels, orientation of vegetation, and other indicators as recommended by the Project Technical Team.

The Consultant performed field visits to portions of the Bear Slough and Corkscrew area. These were identified as areas of concern where flows were uncertain, where data was insufficient to determine flow patterns, or a problem was observed.

TOPOGRAPHIC INFORMATION:
The Consultant reviewed existing delineations of watershed and sub-watershed boundaries and available topographic information, including *Topo2000 Elevation Update (Hinton, 2000): South Florida Water Management District)*. As stated above, there are various minor sub-basins inside the project study area. Existing boundary definitions arise from District efforts over 15 years which were reviewed by other agencies in the area. These delineations were drawn based on local knowledge of the areas, South Florida Water Management District permit information, and through individual basin studies. The major and minor sub-basin perimeters currently presented have been developed on the best available information and were agreed upon by the three counties (Collier, Lee, and Hendry) as well as the unincorporated City of Immokalee and the South Florida Water Management District. The methods for the delineation of these sub-basin boundaries have evolved as more computer models have become more sophisticated and the monitoring network has collected more data for calibration and verification of the models.

HYDROLOGIC INFORMATION:
In evaluating existing reports, it is evident that previous efforts have, in essence, built on the knowledge and findings of preceding efforts. One of the first major studies of hydrological flows conducted in the project study area was the *Corkscrew H & H Study Hydrologic Assessment Report*, completed by consultant, Gee & Jenson in 1993. The Gee & Jenson project study area encompassed approximately 125,000 acres. Gee & Jenson's study area is very similar to the Trafford major sub-basin, except it included all of Camp Keais and excluded some land to the north of Corkscrew Marsh. Their study area was broken into five sub-basins: Flint Pen Strand, Bird Rookery, Gordon Swamp/ Sanctuary, Camp Keais, and Northern Marsh. These sub-basins, with the exception of Bird Rookery Swamp, had different boundaries from the boundaries shown in this report. Gee & Jenson's sub-basins were larger and differently shaped as compared to current sub-basin delineations that have been resolved in more recent studies.

The next considerable effort to study and document hydrology in the area was conducted in 1998 by Dames & Moore – a study of the entire Big Cypress Basin – an area approximately 1,114 square miles. The Dames & Moore study overlaps with this project study area; however, it did not include a large area to the east of SR 29 (Bear Slough); areas proximate to Estero Bay; or areas to the south, such as Golden Gate

Estates and Faka Union. The Dames & Moore report referenced the Gee and Jenson study (1993) along with the Lee County Stormwater Management Plan (1990) to delineate basins. The sub-basins illustrated in the Dames & Moore study are similar to the present-day sub-basins. The major difference is that sub-basins in the Dames & Moore study are made up of combinations of the current basins. For example, in the Dames & Moore study Fakahatchee Strand is labeled as one large basin. The same area is currently divided into eight sub-basins. All the sub-basins from Immokalee south to Dan House are included in the Fakahatchee Strand Basin. The same can be said for the area south of I-75 and East of SR 29 where the entire area is labeled Barron River Basin. Some areas appear to be the same but are named differently, such as the Trafford major sub-basin which has not changed much in extent but was then called the Corkscrew-Cocohatchee Basin. The Dames & Moore report also included two different computer models; one was a SWMM Hydrologic Sub-model and the other was a UNET Hydraulic Sub-model.

The last large study performed on the project study area that included modeling was the *Big Cypress Basin Integrated Hydrologic – Hydraulic Model* (DHI, 2001). Geographically, the area in the integrated hydrologic/hydraulic model is similar to the area studied by Dames & Moore. The scope of this report was to produce an integrated MIKE SHE/MIKE II model to assess the impacts of various water management strategies on flood dynamics, wetland hydro-periods and water supply (DHI, 2001). The objective in developing the model was to model flood levels, peak flows as well as wetland hydroperiod in the watershed and to test various water management scenarios for optimum achievement of flood control and groundwater recharge (DHI, 2001).

The Comprehensive Review Study for the Central & Southern Florida Project, known as the Restudy, recommended a Feasibility Study to identify southwest Florida water resources conditions and to develop potential solutions to any problems that may be identified (Florida Department of Environmental Protection, 2003). This work was focused on the consideration of restoration work to provide additional water flow to the Everglades region. The Southwest Florida Feasibility Study, sponsored jointly by the U.S Army Corps of Engineers and the South Florida Water Management District, utilized the Mike SHE/MIKE II models described above (DHI, 2001) to evaluate water management challenges in the entire region.

2. 3 Major Sub-Basins

The Central Big Cypress Basin has been divided into four major sub-basins. The entire project study area is approximately 610,000 acres. The areas of each major sub-basin, as well as the minor sub-basins, are listed in Table 2.1. Basin boundaries are typically a physical attribute such as a road or a ditch (Photo 2.1). Most of these boundaries are man-made, highlighting the alteration of the hydrology of the project study area from pre-development conditions. The four major sub-basins are: East Collier, Estero Bay, Trafford, and West Collier (Figure 2.1).

The Central Big Cypress Basin has a total of 60 minor sub-basins**.** These 60 sub-basins were derived by the South Florida Water Management District and counties when the four major sub-basins were agreed upon (Personal communications, SFWMD, 2005). There are some sub-basins that have been studied more then others. For example, the Estero Bay and Trafford sub-basins have been extensively studied due to their proximity to urban developments. This is due to hydrological problems that have resulted in these areas due to rapid development (Carlson et al., 1986). This has also affected parts of the Corkscrew sub-basin, which is comprised mainly of natural areas but discharges water to the west and south. With increased development around the Corkscrew Sanctuary, its waters are now diverted and drained out to the coast via canals instead of sheet flowing its way to the coast. Another minor sub-basin of importance is Bear Slough in the East Collier sub-basin, where there is a large farming community. Drainage discharge from much of this area serves as headwaters for the Big Cypress National Preserve. Another minor sub-basin that has received a lot of attention is East Collier/Chokoloskee. This attention has come about from increased saltwater migration, which has resulted in the invasion of mangroves into areas that were formerly vegetated with freshwater wetland plants (Sobczak, 2005).

The sub-basin boundaries shown in Figure 2.1 represent an average wet season. The boundaries do not change with the seasons (i.e., wet vs. dry) under normal meteorological conditions except that, in the dry season, there is little to no runoff due to the limited amount of surface water. Besides the overall topographic slope from north to south in the project study area, the sub-basin boundaries are a combination of large and small roadways, farmland dirt levees, and/or ditches. In the event that a significant storm was to occur (i.e. a 100-Yr Rainfall Event), the project study area's four major sub-basins, in effect, would become one large basin with the same perimeters. This occurred during heavy rainfall events from June through October of 1995 (Dames & Moore, 1998).

Major Flows. The surface water flow of the study area is represented in Figure 2.2. Surface water travels through the study area by both sheet flow and in a series of canals and ditches located throughout the study area. There are numerous water control structures that convey and regulate the flow of water in the case of heavy rain, as shown in Figure 2.2. These facilities include canals, culverts under roads, weirs, and sluice gates.

TABLE 2.1. CENTRAL BIG CYPRESS BASIN MAJOR SUB BASINS

Estero Bay		Trafford		East Collier		West Collier	
Sub basin	Acreage	Sub basin	Acreage	Sub basin	Acreage	Sub basin	Acreage
Flint Pen	9,009	SR 82 E	17,199	Okaloacoochee Northeast	34,880	Immokalee South	10,871
Gordon Swamp	4,806	Corkscrew Marsh North	5,723	Okaloacoochee Northwest	18,925	Camp Keais South	11,419
Panther Island West	4,393	Wildcat Farms	6,890	Okaloacoochee West	8,208	Camp Keais West	7,761
Green Meadows South	5,533	Panther Island East	10,096	Okaloacoochee Central	4,762	FU#7	2,492
		Rookery Swamp	16,586	Okaloacoochee East	14,395	FU#6	2,445
		Corkscrew Southwest	4,933	Okaloacoochee South	16,500	FU#5	3,058
		Hogan Island	3,289	Okaloacoochee Southeast	13,635	GG#7	2,952
		Pipers Ranch	4,404	Sadie Cypress	29,382	GG#6	2,702
		Lake Trafford	1,485	Immokalee East	10,871	GG#5	4,049
		Corkscrew East	10,361	East Collier	80,232	Corkscrew Canal North	4,579
		Immokalee	2,427	Barron River North	9,687	Silver Strand	16,043
		Immokalee North	7,543	SR 29 #7	4,491	Catherine Island	10,837
		Camp Keais North	4,729	SR 29 #6	5,038	Small Rd Island	1,240
		Corkscrew Marsh South	5,521	SR 29 #5	868	Panther Refuge North	5,772
				SR 29 #3	1,533	Panther Refuge South	3,087
				SR 29 #2	575	Fakahatchee North	21,994
				SR 29 #1	9,963	Fakahatchee South	13,949
				Deep Lake	1,243	Fakahatchee Southwest	4,500
				Carnes Town	1,526	Fakahatchee Northwest	7,739
				East Collier / Chokoloskee	5,290	Janes Scenic	20,423
						Dan House	30,625
						South of US 41	24,486
Total	**23,741**	**Total**	**101,185**	**Total**	**272,006**	**Total**	**213,024**
Central Big Cypress Basin Total					**609,956**		

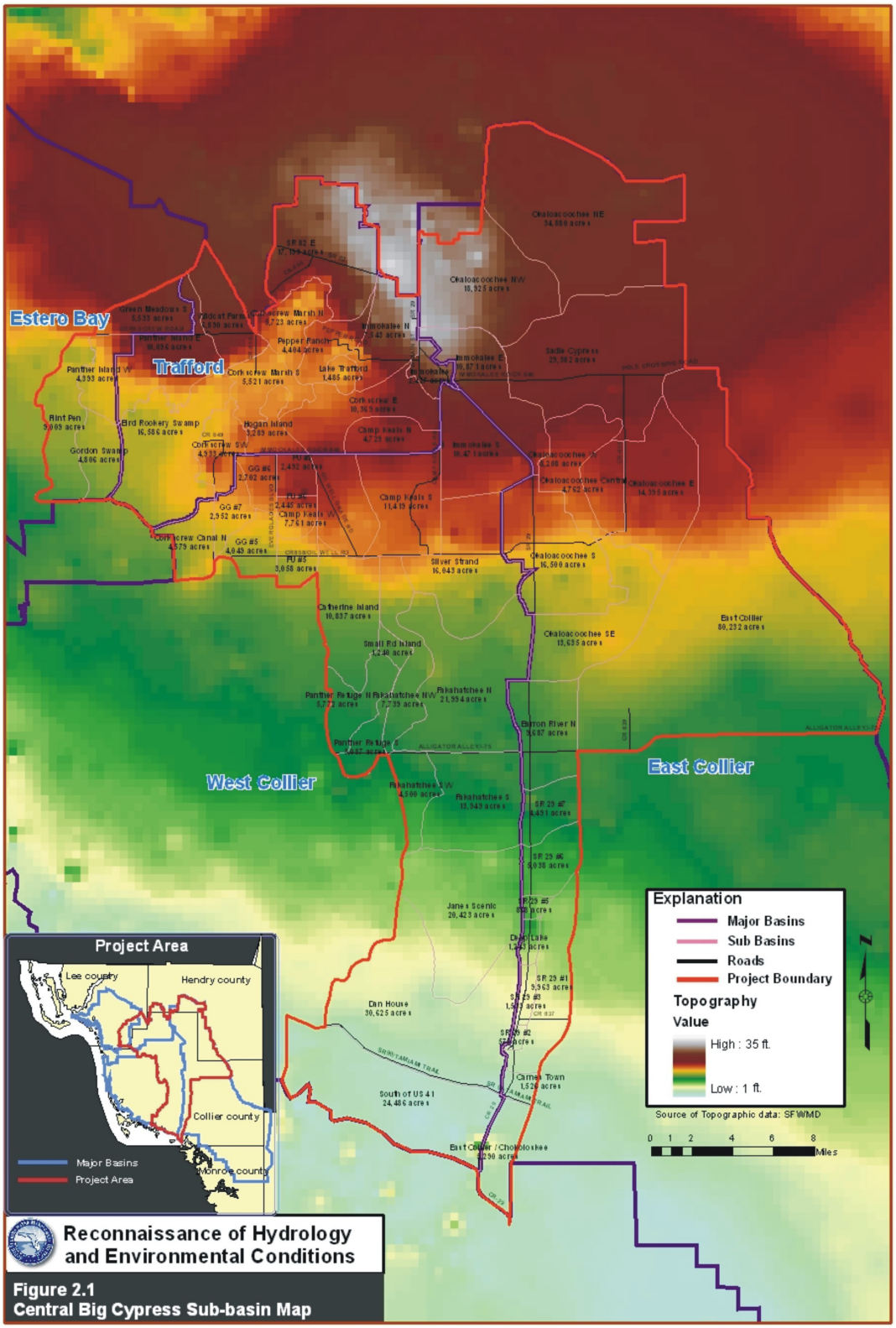


Figure 2.1. Central Big Cypress Sub-basin Map. This figure is inserted in a larger format at the end of this document.

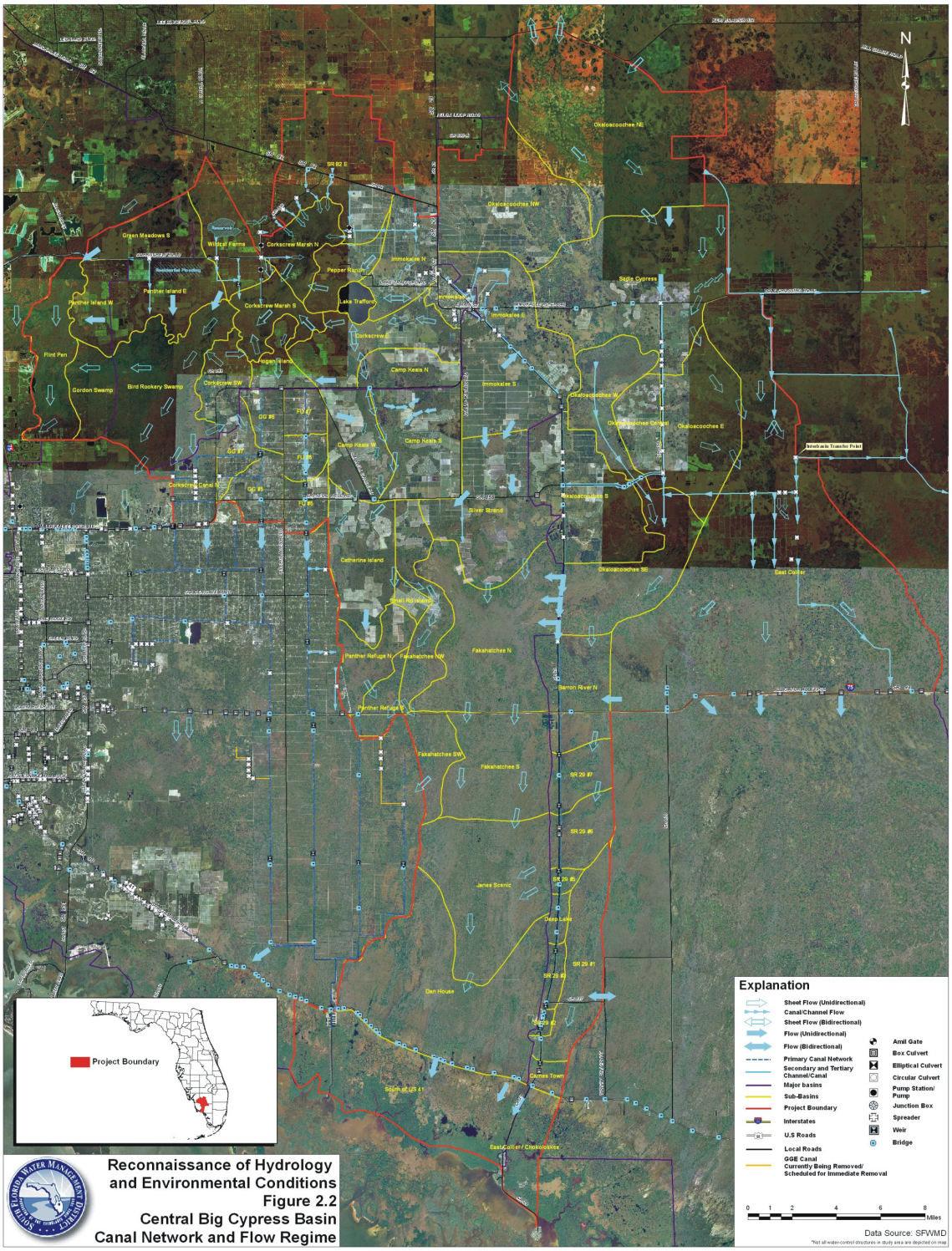


Figure 2.2. Central Big Cypress Basin Canal Network and Flow Regime. This figure is inserted in a larger format at the end of this document.

Surface water flow has been labeled in the figure in the following ways: unidirectional sheet flow, channel flow with direction, bidirectional sheet flow, unidirectional channel flow, and bidirectional channel flow. Sub-basin boundaries that flow in various directions depending on recent precipitation history are shown on Figure 2.2 as "bi-directional flows."

Topographic relief provides general direction to the flow of water in the project study area. The highest point, about 35 ft. MSL[1] , is the Immokalee rise just north of the unincorporated City of Immokalee at the northern boundary of the project study area.

Photo 2.1 Typical Farming Ditch along dirt road in Bear Slough; ditch acts as a basin divide

The Estero Bay Basin is located in the northwestern section of the project study area and is the smallest of the four major sub-basins. It is also the only basin that lies completely in Lee County. Its boundaries are determined primarily by roads – Corkscrew Road serves as a boundary between Estero Bay and Trafford, separating Green Meadows South and Panther Island East. To the west, the Estero Bay Sub-Basin spans all the way to the coast but the coastal areas are outside of the project study area. The boundary for the project study area on the western side was determined, or delineated by permits and canals. This boundary is very similar to the old Imperial River basin boundary described in Dames & Moore's (1998) *Big Cypress Basin Watershed Plan*. This boundary varies depending on how much water is present due to localized thunderstorms. The sub-basin is delineated to the east by artificial features such as Alico Road and a topographical ridge in the area (Dames & Moore, 1998). A review of planning documents shows that this area has a high projected growth rate and contains urban developments that have been expanded from the coastal communities to the west (Collier County Comprehensive Planning Department, 2004).

Major Flows. In the Estero bay basin water flows in a westward direction to the coast from the higher terrain to the east. There is some canalized stormwater runoff flowing through West Panther Island, as well as in Green Meadows South. Stormwater runoff travels west via canals similar to the canal adjacent to Corkscrew Road. The remaining minor sub- basins have runoff sheet flowing to the west from Gordon Swamp

[1] All topography reported in this report is Mean Sea Level expressed relative to the North American Vertical Datum, 1988

through Flint Pen toward the Gulf coast. These minor sub-basins within the Estero Bay sub-basin are the only portion of the project study area that drains to the west.

The Trafford Basin is the second smallest basin and includes the unincorporated City of Immokalee as well as Lake Trafford. This major sub-basin contains a variety of different habitats and terrains. The sub-basin is located almost entirely in Collier County; a small section to the north is in Hendry and a small section to the west is in Lee County. Trafford's boundaries consist of a combination of roads and canals. CR 846 is the basin's southern boundary with the exception of a canal which serves as the boundary around the Corkscrew canal and Golden Gate canal area. To the north the sub-basin is delineated by property lines, permits and ditches. The basin boundary to the east is CR 846 and SR 29 with the exception of the Immokalee area where the delineation again falls back on property lines around Immokalee regional airport. This area has a high projected growth rate since it contains the only large urban development in the project study area (Collier County Comprehensive Planning Department, 2004). This basin has the highest elevation within the project study area (30~35ft NGVD for average high elevations). Much of the basin has been converted from natural lands (predominantly pinelands and some freshwater marsh, wet prairie and cypress swamp) to agricultural uses.

Major Flows. Flow in the Trafford sub-basin is more complex with the headwaters of the basin from the north and east (Figure 2.2). The majority of runoff travels southward from the Immokalee rise into the study area. The surface water has a generalized direction to the west and to the south. Most of this water comes into the SR 82 sub-basin via canals and ditches. These canals run through the sub-basin and stop as they enter the Corkscrew Marsh North minor sub-basin. Here, runoff tends to sheet flow in a general southwest direction following a relief in the topography. Water in the eastern half of the basin goes to the west via sheet flow and some agricultural canals. These canals carry water from Immokalee North, Camp Keais North, the eastern part of Piper's Ranch as well as the eastern part of Corkscrew East, until reaching the Corkscrew Marsh. In this vicinity the canals act as point discharges and the water continues to the southwest via sheet flow. Some of this flow enters Lake Trafford from the east and exits the Lake towards the west, entering the Corkscrew Marsh North, East and South minor sub-basins sheet flowing westward. In addition, flows from Lake Trafford can flow to or from the Corkscrew East minor sub-basin. The direction of flow from Lake Trafford either, westward or southward depends upon rainfall over the area. The outflow from the lake occurs only at stages above 21 ft. NGVD. Precipitation events drive surface flows away from the rainfall, which alters the major direction of flow. As for the northwestern section of the basin, water flows south from Wildcat Farms and Panther Island East by way of canals until they enter either Bird Rookery Swamp or Corkscrew Marsh South where the canals stop. Water that is in the Corkscrew Marsh minor sub-basins sheet flows into the Bird Rookery Swamp minor sub-basin. From there, most of the water sheet flows west into Gordon Swamp while a small portion of the water sheet flows in a more southern direction entering the Golden Gate Estates.

The East Collier Basin is the largest major sub-basin. This sub-basin is comprised of a mixture of farmland and natural areas. Most of the farmland in the sub-basin is located north of I-75. The East Collier sub-basin contains large areas of farmland that due to poor drainage still witness sheet flow during the rainy season (Interagency Project Technical Team, 2005). This basin is located entirely in Collier County. This is mainly because all property located south of I-75 and even a small section north of the interstate is public property included in the Big Cypress National Preserve. To the north, this sub-basin is delineated by a combination of roads and farmland ditches. This is also true for the eastern boundary north of I-75. For the portion of the project study area located south of I-75 the project study area boundary is the topographic divide that directs water into the Barron River canal. This boundary is not a real watershed boundary because the watershed extends much farther east than the project study area. This is also the case for the area immediately south of I-75 and east of SR 29. The project study area boundary is I-75, but in actuality, water does pass underneath the road extending the real watershed boundary. However, I-75 can impede flow until the water can find a path east or west to a culvert. This routinely results in anecdotal observations of standing water north of I-75 when it appears drier to the south of the highway.

Major Flows. Water generally flows to the south in the East Collier sub-basin. The basin's headwaters come from the northeast. This water enters the area by sheet flow that serves as headwaters for the Okaloacoochee Slough as well as the Bear Slough area. The water then continues to sheet flow to the south with some of the water being diverted by various canals and ditches that run along developed land. There is some bi-directional flow in the northern part of the Okaloacoochee NE minor sub-basin, where water can flow to or from watersheds to the north, depending on local conditions (Figure 2.2). There are some large canals in the area; one such canal runs south through the Sadie Cypress minor sub-basin and acts as the main waterway crossing beneath SR 846. Another large canal that runs through the basin is the SR 29 Canal (a.k.a. Barron River Canal) that travels through the Immokalee minor sub-basins and carries the runoff into the Okaloacoochee Southeast minor sub-basin and ultimately to the 10,000 Islands of Florida Bay. Agricultural land use in the eastern half of the East Collier Basin results in a great deal of the water flowing through a network of farming ditches and canals. This is most apparent in the Bear Slough area in Hendry County where such farming ditches convey water southward into the natural lands in Collier County just north of I-75; where, ultimately the water again travels south via sheet flow. The western portion of the study area has I-75 as a barrier. Water pools north of I-75 until it makes its way beneath the highway via a series of cross-drain culverts located along the right of way. The sub-basins south of I-75 have water draining south throughout the year. The western half of the East Collier major sub-basin that is in the project study area drains south mainly through the Barron River Canal along SR 29. The eastern portion still drains south but via sheet flow as depicted in Figure 2.2. There is also some bidirectional canalized water flow in the SR 29 #1 minor sub-basin because of a canal that runs along CR 837. Also, the SR29 structure 6A and 6B directs some flows westward to the Fakahatchee Strand.

The West Collier Basin is another large basin comprised mainly of farmland and natural habitats. The sub-basin is entirely in Collier County. Almost all farmland in the basin is located north of I-75. Its boundaries are made up of a combination of roads and canals. CR 846 is its northern boundary with the exception of the Camp Keais Strand which historically conveyed sheetflow southward to Picayune Strand which serves as the boundary around the Corkscrew canal and Golden Gate Estates. To the west of this sub-basin, past the project study area boundary, the land is drained by a large network of canals. The watershed boundary extends to the coast, but the project study area boundary cuts through the watershed. Therefore, the western boundary for the sub-basin is to a great extent delineated based on property boundaries that drain into each section of the canals. To the east the basin boundary follows SR 29 very closely. In some northern portions of the sub-basin the boundary is the road itself. But in other sections, East and West Collier are divided by the topographic boundary that allows land to the west of the Barron river canal to drain into the canal. A mild divide located approximately one-half mile west of SR 29 can serve as the basin boundary during peak flow conditions.

Major Flows. The West Collier sub-basin drains to the south in both canals and sheet flow. For most of the sub-basins located north of CR 858 surface water drains south by way of various canals and ditches. In the northwest section of the basin, water is drained south by the Golden Gate and Faka Union canals. The only exception to this canalized flow is a winding path of natural land that extends from Lake Trafford to CR 858, and runs along the Camp Keais West and Camp Keais South boundary. The water from this area is then canalized to cross CR 858 and enters the Catherine Island minor sub-basin. This water then proceeds to the Panther Refuge North minor sub-basin and begins to sheet flow south. Water sheet flows south in the rest of the project study area. This causes water to go through Fakahatchee North and around Small Road Island until it connects to I-75. Once the water reaches I-75, it continues along a canal either east or west until it passes underneath the road by way of a culvert. South of I-75, surface water sheet flows south until it reaches US 41(Tamiami Trail). Here it is conveyed by a canal to a culvert which then allows the water to go underneath US 41 and continue sheet flowing down to the coast unobstructed to the 10,000 islands area. These flows are all schematically depicted in Figure 2.2

2.4 Fluctuations in Flow

Prior to 1900 most of South Florida was inundated during the wet season. The average annual rainfall for the project study area (the region) is 52 inches with approximately 75% falling from May to October in the wet season (Cuevas, 2000). The majority of the wet season rains come from localized thunderstorms so rainfall records from stations separated by a few miles can vary significantly (Carlson et al., 1986). Large variations in rainfall across small areas can have a large impact on drainage patterns (Cuevas, 2000; Carlson et al., 1986). The groundwater levels also fluctuate according to the annual rainfall patterns since the shallow aquifer is primarily recharged by infiltration of local rainfall (Carlson et al., 1986).

Drought years bring increased saltwater intrusion and increased frequency of fires (Carlson et al., 1986). During normal rainy seasons the aquifer fills and there is sheet flow over much of the basin making the sloughs act as rivers. When the water rises, the first natural surface flows occur in the major strands and sloughs (Carlson et al., 1986). Then, as the rainy season ends the sheet flow ceases and the surface water level decreases, leaving only water in the sloughs. As it becomes drier the standing water steadily diminishes in the sloughs (Carlson et al., 1986).

Prior to development of the region, runoff flow was directed along natural drainage features of the Immokalee highlands through a series of strands and sloughs, and more broadly as sheet flows to the tidal passages of the Gulf of Mexico (DHI, 2001). Much has changed in the region over the last few decades.

Water that once moved via sheet flow through the basin in a general southwest direction toward the coast now is diverted and steered by the many canals in the area (Carlson et al., 1986). Over time, many canals were constructed to drain land for development and while this made development easier, it also greatly affected the neighboring natural communities (Carlson et al., 1986). The canals have over-drained some areas, which have resulted in a reduction of aquifer storage, invasion of upland vegetation, increased frequency of forest fires and an increase of fresh water discharges to the estuary (Kuester, 1998). The canals have also caused alterations in the water flow leading to lowered dry season water tables, point discharges of runoff rather than sheet flow patterns, decrease of dry season stages in the wetlands and a shortened hydraulic period in the wetlands (Johnson Engineering, Inc., 1998). As a consequence of canal construction some areas that once had a steady flow of water are now drier than ever before (Carlson et al., 1986).

As a historical example, during the 1960s, the extensive construction of the Golden Gate Estates and Faka-Union canal network, as depicted within Figure 2.2, which is approximately nine miles away from the Big Cypress National Preserve, caused water levels within the area to drop roughly 2 ft below pre-construction conditions (Carlson et al., 1986).

Also, as a result of the canals, water in the Central Big Cypress basin now flows either west or south (DHI, 2001). In Estero Bay, Trafford and the northwestern quarter of the West Collier sub-basin, water flows from the east to the west toward the Gulf of Mexico. The rest of the project study area flows from north to south toward the southern coast. Figure 2.2 highlights areas where the flows vary in direction based on localized rainfall events. There are of course some areas where the water flow is uncertain and varies depending on recent conditions. For example, the area between Lake Trafford and Corkscrew has water flowing in opposing directions depending on the time of year (Interagency Project Technical Team, 2005). With the low relief in the area (Figure 2.1), once an area becomes inundated, water can flow in either direction. When there is sheet flow over land it often is diverted by an artificial barrier, such as a berm or a ditch, which can change the direction of water flow. This is also a condition noted in the Bear Slough area of the East Collier Sub-basin (Interagency Project Technical Team, 2005).

Throughout the project study area, canals can simply be a by-product of roadway construction (i.e., providing fill materials). Such was the case for the Barron River Canal (Photo 2.2), materials used for State Road 29, and the creation of the Tamiami Canal was a by-product of the Tamiami Trail (US-41).

Photo 2.2. Barron River Canal along SR 29 within the Okaloacoochee Slough Sub-Basin.

The first major canal was excavated in the 1920's as a result of the US 41, Tamiami Trail, construction. As a result of this road, water now moves in an east-west direction until it can exit south through bridges or water conveyance structures (Sobczak, 2005). Some of the adjacent wetland habitats get too much fresh water while other areas receive too little water. The other major roadway is I-75 which runs east-west through the project study area and like US 41, diverts water to the west until it can pass underneath the road under a bridge or culvert (Sobczak, 2005). State Route 29 parallels a major canal that drains water to the south.

Besides the roads, two large canal systems run through the area. The Faka Union and Golden Gate canal systems are networks of typical ditch and drain systems that tend to over-drain the water table and alter the natural flows (DHI, 2001). These canals, in combination with other developments, have reduced the areas of functional wetlands, lowered groundwater levels, reduced aquifer recharge and contributed to concentrating the flow of runoff instead of allowing the traditional sheet flow across the land (DHI, 2001). About 75% of the annual flow in the major canals occurs in the six-month period June through November (Florida Department of Environmental Protection, 2001). This generally coincides with the wet season. These changes in flow characteristics resulted in a significant shift in the pre-development watershed boundaries (DHI, 2001). For example water that use to sheet flow between the middle sub-basins is now forced south by the network of canals (Carlson et al., 1986,). There is no well-defined system of streams in the basin except the tidal channels along the coast (Carlson et al., 1986). So the only real fixed passages for water flow are these canals

2.5 Flooding Areas

The Central Big Cypress Basin has very low relief and gently slopes to the south and west. The entire area is prone to inundation. This inundation is regarded as natural and is only considered flooding when it impacts human activities. Much of the project study area historically had standing water in the summer time; therefore, some water should be present and should not be considered flooding (Interagency Project Technical Team, 2005).

The DHI water model (Section 2.2; DHI, 2001) is capable of predicting the impacts of flood conditions. It was calibrated against observations made in 1993, a dry year, and in 1995, a wet year. Continuous simulation was performed from June 1993 to August 1995. Design storm distributions were imposed on the August 1, 1995 antecedent moisture conditions. Flood extent and elevations during the wet season were predictably small during the dry model year, but much more extensive during the wet season of the wet year. Most of the floodplain areas were shown to have standing water during the wet year. County Road 846 (Immokalee Road), County Road 858 (Oil Well Road) and I-75 were shown to impede water flows to the Fakahatchee Strand and to Okaloacoochee Slough. The highest flood elevations were in Corkscrew Swamp, the area north of I-75 in Fakahatchee Strand and the area west of the Barron River / SR-29 Canal.)

When heavy rains come most of the inundation is limited to the wetlands (DHI, 2001). For that reason special attention should be given to Corkscrew Swamp and the entire Okaloacoochee Slough drainage so that water is retained in these wetland systems without resulting in downstream or upstream flooding to agricultural systems. Flood storage capacity in the Okaloacoochee Slough is limited. This area will not provide sufficient flood protection to surrounding agricultural lands in the case of a large storm – for example, a 100-year event (Dames & Moore, 1998). This is partly due to the fact that most farmers ditch and drain their own land (Interagency Project Technical Team, 2005). Issues arise when ditches do not properly feed into a canal or when water finds its way into vegetated hillocks. As a result, when too much water reaches the end points of the ditches the water level rises and spills (Interagency Project Technical Team, 2005). The canals are the only direct waterways leading straight to the coast. Due to these conditions rainwater is not drained out of some areas and causes some areas to have standing water of varying depths (Dames & Moore, 1998). These issues are discussed in the Problem Identification Report section of this reconnaissance. Projects to address these issues have been recommended, and are discussed in Section 6 of this report.

2.6 Natural Areas

The project study area is mainly made up of a great deal of natural areas (see Sections 3 and 4). It is comprised of a variety of different habitats, and terrains: natural features such as swamps, marshes (Photo 2.3), wetlands, flatwoods, and estuaries, and man-made canal networks, and small sized urbanized areas. Despite the lack of specific development in this area, canalization of stormwater runoff has affected the wetland habitat and the natural flow of the area has been altered over time.

Photo 2.3 Natural Area in Corkscrew Sanctuary

Sheet flow has been reduced with the construction of canals, and drainage has decreased the extent and duration of natural inundation.

This can be observed in areas of the Big Cypress Preserve where hammocks are growing and vegetation is changing from aquatic to semi-aquatic (Sobczak, 2005). In the southern portion of the project study area and within the Big Cypress Preserve, salt water migration is evident and increasing. Areas located along SR 29 and north of US 41 have undergone an ecological shift and now support mangroves and other estuarine flora. In the western portion of the project study area, where development is rapid, areas in Flint Pen and Gordon Swamp have been drained and converted from undeveloped land to developed areas. Also with the current system of gates in the SR 29 canal, water is retained by closed gates during the dry season and allowed to rapidly flow through the canal when the gates are opened in the wet season. As a result, some downstream areas are very dry in the dry season since water is being held upstream. In the wet season some areas by US 41 are still dry since water is conveyed straight to the coast and not allowed to remain on the land-surface as was the historical case (Sobczak, 2005).

The majority of the natural areas are found south of I-75, and immediately east and west of SR-29. Bear Slough, located within the major sub-basin of East Collier, north of I-75 and east of SR-29 is the most remote natural, area within the project study area. The impact of development in one area of Bear Slough is described below in Section 2.7. Corkscrew Sanctuary and Rookery Swamp represent natural areas that are close to developed areas. The Big Cypress Preserve extends into only a small portion of the project study area, but is connected hydrologically to the project study area. As described in the following section, land use for agriculture or other uses seeks to increase drainage. Again, this can lead to incongruent management goals, because natural areas require management which approximates restoration of historic sheet flow, seasonal inundation, and slower drainage to the extent possible.

Photo 2.4 Typical Cattle Farm, East Collier Sub-Basin

2.7 Developed Areas

Developed land is also a feature of the project study area. Besides the unincorporated City of Immokalee there are large farms throughout much of the western portion of the project study area (Photo 2.4). Further development is inevitable as the population grows (Collier County Comprehensive Planning Department, 2004). The rapid growth and development of Collier County during the past decades, with rapid increases in

population and accompanying agricultural-to-urban land use transitions, has drawn a growing concern regarding water and environmental resources within the project study area region. As development increases, the natural drainage of the area will change if the past pattern of ditching and draining continues. Replacing wetlands and forests with impervious surfaces commonly found in urban developments and development of agricultural lands has increased the speed of stormwater runoff from the land surface (Florida Department of Environmental Protection, 2001). As more development occurs, the presence of standing water becomes less desirable – thus canals and drainage facilities are anticipated. These "works" must meet regulations for both the District and the respective County. Most permitted facilities must monitor groundwater quarterly and normally operate under a five year renewable permit (Florida Department of Environmental Protection, 2001).

In addition to urbanization, agricultural land-use is a significant factor that affects the hydrology of the project study area. Ditches and dikes, utilized to drain and irrigate farmland have been viewed as causing significant diversions to historical runoff patterns (Photo 2.5). In order to meet their farming needs, property owners have created systems of ditch / dike systems, which may cause adverse upstream or downstream effects during heavy rainfall.

2.8 Areas of Concern

Photo 2.5 Typical Farm Berm in Canal, Camp Keais Sub-Basin

Local Property Owner:
A field visit with the Consultant and District staff was conducted, and attended by a local property owner. This field visit represented the general concern about unstructured ditches that drain too rapidly and the likelihood of there being areas that would benefit from flow retention.

The field visit took place at a portion of the Bear Slough considered headwaters of a portion of the slough. The property owner reviewed Consultant project maps and indicated that sheet flow does not occur in a southward direction across his property. In summary, concerns included:

- Unimpeded flow that arises from ditches with no structures (i.e., gates, weirs) provides drainage for adjacent properties, but do not retain water. Rainfall periodically flows over roads and adjacent properties as it continues southward.
- Ditches excavated in limestone, may be disconnected hydraulically from the aquifer, therefore allowing little or no recharge or subsurface infiltration.

Big Cypress Mitigation Bank:

The Consultant and SFWMD staff met with the Director of the Big Cypress Basin Mitigation Bank. He stated that the mitigation bank is divided in two halves separated by the Berry Grove property. The western half, called Ruby Red, is approximately 1277 acres; the eastern half, called StarGlo is 1298 acres.

- A 'rock shelf' oriented on an east-west axis is located approximately three quarters of the way to the south within the mitigation bank sections (halves) and runs through the grove. This 'rock shelf' does act as a hydrologic barrier to surface water sheet flow; however, areas within the west mitigation bank section (Ruby Red) are hydraulically/hydrologically connected to the grove property and to the south.
- Both mitigation bank sections are surrounded by ditches on the north, east and west to prevent offsite flooding from the mitigation bank; however, surface water sheet flow is unimpeded to the south, to the Big Cypress Preserve.

Photo 2. 6. Fixed crest concrete weir located at entrance into CREW management center.

<u>Corkscrew Swamp</u>:
At the Corkscrew Regional Ecosystem Watershed (CREW), field verification focusing on points of discharge and drainages from agricultural areas located adjacent to and entering natural areas was conducted on April 15, 2005. Water levels are controlled by weirs (Photo 2.6), a pumping station (Photo 2.7), and drainage discharges (Photo 2.8). Drainage discharge points affecting the hydrology of the Corkscrew Marsh abound around the borders of the Corkscrew and adjacent Bird Rookery and Flint Pen minor sub-basins. As depicted in Figure 2.2, numerous drainage discharge points located along CR 850, SR 82 and further south along the northeastern boundary of Corkscrew Marsh were identified and visited. Numerous other point discharge locations to the west, southwest, south and southeast of the marsh also exist; however, these locations are not accessible without prior notification to the citrus grove property owners and/or accompaniment of District Compliance Staff. It appears that with the exception of a few major drainages identified during the field visit as channel flow entering the Corkscrew Marsh, i.e. the Carson Gulley Canal intersecting SR 82 from the north, a secondary canal located on CR 850 and approximately one-half mile southwest of the SR 82 intersection, and a drainage ditch located along TPI Road, located approximately one mile west of the entrance to the CREW Management Center on CR 850, the majority of the point discharges enter the marsh as sheet flow within a relatively short distance of the water control structure. All of the point discharge locations identified during the field visit have the potential to convey large amounts of water as channel flow or sheet flow to the natural areas. This water can represent a hydraulic load on the area as well as a potential water quality problem (Interagency

Project Technical Team, 2005). Specific locations of the point discharges that were identified during the field reconnaissance are summarized in Table 2.2.

TABLE 2.2. LOCATIONS OF OBSERVED POINT DISCHARGES TO CORKSCREW SANCTUARY

	Latitude	Longitude
Near TPI Road. A large ditch drains agricultural property on the north side of CR 850. The surface water runoff is conveyed under CR 850 via three, 36-inch diameter culverts	N 26 27' 03.3"	W 081 35' 42.4"
Ditches and a control structure (4, 36-inch culverts) associated with a citrus grove property located on the north and west side of CR 850 (at the 90 degree turn where CR 850 turns north for a short stretch).	N 26 27' 05.4"	W 081 33' 45.8"
Several smaller ditches were observed between the above two points		
A 6-inch diameter metal culvert conveys water from the north side of CR 850; water exits concrete box culverts on the south side of CR 850 and travels southeast into Corkscrew Marsh.	N 26 28' 35.5"	W W 081 33' 18.5"
Surface water runoff conveyed from the citrus groves located on the north side of CR 850 at this location enters Corkscrew Marsh via three, concrete culverts.	N 26 29' 00.1"	W 081 32' 48.7"
Additional surface water runoff conveyed from the citrus groves located on the north side of CR 850 at this location enters Corkscrew Marsh via three, concrete culverts.	N 26 29' 25.3"	W 081 32' 16.3"
Surface water runoff conveyed from the citrus groves located on the north and south side of SR 82 enters Corkscrew Marsh via the Carson Gulley Canal	N 26 30' 18.2"	W 081 30' 40.5"
Pumping station and outfall convey water into the Corkscrew Marsh. Further to the south a ditch conveyed surface water runoff westward into the Marsh.	N 26 28' 10.4"	W 081 29' 53.4"

In and around the Bird Rookery Swamp area and immediately northwest of the Corkscrew Canal, the Audubon Cross Dike surrounds an area of logging tram roads. Projects to improve the local hydrology are currently being implemented or pending implementation. The District is in the process of installing eight, 60-inch culverts to facilitate sheet flow through this area. There are two ditches that originate in the vicinity of a 40-acre palm tree farm that border County Line Road that drain to the south to convey peak flows (Figure 2.2). The District is improving areas immediately to the east by removing existing dirt roads, such as Poor Mans Pass and the plugging of deep water canals which intersect the western, County Line Road ditch and facilitated the drainage of portions of the Gordon Swamp area. Corkscrew Canal is being widened to augment drainage in this area (Interagency Project Technical Team, 2005).

As a result of a meeting of the Project Technical Team, several additional specific concerns in the project study area were expressed:

(Left) Photo 2..7 Citrus Grove Pumping Station located at northeastern boundary of Corkscrew Marsh
(Right) Photo 2.8 Concrete tri-culverts conveying agricultural runoff into Corkscrew Marsh

1. Drainage north of Corkscrew Swamp and Wildcat Farms provides too much water to the south and may include runoff from agricultural land use – primarily citrus.
2. Drainage ditches down the Okaloacoochee Slough and SR29 canal rapidly drain areas that could benefit from flow retention projects; through discussions with Big Cypress Preserve National Park Services the current canal system can allow saltwater migration well within the SR29 Canal system. Apparently, migration can occur as far as north of Tamiami Trail US41.
3. The SR 29 Canal (i.e., Barron River Canal) gate control system needs to be re-configured to convey water more in an west to east fashion (i.e., feeding the Preserve fresh water) versus the current situation – flushed directly out to coast.
4. There needs to be a consensus from agencies to monitor flows under I-75. Field reconnaissance meeting with Big Cypress National Preserve identified that flow data and stage data collection stopped years ago (i.e., since the late 1980's). The original design of I-75 was to make the highway corridor "invisible" to minimize impedance of flow. However, it was identified that data collection to support this has never been analyzed for the existing highway.
5. Within the Bear Slough area of the East Collier minor sub-basin, there is a need for further investigation of a system (i.e., possibly a spreader canal) to dissipate the canal flows coming from a citrus farmland reservoir /impoundment lake directly into the Big Cypress National Preserve. The canal was described as a direct-point discharge and needs to be dissipated prior to entering into the Preserve. The runoff from the farmland is entering into the Preserve, which is an Outstanding Florida Waters (OFW). There may be issues with rate of discharge, erosion, and water quality.

3. HYDROLOGIC AND LAND USE/COVER BASELINE CONDITIONS AND PROJECTED FUTURE CONDITIONS

3.1 Introduction

An important consideration when assessing the environmental condition of an area is the land use and land cover. The land use and cover dictate the local hydrology with respect to stormwater runoff quantity and quality, flooding potential, and ground water recharge. Different land uses/covers, such as residential, industrial, commercial, recreational and wetlands, will impact the hydrology of the basin in unique ways.

Additionally, the changes in land use and cover over time are important in evaluating the hydrology of an area. Florida is experiencing a tremendous increase in population, which in turn spurs the construction of additional utilities, services, institutions, etc. to support the growing communities. These result in land use and land cover changes and ultimately hydrologic changes within the basin. Between the year 2000 and 2025, the State's Office of Economic and Demographic Research has estimated that Florida's population will increase by 53% to nearly 25.5 million residents (The Office of Economic and Demographic Research, March 2005). The heavily populated counties in Southwest Florida, Lee and Collier, are expected to significantly out-pace Florida's growth rate. Collier's population is expected to more than double, and Lee's to increase by about 90% during that time (The Office of Economic and Demographic Research, March 2005). While most of the population is, and will likely continue to be located along the coast, an increase in development is also expected in inland areas, specifically within the Central Big Cypress Basin (the CBCB project area). Other considerations affecting the land use/land cover and corresponding hydrology include the competing interests of the agricultural community as well as conservation, preservation and restoration efforts.

The purpose of this chapter is to review the existing and expected future land use/cover within the Basin boundaries in order to better understand existing and future hydrologic conditions. The consideration of land use and cover is especially important within the boundaries of the Central Big Cypress Basin as increasing development demands encounter conservation, preservation and restoration initiatives.

3.2 Methods

The initial activity in evaluating the hydrologic effects of the land uses was obtaining existing and future development land use/cover maps for the CBCB project area. Generally, this information can be gathered from county planning departments and similar agencies.

The majority of the information provided in this chapter is based on a review of existing information provided by the Project Technical Team – primarily South Florida Water Management District staff. Electronic data available on the county and other agency websites were obtained. Some of the reports include the Immokalee Area Master Plan

including existing and future land use maps (Collier County Planning Services Department Comprehensive Planning Section, 2003 (2)), Golden Gate Area Master Plan (Collier County Planning Services Department Comprehensive Planning Section; 2003 (1)), The Lee Plan (Lee County Department of Community Development Division of Planning, 2003), Collier County Growth Management Plan Documents, South West Florida Feasibility Study preliminary data (South West Florida Feasibility Study, 2005), Ave Maria Future Land Use Map, South Florida Water Management District Baseline 2000 Land Use Map, among others. Additionally, the Preliminary Findings Report of the Collier County 2005 Residential Build-Out Study dated March 2005 and the 2025 Long Range Transportation Plan Update (revised and adopted March 23, 2001) were reviewed. Staff members from the South Florida Water Management District and County Planning Departments were also contacted to obtain additional information on the CBCB project area.

Land use and cover has received greater attention recently in Southwest Florida as efforts are made to model impacts resulting from various future scenarios. There are three specific documents which present the most up to date future land use and cover information for the study area, which are the LWC planning area 2025 land use map, the LWC planning area 2050 land use map (utilized for CERP work) and the Collier County Future Land Use Map. The Collier County Future Land Use Map does not purport to predict future conditions, but rather maintains future conditions based on projects presented to County planning staff. The LWC planning area 2025 and 2050 land use maps have been developed by staff working on the South West Florida Feasibility Study (SWFFS) based on a comprehensive review of base mapping of other studies, county planning documents and aerial photographs, as well as coordination and meetings with agencies and individual land owners. Based on the information obtained, guidelines were created by District and County planning staff in order to provide the best estimate of development for both the 2025 and 2050 scenario and were applied to baseline data in order to generate these future land use maps. Although mentioned above, the 2050 land use map used for CERP work is beyond the planning horizon of this reconnaissance and is not presented in this report. It is important to note that only a portion of the project study area for the SWFFS is in the Central Big Cypress Basin which is the focus of this report. It is also important to note that although the map presented as the future land use/land cover for 2025 appears definitive, it represents a projection of future land use based on the input of personnel involved in the SWFFS (South West Florida Feasibility Study, 2005).

The mapping conducted as part of the SWFFS was chosen as the best estimate of future conditions due to its comprehensiveness. A comparison of the SWFFS mapping with other available county land use/cover maps did not reveal material discrepancies. In comparing the preliminary findings of the 2005 Residential Build-Out Study to the SWFFS, similar projections were found although the build-out study included two areas of growth not included in the SWFFS.

However, the build-out study does not make any predictions for when build out will occur (Collier County Comprehensive Planning Department, 2005) and therefore this

report considers the SWFFS the best available representation of the 2025 planning horizon.

For the purposes of this report, the extensive land use/land cover classifications were condensed from over 50 categories used in the SWFSS maps to only 18. The collapsing of the categories was done based on hydrologic considerations, in other words, classifications that would have similar hydrologic effects were combined in order to more readily discern the changes between existing and future conditions. For example, Commercial and Services includes Commercial & Services, Institutional, Urban Open Land, Urban Open Land in Transition, Communications and Utilities. Table 3.1 provides the consolidated land use/cover classifications used for this project.

TABLE 3.1. CENTRAL BIG CYPRESS BASIN CONSOLIDATED LAND USE/LAND COVER CATEGORIES

Central Big Cypress Basin Report Land Use/Land Cover Categories	SWFFS Land Use/Land Cover Categories
Agriculture	Improved Pasture
	Unimproved and Woodland Pasture
	Row Crops
	Field Crops
	Sugar Cane
	Tree Crops
	Citrus Groves
	Feeding Operations
	Nurseries and Vineyards
	Sod Farm
	Specialty Farms
	Rural Open/Fallow Land
Barren	Beaches Other Than Swimming Beaches
	Sand Other Than Beaches
	Disturbed Lands
Commercial & Services	Commercial and Services
	Institutional
	Urban Open Land
	Urban Land in Transition
	Communications
	Utilities
Extractive	Extractive
	Holding Pond/Borrow Area
Golf Courses	Golf Courses
Industrial	Industrial
	Light Industrial
Mobile Homes	Mobile Homes
Rangeland	Herbaceous
	Shrub and brushland
	Mixed Rangeland
Recreational Other Than Golf	Recreational Other Than Golf
Residential High Density	Residential High Density
Residential Low Density	Residential Low Density
Residential Medium Density	Residential Medium Density
Transportation	Transportation
Upland Forests	Upland Coniferous Forests
	Upland Hardwood Forests
	Exotic Tree Species
	Tree Plantations
Water	Bays and Estuaries
	Stream and Waterways
	Lakes
	Reservoirs
	Slough Waters
Wetlands	Wetland Hardwood Forests
	Mangrove Swamps
	Wetland Coniferous Forests
	Wetland Mixed Forests Vegetated Non-Forested Wetlands
	Freshwater Marshes
	Wet Prairies
	Aquatic Vegetation
	Saltwater Marshes
	Non-Vegetated Wetlands

3.3 Existing and Projected Future Land Use/Cover Conditions

3.3.1 Baseline Conditions

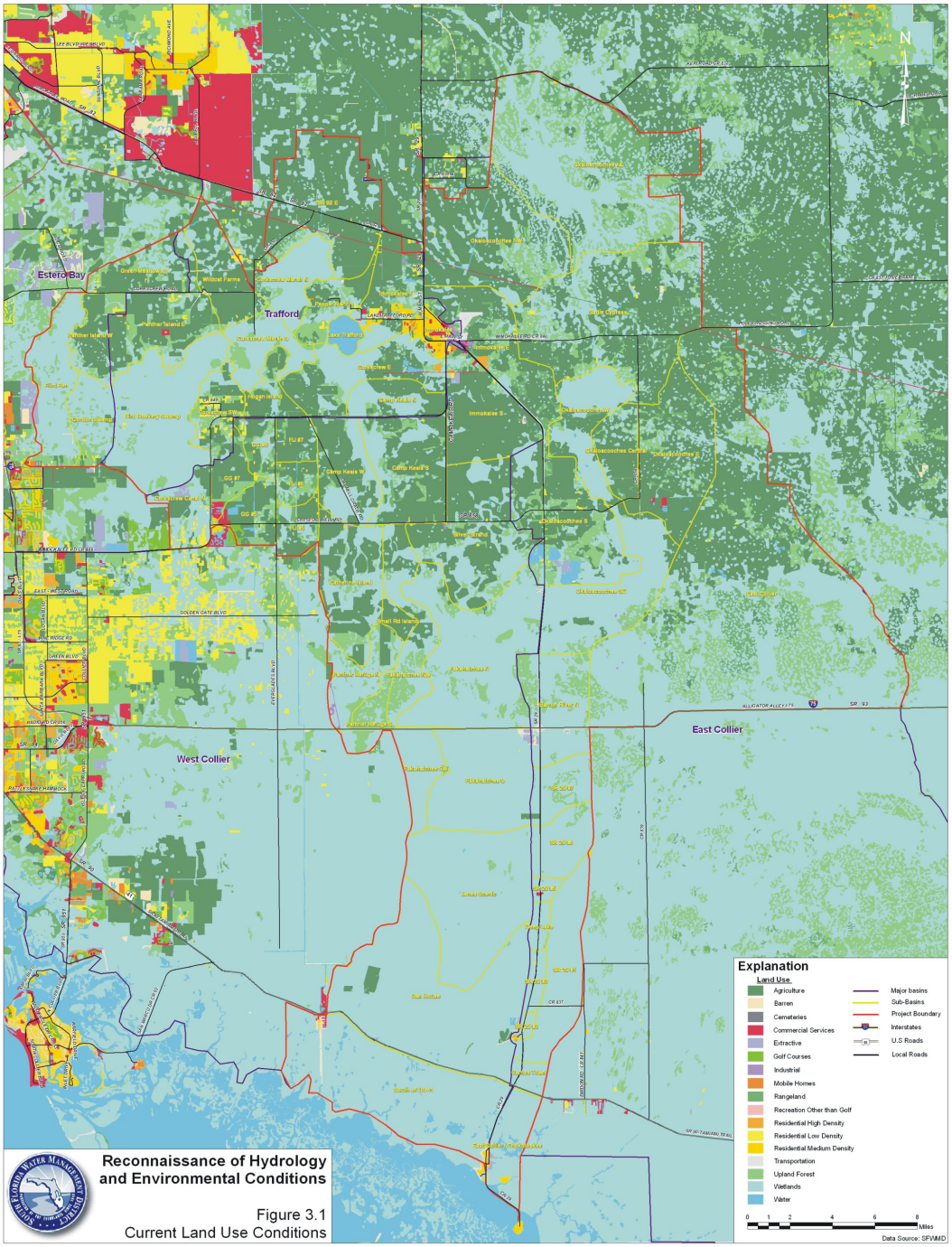
Figure 3.1 illustrates existing Land Use/Land Cover Baseline Conditions for the Central Big Cypress Basin. The Baseline map is a simplified version of the Draft Lower West Coast (LWC) Planning Area 2000 – base Land Use/Land Cover map completed as part of the ongoing South West Florida Feasibility Study SWFFS.

3.3.2 Projected Future Conditions

Figure 3.2 illustrates Projected 2025 Land Use/Cover Conditions for the Central Big Cypress Basin. The future conditions map presented is based on the Draft LWC Planning Area Estimated 2025 Land Use map completed as part of the ongoing SWFFS.

3.3.3 Existing vs. Future Conditions General Comparison

An overall comparison of projected land use changes in the CBCB project study area is summarized in Table 3.2. Figure 3.2 graphically shows the areas where changes are planned. A comparison of existing land use/land cover within the CBCB study area compared to future land use/land cover conditions indicates no material change within the Basin south of CR 858 Oil Well Road. This area comprises a substantial portion of the basin and includes a combination of wetlands and water land use/land cover classifications with small amounts of agricultural areas intermingled. The majority of this portion of the project area is already part of preservation areas, including the Florida Panther National Wildlife Refuge, Fakahatchee Strand State Preserve, Big Cypress National Preserve and Everglades National Park, with additional strategic land acquisitions planned for the future (U.S Army Corps of Engineers, 2004).



.**Figure 3.1. Current Land Use Conditions**. This figure is inserted in a larger format at the end of this document.

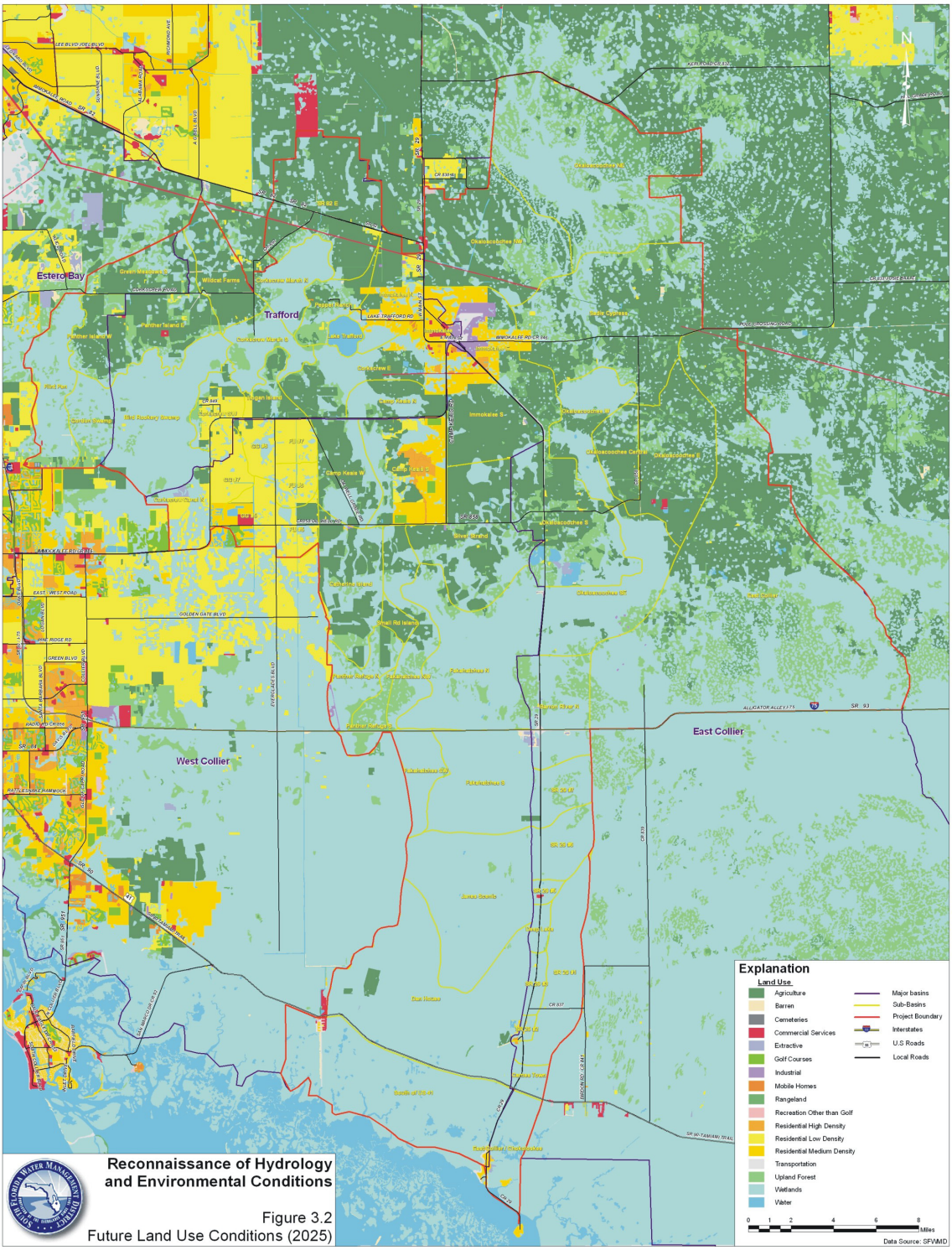


Figure 3.2 Future Land Use Conditions (2025). This figure is inserted in a larger format at the end of this document.

TABLE 3.2. CENTRAL BIG CYPRESS BASIN EXISTING AND FUTURE LAND USE/LAND COVER AREA COMPARISON

Land Use/ Land Cover	Existing (2000) Acres	Future (2025) Acres	Change acres
Agriculture	172,754	150,213	-22,541
Barren	1,045	958	- 87
Commercial & Services	1,435	1,391	- 44
Extractive	1,039	656	- 383
Golf Courses	188	546	+ 358
Industrial	582	1,877	+ 1,295
Mobile Homes	175	175	No change
Rangeland	16,417	14,166	- 2,251
Recreational Other Than Golf	51	119	+ 68
Residential High Density	279	1220	+ 941
Residential Low Density	2,592	19,437	+ 16,845
Residential Medium Density	2,194	15,380	+ 13,186
Transportation	1,838	1,838	No change
Upland Forests	63,518	55,854	- 7,664
Water	4,971	4,971	No change
Wetlands	340,493	340,769	+ 276

Source: SFWMD GIS data

Notes: Future conditions presented assume no change in wetlands land cover.
Short hydroperiod wetlands, in the GIS data, are accounted for as upland forest. Therefore, the overall gain in wetlands indicated above does not reflect the fact that short hydroperiod wetlands are lost.

In general the land use/land cover is anticipated to change to more urban land uses. In Lee and Collier counties, the percentage of agricultural land use is projected to decrease as a result of urban encroachment (South Florida Water Management District, 2000). This is reflected in the Table 3.2 above with an estimated reduction of 22,541 agricultural acres and increases in Residential Low Density and Residential Medium Density acreages of 16,845 and 13,186 acres respectively. Although agricultural acreage reductions are projected, more intensive agricultural land uses are anticipated, such as an increase in citrus production in Hendry County and northern Collier County. These shifts in agricultural activity have the potential of further impacting the natural hydrology and introducing contaminants to downstream surface waters (South Florida Water Management District, 2000).

Other county-wide general land use/land cover changes anticipated to occur involve planned transportation projects. Table 3.3 below summarizes anticipated transportation route improvements likely to occur within the project study area based on the 2025 Long Range Transportation Plan Update by the Collier County Metropolitan Planning Organization. Roadway improvements will increase impervious area within the project study area thus impacting the hydrology.

TABLE 3.3. CENTRAL BIG CYPRESS BASIN LONG RANGE TRANSPORTATION PLAN UPDATE 2025 (2025 NEEDS PLAN IMPROVEMENTS)

Roadway Name	FROM/TO	IMPROVEMENT
Alt. CR 29 (New Market Rd.)	SR 29 North to SR 29 South	Two to Four Lanes
Immokalee Loop Rd.	Lake Trafford Rd. to CR 846 (Immokalee Rd.)	New Four Lane Road
Immokalee Rd.	I-75 to SR 29	Two to Four Lanes
Immokalee Rd.	I-75 to Oil Well Rd.	Four to Six Lanes
Immokalee Rd.	SR 29 to Immokalee Loop Rd.	Two to Four Lanes
Lake Trafford Rd.	Immokalee Loop Rd. to SR 29	Two to Four Lanes
SR 29	SR 82 to 1.75 mile west of CR 846	Two to Four Lanes
SR 29	Alt. CR 29 South to Immokalee Loop Rd.	Two to Four Lanes
SR 82	Lee County Line to SR 29	Two to Four Lanes

Source: Adapted from Collier County Metropolitan Planning Organization, 2001
Note: Table presents transportation projects within the project study area boundary only.

In addition to the general comparison above, the most significant changes in land use/land cover are anticipated to occur in three geographical areas: 1) the growth of the unincorporated town of Immokalee, 2) the development of the Ave Maria University and associated town, and 3) the development of the northernmost extension of the Golden Gate Estates. As these three areas indicated the most substantial change in land use/cover, they are discussed in greater detail in Section 3.4.

3.4 Areas of Significant Land Use/Cover Changes

3.4.1 Immokalee

Immokalee is the only urban center located within the CBCB project study area. Immokalee straddles the boundary between hydrologic sub-basins and is at a regional high point. The west side of Immokalee drains into the Trafford Sub-Basin, the area around the airport to the northeast drains via canals to the East Collier Sub-Basin, and the southern part of the urbanized area drains to the south and west into the West Collier Sub-Basin. The drainage is channelized and controlled, and future development will be required to detain and convey water so that impacts from stormwater are minimized.

As a percentage of the existing population, substantial growth is expected in the unincorporated town of Immokalee. As stated in the *Collier County, FL 2003 Economic, Demographic & Community Profile*, the 2000 Census stated the population of Immokalee was at 21,846 with a projected growth to 37,891 in 2025 (Collier County Community Development & Environmental Services Division Comprehensive Planning Department, July 2004). As evident in the comparison of Figure 3.1a (existing) and Figure 3.2a (future), considerable land use changes are projected to occur in order to meet the needs of this expanding urban center. Table 3.4 below shows the existing land use, future (2025) land use and change in land use. As shown in Table 3.4, substantial agricultural acreage is expected to be converted to medium density residential use.

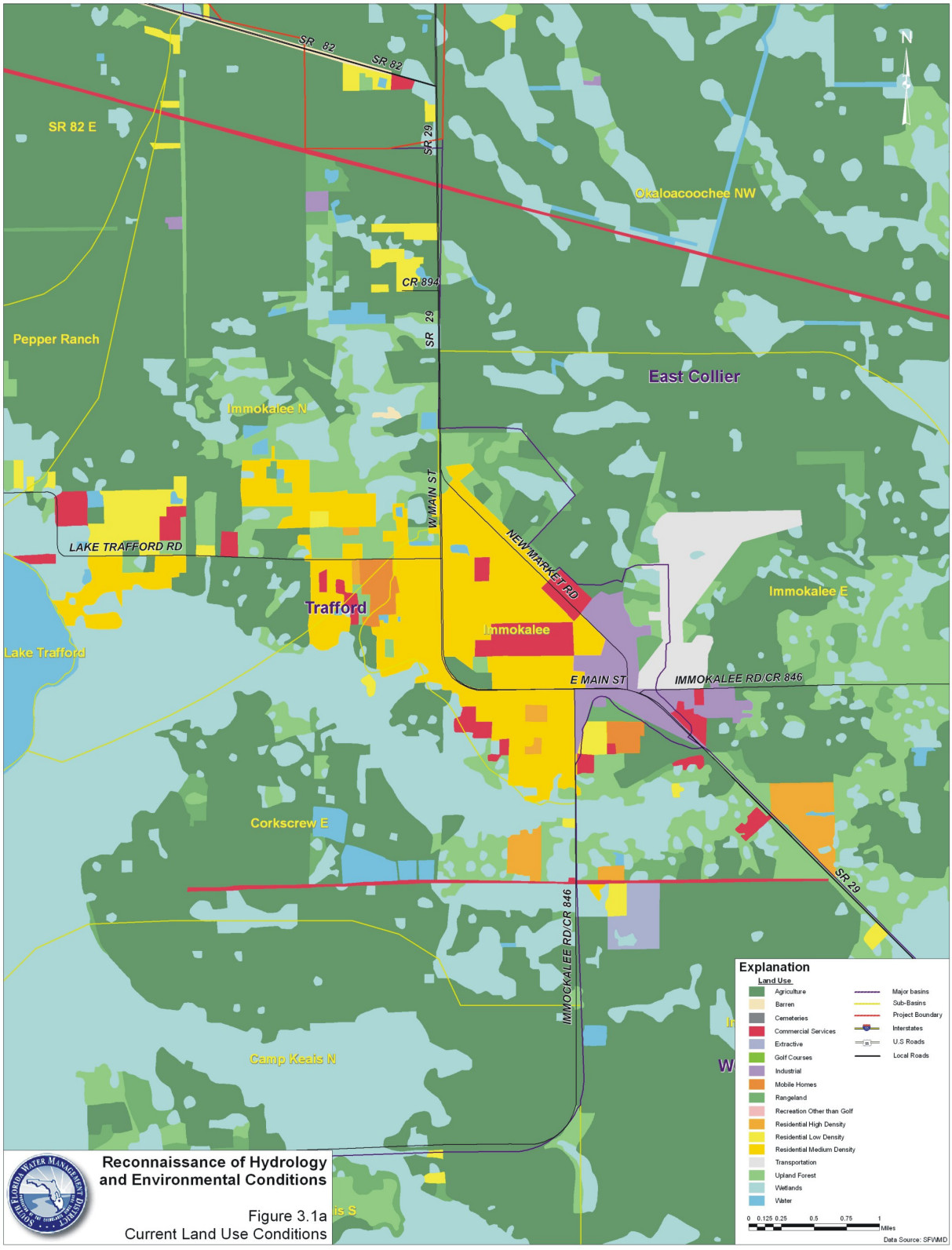


Figure 3.1a. Current Land use Conditions: Immokalee Region.

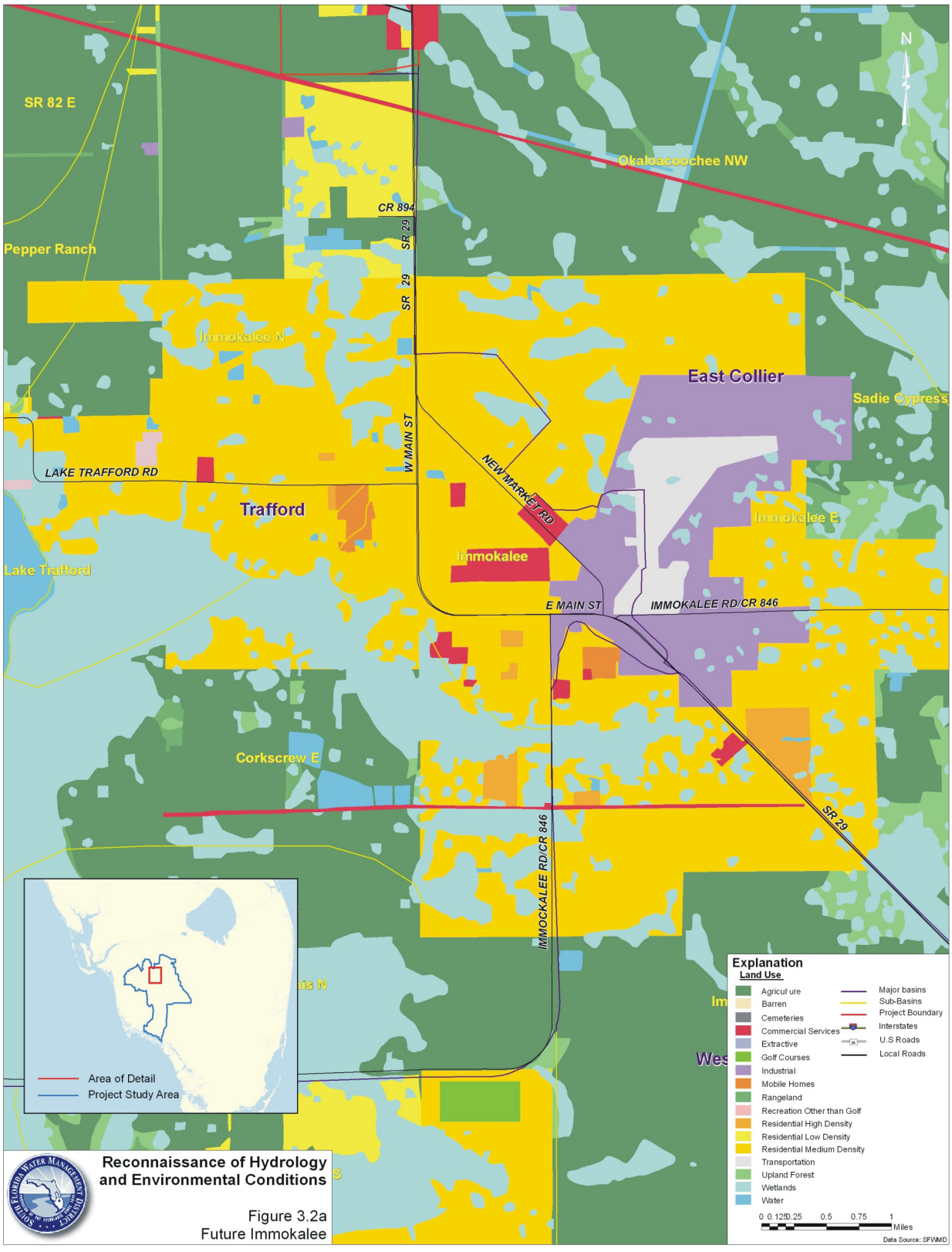


Figure 3.2a. Future (2025) Land use Conditions: Immokalee Region.

TABLE 3.4. IMMOKALEE EXISTING AND FUTURE LAND USE/LAND COVER AREA COMPARISON

Land Use / Land Cover	Existing (2000) Acres	Future (2025) Acres	Change acres
Agriculture	18,842	12,773	- 6,069
Barren	11	3	- 8
Commercial & Services	505	395	- 110
Extractive	96	0	- 96
Golf Courses	0	5	+ 5
Industrial	349	1,646	+ 1,297
Mobile Homes	112	112	No change
Rangeland	1,222	568	- 654
Recreational Other Than Golf	38	38	No change
Residential High Density	240	240	No change
Residential Low Density	408	327	- 81
Residential Medium Density	1,737	9,936	+ 8,199
Transportation	489	489	No change
Upland Forests	3,833	1,350	- 2,483
Water	869	869	No change
Wetlands	10,218	10,218	No change

3.4.2 Town of Ave Maria

As part of the Ave Maria University development and associated Ave Maria town, almost 5,000 acres of agricultural land will be converted to urban land use (Smith, 2005). This development is planned in an area of largely farmland that is south of Immokalee Road and west of Camp Keais Road, in the West Collier Sub-Basin. The existing land use for this development area is shown in Figure 3.1b. Project buildout is expected in 2017 and will result in the Ave Maria town housing an estimated 24,000 people as well as 6,000 residents at the Ave Maria University (Smith, 2005). Future land use conditions of the development area are shown in Figure 3.2b.[2] Although the new development will include public facilities such as schools, single family homes, condominiums and affordable housing units, additional associated development in Immokalee is anticipated (Smith, 2005). Table 3.5 below shows the existing land use, future (2025) land use and change in land use for the Ave Maria development.

[2] Detailed plans for the Ave Maria campus center were not available so the campus center and surrounding residences were all categorized as “Residential High Density” in Figure 3.2b and Table 3.4. The stormwater conditions in Residential High Density are similar to those in Institutional land uses, so this simplification is adequate for this analysis

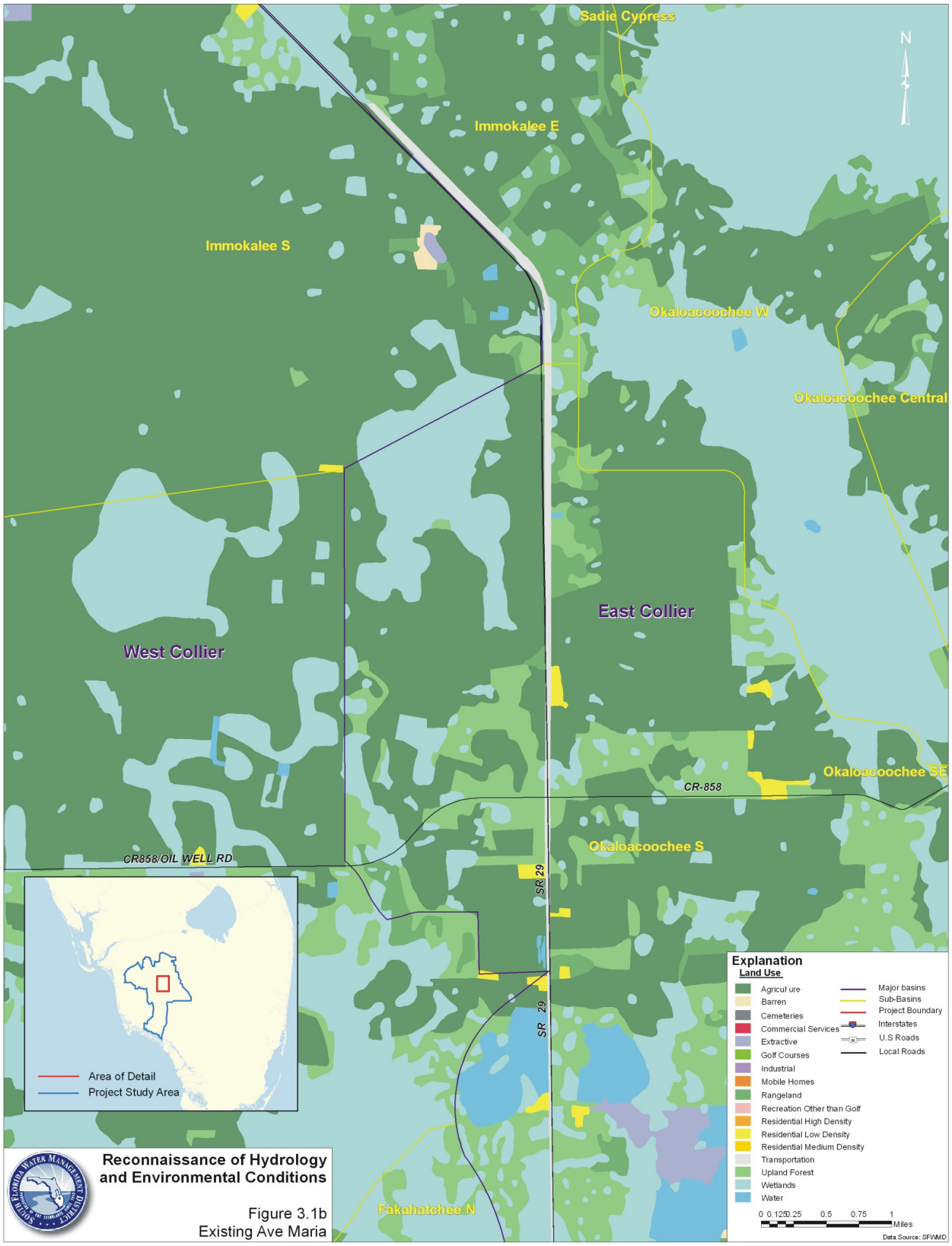


Figure 3.1b. Existing Land Use Conditions: Ave Maria Region.

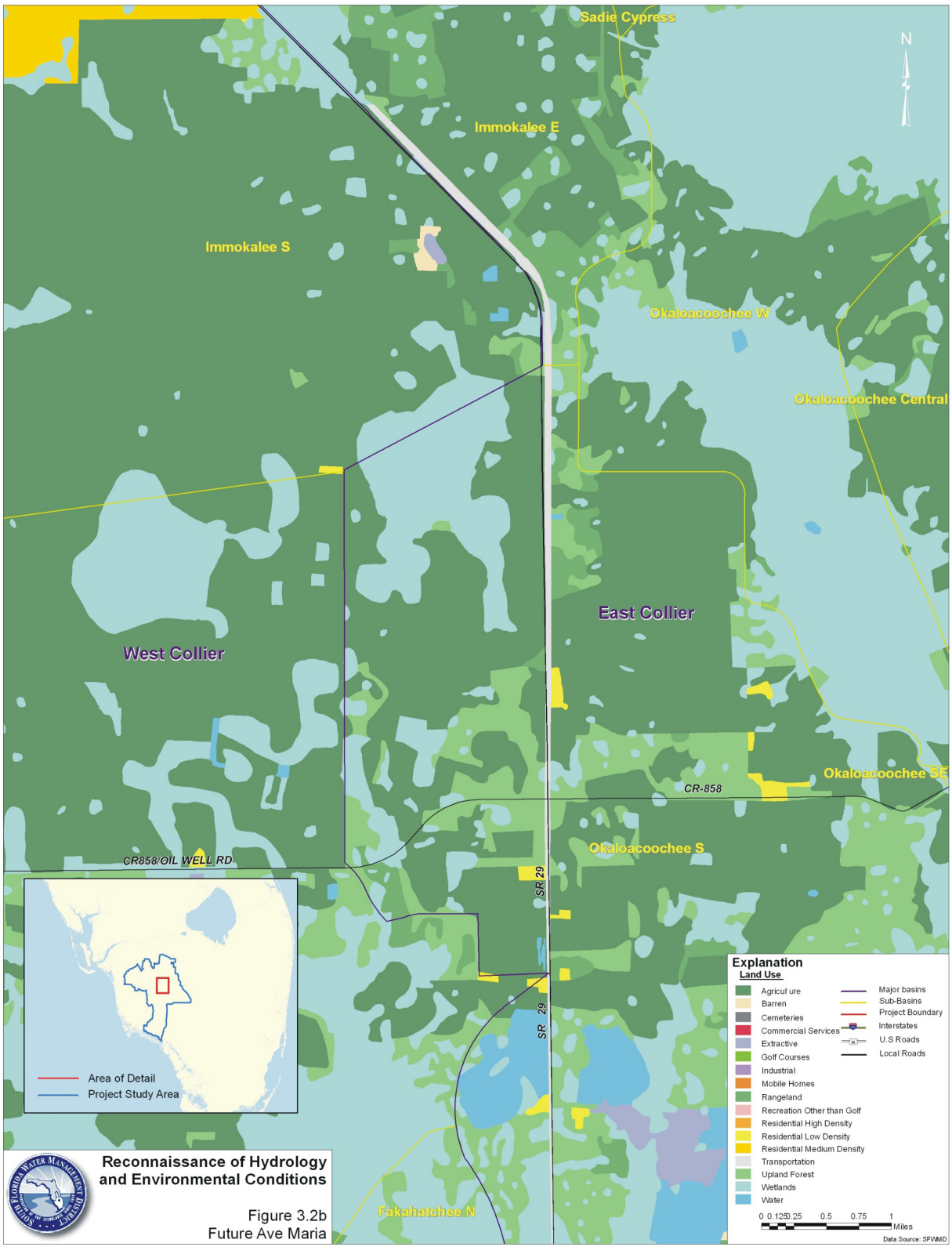


Figure 3.2b. Future (2025) Land Use Conditions: Ave Maria Region.

TABLE 3.5. AVE MARIA EXISTING AND FUTURE LAND USE/LAND COVER AREA COMPARISON

Land Use/ Land Cover	Existing (2000) acres	Future (2025) Acres	Change Acres
Agriculture	5,263	812	- 4,451
Barren	0	0	No change
Commercial & Services	0	0	No change
Extractive	0	0	No change
Golf Courses	0	314	+ 314
Industrial	3	3	No change
Mobile Homes	0	0	No change
Rangeland	106	0	- 106
Recreational Other Than Golf	0	0	No change
Residential High Density	0	931	+ 931
Residential Low Density	9	413	+ 404
Residential Medium Density	9	3,485	+ 3,476
Transportation	0	0	No change
Upland Forests	579	10	- 569
Water	1	1	No change
Wetlands	1,159	1,159	No change

3.4.3 Golden Gate Estates Development

In the 1960's, Gulf America Corporation began the planning and development of the Golden Gate Estates, an approximately 173 square mile area in Collier County, located largely adjacent to the southwestern boundary of the CBCB project area west of Fakahatchee Strand in the Picayune Strand drainage. The area was planned to be developed as a residential subdivision and although infrastructure such as roads and canals were put in place, the development failed prior to building many of the planned residences (United States Army Corps of Engineers, Jacksonville District & South Florida Water Management District, 2004). A northernmost extension of the Golden Gate Estates based on Collier County planning documents, north of Interstate 75, is included within the boundaries of the Central Big Cypress Basin and is one of the three significant areas anticipated to see considerable changes in land use/land cover over the planning horizon of this report. A comparison of existing and future land use/land cover areas for the portion of the Golden Gate Estates within the boundaries of the Central Big Cypress Basin is shown in Table 3.6, Figure 3.1c and Figure 3.2c.

Approximately two-thirds of the agricultural uses will be converted to residential developments in the northernmost extent of the Golden Gate Estates which falls within the boundaries of the project study area. This development will be done in conjunction with additional development located in the Northern Golden Gate Estates and a major restoration project that is focusing on the entire Golden Gate Estates, which extends to the west of the CBCB study area. The restoration project is co-sponsored by the Army Corps of Engineers and the State of Florida (http://www.evergladesplan.org/docs/fs_sgge_061504_english.pdf). The goals of this $362 million project are to:

- Maintain drainage to developed properties,
- Improve aquifer recharge to protect water supply and prevent saltwater intrusion,
- Restore and enhance habitat for fish and wildlife,
- Reduce point discharges of freshwater,
- Preserve upland habitat,
- Control invasive exotic plants,
- Reestablish water flows to wetlands to near historic levels,
- Improve water quality of stormwater runoff,
- Reduce or eliminate overdrainage of adjacent, sensitive ecosystems,
- Provide resource-based recreational opportunities, and
- Provide comprehensive habitat restoration for the greater Everglades system.

These goals will be achieved by large-scale land acquisitions and the adjustments to the hydrologic conditions that will be accomplished by the removal of roads, and construction of spreaders, pump stations and plugging of existing canals.

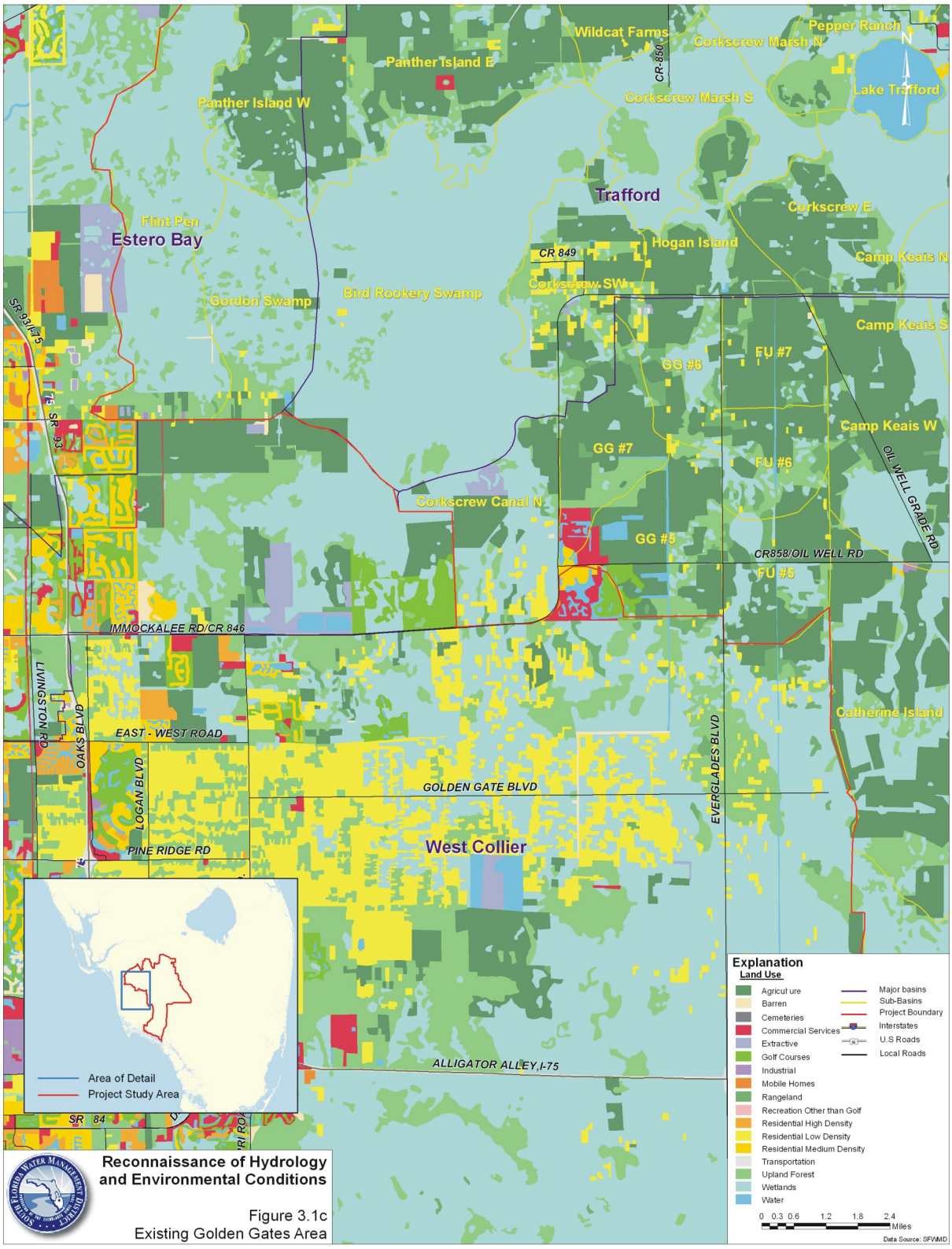


Figure 3.1c. Existing Land Use Conditions: Golden Gate Estates

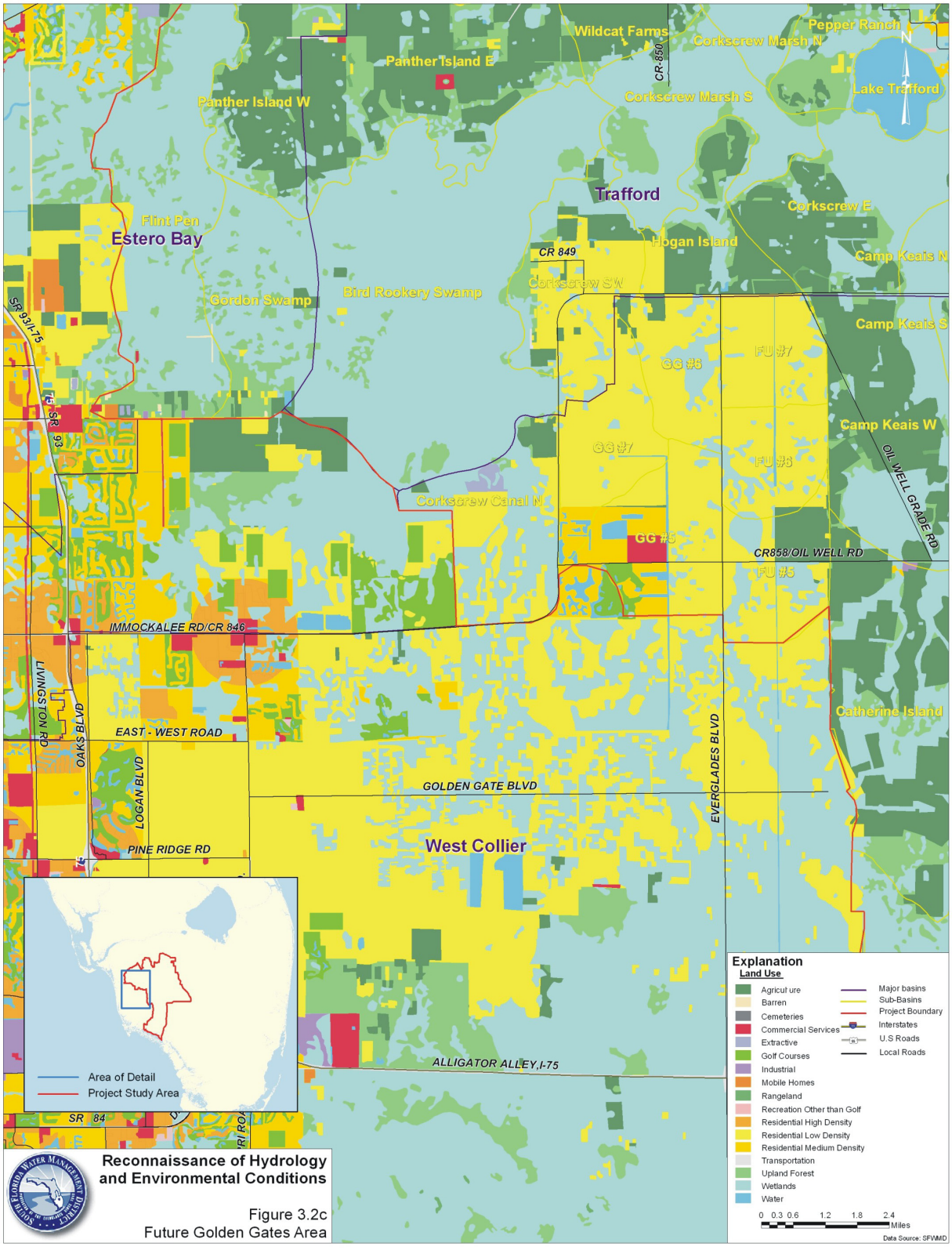


Figure 3.2c. Future (2025) Land Use Conditions: Golden Gate Estates.

TABLE 3.6. GOLDEN GATE ESTATES EXISTING AND FUTURE LAND USE/LAND COVER AREA COMPARISON

Land Use/ Land Cover	Existing (2000) Acres	Future (2025) Acres	Change Acres
Agriculture	17,261	6,849	- 10,412
Barren	64	42	- 22
Commercial & Services	406	256	- 150
Extractive	315	160	- 155
Golf Courses	226	226	No change
Industrial	38	38	No change
Mobile Homes	41	41	No change
Rangeland	1,453	85	- 1,368
Recreational Other Than Golf	0	0	No change
Residential High Density	9	9	No change
Residential Low Density	997	15,427	+14,430
Residential Medium Density	92	1,371	+ 1,279
Transportation	10	10	No change
Upland Forests	6,145	2,544	- 3,601
Water	466	466	No change
Wetlands	20,464	20,464	No change

3.5 Impacts of Land Use/Land Cover Changes on Hydrology

As land use intensifies to meet the needs of the growing population found in the CBCB project study area, hydrological changes will be evident. More intensive agricultural uses which are anticipated to occur on a general level throughout the study area may impact hydrology by:

- possible water table draw down associated with drainage systems and increased water usage
- modifying water runoff from natural sheet flow to channel flow
- inadequately recharging the groundwater due to drainage systems
- potential flooding concerns for areas located downstream of channelized flows and/or modification of previous water runoff patterns

In addition to effecting water quantity and flow patterns, more intensive agricultural uses have the potential to impact water quality as a result of fertilizer and pesticide usage (South Florida Water Management District, 2000). All construction is regulated by the

counties and the SFWMD, and these agencies are charged with reviewing development plans to insure that plans meet drainage regulations (Section 3.6) and that Best Management Practices are installed that minimize impacts.

Similar hydrologic concerns as above are associated with the development of the three significant areas of Immokalee, Ave Maria, and Golden Gate Estates. As these areas are anticipated to develop into more intensive urban land uses from their existing agricultural or forested land uses/land cover, additional stormwater runoff quantity concerns exist due to the increase in impervious area. It will be important for new developments to handle not only the stormwater within their boundaries, but also to manage off-site flows that have historically drained onto the site. Reviews of plans are conducted by the SFWMD, FDEP and the counties by evaluating pre-and post-development stormwater flows.

Water quality impacts are also associated with urban areas. Impacts may originate from point sources, such as industrial facilities, or non-point sources, such as roadways and parking lots. As these developments must satisfy federal, state and local criteria for stormwater quality criteria, the potential impacts associated with these developments is minimized.

3.6 Regulatory Controls

The preceding section, Section 3.5, describes how land use changes can alter conditions. Proposals to change land uses are reviewed and approved by various regulatory means. First, preserves, wetlands, and other special habitats have very limited activity that can take place. Second, zoning and master planning restrict the usage of other lands to allowed activities. However, for activities that are permitted by zoning and lie within areas that are not preserved, regulatory control of stormwater discharges is the primary means of avoiding and minimizing impacts. These regulatory controls are summarized here.

The three counties that comprise the CBCB project study area all regulate development so that stormwater is collected and detained on site, thus alleviating downstream potential for flooding in anything but the most severe storms

The South Florida Water Management District regulates drainage water quality, as well as the limits of controlled stormwater attenuation (i.e., water quantity). These factors have been established within the *Environmental Resource Permit (ERP) Information Manual Volume IV, December 2004 Update*. The manual outlines specific parameters which must be met to modify existing land-use and develop a parcel of land. The water quality and water quantity rules within the South Florida Water Management District jurisdictional area are found within Florida Administration Codes (FAC) 40E-4, 40E-40, and 40E-400. The ERP Manual, Section 5.0 is specific to wet / dry, retention / detention systems as well as the specified volume of water warranted for each impervious area. In addition, Water Quantity, listed within the ERP Manual Section 6.0 provides guidance on the Design Storm ($Q_{allowable}$), which is typically set as a 25-yr frequency / 72 hour duration for setting pre-development and post-development discharge rates. The Flood

Criteria included in the South Florida Water Management District ERP Manual specify the peak stage criteria as utilizing the 100-yr frequency / 72 hour rainfall event.

In addition to SFWMD requirements, there are additional regulatory considerations for the CBCB project area, which includes a national preserve (i.e., the Big Cypress National Preserve) and other volume-sensitive areas. For instance, Water Quality provisions established by the Florida Department of Environmental Protection (FDEP) in protecting National Preserves, qualifies Big Cypress National Preserve as an Outstanding Florida Waters (OFW) as per FAC 62-302.700. This designation allows for more stringent criteria for water quality provisions to adjacent parcels which discharge stormwater into the preserve. Specific Design criteria for discharging into OFWs are discussed within the ERP Manual under 5.2.2 (b).4 and 5.

Furthermore, there are specific considerations when determining pre-development versus post-development project discharges within the Project Study Area. *Collier County Ordinance 90-10 Summary of Allowable Post-Development Discharge by Drainage Basins* provides critical criteria for the design storm discharge rates, Design Storm ($Q_{allowable}$), within the Area. Table 3.7 presents the Collier County 90-10 discharge formulas.

Section 90-27 of the Collier County Code of Ordinances established the water management policy of Collier County within the limits of the authority allowable by the adopted rules of the South Florida Water Management District. It defines those projects that are exempt from the South Florida Water Management District regulations. The intent of the ordinances is to provide the maximum beneficial use, development, conservation and protection of the water resources of the County in the best interest of the public and to prevent the depletion, deterioration, waste, and unreasonable use of water resources.

These discharge regulations, set forth by Collier County, are more stringent than the SFWMD's allowable discharge rates set within Section 6.0 of the Design Manual; hence, it may be deduced that these stringent ordinances have been enacted where there is "volume sensitivity" within an area. These rules are crucial for providing a "managed" water system and controlling new developments such that the net impacts are minimal to the environment as well as to downstream and upstream properties (South Florida Water Management District Project Technical Team, 2005).

If a storm, larger than the typical design storm were to occur, there is a likelihood of flooding within the Project Study Area. This occurred in 1995 when the Project Study Area became one large watershed – without delineation. In this instance, flooding was significant. Since that occurrence, there have been technical hydrologic / hydraulic evaluations of some of the Project Study Area; however, further planning is viewed as being warranted due to the anticipated growth of the area.

TABLE 3.7. COLLIER COUNTY ORDINANCE 90-10: SUMMARY OF ALLOWABLE POST-DEVELOPMENT DISCHARGE BY DRAINAGE BASINS

Drainage Basin Name[(1)]	County	Design Storm Event	$Q_{allowable}$ (csm) *cfs/ mile*^{2}	Origin of Rate
Airport Road Canal	Collier	25-year, 3-day	25.6csm*, 38.4csm**	Collier County
District Six	Collier	25-year, 3-day	.06 cfs/acre	Collier County
Golden Gate Canal	Collier	25-year, 3-day	.1cfs/acre or less (Pre vs Post)	Collier County
Cocohatchee Canal	Collier	25-year, 3-day	25.6csm (.4cfs/acre)	Collier County
Lely Canal	Collier	25-year, 3-day	38.4csm	Collier County
Fakahatchee Strand	Collier	25-year, 3-day	.05 cfs/acre or less	Pre/post calcs.
10 mile/6 mile Canal	Lee	25-year, 3-day		Needles Report
North Colonial waterway	Lee	25-year, 3-day	37csm	Canal design
Caloosahatchee River	Lee, Glades, Hendry	25-year, 3-day	30csm	Corps Design
Hendry County Plan	Hendry	25-year, 3-day	.46"/day	Dist. Canal Design Crit.
Townsend Canal	Hendry	25-year, 3-day	30csm	Corps Design
Tidal Areas	***			
Harvey Basin		25-year, 3-day	35.2csm (.055cfs/acre)	
Wiggins Pass Basin		25-year, 3-day	83.2csm(.13cfs/acre)	

(1) Drainage Basin Name per Collier County designation.

* North of Golden Gate Blvd.

** South of Golden Gate Blvd.

*** All Tidal Areas discharging to "outstanding Florida waters" are limited to pre vs post-discharge. All other tidal areas are unlimited discharge within limits that will not cause adverse impacts to environmental features such as sea grass beds, oyster beds. Mangrove areas, etc.

In all other areas of Collier County off-site discharge shall not be in excess of .15 cfs/acre.

Variations to the above requirement may be allowed with County staff approval based upon special engineering studies prepared by a Registered Professional Engineer. Unless otherwise specified by previous South Florida Water Management District permits of South Florida Water Management District criteria, a stormwater event of a 3 day duration and 25 year return frequency shall be used in computing off-site discharges. Allowable discharges will be designated by South Florida Water Management District on a case by case basis upon request.

Another important control on development in Collier County is the Collier County Transfer of Development Right (TDR) Program. This is a novel, highly developed conservation easement program. The TDR program was adopted by ordinance February 2004. The intention is to direct development in the Rural Fringe Mixed Use (RFMU) District away from environmentally sensitive lands including large connected wetland systems and significant areas of habitat for listed species, while allowing property owners of such lands to recover lost value and residential development potential through an economically viable process of transferring such rights to other more suitable lands Additionally, the TDR Program responds to the Collier County Growth Management Plan's objectives in focusing growth toward areas where services such as sewer, water and transportation exist or can be readily provided. The RFMU occurs in two places within the project study area; both are East of County Road 951.

Lands designated for conservation ("sending") and lands more suitable for development ("receiving") are present. The two locations are 1) South and East of Naples-Immokalee Rd, and 2) the vicinity of Sub-basin GGE #3, along the southern border of the Basin). Owners of sensitive "sending lands" can sell their residential development rights yet maintain limited permitted and conditional uses, as provided for in Collier County's Land Development Code (LDC), Sub-Sections 2.03.08 and 2.03.07. Credits from RFMU can be transferred into the less sensitive "receiving lands" (Urban Residential Fringe and RFMU District Receiving Lands) as provided in Section 2.6.39.4 and 2.6.39.5 of the LDC. Participation in the Collier County TDR Program is voluntary. However, land uses in the RFMU Sending Lands are restricted. TDR credits must be issued and recorded by Collier County in the public records. A registry for interested buyers and sellers has been created by the County. The program is more thoroughly explained at http://www.colliergov.net/compplanning/tdr/index.htm.

The Hendry County Code of Ordinances, Chapter 1-55 Natural Resources Protection, Article III Stormwater Management Regulations, Section 83, defines the County's rules for post-development discharge. Section 1-55-83 states that stormwater management facilities shall be designed and constructed for each development which is subject to this article so as to accommodate the runoff from a 25-year design storm of 24-hour duration, and the detention and retention facilities shall be designed and constructed so that in such a storm the post-development runoff rates are essentially the same as the pre-development runoff would have been from the site. In addition the facilities must be designed and constructed in a manner which insures compliance with applicable federal, state and regional regulations for drainage and water quality (Ordinance No. 91-23, § 5(55.2B-12), 8-27-1991).

Hence, Hendry County's water quantity regulation, per the Code of Ordinances, utilizes different rainfall duration than the ERP Manual's Section 6.0. The ERP Manual provides guidance on the Design Storm ($Q_{allowable}$), which is typically set as a 25-yr frequency / 72 hour duration for setting pre-development and post-development discharge rates. While using a smaller rain event, and thus potentially lower rainfall depth, peak runoff rate may be similar because the peak rainfall intensity may be the same. Typically within SFWMD, the difference in rainfall (inches) between a 24-hr event and a 72-hr event is 135.9%.

Lee County has allowable discharge (water quantity) and water quality standards which correspond to the SFWMD regulations. As indicated in Lee County's Land Development Code, Division 3 Surface Water Management, Chapter 10, Section 10-321(a), states: "a stormwater management design is to be in accordance with SFWMD requirements. A stormwater management system shall be provided for the adequate control of stormwater runoff that originates within a development or that flows onto or across the development from adjacent lands. All stormwater management systems shall be designed in accordance with South Florida Water Management District (SFWMD) requirements and shall provide for the attenuation/retention of stormwater from the site. Issuance of a SFWMD permit shall be deemed to be in compliance with this chapter

and review of these projects shall be limited to external impacts and wet season water table elevation."

3.7 Areas of Concern

In the development of this section, it is important to note that although the future land use map has been developed with best available information and with the assistance of County Planners, individual property owners, different members of the communities, a variety of agency staff and concerned individuals, the future conditions presented are not definitive. In the development of the included figures, County planning documents were obtained and combined to form a regional view. As discussed in the SWFFS, "The planning horizon varies from county to county. Some plans are for 2010, some extend to 2020, and some simply say 'future'" (South West Florida Feasibility Study Technical Members, 2005). Specifically, in conversations with Collier County planning staff, it was noted that the Future Land Use map was developed and is maintained based on projects that are reviewed by the County planning staff. Although population projections are conducted by the county, the Future Land Use Map does not purport to have a specific planning horizon. Based on the history of development in other portions of Florida, particularly Southeast Florida, unless development is prohibited or restricted, areas that were once thought to be undesirable often succumb to development pressure. While these uncertainties in future development are acknowledged, the information gathered provides valuable insight to future growth trends.

The project study area is likely to undergo concentrated development in several areas. These are highlighted in this report as separate sub-chapters, namely the Ave Maria development, the Immokalee area, and the northern most Golden Gate Estates, which is largely adjacent to this project study area. The Ave Maria project is a large scale project that has integrated stormwater planning and best management practices into its design. Although an area of concern, if the plans are consistent with the regulatory controls already in place any impacts to stormwater and hydrological conditions should be minimal.

Growth around Immokalee, unlike Ave Maria, is not a single planned development. In this case the cumulative impacts of multiple projects must be evaluated by the project proponents, Collier County, and the South Florida Water Management District. This area of concern will require ongoing review of even small projects for the potential cumulative impacts.

The Golden Gate Estates is the only one for which a large scale project, the Picayune Strand Restoration project (formerly Southern Golden Gate Estates Restoration Project), is proposed for completion prior to build out of Northern Golden Gate Estates. The Picayune Strand Restoration project was carefully reviewed to ensure that the adjacent housing developments would not be adversely impacted by the plugging of canals.

In addition to the growth areas discussed within the report, the 2005 Residential Build-Out Study anticipates significant growth to occur in two additional areas: one area located immediately east of the Ave Maria development and the other area located immediately northwest of Lake Trafford near Immokalee. Since no current plans or development reviews have been submitted to the County and due to the uncertainty as to when build-out will occur, these areas were not presented in the report figures.

As reviewed in the report, the Collier County Metropolitan Planning Organization has reported a number of anticipated roadway improvements within the project study area which are listed in Table 3.3 of this report. The SWFFS data, presented graphically and summarized in tabular format in this report, does not list any change in transportation land use/land cover. Future roadway improvements will increase the impervious area thus increasing runoff that must be managed. The hydrological impacts due to the future roadway improvements can be minimized through the planning, design and regulatory process.

4. ENVIRONMENTAL ASSESSMENT

4.1 Introduction

The Big Cypress Basin project study area, located in the central portion of the Big Cypress Basin, encompasses over 950 square miles of varied habitat ranging from freshwater and estuarine wetlands to upland forested communities, agricultural lands and developed, urban areas. It has changed from an area with small urban centers and extensive agricultural interests, largely cattle on an open range, to a large metropolitan area (Naples) surrounded by a mixture of publicly-owned natural lands and intensive agriculture.

This Section of the Report will provide an overview of pre-development and current environmental conditions within the project study area including the identification of areas of special environmental value, i.e. wetlands, estuaries, other refuges for threatened and/or endangered species, etc. The spatial distributions and associated acreages of various habitat types comprising the project study area will be documented as well as past and projected future losses due to development. Finally, current and proposed restoration efforts to regain lost natural habitats and hydrology will be described.

4.2 Pre-Development

The topography of South Florida is characterized by a gradual decline in elevation towards the south-southwest. During the wet season from June through October, rainfall drained as an expansive, slow moving overland flow that inundated the land surface, filled the many topographic depressions, and recharged the shallower aquifers in the region. Human activities during the last 50 years, including agriculture, roads, canals, residential development, and strip mines have greatly limited overland sheet flow and altered natural hydrologic regimes over most of the CBCB region.

A portion of the surface water that flows into the CBCB originates from a ridge extending east from Fort Myers to Immokalee. Water in this area moves south into the large wetland that includes Lake Trafford, Corkscrew Marsh, and Corkscrew Swamp. These flows continue south to the Ten Thousand Islands via 1) Lake Trafford through Camp Keais Strand and into Fakahatchee Strand and Picayune Strand, and 2) Corkscrew Marsh through Corkscrew Swamp, Bird Rookery Strand, and finally Picayune Strand and the Belle Meade area. During periods of higher water levels, some of the flows through Corkscrew move to the west through Gordon Swamp and Flint Pen Strand and then into creeks that pass through the coastal ridge to the Gulf of Mexico. Additional major flows into the Ten Thousand Islands originate from another ridge that extends east from an area approximately midway between Immokalee and LaBelle. The Okaloacoochee Slough originates in a saddle on this ridge and it flows generally south, skirting the east side of the higher elevation lands on which Immokalee is located. Most of the water in Okaloacoochee Slough flows into the north end of

Fakahatchee Strand, with smaller flows into Bear Island and a number of smaller flowways distributed through the western Big Cypress National Preserve.

4.3 Environmental Setting

The Central Big Cypress Basin project study area is located primarily within Collier County, with smaller portions in Southeast Lee County and Southwest Hendry County, Florida. Centrally-located within the Big Cypress Basin and encompassing over 950 square miles the project study area is comprised of four major sub-basins: the Estero Bay Sub-Basin, the Trafford Sub-Basin, the East Collier Sub-Basin and the West Collier Sub-Basin. As depicted in Figure 2.2 the project study area is irregularly-shaped extending as far as Keri Road/County Road 832 to the north, almost to Interstate 75 to the west at the study area's westernmost boundary, and approximately 17 to 18 miles east of State Road 29 at its easternmost boundary near Interstate 75. South of Interstate 75 the project study area narrows substantially and is bounded by Everglades Boulevard to the west and County Road 839 to the east as it extends south of U.S. 41 (Tamiami Trail) to the southern coastline. The estuarine area of influence of the project study area includes Chokoloskee Bay westward to Faka Union Bay and Pumpkin Bay.

The Central Big Cypress Basin project study area contains some of the most diverse plant and wildlife communities in North America and provides habitat for Federally-listed endangered species including the Florida Panther, Wood Stork and Snail Kite. Inclusive within the project study area are many hydrologically/ecologically significant natural areas such as Lake Trafford, Corkscrew Swamp Sanctuary, Panther National Wildlife Refuge, Big Cypress Mitigation Bank, Fakahatchee Strand Preserve State Park, Big Cypress National Preserve and Collier-Seminole State Park.

4.3.1 Infrastructure

The Central Big Cypress Basin project study area has an infrastructure of roads, bridges, canals, drainage ditches, weirs, and other water control structures and infrastructure. The majority of the project study area is uninhabited and contains numerous dirt/farm roads, many of which resulted from the excavation of drainage ditches to facilitate agriculture. Some homes, hunting camps and trailers within the project study area do not have electric and/or telephone service or septic service in the more remote areas.

Some of the major highways and roads intersecting the project study area are Interstate 75, which intersects the project study area as it runs east to west and becomes the approximate western boundary as it turns to the north on the west coast of Florida. State Road 29 divides the project study area medially near Lake Trafford and continues south through the unincorporated City of Immokalee along the eastern portion of the project study area to Chokoloskee Bay. U.S. 41 (Tamiami Trail) intersects the southern portion of the project study area as it parallels the southern coastline. Immokalee Road/County Road 846 enters the northern portion of project study area from the east joining State Road 29 temporarily before continuing westward along the southern

portion of the Corkscrew Swamp Sanctuary and exiting to the south into the North Golden Gate Estates. County Road 858 runs south from Immokalee Road/County Road 846 within the east section of the project study area turning westward in the southwest portion of Hendry County and continues westward into the North Golden Gate Estates. A small section of State Road 82 intersects the extreme northern portion of the project study area as it runs northwest from State Road 29. County Road 850 branches off from State Road 82 becoming Corkscrew Road as it continues west bounding the CREW Sanctuary along its north and northwestern portions. Refer to Figure 2.2.

4.3.2 Geology and Soils

Collier County has the Big Cypress Swamp province and lies partially below an elevation of 16-feet with some calcareous shell, sand and admixture of marl as a near subsurface bedding for the geology. The covering of sediments within the ancient river valley and elevated broad areas of landmass may explain the occurrence of changes in eustatic sea levels. Sea level changes formed the present day marine terraces that largely control the topography and drainage throughout the State of Florida. Three marine terraces: Recent or Holocene age deposition makes up the surficial sediments. The Pamlico terrace ranges between 8 to 25 feet above sea level, and the Silver Bluff terrace, the lowest in elevation; is less than 10 feet above sea level and gradates toward the western seaboard. The deposits were formed during the Pleistocene time when sea level rose and fell in response to the advance and retreat of the continental ice sheets. When sea level is relatively stationary for long periods, shoreline features develop. In southwest Florida the Pleistocene deposits are represented by the Anastasia Formation (a coquinoid limestone, sand and clay), alternating marine and freshwater limestone consisting of mollusks, interbedded clays, and sands of the Ft. Thompson Formation, Caloosahatchee Formation (shell hash limestone and clay), and the Hawthorn Group sediments.

Rock units range in age within the Study area from Recent to Miocene to Oligocene. Formations and groups discussed in this report include from land surface: the Ft. Thompson Formation, Tamiami Formation (which includes the Bonita Springs Marl and Pine Crest Sand members), the Hawthorn Group (which consists of the Peace River Formation within the upper unit and Arcadia Formation belonging to the lower Hawthorn Group sediments), and, to a lesser extent, the early Oligocene Series of the Suwannee Limestone.

Pleistocene - Holocene Series

The sediment that extends from land surface to approximately 10-feet or more below land surface is a thin veneer of undifferentiated Holocene/Pleistocene-age material. The western part of the study area the surficial sediment are composed of Pleistocene undifferentiated Pamlico/Ft. Thompson Formations, and where present, the Pinecrest Limestone Member of the Tamiami Formation. The Ft. Thompson Formation, which occurs at land surface in specific areas and is breached by either the Pliocene-age green dolosilts of the Bonita Springs Marl Member or the middle to late Pliocene-age

beds of the Pinecrest Sand Member, consist of mixed shell assemblage of marine and freshwater.

Pliocene Series

The rocks above the Tamiami Formation vary throughout the planning area, but within the Tamiami Formation two locally identifiable members are of particular interest. The Bonita Springs Marl identified by Missimer (1984) within the locale of the Bonita Springs area is the lowermost member of the Tamiami Formation. The Marl is a discontinuous deposit of unconsolidated sand, green dolosilts, and lime mud matrix. The member is considered a confining unit to the Holocene – Pliocene sediments and the water table aquifer. The Ochopee Limestone (Hunter, 1968), is described as a light gray calcarenite with white fossiliferous limestone within the type section of the study area. It is considered the basal member of the Tamiami Formation

The Tamiami Formation is characterized by a fossiliferous sandy limestone. In northern Hendry and southern Glades counties the formation is thin and difficult to distinguish from the younger biogenic limestone of the Ft. Thompson Limestone and Caloosahatchee Marl.

Miocene Series

Rocks of Miocene age in the planning area belong to the Hawthorn Group sediments. The Hawthorn Group is divided into an upper clastic formation and a lower carbonate formation. The Peace River Formation makes up the upper sequence within the Hawthorn Group is a siliclastic stratum, composed primarily of greenish-gray phosphatic silts interbedded with coarse sand and sandstones. The formation also consists of interbedded quartz sand, clays, and minor carbonates. The siliclastics comprise more than two-thirds of the formation. The lower carbonate sequence is the Arcadia Formation and is described as phosphatic dolomite, composed of poorly to moderately indurated phosphatic micrites, very pale orange, poorly sorted, fossiliferous, clayey, and sandy. The base of the Hawthorn Group occurs at the contact between the Suwannee Limestone of the Oligocene Series and the Lower Hawthorn/Tampa Limestone. The top of the Hawthorn Group is identified by the first occurrence of a continuous greenish-gray dolosilts.

Oligocene Series

Rocks of Oligocene age in the planning area belong to the Suwannee Limestone. The Suwannee Limestone is generally fossiliferous, yellow to pale orange, moderately indurated, very porous calcerenite interbedded with sandy phosphatic limestones and dolomites. The formation varies in thickness from 50 feet to more than 150 feet.

Soils

Soils in southwest Florida can be divided into two major regions. In the more southern areas, they are often relatively undifferentiated substrates of sand, marl, rock, and organics, while in the more northern areas they are typically deep sands, many of which have developed characteristic soil profiles.

The southern portion of southwest Florida is dominated by wetlands and poorly drained uplands. The uplands, which become more common to the north, most likely have sandy substrates, sometimes shallowly overlying limestone. The wetlands can have any of the four types of substrate, although organics are only found in the deeper wetlands and marls are more common in shallow wetlands, particularly where limestone is near the ground surface. The presence of these two substrates is associated with biological processes. Limestone and sand substrates, which are not a product of biological processes, can occur anywhere, regardless of hydrology.

The northern areas are at higher topographic elevations, and as a result have a larger proportion of uplands interspersed with a large number of small to large wetlands. Sandy soils dominate the area, with shallow to deep organics filling in depressions in this landscape. Rock is rarely at the ground surface, although it can locally be found at shallow depths below ground. Marl soils are also uncommon, but can be found locally in shallow wetlands, where limestone is near the ground surface. The sandy soils can be extremely well drained at some higher elevation sites or in locations where there is substantial relief over short distances and the water table is relatively far below ground in the vicinity of the break in the ground surface slope. Otherwise the soils are typically saturated, if not inundated, during the summer wet season, and poorly drained even during much of the winter – spring dry season.

4.3.3 Aquifers

Three major aquifers or producing zones have been identified: The upper surficial aquifer consisting of sands, shells, and limestones, within the sediments of the Ft. Thompson and Tamiami Formations that are Holocene- Pliocene age, respectively. This aquifer and the lower Tamiami/Ochopee Aquifer are separated by the Bonita Springs Marl confining unit. Below the lower Tamiami aquifer lays another confining unit of the Miocene age sediments, Upper Peace River confinement. The Sandstone aquifer lies between the Upper Peace River and Basal Peace River confining unit. The lower Hawthorn/Tampa producing zone (which includes the basal part of the lower Hawthorn aquifer of Sproul et al., 1972) and the Suwannee aquifer are considered parts of the Floridan Aquifer System.

4.3.4 Air Quality

Air quality within the Central Big Cypress Basin project study area is in compliance with the Environmental Protection Agency (EPA) and the Florida Department of Environmental Protection (FDEP) air standards. There are no non-attainment basins in the area or its immediate surroundings.

4.3.5 Climate

The climate of the Big Cypress region is affected by both tropical and temperate zone influences. It is characterized by hot, humid summers and mild, dry winters. Temperature and rainfall patterns have been used to classify the western part of South Florida as having a tropical savanna climate as contrasted with southeastern Florida which is a subtropical region. Within the southern portion of the project study area drought conditions prevail for part of the year due to a relatively short wet season which does not compensate for yearly water losses. The mean annual temperature is 23˚ Centigrade (74˚ Fahrenheit), and mean monthly temperatures range from a January low of 14˚ Centigrade (57˚ Fahrenheit) at Immokalee to an August high of 28˚ Centigrade (83˚ Fahrenheit) at Tamiami Trail (U.S 41) Forty Mile Bend. Both the amount of annual rainfall and its seasonal distribution are highly variable. Mean monthly rainfall ranges from a low of 1.5 millimeters (0.06 inches) at Immokalee during April to a high of 287 millimeters (11.3 inches) at the Flamingo Ranger Station (Big Cypress Preserve) during September. The wet season begins sometime between early May and early July and continues until mid-September or the beginning of October. The aerial distribution of rainfall is also quite variable and it is not unusual for more rain to fall within the interior versus coastal areas. Hurricanes can also provide tremendous amounts of rain, sometimes as much as one-third of the annual total (Carlson et al., 1986). The principal source of recharge to the shallow aquifer system is rainfall. Discharge is most prominent during the rainy season when control structures are open; whereupon, groundwater moves to streams and canals and then to the coastal waters. Evapotranspiration and pumping are also major factors that lower groundwater levels.

4.3.6 Hydrology

The hydrology of the project study area is described in detail in Section 2 of this report. The Central Big Cypress Basin project study area, and area comprising approximately 610,000 acres and/or approximately 950 square miles, lies within the Big Cypress Swamp, a recognizable hydrological unit that encompasses a total area of about 640,000 hectares (1,568,000 acres). As previously mentioned, the project study area is comprised of four major sub-basins, Estero Bay Basin, Trafford Basin, East Collier Basin and West Collier Basin and has been further subdivided into 60 minor sub-basins. Natural surface water flow within the study area is generally southward with some westward flow leaving CREW toward Estero Bay. Variations in annual rainfall cause both flood periods and extended droughts. During years with heavy rainfall aquifer recharge and discharge to the coastal waters occurs. There is surface water/sheet flow over extensive areas of the study area and the deeper sloughs function as rivers. During local storms, water can actually run upslope if rain falls faster than the down slope gradient can facilitate drainage. With the onset of the dry season, areas of standing water steadily diminish. Drought years stress the natural system with saltwater intrusion and/or increased fires (Carlson et al., 1986).

Canals and major drainage ditches, such as the Interstate 75 canal, the Tamiami Trail canal and the State Road 29 canal have pronounced effects upon drainage and natural sheet flow within the project study area.

Interstate 75 was constructed with two-lane east- and westbound roadways that connect the east and west coasts of south Florida. Interstate 75 was built overtop and is an expanded version of what was previously State Road 84 and commonly called "Alligator Alley." Originally, the design for Interstate 75 incorporated only one interior interchange between Naples and Fort Lauderdale – at Collier Blvd (Exit 101) – to address environmental concerns that the expanded traffic flow of the super highway would negatively affect the Big Cypress. However, an exchange was also retained at State Road 29 to meet the commercial interests of Immokalee and Everglades City. At present, approximately 24 miles of Interstate 75 intersect the Central Big Cypress Basin project study area. Over 20 water control structures were constructed along Interstate 75 to facilitate north-south sheet flow exchange, 5 of which lie within the project study area; however, the efficacy of these structures is being evaluated as part of one of the projects discussed in Section 6.3 of this Report.

The Tamiami Trail is an elevated causeway that crosses 100 miles of freshwater wetlands in south Florida between Miami and Naples. Approximately 10 miles of the Trail runs through the project study area. Recent efforts to restore water flows across the Trail have focused upon increasing the total number of water conveyances/water control structures under the roadbed, but this approach does not address restoration issues away from the roadway, both upstream and downstream, that are intimately related to restoring hydrologic flows across the Trail (Sobczak, 2005). Currently, approximately 20 water conveyances/water control structures are located along the Tamiami Trail within the project study area.

State Road 29 was originally built in 1926 in conjunction with a railroad grade to the west. It was also overhauled and widened in the 1990's to accommodate traffic. A few hydrologic upgrades were also added during construction. Several roadbed culverts were added at the tailwaters of Deep Lake Strand – all of which are circular concrete culverts measuring 2 feet in diameter. Two adjustable canal weirs were also added. The Barron River Canal runs parallel with State Road 29. It also lies in a parallel direction to regional surface water flow and, more importantly, is connected directly to tide at its downstream end. This parallel orientation of the Barron River Canal to the direction of the regional surface water flow made it largely unnecessary from a flood-control standpoint to retain gaps in the roadbed for water passage under the road. While State Road 29 has a minimum number of water conveyances/water control structures, its adjacent canal contains a water control feature that the Tamiami Trail is noticeably lacking: stop gates in its canal. The Barron River Canal incorporates 10 stop gates, 7 of which are metal and can be removed and inserted depending upon seasonal conditions. The canal has a much larger capacity to drain both surface water and groundwater from the freshwater system than do natural flow ways. Flow rates in the natural system are limited by a flat topography and slow infiltration into the underlying aquifer (the marl and peat soils form semi-permeable seal). Conversely, the

depth and length of the canal, its direct connection to tide, and the direct connection it has to the underlying aquifer makes the Barron River Canal a more efficient drain than any of the natural flow systems that it intercepts. The rapid drainage has resulted in the disruption of the natural sheet flow condition in this area (Section 2). The canal also receives groundwater seepage from along its banks – a source of water not available to natural flow ways, and one that flows in and down the canal even after water levels have receded below ground (Sobczak, 2005).

4.3.7 Plant Communities

The Central Big Cypress Basin project study area is comparable to the freshwater Everglades in terms of natural community diversity, although the communities tend to form more of a mosaic as opposed to vast expanses of a single community type (SFWMD, 2004). Temperate species are abundant and dominate the flora of the Central Big Cypress Basin project study area, but many of the species are plants with tropical affinities. Of the roughly 1,600 species in South Florida, 61% are tropical in origin and 39 % temperate. Most tropical species are found in the mixed hardwood hammock communities, but some occur in other habitats. The tropical plants in Florida are species capable of dispersal over a distance of salt water, since there has probably never been a land bridge between South America and Florida which could have permitted these species to spread terrestrially. South Florida's temperate species generally range northward into the southeastern coastal plain. Temperate species dominate the pinelands, cypress and mixed swamp forests, and prairie and marsh communities (Carlson et al., 1986).

It has been documented that changes in hydrology will result in changes in biology and ecology. Major and minor drainage construction within the project study area has altered the hydrology and, in some areas, the natural flow ways. The US Army Corps of Engineers has documented changes in the composition of plant communities in the Southern Golden Gate Estates Project Area over the past few decades. For example, The native sabal palm (*Sabal palmetto*), also commonly called the cabbage palm, has become dominant throughout much of the project area. A review of historic aerial photographs suggests a sparse parent population has given rise to a successful population of offspring, all at about the same time. It appears the population increase occurred as the hydrology of the area changed. The Florida Division of Forestry now considers the sabal palm an invasive species that requires control in order to maintain diversity in the ecosystem (U.S Army Corps of Engineers, 2004).

Habitat types within the project study area were categorized utilizing the Florida Land Use, Cover and Forms Classification System level II format. The following table, derived from SFWMD data, indicates the breakdown and areas of habitat types found within the Central Big Cypress Basin project study area and within each of the four major sub-basins.

As depicted in the Table 4.1 approximately 335,725 acres or 56% of the 600,000 acres comprising the project study area is wetlands; approximately 60,739 acres or 10% of the study area is composed of upland forests; approximately 188, 273 acres or 32% is

agricultural, open land and/or rangeland; approximately 7,561 acres or 1.2% is urbanized or developed land; and approximately 4,983 acres or .8% is comprised of water.

TABLE 4.1 HABITAT TYPES IN THE CENTRAL BIG CYPRESS BASIN, Acres

	ESTERO BAY	TRAFFORD	EAST COLLIER	WEST COLLIER	STUDY AREA
Urban and Built Up	**378**	**3,561**	**1,136**	**2,486**	**7,561**
Agriculture, Open Land, and Rangeland	**7,848**	**40,221**	**85,620**	**54,585**	**188,273**
Upland Coniferous Forest	3,897	5,170	19,004	12,831	40,902
Upland Hardwood Forest	321	1,533	3,313	1,644	6,810
Exotic Tree Species	6	1,884	9,707	1,421	13,017
Tree Plantations				10	10
Total Upland Forests	**4,223**	**8,587**	**32,024**	**15,906**	**60,739**
Streams and Waterways		63	165	201	430
Lakes		1,493	30	213	1,736
Reservoirs	31	264	782	631	1,708
Bays and Estuaries			368	502	870
Slough Waters			28	211	239
Total Water	**31**	**1,821**	**1,374**	**1,757**	**4,983**
Wetland Hardwood Forest	1,052	11,784	21,375	22,998	57,209
Wetland Coniferous Forest	7,943	12,114	23,917	63,879	107,853
Wetland Forest, mixed	3,375	6,610	19,085	32,182	61,252
Vegetated Non-forested Wetlands	2,146	12,438	65,052	29,775	109,411
Total Wetlands	**14,515**	**42,947**	**129,429**	**148,834**	**335,725**
TOTALS	**26,995**	**97,136**	**249,583**	**223,569**	**597,282**

4.3.8 Fire

Fires were a common occurrence within the pre-drainage Central Big Cypress Basin project study area and played an important ecological role in maintaining the health and diversity of terrestrial communities. Lightning strikes commonly caused most fires although early humane inhabitants may have been responsible for starting a few (U.S Army Corps of Engineers, 2004). With the changing of seasons and diminishing rainfall dried wetlands became susceptible to fire during the winter and early spring.

Due to longer dry periods as a consequence of drainage projects, fires today commonly burn farther from prairies and pine flatwoods into adjacent cypress sloughs or other hydric forest communities. This alters species compositions in communities formerly more hydric, as most resident wetlands species are not well adapted to withstand fires. Additionally, developing infrastructure and coincident over-drainage of the study area has increased the frequency and intensity of forest fires. The intensity of the fires has burned out the soil organic matter that is associated with many of the hydric plant communities. The increased frequency and intensity of wildfire favors a less diverse plant community dominated by fire tolerant species, primarily sabal palm (*Sabal palmetto*) (U.S Army Corps of Engineers, 2004).

4.3.9 Fish and Wildlife Resources

Due to the pronounced wet season and dry season in south Florida wetland systems within the Big Cypress Basin project study area, as in other locations within south Florida, contain water during the summer and fall yet may dry out completely during the winter and early spring. These seasonal cycles and the dramatic affect upon the local habitat serves to increase the biodiversity of wildlife which can effectively utilize these wet/dry communities. Plant communities have been established in frequently flooded nutrient-poor substrates such as coral, marl and sand. The location of the project study area within south Florida exposes plant and animal communities to the natural invasion and migration of flora and fauna from outside areas (U.S Army Corps of Engineers, 2004). The southern portion of the project study area includes mangrove estuaries which provide home and refuge for a variety of wildlife.

It has been documented that over-drainage within an area resulting in altered and diminished hydroperiod can increase fire frequency, accelerate the invasion of exotic and nuisance species, and degrade resources for vertebrates. Plant diversity has been reduced as a result of replacement of historic cypress communities by monocultures of cabbage palm and non-native plant species. Reductions in species dependant upon wetland systems for all or part of their life cycle, such as amphibians, some reptiles, and forage fish, has been confirmed by ongoing surveys. Increased high-intensity wildfire has eliminated pine canopy that could be utilized by migratory birds and/or state and federally-listed species.

4.3.10 Wading Birds

Relatively undisturbed wetlands within the Big Cypress Basin project study area, such as Corkscrew Swamp Sanctuary, Fakahatchee Strand State Preserve, Collier-Seminole State Park and the Big Cypress National Preserve support significant populations of wading birds. As early as 1912, the National Audubon Society had seasonal wardens in the Corkscrew swamp area to protect the then nesting colonies of wood storks, egrets, and other wading birds (Buchheister, no date). The Big Cypress National Preserve is probably more important to wading birds as a feeding habitat. The preserve's extensive wetlands offer a variety of feeding areas no longer found elsewhere in South Florida. Although the preserve's rookeries are small in comparison to the Cattle Egret and White Ibis dominated rookeries elsewhere, the preserve's Little Blue Heron colonies are among the largest in Florida (Carlson et al., 1986).

4.3.11 Small Mammals

Data from ongoing small mammal trapping conducted in areas located immediately adjacent to the project study area's central-west boundary suggest that populations and distributions of small mammals such as cotton mice, rice water rats and cotton rats respond positively to wetter conditions. An increase in the small mammal population, if their numbers have been depressed by over-drainage, would provide greater food resources for predators such as hawks, snakes, bobcats, etc. (U.S Army Corps of Engineers, 2004).

4.3.12 Threatened and Endangered Species

Table 4.2 lists state and federally listed vertebrate species (excluding fish, whales, invertebrates and plants) that are known to occur in the vicinity of or may occur within the Big Cypress Basin project area. The following information sources were used to ascertain the presence of state and federally listed vertebrate species (excluding fish and whales) based upon sightings, nest sites and/or the presence of prime or suitable habitat. All of these sources are included within, intersect or encompass the project study area.

- The National Audubon Society's Research Report No. 8 on The Big Cypress National Preserve (BCNP);
- CERP-Picayune Strand Restoration (formerly Southern Golden Gate Estates Ecosystem Restoration) Final Integrated Project Implementation Report and Environmental Impact Statement (SGGE);
- Provisional listed species distribution information supplied by the U.S. Fish & Wildlife Service for the Southwest Florida Feasibility Study (SWFFS). Please note this information was recently released as a courtesy and has not been qualified.
- Fakahatchee Strand Preserve State Park (FSPSP) Unit Management Plan;
- Collier-Seminole State Park (CSSP) Unit Management Plan; and

TABLE 4.2 BIG CYPRESS BASIN LISTED VERTEBRATE SPECIES

	BCNP	SGGE	SWFFS	FSPSP	CSSP	SLCWP
AMPHIBIANS						
gopher frog						X
REPTILES						
American alligator	X	X		X	X	X
American crocodile	X	X	X	X	X	
Eastern Indigo snake	X	X		X	X	
Gopher tortoise					X	X
loggerhead sea turtle			X			
green sea turtle			X			
leatherback sea turtle			X			
Kemp's ridley sea turtle			X			
BIRDS						
Piping plover			X			
Brown pelican	X			X	X	X
limpkin						X
reddish egret	X			X		X
little blue heron	X			X	X	X
tricolored heron				X	X	X
white ibis				X	X	
Florida sandhill crane	X			X		X
whooping crane			X			
wood stork	X	X	X	X	X	X
roseate spoonbill	X			X	X	X
burrowing owl						X
crested caracara	X		X			X
peregrine falcon	X			X		
Southeastern American kestrel	X					X
bald eagle	X	X	X	X	X	X
osprey	X			X	X	
snail kite	X	X	X		X	X
Florida scrub jay			X			X
Cape Sable seaside sparrow	X		X			
Florida grasshopper sparrow			X			
white-crowned pigeon				X	X	
ivory-billed woodpecker	X					
red-cockaded woodpecker	X	X	X		X	X
MAMMALS						
Florida panther	X	X	X	X	X	X
Florida black bear	X			X	X	X
Everglades mink	X			X		X
Big Cypress fox squirrel				X	X	
Florida manatee	X	X	X	X	X	

- South Lee County Watershed Plan (SLCWP). Note the presence of listed species was based solely upon prime/suitable habitat.

4.3.13 Exotic Plant and Animal Species

Exotic plants and animals produce drastic alterations in the composition and structure of natural communities, although many of these changes are poorly documented, such as impacts resulting from the spread of feral hogs and exotic fish. Some that are well documented include the spread of melaleuca and other exotic plants. Some species, such as melaleuca and feral hogs, can readily utilize undisturbed natural communities. Development has facilitated the invasion of exotics by creating an abundance of disturbed sites that normally would have been recolonized by native species, but these species are now being outcompeted by more rapidly invading exotics. Farms and residential areas create new habitats that are more suitable to new species, which then invade adjacent natural areas and impact native populations either directly by predation or indirectly through competition for resources (SFWMD, 2004).

4.4 Effects of Future Land Use on Natural Resources

The goal of this section is to describe the potential effects of changes in land use on the natural resources in the project study area. This will be conducted by using an assessment tool developed to measure the potential impacts of landscape alterations on environmental resources in the Big Cypress Basin (BCB).

This section is divided into three sub-sections. The first sub-section describes the components of the environmental assessment tool. The second section assesses the potential impacts of proposed land activities on ecosystem functions. The last section highlights the most important findings of the BCB environmental assessment.

4.4.1 Environmental Assessment Tool Description

The environmental assessment tool was developed using the Big Cypress Basin conceptual ecological model (CEM) (SFWMD, 2003) as a guideline. The Big Cypress CEM presents a suite of assumptions that explain the hypothesized cause and effect linkages among environmental stressors and ecosystem functions. These linkages were used in this study to identify the ecological functions land use activities and restoration efforts have affected in the BCB ecosystem. In addition, the BCB model (SFWMD, 2003) lists the set of performance measures used as indicators of environmental conditions in the Basin that have been selected as targets for restoration. These performance measures were used in this study to identify the ecosystem characteristics and site changes that would be useful to monitor.

The environmental assessment tool has two main components (Table 4.3). First, it lists the environmental indicators and their associated performance measures. Second, it lists land use activities identified in the basin and their associated effect on the ecosystem functions.

TABLE 4.3. BIG CYPRESS BASIN ENVIRONMENTAL ASSESSMENT TOOL

Selected Ecosystem Indicators	Ecosystem Indicator Description	Selected Performance Measure	Development (habitat fragmentation, drainage, water withdrawals, retention areas, water quality, fire regime)	Habitat fragmentation (areal extent decrease, roads, power lines, train tracks, ditches, canals)	Drainage (Drier Condition)	Water Withdrawals	Retention Areas	Water chemistry in canals (higher nutrients, dissolved solids & mercury)	Decrease Fire Frequency (over developed areas)	Wetland Restoration	Preservation (Undisturbed habitat)	Herbicides	Water Quality - Stormwater Pollution Prevention Plans (BMPs)	Re-establish Hydroperiod	Prescribed Fire (Increase fire frequency in drier natural areas)
Plant Populations	The rate of change in community response to increase/decrease levels of stressors, restoration or preservation efforts will vary depending on community type: • early successional communities - herbaceous wetland and pine forest tend to respond more rapidly to changes than do later successional communities such as hammock forest and cypress wetlands	• Measure Major Plant Community cover, density, composition, structure and distribution	• Destroys all types of natural vegetation	• Reduces the extent of biota resource base to the point where the habitat no longer supports viable populations.	• Due to drier conditions new upland communities are developing, but wetlands are decreasing.		• Beneficial to wetland if retention sites were incorporated where sites have been previously drained	• Native species are adapted to low nutrient/dissolved solids/contaminant conditions. New water chemistry is contributing to a shift in species composition toward more tolerant species.	• Lack of fires allowed succession to proceed so that herbaceous communities are invaded by dense shrub tickets and pineland & cypress forest & herbaceous wetland are invaded by shrubs & hardwood forests.	• Upland development (wetlands are protected) result in wetlands becoming more isolated from each other; as well as from other natural parts of the system.		• Exotic plant control		• Redevelopment of a closed cypress canopy and seedling re-establishment; • Decrease or stressed of species less tolerant to inundation (slash pine, laurel oak, and grape vines).	
Plant Community Gradients	• Short hydroperiod pinelands are found in the north(Slash pine = Endangered ecosystem) on uplands; through marshes southward tend toward long hydroperiod Cypress forest on lower elevations, closer to sea level.	• Measure cover, density, composition, structure and distribution of native plant communities and exotics. • Measure herbaceous communities and open pinelands vs. exotic woody vegetation such as malaleuca, Brazilian pepper, or downy rosemyrtle • Measure herbaceous marsh communities vs. cattails and primrose	• Currently wetlands are protected • Upland forests are being destroyed		• Drier conditions shift composition of affected wetland towards composition found in more upland communities (red maple, laurel oak, malaleuca) or shallower wetland types (slash pine, cabbage palm)		• Beneficial to wetland if retention sites were incorporated where sites have been previously drained		• Produce shifts from herbaceous to shrubby communities and from open pineland/herbaceous-wetland/cypress forest to shrub/hardwood dominated forest			• Exotic plant control			• Control shrubs and hardwood communities on pine Flatwoods [To maintain pine Flatwoods forest with its associated ground cover vegetation (grasses, sedges, forbs and little shrubs)].
Plant Community Mosaic	Superimposed on the most extensive natural communities: • Maintain small open-water ponds scattered on deeper depressions • Maintain small islands of hardwood forest (hammocks) on elevated sites among or along the edges of deeper herbaceous and forested wetlands • Maintain the dominance of temperate species • Support a tropical component most prevalent in temperate forested uplands and close to the coast; & further inland in association with larger deeper (swamp communities) (protected from cold by forest canopy and/or the standing water)	• Measure cover, density, composition, structure and distribution of native plant communities and exotics. • Measure open pinelands/herbaceous communities vs. exotic woody vegetation such as malaleuca, Brazilian pepper, or downy rosemyrtle • Measure herbaceous marsh communities vs. cattails and primrose • Measure tropical component in forested uplands and further inland in association with swamp communities • Measure small islands of hardwood forest along the edges of forested wetlands	• Destroy all types of natural vegetation. • Farms & residential areas create habitats that are more suitable to new species which then invade adjacent natural areas and impact native population.	• Causes wetland isolation	• Shift wetland plant communities towards shallower wetland types (cabbage palm); or even to upland types (malaleuca)		• Increasing the depth of and/or duration of inundation can convert uplands to wetlands and wetlands to aquatic habitats (too deeply flooded to support upland vegetation, but too short hydroperiod to produce wetland communities)	• Shift from diverse herbaceous community to dominance of primrose and cattails.	• Severe sites (dry-no fires) convert vegetation mosaic to early successional communities dominated by weedy herbaceous/vine/shrub species			• Exotic plant control		• Presence of tropical plant species in association with major wetlands would indicate the presence of a hydrology adequate to protect this resource	• Remove dense undergrowth (saw palmetto) and create open spaces of ground to encourage growth of native shrubs and wildflowers. Pines survive the small fire.

TABLE 4.3. BIG CYPRESS BASIN ENVIRONMENTAL ASSESSMENT TOOL

Selected Ecosystem Indicators	Ecosystem Indicator Description	Selected Performance Measure	Development (habitat fragmentation, drainage, water withdrawals, retention areas, water quality, fire regime)	Habitat fragmentation (areal extent decrease, roads, power lines, train tracks, ditches, canals)	Drainage (Drier Condition)	Water Withdrawals	Retention Areas	Water chemistry in canals (higher nutrients, dissolved solids & mercury)	Decrease Fire Frequency (over developed areas)	Wetland Restoration	Preservation (Undisturbed habitat)	Herbicides	Water Quality - Stormwater Pollution Prevention Plans (BMPs)	Re-establish Hydroperiod	Prescribed Fire (Increase fire frequency in drier natural areas)
Exotic Woody Vegetation	• Colonization facilitated by dry conditions and access routes	• Measure cover, density, composition, structure and distribution of native plant communities and exotics. • open pinelands/herbaceous communities vs. exotic woody vegetation such as melaleuca, Brazilian pepper, or downy rosemyrtle	• Has facilitated the invasion of exotics by creating an abundance of disturbed sites that would have been colonized by natives but are out compete by exotics. • Farms & residential areas create habitats that are more suitable to new species which then invade adjacent natural areas and impact native population. • Increase of exotics & invasive woody vegetation such as malaleuca, Brazilian pepper, or herbaceous exotics such as downy rosemyrtle , cattails and primrose willow dominate herbaceous communities or upland pinelands.	• Increase exotic plants (facilitate exotic vegetation invasion)	• Due to drier condition - prompted colonization by exotic species such as malaleuca.				• Prompted colonization by exotic species . • Increase community composition of more fire tolerant species (cabbage palm, malaleuca)			• Exotic plant control			• Removes invasive exotic species
Wetland Soil Accretion	• Indicator of the status of wetland function; hydrologic flow	• Measure rate of change of soil accumulation.	• Damming could cause the accumulation of soil and promote succession. • Organic soils could be lost due to oxidation caused by drier conditions and soil exposure to air.		• Organic soils are lost due to oxidation caused by drier conditions and soil exposure to air.									• Response to hydrologic restoration is very slow	
Florida Panther Habitat	• Large expanses of undisturbed habitat comprised on natural, semi-natural and agricultural land uses. • Require dry areas for daytime resting, but can travel through inundated habitats wetland habitats where deer inhabit [preferred food item]	• Presence of large expanses of undisturbed habitat	• Destroys Florida panther habitat	• Destroys Florida panther habitat							• Support Florida panther habitat	• Support Florida panther habitat			• Support Florida panther habitat
Faunal Populations	• Affected by land activities that influence habitat isolation, fragmentation, water quality, hydrology and fire regime.			• Expose wildlife to hazards associated with development increase as habitats become smaller (such as roads). • Reduces the extent of biota resource base to the point where the habitat no longer supports viable populations. • Animal communities range decreases due to habitat isolation.				• Increase body burden of toxins in top predators						• Support aquatic species dependent on high water levels for reproduction.	

TABLE 4.3. BIG CYPRESS BASIN ENVIRONMENTAL ASSESSMENT TOOL

Selected Ecosystem Indicators	Ecosystem Indicator Description	Selected Performance Measure	Development (habitat fragmentation, drainage, water withdrawals, retention areas, water quality, fire regime)	Habitat fragmentation (areal extent decrease, roads, power lines, train tracks, ditches, canals)	Drainage (Drier Condition)	Water Withdrawals	Retention Areas	Water chemistry in canals (higher nutrients, dissolved solids & mercury)	Decrease Fire Frequency (over developed areas)	Wetland Restoration	Preservation (Undisturbed habitat)	Herbicides	Water Quality - Stormwater Pollution Prevention Plans (BMPs)	Re-establish Hydroperiod	Prescribed Fire (Increase fire frequency in drier natural areas)
Black Bear	• Prefer high diversity and productive habitat	• Measure Presence, Distribution, Relative abundance	• Development eliminate their habitat												
Red-cockaded Woodpecker	• Old-mature live upland forest	• Measure Nesting Success	• Development eliminate their habitat												
Wading Birds (Wood storks)	• Hydrologic conditions; timing of the initiation water recession	• Measure number of nesting pairs, nesting success, increase in nesting colonies		• Decrease food supply to wading birds during the dry season • fish can't reach surrounding uplands	• Decrease food supply to wading birds during the dry season; fish cannot reach surrounding uplands										
Wetland Aquatic Fauna	• Includes native fish, crayfish and amphibians populations.	• Measure Presence, Distribution, Relative abundance		• Decrease native amphibians, fish, and crayfish populations that depend on marsh aquatic habitat to reach adjacent uplands for reproduction and food supply.	• Decrease native amphibians, fish, and crayfish populations that depend on inundated/moist wetland during the dry season (lower water levels and shorter hydroperiods).					• Increase native amphibians, fish, and crayfish populations that depend on inundated/moist wetland during the dry season (lower water levels and shorter hydroperiods).	• Increase native amphibians, fish, and crayfish populations that depend on inundated/moist wetland during the dry season (lower water levels and shorter hydroperiods).			• Increase native amphibians, fish, and crayfish populations that depend on inundated/moist wetland during the dry season (lower water levels and shorter hydroperiods).	
Exotic Animals	• Detrimental to the natural habitat of south Florida. • Introduced mostly by citizens that have turned loose their pets, such as Pythons, boa constrictors, parakeets, and parrots. • Wild hogs have also increased in numbers. Their digging disrupts native vegetation, disrupt successional patterns, alters nutrient cycling as well as important archaeological sites. Therefore, they can have both direct and indirect effects on some fauna either through predation or alteration of the forest floor habitat. • Blue and spotted tilapias, oscars, and Mayan cichlids, exotic fish which have invaded the Everglades, pose a threat to native fish populations through predation and competition for nesting sites. Eradication of these fish is impossible, and no effective control method has yet been found.	• Measure abundance, density, distribution. • Measure acres with feral hogs soil disturbance	• Blue and spotted tilapias, oscars, and Mayan cichlids, exotic fish which have invaded the Everglades, pose a threat to native fish populations through predation and competition for nesting sites.	• Increase exotic animals	• Exotic fish which have invaded the Everglades (blue and spotted tilapias, oscars, and Mayan cichlids), pose a threat to native fish populations through predation and competition for nesting sites.			• Many exotic animals can survive in poor water quality conditions. Once established they are very difficult to eradicate/control.						

TABLE 4.3. BIG CYPRESS BASIN ENVIRONMENTAL ASSESSMENT TOOL

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Water Chemistry	• An increase in nutrients and solids have been observed.	• Measure water constituents loads and concentrations						• Increased nutrient and dissolved minerals					• Prevent erosion, off-site sedimentation, and turbidity in waterbodies adjacent to construction sites.		
Total Phosphorus	• Inputs from agriculture and urban areas	• Measure TP loads and concentrations	• Increase loads and concentration												
Total Solids	• Increase in waterways due to increase in impervious surfaces and habitat destruction.	• Measure total solids loads and concentrations													
Organics (Pesticides)	• Inputs from agriculture and urban areas	• Measure organics concentrations in water column and toxicity to animals.	• Increase concentration					• Increase concentration in ditches.							
Trace Metals (Mercury)		• Measure trace metals concentrations in water column and animal tissue	• Increase concentration					• Increase concentration in ditches.							
Hardness	• Hardness (measure non-precipitation water inputs from canal flows)	• Measure loads and concentrations near canals	• Increase in canals					• Increase concentration in canals.							
DO (Lake Trafford)	• DO (Lake Trafford) - large accumulation of sediments will be removed	• Measure and compare to TMDL established in Lake Trafford.	• Decrease DO in lake in association with increase sediments												
Runoff Rate	• Develop hydrologic performance measures to evaluate site relative to its hydrologic targets (established by SFWMM and NSM)	• Measure average inundation duration (hydroperiod), • Number of dry events, • Seasonal amplitude and interannual variability in water levels, • Overland flow volumes, • Maximum and minimum water levels, • Unset of dry season water level recession (hydrological models need to be developed for the Big Cypress Basin)	• Increase runoff rate (canals & impervious surfaces)		• Lower water table • Reduced depth of inundation • Shorter hydroperiods (particularly around/ downstream of ditches and canals)										
Standing water	• Created by dikes, levees and other water control structures.	• Measure water level			• Eliminated standing water (that helps protect the tropical vegetation from winter freezes)		• Increasing the depth of inundation and shorten its duration								

TABLE 4.3. BIG CYPRESS BASIN ENVIRONMENTAL ASSESSMENT TOOL

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Lower water levels in/around wells	• Created by drainage system and water extraction (water supply)	• Measure water level	• Decrease water table			• Lower water levels - (max for citrus growth)									• Reduce intensity of fires. Sustain desirable fire frequency.
Natural Fire Frequency Intensity	• Affected by wetland isolation, dry conditions; lack of fire has allowed succession to occur	• Measure fire frequency and intensity.	• Increase fire		• Increase frequency/severity of fires				• Increase severity of fine when they finally occur						
Dry season fire	• Affected by wetland isolation, dry conditions; lack of fire has allowed succession to occur	• Measure fire frequency and intensity.	• Created less frequent, but more intense fires.		• Increase severity of fires										

A detailed description of each of the two main components is provided below. This description emphasizes the importance of each of these two components for the Big Cypress Basin.

4.4.1.1 Ecosystem Indicators

The Big Cypress Basin is a complex ecosystem. It contains a variety of geographical regions with different spatial limits at several urban developmental stages (Figure 3.1 Existing Land Use 2000): 1) the minimally urbanized Big Cypress National Preserve/Fakahatchee Strand Sate Preserve, 2) the highly urbanized areas extending east from Naples, and 3) mildly urbanized Corkscrew-Immokalee area containing a mixture of agricultural, sub-urban and natural areas. Despite this complexity, the Basin can be characterized by a set of environmental indicators: vegetation and faunal communities, water quality, hydrology, and fire regime (Table 4.3). It is the status of these indicators that are used to evaluate the effects of environmental alterations on the ecosystem.

The plant community gradient is maintained by the gentle topographic gradient and its associated hydroperiod. This gradient is characterized by progression of short hydroperiod temperate pinelands on upland forest through marshes towards long hydroperiod cypress forest.

Superimposed on the natural community gradient is the plant community mosaic. This mosaic is maintained by small open-water ponds scattered on deeper depressions and small islands of hardwood forest on elevated sites among or along the edges of marshes and cypress wetlands. In addition, the area supports a tropical plant component most prevalent close to the coast, in temperate forested uplands and further inland in association with deeper swamp communities. These tropical communities are protected from the cold by the forest canopy and by the standing water in deeper areas. The primary factors influencing the distribution of these communities (and supporting the community mosaic) are the range of annual fluctuations in water level above and below the ground and the duration of inundation. In addition, these communities are supported by the frequent fires controlling the dominant plant communities.

A strong exotic and invasive woody vegetation component is present in the Big Cypress Basin. Exotic woody vegetation such as melaleuca, Brazilian pepper, or downy rosemyrtle dominates areas previously occupied by herbaceous communities or upland pinelands. Invasive species such as cattail and primrose willow have replaced natural marsh communities. The primary factor facilitating the spread of these communities is development and its associated drying and compartmentalization of the land. These environmental changes gave these invasive plants an ecological advantage, in conjunction with the drainage and roads systems that facilitated their dispersal. In addition, these nuisance communities are supported by the activities of feral hogs that annually turn over thousands of soil acres.

One of the often-stated functions of wetlands is their ability to remove soils and other particulates from water, thus retaining soils that would otherwise reach aquatic ecosystems. This vital function is supported in the Big Cypress Basin by the sheet flow moving from north to south and southwest. Interruption of this flow by damming could cause the accumulation of soil and promote succession. On the other hand, interruption of this flow by drainage could cause reduction of this organic soil due to oxidation by exposure to air or by fire.

There are many animal communities inhabiting the Big Cypress Basin. Several of these animal communities serve as indicators of the environmental condition of the major plant communities such upland forests and wetlands. For instance, the Florida Panther is an indicator of large expanses of undeveloped land (mixture of natural and agricultural land uses). Currently, it lives in the remaining expanse of relatively undeveloped lands in the Big Cypress Basin. This land includes Fakahatchee Strand State Preserve, Okaloacoochee Slough, Picayune Strand State Forest, Big Cypress National Preserve, Florida Panther National Wildlife Refuge, Corkscrew Swamp National Audubon Sanctuary, Big Cypress Seminole Indian Reservation, portions of Everglades National Park, and adjacent large tracts in cattle ranches, vegetable farms, and citrus groves. This makes the Big Cypress Basin the only site remaining habitat suitable for the Florida Panther.

The black bear is a great indicator of the many habitats, and their connectivity, found in the Big Cypress Basin. The black bear is an omnivore that likes large forests with small sunny openings within the forest that provide the many kinds of food for the bears, while the large trees (over 20 inches in diameter) with furrowed bark provide bedding sites. The black bear also likes lowlands and wetlands which are important sources of vegetation. Streams and woodland pools are important for drinking and cooling.

The red-cockaded woodpecker is an indicator of older mature pine forests. It is the only woodpecker that excavates cavities exclusively in living pine trees.

The wading bird population is an indicator of the hydrological conditions of the habitat. The decline in nesting success in the Big Cypress Swamp is attributed to the loss of early dry season (November, December) foraging habitat of the higher elevation wetlands that have been drained and developed.

Native fish, crayfish and amphibians are indicators of the condition of dry season marsh refugia which has been replaced by deep canals and excavations and affected by altered hydrology.

Water quality is an indicator of the chemical composition of the water. Native populations in the Big Cypress Basin are adapted to low concentrations of dissolved nutrients and solids. Eutrophication, the enrichment of water with nutrients, produces shifts from diverse herbaceous communities to communities dominated by few species adapted to high nutrient and dissolved mineral concentrations, such as cattail and primrose.

The fire regime is an indicator of the hydrological condition of the Basin. Fire occurring during the dry season or reduction in the number of fires can result in successional shifts from herbaceous to shrubby communities and from open pineland/herbaceous wetlands, and cypress forests to shrub and hardwood dominated forests. In addition, it can decrease stability of the ecosystem as fuel builds up and severe fires convert sites to early successional communities which are less abundant in natural communities.

Each of these environmental indicators is affected by human activities in the Big Cypress basin as explained in the next section.

4.4.1.2 Landscape Activities

Currently, human activities in the Big Cypress Basin have two purposes: 1) develop the land to accommodate for human population growth and 2) protect the land to balance the detrimental effects of urban development. Activities associated with urban development include:

- Fragmentation of the natural habitat (to accommodate for different uses: agriculture, industries, housing)
- Development of a drainage system
- Withdrawals of water
- Creation of water retention areas
- Alteration of the water quality
- Alteration of the natural fire regime

Each of these activities produces a negative effect on the environment, which hinders its ability to provide the services that humans intend to derive as listed in Table 4.3.

The cumulative effects of these activities have prompted stakeholders to consider several restoration efforts to sustain valued ecosystem functions (Table 4.3). The types of restoration activities considered depend on the plant community involved, but would primarily be associated with restoring and/or maintaining natural hydrology (quantity/quality) and fire regimes, and controlling the more aggressive exotic and nuisance plant species.

4.4.2. Big Cypress Basin Environmental Assessment

The Big Cypress environmental assessment involved 1) using the environmental assessment tool to identify the effects of proposed land use activities; 2) identify the location of planned urban development and restoration activities; 3) determine the ecological significance of those activities; 4) prioritize areas where restoration efforts need to focus; and 5) provide recommendations for future land use. Figure 4.1 shows the current areas subject to development pressure, and Figure 4.2 shows the areas predicted to be altered by development by 2025.

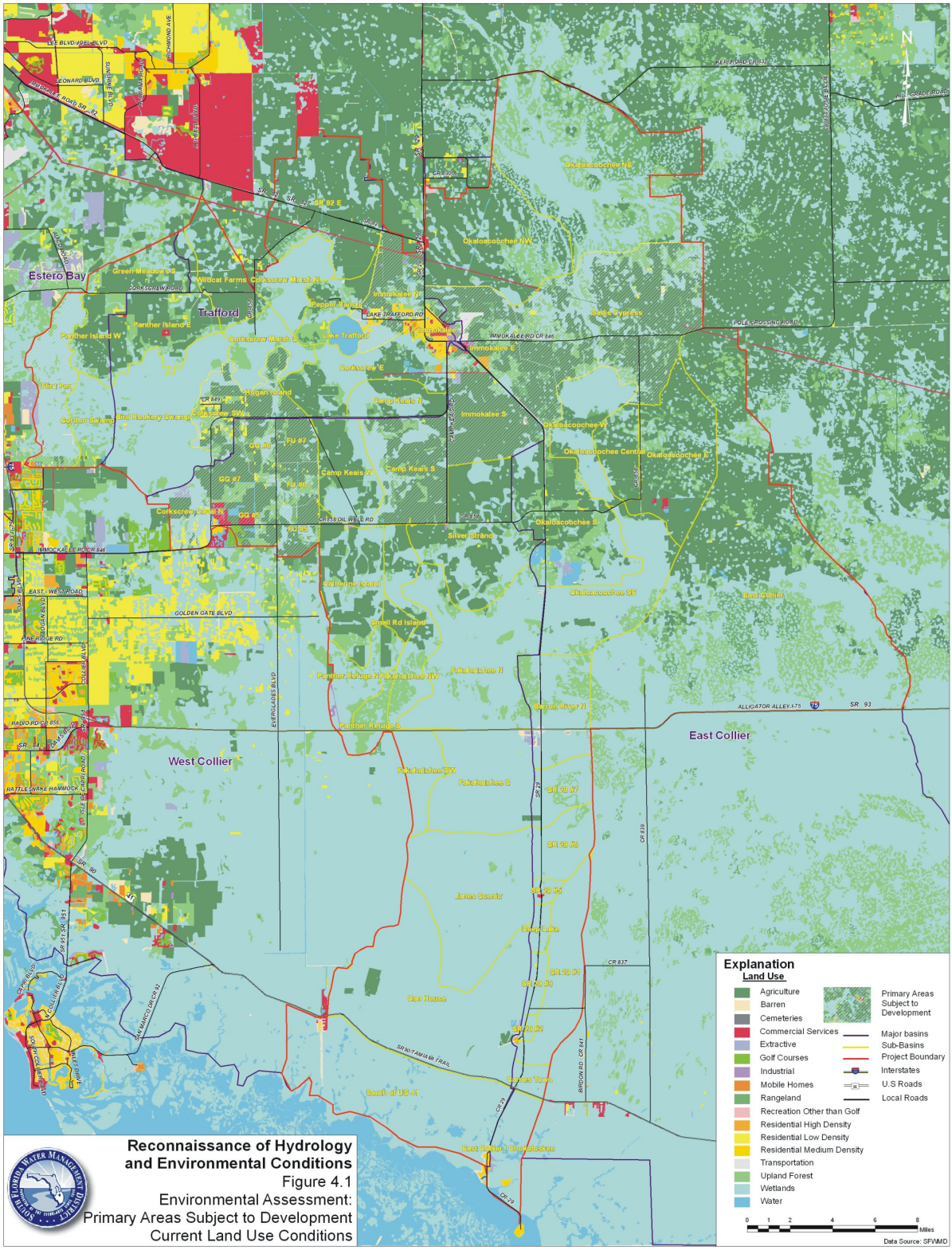

Figure 4.1. Environmental Assessment: Primary Areas Subject to Development. Current Land Use Conditions. This figure is inserted in a larger format at the end of this document.

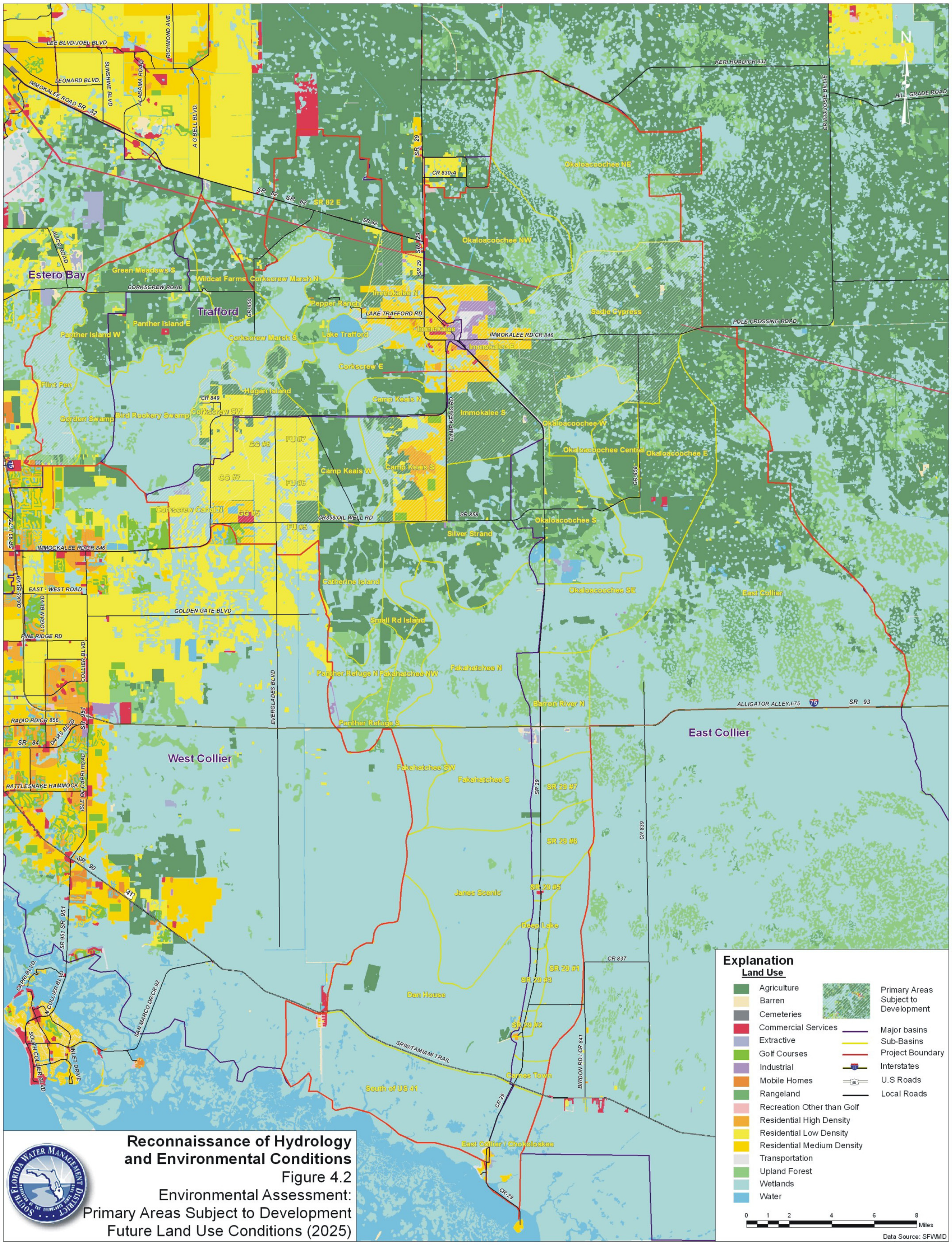

Figure 4.2. Environmental Assessment: Primary Areas Subject to Development. Future (2025) Land Use Conditions. This figure is inserted in a larger format at the end of this document.

4.4.2.1 Environmental Assessment Tool Application

The environmental assessment of the effects of proposed future land use activities on environmental indicators was conducted using the tool described above in Section 4.4.1. While consulting Table 4.3, first, the proposed future land activities were identified from the first row. Second, affected ecosystem indicators were determined from the first column. Next, the hypothesized effects of those alterations on ecosystem indicators were determined from the cell intercepting the previously selected column and row. For instance, Table 4.3 indicates that urban/agricultural development (landscape activity) has facilitated the invasion of exotics (selected ecosystem indicator) by creating an abundance of disturbed sites that would have been colonized by native species but are out competed by exotic species (hypothesized effect). Similarly, the table indicates that retention areas (land activity) can alter the vegetation mosaic (selected ecosystem indicator) by increasing the depth of and/or duration of inundation which can convert uplands to wetlands and wetlands to aquatic habitats (hypothesized effect). Finally, the set of performance measures to use for the assessment were determined based on the ecosystem indicator previously selected as listed in Table 4.3.

4.4.2.2 Future Restoration Activities on the Basin

Planned restoration activities in the Basin indicate that these projects are primarily concerned with the following (Table 4.4):

- Protection, buffering, and management of existing public lands
- Restoration of degraded habitat, and minimization of further habitat loss
- Protection of flood plains from further development to minimize needs for additional drainage projects
- Protection of habitat loss by severe fires
- Restoration of more natural distribution, timing and quantities of fresh water into the coastal estuaries
- Improvement of aquifer recharge
- Improvement to water quality by addressing point source and non-point source discharges through the adoption of best management practices
- Protection of ground water from pollutant loading, saltwater intrusion

It is important to note that the time response to restoration efforts depends on the rate of change in these biological communities in response to increase/decreases levels of stressor, but it is expected to vary from three to more than twenty years depending on community type and management. For instance, early successional communities tend to respond more frequently to changes than do later successional communities. Response of the fish population to restore hydroperiod, and wetland restoration should be fast (<5 years). Response of the wading bird population (increasing nesting pairs, nesting success and reestablishment of subsidiary colonies) should be evident over a decade-long time scale after water table recovery. On the other hand, organic soil has a

slow recovery even when hydrologic regime is re-established and could take more than 20 years.

TABLE 4.4 LIST OF RESTORATION PROJECTS IN THE CENTRAL BIG CYPRESS BASIN

Site	Restoration Project[1]
BCNP	Mineral Rights
BCNP	Plant Diversity
BCNP	Preserve Addition
BCNP	Private Inholdings
Belle Meade/Henderson Creek	Land Acquisition
Belle Meade/Henderson Creek	Restoration Project
Big Cypress habitats	Aquatic animal dynamics
Big Cypress Reservation	Impacts of Sludge deposition on P levels
Big Cypress Reservation	Phosphorus Assimilative Capacity of C&SF Canals
Corkscrew (CREW)	Project Addition/Imperial River Flowways
Cypress Wetland	Nutrient Threshold Work
Dade Co. Training Jetport	Land Adjacent
Fakahatchee Strand State Preserve	Exotic Species Removal
Golden Gate Estates S.	Hydrological Restoration
Golden Gate Estates S.	Land Acquisition Project
Gray Limestone Aquifer (S. FL)	Hydrological Reconnaissance
Lake Trafford	Restoration
Okaloacoochee Slough	Restoration Project
Picayune Strand State Forest	Exotic Species Removal
Pinelands/Cypress Wetland	Effects of fire regime
Rookery Bay	Hydrological Restoration
Seminole State Park (Collier)	Exotic Species Removal
Seminole Tribe	BMPs
Seminole Tribe	Water Conservation Project
Short hydroperiod Graminoid Wetland	Stand structure & productivity of short hydroperiod graminoid wetland
Southwest Surficial Aquifer	System investigation
Sunniland	Subsurface sand body investigation
Surficial Aquifer of S. Fl	Stratigraphy & hydrogeology
System Wide	Melaleuca control
Tamiami Trail	Additional Water Conveyance Structures
Twelve Mile Slough	Restoration Project

[1] Includes projects outside the Central Big Cypress Project Study Area that were reviewed for their consistency with the Environmental Assessment Tool. See Section 6 for projects list within the project study area.

In addition, restoration projects that directly affect vegetation (fire management) will produce more rapid responses than will management actions that indirectly affect it, such as changes in hydrology.

4.4.2.3 Planned Land Use Activities on the Basin

Examination of land use maps showing future urban development in the Basin (Figure 3.2 and Figure 4.3) indicates that these projects are primarily associated with the conversion of: 1) agricultural land and upland forest to urban areas; and to a lesser extent, 2) extractive material to high density residential (Table 4.5).

The expected effect of this development was determined from Table 4.3. It appears that lowering of the water table, disruption of sheet flow and habitat fragmentation are the main concerns with future development.

The prioritization of the effects into a level of threat was based on number of ecosystem functions affected and their widespread effect (Table 4.5).

A summary of the findings follows.

Estero Bay

Urban development plans for Estero Bay indicate that landuse changes are mainly occurring within the Flint Pen minor sub-basin. A small area of extractive material and approximately 2% of the upland forest in the area will be converted to low residential housing. In addition, an area south of Flint Pen (outside the study area) will be converted to residential areas.

This urban development could potentially affect southwest sheet flow to the Bay area and drying of adjacent wetland. Planned urban development in the Estero Bay sub-basin calls for high priority restoration efforts.

Trafford

Urban development plans for the Trafford sub-basin indicate that landuse changes are mainly occurring within the Corkscrew SW and Hogan Island minor sub-basins. In Corkscrew SW, all upland forest not directly facing CREW will be converted to low residential housing. The drainage needed to develop the area could affect CREW's wetland as well as the short hydroperiod herbaceous wetland present within the sub-basin. The level of threat is medium because the upland forest directly facing CREW will not be developed. This minimizes the ecological effects. It is recommended that development is limited to agricultural areas and to add central sewer in order to minimize effects even further.

TABLE 4.5. CENTRAL BIG CYPRESS BASIN ENVIRONMENTAL ASSESSMENT OF AREAS SUBJECT TO FUTURE DEVELOPMENT

Major Sub Basin	Minor Sub-Basin	Land Use Plan	Effect	Level of Threat	Recommendation
Estero Bay	Flint Pen	An area of extractive material will be converted to low residential	Sheet flow in the area will be channelized and area will be drained. This could cause a potential drying of adjacent wetland.	High	Restore sheet flow to the headwaters of the Orange River. It provides southwest sheet flow to Estero Bay. Implement stormwater runoff BMPs.
		Approximately 2% of the upland forest in the area will be converted to low residential			
		South of Flint Pen, the area of the Golden Glades Estate remaining upland forest land will be converted to residential			
Trafford	Corkscrew SW	All upland forest not directly adjacent to Crew will be converted to low residential area.	Drainage needed to develop the area could affect the wetland, as well as the remaining upland forest.	Medium	Limit development to the agricultural areas. Implement stormwater runoff BMPs. Add central sewer.
	Hogan Island	Mostly agricultural land conversion to low residential. There is little impact to upland forest.	Potential drainage problem to adjacent wetland.	Low	Add central sewer. Implement stormwater runoff BMPs.
W. Collier (N)	Crew Canal N, GG5, GG6, GG7, FU 5, FU6, FU7 and Camp Keais S	Agricultural and basically all upland forest will be converted to residential areas (except for a small patch of agricultural land in GG5)	Upland forest in this area serves as a corridor between the Picayune Strand State Forest and CREW. Potential impact to bird and wide-ranging mammal communities. Drainage created could have a potential reversed water flow, unnatural water flow delivery effect on adjacent wetlands and on southward sheet flow to Fakahatchee Strand and the Panther Refuge. Drainage created could cut hydrological connection between the wetlands in the north (CREW and Fakahatchee).	High	Optimize the upland forest buffer to the wetland. It provides a corridor for bird communities in the area, a hydrological connection among the wetlands, and provides sheet flow to the Fakahatchee Strand and the Panther Refuge. Implement stormwater runoff BMPs.

TABLE 4.5. CENTRAL BIG CYPRESS BASIN ENVIRONMENTAL ASSESSMENT OF AREAS SUBJECT TO FUTURE DEVELOPMENT

Major Sub Basin	Minor Sub-Basin	Land Use Plan	Effect	Level of Threat	Recommendation
W. Collier (NE Corner)	Immokalee S	Convert all upland forest adjacent to wetland to residential. Convert agricultural land, extractive materials and mobile parks to residential.	Drainage needed to develop the area could affect the wetland, as well as the remaining upland forest.	High	Provide large upland forest buffers (greater than 25 ft) around the wetland. This project has the potential of drying the wetland and increase sedimentation problems in Lake Trafford due to nutrients not being removed by the wetland. Implement stormwater runoff BMPs.
Trafford (E) & E Collier (NW) Section Near Immokalee	Immokalee	Small patches of agricultural land will be converted to residential.	Potential drainage problem to adjacent wetland.	Low	Restoration priority status is low because the area is already developed. Implement stormwater runoff BMPs.
	Immokalee N	Mostly all upland forest, close to Lake Trafford, and some agricultural land will be converted to residential.	In addition to affecting bird communities near the Lake, the sedimentation problem in the Lake will increase, due to an increase in impervious surface.	High for Lake Trafford	Limit development to agricultural areas. Implement stringent agricultural and stormwater BMPs.
	Immokalee E & Sadie Cypress	Sections affected are mostly conversion of agricultural land and some upland forests along Immokalee Rd/CR 846 to residential.	Destruction of upland forest. Important panther area.	Medium	Protect upland forests along Immokalee Rd/CR 846. Implement stormwater BMPs. Establish preserve for wildlife under path.

Note: GIS data do not identify short hydroperiod herbaceous wetlands and therefore do not show on maps. Consequently, these wetlands disappear or are lost to development

In Hogan Island, agricultural land will be converted to low residential with little impacts to forested land. This could cause a potential drainage problem to the adjacent wetland, but the level of threat is low. It is recommended that central sewer is added in order to minimize ecological effects.

In general, urban development in the Trafford sub-basin could potentially affect adjacent wetlands, as well as the upland forest. Planned urban development in the Trafford sub-basin is mostly low/medium except areas near Lake Trafford. It is recommended that development is limited to agricultural areas and central sewer be added.

West Collier

Urban development plans for northern section of West Collier indicate that land use changes are occurring within several minor sub-basins: the Corkscrew Canal North, GG5, GG6, GG7, FU5, FU6, FU7 and Camp Keais South. Agricultural (except for a small patch of agricultural land in GG5) and basically all available upland forested land are being converted to residential areas. Due to habitat fragmentation and drainage, urban development in the sub-basin could affect the north-south gradient in community composition, the plant community mosaic, sheet flow to Fakahatchee Strand, the bird communities reproductive success, as well as the hydrological connection among wetlands. Planned urban development in West Collier calls for high priority restoration efforts. It is recommended that an upland forest buffer be created to optimize the hydrological connection between the Fakahatchee Strand and CREW and provide a corridor for bird communities in the area. In order to protect valued ecological functions it is also recommended that central sewer be added.

Urban development plans for the northern-east section of West Collier are focused in the minor sub-basin, Immokalee South. Upland forests adjacent to wetlands, agricultural land, extractive materials and mobile home parks are being converted to residential areas. The level of threat is high because the drainage needed to develop this area could affect the wetland, the remaining upland forest and even Lake Trafford. It is recommended that an upland forest buffer be created to protect the wetland. By protecting the wetland, its role in nutrient removal is protected, and consequently, sedimentation problems in Lake Trafford are also ameliorated.

East Collier

There are no planned urban development projects in East Collier, except for a small project on Immokalee East and Sadie Cypress minor sub-basins. Sections affected are mostly conversion of agricultural land and some upland forest to residential areas along Immokalee Rd/CR 846. The drainage needed to develop the area could affect the adjacent wetland, as well as the remaining forest.

Urban development outside East Collier could affect sheet flow in this sub-basin. It is recommended that restoration projects focus on maintaining sheet flow and hydrological connectivity.

In general, management recommendations to decrease impacts primarily indicate that it is imperative to protect upland forest within the Central Big Cypress Basin, in particular upland forest adjacent to wetlands. In addition, it is imperative that central sewers are added to areas being developed.

4.4.2.4. Environmental Monitoring and Performance Measures

Finally, in order to assess the actual effects of future land use practices in the Big Cypress Basin, it would be necessary to implement a sampling monitoring program that considers the areas adjacent to proposed development, as well as areas set aside for preservation which are not necessarily in direct contact with proposed urban areas. Among the ecosystem attributes to monitor would be:

- Sheet flow characteristics in CREW, around Lake Trafford, between Camp Keais W and Camp Keais S, as well as in the Fakahatchee Strand. The existing network of monitoring stations can be used to collect these data.
- Water levels in wetlands adjacent to all urban development projects and in Lake Trafford. New development projects should include monitoring stations as part of any conditional approvals.
- Sedimentation rates in all wetlands and in Lake Trafford, as part of the ongoing restoration project.
- Fish population characteristics in Lake Trafford and in the wetlands, as part of the ongoing restoration project.
- Vegetation community composition in wetland areas
- Bird species composition in upland forests and wetland areas

4.4.3 Concluding Remarks

In conclusion, the proposed urban development could represent a risk to the ecological integrity of the Central Big Cypress Basin. It has the potential of affecting the characteristic plant community gradient and mosaic by selectively removing upland forest from the ecosystem and by facilitating the invasion of exotic woody species. Accordingly, animal communities in the area will also be affected. In addition, the proposed urban development has the potential of affecting the hydrological regime of the area by lowering the water table. As a result, the potential for forest fires could increase. Furthermore, the water quality characteristics could be degraded by the expected increase in solids and contaminants.

Finally, it is recommended that in order to decrease the expected effects of the proposed urban development, that upland forest destruction is substantially decreased, particularly around those areas in direct contact with wetlands. In addition, special attention should be given to the quantity and quality of storm water. An important new tool for restricting growth in ecological sensitive areas is the Collier County Transfer of Development Rights Program (see Section 3.6) which rewards landowners for turning

over the development rights in highly sensitive lands and sells the right for development in less sensitive lands.

5. WATER QUALITY ASSESSMENT AND MONITORING PLAN

5.1 Introduction

This Section of the Report will focus on existing water quality conditions in the project study area. It will review the existing conditions, describe the existing monitoring network, discuss water quality problems in each of the major sub-basins in the Central Big Cypress Basin (CBCB) project study area, and make recommendations regarding additional monitoring.

5.2 Sources of Information

5.2.1 Summaries of Monitoring Results

Water quality in southern Florida was affected at a regional level by the Central and Southern Florida (C&SF) Project, initiated in 1948 for flood control and water supply purposes. The C&SF Comprehensive Review Study "Restudy" (U.S. Army Corps of Engineers, 1999) evaluated the impacts of this project on water resources and made recommendations about changes to the C&SF that would protect and restore the environment while meeting future water needs. This report led to the Final Integrated Feasibility Report and Programmatic Environmental Impact Statement, now known as the Comprehensive Everglades Restoration Plan (CERP) (U.S. Army Corps of Engineers, 1999). Specific goals of the studies derived from the Restudy include:

1. Identify links between water quality and ecosystem functions.
2. Identify degraded waterbodies.
3. Identify and quantify types and sources of pollution.
4. Develop targets for reducing pollution.
5. Inventory and evaluate measures available to improve water quality.
6. Integrate existing water-quality restoration and management programs with projects of the Everglades Restoration plan and other federal, state, tribal, and local projects and programs.
7. Recommend new programs and projects to implement the plan.
8. Identify appropriate funding sources

.

The Restudy only assessed water resource issues in southwest Florida related to the Caloosahatchee River Basin, which is north of this project study area and drains land from the Lake Okeechobee area to the Gulf of Mexico. The Restudy recognized that, in addition to addressing the Caloosahatchee River Basin water resource issues, other watersheds required a comprehensive review of environmental conditions related to water quality. The Southwest Florida Feasibility Study (SWFFS) was one of the recommendations resulting from the Restudy (U.S Army Corps of Engineers and the South Florida Water Management District, 2002). One component of the SWFFS was the *Compilation, Evaluation, and Archiving of Existing Water Quality Data for Southwest Florida* (SFWMD, 2004).

The SWFFS water quality report evaluated water quality conditions in a 4,300 square mile area comprising two major drainage basins, the drainage divide of the Caloosahatchee River, and the Big Cypress Swamp / Everglades system. The 950 square miles of this CBCB project study area were included in the second major basin of the SWFFS study area. The SWFFS represents the most recent and thorough review of conditions in the project study area. The SWFFS assembled data from 168 water quality studies with data from 1901 through 2003. A total of 9 million records were assembled for this study, screened, and analyzed for quality control.

The SWFFS not only summarized the available water quality data. It also compared the data to water quality standards and reported on areas where water quality problems exist, summarized trends in water quality, and pointed out gaps in data. The SWFFS results for the project study area of this CBCB report are summarized in the following sections.

Other major reviews of water quality in the project study area were reported by McPherson, et al (2000) and Milller, et al. (2003). McPherson, et al (2000) provided additional information about the impacts of water quality on human and environmental health, called for additional monitoring and mitigation efforts and summarized water quality standards and recommended goals. This study compared the water quality found in south Florida to that of other waters in the Nation. It found that phosphorus is above background levels, dissolved organic carbon is elevated, and some of the areas that receive agricultural runoff have elevated (but not action level) amounts of pesticides.

The Miller, et al. (2003) report focused on the Big Cypress and Everglades areas. It described long term trends in water quality and discharge into the preserve areas. It documented increases in discharges in the 1960's, after the C&SF Project, and showed generally flat trends in most water quality parameters. This report did show decreases in total phosphorus in the past two decades and summarized data on pesticide residues in the Barron River Canal. However, the SWFFS provided even more recent summaries of monitoring data and it was inclusive of the areas described in these reports.

5.2.2 Current Monitoring Programs

Water quality monitoring is conducted by several agencies as well as private entities in support of permit requirements. Agencies collect monitoring data for legal mandates, interagency memoranda of agreement, compliance monitoring, and research. Water quality monitoring includes water samples as well as fish tissue and sediment samples at selected locations. Figure 5.1 shows the identified long-term water quality monitoring stations in the project study area that have provided historical data as well as the current monitoring program. This figure displays the monitoring stations as shown in the context of the existing land use information summarized in Section 4 of this Report.

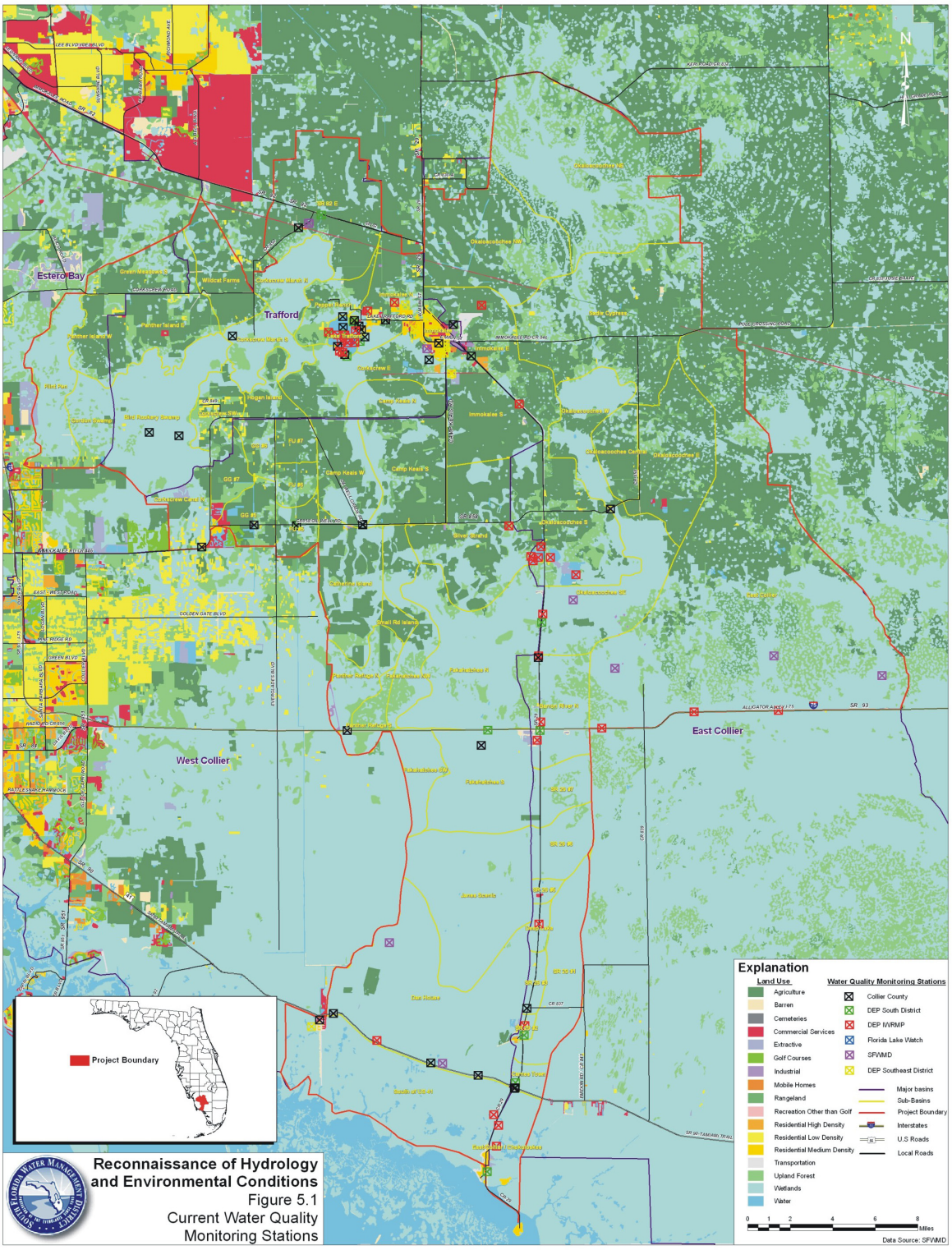

Figure 5.1. Current Water Quality Monitoring Stations. This figure is inserted in a larger format at the end of this document.

The Florida DEP collects data to support the production of the listing of impaired water bodies 305(b)-report, and to generate information in support of the state's total maximum daily load (TMDL) program (Florida Department of Environmental Protection, 2005). These regulatory requirements have been integrated into the DEP's monitoring program as an Integrated Water Resource Monitoring Network (IWRM) Program that is comprised of three tiers: "Tier I monitoring is comprised of status and trend monitoring designed to answer state-wide to regional questions. Tier II monitoring includes basin assessments and monitoring required for TMDL development. This monitoring is more localized in nature than that occurring under Tier 1 monitoring, yet may encompass a broader area then that employed in Tier III. Tier III includes all monitoring tied to regulatory permits issued by DEP and is associated with evaluating the effectiveness of best management practices or BMPs" (Florida Department of Environmental Protection, 2005). Water quality sampling methods have been standardized and are available in the Sampling Manual (Florida Department of Environmental Protection, 2004).

The Big Cypress Basin - Estero Bay Regional Research Database Project (2005) is another source of data and reports on water quality, planning studies, and other reports about the project area. The South Florida Information Access (SOFIA) Website (http://sofia.usgs.gov/) is a database that provides links to numerous reports pertaining to South Florida, the Everglades, and the project study area.

The South Florida Water Management District has a regular monitoring program, conducted in cooperation with Collier County. These data, as well as data collected by the National Park Service and the U.S Geological Survey, were summarized in the SWFFS; new data are publicly accessible and maintained in the DBHYDRO database (South Florida Water Management District, 2005) and the USEPA STORET databases (Florida Department of Environmental Protection. 2005).

5.3. Water Quality Concerns

The project study area is a low relief area that drains from the north, at a maximum elevation above sea level of about 35' NAVD88. Most of the drainage is south to the Ten Thousand Islands and Florida Bay, with a small portion of the northwestern part of the project study area in the Estero Bay sub-basin that drains west to the Gulf of Mexico. The surface water is fresh, except for estuarine areas south of SR 41, the Tamiami Trail. In addition, during dry periods brackish water can intrude northward along the Barron River Canal.

The federal Clean Water Act allows states to set water quality standards, subject to review by the U.S. Environmental Protection Agency. The Florida Administrative Code (Rule 62-302.400) has defined five classifications of Florida surface waters: They are:

- Class I Potable water supplies.
- Class II Shellfish propagation or harvesting.
- Class III Recreation, propagation and maintenance of a healthy, well balanced population of fish and wildlife.

Class IV Agricultural Water Supplies.
Class V Navigation, utility and industrial use.

All of the fresh waters in the project study area are Class III. The estuarine areas south of the project study area in the Ten Thousand Islands region are Class II.

There is an Anti-Degradation Clause (Rule 62-302.300, F.A.C) that prohibits any action that degrades water quality from ambient levels for waters designated as Outstanding Florida Waters, even if a single action does not trigger a violation of a numerical water quality standard. All of the Preserves and Sanctuaries listed in Section 4 of this CBCB Report are designated as Outstanding Florida Waters. The Anti-Degradation Clause restricts discharges in other waters from lowering water quality below specific minimum regulated standards.

The specific minimum standards adopted by the State of Florida are in Section 62-302.530 of the Florida Administrative Code (see: http://www.epa.gov/waterscience/standards/wqslibrary/fl/fl_4 62-302t.pdf). There are no specific criteria for nutrients, but rather additions are limited that might affect the biological or other standards. The Clean Water Act also required that states identify existing water bodies that fail to meet their water quality standards and to develop Total Maximum Daily Loads (TMDL) for each impaired water body. This list, adopted by the Florida Legislature in 1999 and updated in 2002, is called the 303(d) list. The water bodies that are considered impaired are described below in Section 5.4 for each sub-basin.

The project study area historically had water quality similar to that currently found in the Everglades and pristine areas of the Big Cypress preserve. Because of the very low topographic gradients, surface flows were generally by sheet flow. These areas are characterized as being very low in nutrients, with phosphorus being the nutrient that is available in limiting supply. The Everglades background total phosphorus concentration is 0.01 mg/L (McPherson, et al., 2000). This low background nutrient value is easily upset by nutrient additions. Nutrients can enter surface waters from agricultural runoff and from stormwater runoff from residential and commercial development. The addition of nutrients promotes the growth of invasive plants at the expense of native flora, and the additional plant growth results in more organic growth that can lead to oxygen depletion and other deleterious impacts on water quality.

When plant material decomposes some of the degradation products become stable dissolved organic carbon compounds (DOC) that make the water dark-colored and can provide substrates for bacterial decomposition. DOC is another parameter of concern in the project study area.

Mercury is the metal of potential concern. When inorganic metallic mercury enters anaerobic sediments, it can be converted to methyl-mercury, which is biologically active and mobile in food chains.

Pesticides migrate into surface and groundwater, and some of these compounds are long-lived. Pesticide levels are monitored in the project study area.

The SWFFS conducted a comparison of data to benchmark values, regulatory limits and other measures of water quality. This was done through a computerized flow chart procedure called "Waters of Concern Calculator." This procedure, with several caveats, identified waters that could be degraded based on aquatic life, water quality criteria and nutrient impact thresholds. Caveats include the use of watershed delineations from the U.S. Army Corps of Engineers with boundaries that are not everywhere consistent with those developed later by the SFWMD and presented in Section 2 of this CBCB Report, several anomalies resulting from uncertain knowledge of background values, and limitations of the water quality monitoring dataset[3].

In addition, for each water quality parameter that is identified as possibly being of concern in Table 5.1 there may be extenuating circumstances that explain levels that exceed the benchmark values other than pollution by anthropogenic sources. These caveats are reproduced from SWFFS (2004):

Coliform Bacteria. It is widely recognized that using fecal and total coliform bacteria as an indicator of the presence of harmful pathogens can result in false positives. Elevated fecal coliform bacteria counts can come from human sources and indicate problems with wastewater treatment, septic systems, or poorly managed human waste in heavily used recreational areas. However, such elevated counts are also common in stormwater and might represent bacteria from livestock or from wild animals. Therefore, exceedances of fecal coliform standards should serve more as a starting point to focus attention on identifying likely human and/or natural sources of bacteria. Where combined sewers, old septic systems, livestock operations, or heavily used recreation areas are potential sources, attention should be paid to determining whether elevated bacteria levels reflect natural background or anthropogenic sources (SWFFS, 2004, p.50).

Dissolved Oxygen. In south Florida, natural background conditions tend to encourage lower DO levels than would typically be found in waterbodies farther north where water quality standards for dissolved oxygen were originally derived. Significant groundwater contributions to surface flow, shallow water columns, slowly moving water with little turbulence, and high ambient air temperatures all tend to encourage naturally low DO concentrations that might fail to meet the state's water quality standards (SWFFS, 2004, p.52).

[3] "It is not appropriate, however, to directly compare FDEPs Planning and Verified lists with the Waters of Potential and Verified Concern lists generated by this SWFFS effort. The water quality data do not correspond exactly, and the basins used to aggregate water quality data are delineated differently because this analysis used basin delineations developed from county stormwater management plans and local H&H [Hydrology and Hydraulics] modeling efforts" (SWFFS, 2002, p.43).

Unionized Ammonia. The numeric criterion for un-ionized ammonia is relatively low at 0.02 mg/L. Because there is no un-ionized ammonia criterion for Class III marine waters, care should be taken when considering potential and verified concerns for un-ionized ammonia in basins that may contain water quality monitoring stations in estuarine or marine waters. The delineation of marine versus fresh waters is represented as a static line in the basins GIS coverage for the SWFFS water quality analysis, but in the real world this boundary is not static and is influenced by seasonal rainfall, flow patterns, and tidal influences (SWFFS, 2004, p. 53).

Nutrients. Chlorophyll concentrations and TSI [Trophic Status Index] scores are the primary surrogate indicators FDEP uses to identify nutrient problems in waterbodies. Although the IWR [Impaired Waters Rule] allows for other evidence of nutrient impairments such as fish kills and abundant aquatic macrophytes to serve as sufficient grounds for a nutrient problem, this type of data is very rarely if ever available in a database format that would support automated watershed assessments. Another consideration is that the IWR allows waters to be listed if the annual mean chlorophyll a value has increased greater than 50% over historical values. In some cases, if the early data have relatively low chlorophyll *a* concentrations (e.g., 3 µg/L) and later data are 50% higher (e.g., 6 µg/L) [sic], this would result in a potential concern for nutrients while chlorophyll *a* concentrations are still low relative to statewide values. This example of 50% increases from historically low values explains the nutrient concerns in the southeastern portion of the study area including the Big Cypress and Everglades National Park basins. Of the 45 waters of potential concern, 11 freshwater basins had an annual mean chlorophyll *a* concentration greater than the threshold of 20 µg/L. Seventeen estuarine basins had an annual mean chlorophyll *a* concentration greater than 11 µg/L. Fourteen basins had potential concerns because the annual mean had increased more than 50% over historic values, and three lakes had Trophic State Index violations (SWFFS, 2004, pp-55-56).

Iron. Iron is an abundant element and can occur naturally in darkly colored waters like those found throughout Florida. Care should be taken to distinguish naturally caused background iron concentrations from unusual spikes in iron that might be anthropogenic in origin. FDEP has also indicated concerns regarding the quality assurance and quality control associated with older metals samples commonly available in existing databases. New metals samples will be required to have significantly more supporting metadata regarding QA/QC in order to be considered by FDEP as part of the Impaired Waters Rule. Because the numeric criterion for iron varies between fresh and marine waters, iron exceedances in basins that could contain both fresh and marine waters should be considered station by station and sample by sample (SWFFS, 2004, p. 57).

Copper. FDEP has indicated concerns regarding the quality assurance and quality control associated with older metals samples commonly available in existing databases. New metals samples will be required to have significantly more

supporting metadata regarding QA/QC in order to be considered by FDEP as part of the Impaired Waters Rule. Because copper toxicity diminishes with increasing hardness, the copper criterion is different for fresh and marine waters. Copper exceedances in basins that might contain both fresh and marine waters should be considered station by station and sample by sample (SWFFS, 2004, p.58).

pH. Because the pH criteria are contingent on natural background conditions, care should be taken to review available ambient data for the waterbody in question to understand just what the natural background conditions might be (SWFFS, 2004, p.61).

Turbidity. As with other criteria where the threshold is some value above natural background conditions, it is challenging to define what natural background values are from limited data sets (SWFFS, 2004, p.62).

The results of the SWFFS analysis, along with the caveats where appropriate, are summarized for the subset of basins included in this CBCB project study area below in Table 5.1. Table 5.1 is derived from data presented in Section 9 of the SWFFS. The areas of potential concern, and the verified areas of potential concern, were mapped in the SWFFS based on watershed boundaries delineated by the U.S. Army Corps of Engineers and presented in Appendix E of the SWFFS. These areas of concern were compared with the major watershed boundaries described in Section 2 of this report to create Figure 5.2.

The watershed delineations in the SWFFS are different from those used in this Report, and they are also different from the Water Body Identification boundaries (WBID) used by FDEP in developing 303(d) impaired water body lists. The WBID list is based on surface water bodies. The boundaries the Army Corps developed and that were used by the SWFFS were based on county-level stormwater planning units. The watershed areas developed for the SWFFS tend to be smaller in more developed areas and do not reflect the best estimate of true hydrologic boundaries as well as those presented in Section 2 and shown in Figure 2.1 of this Report. The boundaries used in the SWFFS are compared with those presented in Section 2 of this CBCB Report in Figure 5.2

TABLE 5.1. WATER QUALITY PARAMETERS OF POTENTIAL CONCERN (Data from SWFFS, 2004)*

	Estero Bay	Trafford	E. Collier	W. Collier
Fecal Coliform Bacteria	-	+	+	+
Dissolved Oxygen	-	-	+	+
Unionized Ammonia (1)	+	+	+	+
Nutrients	+	+	+	+ (2)
Iron (3)			+	+
Copper	-	-	+	-
Conductance	-	-	-	+ (4)
pH	-	+ (5)	-	-
Turbidity	-	+	-	-

Notes: * Plus marks (+) indicate that some of the monitoring results, as reported in the SWFFS were in exceedance of standards and agency goals. Sub-Basins are shown in Figure 2.1.

(1) Unionized ammonia is a consequence of livestock waste and extra fertilizer applications. However, it is pH and temperature sensitive, and not measured the same way by all agencies. There is also no criterion of unionized ammonia in marine waters.

(2) Only the northern section of the West Collier sub-basin exceeded nutrient standards.

(3) Iron is a naturally occurring metal, especially in areas that are naturally rich in humic (DOC) materials. Iron is not toxic and although the presence of iron in high concentrations can represent an exceedance of a water quality standard it may not represent an ecological risk.

(4) Conductance is a measure of the total amount of dissolved ions in solution. The southern portion of the West Collier basin exceeds the standard, which is based on the background levels, probably because of migration of marine waters.

(5) pH exceedances are based on comparisons with backgrounds, and the SWFFS reports that the background for the Lake Trafford and Corkscrew areas reported here may be incorrect, suggesting that this is an artifact.

The SWFFS developed two specific sets of performance measures that can be utilized to track the success of the SWFFS program during implementation. The first set of performance measures are assessment measures. Modeling is being used in the SWFFS to determine how these assessment measures should respond to changes in water quality management, and monitoring will be used to measure the responses as compared to the modeling. These studies, currently underway, will provide a consistent tool for the evaluation of water quality changes. The assessment measures include Dissolved Oxygen, Specific Conductance, Salinity, Turbidity, Total Suspended Solids, Color, Photosynthetically Active Radiation, Secchi disc depth, Chlorophyll *a*, Total Nitrogen / Ammonia / Kjeldahl Nitrogen / Nitrate / Nitrite/ Dissolved inorganic Nitrogen, Total Phosphorus, Soluble Reactive Phosphorus (Orthophosphate), Chloride, Sulfate, Silica, Pesticides, and Trace Metals.

In addition to these assessment endpoints, the SWFFS developed a set of evaluation metrics to measure the performance of the Plan. These evaluation performance measures are intended to be used to predict the performance of specific management alternatives. They include: Dissolved Oxygen, Salinity, Turbidity, Total Suspended Solids, Photosynthetically Active Radiation, Color, Chlorophyll *a*, Total Nitrogen,

Dissolved inorganic Nitrogen, Total Phosphorus, and Soluble Reactive Phosphorus (Orthophosphate), Target values for these assessment endpoints are under development for different areas, including water quality treatment areas, receiving waters, and “waters to be restored.”

5.4 Existing Monitoring

The existing monitoring efforts by the agencies described in Section 5.2 are not dispersed evenly throughout the project study area (Figure 5.1). Monitoring is done to assess conditions in and around potential impact areas, or near sensitive receptors. The SWFFS identified areas where the historical record indicated exceedances of water quality standards or goals. These are summarized in Table 5.1. It must be emphasized that a plus (+) mark in Table 5.1 does not imply a regulatory exceedance. For example, the CERP project has set a total phosphorus goal of 0.01 mg/L, based on nutrient measurements in undeveloped areas. This goal may not be achievable in developed areas, as indicated by the row of plus (+) marks for nutrients in Table 5.1. The geographic distributions of these efforts are described in the following sub-sections.

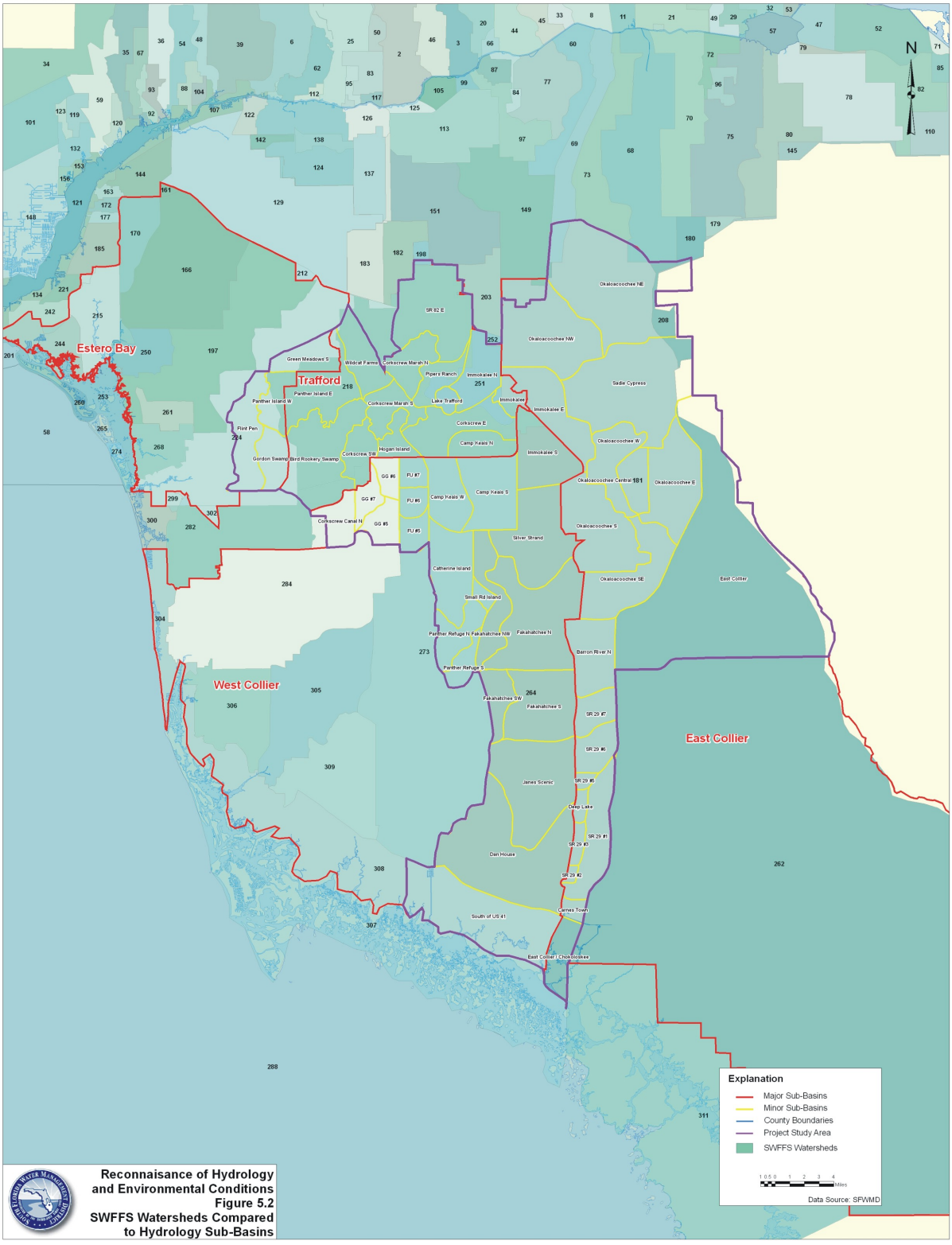

Figure 5.2 SWFFS Watersheds Compared to Hydrology Sub-basins. This figure is inserted in a larger format at the end of this document.

5.4.1 Estero Bay Sub-Basin

The Estero Bay Sub-Basin extends westward to the Gulf of Mexico, beyond the western limits of the project study area boundary. The part of this Sub-Basin that is included in the project area is the eastern headwaters area. This area includes wetlands, agricultural rangeland, and some low to medium density residential areas. There are no regular monthly SFWMD / Collier County water quality monitoring stations specifically in the part (37 square miles) of the project study area in the Estero Bay sub-basin, but there are monitoring stations immediately downstream and in and around Fort Myers and Fort Myers Beach to the west.

Water quality samples have been taken historically in the project study area, and the data are adequate for the SWFFS to include generalizations about parameters of concern in the sub-basin. These parameters of concern are summarized in Table 5.1.

The portion of the Estero Bay sub-basin within the project area is generally a headwaters area. It is not subject to pollution from upstream areas, and the nutrient and turbidity from the agricultural and residential uses manifests itself as problems downstream. The only parameters of concern in the project study area are unionized ammonia which may be a sampling artifact, because a portion of the surface water could be actually derived from groundwater and not surface runoff. The areas downstream of the project study area have demonstrated water quality problems associated with development, including nutrient enrichment, elevated turbidity, and pesticides. Additional monitoring in this area may provide better early warning of problems downstream.

5.4.2 Trafford Sub-Basin

The Trafford Sub-Basin is the second smallest in the project study area (158 square miles). It contains the wetlands of the Corkscrew Sanctuary as well as agricultural rangeland and fields, low to medium density residential areas, and the standing water of Lake Trafford. It also contains the only town in the project study area, the unincorporated City of Immokalee.

Long-term monitoring stations are established at the inlet to the Corkscrew Sanctuary, near Lake Trafford, and several stations along the eastern side of the sub-basin.

Water quality problems in the Trafford Sub-basin, as summarized in Table 5.1, are typical of agricultural areas and include exceedances of fecal bacteria, nutrients, unionized ammonia, and turbidity. The Lake Trafford basin, as defined by the Florida Department of Environmental Protection (1998), is a 303(d) impaired water body because of nutrient enrichment, mercury in fish tissue, fecal coliforms, turbidity, and low dissolved oxygen. The Army Corps of Engineers is implementing a dredging program to remove the thick layer of organic-enriched muck that has led to the water quality impairment and that removes oxygen from the waters and has led to large fish kills

(http://www.saj.usace.army.mil/projects/laketraf.htm). This project will protect the headwaters of the Corkscrew Sanctuary and Camp Keais Strand.

Corkscrew Sanctuary receives direct agricultural runoff in addition to occasional outflows from Lake Trafford. Because of the ecological significance of the Corkscrew Sanctuary, the nutrient enrichment is problematic. Some of the nutrients could be eliminated from the inlets to the Corkscrew Sanctuary if the flows were detained (see Section 2.6) to allow the nutrients to become bound in sediments and plant growth before the nutrients are allowed to flow into the Sanctuary in dissolved forms.

5.4.3 East Collier Sub-Basin

The East Collier sub-basin extends along the entire eastern side of the project study area and includes 425 square miles of agricultural lands, low and medium density residential, and even some of the Big Cypress Preserve along its southeastern border. This sub-basin includes the Okaloacoochee Slough in the north and the Barron River Canal to the south.

There are monitoring stations dispersed throughout the project study area, as well as several important monitoring stations in the Big Cypress Preserve to the east of the border of the project study area. There is an extensive area comprising the headwaters of the Okaloacoochee Slough drainage where monitoring locations are lacking.

The Bear Slough area along the eastern boundary of the sub-basin is largely agricultural. Its drainages flow through canals until they are intercepted by the I-75 canal, where the water is diverted west to the Barron River or through culverts to the Big Cypress Preserve south of I-75.

The Okaloacoochee Slough provides channel flow and sheet flow from agricultural land, and the Barron River Canal expedites flow to the Ten Thousand Islands area along the southern coast. During low flow periods, the Barron River Canal may expedite the migration of marine or estuarine waters northward. These alternating flows, as described in Section 2, provide the basis of water quality problems.

These water quality problems include fecal coliform bacteria, and nutrients, including unionized ammonia. The three monitoring stations in the East Collier sub-basin immediately north of the I-75 corridor consistently exhibited levels of total phosphorus above the background benchmark of 0.010 mg/L during the study period of 1991-2000 (Miller, et al., 2003). These elevated phosphorus levels, derived from agricultural runoff north of the Big Cypress Preserve, are high enough to create blooms of algae, depress dissolved oxygen, and cause habitat alteration.

The extensive drainage of organically enriched, tea-colored humic waters probably explains the elevated levels of iron found in the sub-basin, and the inclusion of iron as parameter of potential concern in Table 5.1 is probably an artifact. Agricultural runoff in this sub-basin area contains pesticides, and pesticide residues have been measured in the sediments of the Barron River Canal (Miller, et al. 2003). The Barron River Canal

drains to the south and to the west, into the Fakahatchee Strand in the West Collier sub-basin.

5.4.4 West Collier Sub-Basin

The West Collier sub-basin is almost as big as the East Collier sub-basin with an area of 330 square miles. This area is very diverse. This basin is characterized by some housing development and extensive agricultural activity in the northern part of the sub-basin, and large areas of undeveloped land with southerly sheet flow through the Fakahatchee Strand in the south. It is immediately east of the Golden Gate Estates, where a series of north-south drainages has affected flows. This area is slated for restoration which will improve detention of water. Finally, the area is influenced by marine conditions in the estuarine area immediately south of the Tamiami trail (U.S. 41).

This sub-basin is represented by 18 separate monitoring stations. Geographic coverage is good. These stations are dispersed in wilderness areas and farm roads as well as along major roadways, including CR 858 / Oil Field Road (4) and the Tamiami Trail / U.S. 41 (4).

Because of the variety of habitats, parts of the West Collier sub-basin, particularly north of I-75, reflect the same water quality problems related to nutrient enrichment as described above for the East Collier Basin. South of I-75 this basin is almost entirely wetland, and these conditions are similar to the sheet flow characteristic of pre-development conditions, including the high water quality characteristic of these conditions. Because the southern part of the West Collier sub-basin lacks the canal drainage (Barron River) characteristic of the East Collier sub-basin, there is no extensive migration of salt water, as measured by conductivity, north of the estuarine minor sub-basin south of U.S. 41. Although not listed as a 303(d) impaired water body, the West Collier Sub-Basin will benefit from the reversal of flows anticipated as a consequence of the implementation of the Picayune Strand Restoration project.

5.5 Data Gaps and Additional Needs

The SWFFS identified two sources of gaps in their analysis of areas of potential water quality concerns: 1) the size and shape of the minor sub-basins used for the analyses could be refined based on a better understanding of the hydrology in the areas, and 2) additional monitoring extent and frequency. The first data gap is not addressed in the SWFFS, but the second is analyzed in Appendix I of the report.

The first data gap is illustrated in Figure 5.2. This figure compares the watersheds used in the SWFFS compared with those developed for the project study area as shown in Figure 2.2 of this CBCB Report. The sub-basins described in this Report are delineated based on the best available hydrologic data that were used by the recent MIKE SHE II model (DHI, 2002). The watersheds from the SWFFS were received from the U.S Army Corps of Engineers and were reportedly based on the stormwater planning units used by the Counties. These are generally in accordance, but there are several SWFFS watersheds that span the boundaries of the hydrologic sub-basins. These are evident

in Figure 5.2 and are listed in Table 5.2. Furthermore, the stormwater planning-based watersheds in the SWFFS are not as sub-divided in the southern portions of the West and East Collier sub-basins as was done in the modeling studies on which this Report is based. This is not currently a serious data gap because the southern part of the sub-basins is not developed, but better baseline data, particularly around the Tamiami Trail / U.S 41 Corridor would be useful in providing guidance for restoration efforts along this corridor and the Barron River Canal.

The data gap based on the frequency of sampling is presented in the SWFFS. The SWFFS considered those parameters for which the analyses were incomplete because of a lack of data to enter into the "Waters of Concern Calculator." The County and SFWMD sampling has been done monthly since 1998, so this data gap is largely filled. The FDEP sampling is done less frequently, and is based on collecting sufficient data to determine if a specific Water Body Identification (WBID) area is impaired. This required a data set of 20 samples per WBID.

The most complete data are available for the watersheds near the urbanized areas. The density of data is most diffuse in the undeveloped areas that are characteristic of most of the project study area. The historical data record for many of the stations includes only quarterly sampling, whereas the standard for more current sampling is monthly sampling. The parameters for which datasets are incomplete are summarized in Table 5.2. This table, derived from Appendix I of the SWFFS, indicates that many of the parameters do not have an historical record of monthly sampling. However, the record was sufficient to cause concerns as shown in Table 5.1. There is a consensus among the agencies charged with monitoring water quality that the current program is sufficient to resolve the gaps reported in Table 5.2 from the historical data set.

TABLE 5.2. WATER QUALITY DATA GAPS (Data from SWFFS, 2004)

Hydrologic Sub-basins	Estero Bay		Trafford			West Collier				East Collier					
SWFFS Watershed	224	218	218	251	220	264	273	308	309	181	208 (1)	264	273	308	309
Coliform Bacteria	+	+	+	+		+	+	+	+	+		+	+	+	+
Dissolved Oxygen	+	+	+	+		+	+	+	+	+		+	+	+	+
NO_3 / Ammonia	+	+	+	+		+	+	+	+	+		+	+	+	+
Phosphorus	+				+	+	+	+		+		+	+	+	
Iron		+	+			+	+	+	+	+		+	+	+	+
Copper	+	+	+				+	+		+			+	+	
Conductance	+	+	+	+		+	+	+	+	+		+	+	+	+
pH	+	+	+	+		+	+	+	+	+		+	+	+	+
Turbidity						+	+	+	+	+		+	+	+	+
Chlorophyll	+				+	+	+	+		+		+	+	+	
Alkalinity		+	+	+		+	+	+		+		+	+	+	
Metals		+	+			+	+	+	+	+		+	+	+	+
Pesticides	+			+			+			+			+		

Notes: See Appendix I of the Southwest Florida Feasibility Study (2004). Sub-basins are shown in Figure 2.1. The marked (+) parameters are those that the SWFFS reported as having insufficient data to verify the potential for water quality impairment. The plus (+) marks indicate that long term data are incomplete for any of the measured parameters at any of the monitoring stations within a sub-basin in the data types listed in the first column. For example, pesticides could be checked if data are incomplete for any of the pesticides considered in the evaluation.

Underlined watershed numbers span the border between the hydrologic-based sub-basins described in Section 2 of this Report and are therefore repeated in two sub-basins.

Data gap analysis is not included in the SWFFS for the small watersheds: 252, and 208.

(1) This hydrologic sub-basin is not included in the summary of data gaps by the SWFFS

5.6. Monitoring Recommendations

The data gaps presented in Table 5.2 reflect historical conditions as summarized in the SWFFS report of 2004. The current monitoring program being implemented is working to fill the identified data gaps. Collier County, since 1998, has cooperated with the SFWMD to sample surface water monthly. This has produced a very good record to support the 303(d) and TMDL efforts. The agencies that collect water quality monitoring data meet regularly, share data, and allocate resources effectively to meet the region's needs. The existing programs produce high quality data that meet regulatory and compliance needs.

The existing monitoring programs generally provide a good record for current conditions. However, it is critical that the monitoring programs put in place baseline monitoring that can be used to set goals in areas that are likely to undergo rapid development and land use alteration. These are described in Section 4 of this Report.

Estero Bay Sub-Basin. This area is likely to experience some development pressure from Fort Myers to the west. It is the headwaters of an area that is impaired downstream, outside the project study area, and is consequently well monitored. An additional monitoring station along Corkscrew Road in the Green Meadows South or the Panther Island West sub-basin would capture data from the developments to the east, and a station in Flint Pen could be added to monitor flows exiting Bird Rookery Swamp to the east. These stations should monitor bimonthly nutrients, dissolved oxygen, turbidity, and coliforms. Toxicants (pesticides, metals, etc.) should be monitored annually.

Trafford Sub-Basin. The unincorporated City of Immokalee is expected to grow, and Lake Trafford is already the subject of a significant water quality restoration project. Water quality monitoring is in place and adequate for this area.

West Collier Sub-Basin. The largest new proposed development is the Ave Maria plan in the northeast corner of the West Collier Sub-basin. This area is well monitored. The southern extent of this sub-basin includes the area adjacent to the Picayune Strand Restoration project. Water quality is monitored along the major canals, but it would be beneficial to add additional monitoring of stage and flow, under the I-75 and Tamiami Trail corridors[4].

[4] Project Technical Team recommendation

East Collier Sub-Basin. This area includes the most remote sections of the project study area, with wilderness areas to the south and agricultural areas to the north. The wilderness area surrounding Okaloacoochee Slough is an area that could be the target of future restoration projects. Currently water flows through channels to the Okaloacoochee Slough instead of the historic sheet flows. The flows under SR 29 could be plugged or gated to detain upstream flow and divert water and restore sheet flow. More monitoring of flow and water quality at the three bridges that pass under SR 29 and the SR 29 Canal would provide data that are needed to design any restoration project in this area. These stations should monitor bimonthly nutrients, dissolved oxygen, turbidity, and coliforms. Toxicants (pesticides, metals, etc.) should be monitored annually[4].

Another area where additional flow and stage monitoring would be useful is around I-75. Anecdotal observations suggest that water impounds north of the east-west segment of I-75, flowing parallel to the highway. Monitoring data designed to confirm these observations would help direct projects to allow water to pass under I-75 to the south.
Another recommendation would be to better integrate surface water quality programs with: 1) biological and habitat assessment monitoring, 2) wetlands and estuaries, and, 3) sediment sampling. The link between water quality parameters and ecological impacts is known in general, but the ecosystems are complex, not all are limited by phosphorus, and some fundamental questions remain. For example, the relative importance of groundwater intrusion into surface water in some remote areas of eastern Collier County that are deficient in dissolved oxygen are not known. This could explain why parts of the East Collier Sub-Basin show Dissolved Oxygen as a water quality concern, even though the areas are remote and not subject to pollutants that consume oxygen.

6.0 PROBLEM IDENTIFICATION REPORT

6.1 Introduction

The preceding sections of this Reconnaissance Report described the existing conditions in the Central Big Cypress Basin (CBCB) project study area and described current problems and potential future problems related to hydrological conditions, natural resources, land uses, and water quality. This section of the Report will summarize the existing and potential future problems, describe plans already underway to remediate or mitigate problems, prioritize the possible actions, and make recommendations for additional actions that will preserve the ecosystems in the project study area.

Problems refer to actions or activities that can negatively impact ecosystems. A negative impact is one that results in an alteration from the conditions that would occur if no human activity was present. For example, naturally occurring fires, although they can destroy wildlife and affect large tracts, are not a problem as long as they are part of the natural landscape. However, if the area was subject to drying conditions because of artificial drainage, then the fire would not be natural and the impacts would represent a problem.

6.2 Problem Types

The problem types are summarized in the following sub-sections in the same categories as presented in preceding sections of the Report. Backup and details are available as follows:

Hydrology and Watershed Boundaries:	Section 2.0
Land Use	Section 3.0
Natural Resources and Environmental Assessment	Section 4.0
Water Quality	Section 5.0

The environmental problems described in the previous sections were reviewed for this summary section. Each of the maps and tables in the preceding sections, and the proposals for restoration and mitigation were also evaluated. Locations where the mapping of problems is evident were evaluated to determine if multiple problems could occur. This is typically the case, for example, as a change in land use that could affect habitat of an endangered species is very likely to also affect water quality. Consequently, the solutions to the problems are addressed in Section 6.4 as entire projects with multiple goals, not isolated projects that might only address a single parameter.

This section considers all the environmental problems identified in preceding sections and possible projects to address these problems. Short sections that describe the possible problems as they relate to hydrology, natural resources, land use, and water

quality follow, but the proposed projects and recommendations typically address more than one type of problem.

Activities that can potentially result in environmental problems typically span more than one of these categories. For example, a change in the hydrology can affect the natural resources, and a change in land use can affect hydrology which in turn can affect natural resources. Nonetheless, it is useful to identify the proximate impacts of various activities and recognize that secondary impacts through ecosystem dynamics are likely to occur.

6.2.1 Hydrology

The pre-development hydrology in the CBCB project study area consisted of surface sheet flow in a general direction from northeast to southwest, with some water draining outside the CBCB to the east and to the west. This natural condition maximized aquifer recharge, surface water retention, and precipitation and uptake of nutrients and reduction of turbidity. Although the most dramatic change in regional hydrology occurred by the Central and Southern Florida (C&SF) Project, for flood control and water supply purposes, the elements of the project did not have significant impact on the hydrology of the CBCB area. A significant portion of the water flow is now channelized as a consequence of agricultural and residential developments. Drainage was constructed in the 1960's as part of the Golden Gate Estates development, which is adjacent to the West Collier Sub-basin. Except in areas where there are natural sloughs and sheet flow, much of the study area is now drier than pre-development conditions. In addition, farming activity resulted in the drainage of large tracts by the construction of drainage ditches.

In addition to channelization that was carried out as part of agricultural development, and the C&SF and Golden Gate Estates projects, other activities have impacted hydrology:

- Roads tend to restrict flows perpendicular to their paths and enhance flows parallel to the roads in roadside ditches. The Tamiami Trail, SR 41, altered fresh water drainage. Salt water to migrated farther north because of the diversion of fresh water flows and the construction of large north-south canals through uplands and wetlands to the estuaries that eliminated sheet flow.

- Agricultural activities utilize extensive groundwater resources and generally result in increased drainage through the construction of surface ditches. The largest users of groundwater for agriculture are citrus production and plant nurseries, neither of which are extensive in the project study area but both of which could increase in the future.

- The development of land to residential, commercial, and industrial purposes requires the drainage of land. New development is required to detain stormwater flows on site, which prevents additional new drainage, but the habitat that is

developed is altered and ecosystem functions are lost. Older development is designed to throw water away as quickly as possible.

Plans are underway to restore the pre-development drainage of the region to the extent that is feasible and to mitigate the impacts of some of the changes that occurred in the past. The largest restoration project in the entire region is the Central Everglades Restoration Project (CERP). Other projects are also planned, and CERP and the other restoration efforts working to restore the natural flow regimes are described in Section 6.3

Several portions of the project study area are subject to fluctuations in water levels that result in problems. The Bear Slough area in the Eastern Collier County Sub-Basin was identified as one area of concern because of existing hydrological conditions (Section 2.8). This largely agricultural area is subject to periodic inundation during periods of high precipitation. These conditions have been prominent again during recent wet periods in June and July, 2005.

Photo 6.1. Flooded Farm Road During a Relatively Dry Period in Bear Slough, East Collier Sub-Basin (April, 2005)

Property owners have reported to the District that sheet flow is impeded by plugged farm ditches, blocked sloughs, and roads and farm paths that lack culverts or have blocked culverts. One such condition is shown in Photo 2.5. Conditions are severe enough that roads are covered with standing water for extended periods (Photo 6.1). Restoration of this area is discussed in Section 6.3.1.

The Barron River Canal, adjacent to SR29, is highly channelized and contributes to rapid drainage of adjacent minor sub-basins in the West Collier Sub-Basin, in particular the Jane's Scenic basin. Besides reducing the ability of these areas to absorb storm flow, the rapid drainage has been implicated in the migration of salt water into areas that were formerly fresh water. Restoration projects for this area are discussed in Section 6.3.4.

The CREW area receives discharge and drainages from agricultural areas located adjacent to and entering natural areas (Section 2.8). Water levels are controlled by weirs (Photo 2.6), a pumping station (Photo 2.7), and drainage discharges (Photo 2.8). Drainage discharge points affecting the hydrology of the Corkscrew Marsh abound around the borders of the Corkscrew and adjacent Bird Rookery and Flint Pen minor

sub-basins. As depicted in Figure 2.2, numerous drainage discharge points located along CR 850, SR 82 and further south along the northeastern boundary of Corkscrew Marsh were identified and visited. See Table 6.2 for the specific locations of these discharge points. Numerous other point discharge locations to the west, southwest, south and southeast of the marsh also exist. All of the point discharge locations have the potential to convey large amounts of water as channel flow or sheet flow to the natural areas. This water can represent a hydraulic load on the area as well as a potential water quality problem. A proposal to ameliorate this condition is described in Section 6.3.7.

I-75 and SR41 and their adjacent canals have affected flows across the corridors. Several projects are in planning to restore the hydrology to the conditions prior to development (Sections 6.3.1 and 6.3.5). In addition, County roads, including CR 858 (Camp Keais Road) and CR 846 (Oil Well Road) cross important drainages such as Camp Keais Strand and disrupt the hydrology (Section 6.3.3).

6.2.2 Natural Resources

Natural resources include the plants and animals that live within the CBCB project study area. Generally if a habitat of adequate size is preserved, for example a hardwood hammock, or a sawgrass wetland, all the plants and animals that are adapted to the habitat will prosper. The performance measures described in Section 3 use specific indicators to determine the viability of various habitats. Some organisms can tolerate human presence to a degree (grey squirrel), but others, like the Florida Panther, are extremely shy and require very large home ranges. The key to natural resource preservation is habitat preservation.

The Florida Panther in particular needs large home ranges free from human activity. Numerous land acquisition projects, described in Section 6.3, focus on increasing habitat for the Florida Panther as well as other endangered species. In particular, the CREW acquisition project described in Section 6.3.7 of this document could help with natural resources protection.

Any change in land use from a pre-development type will affect the plants and animals that depend on the habitat. The goal of remediation efforts then is to provide a hydrologic regime that is consistent with pre-development conditions, and to try to mimic pre-development conditions by eliminating invasive species, providing large habitats, establishing a normal fire regime, and controlling fragmentation with transportation or utility corridors.

6.2.3 Land Use

Changes to land use alter ecosystems. These changes occur through the following mechanisms:

- The direct removal or alteration of vegetation affects all levels of an ecosystem. One consequence of the removal of an overstory is the subsequent development of communities of invasive species. Southern Florida has seen a large growth of the Asian invasive wetland tree, *Melaleuca quinquenervia* in the past few decades, which requires extensive efforts to control (Laroche and Baker, 2001).

- Land use changes are generally accompanied by increasing the drainage from the system. This is done by adding drainage channels, which increases the velocity and volume of flow in flowways, both natural sloughs and canals. This results in the loss of wetlands and lowering of the aquifer.

- The drying of the terrain can result in an increased susceptibility to fire.

- The presence of human activity results in the restriction of habitat for animals that require large tracts of land (e.g. Florida Panther) or restricted diets and habitats (e.g. Florida tree snail, lives only in tropical hardwood hammocks).

- Land use changes in general, and agricultural and industrial activities in particular, increase the risk of environmental exposure to toxicants, nutrients, turbidity, bacteria, and reduction in dissolved oxygen. These changes negatively impact aquatic life.

The projected changes in land use in the project study area are described in detail in Section 4 of this report. Table 3.2 compares existing and projected future (2025) land use. The major changes that are anticipated include a conversion of 7% of the total project area (22,500 acres) from agricultural uses to residential uses (or similar uses such as institutional development of the Ave Maria University campus). The majority of this change is anticipated in the Immokalee area, the westward growth of Naples into the northern Golden Gate Estates, and the Ave Maria development east of northern Golden Gate Estates and south of Immokalee.

The consequences of the conversion of agricultural uses to residential/institutional will have many impacts on these areas. Agricultural areas can provide good habitat for some wildlife, a function that can be virtually lost subsequent to the residential development. Agricultural use however, has resulted in the prior conversion of wetlands to drained fields with a concomitant accelerated drainage of surface water. There is a potential through the permitting process to increase stormwater retention during the planned developments. It may be possible to encourage developers to include wetlands, wildlife corridors, herpetile culverts, and other features in their plans. The decreased use of agricultural chemicals, increased stormwater retention and proper treatment of sewage, can potentially result in improved water quality as well.

Impacts in these areas will be considered during site plan approval on a project-by-project basis. However, there is a potential for cumulative impacts to occur as many developments, each of which is relatively benign, cause the conversion of land to residential and institutional uses.

The Ave Maria college development is being evaluated as a single and complete project, and the agency and public reviews will consider the cumulative impacts of the entire project. The other areas under development will be more prone to cumulative impacts because of the many separate developments. Collier County has recognized this and is undergoing a special study of the Immokalee Redevelopment area (Collier County Community Redevelopment Agency (CRA), 2004). This study has created a planning overlay district for the Immokalee area. It calls out the need for additional water, sewerage, and stormwater utility development, but no specific plans are included in the drafts that are currently available. This study also points out the need for further review of development around Lake Trafford. This plan should call for specific stormwater projects to meet the goals it presents of restoring sheet flow to the Corkscrew Sanctuary and to control runoff to the south. When completed, reviewed, and approved, this regional master plan should protect this area from unforeseen cumulative impacts.

There is also a Golden Gate Area Master Plan (Collier County Planning Services Department, 2004). This is a policy document that will manage growth. It makes specific recommendations about providing greenways, natural areas, clustering development, and calls for more sewered systems instead of the existing areas that rely on septic systems. It also recognizes the importance of the Southern Golden Gate Estates as a natural area. However, individual projects can still cause cumulative impacts to surface and groundwater resources and still be compliant with the Golden Gate Area Master Plan. Reviews of plans must consistently consider the potential for cumulative impacts.

Land use changes have a high potential for cumulative impacts. This problem can be addressed by agency reviews of proposed projects that consider regional impacts of multiple projects. The hydrologic impacts can be addressed by the utilization of the regional watershed model described in Section 2 of this report. Some specific ideas for maximizing the benefits and minimizing the impacts of the planned land use conversions related to wildlife preservation are presented in Section 6.3.5 below.

6.2.4 Water Quality

The pre-development conditions in the CBCB project study area, as indicated today in pristine areas of the Everglades, were characterized by clear water low in nutrients. Almost any change in conditions from the pre-development state, including all the hydrological and land use changes discussed above, negatively impact water quality.

Various development activities affect water quality differently. Agricultural interests generally drain their fields, thereby decreasing retention, increasing flow rates, and raising turbidity. This activity also results in more nutrient and pesticide transport. Residential development is required by recent permitting to retain water on site, but nutrient discharges increase, pesticides may be discharged, and associated road construction can lead to the discharge of hydrocarbons.

Channelized flows move at higher velocities, and higher velocity water is capable of suspending particles that result in turbidity, nutrient, bacterial, and toxicant transport. In addition, as discussed above, many human activities result in the addition of toxins and nutrients to the water that degrades water quality. Section 5 of this Report documents the changes that have occurred in water quality within the Sub-basins. In general, a goal of development is to not increase the discharge of nutrients, organic material, or toxicants, and the flow of water should be maintained in pre-development conditions. Specific projects to restore these conditions are summarized in Section 6.3

Compliance reviews and responses to concerns are performed by the review agencies. In addition, Section 5.6 of this report provides some specific water quality monitoring recommendations for new monitoring stations. These include new stations along Corkscrew Road in the Green Meadows South or the Panther Island West sub-basin that would capture data from the developments to the east, and a station in Flint Pen could be added to monitor flows exiting Bird Rookery Swamp to the east. More monitoring of flow and water quality at the three bridges that pass under SR 29 and the SR 29 Canal would provide data that are needed to design any restoration project in this area These stations should monitor bimonthly nutrients, dissolved oxygen, turbidity, and coliforms. Toxicants (pesticides, metals, etc.) should be monitored annually. The Tamiami Trail (US41) will have additional stage and flow monitoring proposed under a project described in Section 6.3.6.

6.3. Restoration Plans

The project study area has been the subject of investigation by numerous agencies, including the Counties (Collier, Hendry, and Lee), the Florida Department of Environmental Protection, the South Florida Water Management District, the Army Corps of Engineers, the U.S. Park Service, Corkscrew Regional Ecosystem Watershed (CREW), citizens groups, and several interagency task groups. The descriptions below are taken from agency publications, web sites, and a draft database in preparation for the South West Florida Feasibility Study (2005) by the Big Cypress Watersheds Regional Coordination Team (2005). The draft information is summarized in Table 6.1 and presented for discussion purposes. It should be understood that some of these projects are still in the conceptual stage. The locations of the projects described below are shown in Figure 6.1.

The projects described in the following sub-sections utilize similar techniques to achieve habitat restoration. Generally, the hydrology of the project areas is restored. This is accomplished by the plugging or filling of ditches that would otherwise lower the water table and hasten the downstream flows. In some cases small dams or other control structures are part of the project. These structures retain water upstream and/or prevent rapid plug flow through channels and restore the natural sheet flow of the region.

A general goal of increased water retention is a component of many projects, but the potential of roads to act as unnatural dams is also the focus of some projects. As discussed above, I-75 and SR 41 block flows to Florida Bay, Picayune Strand, and the Everglades. County Roads 858 (Camp Keais Road) and 846 (Oil Well Road) all block water flow through Camp Keais Strand. State Route 29 halts east-west flows and the adjacent Barron River Canal diverts the natural east-west flows to a north-south flow. Each of these roadways is the subject of restoration projects described below. Generally a combination of culverts and control structures are an appropriate response to these roadways. Part of these restoration projects includes settling basins and constructed filter marshes.

An important consequence of the slowing down of water flows via filter marshes and control structures is that suspended particles are removed from the water column. This enhances water quality (Section 5) by removing turbidity, some nutrients and toxicants, and allows time for natural biodegradation to consume organic material that might otherwise consume oxygen in deeper channels. The water quality improvements are also enhanced by the restoration of native vegetation that further acts to absorb nutrients, add oxygen, and trap sediments.

Habitat restoration via the removal of exotic species, and the introduction of native species, is a further important component of many of these projects. Finally, control of fires by controlled burns is also utilized to restore natural conditions. Details of each major project are in the following sub-sections

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TABLE 6.1. RESTORATION PROJECTS IN THE PROJECT STUDY AREA

Area of Concern	Problem	Restoration Project	Activities	Objectives
Corkscrew Swamp	Drainage Discharge Points Water quality concerns due to agricultural runoff	Corkscrew Regional Ecosystems Watershed Plans	Land Acquisition to create a wildlife corridor Several restoration projects: • Installation of culverts • Removal of existing dirt roads • Plugging of deep water canals • Create filter marshes • Convert successional pasture into dry pine fatwood	Enhance and preserve natural conditions Improve local hydrology and increase retention of high flows, improve sheet flow and water quality in CREW
		Bird Rookery Swamp Restoration	Restoration of upland area	Restore hydrologic (Southwestward) sheet flow through area. Increase retention time within the Cocohatchee river canal and Corkscrew canal
Bear Slough	Direct point of discharge draining agricultural land Rate of discharge Erosion Water quality	Assessment of existing drainage structures and opportunities for WQ treatment features	No current project	Improve hydrologic flow conditions entering BCB Improve WQ
Camp Keais Strand	Channelized flow	Camp Keais Strand	Redesign of feeder canals and ditches Marsh restoration Land acquisition Fill removal, Restoration of ditches Exotic species removal.	Improve water quality/ improve water flow along entire flowway
Barron River Canal SR-29	Channelized flow	Barron River Canal Flowway Restoration	Plug canal south of Immokalee, and north of the Okaloacoochee slough, install spreader pumps/canals, fill in drainage ditches in similar fashion as the work being conducted in the Picayune Strand Restoration	Improve water flow from Okaloacoochee Slough into Panther refuge Restore hydrologic connectivity along SR 29

Area of Concern	Problem	Restoration Project	Activities	Objectives
Drainage ditches down Okaloacoochee Slough	Channelized flow	Okaloacoochee Slough restoration projects	Acquisition of property Okaloacoochee slough wildlife area hydrologic Restoration	Improve water flow from Okaloacoochee Slough into Panther refuge Restore habitats Remove agricultural ditches Protect and recharge groundwater Protect panther habitat Improve water quality Secure natural sheet flow in the area
			Okaloacoochee slough C-1, C-2 hydrologic restoration	Restore/Improve hydrologic conditions in the Florida Panther National wildlife refuge
		Twelve Mile Slough	Land Acquisition in Hendry County	Restore habitats, improve hydraulic retention capacity and minimize downstream flooding
Flows under I-75	Lowering of water table on south side of I-75 Encroachment of invasive species	I-75 Canal Improvements	Design/construction of a water control system Study flow restriction across I-75	Improve hydrologic conditions of the Panther refuge
Tamiami Trail (SR41)		Tamiami Trail Culverts	Increase the number of water conveyance structures along a 45 mile stretch of SR41 (To date, only the portion of SR 41 from SR 29 to SR 951 in Collier County has been completed) Remove plugs that block flow beneath SR41	Restore natural hydropattern to the Southern Big Cypress Basin Restrict flow in a east-west direction and direct flow to new culverts Improve natural sheet flow

Area of Concern	Problem	Restoration Project	Activities	Objectives
Lake Trafford	High nutrient levels Oxygen depletion Water degradation	Lake Trafford Restoration	Dredging of sediments	Improve water quality in Lake Trafford
Projects Adjacent to the Central Big Cypress Basin Study Area	Channelized flow	Miccosukee Water Management Plan	Construct a managed wetland west/south of CBCB	WQ Treatment of discharges
		L-28 Interceptor Modifications	Modifications of levees and canals/water control structures	Reestablish sheet flow from the west feeder canal across Big Cypress Reservation and into the Big Cypress Preserve, maintain flood protection Maintain water quality and long term preservation of the Rookery Bay National Estuarine Research Reserve (RBNERR)
		Henderson Creek/Bell Meade Restoration	Land acquisition Drainage control	Protection of upland and wetland communities. Increase storm water retention control runoff
		Big Cypress Mitigation Bank in South Western Hendy County	Create functional wetland for which credits can be sold to developers	Habitat Restoration
		Fakahatchee Strand Restoration	Plugging of canals to improve sheet flow	Maintain fresh water wetlands Improve sheet flow Improve water quality
		Southern Golden Glades Estates Picayune Strand Restoration		Accommodate development without adverse hydrologic impact

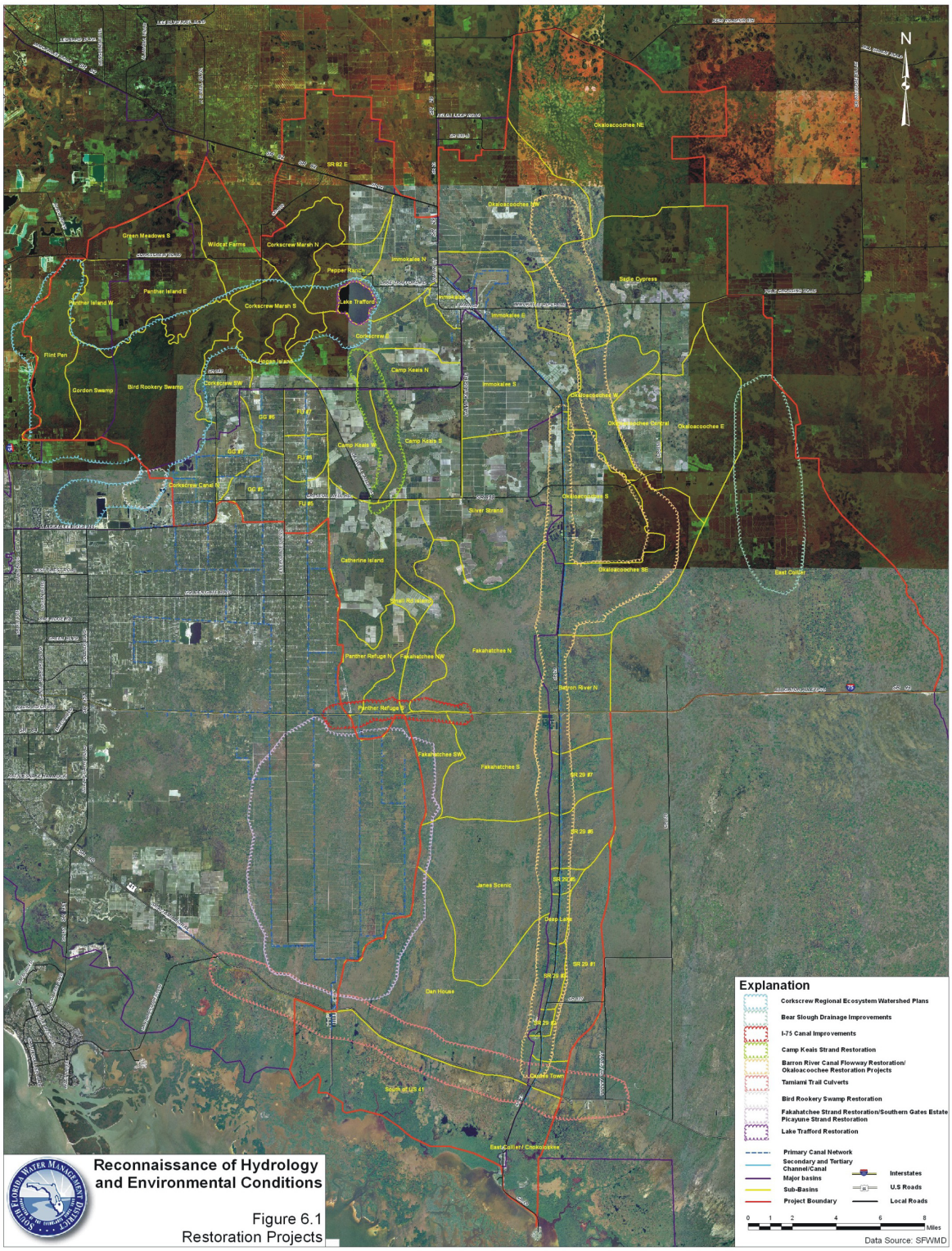

Figure 6.1. Restoration Projects. This figure is inserted in a larger format at the end of this document.

6.3.1 Bear Slough Drainage Improvements

The frequent flooding that occurs in the Bear Slough area of East Collier County could be controlled by a series of small, low-impact, but potentially very effective activities. There is no specific project that has been proposed for this area. First, a thorough assessment of the existing drainage structures should be undertaken. Most of these are on private property, so the enlistment and full cooperation of private landowners would have to be obtained, which is not anticipated to be a problem since they would receive the greatest benefit from this project. Second, drainages that are blocked could be restored, and in some cases physical repairs of structures might be required. Third, recommendations for additional drainage structures, including culverts would be recommended after a thorough engineering and modeling review.

Another opportunity to improve drainage in the Bear Slough area is to collaborate with the Big Cypress Mitigation Bank a 2,577-acre freshwater bank located in southwestern Hendry County (http://www.mitigationbank.com/ mitigationbanks.htm). This site borders Big Cypress National Preserve on its eastern side and is surrounded by agricultural development on the other sides. There are two large plots to the Bank, separated by the Berry Grove citrus property. The western half, called Ruby Red, is approximately 1277 acres; the eastern half, called StarGlo is 1298 acres

6.3.2 I-75 Canal Improvements

The improvement of I-75, including its borrow ditches and Merritt Canal has adversely impacted the natural hydrology of the Florida Panther National Wildlife Refuge. The I-75 Canal and Merritt Canal drain the groundwater in the southern portion of the refuge. The lowered water table is believed responsible for the encroachment of cabbage palm onto the refuge. The refuge spends approximately $360,000 a year on cabbage palm control.

This project entails the design, permitting, and construction of a water control system on the section of the I-75 Canal that runs along the southern border of the Florida Panther National Wildlife Refuge. The water control system will be used to restore/improve hydrologic conditions on the refuge by raising canal water levels adjacent to the refuge.

An additional study should review the role of I-75 in restricting flow to the south, underneath the road. It appears that at times the water is impounded by the road in some areas.

6.3.3. Camp Keais Strand Flowway Restoration

The SFWMD has planned to restore the flowways of the Camp Keais Strand by improving the flow constrictions imposed by farm roads, ditches and inadequate culverts. Such project elements will also provide stormwater treatment and reduce point discharges to natural preserves on public lands and to the estuaries. These measures

would lead to a reduction in loading of priority pollutants such as total nitrogen, total suspended solids and phosphorus. These projects could benefit from land acquisitions to provide habitat in Camp Keais Strand, as proposed by the CREW.

One of the Camp Keais components would restore sheet flow between the Panther Refuge and Corkscrew Swamp. This flowway is the headwaters of Stumpy Strand and Lucky Lake Strand that are the primary wetland systems of the Florida Panther National Wildlife Refuge. Encroachments by roadways, agricultural developments and exotic vegetation have restricted the historic conveyance and ecological functions of the wetlands and wildlife habitats. In addition, the rapid urban developments in the I-75 corridor of South Lee – North Collier have necessitated the enhancement of this flowway for relief of flood waves as recommended by the south Lee County watershed plan. Another SFWMD project planned for Camp Keais, near Immokalee, is a marsh restoration project of a section of marsh that was cleared and prepared for farming. The initial task of this project was for berm removal, filling of ditches, sheet flow restoration, and shrub control through mechanical removal and controlled burning. In addition, control of willow and myrtle is planned. Acquisition of adjoining land to the west is necessary to protect the marsh from reinvasion of these exotic species.

6.3.4. Okaloacoochee / Barron River Restoration Projects

The Okaloacoochee Slough starts in the northeastern corner of the project study area and drains most of the East Collier portion of the study into the Barron River Canal. It has large tracts of agricultural areas as well as extensive natural areas. It provides important panther habitat and habitat for other rare species as well as valuable wetlands. Past land uses have altered the hydrology and natural history. Several projects are under way or in planning to restore this important area.

Several projects involve the acquisition of property. These include purchase of 10,240 acres adjacent to the Okaloacoochee State Forest, and two parcels totaling over 26,000 acres owned by Alico, Incorporated that have been ditched and drained for agricultural purposes. All these properties would require restoration, in the form of ditch removal, pasture and agricultural plot reclamation, and removal of exotic plants with subsequent replanting.

The Okaloacoochee Slough Wildlife Management Area Hydrologic Restoration and the Okaloacoochee Slough C1 and C2 Hydrological Restoration project both involve ditch filling, exotic control, habitat restoration and replanting, and in some areas prescribed burns. These projects are intended to remove agricultural ditches that impact flows to former wetlands and drain these areas. The project would restore habitats and improve the hydraulic retention capacity of the area, minimizing downstream flooding.

The Barron River Canal Restoration would restore hydrologic connectivity along State Road 29 in Collier County, Florida, beginning approximately 5 miles south of Immokalee at Owl Hammock and end at the intersection of the SR 29 / Barron River Canal and US 41 (Tamiami Trail). Lands adjacent to this project that would be directly affected would include the Big Cypress National Preserve, Florida Panther National Wildlife Refuge

and Fakahatchee Strand State Preserve. Indirectly affected areas would include the estuarine systems for the Rookery Bay - 10,000 Islands National Estuarine Research Reserve and Everglades National Park. The reason for this effort is to restore the pre-development conditions that were altered during the logging operations which occurred during the 1920's. Railroad beds were constructed utilizing fill from a borrow ditch that impeded and intercepted the natural southwestward sheet flow of water through the project area. As the years went by, State Road 29 was constructed for vehicle traffic on and along the old railroad bed, this further impacted the westward sheet flow under and across SR 29. Also as the town of Immokalee, located northward of the project location, began to grow and agriculture became predominant on the lands adjacent to the northern terminus of this proposed project, stormwater from Immokalee and these agricultural areas was discharged to the SR 29/Barron River Canal.

A related project is the Florida Panther National Wildlife Refuge Okaloacoochee Slough Hydrologic Restoration. The project entails the restoration of Okaloacoochee Slough's flow into the Florida Panther National Wildlife Refuge through dredging, culverting, and construction of a water control structure systems in the section of the SR 29/Barron River Canal adjacent to the Refuge. The water control system will be used to restore/improve hydrologic conditions on the refuge by raising canal water levels adjacent to refuge. Okaloacoochee Slough's flow into the Florida Panther National Wildlife Refuge is impeded by SR-29 and the SR 29/Barron River Canal.

6.3.5. Enhancing Habitat Corridors

The CREW acquisition plan discussed below in Section 6.3.7, which includes the purchase of extensive tracts of land between Corkscrew Sanctuary, Bird Rookery Sanctuary and Camp Keais Strand, is a model acquisition program that protects land and consolidates isolated land that is currently protected. The CREW plan would link Flint-Penn Strand through Bird Rookery to the Camp Keais area to the Big Cypress National Preserve area. The Panther Eco-scape to Okaloacoochee Slough to Big Cypress National preserve is another example of large scale landscape corridor acquisition in the basin.

Roads and associated development are the principal causes of the splintering of habitat and breaks in wildlife corridors. Many animals, particularly animals with large home ranges, such as the Florida Panther, need tracts of land that are not bisected by human activity. Roads also provide corridors for the invasion of exotic species. Animals that are not shy around people, such as coyotes, use the roadways for traveling, and many plant species can have seeds inadvertently or intentionally carried by cars and trucks. Ideally vast tracks of wilderness would be preserved, and this is the goal of the aforementioned CREW acquisition plan. However, even in that plan, existing roadways would still be a part of the landscape.

Land that is used for agriculture or planned for residential development can include planning elements that allow for the creation of small wildlife corridors. There is no specific commitment to include habitat corridor restoration as part of the planning

process for developers, but this would be a valuable addition to any review. The site plan review process can encourage developers to include green corridors along their site boundaries via the retention or planting of vegetated buffers that connect property boundaries.

Another important way to minimize the impacts of roads on wildlife corridors is to incorporate design elements that minimize the negative effects of roads. Roadway planning can minimize impacts on wildlife corridors via simple changes to plans that include:

- Not mowing, or mowing less frequently, the outside edges of rights-of-way,
- Adding signage ("deer crossing," etc.),
- Using roadway lighting that shields unwanted light to the sides, and raising the height of lights to protect bats from injury that may be feeding on insects attracted to the lights,
- Extending the length of bridge ramps through wetlands to provide easier crossings for far ranging animals such as the Florida Panther (http://www.fhwa.dot.gov/environment/wildlifeprotection/index.cfm?fuseaction=home.viewArticle&articleID=18),
- Adding nesting boxes along rights-of-way and platforms,
- Include frequent culverts that connect roadside swales so that roads to not act as dams.
- Include dry culverts to aid the movements of reptiles and amphibians.
- Large wildlife under-crossings for wide ranging mammal species.

These sorts of small features could be added to road expansion projects as appropriate throughout the project study area.

6.3.6. Tamiami Trail Culverts

(Project description from: http://www.saj.usace.army.mil/projects/tamltrep.htm**)**

The proposed project is located on the Tamiami Trail (US-41) in Collier County between SR 92 (Collier Seminole State Park) to the west and 50 Mile Bend to the east (roughly 43 miles). Project begins roughly 50 miles west of Miami and continues for 43 miles to the west. Locations, sizes, and number of water conveyance structures have been identified, but further analysis will be conducted to verify proposed structure locations.

This project will help restore a more natural hydropattern to the southern Big Cypress Basin and coastal areas to the south. The Big Cypress swamp is a national preserve encompassing some 729,000 acres. In 1928, the Tamiami Trail (US-41), an east-west route, was completed between Miami and Naples, Florida. To construct the road, a borrow canal was excavated on the northern side of the road bed. The effect of the road and adjacent borrow canal has been to intercept existing flowways to the Big Cypress National Preserve, and channelize flows through only a very few bridges/culverts. Currently, due to the channelization of flowways, some wetland habitats receive too much fresh water, while others do not receive enough. Also, the seasonal hydropatterns (quantity, timing, and distribution of surface water flows) are interrupted. It is important to increase the number of flowways to restore a more natural hydropattern. The project

would provide improved habitat for plants and animals that live in the Everglades communities by restoring wetlands and decreasing the spread of exotic plants, which are able to establish when hydroperiods are reduced.

This project calls for the construction of 87 additional culverts under Tamiami Trail located at 30 separate sites; per site culvert counts range from 1 to 7. In conjunction with the added culverts, a total of 29 blocking plugs would be constructed in the existing borrow canal. These plugs would extend from the top of road to the existing natural grade on the opposite (northern) side of the canal. By blocking the east-west flow of the borrow canal, a balance of runoff conveyed by the proposed culverts would be achieved. The exact locations would be set after field inspection to determine the best location in the natural drainage swales to isolate the culvert structures. The success of this project will rely on the location of the culverts. They will be placed to provide maximum benefits for hydrology as well as achieving the habitat modifications intended. This project will improve the natural sheet flow of surface water within the watersheds of Ten Thousand Islands National Wildlife Refuge & Aquatic Preserve, Southern Golden Gate Estates, Fakahatchee Strand State Preserve, Big Cypress National Preserve, and Everglades National Park. By creating a more diffuse flowway beneath the Tamiami Trail, a more natural hydropattern will be established north and south of this highway. Improvement of the natural hydrology will also enhance biological restoration for the region. This project will directly support objectives for several other south Florida projects (i.e. Levee L-28 modification and restoration of Southern Golden Gate Estates). In order for these projects to meet their respective design objectives, the additional water conveyance structures under the Tamiami Trail will need to be completed.

This project is now expected to be completed in 2005. Based on Sections 2 and 5 of this report, it is advisable to review these plans to insure that additional monitoring of stage and flow is included so that the effectiveness of the project can be measured. Phase II is needed and should be pursued.

6.3.7. Corkscrew Regional Ecosystem Watershed Plans

The Corkscrew Regional Ecosystem Watershed (CREW) Trust is a non-profit organization formed in 1989 to promote stewardship of the natural areas in this watershed. They have developed a stewardship and land acquisition plan that is copied below as Figure 6.2. Note that this plan includes acquisitions that would link Flint Pen Strand, Bird Rookery Swamp, the Corkscrew Sanctuary and the Lake Trafford area via a wildlife corridor along Camp Keais Strand to the Florida Panther National Wildlife Refuge. The connection of all these natural areas would enhance the value of each of them. These acquisitions include several separate projects, including a large tract of 27,000 acres that is already acquired plus a 20,000 acre plot that is planned for acquisition, a 30 acre plot in the center of CREW that was purchased with restoration funding, the Pepper Ranch acquisition between Corkscrew Marsh and Lake Trafford, and numerous acquisitions in Okaloacoochee Slough.

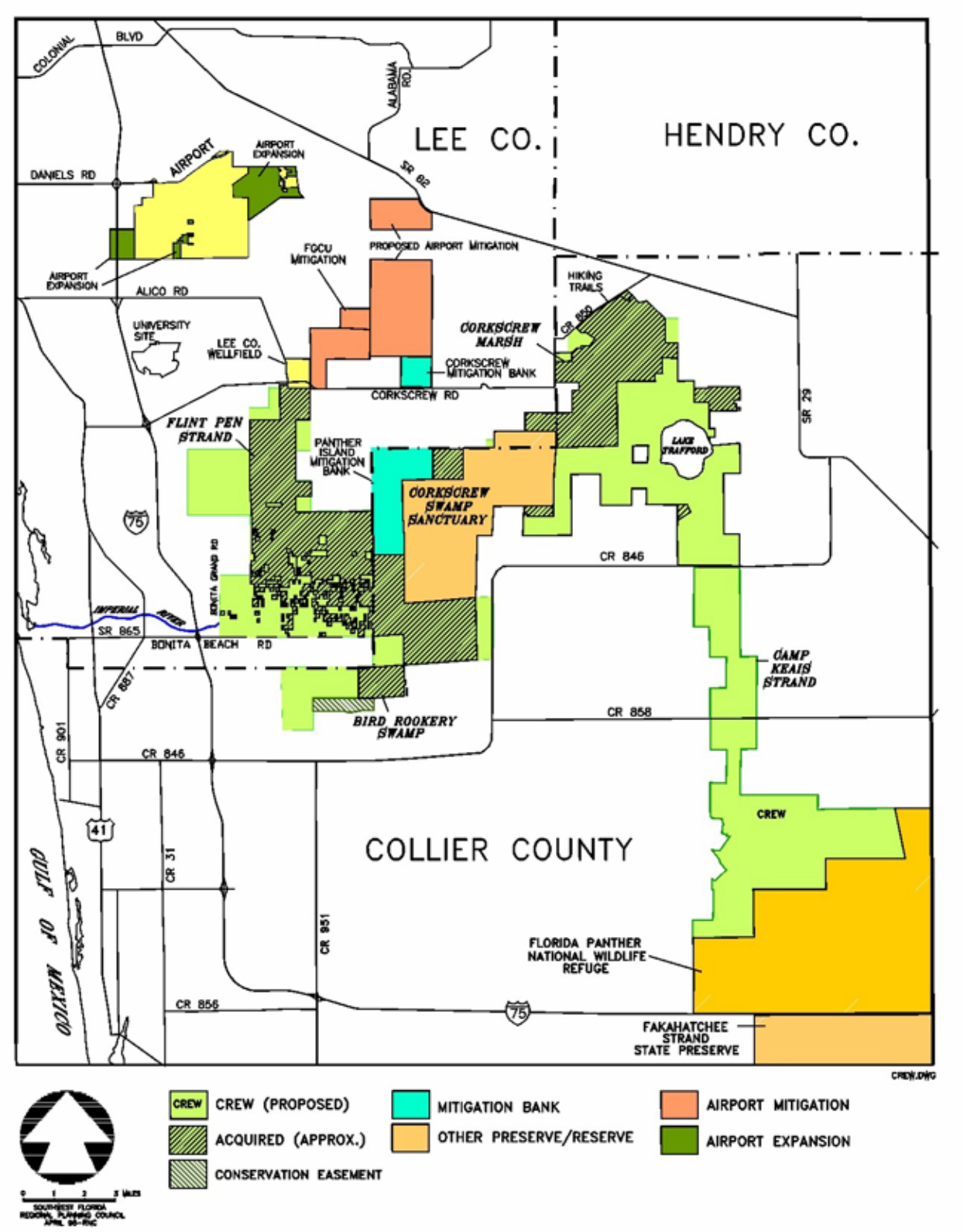

Figure 6.2. Corkscrew Regional Ecosystem Watershed. Current and Proposed Boundaries (Source: http://www.crewtrust.org/map1.htm).

In addition to the acquisition of land, several restoration projects for CREW are in planning phases. There is a plan to remove Willow that has invaded a sawgrass area due to the lack of fires in the marshes. Another project in east Corkscrew marsh would convert successional pasture into a dry pine flatwood.

There are some projects that are addressing the hydrology problem related to the point discharges to the CREW area. The Audubon Cross Dike surrounds an area of logging tram roads in and around the Bird Rookery Swamp area and immediately northwest of the Corkscrew Canal. Projects to improve the local hydrology are currently being implemented or pending implementation. The District is in the process of installing eight, 60-inch culverts to facilitate sheet flow through this area. There are two ditches that originate in the vicinity of a 40-acre palm tree farm that border County Line Road that drain to the south to convey peak flows (Figure 2.2). The District is improving areas immediately to the east by removing existing dirt roads, such as Poor Mans Pass and the plugging of deep water canals which intersect the western, County Line Road ditch and facilitated the drainage of portions of the Gordon Swamp area. The Corkscrew Canal is being widened to augment drainage in this area (Interagency Project Technical Team, 2005). In addition to these projects, several other discharge points could be replaced with manifolds, or shallow dams to convert the flows to sheet flows. The retention of high flows not only restores the natural hydrology, it also allows for the settling of sediments, improves water quality and enhances groundwater recharge.

6.3.8. Bird Rookery Swamp Restoration

As described above, during logging operations, which occurred during the 1920's in the project area, elevated tram/railroad beds were constructed which now impede the natural and historic southwestward sheet flow of water through the project area. The above actions have resulted in:

- Altered historic hydroperiod for lands within and adjacent to Bird Rookery Swamp.
- Hydrologically disconnected and redirected the historic southwest and westward sheet flows within the project area.
- Potentially altered the historic and natural distribution of native plant and animal species occurring within and on lands adjacent to the project area.
- Habitat and hydroperiod alterations occurring along the elevated tram/railroad corridors have allowed exotic plant species such as Brazilian Pepper and Melaleuca to invade the proposed project area displacing native species.
- Altered discharges to adjacent drainage sub-basins resulting in increased or decreased deliveries of freshwater to the respective estuarine systems.
- Potentially increased flooding of adjacent low lying residential lands.
- Reduced recharge to the underlying aquifers in the project and adjacent areas.

This project would restore the hydrologic flow through the area. This would not only benefit Bird Rookery Swamp but also the adjacent area in CREW area. Some land to the south and west within the Cocohatchee River Canal and Corkscrew Canals would be affected by the increased retention time.

Another project in this area involves the restoration of an upland area on the east side of Bird Rookery swamp that was illegally farmed in the 1950's. There is a project proposed to restore this area to a dry pine flatwood.

6.3.9. Twelve Mile Slough

This is a proposed land acquisition of approximately 15,000 acres in Hendry County, on the border of the CBCB project study area. This "river of grass" slough is an important headwater to the Okaloacoochee Slough. This is a major slough of the Caloosahatchee River/Big Cypress Watershed. The land at this site serves to protect and recharge groundwater, and is important habitat for Florida panther, snail kite, and many other wildlife species. The entire length of the site's eastern boundary is contiguous with the 32,162-acre Okaloacoochee Slough State Forest/Wildlife Management Area. The property connects to Okaloacoochee Slough Wildlife Management Area and Spirit of the Wild to the north.

This acquisition is being done by the State via the Nature Conservancy as an intermediary (http://www.dep.state.fl.us/lands/acquisition/FloridaForever/FFAnnual2004/Project%20Descriptions/Twelve%20Mile%20Slough.pdf). This project will protect panther habitat as well as other important species and will secure the natural sheet flow hydrology of the area.

6.3.10. Lake Trafford Restoration

Lake Trafford is the central feature of the Trafford Sub-basin and the largest body of fresh water in the CBCB project study area. It is also the headwaters of the Corkscrew Sanctuary. It has accumulated large deposits of organically enriched sediments that consume oxygen when they decompose. This has resulted in low oxygen levels that have resulted in fish kills, and the high nutrient levels have supported the development of large growths of nuisance aquatic weeds. This project is removing four million cubic yards of sediments, or the top three feet of sediment from the lake bottom. The retention site for the spoils will be part of the CREW property acquisitions.

6.3.11. Central Everglades Restoration Project (CERP)

The largest and most significant remediation plan for the CBCB project study, and indeed the largest restoration plan in the entire United States, is the CERP project. "The overarching objective of the Plan is the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection" (Water Resources Development Act, 2000). CERP is working toward this objective through 40 distinct projects related to watershed and ecosystem restoration. The projects in the project study area are summarized

below, and details of these projects and others that indirectly influence the project study area can be found in http://www.evergladesplan.org/pm/landing_pp.cfm. Some of the projects described in the preceding sub-sections are joint CERP projects with other agencies, including the SFWMD, the Counties, and FDEP. They are all within the project study area and shown of Figure 6.1.

6.3.12. Adjacent Projects Not in Project Study Area

Picayune Strand Restoration (formerly Southern Golden Gate Estates Ecosystem Restoration)

This restoration project will result in enhanced sheet flows to areas within the Picayune Strand project area. This project includes a combination of spreader channels, canal plugs, road removal and pump stations in the Western Basin and Big Cypress, Collier County, south of I-75 and north of U.S. 41 between the Belle Meade Area and the Fakahatchee Strand State Preserve.

The purpose of this project is to restore and enhance the wetlands in Southern Golden Gate Estates and in adjacent public lands by reducing over-drainage. Implementation of the restoration plan would also improve the water quality of coastal estuaries by moderating the large salinity fluctuations caused by freshwater point discharge of the Faka Union Canal.

Henderson Creek / Belle Meade Restoration

This region of southwest Florida is currently facing a high urban growth rate. Changes in land-use within the primary watersheds that drain into the Rookery Bay Estuary and adjacent waters have been identified in the Rookery Bay National Estuarine Research Reserve (RBNERR) Management Plan as the highest priority resource issue that threatens the long-term preservation of RBNERR estuarine resources.

The coastal habitats in Collier County have been impacted by alterations of hydrology and habitat due to channelization of natural systems. Roads, canals, planned unit developments, commercial projects, and agriculture represent primary land-uses within RBNERR watersheds. These alterations have greatly modified the volume, timing and quality of freshwater entering the fragile estuarine ecosystems. In addition, channelized flow in these watersheds has severely restricted the ability of the associated wetlands to filter pollutants.

The area known locally as Belle Meade, located west of the Southern Golden Gate Estates, is the primary drainage basin for the Henderson Creek Estuary and is currently targeted for acquisition by the Florida Department of Environmental Protection. Historically, freshwater traveled across the surface of the land, percolating through wetland flowways before entering Henderson Creek. While channelization and development have disrupted this system, acquisition and restoration of the undeveloped lands surrounding Henderson Creek, which link the watershed and estuary, can stop

further hydrologic and habitat disturbance. These estuarine areas provide critical nursery habitat for commercially and recreationally important finfish and shellfish. Land acquisition will assure long-term protection of the upland and wetland communities associated with these parcels. The drainage controls for this project, although primarily intended to control runoff to the estuary, will also increase stormwater retention in the Belle Meade basin that in turn will influence the West Collier Sub-Basin of this project study area.

6.4 Recommendations and Priorities

The projects described in Section 6.3 above include investigations, land acquisitions, and restoration efforts. Consistent with the CERP vision statement, the primary objective of planning, research, and restoration efforts in the CBCB project study area should be, to the extent feasible:

Recommendation 1: The restoration of pre-development sheet flow hydrology.

This effort will result in:

- Increases in freshwater wetlands,
- More wildlife habitat because of the periodic inundation that requires the clustering of future development on natural uplands,
- Fewer forest fires,
- More control of saltwater migration

In order to restore the hydrology, to the extent feasible, to pre-development conditions sub-regional hydrologic models should be developed to enhance the analysis and design of improvements to the major flowways (Okaloacoochee Slough, Barron River Canal, Camp Keais, etc.). These are the flowways most likely to be influenced by planned future growth and development in the Camp Keais, Immokalee and northeastern portions of the project study area.

Growth management is another area where agencies should coordinate efforts. The area has large tracts that are suitable for development, and it is expected that the current rapid development will continue into the future. This growth can be accommodated, but there will be environmental impacts if it is not limited to land areas that are intrinsically suited to development. These areas include existing upland areas and some agricultural areas. This leads to:

Recommendation 2: Existing County-level master plans should be enforced via zoning and land use approvals to cluster development in upland areas near existing development or via the conversion of agricultural land.

A key to providing adequate land for the maintenance and improvement of the aquifer upon which all development depends is the retention of large tracts of land that are used to infiltrate and subsequently store surface water. These large tracts of land,

particularly contiguous large tracts, provide essential habitat for Florida's many unique and endangered plants and animals. The most secure way to preserve and to expand the land is to add land into the public trust.

Recommendation 3: Continue to pursue an aggressive plan of buying and securing conservation lands to expand upon the existing preserves, to protect the watersheds of the preserves, and to buffer the borders of the preserves from further development.

It must also be acknowledged that some important habitats are degraded, either through pollutants (e.g. Lake Trafford), invasive species, or past drainage projects. The restoration projects that are planned for the project study area are valuable and should receive continuing public funding.

Recommendation 4: Planned restoration projects should be funded and expedited.

Prioritization of projects is difficult, because all the projects that have been reviewed have significant merit. However, if funding limits require difficult choices, the folling priorities are recommended.

Priority 1: Land Acquisition and Management. Land values in South Florida have historically increased faster than the inflation rate, so a purchase of land now will save future dollars, and once land is developed it becomes virtually impossible to acquire for conservation.

Priority 2: Hydrological Restoration Projects. The entire regional plan requires active efforts to alter hydrological flow patterns.

Priority 3: Research and Studies. Ongoing research, and particularly the performance evaluation of the restoration projects is important, but adequate information is available now to initiate the land acquisitions and restoration projects that are given higher priority status. There is a need for development of sub-regional hydrologic models of the major flowways (Okaloacoochee Slough, Barron River Canal, Camp Keais, etc.) that are likely to be influenced by future growth and development.

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(Web links are also embedded in the text)

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Personal Communications

Numerous interviews with knowledgeable individuals were held as part of the background research for this report.

The Project Technical Team

The following individuals were in attendance at the Project Kick-Off Meeting at the South Florida Water Management District Ft. Myers Office on March 22nd 2005 or subsequent meetings of the Project Technical Team. All the participants contributed information and review comments during the development of this Report. Their generous participation is greatly appreciated.

Liz Abbott, South Florida Water Management District
Karen Bickford, Florida Department of Environmental Protection
Jim Beever, Florida Fish & Wildlife Conservation Commission
Clyde Dabbs, South Florida Water Management District
Mike Duever, South Florida Water Management District
Bobby Pearce, South Florida Water Management District
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Tim Howard, South Florida Water Management District
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Ananta Nath, South Florida Water Management District
Bobby Pearce, South Florida Water Management District
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Steve Preston, Collier County Stormwater
Bob Sobczak, NPS-Big Cypress
Steve Sentes, South Florida Water Management District
Janet Starnes, South Florida Water Management District
Daryl Thomas, U.S. Fish and Wildlife Service
Rhonda Watkins, Collier County Pollution Control Department

Provisional Information re: endangered species, threatened species and species of special concern within the Southwest Florida Feasibility Study project study area supplied by the U.S. Fish and Wildlife Service, Vero Beach, FL office. This information has not been qualified and was supplied as a courtesy.

FIELD MEETINGS:

The following individuals were in attendance at Field Meetings and participated in discussions, which were utilized to develop this Report, held within the Bear Slough

Area on Friday, April 8, 2004, Corkscrew Sanctuary Area on Friday, April 15, 2004, or the Okaloacoochee Slough and Bear Slough areas on Friday, April 22, 2004. Their generous participation is greatly appreciated.

Liz Abbott, South Florida Water Management District
Steve Sentes, South Florida Water Management District
Scott Legg, South Florida Water Management District
Clyde Dabbs, South Florida Water Management District
Pat Howell, Property Owner
Les Alderman, Big Cypress Mitigation Bank-Executive Director
Glen Holt, Big Cypress Mitigation Bank-Subcontractor (Construction/Plant)
Bobby Murray, Berry Groves-Production Manager
Ellen Lindblad, Executive Director, CREW Land and Water Trust
Jim Goodwin, Land Manager, Southwest Florida Region, South Florida Water Management District
Bobby Pearce, South Florida Water Management District

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