SOUTHERN GOLDEN GATE ESTATES

WATERSHED PLANNING ASSISTANCE

COOPERATIVE STUDY

FINAL REPORT
OCTOBER 2003

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
BIG CYPRESS BASIN

and

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

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INTRODUCTION

Purpose of Study

This study was initiated by the Big Cypress Basin of the South Florida Water Management District (District) to provide information to be used in the development of the Big Cypress Basin Watershed Plan. The District entered a cooperative agreement with the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) to procure data and analyses of the soils, vegetation, topography, and water table fluctuations in the portion of the watershed known as the Picayune Strand State Forest (PSSF) and the Ten Thousand Islands National Wildlife Refuge south of the PSSF to the estuarine boundary of the Refuge. The PSSF includes an area known as the Southern Golden Gate Estates, a large tract that was the focus of the study and of this report. The information obtained in this study will be used by the District to enhance and expand the scope of its "Hydrologic Restoration of Southern Golden Gate Estates—Conceptual Plan" (Abbott and Nath 1996). The goal of the study was to update the analysis of the hydrologic restoration strategy proposed in the Conceptual Plan using more detailed site-specific data and to predict the effects of the proposed strategy on the existing plant communities in the study area. In addition, data acquired during this study can serve as a "baseline" that can be augmented to track hydrological and biological changes that occur in the PSSF and the Refuge over the duration of the hydrologic restoration process.

Environmental Setting

The Southern Golden Gate Estates (SGGE) encompasses an approximately 94 square-mile area of sensitive environmental landscape in Collier County, Florida, between Interstate

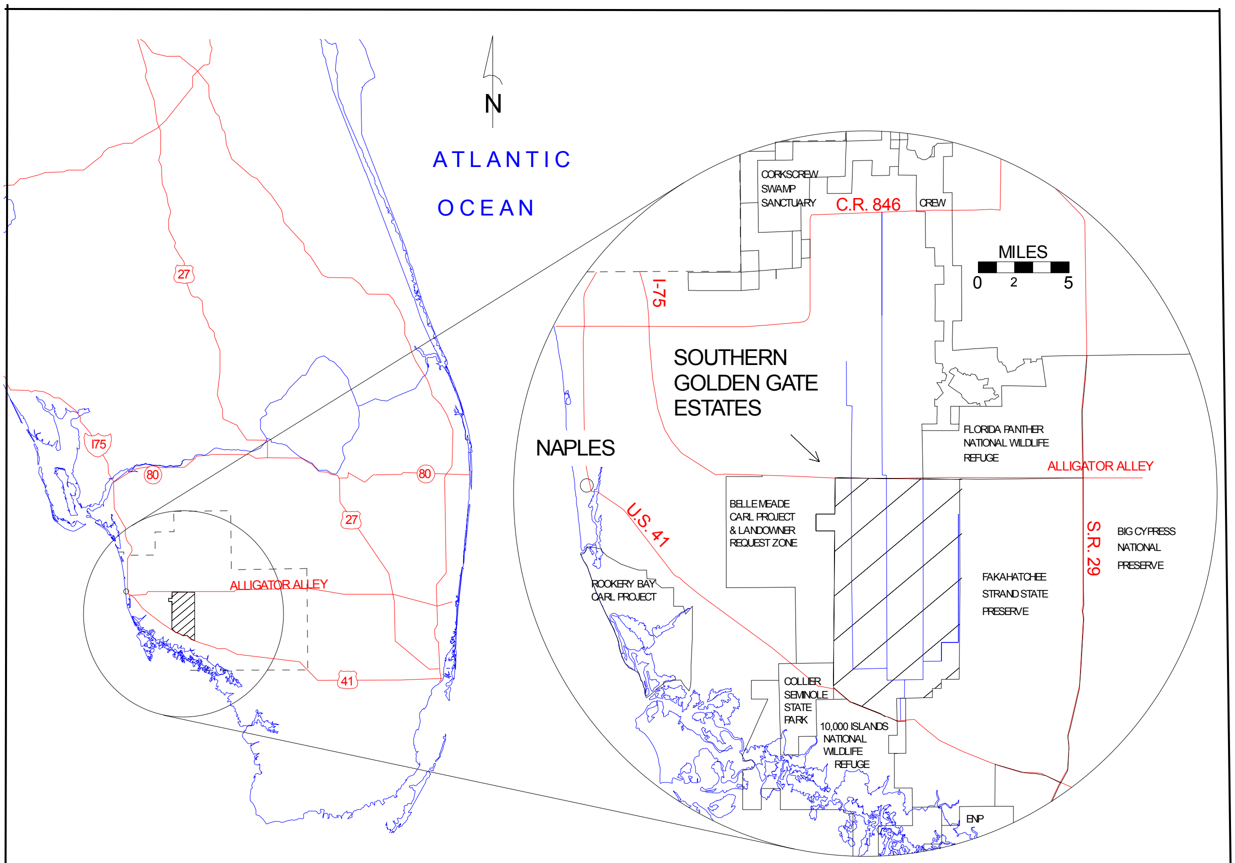


FIGURE 1: SGGE Location Map

Highway 75 ("Alligator Alley") and U.S. Highway 41 (Figure 1). Located southwest of the Florida Panther National Wildlife Refuge, north of the Ten Thousand Islands National Wildlife Refuge, west of the Fakahatchee Strand State Preserve, and east of the Belle Meade State Conservation and Recreation Land Projects area, the SGGE constitutes the heart of the PSSF. It contains some of the most diverse plant and wildlife communities of the North American continent. Prior to anthropogenic impacts, the area was characterized by seasonal flooding several months of the year. Broad, slow moving sheetflow sustained wetland vegetation and rejuvenated freshwater aquifers. Three major flowways contributed freshwater to the Ten Thousand Islands estuary.

However, significant alterations in the area's hydrology and plant communities have occurred within the SGGE since cypress logging operations began in the 1940s and 1950s.

Land drainage activities began in southwest Florida with the diversion and channelization of the Caloosahatchee River during this time, which later culminated in the development of the Golden Gate Estates in the 1960s. Golden Gate Estates is a very large subdivision bisected by I-75 into northern and southern tracts, known as NGGE and SGGE, respectively. When the Golden Gate Estates was subdivided in the 1960s, an extensive network of roads and canals were built and thousands of lots were sold. The developer, Gulf America Corporation, went out of business and many of the planned homes were never built. Today the vast majority of existing homes are located in the NGGE, which has been zoned for single family residential use. The SGGE has undergone very little further development, and was targeted for restoration efforts beginning in the 1970s as the impacts of the extensive drainage became recognized. Presently, a network of over 300 miles of roads intercepts the historic flowways and four major canals significantly drain the landscape, resulting in reduction of aquifer storage, increased freshwater shock load discharges to the estuary, degradation of plant communities, and increased frequency of forest fires in the SGGE area.

Hydrologic Restoration Plan

Concern over the gradual degradation of environmental quality and water supply potential of the region prompted the U.S. Congress to authorize a Golden Gate Estates Feasibility Study by the U.S. Army Corps of Engineers (COE) in 1978. A Reconnaissance Report for the Golden Gate Estates was developed by the COE in 1980. In 1986, the COE released the Golden Gate Estates Feasibility Report which developed a number of alternative restoration plans, but recommended no federal involvement for project implementation at that time. The State of Florida identified the area as a component of the Save Our Everglades program in 1985, and included it in its Conservation and Recreation Lands (CARL) acquisition program initiative. In 1996, at the direction of the Governor of Florida, the District developed a conceptual hydrologic restoration plan (Conceptual Plan) for the SGGE with the goal of enhancing the environmental value and water resources of the region. The basic premise of the Conceptual Plan was to reduce the over drainage by restoring historic flow ways and sheet flow patterns while maintaining the existing levels of flood protection for areas north of the SGGE.

The implementation of the Conceptual Plan was included among a number of South Florida Critical Ecosystem Restoration projects authorized under the Water Resources Development Act (WRDA) of 1996. However, the Plan could not be authorized for implementation since the state received federal funds to acquire SGGE lands under the "Farm Bill" (Section 390 of the Federal Agriculture Improvement and Reform Act of 1996, PL 104-127) in excess of the limit of federal participation criteria set by WRDA 1996. The project has now been proposed for implementation as an "Other Project Element" of the Comprehensive Everglades Restoration Plan (CERP) authorized by WRDA 2000. A Project Management Plan for the hydrologic restoration of the SGGE has been developed by the COE and the District as joint sponsors. The database and analyses developed as a part of this Watershed Planning Assistance Cooperative Study Report will be incorporated into the Project Implementation Report (PIR), a feasibility report updating the Conceptual Plan that will be used in the jointly sponsored proposal for WRDA 2004 funding. It is to be noted that the MIKE-SHE model set-up used in this study is being updated and additional alternative water management strategies are being analyzed in the PIR effort to formulate a cost-effective restoration plan. The table below summarizes the sequence of events in the SGGE restoration process.

TABLE 1

RESTORATION OF SOUTHERN GOLDEN GATE ESTATES (SGGE)

CHRONOLOGY

Late 1950s	• Gulf America Corporation (GAC) begins acquiring land in Collier County.
Early 1960s	• Golden Gate Estates (GGE) subdivision plan submitted to and approved by Collier County. • Subdivision platted for commercial, multifamily, and single family residential use.
August 1963	• Construction of the first GAC canal (lower portion of the Golden Gate Canal) completed.
1960s – early 1970s	• Extensive land sales program by GAC. • Estimated GGE owners in excess of 50,000 worldwide.
Late 1960s	• General awareness developed regarding the need for careful management of natural resources, particularly South Florida's water resources.
1968–1971	• Construction and completion of the Faka Union canal system.
1974	• "Hydrologic Study of the GAC Canal Network" by Black, Crow and Eidsness, Inc. is the first engineering study to address environmental aspects of the GAC canal system. Also evaluated flood protection. Prepared for Collier County Water Management Advisory Board.
March 1975	• GGE Study Committee established by the Board of County Commissioners: • Represented formal Collier County government movement to address GGE issues. • Purpose: To re-evaluate the GGE in terms of appropriate long-term urban planning and resource management.
1977	• GGE Redevelopment Study report: • Showed general nature of redevelopment plan. • Major changes in drainage plan and land ownership feasible. • Recommended that a hydrologic engineering plan be prepared.
1978	• Authorization of GGE Feasibility Study by Congress.
1980	• U.S. Army Corps of Engineers Reconnaissance Report for the GGE.
1985	• SGGE included in "Save Our Everglades" portion of the CARL program.
1986	• U.S. Army Corps of Engineers (COE) GGE Feasibility Report: • Evaluated three alternatives for modifying the canal network. • Alternative C offered greatest attainment of multipurpose objectives. • Recommended no federal involvement (no economic benefit to nation). Determined was state/local issue.
August 1986	• Committee for Restoration of GGE established by the Kissimmee River—Lake Okeechobee Everglades Coordinating Council. Purpose was to keep restoration of SGGE on agenda of important state environmental issues.
October 1991	• Agreement between District and Florida Department of Environmental Protection (FDEP) to fund land acquisition personnel.
February 1992	• District directed by Governor Lawton Chiles to "…develop a conceptual hydrologic restoration plan for SGGE, using the Corps' Feasibility Report as a primary reference."
February 1996	• District submits "Hydrologic Restoration of Southern Golden Gate Estates – Conceptual Plan" to the Governor of Florida.
June 1996	• FDEP's Office of Ecosystem Management institutes interagency coordination.

October 1996	• Cooperative Watershed Planning Assistance Study agreement with USDA NRCS to enhance database on soils, vegetation, topography and hydrologic-ecologic assessment of the restoration plan.
January 1997	• Interagency Technical Advisory Committee convened with representatives from Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Geological Survey, FDEP, Florida Game & Fresh Water Fish Commission and others, to provide input and assistance for duration of study.
June 1997	• South Florida Ecosystem Restoration workgroup ranks the project 7th among the South Florida Critical Restoration Projects recommended for funding under WRDA 1996 initiative.
February 1998	• Assistant Secretary of Army approves letter report for funding under WRDA 1996.
April 1998	• Federal Farm Bill funds of $25 million provided to FDEP to enhance SGGE land acquisition efforts.
July 1998	• Settlement of lawsuit brought by SGGE landowner's group (representing more than 2,000 landowners) under which FDEP acquires 2,968 acres of land in SGGE.
October 1998	• Governor and Cabinet approve purchase of 8,526 acres of land from Avatar Properties, Inc., the largest landowner in the SGGE project area.
August 1999	• Corps of Engineers rules that implementation of the proposed SGGE hydrologic restoration plan cannot be funded as a Critical Restoration Project due to $25 million limit of federal assistance under WRDA 1996 criteria, but funding will be considered as an element of the Comprehensive Everglades Restoration Plan (CERP).
May 2000	• Florida Cabinet approves accelerated land acquisition mechanism by authorizing state to offer 25% more than the appraised value of land to willing sellers.
September 2000	• Corps of Engineers and District jointly initiate Master Program Management Plan development for restoration project implementation as a CERP element.
January 2001	• Florida Cabinet approves proceeding with Eminent Domain classification for remaining land acquisition in SGGE.
March 2001	• Project Management Plan agreement signed by Corps of Engineers and District, and Project Implementation Report initiated.
May 2001 to present	• Project Implementation Report development continuation.

CHARACTERIZATION OF THE STUDY AREA

Land Use

The Golden Gate Estates (GGE) development occupies a large portion of the Faka Union Canal watershed. Figures 2 and 3, respectively, illustrate the boundaries of the watershed and generalized land uses within the GGE. Much of the area north of I-75 is zoned residential. The residential zoning is low density with a minimum lot size of 2 ¼ acres. The remainder of this area is used for agriculture, predominantly vegetable farming, except in areas of persistent flooding. The most populated portion of the watershed is north of I-75, particularly west of Everglades Boulevard. Telephone and electric services are not available in most areas south of I-75 and this area remains generally undeveloped. A small urban area called Port of the Islands exists near the intersection of the Faka Union Canal and I-75. South of I-75, the majority of the land cover is identified as wetlands (Figure 3). It will be shown later in this report that many of these areas no longer meet the ecological criteria for this designation, however.

Geology and Soils

The area encompassed by this study lies within Big Cypress physiographic region of the lower Coastal Lowlands topographic division. The dominant geomorphic features are the Southwestern Slope and Reticulated Coastal Swamps. Limestone and marine deposits underlying the area were formed during the Pleistocene epoch. Duever, et al. (1986) classified four major soil groups (rock, sand, marl, and organics) in the Big Cypress National Preserve. These major soil groups are also found in the study area.

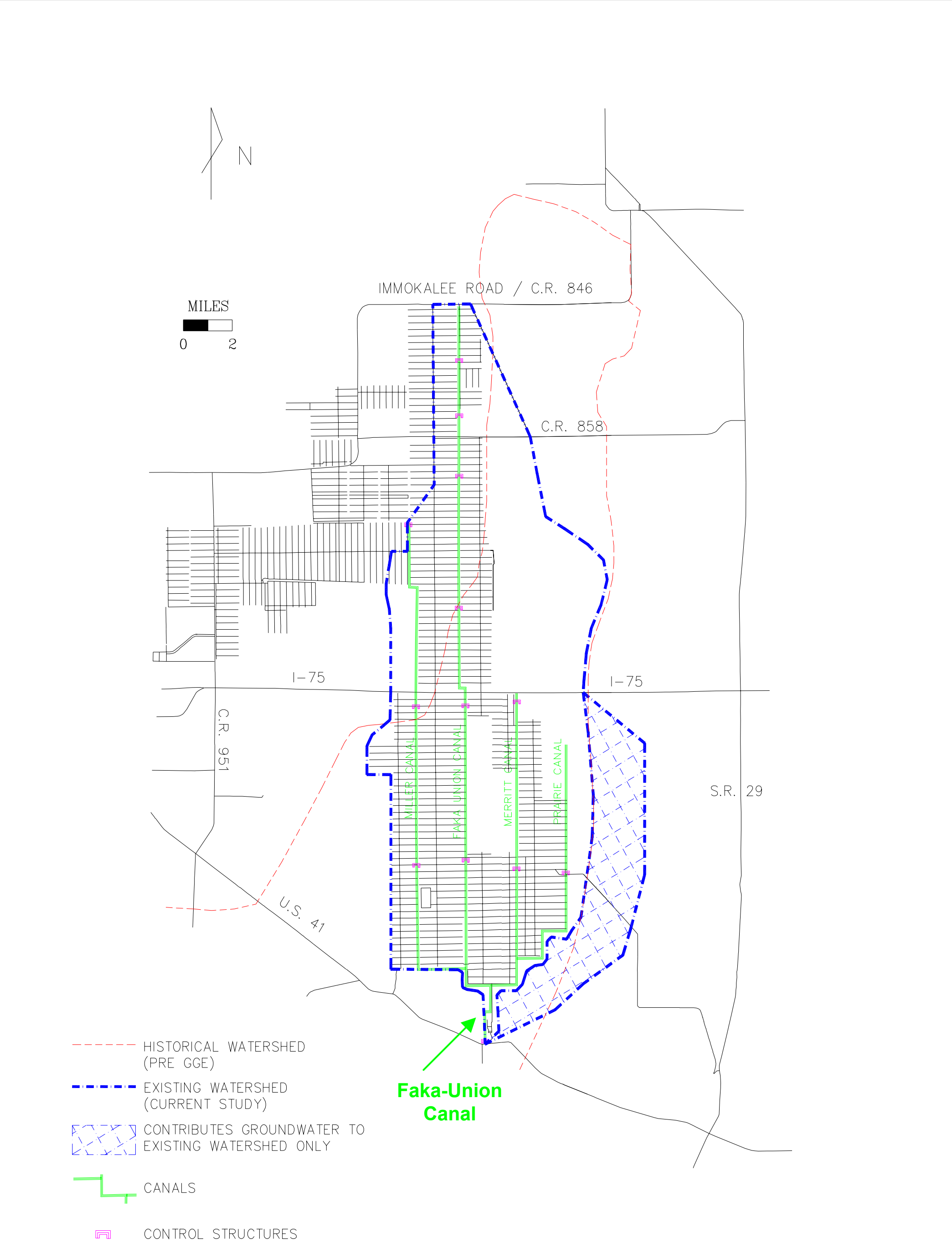


FIGURE 2. Faka Union Canal Watershed Boundary (Existing/Pre-GGE)

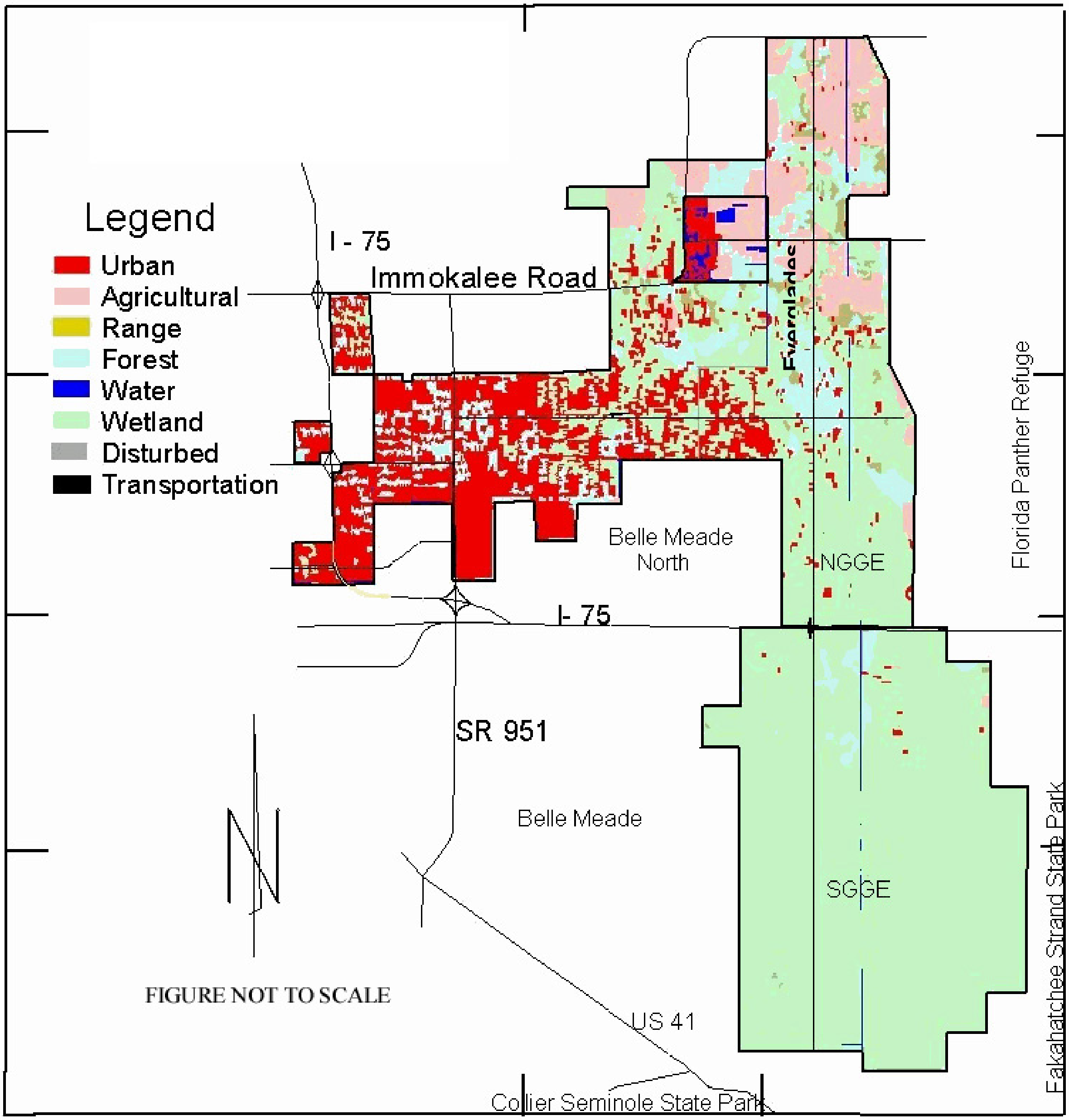


Figure 3: Land Use/Land Cover Map of Golden Gate Estates Area (1995, Florida Dept. of Transportation)

Soils throughout the study area vary in thickness over limestone. There is exposed limestone in the northeastern portion, and the remainder of the area is shallow limestone throughout. The surface thickness of the soil and depth to limestone is greatest in the lower elevations between U.S. 41 and the platted portion of the study area. At the higher elevations of the study area, if the thickness of the soil layer above the limestone is greater than four feet, soil-forming processes occur to form stain layers or cause mineral movement within clay layers above the limestone. South of the four major canals that drain the SGGE, soils in the prairie areas have marl over sandy deposits on rock. The detailed soil map units from the Soil Survey of Collier County Area, Florida (Luidahl et al., 1998) appear to indicate that oxidation through drainage or fire activity has thinned the organic surface layers.

Most of the soils in the study area are characterized as poorly or very poorly drained and historically were subject to intermittent or prolonged flooding. Because of the strong correlation between soil type and vegetation under unaltered conditions, observations of soil types in the SGGE provide information about pre-development natural flowways and land cover. In the 1954 Collier County Soil Survey (Leighty, et al.) the deepest of these flowways and basins are identified as a generic map unit labeled as Cypress Swamp (Cf). The survey names several soils that might be found within this map unit. Most of them have black or dark gray mucky fine sand or peaty muck; in others it is brown peat. According to the current NRCS Soil Survey (Luidahl, et al., 1998), areas mapped as Cf in the 1954 survey have soils with sandy or mucky fine sands. Comparison of 1940 and 1953 aerial photography with the 1954 soil survey information verifies the historic plant communities described in this report.

Plant Communities

The SGGE area is primarily made up of forests and hydric prairies. Leighty, et al.

(1954) indicated the area was largely bald cypress swamp and short grass prairie, with occasional mesic hammock or flatwoods communities. Significant alterations to the hydrology and biology of the area probably began between 1968 and 1971, when the Faka Union Canal system was completed. Gore (1988) estimated that the Faka Union drainage canal system drained the basin 16 times faster than natural drainage, and reduced wetland hydroperiods by 2-4 months, lowering the area's water table by 2-4 feet.

A significant shift has taken place in plant community composition from that of wetland and transitional vegetation to more upland and exotic species-dominated systems. Prior to the 1960s, the dominant native plant communities in the SGGE area were cypress-dominated forests, wet prairies and pine flatwoods. Drainage of the landscape has resulted in decreased hydroperiods, increased frequency and intensity of fires, and degradation of the organic soils that supported the historic communities. In the cypress forest communities, slash pines (*Pinus elliottii* var. *densa*) and saw palmettos (*Serenoa repens*) that are adapted to drier conditions and more intensive fire regimes have colonized, often followed by invasive exotic species like Brazilian pepper (*Schinus terebinthifolius*). In addition, the extensive roadway system in the SGGE has resulted in a loss of tree canopy that has affected understory vegetation, air flows and temperature. Many species, including some endangered orchids and bromeliads, require specific temperature and/or humidity conditions that are found in mature forested systems. In wet prairie communities, shortened hydroperiods have resulted in impacts such as inhibited growth of periphytic algae, which sustain small forage fish, amphibians and macroinvertebrates, that are in turn an important food source for larger animals, particularly wading birds.

Drainage appears to have affected the wetland communities differently. Prairies and cypress sloughs may have superficial resemblance to the communities described by Leighty, et al.; however, species compositions often differ (see Appendix A). Other areas appear to have changed more significantly. Exotic species, mostly Brazilian pepper, have become dominant or co-dominant in many areas that formerly were more hydric.

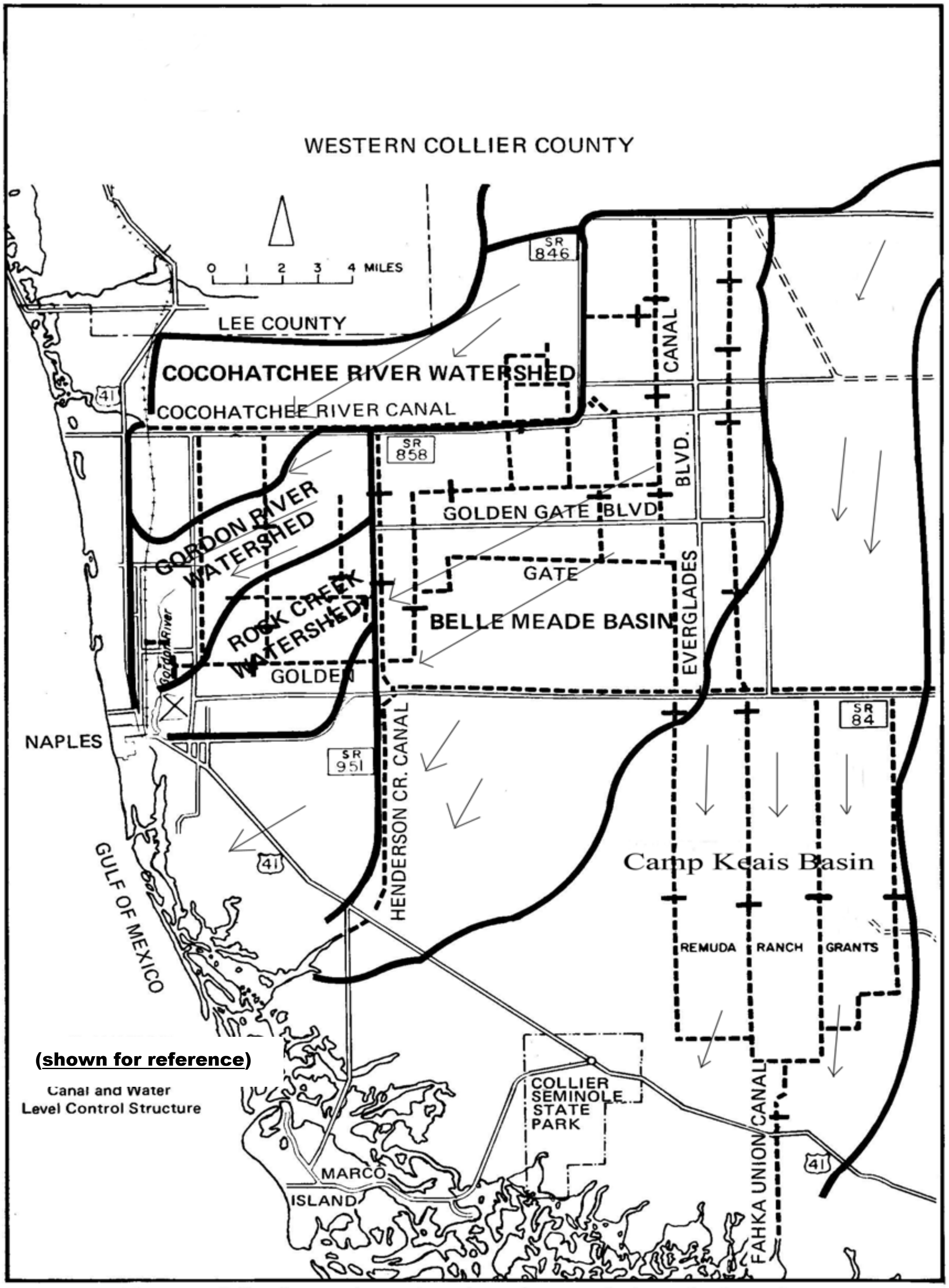
The native sabal palm (*Sabal palmetto*) appears to have become dominant through much of the area during the past few decades. These palms now form dense populations of similar sized, apparently young trees, beneath widely spaced individuals that appear to be very old. Ages of sabal palms here have been subjectively estimated, as features of their growth do not conform to annual or seasonal events, and ages cannot be accurately determined from their physical characteristics (Tomlinson, 1984). Most areas with dense sabal palm populations do not appear to have had dense populations on aerial photographs taken in 1940 and 1953. This suggests a sparse parent population that has given rise to a successful population of offspring, all at about the same time. The younger palms appear to be 2-3 decades old (again, ages determined subjectively), suggesting that the population increase may have occurred since the hydrology of the area was changed.

Fires are important ecological factors in many terrestrial communities in southern Florida. Lightning strikes and the occasional fires that result are common, and in the SGGE human-mediated fires burn many acres nearly every year. Wade et al. (1980) suggested that a naturally occurring fire frequency in sawgrass (*Cladium jamaicense*) prairies may be from three to twenty-five years, typically much more frequent than the latter figure. Marl prairies may be expected to burn even more often (Wade et al., 1980), so that these communities perhaps do not experience fire frequencies greater than before drainage. Other communities, however, may be experiencing fire frequencies much different from frequencies before drainage. Flooded cypress sloughs, for example, probably seldom experienced fires, except for the areas adjacent to prairies (Wade et al., 1980). Fires that occur now may burn closer to, or below the soil surface, as surface water and moisture levels are likely to be lower than levels before drainage.

Gore (1988) noted that wildfires in Collier County increased dramatically after completion of the Golden Gate Estates drainage system. The year following its completion, four times as many acres burned as the cumulative total of acres burned during the eight years of drainage canal construction. Furthermore, the mean acreage burned per year exceeded this cumulative total for the following five years. Evidence of fires is abundant in much of the SGGE area as charred stumps or fallen trunks of cypress trees. Fires commonly burn from prairies or flatwoods farther into adjacent cypress sloughs or other hydric forest communities than was historically common. This alters species compositions in communities formerly more hydric, as most resident species are not well adapted to withstand fires (Wade et al., 1980).

The Watershed

What is now known as the Faka Union Canal watershed, including SGGE and part of NGGE, historically (i.e., 1940s-50s prior to GGE development) encompassed an area of approximately 234 square miles and was known as the Camp Keais watershed (Black, Crow and Eidsness, Inc., 1974). Figure 4 shows these historic watershed boundaries. The extent of the historic watershed has been reduced due to construction of roads, canals and urban and agricultural development. The existing Faka Union Canal watershed is approximately 189 square miles containing approximately 70 miles of canals with 12 weir structures. A grid-like system of roads is spaced every quarter mile over much of the watershed. Pre-GGE development and current Faka Union watershed boundaries are illustrated in Figure 2.



Approximate location of major drainage basins prior to the development of SGGE

Figure 4

Regional Flow Patterns

The topography of the basin is characterized by low relief and poorly defined drainage patterns. Elevations range from 24 feet NGVD in the extreme north end with a gradual slope in the central and southern part to elevations of 2 feet NGVD near the outlet of the basin some 28 miles to the south. Over the basin the water flows in a general southwest direction.

Historically, the general water movement in the watershed was characterized by slow, overland sheetflow a few inches to a few feet deep and several miles wide. Much of the drainage was concentrated in slightly lower sloughs and strands. The area was regularly inundated by several feet of water during the wet season (U.S. Army Corps of Engineers, 1986). During the wet season, overland runoff was stored in depressional areas, peak channel flows were attenuated, and wetland hydroperiods were maintained well into the dry season. Storage of water in wetlands was integral to the hydrology of the watershed. As the wet season ended and throughout the dry season, water stored in depressions was slowly depleted as it recharged the shallow water table aquifer and was used by vegetation in the evapotranspiration process. This reduced the amount of surface runoff. It has been estimated that, of the 50+ average inches of annual rainfall received in western Collier County, historical natural runoff was on the order of 0 to 10 inches annually (Kenner, 1966).

Since their construction, roads and canals largely control the surface flow patterns and the subbasin boundaries. The Faka Union Canal system is made up of four major canals (Miller, Faka Union, Merritt and Prairie) with the Faka Union Canal being the longest, extending approximately 28 miles north from the estuary of the Ten Thousand Islands nearly to County Road 846. The canals have an average excavated depth of approximately ten feet from top of bank to bottom of channel and are trapezoidal in cross-section, with surface widths ranging from 45 to over 200 feet. Canal discharge records measured at the gauging station located upstream from the outfall weir of the Faka Union Canal (near the intersection of the canal and U.S. 41) are available starting in 1969. The average discharges for this period of record are 115 cubic feet per second (cfs) during the dry season (November through May) and 460 cfs during the wet season (June through October), with an extreme discharge of 3,200 cfs occurring right after the canals were built.

The Golden Gate Estates canal system was constructed to provide rapid drainage of surface water, lower the water table to reduce flooding, and provide fill for development. Low-head weirs were constructed to prevent overdrainage during the dry season.

In spite of the operation of these low-head weirs, the effects of the canals on the area's hydrology have been significant and far reaching. The runoff that once slowly drained as overland sheetflow is now channelized in the canals and is released to the Gulf of Mexico as a point discharge at the south end of the Faka Union Canal. This channelization has resulted in both increased runoff volumes and runoff rates. Less runoff is available for groundwater recharge. Due to the shallowness of the water table aquifer, the canals have affected the groundwater levels. The 1974 study by Black, Crow and Eidsness, Inc. stated, "Most of the canals in the system are located in areas where the limestone of the shallow aquifer is within 10 feet of the land surface. Since many of the canals are 10 feet or more in depth there is a direct hydraulic connection between the canal system and the upper portions of the shallow aquifer. Undoubtedly, construction of the Golden Gate Estates canal system has resulted in some drainage of the shallow aquifer, which has caused a general lowering of the groundwater table during the dry season." Another study (Wang, 1978) concluded the water table was lowered 1½ to 2 feet after the construction of the canals.

Since the water table aquifer is open to the land surface, it responds very quickly to changes in monthly rainfall. Sources of recharge to the aquifer include inflow from surface water bodies such as canals, subsurface flow from adjacent areas, and upward seepage from semi-confined aquifers. Generally, recharge occurs after rainfall events when the canal levels immediately upstream from the weirs are higher than adjacent groundwater levels.

SCOPE OF WORK

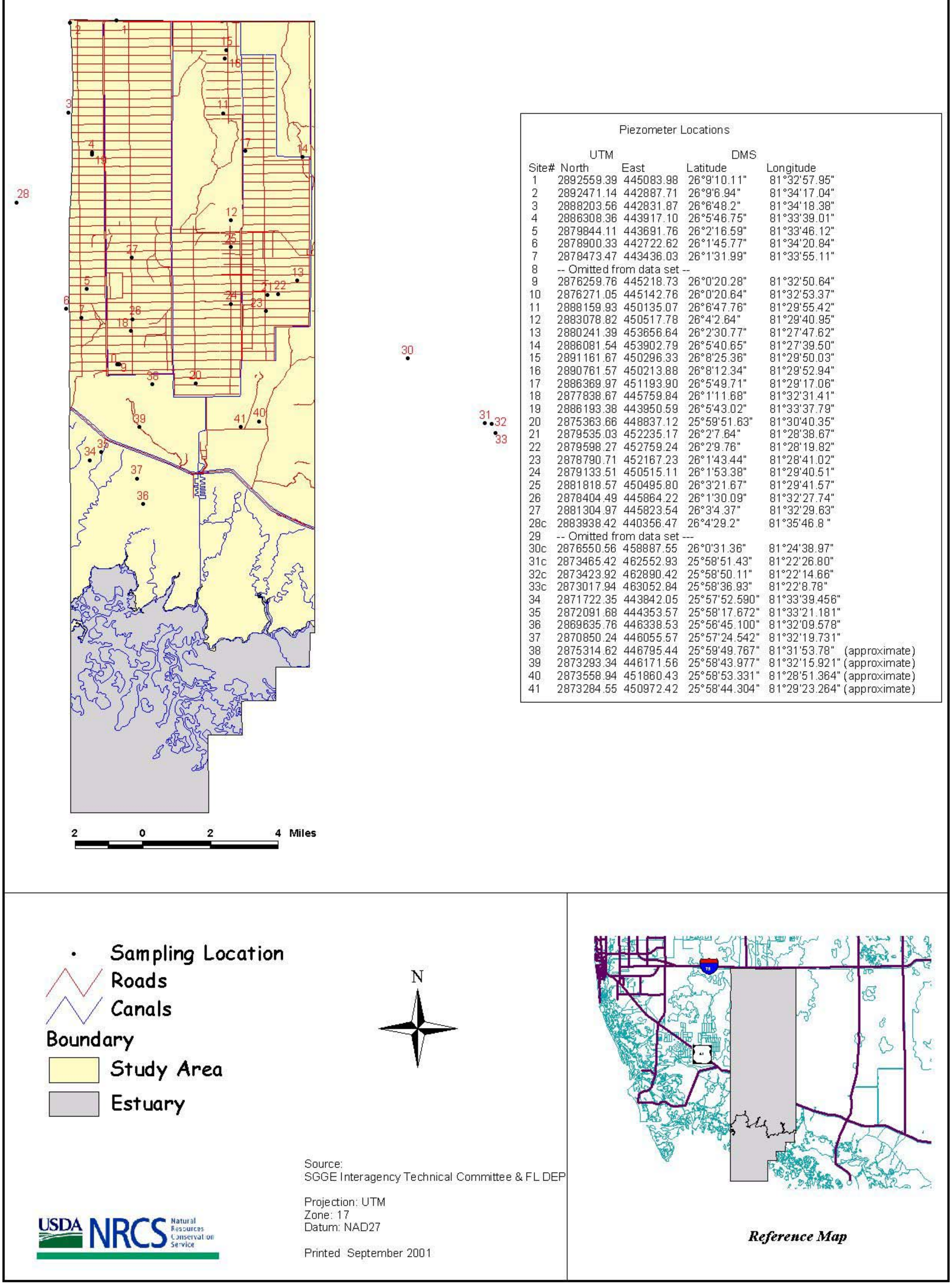
Overview

The purpose of the District's hydrologic restoration plan is to restore historic hydroperiods and sheetflow patterns in the study area to the extent possible while maintaining the existing levels of flood protection for areas north of SGGE. Appendix B contains a detailed site specific analysis of flood hydrology and hydraulics performed to help insure that these levels will be maintained. Since the response of SGGE plant communities to the hydrologic changes will be one of the most fundamental and visible indicators of restoration success, data on both the present and historic hydrological and ecological conditions of the watershed were collected and analyzed for this study. Historic conditions were defined for this study by interpretation of aerial photography and soil survey data recorded in the 1940's and 1950's, prior to the occurrence of significant environmental impacts to the area.

Utilizing plant community associations for soil types contained in the 1954 Collier County Soil Survey (Leighty, et al., 1954) and 1940 and 1953 aerial photography, the historic plant community types were described and mapped in GIS format. 1995 color infrared aerial photography, current soil survey information, and extensive groundtruthing were used to create analogous GIS maps to describe existing plant communities in the study area. The two data sets were compared to examine changes in plant communities over time.

Field surveys of current plant communities, soils, and surficial aquifer levels were conducted at 39 selected sites (see Figure 5). Survey sites were selected to provide a representative sample of the predominant communities in the study area, although constraints

Figure 5: Southern Golden Gate Estates Watershed Planning Study Survey Sites



Piezometer Locations

	UTM		DMS		
Site#	North	East	Latitude	Longitude	
1	2892559.39	445083.98	26°9'10.11"	81°32'57.95"	
2	2892471.14	442887.71	26°9'6.94"	81°34'17.04"	
3	2888203.56	442831.87	26°6'48.2"	81°34'18.38"	
4	2886308.36	443917.10	26°5'46.75"	81°33'39.01"	
5	2879844.11	443691.76	26°2'16.59"	81°33'46.12"	
6	2878900.33	442722.62	26°1'45.77"	81°34'20.84"	
7	2878473.47	443436.03	26°1'31.99"	81°33'55.11"	
8	-- Omitted from data set --				
9	2876259.76	445218.73	26°0'20.28"	81°32'50.64"	
10	2876271.05	445142.76	26°0'20.64"	81°32'53.37"	
11	2888159.93	450135.07	26°6'47.76"	81°29'55.42"	
12	2883078.82	450517.78	26°4'2.64"	81°29'40.95"	
13	2880241.39	453656.64	26°2'30.77"	81°27'47.62"	
14	2886081.54	453902.79	26°5'40.65"	81°27'39.50"	
15	2891161.67	450296.33	26°8'25.36"	81°29'50.03"	
16	2890761.57	450213.88	26°8'12.34"	81°29'52.94"	
17	2886369.97	451193.90	26°5'49.71"	81°29'17.06"	
18	2877838.67	445759.84	26°1'11.68"	81°32'31.41"	
19	2886193.38	443950.59	26°5'43.02"	81°33'37.79"	
20	2875363.66	448837.12	25°59'51.63"	81°30'40.35"	
21	2879535.03	452235.17	26°2'7.64"	81°28'38.67"	
22	2879598.27	452759.24	26°2'9.76"	81°28'19.82"	
23	2878790.71	452167.23	26°1'43.44"	81°28'41.02"	
24	2879133.51	450515.11	26°1'53.38"	81°29'40.51"	
25	2881818.57	450495.80	26°3'21.67"	81°29'41.57"	
26	2878404.49	445864.22	26°1'30.09"	81°32'27.74"	
27	2881304.97	445823.54	26°3'4.37"	81°32'29.63"	
28c	2883938.42	440356.47	26°4'29.2"	81°35'46.8 "	
29	-- Omitted from data set ---				
30c	2876550.56	458887.55	26°0'31.36"	81°24'38.97"	
31c	2873465.42	462552.93	25°58'51.43"	81°22'26.80"	
32c	2873423.92	462890.42	25°58'50.11"	81°22'14.66"	
33c	2873017.94	463052.84	25°58'36.93"	81°22'8.78"	
34	2871722.35	443842.05	25°57'52.590"	81°33'39.456"	
35	2872091.68	444353.57	25°58'17.672"	81°33'21.181"	
36	2869635.76	446338.53	25°56'45.100"	81°32'09.578"	
37	2870850.24	446055.57	25°57'24.542"	81°32'19.731"	
38	2875314.62	446795.44	25°59'49.767"	81°31'53.78"	(approximate)
39	2873293.34	446171.56	25°58'43.977"	81°32'15.921"	(approximate)
40	2873558.94	451860.43	25°58'53.331"	81°28'51.364"	(approximate)
41	2873284.55	450972.42	25°58'44.304"	81°29'23.264"	(approximate)

Source:
SGGE Interagency Technical Committee & FL DEP

Projection: UTM
Zone: 17
Datum: NAD27

Printed September 2001

such as private ownership and lack of physical access to certain areas prevented analysis of an optimal array of sites. Originally, 41 survey sites were chosen; two were determined to be outside of PSSF boundaries and were deleted. Five of the survey sites were chosen as comparison sites ("controls") expected to be affected relatively little by hydrologic restoration of the SGGE. Four of these are located in the Fakahatchee Strand State Preserve (FSSP) to the east of the study area. One is located in the Belle Meade tract on PSSF land west of the study area boundary. At each survey site, surficial aquifer monitoring wells were installed to record water table levels and the soil profile and vegetative assemblages were described. The vegetative assemblages were described in 1997 and again between 1998-2000 to note changes that had occurred since 1997. Eight sites were added to the original 31 in 1999 to characterize the area south of the SGGE road network, as this area will also be affected by hydrologic restoration of the SGGE. Monitoring wells were installed and read, and soil profiles and vegetative assemblages were described at these sites from 1998-2000. In general, this part of the study area was groundtruthed less intensively than the SGGE portion.

Finally, utilizing data gathered in this study, more detailed and accurate hydraulic and hydrologic analyses were performed to refine the hydrologic restoration strategy proposed in the District's Conceptual Plan. Plant community responses to the proposed restoration strategy were predicted using the modeling results and the data gathered on the historic and current communities.

Plant Communities Descriptions

Initially, six major representative plant communities were identified as potentially affected by the restoration: 1) mesic pine flatwoods, 2) hydric pine flatwoods, 3) cypress slough, 4) hardwood hammock, 5) prairie, and 6) *Schinus*-dominated communities. In 1999, with the addition of eight new survey sites to the south in the expanded study area, the brackish marsh community which is prevalent on the Ten Thousand Islands National Wildlife Refuge (TTINWR) was added. Thus, 39 sites representing 7 communities were selected. This allowed for sampling comparisons both within and between communities. Comparison sites were chosen for five of the six native community types. Because most of the brackish marsh sites on the TTINWR are considered relatively undisturbed, no comparison site was chosen for this community type. Of the other five, a hydric pine flatwoods comparison site was chosen in the Belle Meade tract, and cypress slough, hardwood hammock, and prairie sites were located in the FSSP. The fifth comparison site, for mesic pine flatwoods, had to be deleted from the survey when it was discovered not to be in public ownership. As no other adequate site could be located, there is no comparison site for this community type.

The biological communities at each of the 39 survey sites are defined and described primarily by their vascular plant residents in Appendix A. The communities' components were compared with descriptions provided by Leighty, et al. from field reconnaissance performed in the 1940's for the 1954 Collier County Soil Survey. The Soil Survey included descriptions of the plant communities commonly found on the described soils. In describing current conditions of the communities, diversity measures of habitat assemblages were developed for use as descriptive tools. These descriptions can be used for future comparisons to determine whether changes in habitat communities are in line with expectations of land managing entities.

GIS maps showing the distribution of major plant community types in the study area in 1940 and 1995 were created using the plant community descriptions, aerial photography, soil survey information and groundtruthing (Figure 6, Table 2). The maps and table provide a detailed comparison of the location and extent of historic and current plant communities.

Soil Descriptions

The soils at each survey site were described in terms of the uniformity and continuity of soil layers, and morphology (i.e., structure, texture, color, organic matter, permeability, seasonal high water table elevation and hydric condition). Detailed soils information including descriptions of the soil profile for each of the 39 sites surveyed for this study can be found in Appendix A.

Water Table Elevation Data

In order to show fluctuations in the shallow water table at the survey sites, shallow surficial aquifer monitoring wells were installed at all SGGE study area sites and at the comparison site on the Belle Meade tract (wells were pre-existing at the FSSP sites). Well water levels were recorded where possible on a biweekly basis between beginning in October 1998. The wells on FSSP property were read monthly by FSSP personnel. Appendix C contains monitoring well data.

Hydrologic-Hydraulic Assessment

For the District's Conceptual Plan, the hydrologic-hydraulic assessment of the watershed and of the alternative restoration strategies was performed by applying the U.S. Environmental Protection Agency's continuous process Hydrologic Simulation Program Fortran (HSPF). However, an enhanced representation of the complex surface and groundwater flow patterns of the watershed was incorporated for this study via the application of the integrated mathematical modeling system MIKE SHE (Refsgaard and Storm, 1995). The MIKE SHE modeling system is an integrated and distributed, physically based, finite difference mathematical

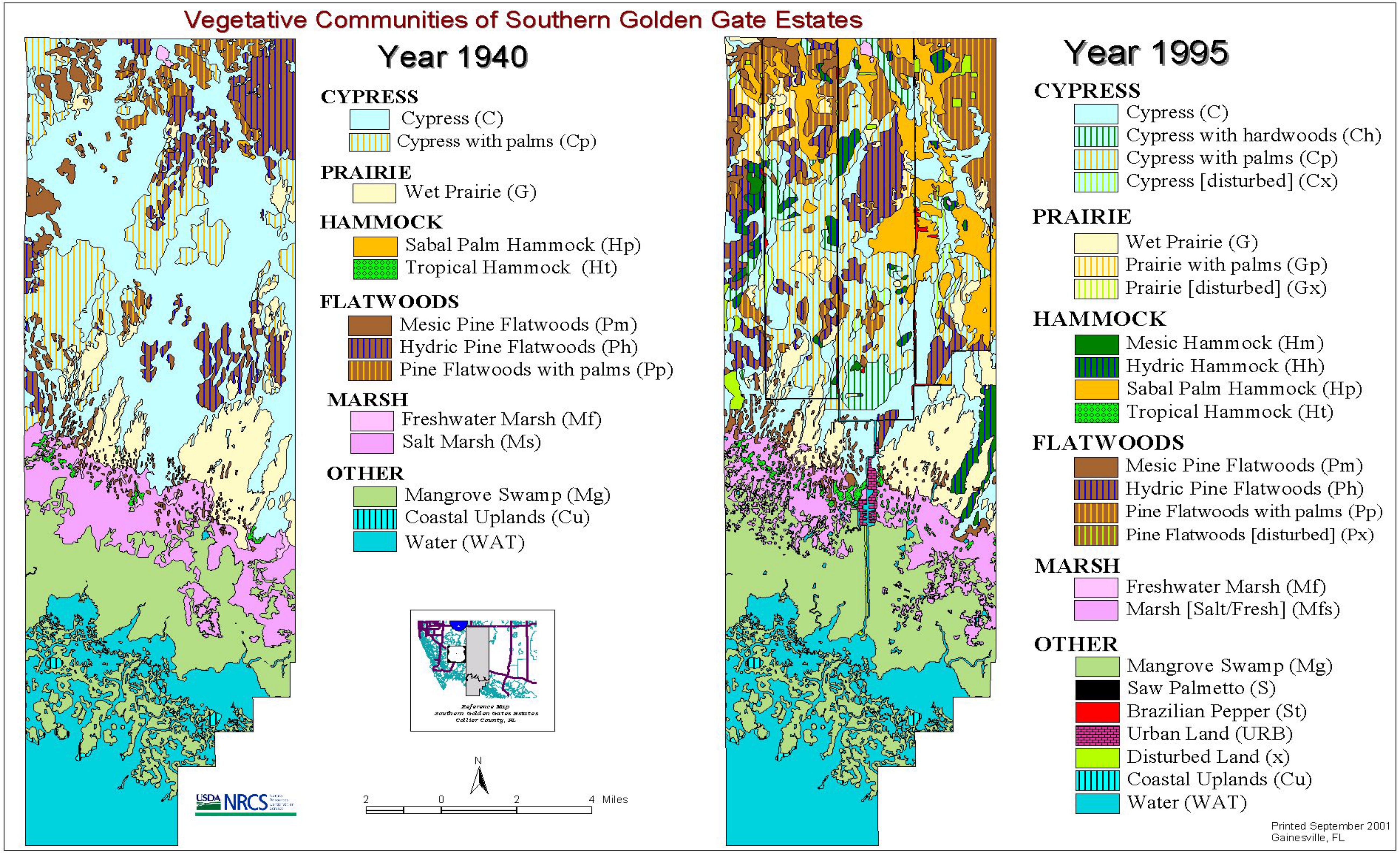


FIGURE 6: Plant Community Maps of Southern Golden Gate Estates for 1940 and 1995

TABLE 2: ACREAGES AND PERCENTAGES OF EACH SGGE PLANT COMMUNITY IN 1940 AND 1995.

Name	**Veg. Symbol**	**1940 Acres**	**Percent of Total Acreage**	**1995 Acres**	**Percent of Total Acreage**	**Difference (1995-1940) in Acres and Percent**	
Cypress	C	30583.1	30.5%	10567.1	10.5%	-20016.0	-19.9%
Cypress with hardwoods	Ch	0.0	0.0%	2845.7	2.8%	2845.7	2.8%
Cypress with palms	Cp	8758.1	8.7%	9025.6	9.0%	267.5	0.3%
Coastal Uplands	Cu	301.9	0.3%	301.9	0.3%	0.0	0.0%
Cypress (disturbed)	Cx	0.0	0.0%	1246.2	1.2%	1246.2	1.2%
Wet Prairie	G	7619.3	7.6%	7031.0	7.0%	-588.3	-0.6%
Prairie with palms	Gp	0.0	0.0%	2043.6	2.0%	2043.6	2.0%
Prairie (disturbed)	Gx	0.0	0.0%	161.8	0.2%	161.8	0.2%
Hydric Hammock	Hh	0.0	0.0%	2574.2	2.6%	2574.2	2.6%
Mesic Hammock	Hm	0.0	0.0%	139.8	0.1%	139.8	0.1%
Sabal Palm Hammock	Hp	55.8	0.1%	7286.4	7.3%	7230.7	7.2%
Tropical Hammock	Ht	264.9	0.3%	688.6	0.7%	423.7	0.4%
Freshwater Marsh	Mf	512.1	0.5%	94.7	0.1%	-417.5	-0.4%
Marsh (Salt/Fresh)	Mfs	8574.2	8.5%	6480.4	6.5%	-2093.8	-2.1%
Mangrove	Mg	16564.5	16.5%	18417.3	18.3%	1852.8	1.8%
Hydric Pine Flatwoods	Ph	7141.2	7.1%	5852.9	5.8%	-1288.3	-1.3%
Mesic Pine Flatwoods	Pm	2908.0	2.9%	1983.0	2.0%	-924.9	-0.9%
Pine Flatwoods with palms	Pp	2408.0	2.4%	6478.1	6.5%	4070.2	4.1%
Pine Flatwoods (disturbed)	Px	0.0	0.0%	48.2	0.0%	48.2	0.0%
Saw Palmetto	S	0.0	0.0%	6.2	0.0%	6.2	0.0%
Brazilian Pepper	St	0.0	0.0%	273.1	0.3%	273.1	0.3%
Urban Land	URB	0.0	0.0%	298.8	0.3%	298.8	0.3%
Water	WAT	14721.9	14.7%	15843.8	15.8%	1121.9	1.1%
Disturbed Land	x	0.0	0.0%	725.0	0.7%	725.0	0.7%
Total:		100412.9	100.0%	100413.5	100.0%		

model. It comprises a number of flow modules, which may be combined to describe flow within the entire land-based part of the hydrological cycle. In addition to surface water flow, groundwater flow through the water table aquifer is considered in the MIKE SHE model. MIKE SHE has been adopted for simulating various water demand and environmental problems for the District since 1997. For detailed information on the development and application of MIKE SHE, see Appendix D.

An extensive database of meteorological and land-based hydrologic-hydraulic data was utilized for the development of the MIKE SHE integrated model for the SGGE. Some of the major input parameters are listed in Appendix D. The model was then applied to generate inundation depths, frequencies, and durations for surveyed elevation points on a quarter mile grid across the modeled area for historic, current, and predicted restored conditions. These conditions were based on implementation of Alternative III-D, an update of Alternative III-C, which was the recommended hydrologic restoration plan for SGGE as presented in the District's Conceptual Plan.

The major features of the Alternative III-D hydrologic restoration design include pumps, spreader channels, canal blocks and road removal to achieve the objectives of restoring hydrology and sheet flow patterns to the extent possible while still providing flood protection for populated areas north of SGGE.

The Alternative III-D design utilizes three pumps, one each on Miller, Faka-Union and Merritt Canals, a dike at each pump to keep water from moving overland to the north after being pumped from each canal, and spreader channels to recreate sheet flow downstream of the pumps. Pumping rates were determined by actual flows measured at the outlet of the canal system just north of U.S. 41. From these measurements it was estimated that flows from Miller Canal, Faka Union Canal, Merritt Canal, and Prairie Canal contribute 20 percent, 50 percent, 18 percent, and 12 percent, respectively, to the total discharge measured at the Faka Union outfall weir located near U.S. 41. Accordingly, pumping rates were calculated along those percentages from the average of 10-year flow records at the outfall weir and distributed at the Miller, Faka Union, and Merritt Canal pump stations. No pumping will occur in the Prairie Canal under Alternative III-D. The design calls for pumps to run from June 1 through October 1. Flows coming down the canals during the rest of the year are allowed to pass the pumps by gravity flow. This schedule was determined via MIKE SHE modeling analysis to prevent flooding in populated areas to the north while achieving SGGE hydrologic restoration objectives. Proposed pumping rates and pump operation schedules are illustrated in Figure 7 on page 28.

Modeling Domain And Modeling Scenarios

The domain of the MIKE SHE model is an area of 139.5 m^2 (see Figure 8, p. 29), which includes areas outside the PSSF (shown as red CARL boundary). Modeling results presented in this report apply to the area within the SGGE modeling boundary. This area was divided into 2232 grid cells with cell dimensions of 1320 ft. by 1320 ft. (quarter mile) each. An explanation of the extended modeling area shown as pink in Figure 8 may be found in Appendix D.

Three temporal scenarios were modeled to evaluate Alternative III-D:

1. Natural Condition: The surface topography and hydrology without the existence of man's influence in the form of canals, roads, etc. (Figure 9, p. 30). The term "natural" hereafter refers to historic conditions as defined previously in this report. (Major roads and canals are shown for reference.)
2. Current Condition: The surface topography and hydrology with the existing (1990-99) networks of canals, roads, and water control structures (Figure 10, p. 31).
3. Restored Condition: The surface topography and hydrology with the proposed elements of Alternative III-D in place (Figure 11, p.32).

Modeling Results

The MIKE SHE model has permitted comparison of water levels, and by extension the major plant communities, associated with natural, current, and restored conditions. In order to best determine the extent to which Alternative III-D will restore historic hydroperiods of the SGGE plant communities, MIKE SHE was applied to analyze parameters of wet season hydroperiods. The spatial and temporal hydroperiod variations for a range of simulated inundation depths under the three modeling scenarios are illustrated in the following series of figures. It is important to note that refinements to MIKE SHE are ongoing, and these refinements will allow the District to further enhance modeling capabilities in the near future; thus, many of the following results are labeled as draft. Results show inundation depths and differences for natural, current and restored conditions within the SGGE model boundary area for an average meteorological year. Appendix D describes how an average meteorological year was determined and provides additional model analyses.

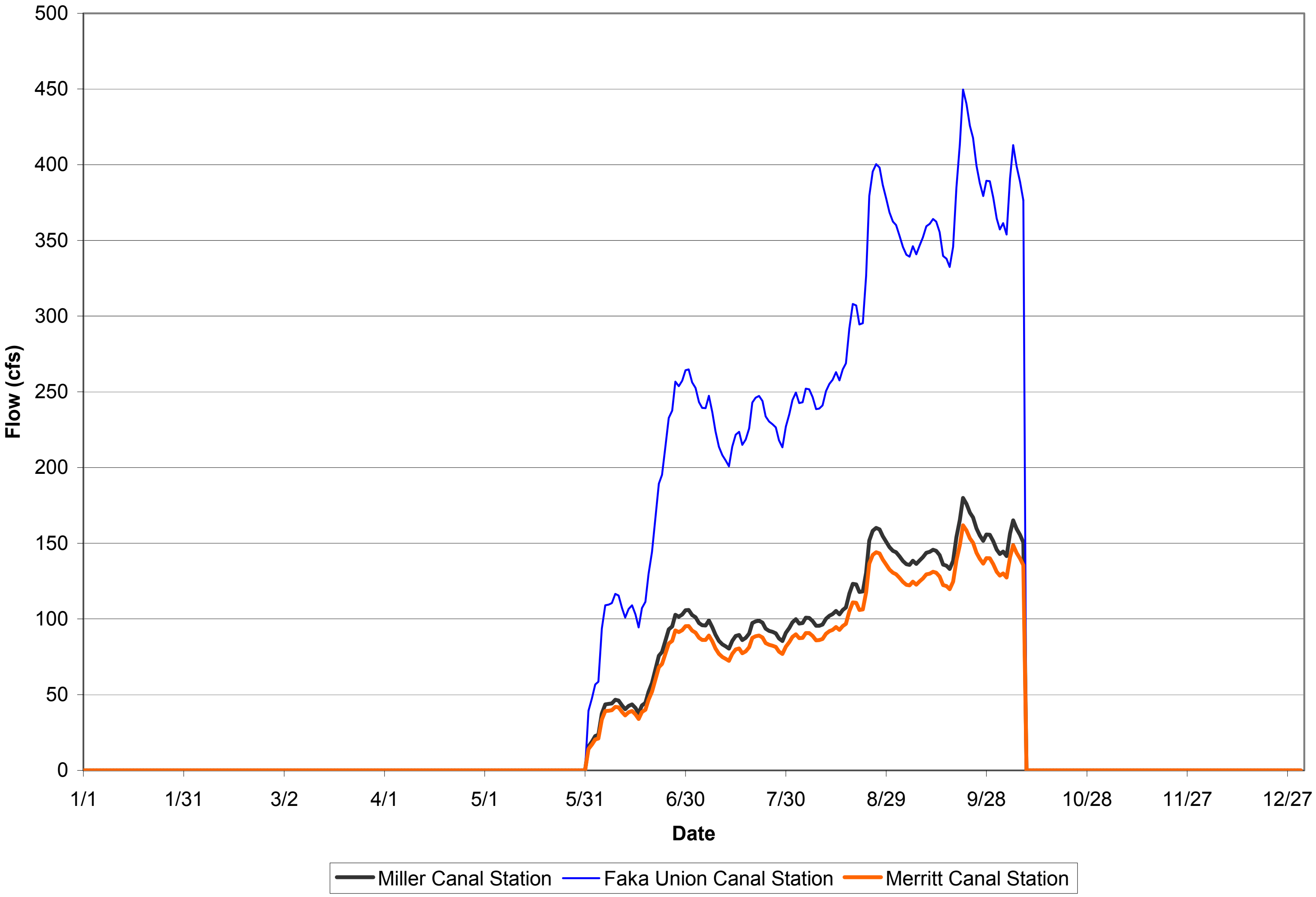


Figure 7: Pumping Rate and Operation Schedule at Designated Pump Stations of Miller Canal, Faka Union Canal, and Merritt Canal

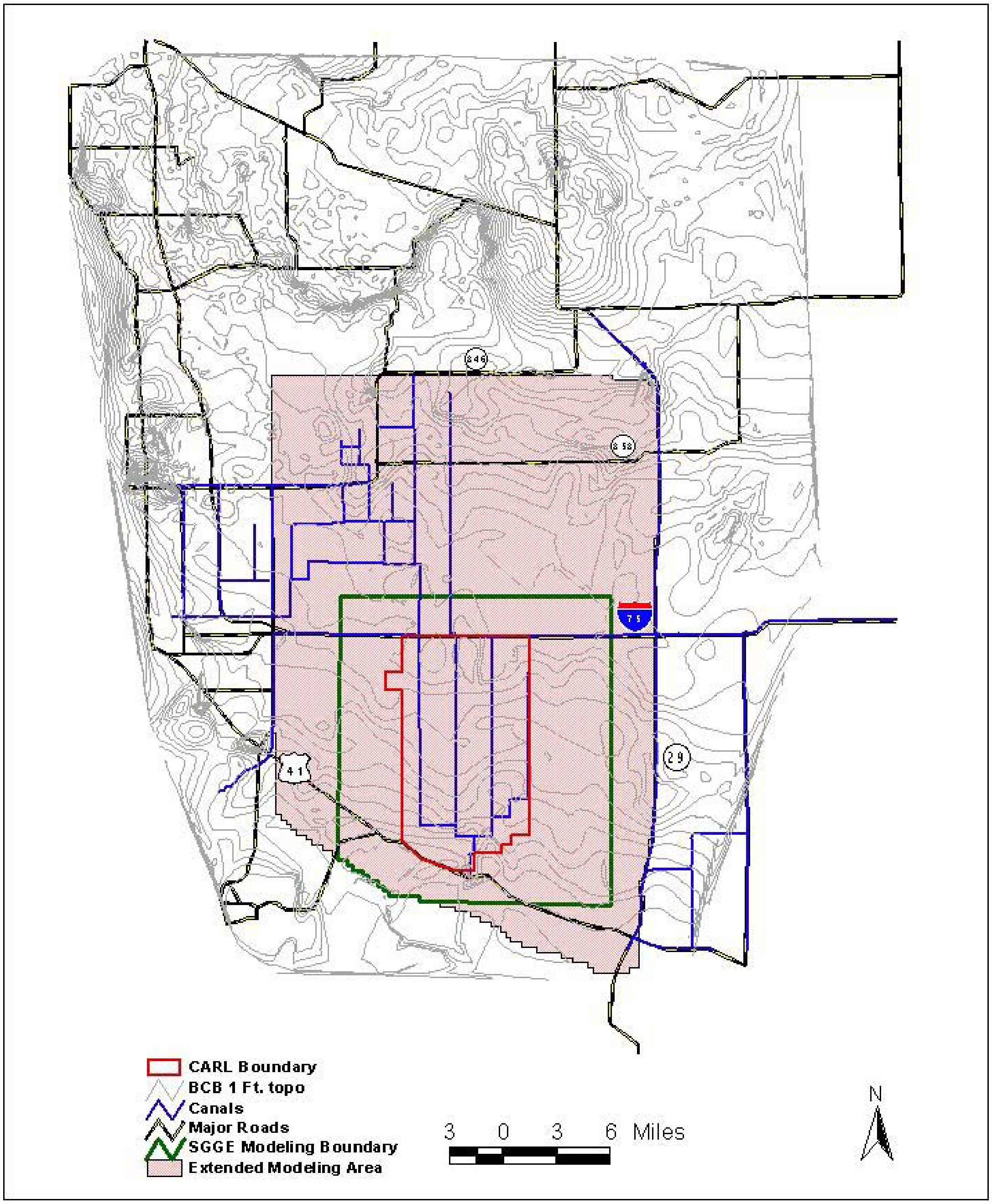


Figure 8 MIKE SHE Modeling Boundaries for SGGE Hydrologic Restoration Plan

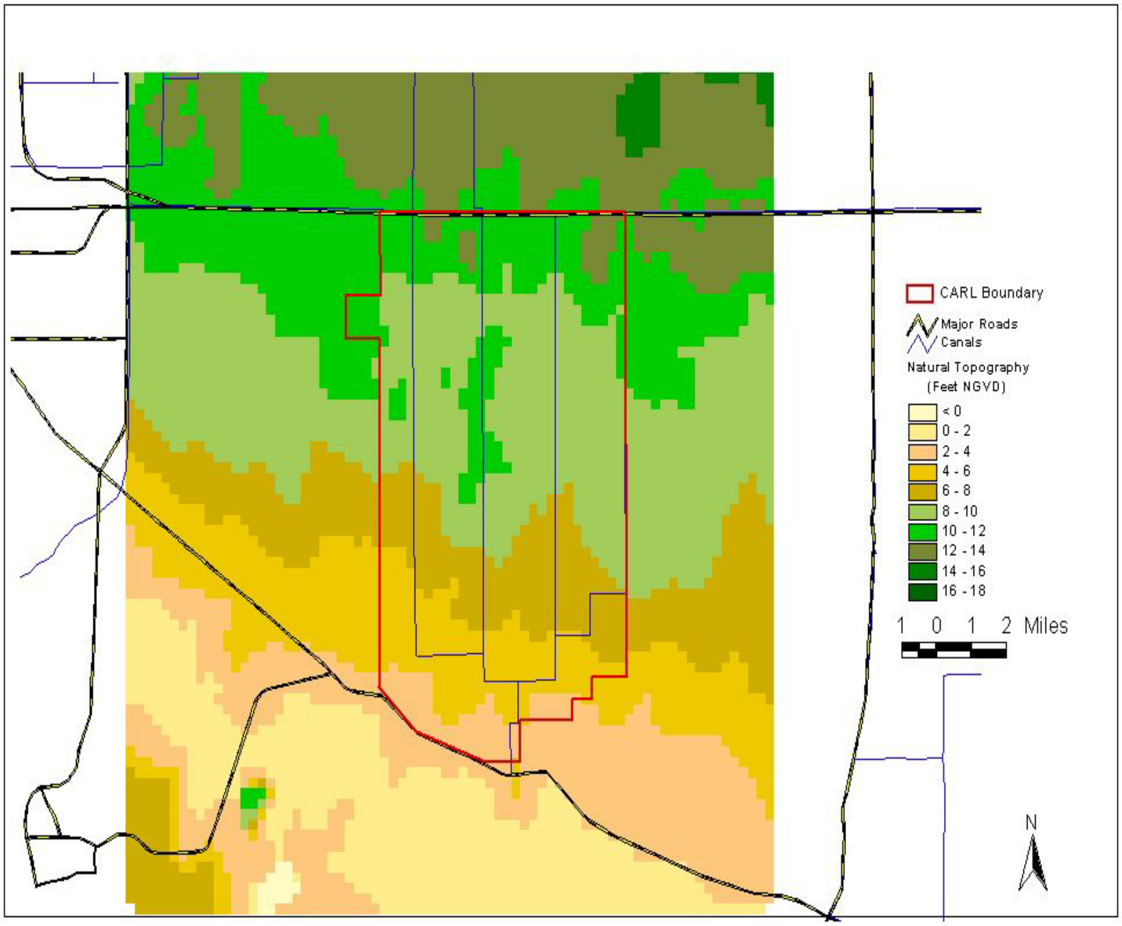


Figure 9: Surface Topography for Natural Condition

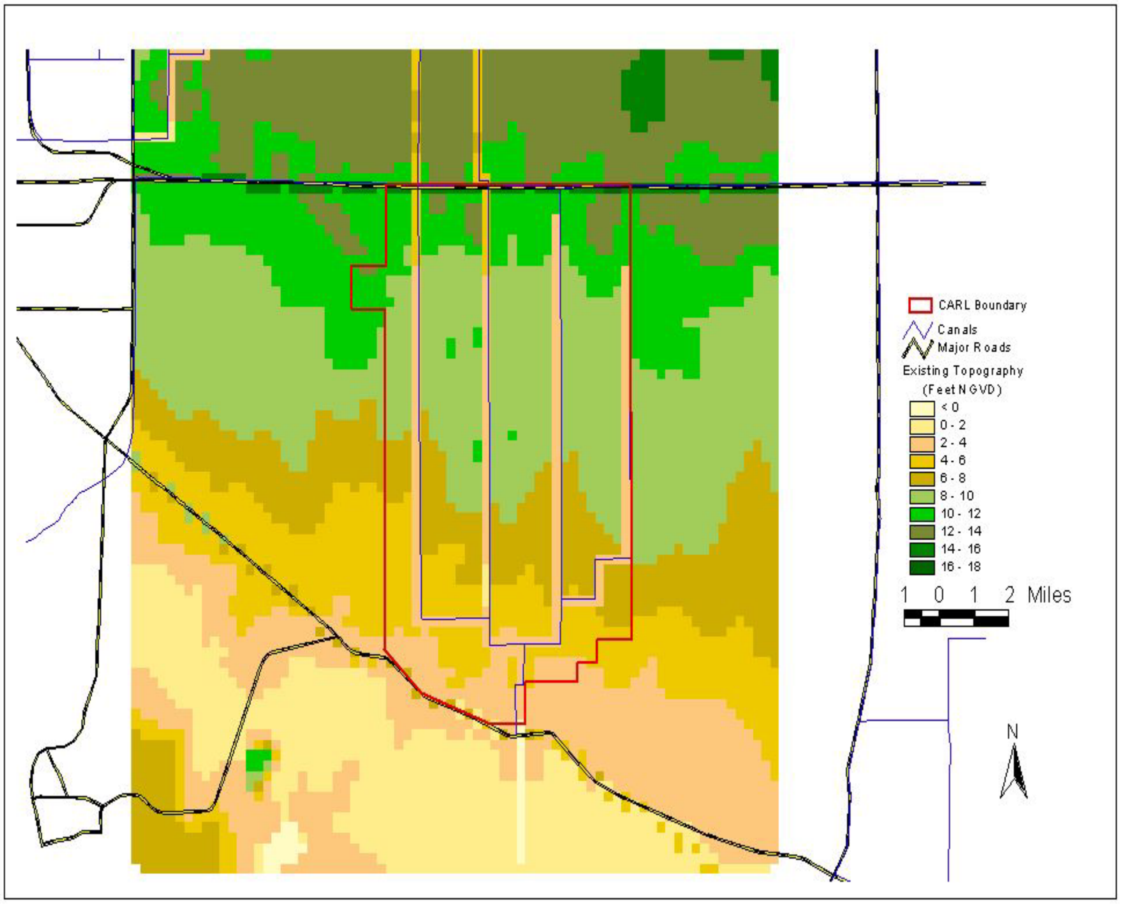


Figure 10: Surface Topography for Current Condition

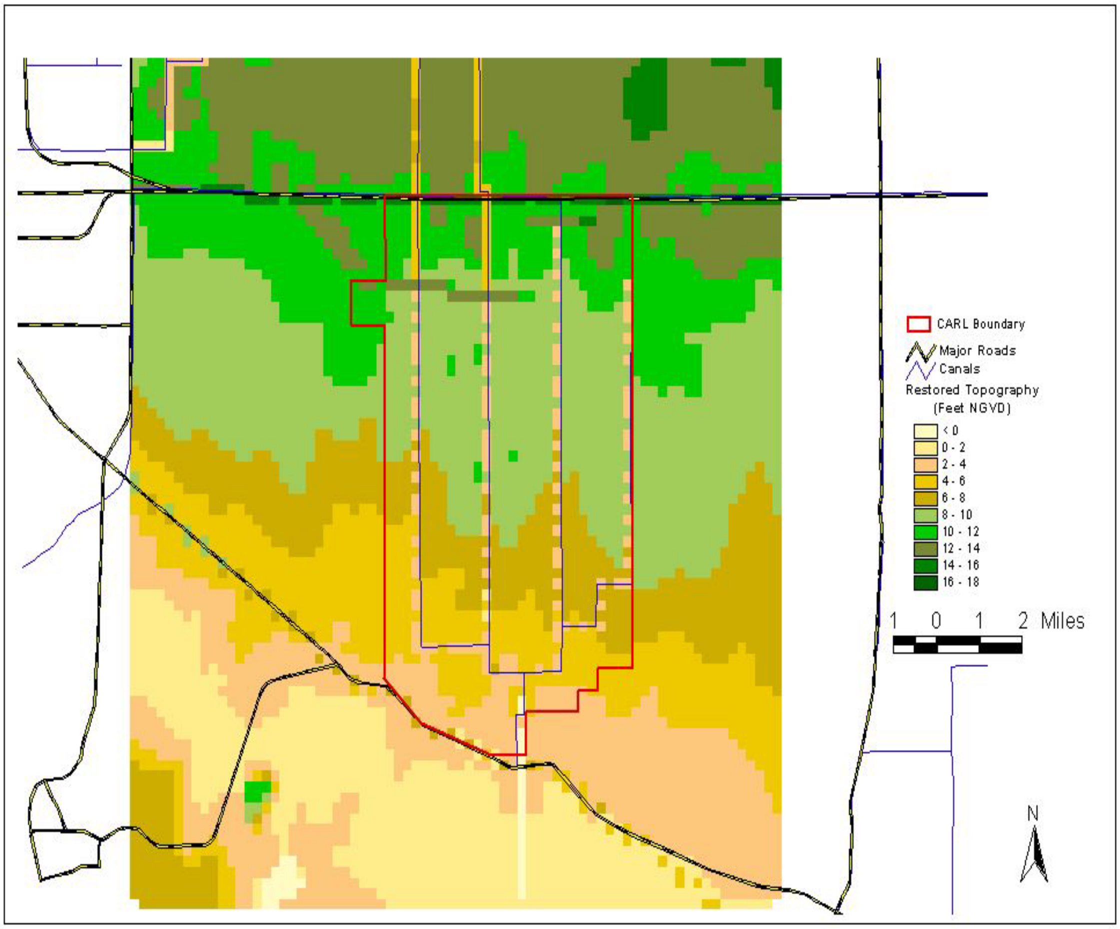


Figure 11: Surface Topography for Restored Condition

Results are shown for the following model analyses:

A. Average inundation depths during wet season (July 1 through October 1) for:
    - Natural Condition (Figure 12).
    - Current Condition (Figure 13).
    - Restored Condition (Figure 14).
B. Maximum one-day water depths during an average year for:
    - Natural Condition (Figure 15).
    - Current Condition (Figure 16).
    - Restored Condition (Figure 17).
C. Difference in wet season average inundation depths between:
    - Current Condition and Natural Condition (Figure 18).
    - Restored Condition and Natural Condition (Figure 19).
D. Number of cells (1320 ft^2) in each inundation depth range and hydroperiod for Natural, Current and Restored Condition, and major plant community type associations for depth ranges and hydroperiods (Figure 20).
E. Difference in number of cells in each inundation depth range between natural condition and other modeling scenarios (Figure 21).

Utilizing the results of these modeling analyses and the hydrology and plant community relationships shown in Table 3, Table 4 provides a comparison of acreages and percentages of major plant community types based on inundation depth ranges predicted by the MIKE SHE model for each modeling scenario.

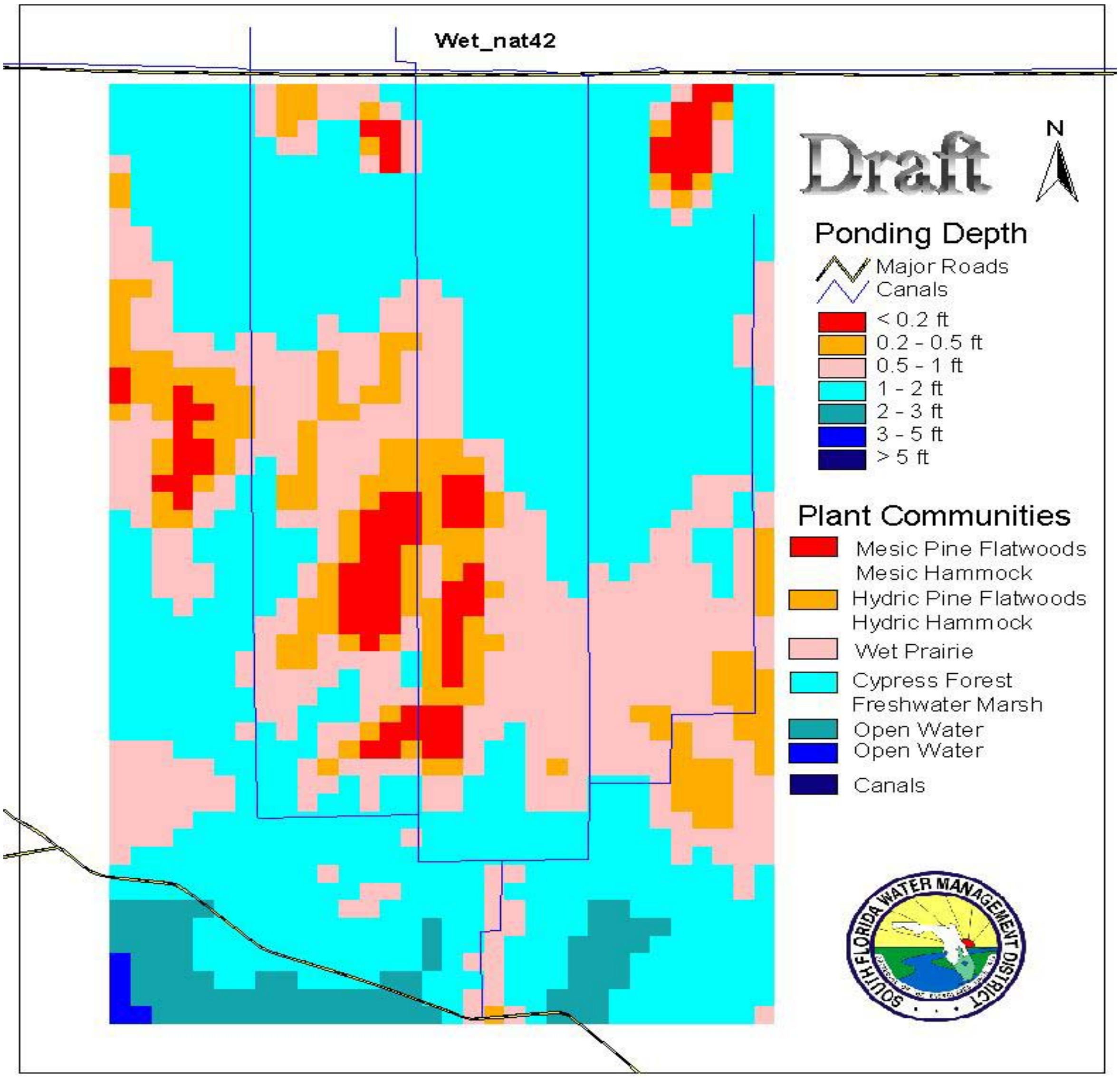


Figure 12: **SGGE Average Inundation Depth During Wet Season (July 1st – October 1st) for Natural Condition**

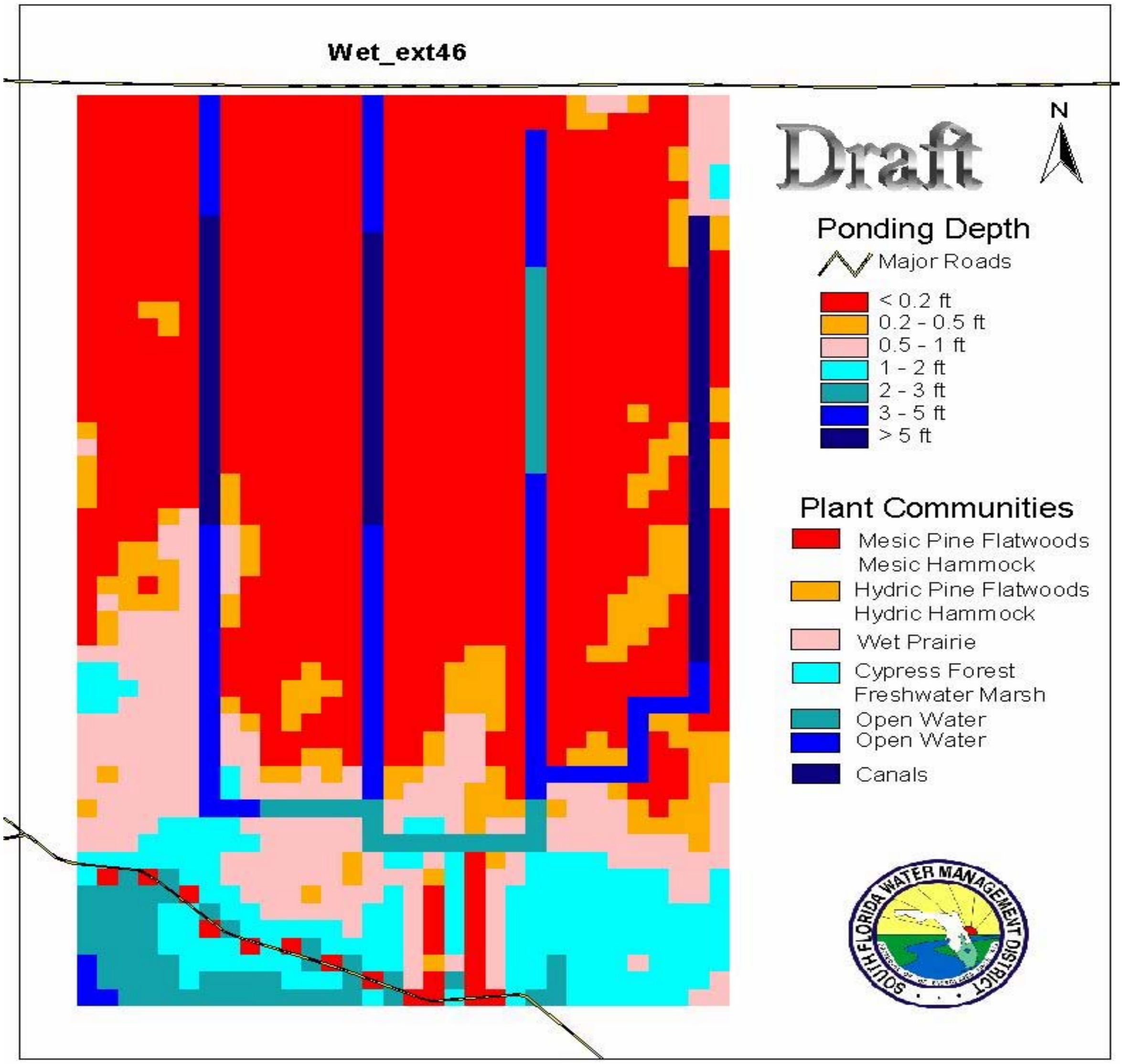


Figure 13: SGGE Average Inundation Depth During Wet Season (July 1st to October 1st) for Current Condition

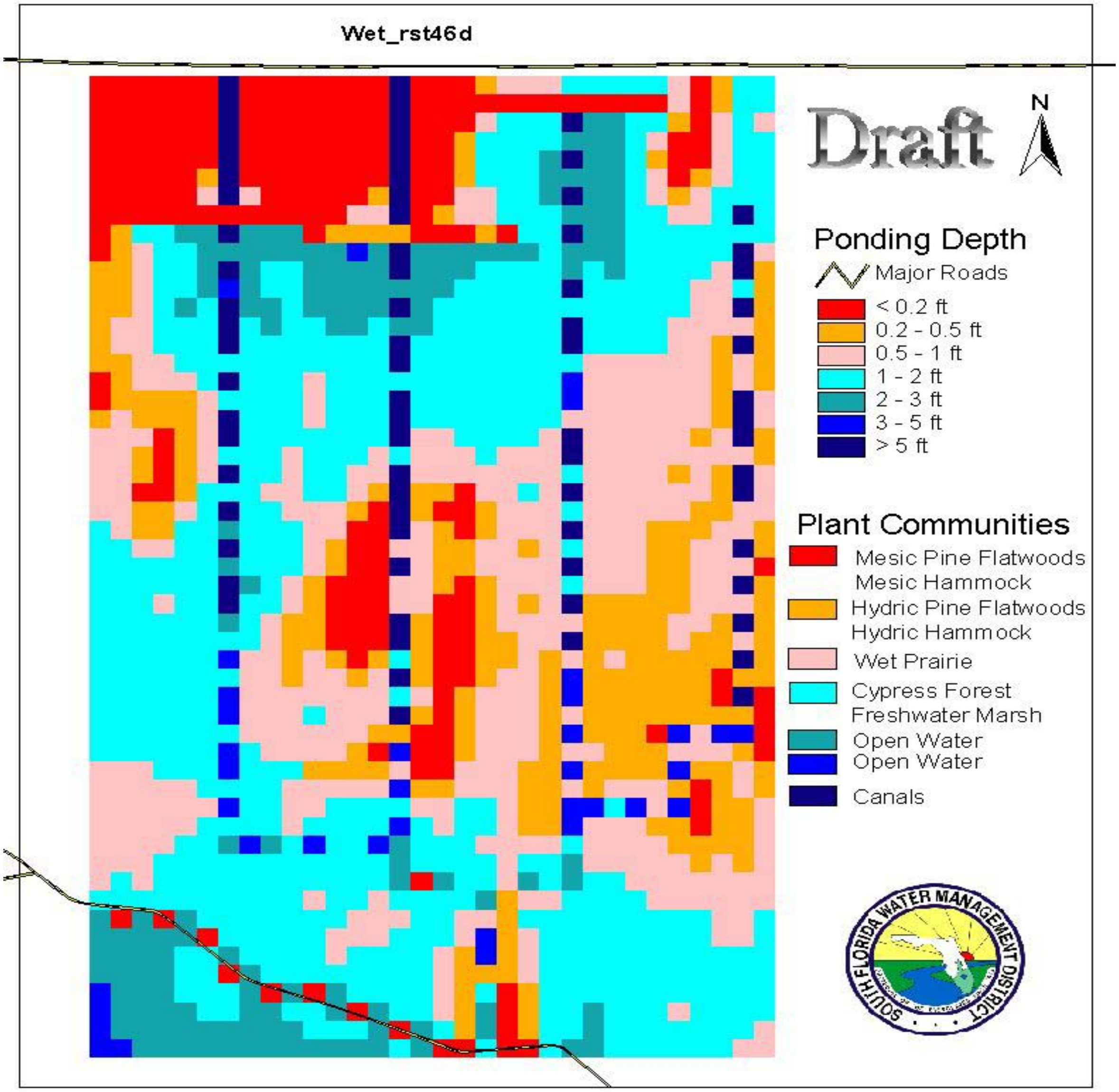


Figure 14: SGGE Average Inundation Depth During Wet Season (July 1st – October 1st) for Restored Condition

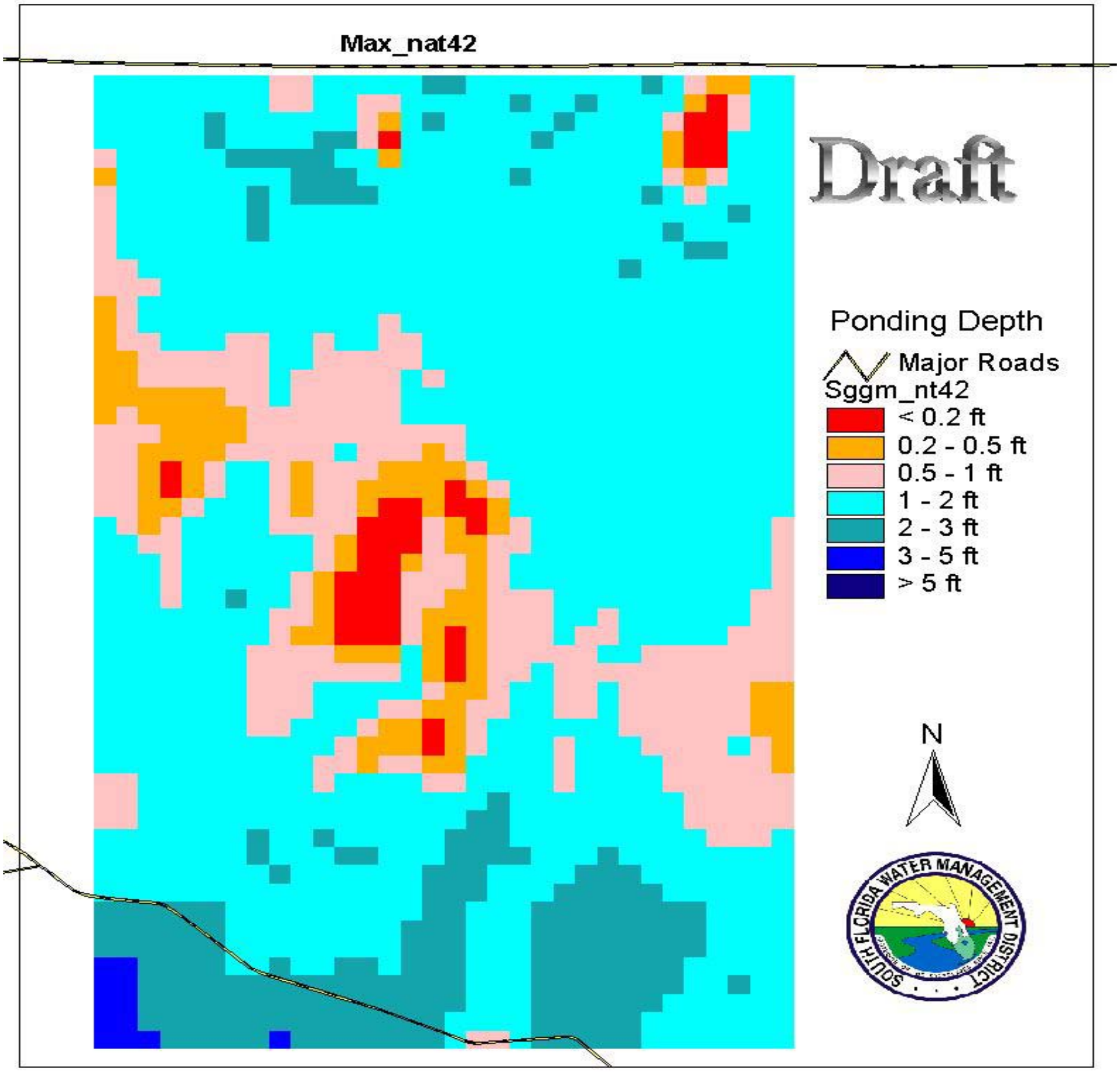


Figure 15: Maximum One-day Water Depths During an Average Year for Natural Condition in SGGE

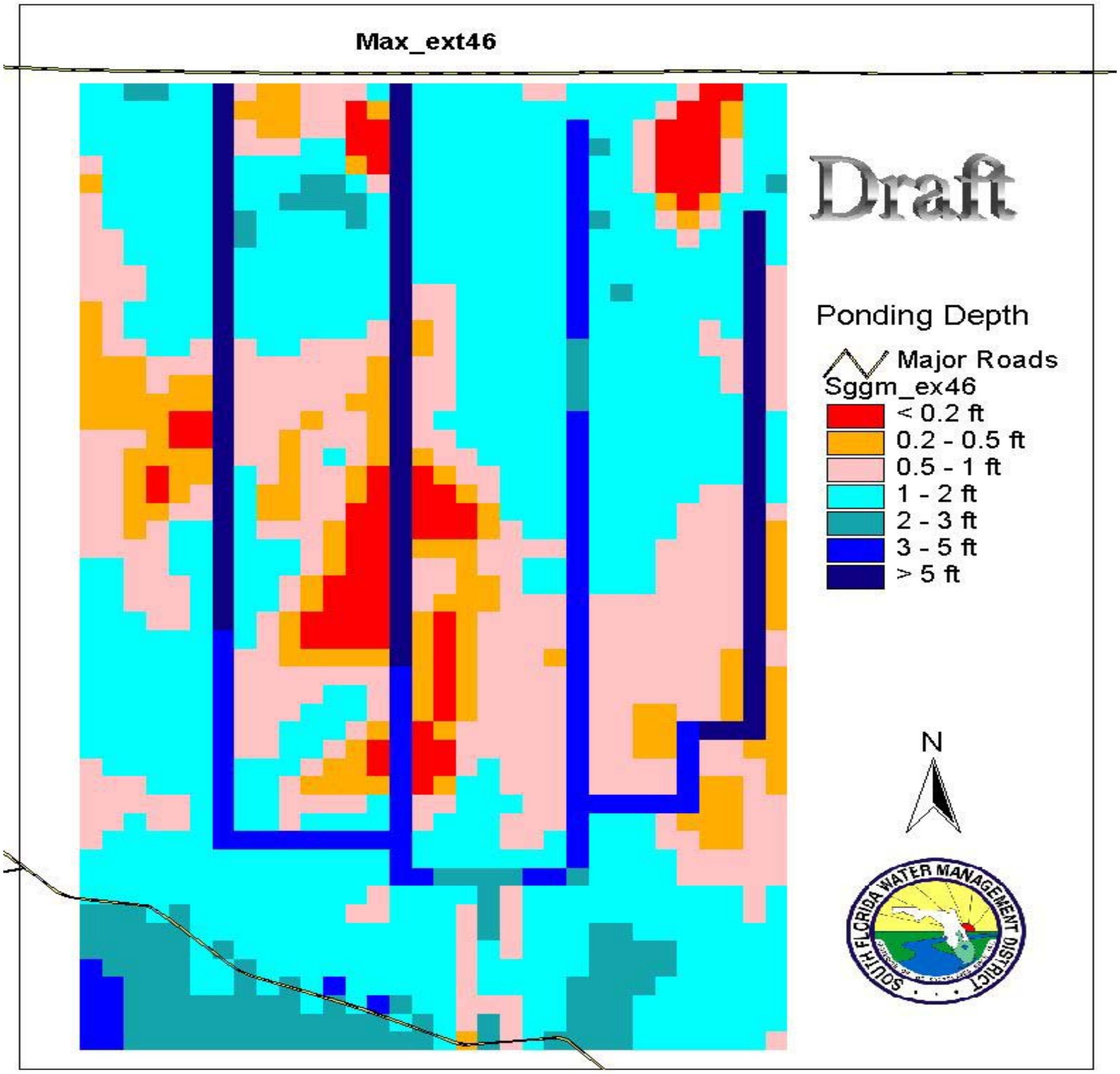


Figure 16: Maximum One-day Water Depths During an Average Year for Current Condition in SGGE

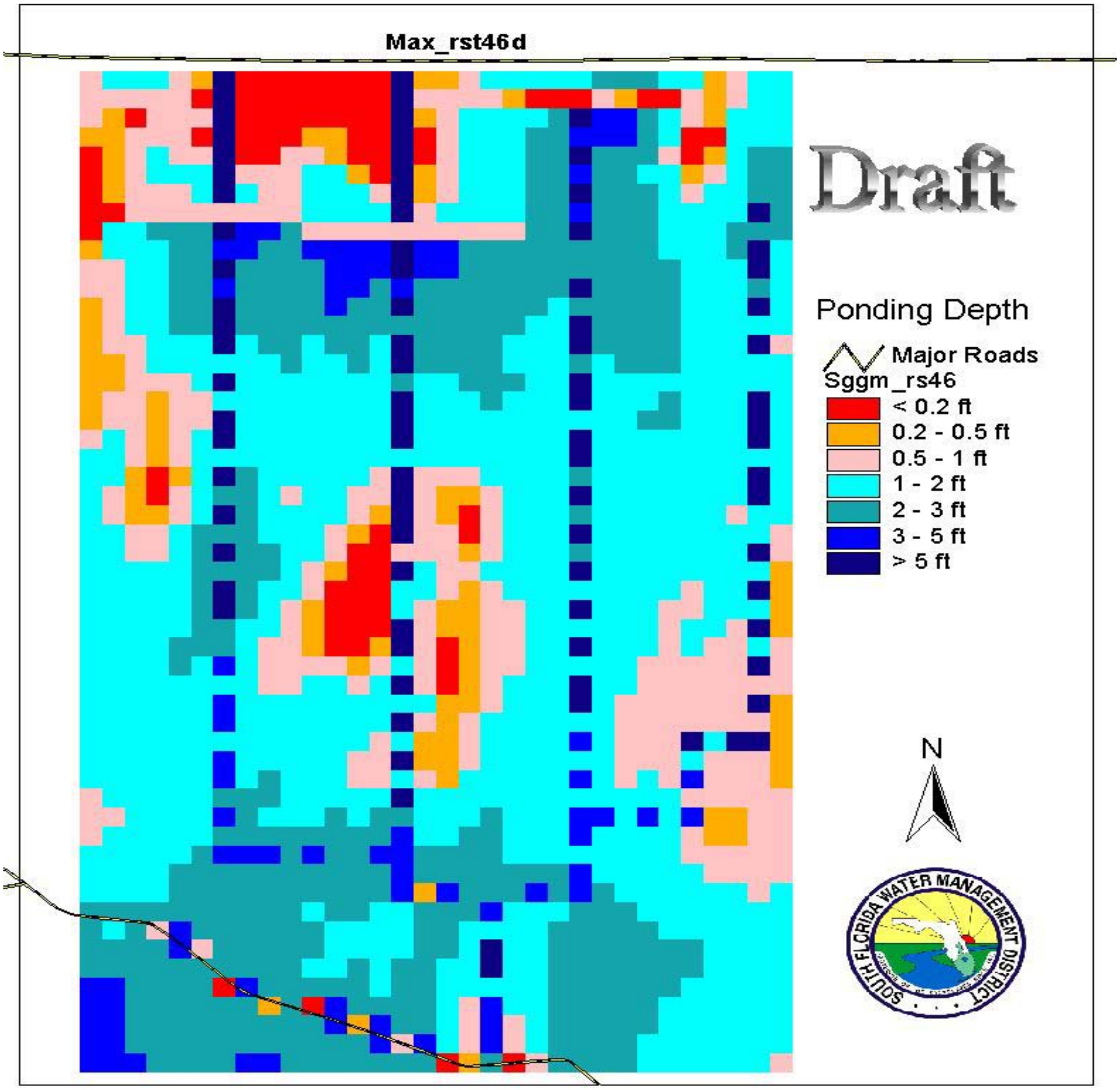


Figure 17: Maximum One-day Water Depths During an Average Year for Restored Condition in SGGE

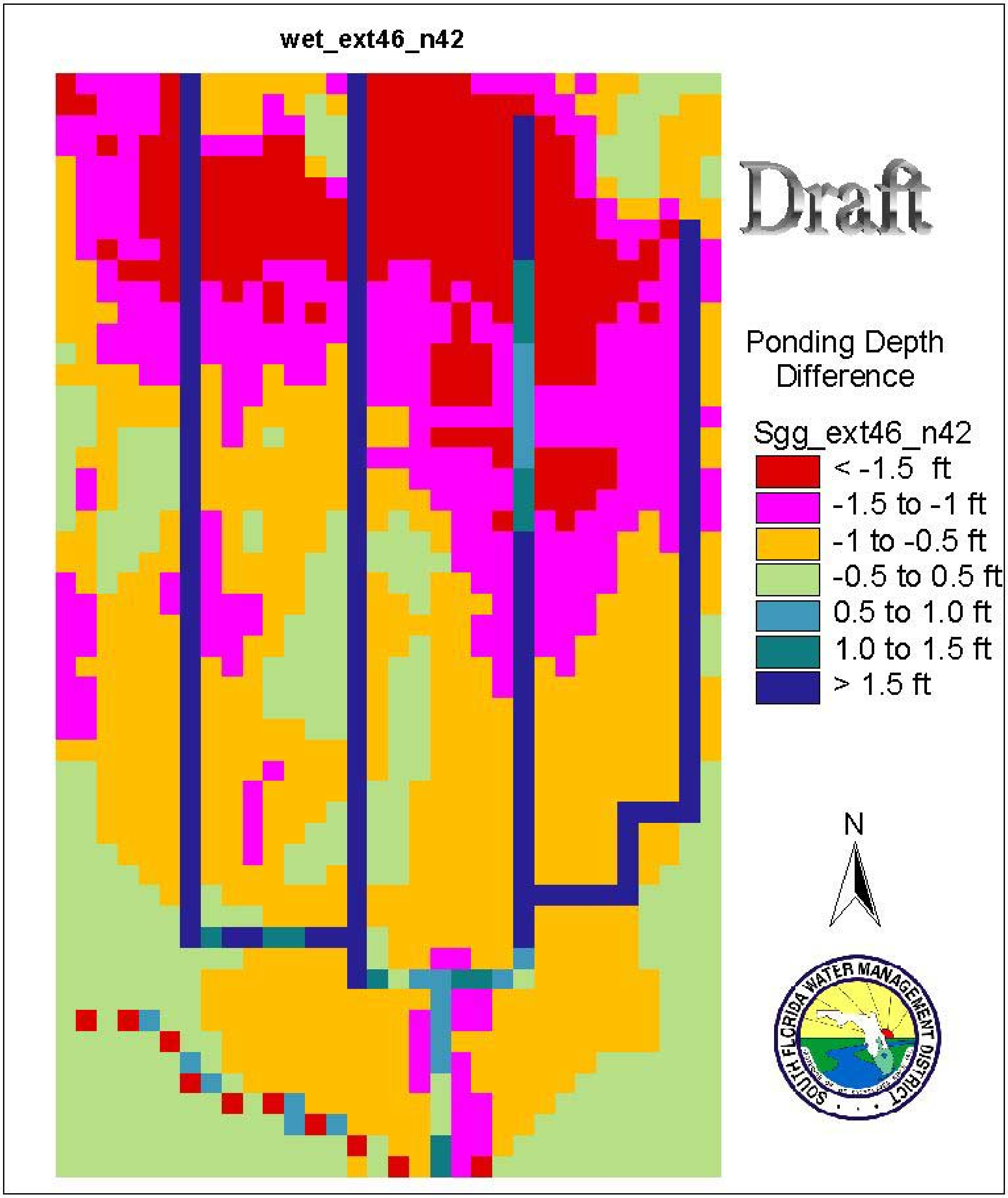


Figure 18: Difference of Wet Season Average Inundation Depth of Current Condition to Wet Season Average Inundation Depth of Natural Condition

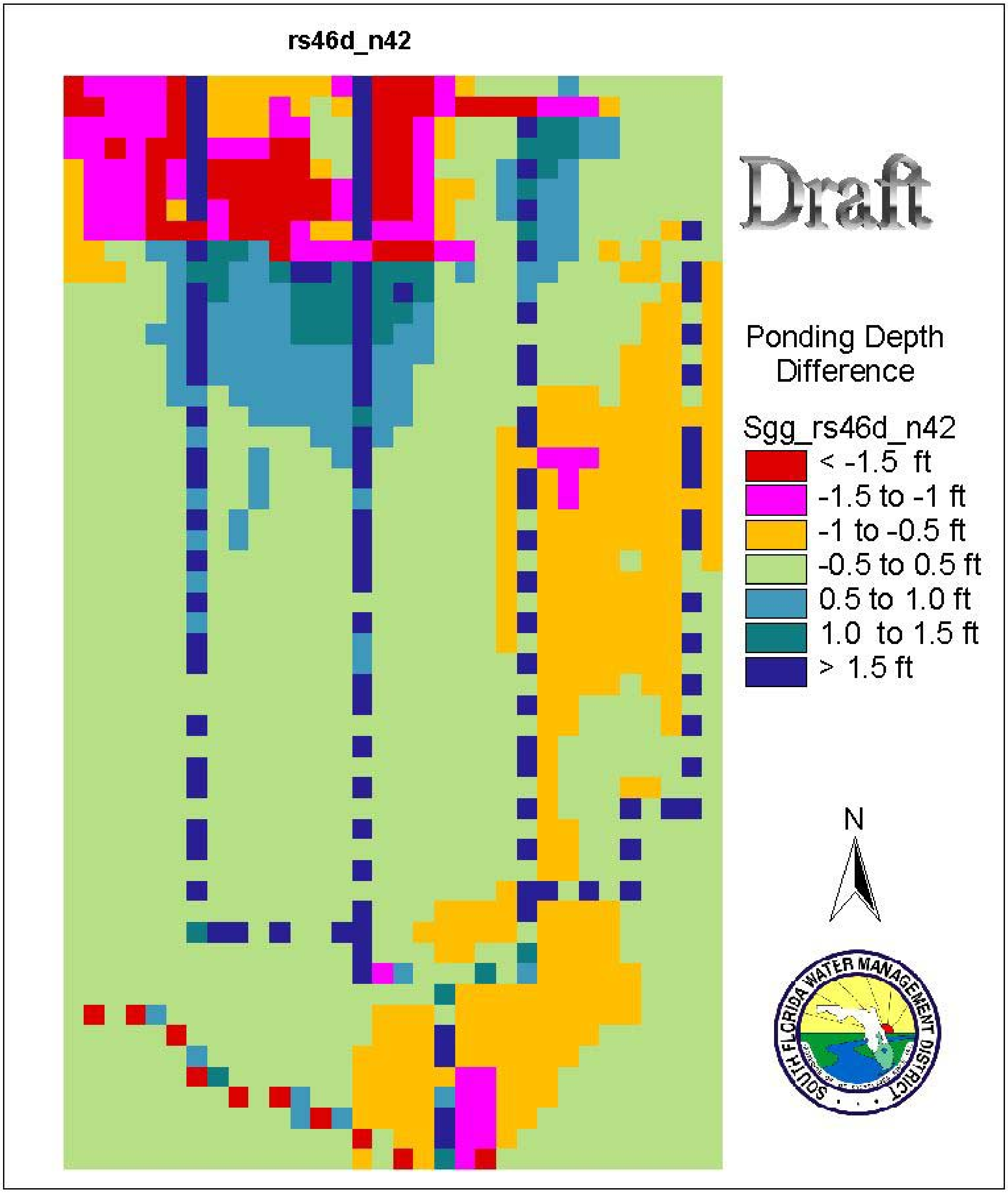


Figure 19: Difference of Wet Season Average Inundation Depth of Restored Condition to Wet Season Average Inundation Depth of Natural Condition

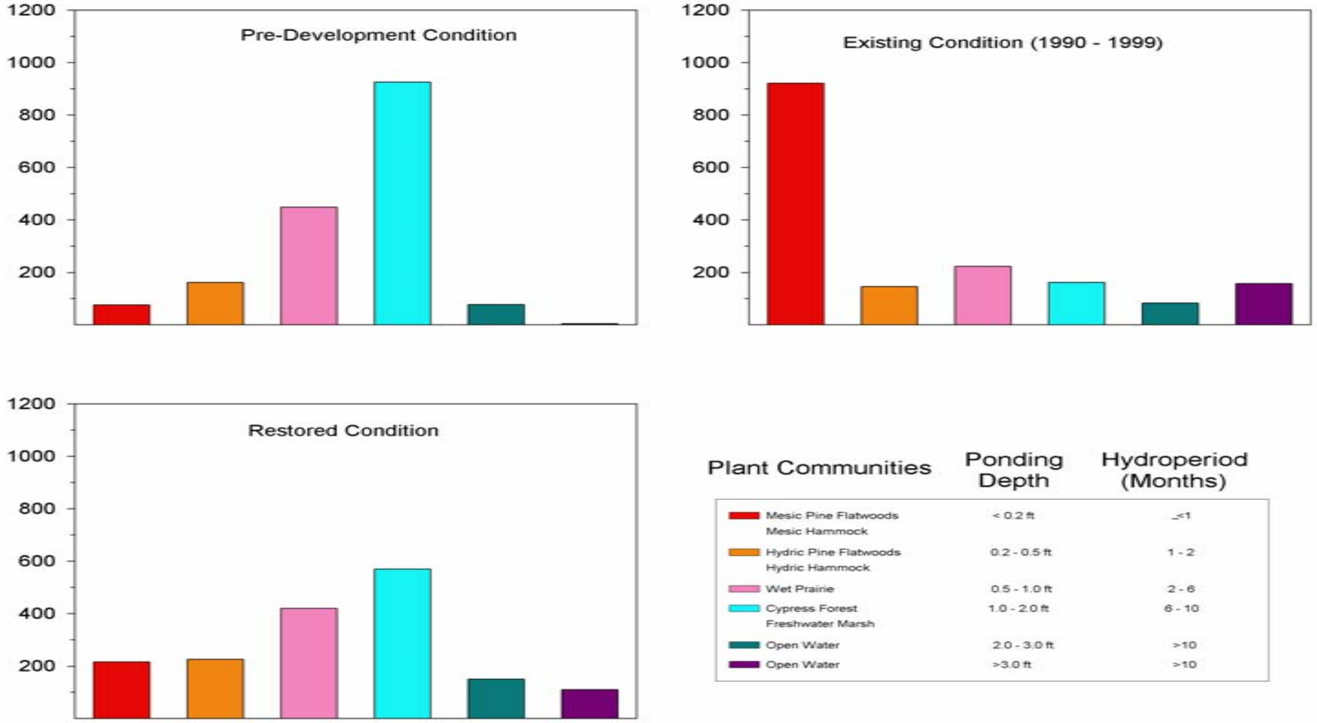


Figure 20: Number of Cells in Each Inundation Depth Range and Hydroperiod for Natural, Current and Restored Condition, and Major Plant Community Type Association.

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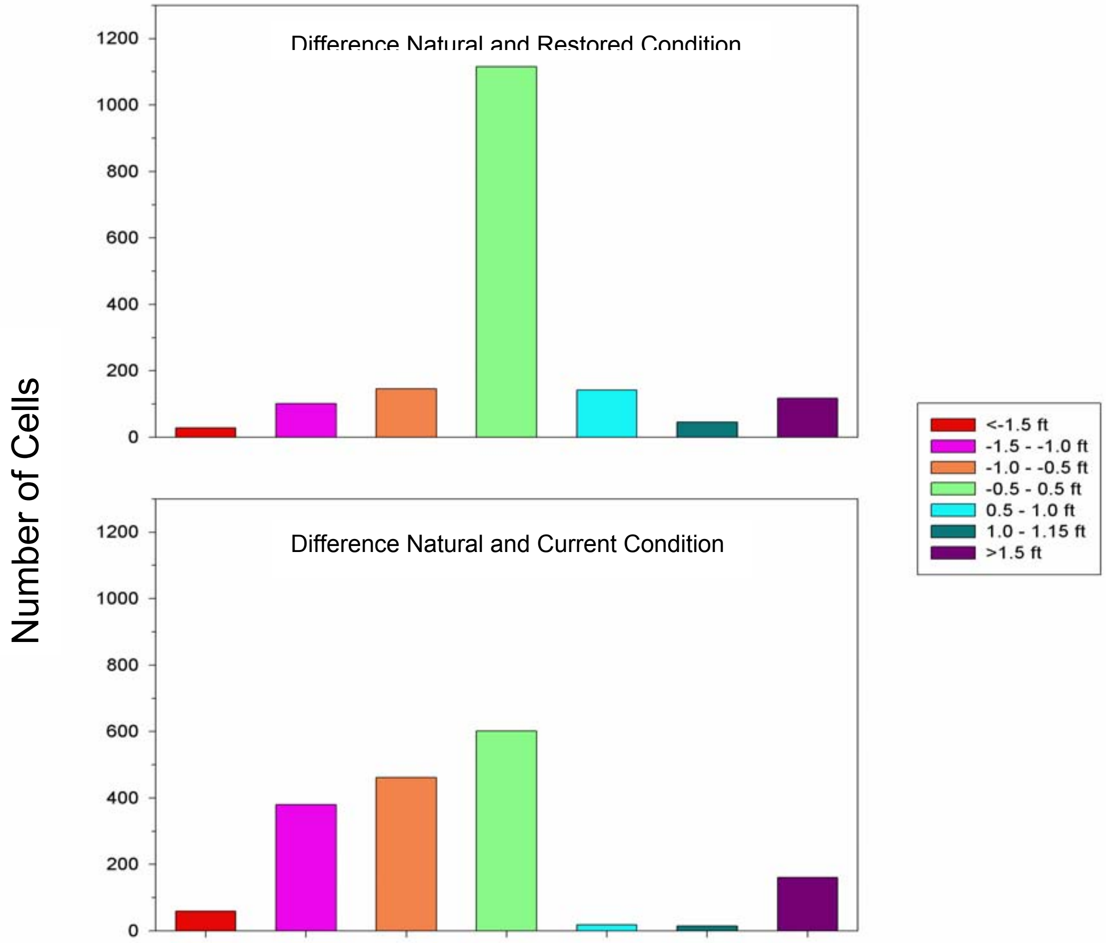

Figure 21: Difference in Number of Cells in Each Inundation Depth Range Between Natural Condition and other Modeling Scenarios

TABLE 3

RELATIONSHIP OF HYDROLOGY TO MAJOR PLANT COMMUNITY TYPES
(based on Duever, et al.,. (1975) and Duever (1984)).

High Water Level (in)	Hydroperiod (mon)	SGGE Plant Communities
≤-6	0	Tropical Hammock (Ht)
≤2	≤1	Mesic Pine Flatwoods (Pm)
≤2	≤1	Mesic Hammock (Hm)
≤2	≤1	Brazilian Pepper (St)
≤2	≤1	Flatwoods with Palms (Pp)
≤2	≤1	Sabal Palm Hammock (Hp)
2 - 6	1 - 2	Hydric Pine Flatwoods (Ph)
2 - 6	1 - 2	Hydric Hammock (Hh)
2 - 6	1 - 2	Flatwoods with Palms (Pp)
2 - 6	1 - 2	Sabal Palm Hammock (Hp)
6 - 12	2 - 6	Wet Prairie (G)
12 - 24	6 - 10	Marsh (Mf, Mfs)
12 - 18	6 - 8	Cypress Forest (C)
18 - 24	8 - 10	Cypress with hardwoods (Ch)
>24	>10	Open Water (WAT)

TABLE 4 COMPARISON OF EXTENT OF MAJOR PLANT COMMUNITY TYPES BASED ON INUNDATION DEPTH RANGES AS PREDICTED BY THE MIKE SHE MODEL FOR NATURAL, CURRENT, AND RESTORED CONDITION.

(Note: All acreage and percentage figures based on MIKE SHE model boundary area.)

ACREAGES

Community Type (listed in order of increasing inundation depth ranges)	Natural Acres	Current Acres	Restored Acres	Difference (Current vs. Natural) Acres	Difference (Restored vs. Natural) Acres
Mesic Pine Flatwoods Mesic Hammock	3040	36880	8640	33840	5600
Hydric Pine Flatwoods Hydric Hammock	6480	5840	9080	-640	2600
Wet Prairie	17960	8960	16840	-9000	-1120
Cypress Forest Freshwater Marsh	37040	6480	22800	-30560	-14240
Open Water 2.0 - 3.0 ft	3120	3360	6040	240	2920
Open Water > 3.0 ft	200	6320	4440	6120	4240
Total:	**67840**	**67840**	**67840**		

PERCENTAGES

Community Type (listed in order of increasing inundation depth ranges)	Natural Acres	Current Acres	Restored Acres	Difference (Current vs. Natural) Acres	Difference (Restored vs. Natural) Acres
Mesic Pine Flatwoods Mesic Hammock	4.5%	54.4%	12.7%	49.9%	8.3%
Hydric Pine Flatwoods Hydric Hammock	9.6%	8.6%	13.4%	-0.9%	3.8%
Wet Prairie	26.5%	13.2%	24.8%	-13.3%	-1.7%
Cypress Forest Freshwater Marsh	54.6%	9.6%	33.6%	-45.0%	-21.0%
Open Water 2.0 - 3.0 ft	4.6%	5.0%	8.9%	0.4%	4.3%
Open Water > 3.0 ft	0.3%	9.3%	6.5%	9.0%	6.3%
Total:	**100.0%**	**100.0%**	**100.0%**		

Predictive Analysis

There were two sets of maps used in the analysis of SGGE restoration. The first were GIS maps of the distribution of major plant community types in SGGE in 1940 and 1995 (Figure 6). The other set of maps was based on hydrology calculated by the MIKE SHE model for natural, current, and restored conditions within the modeling boundary (Figure 8). Restored plant community distributions were predicted based on the hydrologic characteristics of each major community type and on model output of average wet season (July 1 – October 1) water depths.

The two sets of maps and data serve different purposes to some extent and should not be subject to direct comparison. In addition, the MIKE SHE and plant community maps have different boundaries, based on their respective purposes and constraints imposed on the selection of the respective boundaries. For instance, the MIKE SHE model was not designed to deal with tidal influences. The use of a constant mean high tide elevation at the model area's southern boundary was necessary in order to run the model. It should be noted that the lack of data on topography and water circulation patterns greatly limits the usefulness of any model in this area. The model minimizes the amount of area influenced by tides by excluding most of the saline estuarine habitat located south of U.S. 41 (Ms, Mg, WAT in Figure 6). In addition, the MIKE SHE model includes extended coverage to the east, west, and north of SGGE in an effort to minimize problems with model boundary conditions (see Appendix D) and increase the accuracy of the model within the area of interest. These differences become significant when trying to compare plant community acreages and percentages of natural, current, and restored conditions between the two sets of maps.

Another feature that prevents comparison between the MIKE SHE-based maps and the plant community maps is the quarter mile square cell size used in the model, which does not allow for the inclusion of small features or features with a lot of edge, both of which can be more precisely shown on the plant communities map. In the model result maps, the former are usually incorporated into larger features and the latter tend to be erratically distributed because of the necessity to produce average values for each cell.

The plant communities maps provide excellent documentation about where changes have occurred from historic to current conditions. They also represent a valuable baseline with which to compare future change following restoration, particularly where a return to historic conditions is the restoration target. However, while they provide good estimates of plant community acreages for historic and current conditions, they are not able to provide an estimate of restored condition acreages. The only acreage estimates for restoration conditions are those that can be calculated based on the MIKE SHE hydrology model. Thus, comparison of plant community acreages for all three conditions has been based on the MIKE SHE model in this report.

The descriptions of the plant communities utilized for the MIKE SHE model are based on the FLUCCS (Florida Land Use, Cover and Forms Classification System) (Florida Department of Transportation, 1999) and are somewhat modified in format from those utilized for the plant communities survey and shown in Figure 6.

The greatest value of the MIKE SHE model as used in this study is its ability to quantitatively estimate future conditions when certain features of a system are altered in specific ways. Real ecosystems are far too complex to represent accurately in a model. However, the ability of a model to synthesize current understanding of the major features and processes operating within an ecosystem allows manipulation of the model so that the implications of those specific manipulations can be evaluated much more precisely than would otherwise be possible.

PREDICTED PLANT COMMUNITY CHANGES FOLLOWING RESTORATION

The SGGE area was originally dominated by wetland communities, particularly cypress forest and to a lesser extent, herbaceous wet prairies. Even those sites normally designated as uplands, particularly islands of pine flatwoods, often had water at or above the ground surface for at least short periods during wetter portions of the year. Following drainage, cabbage palms, pines, and hardwood species characteristic of drier habitats have increased in many of the cypress forests. In addition, severe and frequent fires have eliminated many of the pine and cypress trees, furthering the conversion of these lands to earlier shrubby successional stages of upland or shallower wetland plant communities. The character of the original SGGE ecological communities has also changed as a result of the invasion of exotic plant species, particularly Brazilian pepper, into drained and disturbed sites.

The long-term goal of the proposed restoration is to return the hydrology of the area downstream of the proposed system of pumps and spreader canals to a condition comparable to that which existed in the SGGE prior to drainage. This will involve the reestablishment of a predominantly wetland ecosystem within the SGGE and the elimination of a point discharge to coastal waters. The combination of a restored hydrologic regime, a restored fire regime, and an appropriate exotic vegetation control program can be expected to return most of SGGE to its pre-drainage character, including the plant communities and wildlife that it supported at that time. However, those areas where canals are not completely removed will obviously not be restored.

Below is a description of the dominant plant communities found in the SGGE study area, and analyses of expected ecological changes to each community type following the proposed hydrologic restoration activities. Further descriptions of each type are contained in Appendix A.

Cypress Forest (C)

Cypress forests (FLUCCS: 621 Cypress) in SGGE are dominated by dense stands of bald cypress *(Taxodium distichum*), and occasional hardwoods such as red maple (*Acer rubrum*), pop ash (*Fraxinus caroliniana*), or pond apple (*Annona glabra*), where these hardwoods provide less than 30 percent canopy cover. Ground cover can be sparse to dense, and emergent in standing water during normal wet season conditions. Epiphytic bromeliads and orchids are locally common in trees and ferns are common on palm trunks. Normal wet season water depths are relatively deep (12 to 24 inches) and hydroperiods are long (6 to 10 months) (Table 3). This community may occur on any type of soil, including sand, marl, rock (hatrack cypress), and organic. One variation of the cypress forest is cypress-with-palms (Cp), which were typically shallow cypress communities in 1940 and drained cypress communities in 1995. Almost 40,000 acres of the lands within SGGE were cypress forest (C, Cp) in 1940 (Table 2), based on the plant communities map (Figure 6).

Since SGGE was drained, the original cypress forest (C) has been reduced by about 20,000 acres based on the plant communities map (Table 2). Although there was little change in the acreage of the cypress-with-palms community (Cp), there were large shifts in where this community was found (Figure 6). It now occupies areas within the south-central study area that were largely cypress (C) in 1940. Much of the original C and Cp acreage has been replaced by sabal palm hammock (Hp) or one of the pine flatwoods (P) communities. This is the single most significant change in plant community structure resulting from the drainage of SGGE.

A small portion of the cypress forest (C) at scattered locations throughout the original cypress communities has been converted to cypress-with-hardwoods (Ch) (FLUCCS: 630 Wetland Forested Mixed), probably due to a lack of fire, which has allowed succession to proceed. These forests are dominated by bald cypress and a variety of hardwoods, such as red maple, pop ash, or pond apple, where these hardwoods provide more than 30 percent canopy cover. Epiphytic bromeliads are common in trees, and ferns are common on palm trunks. Drier conditions could also have allowed hardwoods to invade the original cypress forests, but again only in the absence of fire.

Currently there are about 1,200 acres of the original cypress that are classified as disturbed (Table 2, Figure 6). Disturbed cypress forest (Cx) are cypress forests that have been significantly altered as evidenced by physically altered soils; large areas of charred, dead trees; dominance or partial dominance by ruderal species such as saltbush (*Baccharis halimifolia*), wax myrtle (*Myrica cerifera*), muscadine grape (*Vitis munsoniana*), poison ivy (*Toxicodendron radicans*) or Brazilian pepper (*Schinus terebinthifolius*).

Restoration of cypress communities to their original condition on sites where pre-development hydrology has been restored will likely take many decades. Since the original canopy cypress were probably about 100 to 200 years old, it will take longer where they have been eliminated or greatly reduced in numbers such as in the disturbed areas. Where most of the older cypress stands are still present but have been invaded by palms or hardwoods, it should take less time, on the order of a few decades. The application of an appropriate fire regime and/or mechanical clearing would expedite the recovery of these latter sites. Certain areas are not expected to be restored to their historic condition, such as those located upstream of the pumps and spreader system. They will likely remain in a drier condition that would support pine flatwoods and wet prairie communities, although the vegetative composition of these communities will depend on future fire and exotic plant management.

Freshwater Marsh (Mf)

Freshwater marsh communities (FLUCCS: 641 Freshwater Marshes) are low diversity herbaceous communities dominated by tall, dense stands of grasses and forbs. They have relatively long hydroperiods (6 to 10 months) and deep wet season water depths (12 to 24 inches) (Table 3). They are found primarily on organic soils. Fires are frequent, and retard the invasion of woody vegetation. However, marshes can have occasional bald cypress, where these trees produce less than 30 percent cover. Epiphytes are uncommon due to the lack of trees. In 1940 there were only a few small marshes in the study area, with most of them located along the northern boundary of the salt marshes near the coast.

The conversion of sheetflow across the whole width of the SGGE to a point discharge out of the Faka Union Canal would be expected to have converted all of the freshwater marshes along the coast to salt marsh. However, it cannot be confirmed from study data whether this has actually happened, due to the fact that sufficient groundtruthing was not conducted in that part of the study area. Because of this uncertainty, the 1995 plant community classification has combined salt and fresh marsh into a single class (Mfs) along the coast (Figure 6). The one freshwater marsh near the north boundary of the SGGE is still present, even after drainage.

It may be difficult to reestablish the isolated freshwater marshes near the coast that might have been lost following drainage even if natural sheetflow is returned to the area. If there are no appropriate seed sources at the sites, their isolation from other marsh seed sources may make it difficult for the marsh community to recolonize these sites, at least over the short term. Sea level rise could be an additional impediment to their reestablishment.

Wet Prairie (G)

Wet prairies (FLUCCS: 643 Wet Prairies) are high diversity herbaceous communities dominated by short, open stands of grasses, sedges and forbs. They have relatively short hydroperiods (2 to 6 months) and shallow wet season water depths (2 to 6 inches) (Table 3). They are found on mineral soils, including sand, marl, and rock. Fires are frequent, and retard the invasion of woody vegetation. However, wet prairies can have occasional slash pine (*Pinus elliottii*) or bald cypress, where these trees produce less than 30 percent cover. Epiphytes are uncommon due to the lack of trees. In 1940, wet prairies originally occupied approximately 7,600 acres (Table 2) and were most extensive just upstream of the brackish marshes along the coast, with smaller scattered areas in the northern and eastern portions of the SGGE (Figure 6).

Since the SGGE has been drained, there has been only a small decrease in their acreage (Table 2), and a small change in the distribution of wet prairies (Figure 6). They are still most widespread just upstream of the coastal brackish marshes, with scattered smaller wet prairies farther north, particularly along the eastern side of SGGE. The lack of change between 1940 and 1995 in the larger, more downstream wet prairies is most likely due to their low elevation and proximity to the coast, which could reduce the ability of the canals to drain these sites.

There is currently a substantial acreage of wet prairie with palms (Gp) (Table 2) in the northwest and central portions of the study area on sites that were cypress forest prior to drainage (Figure 6). These probably represent sites where sabal palm (*Sabal palmetto*) invaded following drainage, and subsequent fires eliminated the cypress. There are some small areas of disturbed wet prairie (Gx) that were cypress forest and are now at least partially dominated by ruderal species such as saltbush, wax myrtle, muscadine grape, poison ivy, or Brazilian pepper.

Again fires have probably eliminated the cypress, and with the drier conditions following drainage, early succession upland species are now invading these sites.

Since most of the wet prairie acreage is still currently intact in the southern portion of SGGE, restoration of this habitat to historic conditions should be relatively expeditious once hydrology has been restored. Some small areas will not be restored, including those upstream of the pumps and spreader canals and where canals will not be completely removed. Otherwise, the restored hydrology and an appropriate fire regime (Duever 1984) can be expected to restore most of the altered SGGE wet prairies to their original condition within a decade.

Pine Flatwoods (P)

Most of the SGGE upland communities present in 1940, about 12,500 acres (Table 2), were islands of pine flatwoods (FLUCCS: 411Pine Flatwoods) that were scattered throughout the area and that decreased in both size and aerial coverage as one moved from north to south through SGGE (Figure 6). Pine flatwoods have an open canopy dominated by slash pine. They typically have water slightly above (<6 inches) or below ground during the peak of the wet season and short hydroperiods (<2 months). They can occur on sand or rock substrates. Compared to hydric pine flatwoods (Ph) (FLUCCS: 625 Hydric Pine Flatwoods), which have deeper wet season water depths (<6 inches) and a longer hydroperiod (<2 month), mesic pine flatwoods (Pm) are more elevated with shallower wet season water depths (<2 inches) and a shorter hydroperiod (<1 month). Mesic flatwoods are more likely to be dominated by a dense saw palmetto (*Serenoa repens*), while hydric pine flatwoods are more likely to be dominated by a dense and diverse herbaceous ground cover of grasses, sedges, and forbs. Pine flatwoods with an abundance of sabal palms (Pp) in the subcanopy were also common, particularly in the northern portion of SGGE. The open character of the canopy and shrub strata and the dense groundcover are maintained by intense and frequent fires. Epiphytes are not common due to the small number of trees and their limited branching, as well as the frequent fires.

Currently there is a moderate reduction in the acreage of mesic and hydric pine flatwoods (Table 2), although they generally have a very different distribution from where they occurred in 1940 (Figure 6). The one area where mesic pine flatwoods occurred in both 1940 and 1995 was along both sides of the boundary between fresh and saltwater communities near the coast in the vicinity of Tamiami Trail. Hydric pine flatwoods have tended to expand into what were cypress communities in 1940, but where they originally occurred at that time, they have since been largely replaced by sabal palm or hammock forests.

There has been a substantial increase in the acreage of pine flatwoods that have been heavily invaded by sabal palms (Pp) which provide 30 percent or more shrub cover (Table2). These palms are usually of similar size and appear to be even-aged. Dense palm stands occur on calcareous substrates in both natural uplands and uplands created by drainage (Figure 6). Otherwise, disturbed pine flatwoods (Px) are limited in extent, but can be identified by the presence of physically altered soils, large areas of charred, dead trees, and dominance or partial dominance by ruderal species such as saltbush, wax myrtle, muscadine grape, poison ivy, or Brazilian pepper.

A small area of dense shrubby saw palmetto (S) (FLUCCS: 321, Palmetto Prairies) is indicated as being present near the southwestern corner of the canal system (Table 2) (Figure 6). Slash pines may occur, but are not common, and the ground cover is a sparse mix of mesic grasses and herbs. This community is essentially mesic pine flatwoods where a high fire frequency has eliminated or prevented the invasion of pines.

Restoration of pine flatwoods communities to their original condition will likely take several decades, once natural hydrology has been restored. Since the canopy pines were probably 50 to 100 years old, where they have been eliminated or greatly reduced in numbers, it will take longer. Where most of the older pine stands are still present, but have been invaded by palms or hardwoods, it should take less time. The application of an appropriate fire regime (Duever 1984) and/or mechanical clearing would expedite the recovery of these latter sites. Certain areas are not expected to be restored, such as those located upstream of the pumps and spreader system. Also, those areas where canals have not been completely removed will not be restored.

Hammocks (H)

There was only a very small acreage of hammock in 1940 (Table 2), most likely because of frequent fires in areas dry enough to support these communities. These communities typically have water slightly above (<6 inches) or below ground during the peak of the wet season, and short hydroperiods (<2 months). They can occur on sand or rock substrates. Those dominated by hardwoods are relatively intolerant of fire, while the sabal palm hammocks are not only tolerant but thrive with frequent severe fires.

In 1940 there was only a small area of sabal palm hammock (Hp) (FLUCCS: 428, Cabbage Palm) near the northeast corner of SGGE (Figure 6). This community has an almost monospecific canopy of palms with few shrubs and little groundcover because of the dense canopy. Epiphytic ferns are common on sabal trunks.

Numerous small tropical hammocks (Ht) (FLUCCS: 426, Tropical Hardwoods) were originally found scattered in the more upstream portions of the salt marshes along the coast (Figure 6), where proximity of the warm Gulf waters moderates freezing temperatures associated with winter cold fronts. These forested communities are dominated by a variety of hardwoods with tropical affinities, such as gumbo limbo (*Bursera simaruba*), mastic

(Mastichodendron foetidissimum), or strangler fig (*Ficus aurea*). Sabal palms and live oaks (*Quercus virginiana*) may be common, but are not dominant. Shrub density is moderate and includes small hardwoods such as myrsine (*Rapanea punctata*), wild coffee (*Psychotria nervosa*), or indigo berry (*Randia aculeata)*, and seedlings of the canopy species. Ground cover is usually sparse because of the dense canopy. Epiphytic ferns, bromeliads and orchids are common on the hardwoods and palms.

Following drainage of SGGE, hammocks have expanded from a little over 400 acres in 1940 to over 10,000 acres in 1995 (Table 2). Drainage has created drier conditions suitable for hammock communities, although the associated more frequent and intense fires would tend to eliminate them.

The tropical hammocks had more than doubled in acreage from 265 to 689 acres by 1995 (Table 2). Their distribution in SGGE is similar to what it was in 1940, but in addition to sites they occupied at that time, they are now occupying numerous small islands in the coastal salt marshes that had previously supported mesic pine flatwoods (Figure 6). This suggests either a decrease in fire frequency in this area over the last 50 years, or replacement of the less salt tolerant pines by more salt tolerant tropical hardwoods as a result of the reduction of freshwater sheetflow following drainage of SGGE.

Most of the new upland sites created as a result of drainage have a shallow soils over limestone. In addition, drier conditions have promoted the occurrence of frequent and severe fires. This combination of environmental conditions has created an ideal setting for the rapid expansion of the sabal palm hammock community from about 55 acres to almost 7,300 acres (Table 2). This expansion has occurred primarily in the northern and eastern portions of SGGE in cypress habitats, particularly those that tend to be closer to canals (Figure 6).

The lower elevation and wetter hydric hammock (Hh) (FLUCCS: 433, Western Everglades Hardwoods) and slightly higher elevation but still moist mesic hammock (Hm) were not recorded as being present in 1940. In 1995, they occupied over 2,700 acres, although mesic hammock represented only 140 acres (Table 2). They are dominated by hardwoods such as red maple, sabal palm, live oak on drier sites, or laurel oak (*Quercus laurifolia*) on wetter sites (Figure 6). Bald cypress occurs, but is not common. Shrub density is sparse to moderate, and usually made up of small hardwoods including myrsine, wild coffee, indigo berry, or dahoon holly (*Ilex cassine*) and seedlings of the canopy species. Ground cover is variable, often dominated by ferns. Epiphytic bromeliads are common in trees and ferns are common on palm trunks. These two communities have primarily replaced cypress communities. The replacement by hydric hammock of a large area of cypress along the eastern boundary of SGGE to the south of Prairie Canal, which is probably less affected by drainage, suggests that lack of fire is also playing a role in this conversion.

Restoration of SGGE would be expected to substantially reduce the coverage of hammocks, once natural hydrology has been reestablished. However, restoration is likely to require more than just fixing the hydrology. A restored hydrology could be expected to eliminate or at least severely stress substantial areas of all of the hammock types, except the tropical hammocks where water levels have probably not been substantially altered. A combination of a restored fire regime and some amount of mechanical clearing will probably also be required to remove hardwoods or palms that have become established either on shallower wetlands or on pine flatwoods sites.

Coastal Wetlands and Estuaries

There has been a substantial decrease in acreage of salt marsh (Ms) (FLUCCS: 642 Saltwater Marshes), and moderate increases in mangrove swamp (Mg) (FLUCCS: 612 Mangrove Swamps) and water (WAT) (FLUCCS: 540 Bays and Estuaries) between 1940 and 1995 at the southern edge of the SGGE study boundary (Table 2). The general northward advance of mangroves into the salt marshes (Figure 6) is likely to be at least partially due to reduced freshwater flows from SGGE. However, other factors such as a reduced fire frequency and sea level rise could also be involved. There are also more lakes within the 1995 mangrove community than are indicated in the 1940 vegetation map. That could also be associated with some of these same influences, or may be due to less detailed mapping of the mangrove area in the 1954 soil survey. Unfortunately, since the MIKE SHE model does not include this area, it is impossible to try to sort out the relative importance of potential influences. One way to measure the amount of change in freshwater flows to the estuary (and thus potentially plant community composition) would be to compare flows along a transect near the southern boundary of the SGGE hydrology model under natural, current, and restored conditions.

Other Communities

There are several other communities that represent substantial acreages in 1995, but were not present in 1940. These include urban land, disturbed land, and Brazilian pepper (Table 2). The acreage of one plant community, coastal uplands (Cu), has not changed over this same time period.

Urban land (URB) shown in Figure 6 is a residential–resort–marina complex that is not included in the restoration effort.

Disturbed lands (x) are primarily associated with agricultural activities (Figure 6). Soil disturbance associated with activities on these lands will make it very difficult to restore natural communities over the short term, but given a return to natural processes, including restoring hydrology and fire, they are likely to recover over the long term. Mechanical treatment will be required to eliminate unnatural ground contours and established exotic or nuisance plant species.

Brazilian pepper (St) (FLUCCS: 422, Brazilian Pepper) forms a nearly complete shrub layer, sometimes with other trees such as slash pine, bald cypress or sabal palm as canopy emergents. There is typically little ground cover in these very dense thickets and epiphytes seldom occur. This community in SGGE occurs primarily as a result of soil disturbance associated with the canals and adjacent spoil piles (Figure 6). Using spoil material to fill in portions of the canals and restoring natural hydrology should deter recolonization of Brazilian pepper in SGGE.

Average Wet Season Water Levels

One set of output from the MIKE SHE model was average wet season water levels from July 1 through October 1, which is often closely related to hydroperiod (Table 3). These two hydrologic parameters have been shown to be important determinants of the long-term distribution of the major types of plant communities in the Big Cypress National Preserve (Duever 1984). Based on this correspondence between hydroperiod and major plant community types, the acreage of each community type was estimated from the number of cells (each cell equals 40 acres) within each range of inundation depths present under natural, current, and restored conditions.

Results of the MIKE SHE model runs for natural conditions indicated that water depths appropriate for cypress and coastal marsh communities made up about 55 percent of the SGGE model area, wet prairie made up about 25 percent, and flatwoods made up about 15 percent

(Table 4, Figure 12). Large areas south of I-75 exhibited long hydroperiods and are expected to have been occupied by cypress forest with islands of wet prairie and pine flatwoods. The cypress extended further south along the eastern side of SGGE than the western side. There were similarly deeper areas directly north and south of Tamiami Trail (U.S. 41), predominantly herbaceous plant communities including wet prairies and saltwater marshes (Figure 6). Based on assumed water depths for wet prairies, the wet prairies in this area would be expected to be drier than the hydrology predicted by the model indicated, but the model hydrology was appropriate for the extensive coastal marshes. The relatively drier upland communities existed as islands in the vicinity of I-75 and along an east-west belt across the center of SGGE. The intermediate hydroperiod wet prairies were located as transitions between the cypress and pine flatwoods communities, and over a large area between the deeper northern cypress and southern coastal marshes in the southeastern portion of SGGE.

With the canals in place for many years, upland conditions have come to dominate the vast majority of SGGE. However, until a program of canal maintenance begain in the mid-1990's, dense submerged and floating vegetation proliferated in the canals and attenuated the drainage. It is important to remember that SGGE plant communities are still in transition, responding to the hydrologic, fire, and edaphic conditions that currently exist, and modified by the introduction of invasive species to the area. Some mix of pine flatwoods or palm hammocks will result where fires are frequent, as will a variety of types of hardwood hammocks where fires are infrequent. About half of the original wet prairies will likely survive in a transition zone extending from the southern end of the SGGE canal system to the coastal marshes in the vicinity of Tamiami Trail. The 9,860 acres of open water is an artificially high figure for the restored condition because it includes the canals, which in the MIKE SHE model are one cell (1320 feet) wide rather than the generally <100 foot width that they are in reality. Most of the acreage in the remnant canal cells should most appropriately be distributed among the habitats present in adjacent cells.

Looking at differences between natural and current water levels, the only areas that have not changed in average depth are areas that were and still are upland or coastal marsh communities (Figure 18). The upland communities were already dry, while water levels in the coastal marshes are probably more strongly influenced by Gulf of Mexico water levels than flows through SGGE. The long hydroperiod cypress areas in the northern part of SGGE were the most impacted in terms of reduced water levels, while the shallower wetlands, particularly the large area between the cypress and the coastal marshes, showed intermediate impacts.

The relative magnitude of the changes is reflected in Figures 20 and 21 in the number of MIKE SHE model cells where water depths have changed to different degrees. The large increase in drier cells is clearly evident. One change depicted in Figure 21, namely where water depths have increased by more than 1.5 feet, is actually an artifact of the model because it includes the canals, which in the model are one cell (1320 feet) wide rather than the generally <100 foot width that they are in reality.

Modeling indicates that restoration will increase inundation depths substantially from current conditions in the areas downstream of the pumps, while retaining drained conditions upstream of the pumps (Figure 14). However, only about half of the historic cypress acreage is expected to be restored (Table 4) (Figure 20). A portion of the deepwater cypress community should reestablish south of I-75, but not extend as far south along the eastern side of SGGE as it had under natural conditions (Figures 14 and 6). At the same time, hydroperiods appropriate for cypress forest establishment should occur along the western side of SGGE. Most of the wet prairie acreage should be restored, but not necessarily in the same locations, since much of it is occupying what was originally cypress habitat. The upland communities will still occupy substantially more area than they did originally, including some of what were originally wet prairies (Table 2) (Figure 20). Another deviation from natural conditions indicated by the modeling results is deeper inundation depths just downstream of the pumps (Figure 14). Pumping may push water into this area faster than the spreader channels can convert it into overland flow through SGGE. The acreage of open water is artificially high in the restored condition because it includes the remnant sections of canals, which in the model are one cell (1320 feet) wide rather than the generally <100 foot width that they are in reality. Most of the acreage in the remnant canal cells should most appropriately be distributed among the habitats present adjacent cells (Figure 14).

Large differences in water levels between the restored and natural conditions should be limited to a few distinct areas (Figure 19). Most of the current uplands upstream of the pumps are drained wetlands. Palms are a dominant feature in this area, and there has been some discussion about removal of many of them. However, given the likely soil characteristics that contributed to their original establishment, they may reestablish in the absence of restored hydrology. A wetter than expected area located downstream of each of the pumps was discussed earlier. Also, the drier than expected area along most of the eastern portion of SGGE appears to be the result of incomplete restoration of flows.

The relative magnitude of these changes from natural to restored conditions are reflected in the number of MIKE SHE model cells where inundation depths have changed to different degrees (Figure 21). This indicates a substantial return to natural conditions within SGGE (Table 4). Again, the relatively large number of cells representing water depths of more than 1.5 feet is actually an artifact of the current model because it includes the canals, which in the model are one cell (1320 feet) wide rather than the <100 foot width that they are in reality.

Maximum Annual One-Day Water Levels

Another set of output from the MIKE SHE model was the maximum one-day water depths during an average year throughout SGGE. These were useful for identifying the general presence and location of areas that may be important to terrestrial wildlife since they should remain above water even during the highest one-day water levels expected during an average year under each of the three temporal conditions.

Modeling results showed expansion of the areas of greater inundation for maximum one-day depths under natural conditions, which reduced but did not eliminate any of the shallow water or upland areas normally present (Figures 12 and 15). Annual maximum one-day water depths under current conditions approximated what would be expected for average wet season water depths under natural conditions (Figures 12 and 16). Restoration produced annual maximum one-day water depths that were deeper and more extensive than under natural conditions because of the increased pumping that would be occurring at these times (Figures 15 and 17). However, while the shallow water and upland areas were reduced substantially in size, none were completely eliminated, and those in the vicinity of I-75 were much more extensive. Thus, it appears that while terrestrial wildlife might be stressed somewhat by temporarily reduced habitat availability during normal annual flooding, it is unlikely that their populations would be significantly reduced due to a lack of upland refugia. From another perspective, the idea of concentrating terrestrial wildlife near I-75 would seem undesirable, if it were not for the presence of wildlife fencing along and underpasses under the road.

TIMEFRAMES FOR PLANT COMMUNITY RESPONSE TO RESTORATION

It is important to remember that SGGE plant communities are still in transition from their natural condition. They are by no means stable communities that can be expected to maintain their current characteristics over the long term. In the absence of restoration, they will succeed towards an ecosystem that will be created in response to the combination of hydrologic, fire, and edaphic conditions that currently exist, as modified by the mix of invasive species that are coming to dominate parts of the area. Thus, it is unrealistic to plan for the future of SGGE and its plant and animal populations on the assumption that in the absence of restoration, what currently exists is its likely future condition, with some modification based on active management. It is unlikely that fire has yet finished altering plant communities that existed prior to drainage. It is also unlikely that the spread and structural development of the palm communities has yet stabilized. Thus, regardless of what restoration activities may or may not be planned for SGGE, one must look at the current ecosystem and the processes affecting it from a long-term perspective to evaluate what will likely be the final result of any given alternative. This perspective will allow for better decisions about whether attempting to maintain what currently exists in SGGE, or portions of it, is feasible or will accomplish the restoration goals.

The long-term goal of the proposed restoration is to return the hydrology of the area downstream of the pumps and spreader channels to a condition comparable to that which existed in SGGE prior to drainage. The combination of a restored hydrologic regime, a restored fire regime, and an appropriate exotic vegetation control program can be expected to return most of the SGGE to its pre-drainage character, including the plant communities and wildlife that it supported at that time. This will mean that those new plant and animal communities that have developed under the current hydrologic and fire regimes, but were not present prior to drainage, will be eliminated during the decades following restoration and will be replaced by communities more similar to those present prior to drainage. In addition, extant plant and animal communities that also existed in SGGE prior to construction of the canal system, but have become established in new areas as a result of drainage, will likely return to a more historic distribution pattern.

However, these changes will not happen in a few years. The timeframe for restoration of the original communities will be variable depending on the type of community to be reestablished and the degree to which it has been disturbed, particularly by severe fires. Loss of the older forest trees will require many decades to replace, during which time the sites will be dominated by earlier successional communities, most likely willow in the cypress swamps and a mixture of wax myrtle and herbaceous species in the pine flatwoods. Lost organic soils in some of the deeper wetlands will require centuries to replace, and in the meantime these sites will be dominated by either deeper wetland communities, such as pop ash or pond apple sloughs, or open water.

It is also important to be aware that during these transitions following hydrologic restoration, much of the upland vegetation that colonized the original wetlands will die, and it may take up to a decade to for the majority of the woody material to decompose. Where the originally dominant species have been eliminated from a site, there can be substantial lags in the time it takes for seeds of these species to get to a restored site to successfully germinate, survive and grow to a size where they again dominate the site. Thus, the plant communities on these sites may actually look worse than they did prior to restoration for some time before they start to develop their desired character. Also, during this period it is important to monitor for invasive plant species and eradicate them while their populations are still small.

IMPLICATIONS FOR WILDLIFE AND LISTED SPECIES

The presence and health of wildlife populations are a function of the habitats available to support them. Given the dramatic changes in hydrologic and fire regimes in SGGE over the past fifty years, current wildlife populations in SGGE have undoubtedly changed from those present in the area during pre-development conditions. In these types of situations, wildlife populations usually decrease in natural diversity with the loss of specialist species adapted to relatively stable environmental conditions and more mature plant communities. The greatly increased level of disturbance associated with the road and canal system has most likely resulted in an increase in species that are widespread and abundant over much of southwest Florida as a result of landscape alterations that are occurring throughout the area. A preliminary list of wildlife recently recorded from Picayune Strand State Forest (including both SGGE and the adjacent Belle Meade Conservation and Recreation Lands project) is found in Appendix E of this report.

Much of the historic SGGE wetland habitat is being replaced by upland communities, most of which are currently in early stages of the transition and thus appear to be in a very disturbed condition. This has obvious implications for wetland dependent species such as amphibians, otters, and wading birds and the forage fish and aquatic invertebrates upon which they depend, all of whose populations have likely been greatly reduced in SGGE since drainage.

Some species have undoubtedly become more abundant as upland habitats have become more widespread in SGGE. However, at least some of these species may not be able to tolerate conditions in some of the new upland habitats, such as the intensity of the fires that are occurring as a result of the steadily increasing abundance of palms. Alternatively, the lack of fire in pine flatwoods portions of SGGE is allowing the development of dense woody vegetation that is not suitable for species adapted to the open character of pine flatwoods with their dense herbaceous groundcover.

The most critically endangered animal in the SGGE study area is the Florida panther (*Felis concolor coryi*). Important characteristics of panther habitat are areas with little human activity, and habitat for prey species, particularly deer and hogs. While some researchers have reported that panthers prefer forested habitats, others have suggested they utilize a wider range of habitats. The latter would seem to be more consistent with the distribution of their prey. Deer are known to be an edge species; that is, they do best in areas where there is extensive contact between forested and open herbaceous communities. Hogs are another favored prey species. They seem to utilize all of the natural plant communities in SGGE, particularly the receding wetland edges during the dry season. Some restored SGGE wetlands may not provide ideal habitat for panthers because of extensive areas of deeper water; however, the removal of a continuous road system in these areas of increased hydroperiod will benefit the panther through the significantly reduced human use of the area. Thus, it would be reasonable to expect an increase in panther use and perhaps panther breeding activity in SGGE following restoration.

The Big Cypress fox squirrel (*Scuirus niger avicennia*) and the red-cockaded woodpecker (*Picoides borealis*) are listed species that would ordinarily benefit from the increase in upland habitat. However, the lack of fire in some areas is expanding the distribution of hammock into pine flatwoods, while in other areas, the increase in palms and the associated high fire intensities may eliminate hardwood hammock and pine flatwoods communities that might otherwise provide them with good habitat.

Restoration could also benefit the wood stork by providing additional foraging habitat within a reasonable distance of the large rookery at Corkscrew Swamp. Breeding success of this species in South Florida has declined drastically over the last 50 years, mainly due to the loss of seasonal wetlands.

The significantly reduced duration of flooding in SGGE has likely had dramatic impacts on tropical vegetation due to the loss of freeze protection that results from the moderating influence of standing water when winter cold fronts pass through the area. This could be particularly important to listed epiphytic orchids, bromeliads, and ferns, which are extremely vulnerable to freezes. Rooted tropical vegetation would also be affected by loss of aboveground stems and leaves, but most are likely to resprout from their roots, although with repeated freezes, they too may eventually succumb.

OTHER CONSIDERATIONS

Water Quality

There is some concern about the quality of water coming down canals from NGGE, particularly in terms of phosphorus input from the increasing numbers of septic tanks in the area. This and nutrients derived from vegetation killed as a result of restoration efforts could potentially encourage the growth of nuisance plant species. It will be important to monitor SGGE for nuisance species, e.g. cattails and primrose willow, and provide control before they come to dominate sites. If phosphorus levels become sufficiently high as NGGE develops, it may become necessary to institute some sort of treatment of canal inflows to protect the character of SGGE's native communities. One option would be to identify a "water treatment area", which could function as a buffer between the canal inflows and the portion of SGGE that is to be restored to natural condition. The input of nutrients from dying vegetation should be a temporary problem manageable by mechanical and/or herbicide treatment until the native community has become established.

Problems with Adequacy of the Model

The MIKE SHE model has produced useful information in evaluating the likely changes in hydrology resulting from the proposed engineering redesign, relative to both natural and current conditions in SGGE. However, the less than perfect match between the spatial distribution of hydroperiods predicted by the model and the existing knowledge of plant community distributions under natural and current conditions indicates that the model does not adequately represent real world hydrology in SGGE.

One problem is uncertainty about the adequacy of the topographic data available when this analysis was done. Future analysis of new topographic data, available by the publication date of this report, should either increase confidence in the current topographic data or provide improved data.

Another potentially significant problem is the use of fixed water levels in the boundary cells. Current values for each boundary cell are calculated by a version of the MIKE SHE model using a larger geographic area than SGGE, which is intended to minimize water depth inaccuracies along the SGGE boundary. However, daily output for the 365-day year from the larger model is averaged to produce a single value for each SGGE boundary cells, and this average is used as a constant boundary water level in the SGGE model runs. Thus, compared to interior SGGE water levels during wet periods, water levels at the boundary are relatively low, and during low water periods, they are relatively high. Since water flows downhill, the result is to produce more average water levels, at least in portions of SGGE, than occur in the real world. Once a MIKE SHE model of the entire Big Cypress Basin is completed, it should allow model runs where the boundaries of SGGE are remote from the MIKE SHE model boundaries.

It is also possible that our understanding of plant community – hydrology relationships for other areas may not be directly applicable to SGGE, and may require some modification to adequately represent how these processes operate in SGGE. Hopefully, monitoring associated with the restoration will help sort out these kinds of problems.

Roads

The current restoration design removes most of the roads within SGGE to help restore natural flowways. Under natural conditions, sheetflow during the wet season occurred across virtually the whole SGGE, interrupted only by scattered upland islands.

Adjacent Lands

Most of the lands surrounding SGGE are in public ownership or are scheduled for acquisition. The primary purpose of their acquisition has been for conservation of their natural resources. Other than some outparcels in the Belle Meade tract and along US 41, the only private lands are found along the western portion of the northern boundary. The planned restoration will significantly help to restore the hydrologic and fire regimes and thus the associated biotic resources on all of the surrounding public lands, while maintaining current levels of flood protection for the private lands to the north.

Water table gradients from SGGE into Fakahatchee Strand have been monitored for over ten years. Data from these monitoring wells and an earlier United States Geological Survey study (Swayze and McPherson, 1977) have shown that water table drawdowns associated with the SGGE canals have extended over two miles into Fakahatchee Strand. The plant communities in the areas affected by this drawdown have been severely impacted, most obviously by wildfires that have completely changed the character of these lands, particularly as one gets closer to the easternmost SGGE canal. Similar impacts are most likely occurring on the Belle Meade tract and the Florida Panther National Wildlife Refuge. Changes on the Ten Thousand Islands Refuge are more likely associated with alterations in salinity due to reduced overland freshwater flows that are currently diverted to the Faka Union Canal. Although not documented at this time, it is likely that the distribution of plant and animal communities within this freshwater – saline transition zone have been modified by drainage associated with the SGGE canal system.

RECOMMENDATIONS

Restoration and Management

The incomplete restoration of natural conditions was intentional in the northwest corner of SGGE to retain some upland habitat for terrestrial wildlife and listed species such as the panther. A significant loss of upland plant communities, particularly pinelands, has occurred regionally. However, the wetter conditions predicted by the MIKE SHE model immediately downstream of the pumps and along most of the western side of SGGE are considered undesirable. Exploration of possible modifications in the current restoration design has suggested several possibilities. The largest change would be to redesign the spreader system so that a much larger proportion of the water is moved farther east. This would help to relieve the excess water levels to the west and an apparent lack of sufficient water to the east. Another separate consideration would be to not build the pump on Merritt Canal. The Florida Panther National Wildlife Refuge is located immediately upstream of this canal, which U.S. Fish and Wildlife Service staff believe is excessively draining the Refuge. Thus, it appears that merely installing plugs along the entire length of the Merritt Canal without pumping would significantly benefit the Refuge without creating any adverse impacts in the area.

One of the important considerations about the restoration of SGGE is that while a restored hydrology is crucial to meeting our goals, it is not sufficient to meeting them. As has been stated repeatedly, an appropriate fire regime was a major factor in creating and maintaining the natural communities, and it will be necessary to bring them back. There is also the option of making a management decision to implement a different fire regime in parts or all of SGGE, if considered appropriate to meet certain objectives. One example might be to reduce the fire frequency to allow for the presence of a greater number of mesic and hydric hammocks or merely a larger number of hardwoods in the pine and cypress communities, but at the expense of herbaceous species and high-quality browse.

Another important consideration is the problem of invasive exotic and native plants. While an improved hydrology will help with certain problem species at certain sites, herbicides and mechanical control programs will need to be instituted to deal with some species and will also be necessary in some locations where hydrology cannot do the whole job. These programs will also be necessary where hydrologic restoration is not planned, such as in the northwestern corner of SGGE or along remaining canal sections. It will be important to work to minimize the chances of bringing new invasive species in during the restoration effort and to be prepared to deal quickly with any that might appear. Problem species that can be carried to a site on heavy equipment include cogon grass, torpedo grass, elephant grass, and climbing fern, among many others.

Monitoring Restoration Success

The Interagency Technical Committee (Committee) assisting the District and NRCS on this study has outlined recommendations for the monitoring of restoration effectiveness in both the terrestrial/freshwater ecosystems in and around the study area and the estuarine ecosystem of the Ten Thousand Islands. Recommendations are divided into fours categories: Hydrological, Water Quality, Fish and Wildlife Resources, and Listed Species. Recommendations are numbered for ease of reference and do not indicate priority.

<u>Hydrological</u>

1. Continue collection of baseline well data from Watershed Planning Assistance Study.
2. Establish new monitoring wells:
   - along four new east/west well transects with approximately six wells per transect distributed among major community types, and twelve monitoring recorders. One line of wells would be located north of the spreader swales, and one located immediately below. The other two transects should be extensions of existing Fakahatchee Strand State Preserve transects.
   - at six new locations in North Golden Gate Estates (to be determined).
3. Coordinate/calibrate all available well/water level monitoring data in the vicinity of the SGGE, including:
   - Tamiami Trail Culverts and Plugs Critical Project.
   - Belle Meade tract of Picayune State Forest.
   - Ten Thousand Islands and Panther National Wildlife Refuges.
   - Fakahatchee Strand State Preserve.
   - Big Cypress Basin surface and groundwater wells in SGGE and adjacent watersheds.
   - U. S. Geological Survey wells.
   - main conveyance canals and or weir structures.
4. Add weather station in SGGE.
5. Monitor post-restoration conditions in estuarine environments and compare with hydrologic model predictions:
   - Analyze the data obtained to compare water quality among estuarine spatial homologues (i.e., geomorphologic congruous points on neighboring estuaries along estuarine fresh to marine water gradients) with model predictions.
   - In cooperation with projects being developed in other watersheds by the U.S.

Geological Survey and the District, develop hydrological model modules that can convert freshwater discharge measurements to salinity measurements.

- Monitor, identify, and quantify freshwater fluxes into estuaries by using surface and groundwater geochemistry, potentially using isotopic and dissolved inorganic carbon water-characterization techniques to identify different surface and groundwater sources.
- Develop a monitoring plan for surface and groundwater levels similar to that already developed in the freshwater portions of the SGGE project; for terrestrial habitats within the downstream estuarine environment, to include water table elevations, surface water depths, and hydroperiods.

Water Quality

1. Continue collection of existing baseline water quality data at established Collier County water quality sampling sites, including those established by the County and the Southwest Florida Water Quality Consortium.
2. Add additional water quality monitoring sites (to be proposed).
3. At a minimum, monitor and standardize monitoring methodologies and lab analyses for phosphorus, organochlorines, pH, temperature, and conductivity (salinity) for each site. Where data needs are identified, monitor chlorophyll *a*, fecal coliform, and other nutrients or heavy metals.
4. Conduct water quality monitoring on a quarterly basis at minimum and monthly where data needs are identified.
5. Monitor and compare salinity and other water quality parameters from altered and

unaffected neighboring bays:

- Continue collection of existing baseline water quality data at Blackwater, Faka-Union, and Fakahatchee Bays.
- Establish additional water quality monitoring stations in locations further upstream in Blackwater, Faka-Union, Fakahatchee, and Pumpkin Bays.
- Establish an additional water quality monitoring station in Pumpkin Bay.
- Establish spatial homologues along the unaltered Fakahatchee estuary to identify and monitor restoration targets at the same homologue within altered estuaries.
- Sample water quality parameters in sheetflow ecosystem (as opposed to canals) during periods of flow.
- After the project area is surveyed for contaminants, monitor the success of recovery of contaminated sites if remediation is recommended.

Fish and Wildlife Resources

1. Continue existing baseline wildlife studies for a minimum of three years including all studies currently contracted through the District, studies being conducted through the Florida Division of Forestry, and breeding bird surveys (point counts). Prioritize frog and herpetofauna surveys for 2002 wet season. The SGGE Project Development Team authorized under the CERP should assess first year data to see where methodologies can be improved, parameters added or modified, or locations of data collection modified to reflect restoration monitoring goals. Sampling locations should be reviewed to assure that sites will be accessible post-restoration.
2. Continue aerial wading bird studies. Conduct year-round baseline study. Begin post-

restoration data collection after one full growing season, conduct for three consecutive years, then at less frequent intervals.

3. Add new baseline wildlife studies where appropriate to meet restoration goals. Recommended studies include aquatic macroinvertebrates, apple snails, alligators, insects, exotic fish, and epiphytes.
4. Continue existing Big Cypress Basin baseline vegetation studies. Initiate post-restoration monitoring after one full growing season, and conduct for three consecutive years, then at less frequent intervals. Sampling locations should be reviewed to assure that sites will be accessible post-restoration.
5. Continue timber cruise surveys by Florida Division of Forestry.
6. Monitor biologic response of estuarine aquatic ecosystems.
    - Continue baseline data studies of oyster health, growth, recruitment, and distribution for Blackwater and Faka-Union estuaries.
    - Expand baseline oyster studies to Fakahatchee and Pumpkin Bays.
    - Continue baseline studies of steno-and euryhaline crab populations in Blackwater, Faka-Union, and Fakahatchee Bays.
    - Expand baseline studies of steno-and euryhaline crab populations to Pumpkin Bay.
    - Replicate transient fish population studies (Browder et al. 1986, 1987, 1988) for Ten Thousand Islands and associated bay systems before project restoration. Repeat studies post-restoration.
    - Continue fish trawl monitoring project being conducted by Rookery Bay National Estuarine Research Reserve staff (O'Donnell and Shirley, unpublished data).
    - Map distribution of sea grasses in Faka-Union, Fakahatchee, Pumpkin, and Blackwater estuaries pre- and post-restoration.

7. Monitor biologic response of intertidally influenced terrestrial ecosystems.
    - Monitor aerial coverage and degree of fragmentation of salt marsh and mangrove habitat to establish changes in ecotones pre-and post-restoration.
    - Continue existing monitoring and expand baseline vegetative transects in salt marsh ecotones.
    - Establish pre-restoration baseline studies for fish species in upper estuarine areas and monitor changes in fish species composition and abundance post-restoration.
8. Monitor and document Division of Forestry fire regimes for effects on plant communities.

<u>Listed Species</u>

1. Monitor state-listed species of concern including state-listed wading birds, the Florida black bear, and Big Cypress fox squirrel, to determine the effects of the restoration.
2. Monitor the endangered Florida panther population to determine the effects of restoration on panther habitat and the panther population.
    - Assess telemetry data on an annual basis for potential changes in patterns of panther habitat use, number of panthers utilizing SGGE area, and demography of the panther population utilizing the area.
    - Coordinate with the Naples office of the Florida Fish and Wildlife Conservation Commission to determine if panther denning activities are occurring in potential restoration construction project areas.
    - Establish a baseline panther prey base study pre-restoration followed by a prey base study one year after restoration is completed and on five-year intervals thereafter.

3. Monitor the endangered wood stork and snail kite populations to determine the effects of the restoration on foraging habitat productivity.
   - Continue aerial wading bird studies. Conduct year-round baseline study. Begin post-restoration surveys after one full growing season, conduct for three consecutive years, then at less frequent intervals.
4. Monitor the endangered Florida manatee population and manatee critical habitat.
   - Continue to monitor manatees that utilize the affected project area using annual surveys and existing and potentially additional telemetry studies.
   - Establish baseline sea grass surveys in Faka-Union Bay at a minimum, and in Blackwater, Fakahatchee, and Pumpkin Bays if historical sea grass presence is established.
5. Monitor the concentration of manatees at the Port of the Islands basin and within Faka-Union canal to determine the effects of the restoration on warm-water refugia at Port of the Islands.
   - Establish and monitor baseline information for the Port of the Islands basin (including weir) and Faka-Union canal including water depth, temperature, and surface water quantity and quality. Continue monitoring throughout construction of restoration project and post-restoration at a frequency based on effect of the project.
6. Monitor the endangered American crocodile population for effects of the restoration.
   - Continue existing crocodile surveys by the University of Florida in affected project estuaries post-restoration at a frequency based on the effect of the project.
7. Monitor the red-cockaded woodpecker population within and adjacent to the project.
   - Continue monitoring of the red-cockaded woodpecker population within the adjacent Belle Meade portion of Picayune Strand State Forest, Fakahatchee Strand State

Preserve and Big Cypress Preserve.

- Establish a baseline survey for red-cockaded woodpeckers within the project boundaries. Continue monitoring for location of red-cockaded woodpeckers on at least three-year intervals after restoration.
- Conduct a baseline red-cockaded woodpecker habitat suitability assessment. Re-assess habitat suitability on five-year intervals after restoration.

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