# Spring Creek Restoration Plan

Source: GoogleEarth 2016

James W. Beever III and Tim Walker
Southwest Florida Regional Planning Council
1400 Colonial Boulevard, Suite 1
Fort Myers, FL  33907

Contact Name and Telephone Number:
Jim Beever
(239- 938-1813, ext 224)
jbeever@swfrpc.org

***Table of Contents***

***Disclaimer*** The material and descriptions complied for these pages are not to be considered Agency guidance, policy, or any part of any rule-making effort, but are provided for informational and discussion purposes only. They are not intended, nor can they be relied upon, to create any rights enforceable by any party in litigation with the United States.

Reference herein to any specific commercial products or non-profit organization, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government and shall not be used for advertising or product endorsement purposes.

The documents on this website contain links, for example ((Embedded image moved to file: pic01212.gif)), to information created and maintained by other public and private organizations. Please be aware that we do not control or guarantee the accuracy, relevance, timeliness, or completeness of this outside information. Further, the inclusion of links to a particular item(s) is not intended to reflect their importance, nor is it intended to endorse any view expressed or products or services offered by the author of the reference or the organization operating the service on which the reference is maintained.

If you have any questions or comments on the content, navigation, maintenance, etc., of these pages, please contact:

James W. Beever III
Southwest Florida Regional Planning Council
1400 Colonial Boulevard, Suite 1
Fort Myers, Florida 33907

Contact Name and Telephone Number:
Jim Beever
(239- 938-1818, ext 224)
jbeever@swfrpc.org

## *Acknowledgements*

Original GIS work was provided by Mr. Tim Walker. Assistance at the various public meetings was provided by Mr. Dave Crawford, Mr. Charles Kammerer, and Dr. Lisa Beever.

This project has benefited immensely from the contributions of numerous agencies and individuals that have contributed information, time, and opinion to the contents and recommendations. This document contains information compiled from reviewing documents provided by the staff of the City of Bonita Springs, Lee County Natural Resources, South Florida Water Management District (SFWMD), United States Geological Survey (USGS), Charlotte Harbor National Estuary Program (CHNEP) and other cited sources which address the specific issues. All city staff, agencies and businesses involved were extremely helpful in the preparation of this report.

Special thanks to all the citizens and community organizers who have participated and attended the public meetings throughout the watershed that have identified important issues and added significant value in understanding the human dimensions of the conditions, health, and enjoyment of Spring Creek.

THIS REPORT WAS DEVELOPED UNDER FUNDING FROM THE CITY OF BONITA SPRINGS

# Abstract

The Southwest Florida Regional Planning Council (SWFRPC) is assisting the City of Bonita Springs in developing a Spring Creek Restoration Plan that will include plans for restoration of hydrology, water quality, habitat, and navigation.

The Spring Creek Watershed is located in the southern area of Lee County. It is approximately ten (10) square miles in size. The watershed mouth originates at Estero Bay approximately 6,000 feet south of Coconut Road. The watershed is approximately two miles wide and five miles long. This watershed is generally located south of the Halfway Creek Watershed and north and west of the Imperial River Watershed.

In the development of this Vulnerability Assessment we met with the City of Bonita Springs staff to introduce the project and began discussions of previously identified and considered restoration needs, vulnerabilities and potential mitigations. We completed initial meetings with citizens at Cedar Creek, Imperial Harbor, Pelican Landing, and Spring Creek Village. We confirmed the scope of work, selected protocols, and confirmed accepted population projections for the watershed. We undertook data acquisition, continued meetings and fact-finding as needed, and coordinated data needs. We distributed and responded to all time-critical data requests, and set up and performed site visits for project assessments. We then applied the Regional Restoration Coordination Team, Southwest Florida Comprehensive Watershed Plan, and Southwest Florida Vulnerabilities Assessment to the watershed to identify vulnerabilities.

Identified Vulnerabilities for the Spring Creek Watershed include:

1) Improved reconnection of the original headwaters of Spring Creek located east of Interstate 75 in the Flint Penn strand to the headwaters located in the San Carlos Estates and the north branch of Spring Creek
2) Improvement of undersized culverts to larger capacity
3) Removal of man-made damming of tributaries to the creek
4) Modifications of weirs and causeway barriers impeding flow in the upper and middle reaches of the creek
5) Placement of ditch block structures in swales within San Carlos Estates to delay and control runoff
6) Removing sand shoals that have formed in the estuarine portions of the creek providing reasonable navigational access
7) Removing muck and debris in the freshwater portions of the creek that have accumulated over time
8) Copper pollution associated with human activities
9) Bacterial pollution as indicated by fecal coliform in the freshwater and estuarine parts of Spring Creek
10) Increases in nitrogen in the freshwater and estuarine parts of Spring Creek

11) The low dissolved oxygen events can likely be improved by addressing the issues of hydrologic flow, nutrients, and anthropogenic oxygen-demanding pollution sources
12) Completing the proposed Florida Forever Land Acquisitions
13) Removing exotic vegetation from existing conservation easements
14) Removing exotics along the main channels of Spring Creek
15) Removing exotics with the stormwater management systems of existing developments with outfalls to Spring Creek
16) Creation of filter marshes in appropriate locations to offset the loss of freshwater headwater wetlands
17) Improving public access to Spring Creek viewing, canoeing and kayaking
18) Development of a Climate Change Adaptation Plan for the Spring Creek Watershed

Following acceptance of this report we proceeded with the development of **The Spring Creek Restoration Plan** that describes how to address these vulnerabilities.

Spring Creek is restorable. The order of restoration actions and the use of timely opportunities will improve the chances of restoration success and decrease negative unintended consequences of restoration actions. The primary goal of the restoration action is to improve the health of the creek in the areas of flows, water quality, habitat, and appropriate recreational opportunities. This subsequently will improve the quality of life for the residents of the Spring Creek watershed and subsequently for parts of the City of Bonita Springs.

# INTRODUCTION:

## *The Spring Creek Watershed*

The Spring Creek Watershed is located in the southern area of Lee County. It is approximately ten (10) square miles in size comprising 2,974.44 hectares (7,350 acres) or 4% of the Estero Bay watershed. The watershed mouth originates at Estero Bay, approximately 6,000 feet south of Coconut Road. The watershed is approximately two miles wide and five miles long. This watershed is generally located south of the Halfway Creek Watershed and north and west of the Imperial River Watershed. The Lee County Surface Water Management Master Plan notes that the watershed had decreased in area by approximately two square miles from the original 1979 "Water Management in Lee County" report. The decrease in area occurred north and east of Coconut Road. The only flow crossing the watershed boundary occurs in Bonita Bay. This tidal saltwater slough connects to the Imperial River at the southern boundary of the watershed. The main conveyance in the Spring Creek watershed is a natural channel beginning at Estero Bay and running approximately five miles to the railroad bridge. The creek is tidally controlled by Estero Bay to the FPL bridge crossing. The channel narrows at US 41 from approximately 100' to a width of 30' with an average bottom of -4.0' NGVD. At the railroad bridge it becomes a dug channel to Old US 41 with an approximate bottom of 5.0' NGVD. Attached are plans and profiles of Spring Creek taken from the Lee County

Surface Water Management Master Plan showing five significant structures. These structures are the twin bridges at US 41, a concrete bridge at the power line easement, corrugated metal pipes in Imperial Harbor, a railroad bridge and a box culvert at Old US 41. The basin consists of residential, golf course, and commercial development as well as farm fields and vacant land areas. The creek contains no water control structures. Per SFWMD criteria the allowable discharge for new development in the watershed is limited to 81 csm for the 3 day – 25 year event.

It is a highly modified watershed and probably was at least twice the size of what it is today before Interstate 75 was constructed. The watershed boundary has changed somewhat since the 1979 "Water Management in Lee County" report by Johnson Engineering and the "Lee County Interim Surface Water Management Plan." The watershed has decreased in size approximately two square miles from the 1979 report. The majority of this area was north of Coconut Road and its extension to the east. Johnson Engineering utilized a number of verification methods including SFWMD permit information and on-the-ground reconnaissance to generally confirm the watershed boundary. The only significant flow crossing along the watershed boundary is a tidal brackish water slough that runs north-south through Bonita Bay. This slough cuts across the south watershed boundary and connects Spring Creek with the Imperial River. The Spring Creek Watershed boundary within Bonita Bay has been determined from Bonita Bay permit data on file at South Florida Water Management District. The Spring Creek main trunk west of Old US 41 remains a natural channel which has seen little modification.

A general description of the Spring Creek Watershed boundary is as follows: beginning at the intersection of Coconut Road and Spring Creek Road and running east to US 41; then south along U.S. 41 to the north line of Section 16, Township 47 South, Range 25 East; then running north along the north line of Section 16 to the northeast corner of Section 15; then north to the half section line of Section 11, Township 47 South, Range 25 East; then east to I-75; then south along I-75 to a point approximately 600 feet south of Strike Lane; then west to the east line of Bonita Springs Golf and Country Club; then south to the north line of Bonita Springs Golf Villas; then east, south, west, north and west around Bonita Springs Golf Villas to Corzine Road; then south along Corzine Road to Shangrila Road; then southwest along Shangrila Road to Old US 41; then south along Old US 41 for 1,000 feet; then generally west by contour to a point on US 41 approximately 2,000 feet north of West Terry Street; then continuing west through Bonita Bay; then north by contour to the mouth of Spring Creek.

Spring Creek is located in the Estero Bay Watershed in Lee County, Florida. The Estero Bay Watershed is located on the lower west coast of Florida, on the Gulf of Mexico. The Estero Bay watershed encompasses 89,443.54 hectares (221,019.8 acres), or 345.3 square miles. The Estero Bay Watershed is listed as U. S. Geological Service (USGS) Cataloging Unit: Everglades – West Coast: 03090204. The Estero Bay Watershed is a sub-basin within the CHNEP study area.

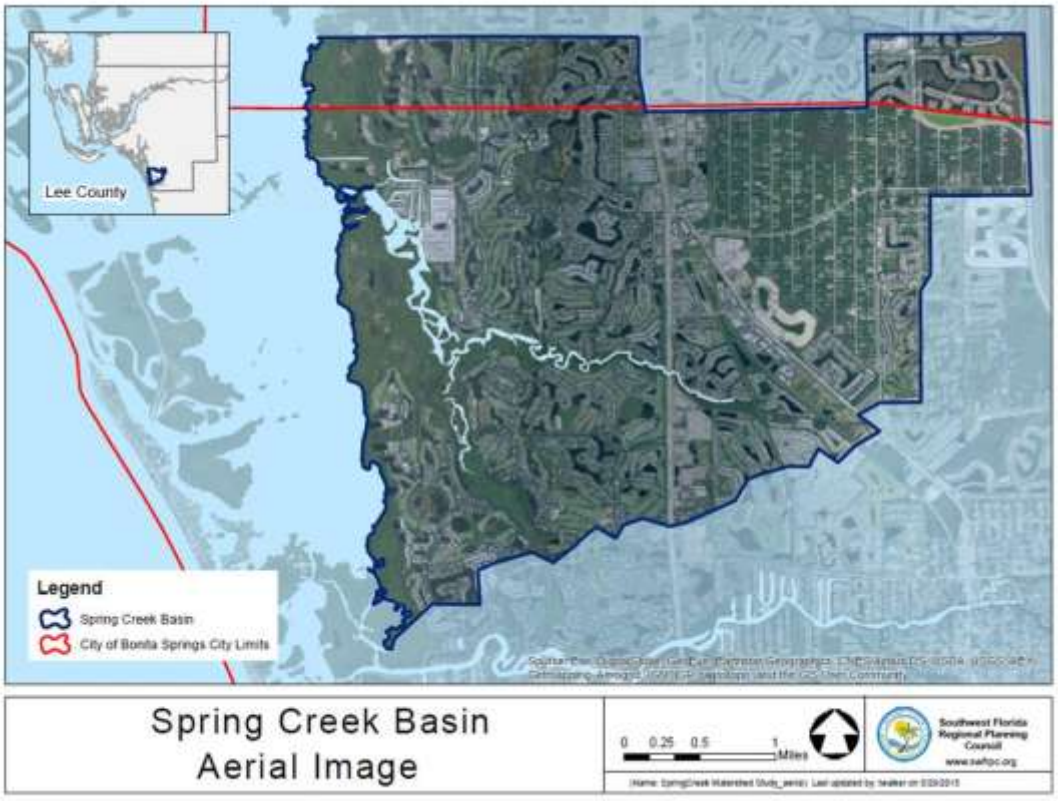



Figure 1: Aerial of the Spring Creek Watershed

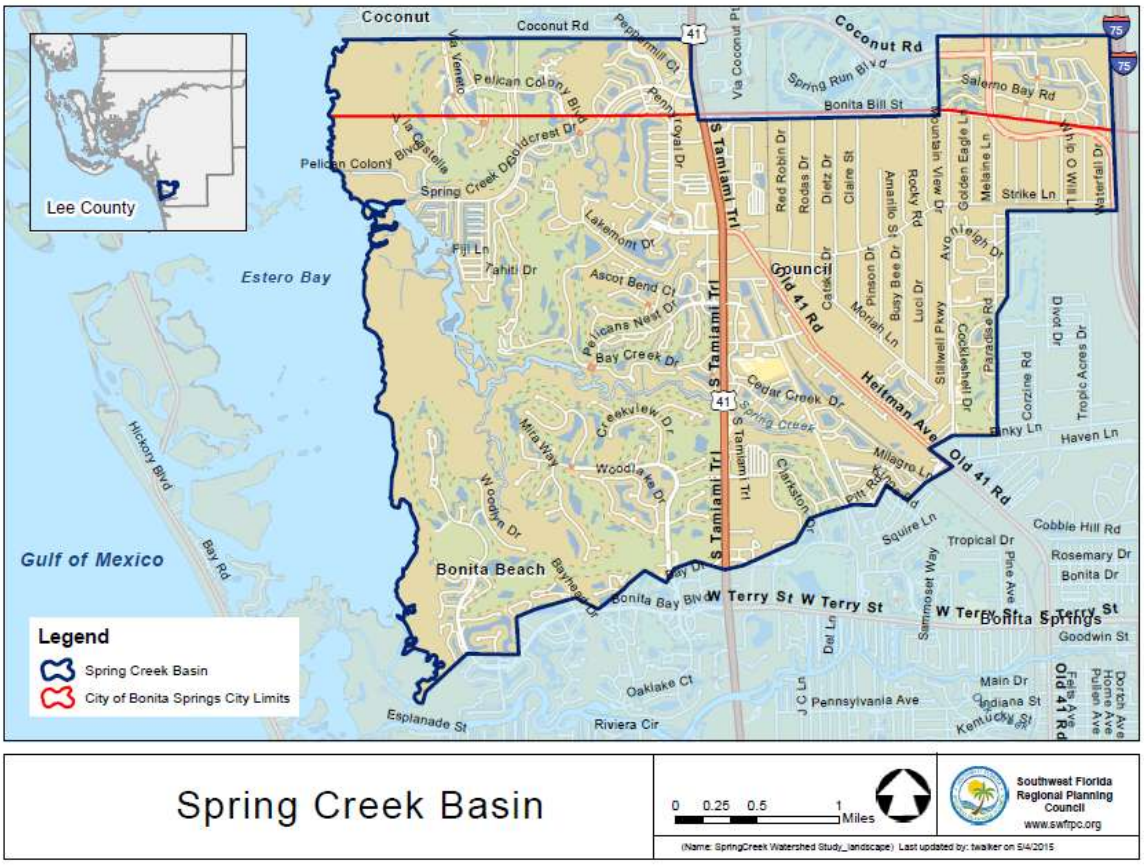



Figure 2: Landmark map of the Spring Creek Watershed

# Part 1: The Seven (7) Hydrology Actions: Summary of Hydrology Vulnerabilities and Issues of Concern for Spring Creek

## *Existing Hydrology and Hydraulics Plans*

Spring Creek tributary flows to Estero Bay have been altered by enhancements intended to drain land surfaces during the wet season and to retain water behind weirs and salinity barriers during the dry season. This continues to result in a spiked hydroperiod with reduced to little discharge of water during the dry season and sharp peaks of discharge during rain events, particularly when water control structures are opened or overtopped. The reduction of surface water retention through percolation into the landscape and the elimination of gradual sheetflow delivery to the estuary has shortened freshwater wetland hydroperiods. Surface water table elevations have been lowered, formerly flowing

springs ceased and or capped and drought conditions are accentuated, encouraging the invasion of exotic vegetation into wetlands and increasing the severity of fire season. Fisheries and wildlife that are dependent on depressional wetlands and riparian habitats lose valuable breeding periods and nursery habitats as the hydrologic system acts as a flush plumbing mechanism. In some areas, wading bird breeding, particularly wood stork, is reduced and fails as wetlands drain too quickly and vital food concentration is lost. Amphibians, such as gopher frogs and tree frogs, are unable to complete reproductive life cycles. Under these conditions, exotic fish, amphibian and plant species fill in and flourish.

Data for analysis in this section is from the US Geological Survey.

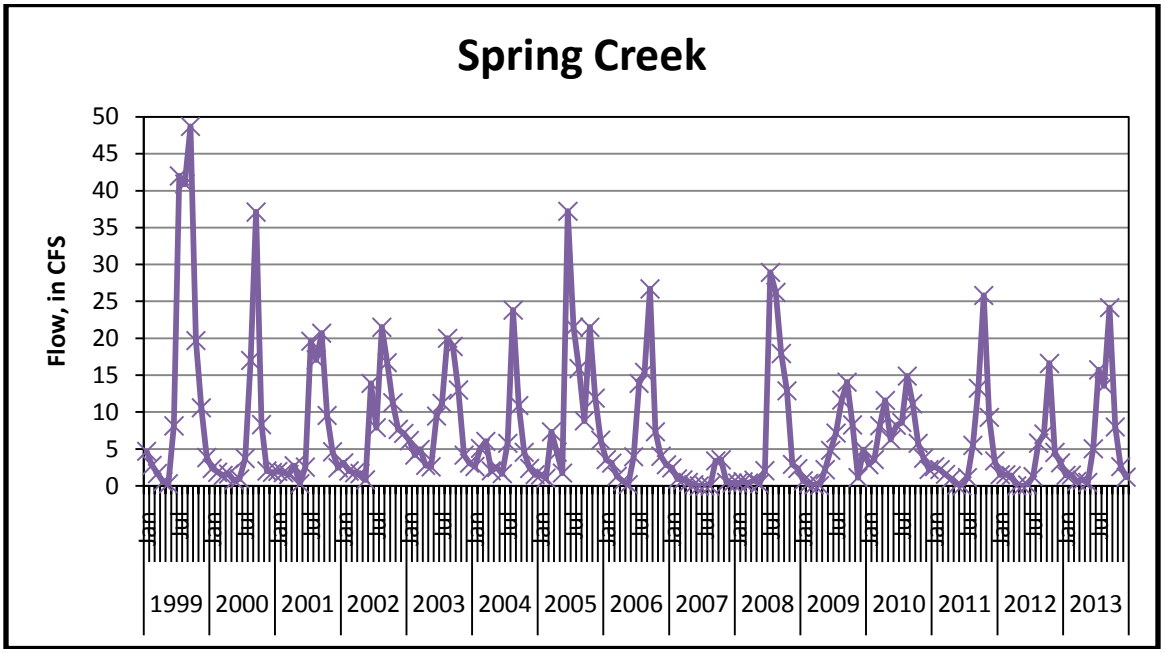



Figure 3: Recent Spring Creek Hydroperiod

In 2002, the City of Bonita Springs completed a Stormwater Master Plan (SMP). The SMP presented the history of flooding in Bonita Springs, prepared 2 foot contour maps of the City, delineated drainage basins, and identified thirteen of the most seriously flood prone areas. General cost estimates were prepared for improvements in these areas, with detailed estimates for remedial measures within the three more serious problem areas. The improvements in the thirteen areas were estimated to cost approximately $4 million in 2002. The SMP also estimated annual Stormwater system maintenance costs and projected this to a cost per household. The total value of the annual O & M (operation & maintenance) costs was expected to total approximately $0.5 million per year. The City initiated a feasibility study for a Stormwater Utility. The report for the Feasibility Study of a Stormwater Utility was completed. Over the prior years the City has undertaken many medium and large scale projects to improve both storm water quantity and quality, including the Shangri-La Drainage project and the Felts Avenue water quality project.

Several projects have implemented a portion of some of the thirteen areas addressed in the Stormwater Master Plan. The City has also been able to obtain two grants from SFWMD to assist in these improvements. Currently, the City has developed 5-year Financial Plans that show the City funding the recommended CIP improvements over a 10-year period, along with the necessary O & M. Lee County and Bonita Springs have prepared GIS maps of outfall locations for their NPDES permits.

Hydrology management issues of concern for the Spring Creek Watershed include:

1) The reconnection of the original headwaters of Spring Creek located east of Interstate 75 in the Flint Penn strand to the headwaters located in the San Carlos Estates and the north branch of Spring Creek

2) Improvement of undersized culverts to larger capacity

3) Removal of man-made damming of tributaries to the creek

4) Modifications of weirs and causeway barriers impeding flow in the upper and middle reaches of the creek

5) Placement ditch block/ structures in swales within San Carlos Estates to delay and control runoff

6) Removing sand shoals that have formed in the lower estuarine portions of the creek

7) Removing muck and debris in the freshwater portions of the creek that have accumulated over time

It is a general truism of habitat restoration that if the restorers get the water right (hydrology) then other restoration benefits will follow from natural recruitment of vegetation and animals, and source reduction of pollutants. The more urbanized a watershed the less likely the natural succession of improved water quality and vegetation recruitment will be because source materials may not be present and pollution source can be more than natural, such as herbicide applications. Currently Spring Creek has some opportunities for natural recruitment but some reaches of the Creek are too modified to fully restore without major land use change affecting current human development. This restoration plan does not propose these types of major land use changes. Instead it works within the context of the existing levels of land development in the watershed.

For the purposes of this Restoration Plan, Spring Creek will be described as having an Upper, Middle, and Lower Reach. The Upper Reach is from the water control structures leaving San Carlos Estates to the top of the watershed in the Flint-Penn Strand on Agri-Partners. The Middle Reach extends from the Old US 41 bridge to the weirs at the south end of San Carlos Estates. The Lower Spring Creek Reach is from the mouth of Spring Creek at Estero Bay to the Old US 41 Bridge.

### *1) Improved reconnection of the original headwaters of Spring Creek located east of Interstate 75 in the Flint Penn strand to the headwaters located in the San Carlos Estates and the north branch of Spring Creek*

The current Spring Creek Watershed Basin is defined by the SFWMD as beginning west of I-75 and currently includes a small portion of The Brooks adjacent to I-75. There is however a small amount of flow of 160 cfs that enters this defined watershed from flows east of I-75 through a culvert under the Interstate located at an area between the Edison Farms Flint Penn Strand/(western CREW acquisition area) and The Brooks, at the area set aside for a former proposed interstate interchange (Figure 4). This is the remaining connection of the North Branch of Spring Creek to its original headwaters in the Flint Penn Strand. Under current conditions this connection is hydrologically sufficient. However standard Department of Transportation procedures provide that under "Cost Engineering", culverts are not necessarily designed and constructed to be of optimal size for extreme storm events or have inverts that maintain natural waterway base flows. The Standard Manual is the basis for most highway design unless modified for other purposes, which this culvert was not. During the course of this study the western end of the culvert has become more vegetated (Figure 4b) and maintenance may be needed by FDOT to maintain conveyance. If the land east of Interstate 75 undergoes a land use change in the future either as a preserve or for development, the existing culvert may not need to be changed or might need significant re-sizing if increased run-off from increased impervious surfaces is allowed. In the best possible future, the Agri-Partners-Edison Farms site will be protected for conservation and hydrologically restored so that sheetflow returns to that part of the Spring Creek headwaters and a more natural headwaters hydroperiod will provide water westward to the areas west of Interstate 75 through a longer lower daily volume seasonal discharge which would have the effect of reducing the flashiness of the current creek hydrology. Subsequently southward discharges would be able to be reduced east of Interstate 75 and water currently going to the Imperial River watershed could be returned to the Spring Creek watershed where it originally went.

Restoration recommendation 1a :At this time there is no need to change the existing culvert under I-75 for the North Branch of Spring Creek. If development occurs east of the Interstate then this may significantly change to the detriment of the hydrology of Spring Creek. If those lands are conserved and sheetflow restored, Spring Creek hydrology will improve.


Figure 4a: Culvert between Flint Penn Strand (Edison Farms) and The Brooks crossing under Interstate 75.
Source Google Earth 2015


Figure 4b: Culvert between Flint Penn Strand (Edison Farms) and The Brooks crossing under Interstate 75.
Source Google Earth 2016

The original southern branch of Spring Creek was also beginning in the Flint Penn Strand and would have crossed in the area that is now occupied by the north border of the Bonita Springs Utilities facility located east of Interstate 75 and the canal located south of the houses on Strike Lake in the San Carlos Estates Drainage District and north of the Sanibria Loop in Bonita Lakes Estates. There is no culverting under Interstate 75 and the waters that would have flowed westward into Spring Creek are instead directed southward along the Interstate 75 paralleling ditch, to a major culvert undercrossing to the west of the Bonita Spring Utilities plant and after crossing under the Interstate 75, this major canal flows south and then to become part of the north branch of the Imperial River.

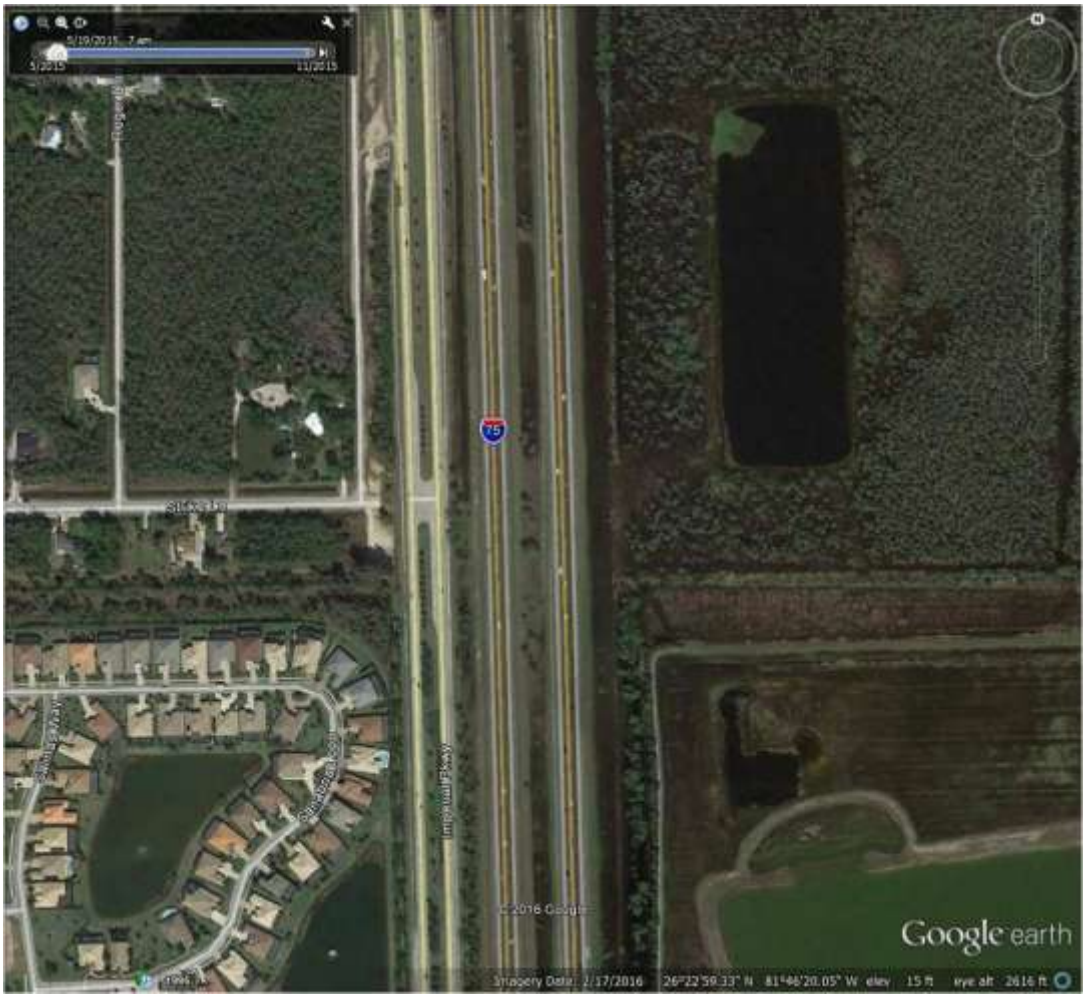



Figure 5: Former location of where the south branch of Spring Creek would have crossed between Flint Penn Strand (Edison Farms) and area west of Interstate 75.
Source Google Earth 2016

Restoration recommendation 1b :At this time there is no viable opportunity to make a restoration of the flows of the headwaters of the south branch of the Spring Creek watershed. While this had been identified in the P D & E with the U.S. Highway Administration during the I-75 improvement planning process, those agencies chose to take no action in that project.

## *2) Improvement of undersized culverts to larger capacity*

There are 12 areas of culverts or pipes in the middle reaches of Spring Creek that have been identified as impeding or potentially impeding flows. These are indicated in Figure

6 from the South Lee Watershed Plan 2009 update as the locations marked with the number 3.


Figure 6: Locations of areas needing increased conveyance in Spring Creek (indicated by a yellow triangle with the number 3)
Source: South Lee County Watershed Plan Update 2009

The base flows of Spring Creek begin at 160 cfs at the I-75 culvert entering "The Brooks" Basin 3. Subsequently the Creek flows through The Brooks Basin 3 water management system with a discharge to the San Carlos Estates Drainage District of 160 cfs (SFWMD permit 36-03802-P and 36-00288-S) with a control elevation of 14.00' NGVD. This flow continues in the Three Oaks Parkway project (Permit No. 36-04007-P) in an area separated from the other portions of San Carlos Estates by the construction of Three Oaks Parkway. The construction of Three Oaks Parkway provided a box culvert to convey flows of Spring Creek from the area to the east into the San Carlos Estates Drainage District in the permit 36-04007-P. Only Basin D of the approved permit discharges into the Spring Creek Basin and it is limited to 6.9 cfs with a peak stage of 16.8' NGVD for the 25 year – 3 day storm event. The control elevation for Basin D is 14.50' NGVD. This is a severe constriction in allowable flows. The drainage ditch in this area is well maintained. The flow continues through the box culvert into the San Carlos Estates Drainage District (Figure 7).


Figure 7a: Box Culvert at Three Oaks Parkway Extension east side
Source: 2008, Exceptional Engineering, Inc


Figure 7b: Box Culvert at Three Oaks Parkway Extension east side

Source: Google Earth 2016

The San Carlos Estates Drainage District is essentially a boxed-in watershed with a backbone east-west canal system radiating with 14 rib swales systems flanking tributary roads to Strike Lane. Aquatic plants both submerged and floating are prevalent. Spoils from the excavation of the canals were used to form a berm around the property boundary effectively closing off Spring Creek and damming it within the site. The canals flow to the south end of the development where they discharge into two locations that flow under Old US 41 into Spring Creek.


Figure 8: San Carlos Estates canals and road system. Note central Strike Lane and north and south roads that are very different from denser flanking developments.
Source: Google Earth 2016

The North Branch flow crosses under Old US 41 through 2 – 8’ x 4’ box culverts and into the Bernwood Business Park. These culverts are sufficient capacity for a normal year hydrology but could cause backwater during periods of high precipitation concentrated in the watershed. When Old US 41 in this area is being considered for repair or redesign the engineering should consider an additional 1 foot of downstream water elevation from sea level rise and a regular 100-year event occurring in a 10 to 15 year return rate in future changes in seasonal hydrology. It would be best for future culverting and/or bridging to span the entire floodplain rather than constrict it with smaller minimum requirement conveyance. This could also improve opportunities for public water access on the Creek.


Figure 9: Old US41 Box Culvert on the North Branch of Spring Creek Upstream of the Bernwood Business Park Box Culvert
Source: Google Earth 2016

After exiting the box culverts at Old US 41, the headwaters continue into Bernwood Business Park. Inside Bernwood Business Park the tributary is moderately vegetated and the flow passes through another box culvert internal to the Bernwood Business Park (also seen in Figure 9 to the railroad right-of-way.

Pic 20. Culvert in Bernwood Business Park – North Branch

Figure 10:. North Branch Culvert in Bernwood Business Park – North Branch
Source: 2008, Exceptional Engineering, Inc.

The flow continues past Bernwood Business Park to the Seminole Gulf Railroad crossing. The crossing is shown in the picture below. The creek is shallow at the crossing and appears to widen at the crossing during maximum flows. During the field inspection an additional pipe was discovered at the south end of the crossing. This pipe is at a higher elevation and is intended to pass flows during high water events.

There are several 48" RCP pipes along the railroad right-of-way which convey water from the east side ditch to the west side ditch that runs parallel to the tracks. Two of these pipes were located in the area of the north branch. In both instances the pipes were in poor condition and covered with vegetation and debris. Further analysis of the pipes and condition of the conveyance swales along the railroad right-of-way is recommended. These pipes should be replaced with structures allowing a sufficient base flow through this blockage in the range of at least two (2) – 8' x 4' box culverts plus an anticipated 1 foot increase in downstream sea level and a 10-15 year frequency of the current 100-year event.


Figure 11: North Branch of Spring Creek at the railroad crossing
Source: Google Earth 2016

At the railroad right-of-way the vegetation was very heavy as shown in Figure 11. The North Branch then flows west to the FPL easement and encounters pipes in a filled causeway.


Pic 23. 48" RCP at FPL easement

Figure 12: Pic. 23. 48" RCP at FPL easement
Source: 2008, Exceptional Engineering


Figure 13: North Branch of Spring Creek at the FPL easement
Source: Google Earth 2016

As flow exits the FPL easement it flows into the Cedar Creek Subdivision preserve area. This area is heavily vegetated and in some areas the flow is almost completely blocked off or absorbed and evapotranspirated. The North Branch also passes through a small culvert under Cedar Creek Drive. As the north branch exits the Cedar Creek Subdivision it merges with the south branch of Spring Creek.


Figure 14: North Branch of Spring Creek Drive flowing south through Cedar Creek subdivision pacing under Cedar Creek and meeting with the South Branch of Spring Creek
Source: Google Earth 2016

The South Branch of Spring Creek flows out of San Carlos Estates and crosses under Old US 41 through 2 – 10' x 6' box culverts and into the Bernwood Business Park. These culverts are sufficient capacity for a normal year hydrology but could cause backwater during periods of high precipitation concentrated in the watershed. When Old US 41 in this area is being considered for repair or redesign the engineering should consider an additional 1-foot of downstream water elevation from sea level rise and a regular 100-year event occurring in a 10 to 15 year return rate in future changes in seasonal hydrology. It would be best for future culverting and/or bridging to span the entire floodplain rather than constrict it with smaller minimum requirement conveyance. This could also improve opportunities for public water access on navigable Spring Creek.

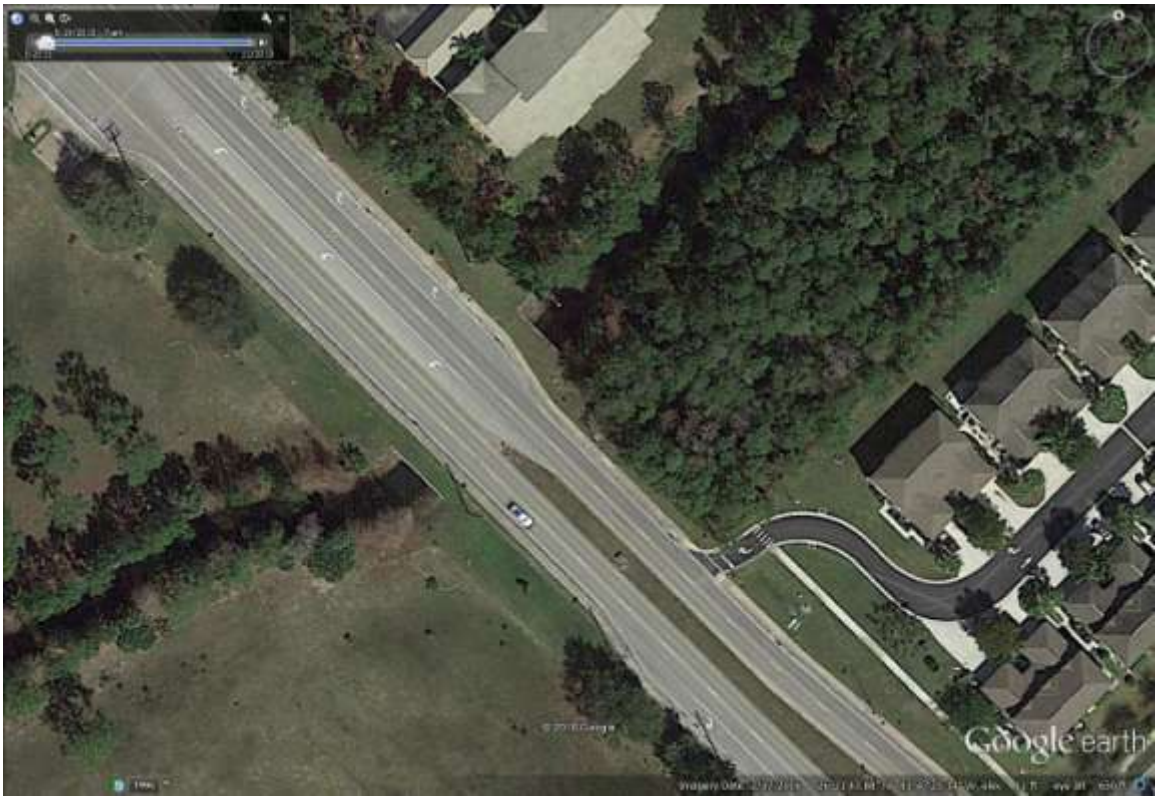



Figure 15: Old US41 Box Culvert on the South Branch of Spring Creek entering Bernwood Business Park
Source 2008: Google Earth 2016

Within Bernwood Business Park there is a cattle crossing and vegetation lines the channel, obstructing it with primrose willow and cattails in some locations.


Pic 11. Cattle Crossing inside Bernwood Business Park

Figure 16: Pic 11. Cattle Crossing of the South Branch inside Bernwood Business Park in 2008
Source: 2008, Exceptional Engineering, Inc

Figure 17: Cattle Crossing inside Bernwood Business Park in 2016
Source: Google Earth

Leaving the Bernwood Business Park the creek shallows and is shallow at the bridged crossing and appears to widen, based on hydric indicators at the crossing during maximum flows. An additional pipe is located at the south end of the crossing at a higher invert elevation indicating the height of high water blocked by the causeway during high water events.


Figure 18: Seminole Gulf Railroad Crossing 2016
Source: Google Earth 2016


Pic 12. Seminole Gulf Railroad Crossing

Figure 19: Pic. 12 Seminole Gulf Railroad South Branch Crossing
Source: 2008, Exceptional Engineering, Inc


Pic 13. Additional Pipe at Railroad Crossing

Figure 20: Pic 13. Additional Pipe at Railroad Crossing
Source 2008, Exceptional Engineering, Inc

The additional pipe can become clogged with debris and has eroded areas both upstream and downstream. The Lee County Master Surface Water Management Plan details the crossing as a 51' bridge with road elevation of 14.1' NGVD. There is no mention of the additional pipe.

As the flow continues past the railroad bridge it again becomes constricted with vegetation until it reaches Imperial Harbor. Spring Creek tributary flows along the northern border of the development and is connected to a tributary branch of Spring Creek that forms a ditch within Imperial Harbor. There is a crossing inside Imperial Harbor consisting of four corrugated metal pipes. The Lee County Master Surface Water Management Plan shows 2-42" CMP's and 1-36" CMP with average inverts of 3.2'. There is also another crossing of this tributary to the east at Milagro Lane where the tributary branch first leaves the main channel of the South Branch of Spring Creek.

t


Figure 21: Crossing of the south branch of Spring Creek by Milagro Lane that connects by Pueblo Bonito Boulevard in a residential area
Source: Google Earth 2016

As flows continues past Imperial Harbor it again becomes densely vegetated to the point of causing a stagnate condition. This vegetation continues to the concrete bridge crossing for the FPL easement crossing. The Lee County Master Surface Water Management Plan shows the FPL crossing as a 40’ concrete bridge crossing with a road elevation of 11.2’.


Pic 17. FPL Easement Bridge Crossing

Figure 22: Pic 17. FPL Easement Bridge Crossing
Source: 2008, Exceptional Engineering, Inc

Figure 23: FPL Easement Bridge Crossing
Source: GoogleEarth 2016

Restoration recommendation 2: It would be best for future culverting and/or bridging to span the entire floodplain rather than constrict it with smaller minimum requirement conveyance. Future repair or redesign should include engineering that provides an additional 1- foot of downstream water elevation from sea level rise and a regular 100-year event occurring in a 10 to 15 year return rate from future changes in seasonal hydrology. The following culverts need to be improved to provide safe passage for exiting base flows and in anticipation of future hydroperiod changes which will include more extreme rain events:

1) Three Oaks Parkway box culvert

2) North Branch and South Branch Old US 41 box culverts

3) The culvert within Bernwood Business Park on the North Branch of Spring Creek

4) The cattle crossing inside Bernwood Business Park on the South Branch

5) The several 48" RCP pipes along the railroad right-of-way which convey water from the east side ditch to the west side ditch that runs parallel to the tracks on the North Branch and the bridge and pipes on the South Branch

6) The Milagro Lane Culvert on the South Branch of Spring Creek

7) The FPL right-of-way bridging and pipes on the North and South Branches.

8) The culvert at Cedar Creek Drive

## *3) Removal of man-made blockage (damming) of tributaries to the creek*

During public meetings citizens identified that there was a location upstream of their community where a tributary of Spring Creek that had been blocked by the property owner so as to use the confined water for their irrigation use. This is located within the Imperial Harbor development where an unnamed tributary to Spring Creek that is located as a linear feature between the residences and an area of storage for recreational vehicles is blocked off from navigation by canoe or kayak with a bridge that has four corrugated metal pipes (CMP) at the south branch of Spring Creek.

This Spring Creek tributary flows along the northern border of the development and is connected to the perimeter ditch of Imperial Harbor. There is a crossing inside Imperial Harbor consisting of four corrugated metal pipes. The Lee County Master Surface Water Management Plan shows 2-42" CMP's and 1-36" CMP with average inverts of 3.2'. The conveyance is very well maintained inside of the Imperial Harbor development.


Pic 14. Imperial Harbor CMP pipe crossing.
Figure 24: Pic 14. Imperial Harbor CMP pipe crossing.
Source 2008, Exceptional Engineering, Inc

Restoration recommendation 3: The existing crossing should be replaced with a culvert bridge with a cross-section spanning of the entire tributary. This will provide improved hydrologic performance and improved maintenance while reducing backwater. Depending on the design this may allow passage of canoes/kayaks.

### *4) Modifications of weirs and causeway barriers impeding flow in the upper and middle reaches of the creek*


Figure 25. San Carlos Estates southernmost weir. Note: flow from erosion.
Source: 2008, Exceptional Engineering, Inc


Figure 26: Erosion around the southernmost weir at San Carlos Estates.
Source 2008: Exceptional Engineering, Inc

Restoration recommendation 4a: The existing pipe and fill crossings should be replaced with culverts with a cross-section spanning of the entire tributary extents. This will provide improved hydrologic performance and improved maintenance while reducing backwater.

Restoration recommendation 4b: The existing weirs at the outlet of San Carlos Estates should be repaired/rebuilt to a modern adjustable weir design with the potential increase of invert to increase retention time and pipe and fill crossings should be replaced with culverts with a cross-section spanning of the entire tributary extents. This will provide improved hydrologic performance and improved maintenance while reducing backwater.

Figure 27: Adjustable weir design at outlet of Suncoast Estates to Powell Creek, Lee County

Figure 28a; Other adjustable weir designs with a fish chute.

Figure 28b; Other adjustable weir designs with side flap gates.

Figure 28c; Other adjustable weir designs with lift gates.

## *5) Placement of ditch block structures in swales within San Carlos Estates to delay and control runoff*

The upper and middle reaches of Spring Creek within San Carlos Estates have been segmented by a set of weirs designed to hold the water table at a design elevation sufficient to keep the ground water table somewhat higher but not so high as to interfere with septic tank function. During wet season high flows this may not provide a problem and since erosion around the southernmost outflow weir of the San Carlos Estates Drainage District has allowed flows to bypass the weir, it is not providing much function.

Developed in 1962, in an area that was historically cypress swamp, hydric pine flatwoods and mesic pine flatwoods, San Carlos Estates is poorly drained with shallow rim canals enclosing the development. Spoils from the excavation of the canals were used to form a berm around the property boundary effectively closing off Spring Creek and damming it within the site. The canals flow to the south end of the development where they discharge into two locations that flow under Old US 41 into Spring Creek. At the time of the construction no SFWMD permits were required. However SFWMD did issue a permit on November 19, 2003 (36-04757-P) for sealing and paving of the existing unpaved roadways and recontouring of existing roadside swales. No information concerning the control elevation could be found within SFWMD files. The plan of reclamation for the San Carlos Estates Drainage District did note a discharge of 182 cfs from the development to Spring Creek. The discharge to Spring Creek occurs at two points leaving the system.

Restoration recommendation 5:

There are opportunities for the placement of ditch block/structures within San Carlos Estates to delay and control runoff before runoff reaches the canal system proper. These can take the form of backyard lipped swales and grassed spreaders swales flanking the Strike Lane Canal.


Figure 29: Example of the areas along Strike Lane Canal that should have grass swales and spreader swales at San Carlos Estates.

Source: Google Earth 2016

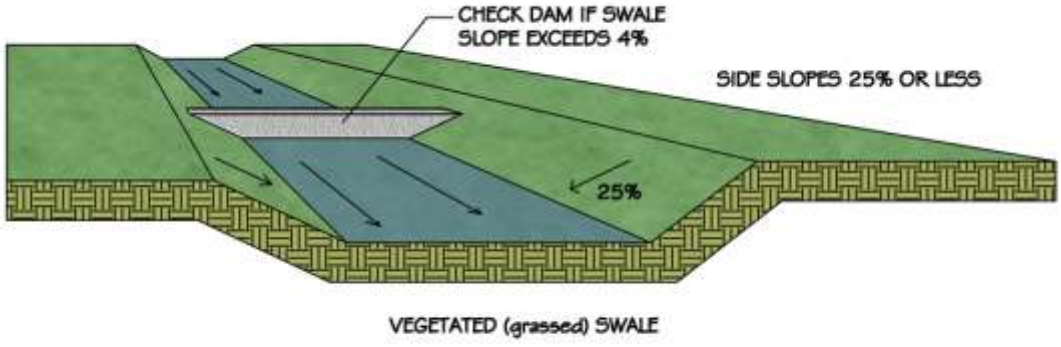



Figure 30: Example design of a grassed swale for roads leading to Strike Lane.

Figure 31: Example design of a grassed swale for roads leading to Strike Lane.

***6) Removing sand shoals that have formed in the estuarine portions of the creek providing reasonable navigational access***


Figure 32: Sand shoaling.
Source: Google Earth 2016

Figure 33: Sand shoaling.
Source: GoogleEarth 2016

The City of Bonita Springs applied for our permits in March of 2015 and they are still under review both by the state and federal reviewing agencies. Michael Poff and Mark Kincaid of Coastal Engineering are the permitting and design firm. The City of Bonita Springs has applied for permits to spot dredge multiple discrete sections within Spring Creek to improve navigation from the main channel in Estero Bay to the existing residential developments along the creek. The DEP Application # is 36-328455-002 and the USACE Application # is SAJ-2015-02084 (LP-RMT).

The proposed dredge depth is -3.5 feet NAVD88 (-2.2 feet MLW). A 0.5 foot over dredge tolerance (-4.0 feet NAVD88 = -2.7 feet MLW) is proposed. The dredging will remove sediment that is creating shoaling that is occurring in several areas along the Creek. It is designed to restore a navigable depth for the existing shallow-draft vessels (14 to 20 feet in length) belonging to residents that have access to Spring Creek. Approximately 3,100 cubic yards (cy) of material will be dredged during the initial dredging event. Dredging will be mechanical and done from a shallow-draft barge. At each location to be dredged, turbidity curtains will be deployed prior to the beginning of dredging and will remain in place until dredging is completed. All work will be conducted only during daylight hours. The proposed work also includes future maintenance dredging event(s) not to exceed an additional 3,100 cy of material. Thus, the total volume of material to be dredged during the life of the permit is 6,200 cy.

Turbidity screens and/or staked silt screens shall be maintained in functional condition, inspected daily, and shall remain in place for the duration of the project construction to ensure that turbidity levels outside the project construction area do not exceed the ambient water quality levels of the Outstanding Florida Waters, and do not contribute to impacts of adjacent wetlands or surface waters. The applicant agrees to abide by the most current Standard Manatee and Marine Turtle Construction Protection Conditions for In-water Work and the Swimming Sea Turtle and Smalltooth Sawfish Construction Protection Conditions. Further, the applicant acknowledges Spring Creek is an Important Manatee Area and will provide a dedicated manatee observer when dredging is ongoing.

For each area that is dredged, the barge will be moved into position and turbidity curtains will be deployed. Due to the narrowness of Spring Creek, extra caution will be used to position the barge so that at least half of the width of the waterway is navigable water for transiting vessels. Substrate type within the proposed dredge cut varies. From Estero Bay (Marker R6) to Marker G45, the substrate is fine grained sand with three areas of oyster shell (between Markers R36 and G45). Upstream of Marker G45, the substrate transitions to silty sand with increasing amounts of organic-rich silt and clay (muck) at the far upstream end.

The dredging will be conducted using a barge-mounted clamshell or track hoe or similar

mechanical equipment. A mechanical bucket free of holes or perforations shall be utilized to minimize siltation during excavation. The spoil material shall be properly contained on the construction equipment during operation within the project area as well as during transportation to and offloading onto the offload area in a manner that prevents return of the spoil material to Waters of the State. Any remaining spoil water shall be transferred to the offload area and not discharged into Waters of the State. No water shall be discharged into the Waters of the State from the offload area.

All spoil material placed on the offload area shall be trucked to an approved offsite upland disposal site. The designation of the offsite upland disposal site shall be a requirement of the Notice to Proceed request issued by the contractor. If the site is not a publicly owned parcel or the sediment is not used for a public purpose, then severance fees will be required.

The majority of the channel is marked. Additional channel markers will be installed at locations where the natural waterway splits into two or more waterways; thus keeping the vessels in the existing channel and avoiding impacts to sensitive natural resources adjacent to portions of the existing waterway.

Within the proposed dredge template for Spring Creek, Coastal Engineering Consultants, Inc.(CEC) identified four areas to be dredged where live oysters are present (Figure 34). A subsequent assessment of the sites conducted by CEC and the Florida Department of Environmental Protection (DEP) on July 14, 2015 found a layer of unconsolidated oyster shell with varying sized clumps of oysters shells comprised primarily of shell with a few live oysters. No rocks encrusted with oysters or large aggregations of oysters were encountered.


Figure 34: Locations of Oysters
Source: Coastal Engineering Consultants, Inc.(CEC)

Approximately 7,100 sq. ft. (0.16 acres) of oyster habitat will be impacted from the four sites.

The area of each site is provided in Figure 35.

Figure 35: Impacts to Oyster Shell

| Channel Marker Reach | Size (sq. ft.) |
|---|---|
| R26 to R28 | 1,231 |
| R36 to R38 | 2,137 |
| R38 to R40 | 521 |
| G43 | 3,198 |
| Total | 7,087 |

Based on the site visit, the estimated percent coverage of live oyster is 10% within the areas to be dredged making the anticipated impact to live oysters equal to 710 square feet (0.016 acres).No indirect impacts to adjacent oysters areas are anticipated because the amount of dredging is minimal and best management practices shall be employed during dredging such as use of turbidity curtains to protect water quality. Therefore, no mitigation is proposed for indirect impacts.

To offset the loss of oyster habitat, the applicant proposes to create an area of new habitat near the mouth of Spring Creek (Figure 36). The proposed new oyster habitat is an arc-shaped area approximately 540 feet in length by 15 feet wide, approximately 8,100 square feet which is larger than the area of that impacted by the dredging of the channel. The mitigation area will be located a minimum of 50 ft from the channel to allow for safe navigation of the turn at existing channel marker R ”8”.


Figure 36: Location of Proposed Oyster Mitigation
Source: Coastal Engineering Consultants, Inc.(CEC)

A layer of geotextile will be placed in an un-vegetated area and oyster shells will be placed on top of the geotextile (Figure 37). To offset the loss of oyster habitat, the applicant proposes to relocate live oysters from the four identified areas (Figure 34) within the dredge cut prior to construction. A minimum of 50% of clumps larger than 1 square foot, and contain one or more live oysters will be manually removed and placed within the mitigation site. Oysters are naturally occurring in Estero Bay and release hundreds of millions of eggs and sperm into the water column producing enough oyster spat to supplement colonization of the contained oyster shell.

Figure 37: Oyster Bags
Source: Coastal Engineering Consultants, Inc.(CEC)

This site was selected because of higher salinity and less influence by extreme seasonal fluctuations typical of tidal creeks in southwest Florida. These fluctuations include extended periods of time when salinity is below the levels at which oysters can survive. Using a location where salinity levels are higher will increase the chances for long-term survival of oysters recruited to the new site.

In addition, the area selected is a shallow area with extensive prop scarring resulting from vessels avoiding the use of the marked channel leading into Estero Bay. The oyster reef may deter boaters from crossing the seagrass bed and prevent further prop scarring of the area. Signs will be posted to clearly mark the proposed navigation hazard. See Florida Uniform Waterway Marker Application.

Within the proposed dredge template for Spring Creek, Estero Bay Aquatic Preserve staff identified three areas where sponges were present (Figure 38). These sponges are to be removed and relocated prior to the beginning of construction.

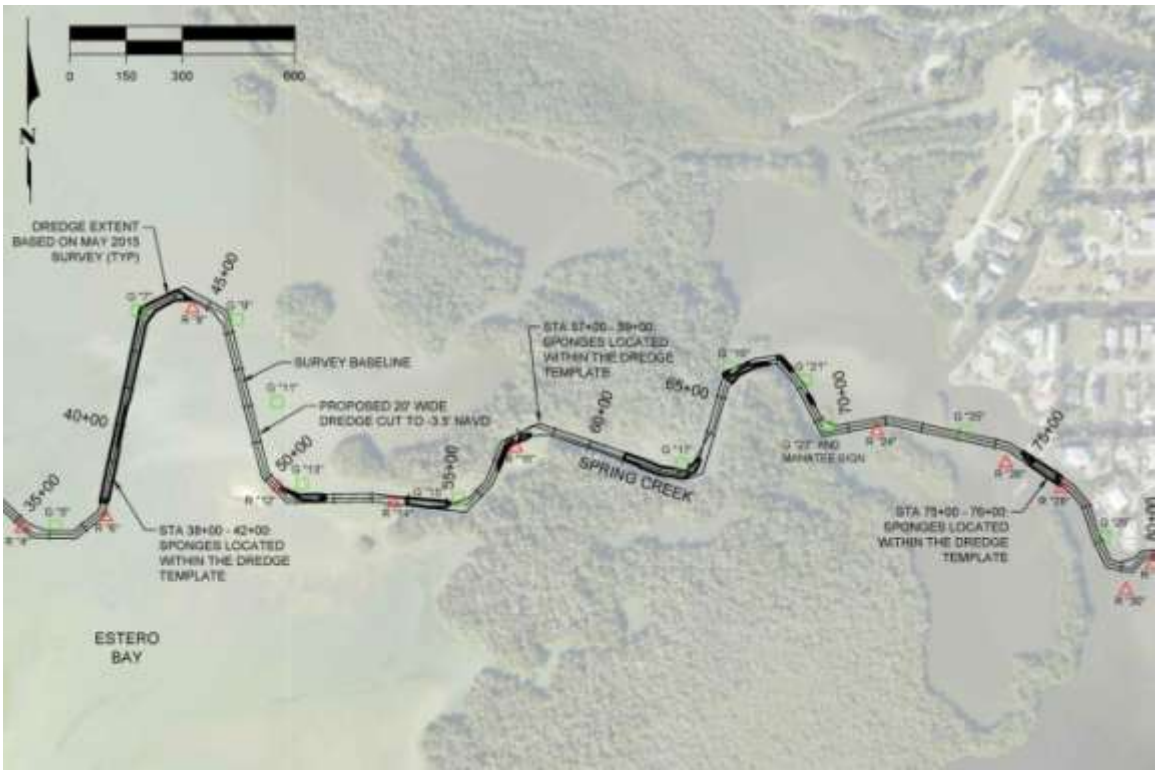



Figure 38: Sponge Locations
Source: Coastal Engineering Consultants, Inc.(CEC)

Prior to the beginning of construction Coastal Engineering and Consultants, Inc. will stake out the channel using survey equipment, then snorkel the site looking for sponges within the stations identified within Figure 38. Upon locating a sponge, CEC staff will determine if it is attached to a substrate. If a sponge is attached, CEC staff will gently pull the sponge to determine if the sponge will dislodge from the substrate. If the sponge does not dislodge, CEC staff will cut the sponge as close to the substrate as possible and place the sponge in a containment cell. Any loose or drifting sponges will be placed in a separate containment cell. All sponges are to remain submerged in the water at all times and shall not be exposed to air.

All sponges will be placed in similar depths and substrate conditions outside of the dredge footprint. Sponges are to be relocated at a minimum of 25 feet from the dredge template. All sponges that were loose at the time of removal will be placed on the bottom. Attached sponges will be secured to the bottom utilizing landscape staples (Figure 39) which will be placed through the sponge and into the substrate. CEC will provide written and photographic documentation of the sponges (loose and attached) to be relocated. Documentation will include initial coordinates, attachment to substrate, type of substrate, and final coordinates.

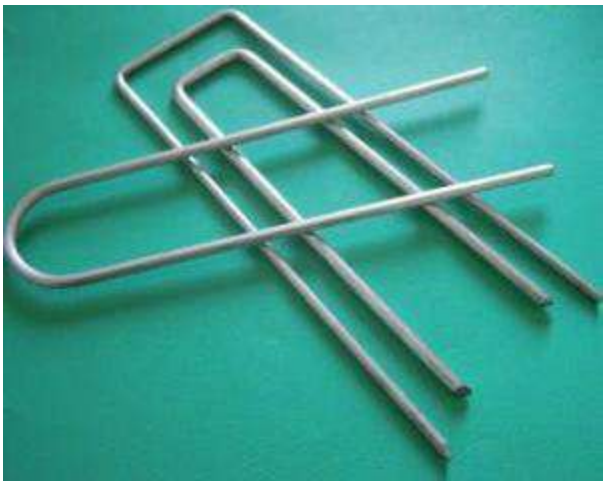


Figure 39: Sponge Landscape Staple
Source: Coastal Engineering Consultants, Inc.(CEC)

Restoration recommendation 6: The City of Bonita Springs is addressing the navigation restoration need with the current dredging proposal and no additional work is needed in the near future if this project is implemented. If erosion control is properly applied in the watershed and stormwater management of solids including total suspended solids (TSS) is improved, the amount and frequency of maintenance dredging can be minimized. Potentially as sea level rise occurs in the future the lower watershed of Spring Creek will become deeper in the central channel at the base rate of approximately 1-foot per 100 years.

### *7) Removing muck and debris in the freshwater portions of the creek that have accumulated over time.*

There are multiple locations where vegetation growth has filled the channels of Spring Creek particularly in the man-altered upper and middle reaches of Spring Creek. Spring Creek at the FPL bridge to the beginning of Imperial Harbor is restricted by exotic vegetation and debris. The flows in this area would benefit if vegetation is removed from creek. Through Imperial Harbour the creek is a dug channel and well maintained. The CMP pipes in Imperial Harbor should be inspected thoroughly and flows analyzed to determine the flow capacity. Upstream from Imperial Harbor through the Seminole Gulf railroad crossing and into Bernwood Business Park the channel has dense vegetation and areas of thick muck bottoms. This vegetation and muck should be removed to aid flows in this area. The box culverts at Old US 41 are well maintained but the channel from the box culverts to San Carlos Estates is moderately covered with vegetation. The system within San Carlos Estates is relatively stagnant to slow-moving during most of the year and accumulates submerged and floating vegetation. The box culvert at Three Oaks Parkway is also well maintained, however upstream of the box culvert and in the area of The Brooks outfall is vegetated. This vegetation should be inspected and exotic species removed.

Mechanical removal is the preferred method of clearing muck, debris, and vegetation out of the channels of Spring Creek in the middle and upper headwaters. It has the benefit of removing excess nutrients that have been incorporated in the plant biomass and not re-contributing harmful nutrients back into the creek ecosystem,. Functionally allowing emergent, floating and submerged vegetation to grow and prosper during the year and then removing it in dry (er) season can be an effective in-stream filter marsh for nutrient loads. In contrast chemical treatments such as the use of copper sulfate will contribute additional pollution both in the nutrients re-mobilized into the system but also in terms of copper pollution, with which the Creek is already impaired.

The North Branch

Flows leaving San Carlos Estates in two areas form into the north branch tributary and south branch tributary. The north branch runs in a manmade canal adjacent to the Villages of Bonita subdivision which rerouted the original creek path to its perimeter. The canal in this area is heavily vegetated as shown in the picture below. Flows could be increased in this by removing the vegetation and removal of trash and debris in the canal.

Pic 19. North Branch adjacent to Villages of Bonita

Figure 40:. Pic 19. North Branch adjacent to Villages of Bonita
Source: 2008, Exceptional Engineering, Inc

Submerged and floating aquatic vegetation are found throughout the canals of the San Carlos Estates Drainage. In some locations the spoil materials from the canal construction have washed back into the canals.


Figure 41: San Carlos Estates berm and canal system.
Source: 2008, Exceptional Engineering, Inc

At the railroad right-of-way, the vegetation in 2008 was very heavy as shown.

As flow exits the FPL easement it flows into the Cedar Creek Subdivision preserve area. This area is heavily vegetated and in some areas the flow is almost completely blocked off or absorbed and evapotranspirated. As the north branch exits the Cedar Creek Subdivision it merges with the south branch of Spring Creek.

Pic 24. restricted flow inside the Cedar Creek Subdivision

Figure 42:. Pic 24.Restricted flow inside the Cedar Creek Subdivision
Source: 2008, Exceptional Engineering, Inc

The South Branch

As flows leave San Carlos Estates in the south branch of Spring Creek they are conveyed by a drainage canal to Old US 41. The photo below shows the intersection of the San Carlos Estates drainage canals and the offsite conveyance. As shown in the photo, as flows leave San Carlos Estates the conveyance is heavily vegetated and flows become restricted at this point to the box culvert at Old US 41.


Figure 43: Intersection of San Carlos Estates canals and offsite conveyance
Source 2008: Exceptional Engineering, Inc

On July 14, 2006, the SFWMD approved permit 36-05877-P titled Old 41 Widening Project. This permit authorized the construction and operation of a surface water management system serving 14.17 hectares (35.01 acres) of roadway improvements with discharges to the Imperial River and Spring Creek. The permit was issued to the City of Bonita Springs. Prior to issuance of the permit, there were no water control structures permitted for this section of Old US 41. The existing roadway drained to roadside ditches with discharge to Spring Creek in the area of existing box culverts. The permit delineated 7 basins with basins 1-2 discharging to the Imperial River and basins 3-7 discharging to Spring Creek. Basin 3 extends from Hope Lutheran Church to the existing 10'X6' box culverts. Runoff is directed to Hope Lutheran Church (36-03118-P) and additional improvements are provided for attenuation and discharge within that system with a permitted control elevation of 9.3'. Basins 4 & 5 include Bernwood Business Park and extend from the existing box culvert to the railroad crossing. This area has a direct impact on the headwaters of Spring Creek. Runoff in this area is directed to the surface water management system for Bernwood Business Park (36-02904-S) which discharges to the headwaters directly downstream of the box culverts at Old US 41. In order to provide water quality and attenuation two existing control structures within Bernwood Business Park were modified and a new control structure proposed to maintain the original peak design discharge for the Business Park. The permitted control elevation for this is 10.00' for Basin 5 and 9.3' for Basin 4. Basin 6 conveys runoff to the existing railroad ditch and provides for offsite flows from two commercial developments. Basin 7 extends from the railroad crossing to the intersection with US 41. The runoff from this basin enters dry detention areas and is discharged to the existing ditch along the FPL

Powerline easement with a control elevation of 10.70' and an allowable discharge of 11.37 cfs. The Lee County Master Surface Water Management Plan lists an average elevation of the box culverts of 6.6'. A USGS monitoring station is located just upstream of the box culverts at Old US 41. Monitoring data shows monthly mean gauge height in feet and monthly mean flow data in cubic feet per second from 2002-2007.

Bernwood Business Park was permitted on March 9, 1995 (36-02904-S) and subsequently modified on several occasions to permit individual lot development as well as modifications to the master stormwater management system. The permit authorized construction and operation of a surface water management system to serve 44.68 hectares (110.41 acres) of industrial development. The development was divided into five basins. Basin 1 flowed into Basin 2 then into the Spring Creek tributary. Basins 3-5 discharged directly to the tributary. The control elevation for all basins discharging to the tributary is 9.3'. The four proposed control structures limited discharge to the tributary to a total of 12.1 cfs. The conveyance in the area of Bernwood Business Park is heavily vegetated causing flows to be restricted. Also, the field inspection revealed that a cattle crossing had been constructed inside Bernwood Business Park. A picture of the cattle crossing is shown below. The cattle crossing does not appear to restrict flow in this area.


Figure 44: Bernwood Business Park upstream to Old US 41
Source: 2008, Exceptional Engineering, Inc

Pic 10. Spring Creek Tributary inside Bernwood Business Park

Figure 45: Pic. 10 Spring Creek Tributary inside Bernwood Business Park
Source: 2008, Exceptional Engineering, Inc

However, as flows continue past Imperial Harbor it again becomes densely vegetated to the point of causing a stagnate condition. This vegetation continues to the concrete bridge crossing for the FPL easement crossing. The Lee County Master Surface Water Management Plan shows the FPL crossing as a 40’ concrete bridge crossing with a road elevation of 11.2’.


Pic 15. Canal inside Imperial Harbor

Figure 46: Pic 15. Canal inside Imperial Harbor
Source: 2008, Exceptional Engineering, Inc


Pic 16. Downstream of Imperial Harbor

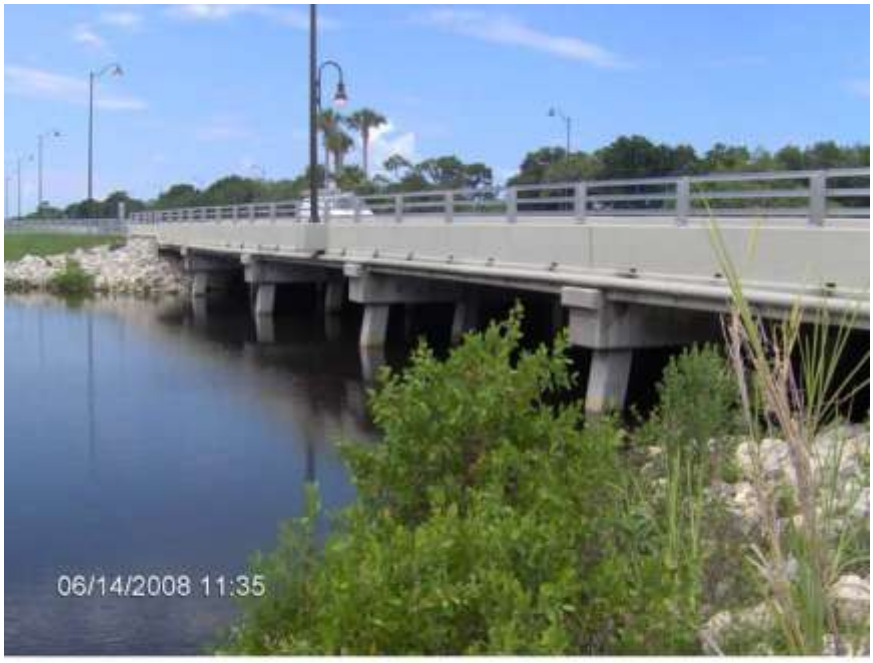
Figure 47:Pic 16. Downstream of Imperial Harbor
Source 2008, Exceptional Engineering, Inc

There is vegetation in the conveyance both upstream and downstream at the FPL bridge

crossing. It is at this point that Spring Creek becomes a natural waterway.

Natural Spring Creek

At the FPL easement crossing, Spring Creek becomes a natural waterway and is controlled by tidal conditions. From the FPL easement to the bridge at US 41, the banks of Spring Creek are vegetated and begin to widen. According to the Lee County Master Surface Water Management Plan, the bridge is 148' with a road elevation of 9.4'. As the creek continues to Estero Bay, it varies greatly in width in excess of 100'. The creek is generally free of vegetation in the areas downstream of US 41.




Pic 18. Bridge crossing at US-41

Figure 48: Pic 18. Bridge crossing at US 41
Source: 2008, Exceptional Engineering, Inc


Figure 49: Bridge crossing at US 41
Source: Google Earth 2016

Restoration recommendation 7: It is recommended that exotic and nuisance vegetation and muck be removed to natural creek /sheetflow depths in the following areas:

1) Headwaters within The Brooks (sheetflow area)

2) North Branch

    i) Villages of Bonita subdivision perimeter ditch

    ii) Canals of San Carlos Estates Drainage

    iii) Railroad Right-Of-Way Canal Ditches East and West

    iv) FPL Right-Of-Way Canal-Ditches East and West

    v) Within Cedar Creek Subdivision

3) South Branch

i) Canals of San Carlos Estates Drainage

ii) Within Bernwood Business Park

iii) Railroad Right-of-Way Canal-Ditches East and West

iv) FPL Right-Of-Way Canal-Ditches East and West

v) Downstream of Imperial Harbor Subdivision

4) Juncture of North Branch and South Branch of Spring Creek

# PART 2: Water Quality: Summary of the Four (4) Water Quality Vulnerabilities and Issues of Concern for Spring Creek

## *8) Copper pollution associated with human activities*

Copper (Cu) is a measure of all dissolved copper in the water column, including hexavalent, bivalent, and trivalent ions. It is a resultant parameter that synthesizes many environmental inputs of copper including: dissolved copper from roadways; antifouling paints for marine applications; treated wood, such as pilings; aquatic algaecides and lake treatments; architectural sources; marine cathodes; human debris; and natural sources.

In December 2008, the City of Naples, just outside the Estero Bay watershed, enacted a ban on copper-containing herbicides commonly used in city lakes for control of aquatic plants. The ordinance states that, "…amending the existing Code to prohibit the use of copper sulfate or any other copper-containing herbicide in City lakes is likely to provide enhanced environmental protection to Naples Bay, decrease the amount of copper entering the City's lakes and natural waterways, including Naples Bay, thus improving water quality…" (City of Naples 2008). At the time of this writing, the Florida Department of Agriculture and Consumer Services has restricted the City of Naples from enforcing this ban.

According to USEPA National Recommended Water Quality Criteria, the "Criterion Continuous Concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect" (US Environmental Protection Agency 2009). For copper in marine or estuarine systems, the CCC is 3.1 µg/L and in freshwater systems, the CCC is 9.0 µg/L. This appears to be a tightening of the federal standards. The general state standard for copper is 3.7 µg/L in Class III marine and Class II fresh waters.

The Lee County Environmental Laboratory had a methodological change in 2009, with results driven substantially by the methods change. The map of impairments will be the only copper information presented in this report. Estuarine Imperial River and estuarine Spring Creek are the two verified impairments for copper within the Estero Bay basin.

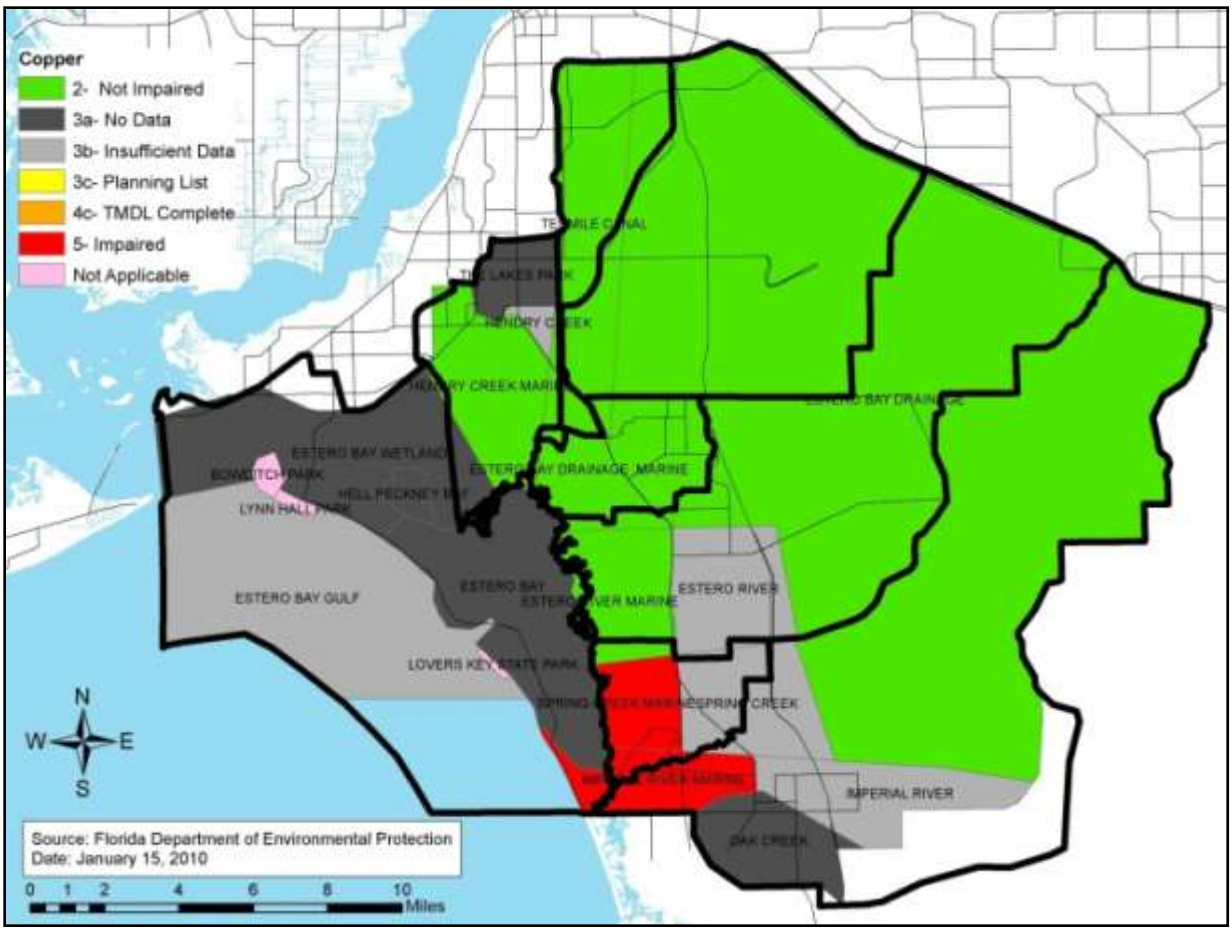



Figure 50: Copper FDEP Impairments

Based upon the most recent FDEP listing of impairments (DEP TMDL homepage http://www.dep.state.fl.us/water/tmdl/index.htm and interactive maps http://fdep.maps.arcgis.com/home/ ) Spring Creek remains impaired for copper.

There is no effective safe way to remove dissolved copper pollution from the water column once it is in the creek. If sediments are enriched with copper they can be removed but the process can re-suspend the copper back into the water column. The most effective way to address a copper impairment is to utilize source reduction. The simple approach would be to

1. No longer allow the use of copper based herbicides and algaecides in the Spring Creek watershed
2. Phase out the use of copper based anti-foulant boat paints
3. Phase out the use of copper/chromium/arsenate dock pilings and require repair replacements to use inert materials

4. Plug major road bridge scuppers and direct bridge flows to stormwater treatment ponds rather than allow direct discharge of road copper into Spring Creek

Restoration recommendation 8: At this time, because of state preemption of copper sulfate regulation the most likely approach to address copper pollution in the Spring Creek Watershed would be to enter into a Basin Management Action Plan (BMAP) with FDEP in coordination with the FDACS that would allow for a copper use reduction plan for the watershed.

## *9) Bacterial pollution as indicated by fecal coliform in the freshwater and estuarine parts of Spring Creek*

Fecal coliform is a measure of bacteriological contamination of the water column based on the activity of *Escheria coli*, commensal bacteria of higher vertebrates. It is a surrogate measure for other more harmful bacteriological and viral contaminants associated with waste material from human and vertebrate fecal discharges. This parameter includes inputs from many environmental inputs of fecal waste including human sewage (from vessel holding tanks, septic tanks, land sludge spreading, and package and other sewage treatment plants), waste from livestock (including cattle and chickens), and waste from wild and feral animals. Fecal coliform can also be naturally high in association with active bird rookeries; therefore, a healthy estuary with normal animal activity will have a natural background level.

According to State of Florida standards, a measurement of more than 800 bacterial colonies per 100 mL on any single day of sampling or a monthly average of 200 colonies per 100 mL indicates impairment in Class III waters. Based on EPA recommendations, Florida's fecal Coliform standards are likely to be amended in the next year or two.

Between 2009 and 2013, average fecal Coliform in estuarine Spring Creek increased an average of 53%. The peak monthly fecal Coliform decreased 13% . The most common peak month was September (40%), however June, August, and October were also represented.

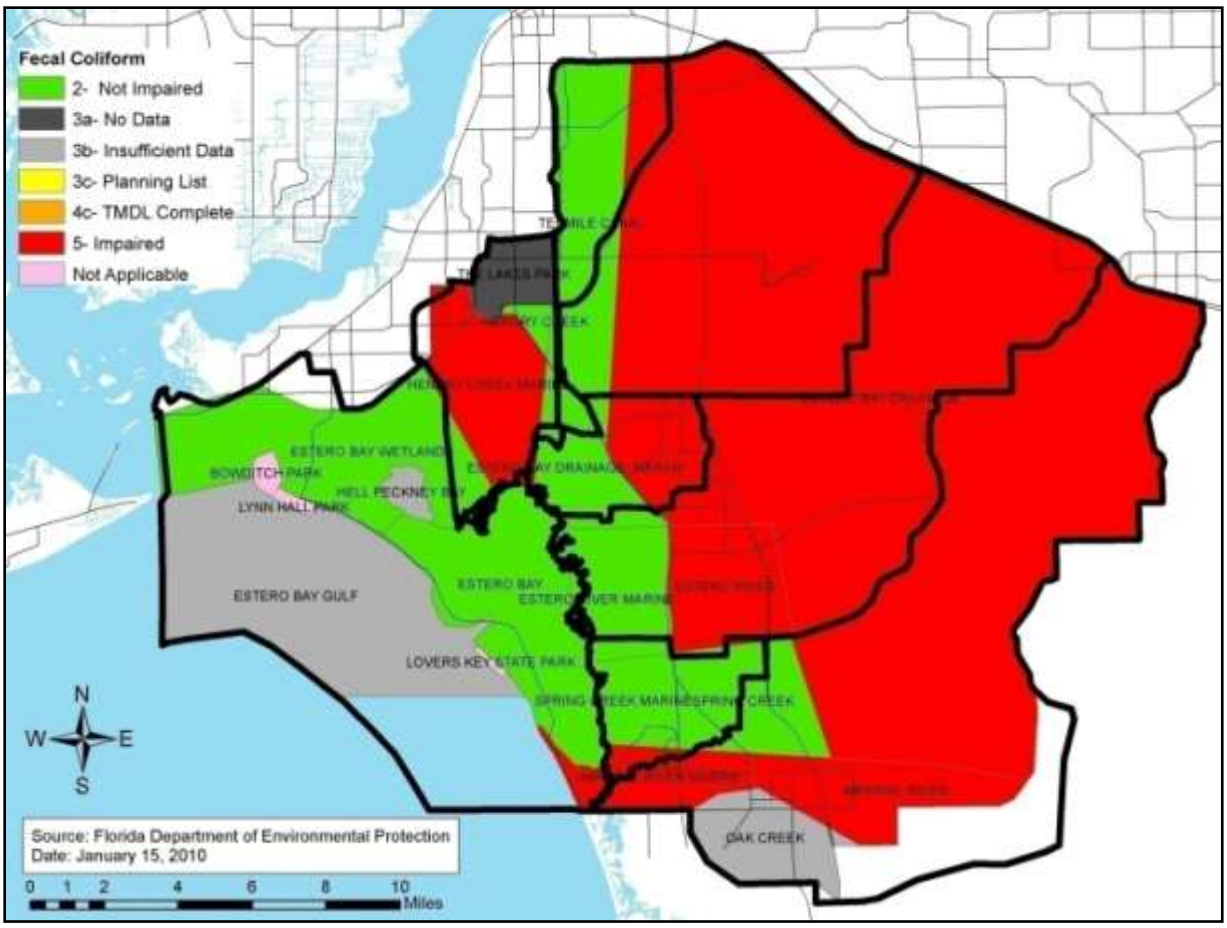


Figure 51: Fecal Coliform FDEP Impairments

| | |
|---|---|
| 2009-2013 change | |
| average | 53% |
| peak | -13% |

| Year | Mean | Peak | Month of Peak |
|---|---|---|---|
| 2009 | 137 | 497 | October |
| 2010 | 206 | 391 | September |
| 2011 | 159 | 281 | August |
| 2012 | 293 | 1,280 | June |
| 2013 | 210 | 432 | September |

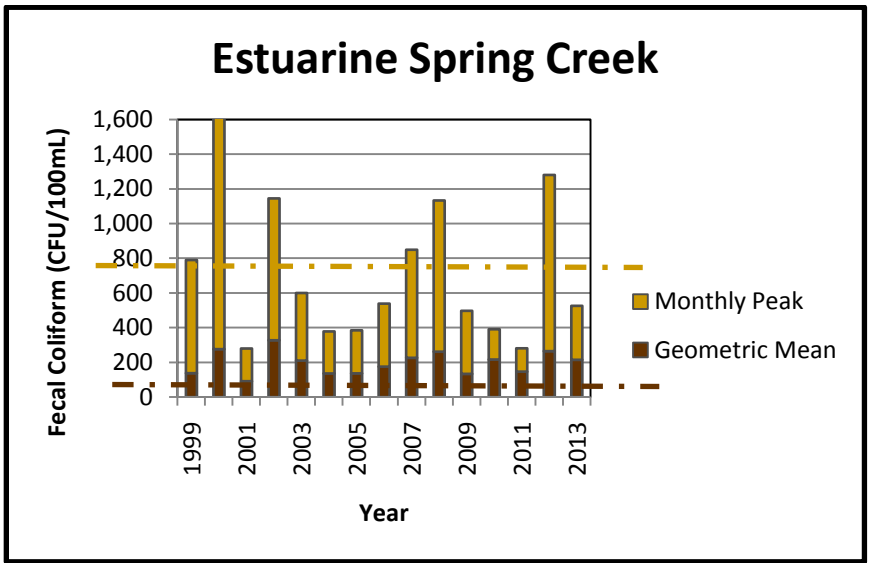



Figure 52: Fecal Coliform in Estuarine Spring Creek

Between 2009 and 2013, average annual fecal Coliform decreased in freshwater Spring Creek. The peak monthly fecal Coliform increased in freshwater, Spring Creek and Imperial River. The average increase was 215%. There was no common peak

| | |
|---|---|
| average | 234% |
| peak | 215% |

| Year | Mean | Peak | Month of Peak |
|---|---|---|---|
| 2009 | 66 | 168 | August |
| 2010 | 68 | 214 | June |
| 2011 | 123 | 500 | July |
| 2012 | 249 | 1,300 | February |
| 2013 | 219 | 530 | April |

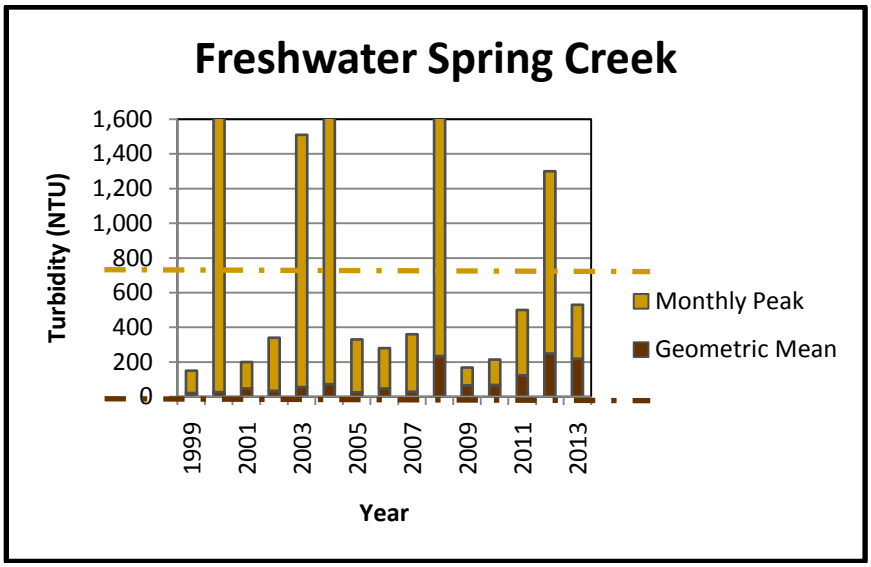



Figure 53: Fecal Coliform in Freshwater Spring Creek

The sources of fecal coliform pollution in Spring Creek are from human, domestic pets, livestock, and wildlife. The Spring Creek watershed does not have any major bird rookeries or wildlife concentrations of waste products that would be a major contributor above background natural levels of fecal coliform. There is cattle grazing in parts of the middle watershed that is seasonal and perhaps associated with tax assessment purposes more than stock production. Human sourced fecal coliform sources include direct contributions in package treatment plants, septic tanks, and homeless camps. Indirect human fecal coliform contributions include domestic pets that are not picked up after, application of natural manure based fertilizers, and although it is not documented , potential land spreading of sludge for agriculture range enhancement.

The solution to human based fecal pollution in a watershed is source reduction. While on-site wastewater treatment systems (OSWTS), AKA septic tanks, can work properly, if they are not maintained the failure will pollute surficial ground waters and lead to pollution of receiving canals and creeks. In the absence of a regular inspection, pump-out and repair-if-needed program older systems increasingly have a probability of failure. Package treatment plants can also work well but will on occasion fail if not maintained properly.

Restoration recommendation 9: The best approach to address fecal coliform pollution in Spring Creek is the following;

a) Adoption and Implementation of a model resolution based on the **Managed Care Model Guidance for Onsite Wastewater Systems Planning, Treatment and Management #2008-02** adopted by the SWFRPC

b) Adoption and Implementation of a model resolution based on the **Wastewater Package Treatment Plant #2007-5** adopted by the SWFRPC

c) Fencing of livestock from the sections of Spring Creek providing a minimum distance of 30 feet from the Creek banks and any channels leading into the creek Note that 100 feet would be optimal.

d) An education program for residents on the importance of picking up after pet waste for human and pet health as well as water quality

## *10) Increases in nitrogen in the freshwater and estuarine parts of Spring Creek*

Parameter: Total Nitrogen

Total nitrogen (TN) is a measure of all dissolved nitrogen in the water column, including nitrates, nitrites and ammonia. It is a resultant parameter that synthesizes many environmental inputs of nitrogen, including the dissolved organics from algae, sea grass, mangrove, and phytoplankton productivity. Also included are anthropogenic inputs, such as from agriculture and fertilizer over-application, which may run off into water bodies.

The USEPA Nutrient Criteria for this area, Aggregate Ecoregion XII, the Southeastern Coastal Plain, is 0.9 mg/L for rivers and streams (USEPA 2000). While the state of Florida has in the past had only narrative criteria for nutrients in water bodies, in response to a lawsuit by the Sierra Club, the Conservancy of Southwest Florida, the Florida Wildlife Federation, and others, USEPA recently issued a determination letter requiring the state to determine and adopt numeric nutrient standards for nitrogen and phosphorus in water bodies. USEPA has stated that the state must propose nutrient limits by January 14, 2010 and the resultant rule must be finalized by October of 2010.

The Lee County Environmental Laboratory provided the data for all total nitrogen analysis. Because nitrogen standards were not adopted before the last water quality assessment conducted for Estero Bay basin, no such map is available to date.

Between 2009 and 2013, average annual total nitrogen increased in estuarine Spring Creek by 40%. However it is still below standards for being considered impaired. The peak monthly nitrogen increased an average of 39%. The most common peak month was January (40%). Other months included July, September and November.

| | | | |
|---|---|---|---|
| Change | | | |
| average | 42% | | |
| peak | 39% | | |
| | | | |
| Year | Mean | Peak | Month of Peak |

| | | | |
|---|---|---|---|
| 2009 | 0.77 | 1.26 | January |
| 2010 | 1.06 | 1.42 | January |
| 2011 | 1.19 | 1.90 | November |
| 2012 | 1.13 | 1.55 | July |
| 2013 | 1.09 | 1.75 | September |

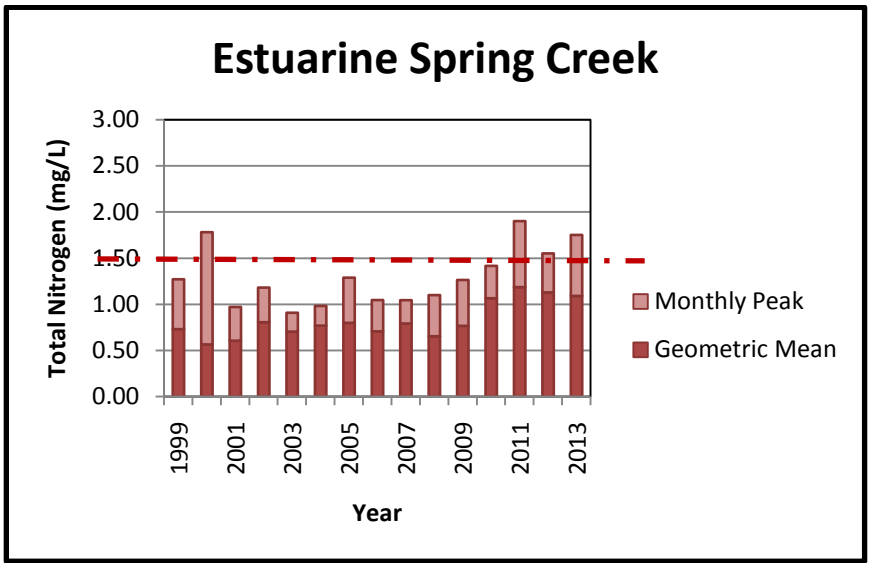



Figure 54: Total Nitrogen in Estuarine Spring Creek

Between 2009 and 2013, average annual total nitrogen increased in freshwater Spring Creek by 54%. The peak monthly total nitrogen increased for an average of 25%. A The most common peak months were September (50%) and June (50%).

| Change | |
|---|---|
| average | 54% |
| peak | 25% |

| Year | Mean | Peak | Month of Peak |
|---|---|---|---|
| 2009 | 0.69 | 1.20 | June |
| 2010 | 0.91 | 1.50 | September |
| 2011 | 1.08 | 1.60 | June |
| 2012 | 1.16 | 1.40 | June |
| 2013 | 1.06 | 1.50 | September |

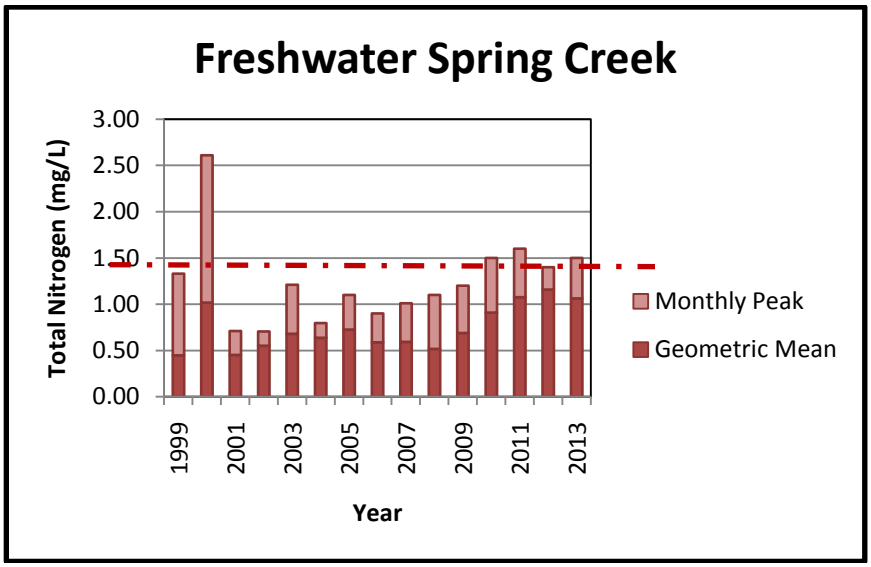



Figure 55: Total Nitrogen in Freshwater Spring Creek

The southwest Florida region has been proactive in addressing nutrient pollution at the local level. The Lower West Coast Watersheds Committee of the Southwest Florida Regional Planning Council developed a resolution regarding fertilizer regulation, which was adopted by Lee County as an ordinance in May of 2008. The ordinance regulates the nitrogen and phosphorus content of landscaping fertilizers, establishes a fertilizer black-out period during the rainy season, and establishes a 10-foot no-fertilizer buffer around waterbodies. All the municipalities in Lee County have followed suit, adopting the Lee County standards in whole, or some variation.

The fertilizer ordinance has shown positive effects in reducing nitrogen loads from domestic residential and commercial sources in southwest Florida watersheds. The four remaining unaddressed nitrogen sources are atmospheric deposition, nitrogen-fixation by certain plants particularly algae, golf course, and agricultural activities. Of these four the most available for improvement is golf course management practices. There are several innovative methods to reduce the use of nitrogen fertilizers on golf courses that improve golf course management, and reduce operations costs. These include the City of Sanibel Golf Course Nutrient and Lake Management Recommendations (BMPs) and the Audubon Golf Course Certification program.

Nitrogen from atmospheric deposition is principally from sources external to the control of the City of Bonita Springs including power plants, incinerators, various industries, and exhaust from internal combustion engines in a greater south Florida air-shed. The presence of nitrogen fixing bacteria and algae can be reduced in the Spring Creek watershed by improvements in the trophic index of stormwater ponds, borrow pits, and the creek itself. This can be achieved in part by management methods of ponds and lakes including littoral shelves vegetated with emergent vegetation, aerators to keep water moving in a system, and floating island filter vegetation mats.

Restoration recommendation 10: The best approaches to address nitrogen pollution in Spring Creek are the following;

a) Continued implementation and enforcement of the stricter local fertilizer restrictions adopted by the City of Bonita Springs
b) Work with the local golf course managers in the Spring Creek Watershed to move toward improved fertilizer management on their golf courses utilizing the City of Sanibel Golf Course Nutrient and Lake Management Recommendations (BMPs)
c) Fencing of livestock from the sections of Spring Creek providing a minimum distance of 30 feet from the creek banks and any channels leading into the creek. Note that 100 feet would be optimal
d) Work with local stormwater pond managers to install and operate littoral shelves vegetated with emergent vegetation, aerators to keep water moving in a system, and floating island filter vegetation mats in a program similar to that utilized by the City of Naples
e) Continue the education program for residents on the importance of fertilizer management for good water quality in Spring Creek

## *11)The low dissolved oxygen events can likely be improved by addressing the issues of hydrologic flow, nutrients, and anthropogenic oxygen demanding pollution sources*

Dissolved Oxygen (DO) is a measure of all dissolved oxygen in the water column. DO is vital to aerobic organisms in the aquatic ecosystem, and most higher taxa require higher DO levels for healthy life cycles and successful reproduction. Many factors affect DO including wind mixing, turbulence, flow volumes and rates, biochemical oxygen demand, algal blooms, photosynthesis and respiration, salinity and thermal stratification, anthropogenic eutrophication, and toxic spills.

Florida's water quality standards state that dissolved oxygen in Class III freshwaters, "…shall not be less than 5.0 [mg/L]," and in Class III marine waters, "Shall not average less than 5.0 in a 24-hour period and shall never be less than 4.0." (Florida State Legislature 2008) Some natural estuaries will experience periods of low DO, during the night due to community respiration exceeding the level of dissolved oxygen in the water column. This is rapidly recovered by community photosynthesis during the day. Prolonged periods of DO below 4.0 mg/L indicate problems. These may be transient, such as an algal bloom. However, prolonged systemic DO depression from anthropogenic inputs and other excess nutrient loading (such as atmospheric deposition) is not recoverable without source reduction efforts. Conditions below 2.0 mg/L are considered anoxic and can be fatal to most fishes and invertebrates.
The map illustrates the water quality assessment for Estero Bay basin waterbodies.

The Lee County Environmental Laboratory provided the data for all dissolved oxygen data.

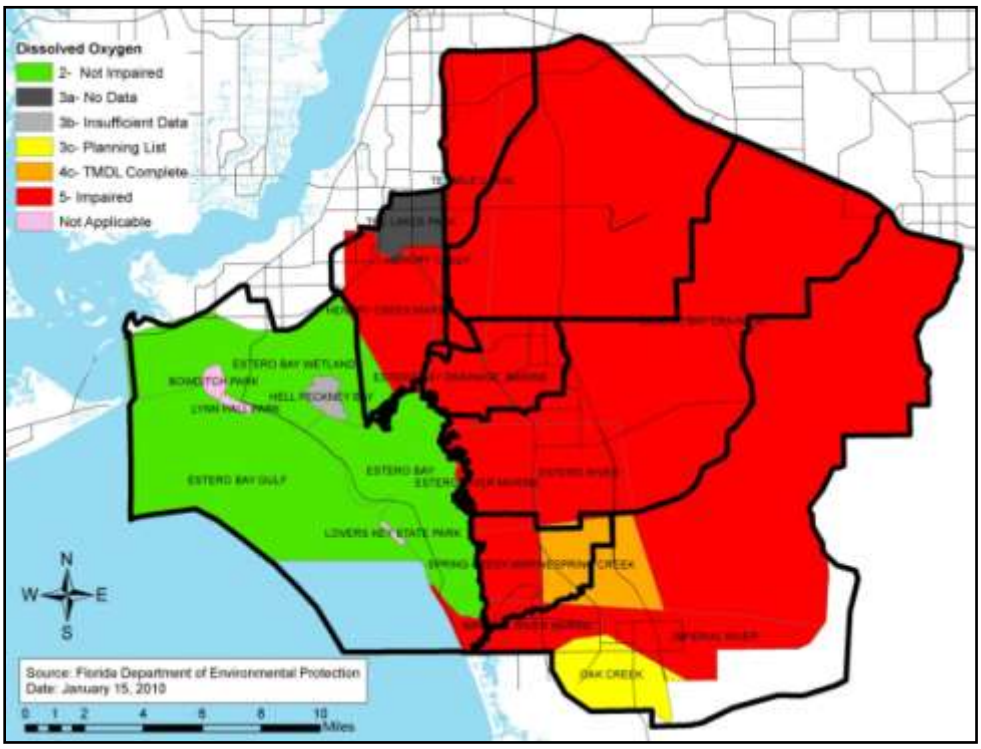



Figure 56 Dissolved Oxygen FDEP Impairments

Between 2009 and 2013, average dissolved oxygen in estuarine Spring Creek had an average decrease that was negligible at 9%. The monthly minimum dissolved oxygen decreased in estuarine Spring Creek by 27%. The most common minimum month was June (60%), however April and November are also represented.

2009-2013 change
average -9%
minimum -27%

| Year | Mean | Min | Month of Min |
|---|---|---|---|
| 2009 | 2.8 | 1.7 | November |
| 2010 | 3.7 | 2.6 | June |
| 2011 | 2.6 | 0.6 | June |
| 2012 | 2.3 | 0.5 | June |
| 2013 | 2.6 | 1.2 | April |

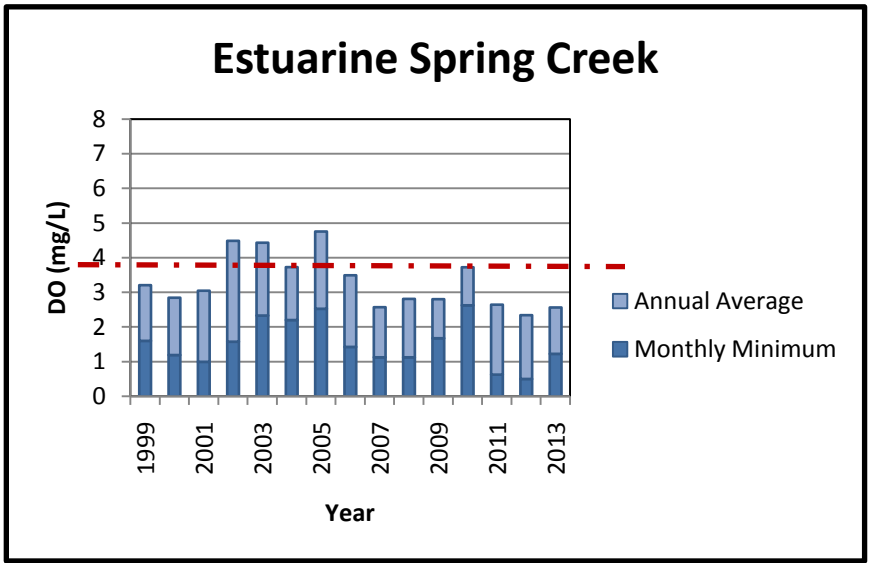



Figure 57: Dissolved Oxygen in Estuarine Spring Creek

Between 2009 and 2013, average dissolved oxygen in freshwater Spring Creek had an average increase of 14%. The monthly minimum dissolved oxygen decreased in freshwater Spring Creek by 6%. The most common minimum month was July (40%), however June, September, and December are also represented.

2009-2013

| Change | |
|---|---|
| average | 14% |
| minimum | -6% |

| Year | Mean | Min | Month of Min |
|---|---|---|---|
| 2009 | 4.5 | 3.2 | June |
| 2010 | 6.8 | 4.6 | September |
| 2011 | 4.5 | 0.9 | July |
| 2012 | 5.3 | 3.0 | July |
| 2013 | 5.1 | 3.0 | December |

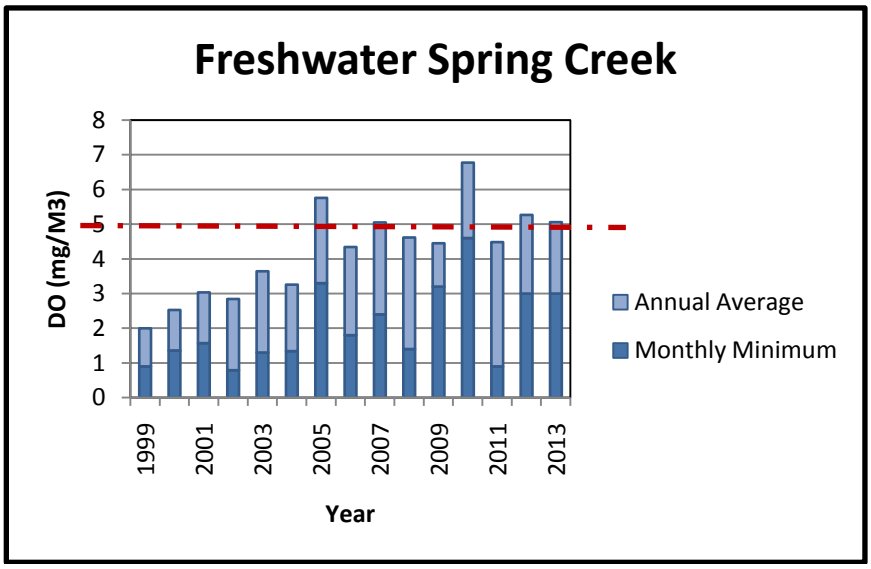



Figure 58: Dissolved Oxygen in Freshwater Spring Creek

Improvement in the flows of Spring Creek by implementation of the restoration recommendations 1 through 7 and implementation of the water quality recommendations 8 through 10 would likely improve the dissolved oxygen issues identified in Spring Creek proper. In addition the utilization littoral shelves vegetated with emergent vegetation, aerators to keep water moving in a system, and floating island filter vegetation mats in a program similar to that utilized by the City of Naples could significantly improve dissolved oxygen conditions within communities of the Spring Creek Watershed.

Restoration recommendation 11: The best approaches to address low dissolved oxygen levels in the Spring Creek watershed are:

a) Implementation of the restoration recommendations 1 through 7 and implementation of the water quality recommendations 8 through 10 of this report

b) Working with local stormwater pond managers to install and operate littoral shelves vegetated with emergent vegetation, aerators to keep water moving in a system, and floating island filter vegetation mats in a program similar to that utilized by the City of Naples

# PART 3: Creek and Riparian Habitats: Summary of the Five (5) Habitat Vulnerabilities and Issues of Concern for Spring Creek

## *12) Completing the proposed Florida Forever Land Acquisitions*

Potential future acquisition sites are identified through the state's Florida Forever program and through the Lee County Master Mitigation Plan, SWF RRCT Restoration Needs, and SWFFS Alternatives Development Group. The predecessor to the Florida Forever program is the Conservation and Recreation Lands (CARL) program.

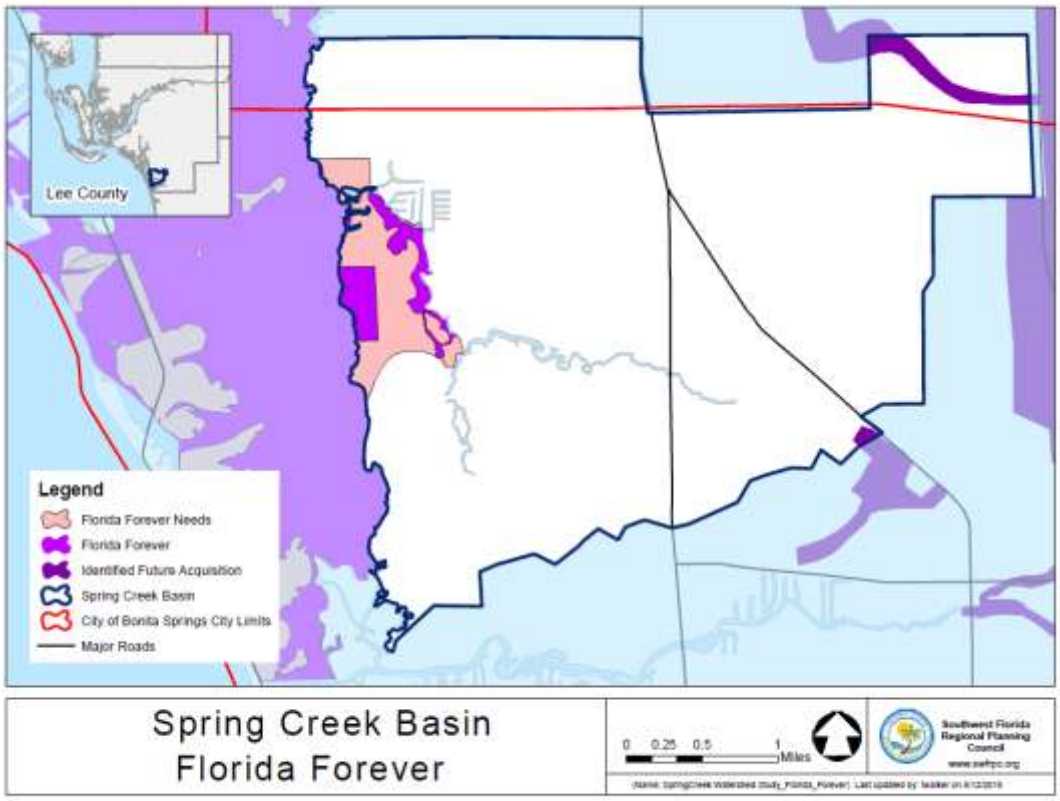



Figure 59: Identified Lands for Potential Future Acquisition

Sources: Florida Natural Areas Inventory, Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program (Lee County Master Mitigation Plan Mapping).

All the identified Florida Forever land parcels (shown in pink on Figure 59) are located in the lower Spring Creek watershed at and near the mouth of the creek.


(270.25 GIS acres) Mangrove swamp, tidal marsh, salt flats + an eagles nest – surrounds isolated area of state lands – provides buffer from adjacent development & golf course – contributes towards protecting water quality in Estero Bay Aquatic Preserve.

Figure 60: Identified Lands for Potential Future Acquisition

Figure 60 is from the last adopted Identified Lands for Potential Future Acquisition. A few of these small parcels have since been developed. We examined the current property records for the sites remaining that are not now in public conservation ownership or have been developed.


Figure 61: Identifier Numbers for Lands for Potential Future Acquisition
Source SWFRPC 2016

We created Figure 60 to label the remaining parcels in the acquisition area. In the preceding Figure 60 the Parcels 5, 7, 9, and 15 are now developed in buildings or

roadways. Parcel 14 is currently state land that is part of the Estero Bay State Park. The other parcels are lands that should be protected as part of the Estero Bay State Park. Parcels 1, 4, and 15 currently have conservation easements on them and may not need to be acquired in a fee-simple format if a management agreement can be reached with the easement holders.

| ID # | NAME | STREET ADDRESS | CITY | STATE | ZIP |
|---|---|---|---|---|---|
| 1 | BAYSIDE IMPROVEMENT CDD | 2300 GLADES RD STE 410W | BOCA RATON | FL | 33431 |
| 2 | BONITA BAY COMMUNITY ASSN | 3531 BONITA BAY BLVD STE 200 | BONITA SPRINGS | FL | 34134 |
| 3 | BONITA BAY COMMUNITY ASSN INC | 3531 BONITA BAY BLVD STE 200 | BONITA SPRINGS | FL | 34134 |
| 4 | BRIGGS H H + LYDIA | 12 PERCH POND RD | CAMPTON | NH | 03223 |
| 6 | GINOS KEVIN T TR | PO BOX 1327 | NAPLES | FL | 34106 |
| 8 | MINETT HARRY P + | 1027 CAPTAIN ADKINS DR | SOUTHPORT | NC | 28461 |
| 10 | PENINSULA SAILFISH LLC | 28 RESEARCH PARK CIR | SAINT CHARLES | MO | 63304 |
| 11 | PENINSULA SAILFISH LLC | 28 RESEARCH PARK CIR | SAINT CHARLES | MO | 63304 |
| 12 | PENINSULA SAILFISH LLC | 28 RESEARCH PARK CIR | SAINT CHARLES | MO | 63304 |
| 13 | PENINSULA SAILFISH LLC | 28 RESEARCH PARK CIR | SAINT CHARLES | MO | 63304 |
| 16 | WHEELER HOWARD JR | 2546 EDISON AVE | FORT MYERS | FL | 33901 |
| 17 | WHEELER JAMES H | 24593 DOLPHIN ST | BONITA SPRINGS | FL | 34134 |
| 18 | WHEELER JAMES H | 24593 DOLPHIN ST | BONITA SPRINGS | FL | 34134 |
| 19 | WHEELER JAMES H + CARLA | 24593 DOLPHIN ST | BONITA SPRINGS | FL | 34134 |

Figure 62: Property Owners of the Identified Lands for Potential Future Acquisition

| ID # | STRAP | BLOCK | LOT | FOLIOID | HIDE_STRAP | TRSPARCEL |
|---|---|---|---|---|---|---|
| 1 | 184725B2000010030 | 00001 | 0030 | 10546367.00000000000 | N | 472518B2000010030 |
| 2 | 194725B3000050000 | 00005 | 0000 | 10281187.00000000000 | N | 472519B3000050000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 204725B4000050000 | 00005 | 0000 | 10281200.00000000000 | N | 472520B4000050000 |
| 4 | 174725B40010D0210 | 0010D | 0210 | 10280389.00000000000 | N | 472517B40010D0210 |
| 6 | 184725B3000030000 | 00003 | 0000 | 10281182.00000000000 | N | 472518B3000030000 |
| 8 | 184725B3000020000 | 00002 | 0000 | 10281181.00000000000 | N | 472518B3000020000 |
| 10 | 204725B1000010000 | 00001 | 0000 | 10281192.00000000000 | N | 472520B1000010000 |
| 11 | 204725B1000011000 | 00001 | 1000 | 10281198.00000000000 | N | 472520B1000011000 |
| 12 | 204725B1000012000 | 00001 | 2000 | 10281199.00000000000 | N | 472520B1000012000 |
| 13 | 174725B4000010070 | 00001 | 0070 | 10280233.00000000000 | N | 472517B4000010070 |
| 16 | 174725B40010D0190 | 0010D | 0190 | 10280387.00000000000 | N | 472517B40010D0190 |
| 17 | 174725B40010D0200 | 0010D | 0200 | 10280388.00000000000 | N | 472517B40010D0200 |
| 18 | 174725B40010D0180 | 0010D | 0180 | 10280386.00000000000 | N | 472517B40010D0180 |
| 19 | 174725B40010A0490 | 0010A | 0490 | 10280326.00000000000 | N | 472517B40010A0490 |

Figure 63: Legal Descriptions of the Identified Lands for Potential Future Acquisition

| ID # | GISACRES | ZONING | LAND USE | LEGAL | Online Site |
|---|---|---|---|---|---|
| 1 | 25.20 | RM-2 | RESOURCE PROTECT., WETLANDS, PRESERVE, CYPRESS HEAD | PARL LYING IN S 990 FT OF GOVT LOT 2 IN SEC 18 + PORT IN SW 1/4 OF SW 1/4 OF NW 1/4 OF SEC 17 AS DESC IN INST#2007-213558 | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10546367 |
| 2 | 40.97 | AG-2 | MANGROVE | GOVT LOT 2 MAINLAND PART SWAMP LESS GOLF COURSE + LESS OR 3135/1435 | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10281187 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | 121.69 | PUD | ACREAGE, NON-AGRICULTURAL, 20 ACRES OR MORE | PAR IN S 1/2 OF SEC LESS S/D + LESS GOLF COURSE LESS 5.00CE LESS OR 3190 PG 587 | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10281200 |
| 4 | 0.03 | RS-1 | MANGROVE | ESTERO BAY SHORES UNIT 1 BLK D PB 12 PG 11 LOT 21 | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10280389 |
| 6 | 35.79 | AG-2 | RESOURCE PROTECT., WETLANDS, PRESERVE, CYPRESS HEAD | GOVT LOT 4 LOCATED IN SEC 18 TWN 47 RGE 25 MAINLAND | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10281182 |
| 8 | 22.21 | AG-2 | MANGROVE | GOVT LOT 3 LOCATED IN SEC 18 TWN 47 RGE 25 MAINLAND | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10281181 |
| 10 | 50.51 | AG-2 | RESOURCE PROTECT., WETLANDS, PRESERVE, CYPRESS HEAD | THE S 1/2 OF NW 1/4 LYING S + W OF THAT CERTAIN CHANNEL SPRING CREEK LYING | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10281192 |
| 11 | 18.69 | AG-2 | RESOURCE PROTECT., WETLANDS, PRESERVE, CYPRESS HEAD | S 1/2 OF N 1/2 OF NW 1/4 LYING S + W OF C/L OF MOST ELY CHANNEL OF SPRING CRK | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10281198 |
| 12 | 18.66 | AG-2 | RESOURCE PROTECT., WETLANDS, PRESERVE, CYPRESS HEAD | N 1/2 OF N 1/2 OF NW 1/4 LYING S + W OF C/L OF MOST ELY CHANNEL OF SPRING CRK | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10281199 |

| | | | | | |
|---|---|---|---|---|---|
| 13 | 22.96 | AG-2 | MANGROVE | ALL THAT PART OF SW 1/4 LYING WEST + SOUTH OF WATERS OF SPRING CREEK | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10280233 |
| 16 | 0.29 | RS-1 | MANGROVE | ESTERO BAY SHORES UNIT 1 BLK.D PB 12 PG 11 LOT 19 | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10280387 |
| 17 | 0.03 | RS-1 | MANGROVE | ESTERO BAY SHORES UNIT 1 BLK.D PB 12 PG 11 LOT 20 | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10280388 |
| 18 | 0.04 | RS-1 | MANGROVE | ESTERO BAY SHORES UNIT 1 BLK.D PB 12 PG 11 LOT 18 | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10280386 |
| 19 | 0.27 | RS-1 | MANGROVE | ESTERO BAY SHORES UNIT 1 BLK A PB 12 PG 11 LOT 49 | http://www.leepa.org/Display/Displayparcel.aspx?folioID=10280326 |

Figure 64: Further Details of the Identified Lands for Potential Future Acquisition

There are several different ways to acquire or otherwise protect these lands as conservation areas. The City of Bonita Springs could decide to provide a match of up to 50% to the FDEP for acquisition of parcel(s) which would significantly improve rankings of that site and increase the likelihood the land would be acquired for protection.

The parcel(s) could be nominated for purchase and purchased by the Lee County Conservation 2020 program. This presumes that the Conservation 2020 program will continue in the future following the referendum in November 2016.

The City of Bonita Springs could offer to transfer existing development rights off the parcel(s) to other locations within the City of Bonita Springs and receive a conservation easement in consideration of that transfer.

The City of Bonita Springs could work with an experienced non-governmental land protection entity such as the Conservancy of Southwest Florida, the Conservation Foundation of Southwest Florida, the Trust For Public Lands, the Nature Conservancy, and/or the Calusa Land Trust to acquire the properties for transfer to the State of Florida at a future date. This method has several advantages in terms of speed and improved negotiation relationships between the property owners and the NGO, as compared to a direct purchase by the government.

Restoration recommendation 12: The City of Bonita Springs should work with the FDEP, the Lee County Conservation 2020 program, and interested non-governmental conservation organizations and explore the use of transfer of development rights to secure the remaining unprotected properties in the Florida Forever Acquisition area at the mouth of Spring Creek. The best agreed-upon tool for protection should be utilized for each property and property owner.

## *13) Removing exotic vegetation from existing conservation easements*

There are 197.047 Hectares (486.92 acres) of the Spring Creek Watershed that are privately managed and are within a conservation easement. These easements are nearly all associated with private development permit requirements. FDEP, Lee County and SFWMD track conservation easements which are transferred to them as a result of development permitting, regardless of size using GIS from which the Figure 66 was derived.

Figure 65: Conservation Easements Holders

| Easement Holder | Total Hectares |
|---|---|
| FDEP | 28.43 |
| SFWMD | 66.57 |
| Lee County | 97.02 |
| Various | 5.03 |
| Total | 197.05 |

Easements are found on lands with underlying ownerships by Baywoods of Bonita Bay, Bonita Bay, Brooks of Bonita, Hyatt Equities, Keystone Development Group, Leffler & La Flamme, Minto Communities, Pelican Landing, Pueblo Bonita, SRK 50, and WCI Communities.

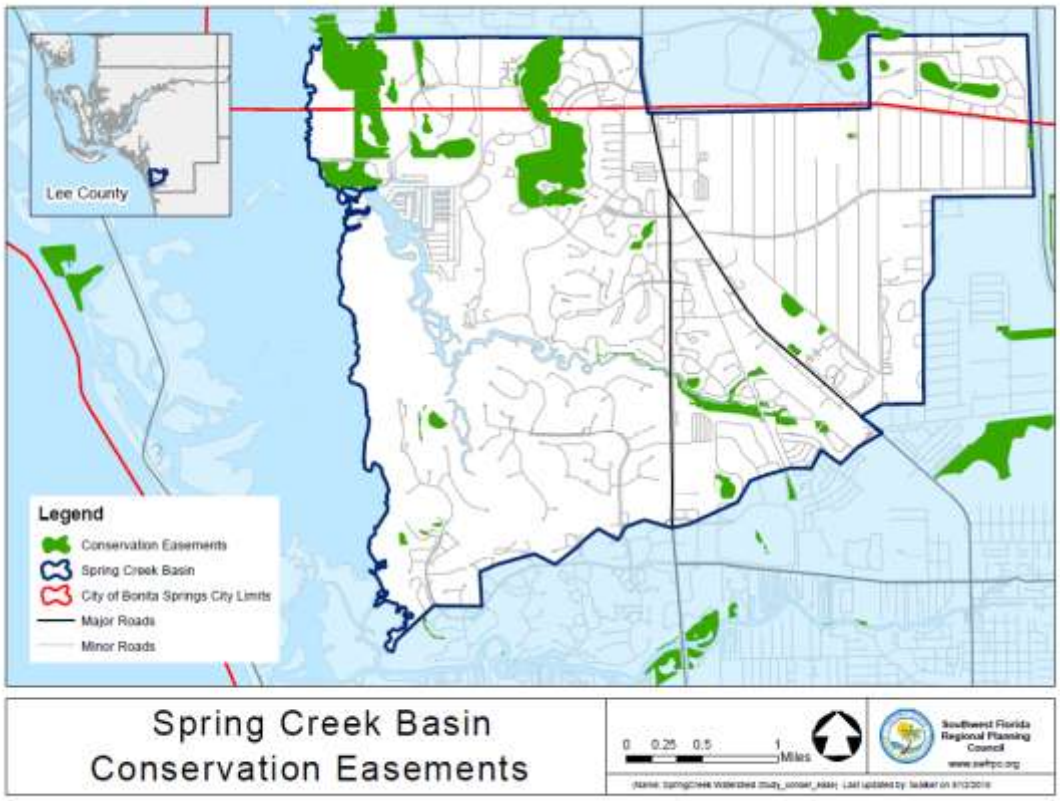



Figure 66: Conservation Easements in the Estero Bay Watershed

While many of these easements are well maintained and exotic vegetation is removed and controlled by responsible land management entities, in the course of the project exotic vegetation was observed in several of the conservation easements including Brazilian pepper, melaleuca, Australian pine, potato-vine, crabs-eye, Old-World climbing fern, bow-string hemp, and Caesar weed.

Generally the maintenance of exotic vegetation is a condition of conservation easements, but older easements may be silent on this or have a limited time period of exotic removal requirement often in the neighborhood of five years. The most successful program for exotic removal from private lands in a city jurisdiction in southwest Florida has been by the City of Sanibel. Their program that includes a combination of new construction and existing maintenance is a good model that includes education and certification of landscapers and builders. All contractors working with vegetation on Sanibel are required to possess a valid Certificate of Competency. All persons hired to plant, transplant, prune, trim, or remove native plants must have a current Competency Card or be supervised by someone who does.

Restoration recommendation 13: The City of Bonita Springs should consider an exotic plant program similar to that utilized by the City of Sanibel in supporting the removal of

exotic vegetation from the jurisdictional area of that city. This program could achieve removal of exotics from conservation easements as well as removal of sources of exotics during new construction, retro-fits and general landscape maintenance.

### *14) Removing exotics along the main channels of Spring Creek*

Invasive exotic vegetation is found along Spring Creek proper in the upper and middle watershed as far downstream of the Old US 41 bridge crossings. As discussed in the hydrology section exotic removal is needed and both the North Branch and South Branch of Spring Creek, including Railroad Right-Of-Way Canal-Ditches East and West, the FPL Right-Of-Way Canal-Ditches East and West, to the juncture of North Branch and South Branch of Spring Creek. Lee County has an ongoing cycle of Clean and Snag projects to maintain flows in tributary streams of Lee County. This program would likely be the best approach to address exotic vegetation within and flanking Spring Creek and its branches.

Restoration recommendation 14: The City of Bonita Springs should work with Lee County to implement a Clean and Snag project on Spring Creek, from its headwaters west of Interstate 75 to the juncture of the North and South Branches of the creek . Where the exotic vegetation is located beyond the creek floodplain, the city should work with the adjacent property owners to obtain permission to further remove exotics in those areas so as to achieve elimination of future sources of re-infestation.

### *15) Removing exotics with the stormwater management systems of existing developments with outfalls to Spring Creek*

Invasive exotic vegetation is found along Spring Creek proper in the stormwater management systems of several communities in the upper and middle watershed within The Brooks (sheetflow area and canals), the canals of San Carlos Estates, the Villages of Bonita subdivision perimeter ditch, within Cedar Creek Subdivision, and within Bernwood Business Park. Depending on the development orders associated with these developments there may already be exotic removal requirements that are the responsibilities of the property owners. For older communities the question of who is responsible for these features is very unclear. This question came up in several of the public meetings we held in the watershed with the communities' residents not knowing which entity was responsible for keeping drainage features maintained and clear of exotics. This matter is beyond the scope of this study and will likely require legal and real estate expertise looking at older documents establishing these communities' drainage district and surface water management systems.

Restoration recommendation 15: The City of Bonita Springs should work with the communities with stormwater management systems that discharge to Spring Creek to determine who is responsible for maintenance and removing exotic vegetation from their stormwater management systems. Where it is determined that the city is responsible it

can implement its programs to address this. Where it is determined that the property owners are responsible, then these communities may require assistance in organizing and identifying how they can implement a cleanup of their stormwater management system.

## *16) Creation of filter marshes in appropriate locations to offset the loss of freshwater headwater wetlands*

One of the important affirmative tools available to implement a BMAP is the restoration and/or creation of depressional or flats wetland treatment systems also known as filter marshes. These systems can reduce water quality pollution through the biological activity of vegetation and wetland metabolism. These processes reduce the pollution concentration and loading in the treatment wetland before discharge to the receiving waterbody.

There is a limited number of studies where the nutrient removal efficiencies of filter marshes have been measured directly with certified methods. Seven of the calibration filter marshes in southwest Florida have sufficient data. One of these, Powell Creek, was young and not yet at full nutrient removal efficiency at the time of measurement.

Figure 67: Southwest Florida Filter Marshes

Billy Creek Filter Marsh (Fort Myers)

Nitrogen removal = 20-40% and Phosphorus removal = 20-60%

Ford Canal Filter Marsh (Fort Myers)

Nitrogen removal = 30% and Phosphorus removal = 40%

Freedom Park Filter Marsh (Naples):

Nitrogen removal = 37-75% and Phosphorus removal = 47-84%

Lakes Park Filter Marsh (South Lee County):

Projected Nitrogen removal = 62.2% and Phosphorus removal = 78%

Popash Creek Filter Marsh (North Fort Myers, Lee Co):

Projected Nitrogen removal = 26% and Phosphorus removal = 43%

Powell Creek Filter Marsh at 1 year (North Fort Myers, Lee Co):

Nitrogen removal = 23.3% and Phosphorus removal = 31%

Ten Mile Canal Filter Marsh (South Lee County):

Nitrogen removal = 68% and Phosphorus removal = 82%

Mean for all documented Southwest Florida  Filter marshes

Mean TN =51.7% TP = 55.7%

These levels of nutrient reduction can have significant positive effects on nutrient loading to Spring Creek if filter marshes are constructed to serve runoff within and to the system.

We examined the potential locations where filter marshes could be created/installed in Spring Creek. Suitable areas need a large enough areal extant to capture flows and then provide sheetflow treatment with emergent vegetation of that portion of the flow from Spring Creek. The best site is located within San Carlos Estates at the wider parts of Strike Lane Canal at the  intersection with Red Robin Drive (Figure 68). This located is almost readapted for filter marsh use.


Figure 68 Potential Filter Marsh Site in San Carlos Estates associated with Strike Lane Canal
Source: Google Earth 2016

The second good site is within the Bernwood Business Park on the South Branch of Spring Creek. This pasture area has room for a multi-celled filter marsh system (Figure 69).


Figure 69: Potential Filter Marsh Site in Bernwood Business Park on the South Branch of Spring Creek
Source: Google Earth 2016

A less preferred site is the canals flanking the FPL easement (Figure 70). Although this area can cover both the North and South Branches of the Creek the narrow canals and issues of access, as well as potential complications with the easement holder, could make this a difficult site to construct and maintain. While there have been wetlands constructed within powerline easements in other locations, it was never an easy legal or physical engineering process.


Figure 70: Potential Filter Marsh Site at the FPL Easements on the North Branch of Spring Creek
Source: Google Earth 2016

Restoration recommendation 16: The City of Bonita Springs should consider establishing filter marshes for water quality and habitat improvement in the location identified in the west outflow of Strike Canal south of Red Robin Drive and the south branch within Bernwood Business Park.

# PART 4: Humans and Human Access

Figure 71: Canoeing Spring Creek
Source CHNEP 2015

### *17) Improving public access to Spring Creek viewing, canoeing and kayaking*

We examined and surveyed the existing and potential opportunities for launching and retrieving canoes and kayaks on the navigable Spring Creek watershed. This includes sites where a t-dock could be placed though a narrow mangrove fringe and sufficient area of upland for vehicle parking. We identified 5 existing kayak/canoe launch/landing sites indicated in blue dots on Figure 72.

Surveying the existing navigable shoreline located west of the Old US 41 Bridge that was not developed to the extent that prevents access or has natural resources of a large enough extent as to make access damaging to the habitats of the Creek, we found 5 potential new access sites.

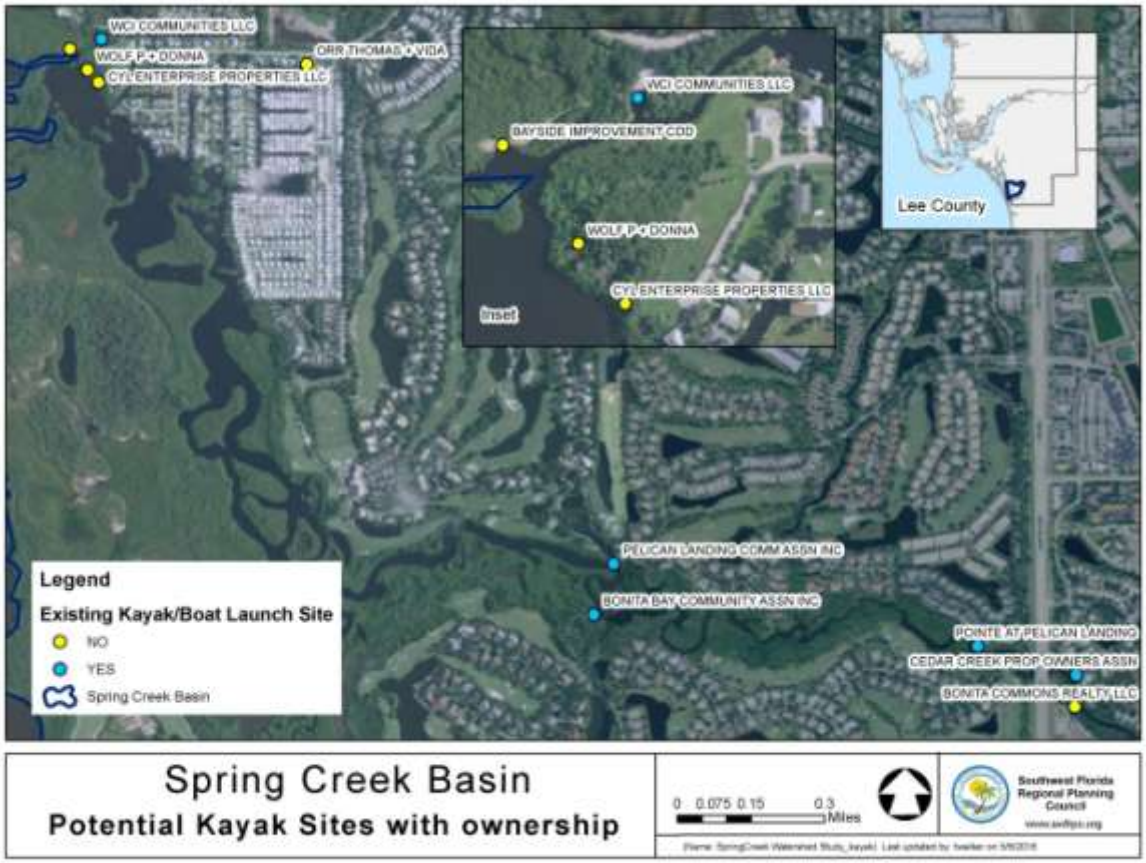



Figure 72: Existing and potential kayak/canoe sites on navigable Spring Creek.
Source: SWFRPC 2016


Figure 73: Bonita Commons LLC potential kayak/canoe sites on navigable Spring Creek. Source: SWFRPC 2016


Figure 74: Bayside Improvement CDD potential kayak/canoe sites on navigable Spring Creek.
Source: SWFRPC 2016


Figure 75: P. and Donna Wolf potential kayak/canoe site on navigable Spring Creek. Source: SWFRPC 2016


Figure 76: Thomas and Vida Orr potential kayak/canoe site on navigable Spring Creek. Source: SWFRPC 2016


Figure 77: CYL Enterprise Properties, LLC potential kayak/canoe site on navigable Spring Creek.
Source: SWFRPC 2016

Each potential site was then evaluated for its land use cover (Figure 78) and any impediments to use. This reduced the number of potential sites to three.

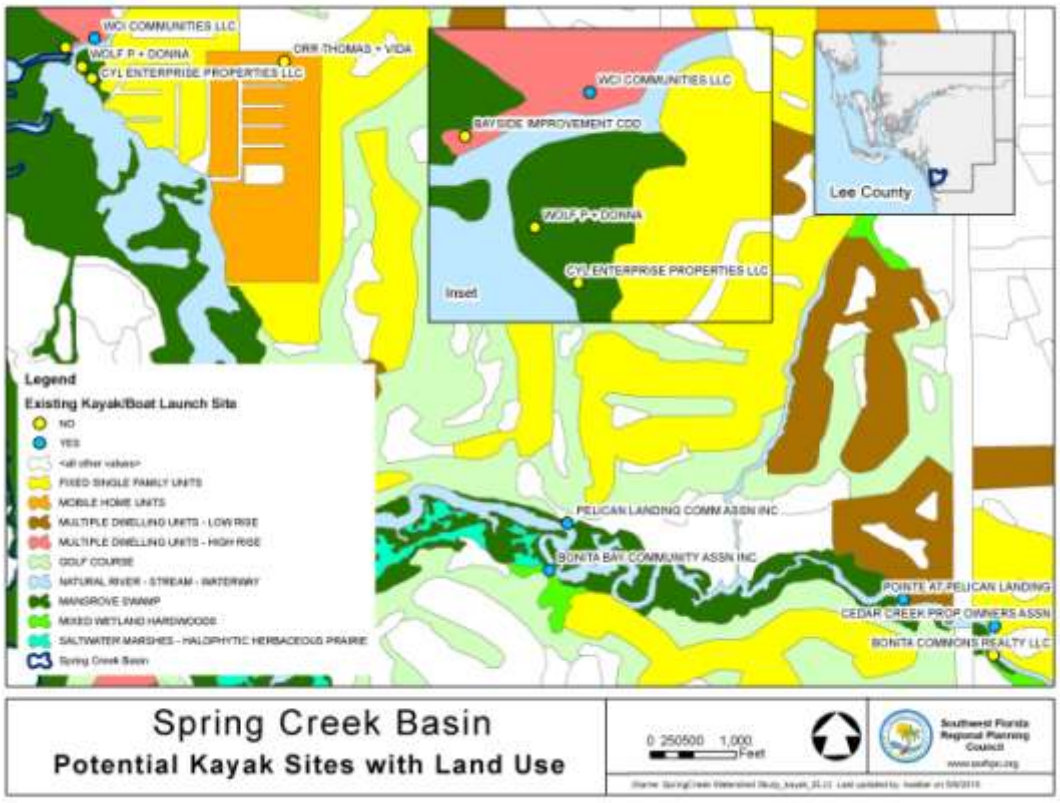



Figure 78: Landuse Map of Potential Kayak Sites on Navigable Spring Creek
Source: SWFRPC 2016

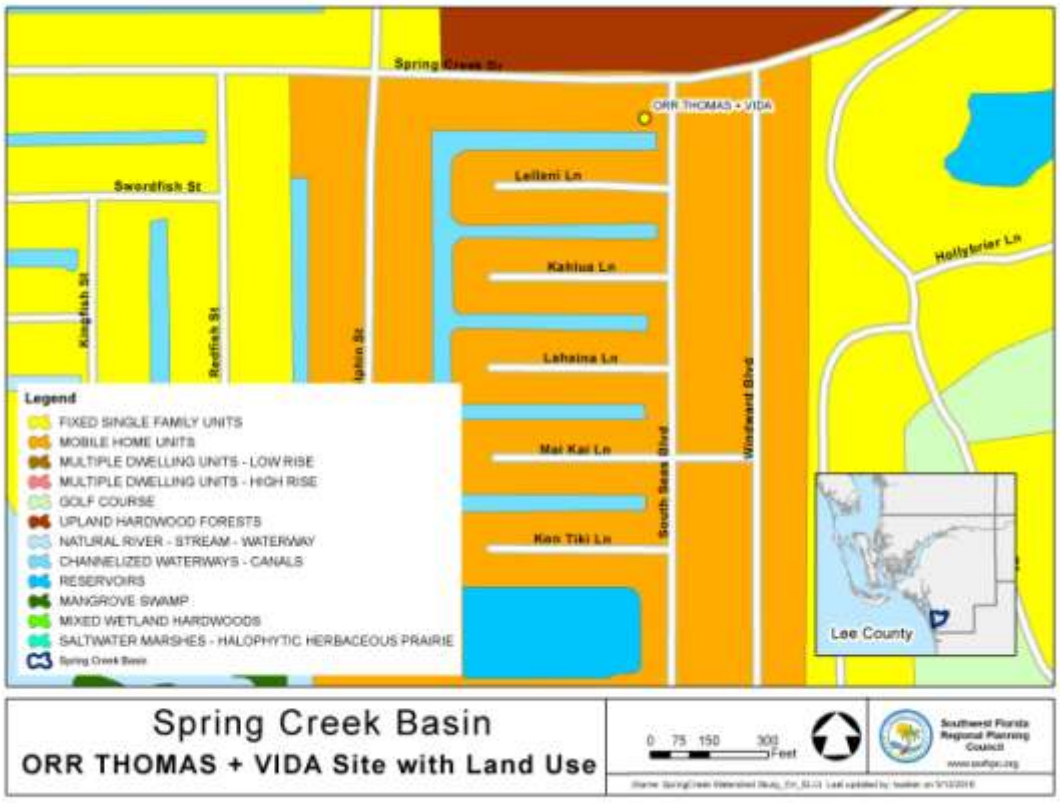



Figure 79: Landuse map Thomas and Vida Orr Site
Source: SWFRPC 2016

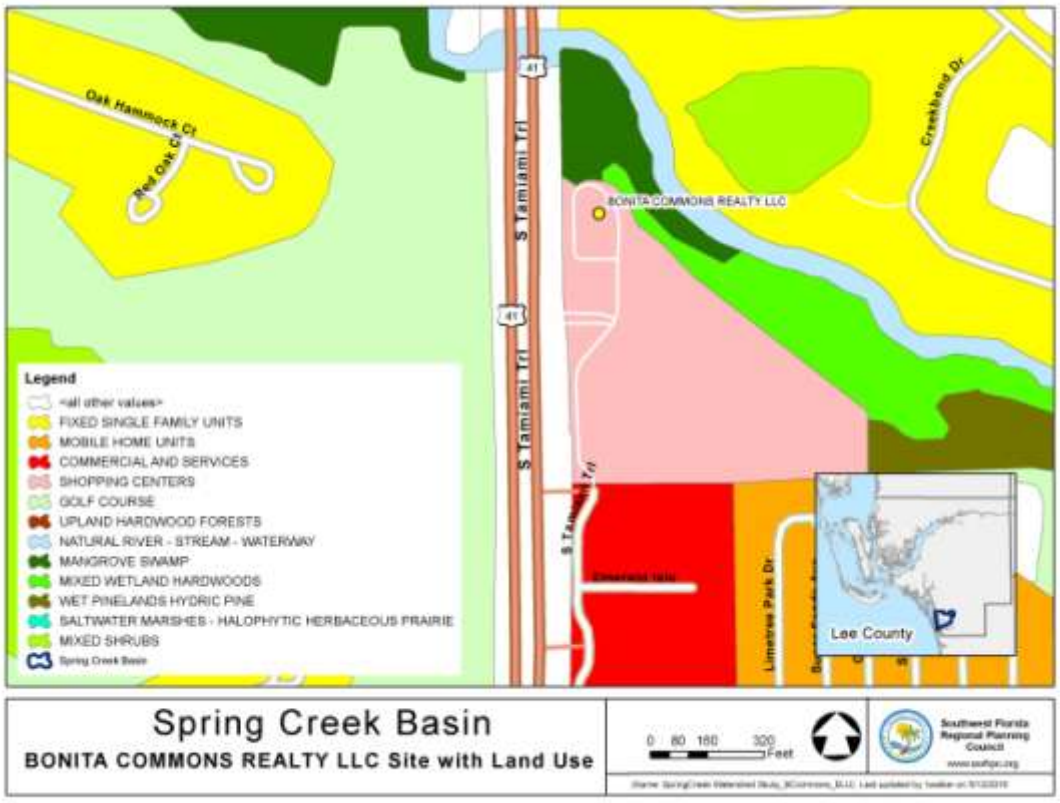



Figure 80: Landuse Map Bonita Commons Realty LLC Site
Source: SWFRPC 2016

Restoration recommendation 17: Based upon analysis of the navigable portion of Spring Creek there are two remaining locations for a pubic kayak/canoe launch with limited parking They are the northwest corner of the Bonita Commons Realty site and the Thomas and Vida Orr site. Given the commercial nature of the Bonita Commons site, it is the recommended site since an opportunity for associated business and a parking situation less disruptive to a community neighborhood can be found there.

## *18) Development of a Climate Change Adaptation Plan for the Spring Creek Watershed*

Southwest Florida, including the Spring Creek Watershed, is currently experiencing climate change. The natural setting of southwest Florida coupled with extensive overinvestment in the areas closest to the coast have placed the region at the forefront of geographic areas that are among the first to suffer the negative effects of a changing climate. More severe tropical storms and hurricanes with increased wind speeds and storm surges have already severely damaged both coastal and interior communities of southwest Florida. Significant losses of mature mangrove forest, water quality

degradation, and barrier island geomorphic changes have already occurred. Longer, more severe dry season droughts, coupled with shorter duration wet seasons consisting of higher volume precipitation, have generated a pattern of drought and flood impacting both natural and man-made ecosystems. Even in the most probable, lowest impact future climate change scenario predictions, the future for southwest Florida will include increased climate instability; wetter wet seasons; drier dry seasons; more extreme hot and cold events; increased coastal erosion; continuous sea level rise; shifts in fauna and flora with reductions in temperate species and expansions of tropical invasive exotics; increasing occurrence of tropical diseases in plants, wildlife and humans; destabilization of aquatic food webs including increased harmful algae blooms; increasing strains upon and costs in infrastructure; and increased uncertainty concerning variable risk assessment with uncertain actuarial futures.

Maintaining the status quo in the management of ecosystems in the face of such likely changes would result in substantial losses of ecosystem services and economic values as climate change progresses. In the absence of effective avoidance, mitigation, minimization and adaptation, climate-related failures will result in greater difficulty in addressing the priority problems identified in the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation and Management Plan (CCMP): hydrologic alteration, water quality degradation, fish and wildlife habitat loss, and stewardship gaps.

The Comprehensive Southwest Florida/Charlotte Harbor Climate Change Vulnerability Assessment (2009) examined the current climate and ongoing climate change in southwest Florida along with five future scenarios of climate change into the year 2200.

The likely effects of climate change and particularly tropical storms, drought and sea level rise, on southwest Florida ecosystems and infrastructure development are too great for policymakers, property owners, and the public-at-large to stand by and wait for greater evidence before considering strategies for adaptation. It is essential to plan and act now to mitigate, minimize, and adapt to the negative effects of climate change, and to examine the possibilities of providing benefits to human and natural systems by adapting to the changing planet. Development of a Climate Change Adaptation Plan for the Spring Creek Watershed is needed to prepare for these changes.

***Climate change resilience*** is the capacity of an individual, community, or institution to dynamically and effectively respond to shifting climate impact circumstances while continuing to function at an acceptable level. It is the ability to survive, recover from, and/or live with the effects of climate change. It includes the ability to understand potential impacts and to take appropriate action before, during, and after a particular consequence to minimize negative effects and maintain the ability to respond to changing conditions.

On January 12, 2010 Lee County contracted with the Southwest Florida Regional Planning Council (SWFRPC) to develop a Climate Change Vulnerability Assessment (CCVA) for the unincorporated portions of the county. This was completed on March 18, 2010 and provided to the County for review.

That project included an assessment of significant potential effects of climate change on the human and native ecosystems of Lee County, including consequences for human and natural resources resulting from and related to (1) sea level rise, (2) aquatic and atmospheric temperature rise, (3) changes in rainfall patterns, (4) increased storm intensity, (5) waterbody chemistry, and (6) general weather instability.

A second part of the same contract was to develop the following Lee County Climate Change Resiliency Strategy (CCRS). The CCRS includes a process for identifying potential climate change resiliency strategies through coordination and consultation with local government leadership in 39 Lee County departments and divisions, including constitutional offices. Identification of resiliency strategies that could be utilized by Lee County to reduce the negative effects of climate change will also help in positioning the County to take advantage of potential climate prosperity opportunities. The CCRS is a toolbox that contains a wide variety of ideas and opportunities for the County to employ in climate change planning, energy savings, and cost savings. The CCRS informs the County of options and opportunities but it *does not prioritize those actions or direct County policy*. Prioritization would require a full public planning process incorporating public participation as part of a *full adaptation plan*.

Note that the CCRS is not an adaptation plan. In addition to a full public participation component that involves the total Lee County community in partnership with County leadership in setting adaptation goals and identifying the priority of adaptation actions to address the various climate change vulnerabilities, an adaptation plan also results in fully developed strategies for implementation. This extent of planning can be accomplished after the County determines inappropriate funding priority for the project.

Successful resilience and adaptation to climate change requires plans and strategies that respond to both the unique vulnerabilities and the priorities of the places they protect. Plans and strategies need to be flexible, to respond to changing conditions and information and to have realistic assessments of the degree of risk and cost that can be sustained. This document identifies the key elements of climate change resiliency for Lee County, and provides some of the information and resources that the County can use in climate change resiliency planning. There are several critical elements that are recommended by the EPA for climate ready adaptation plans and resiliency planning. These elements will be found in this report and include:

- Description of specific implementation actions
- A summary of considerations used to set priorities and select actions
- Communication with stakeholders and decision makers; and
- Monitoring and evaluation of results

Following the completion of the CCVA, an online survey was sent to Lee County division heads, the Lee County Commission members and the Lee County constitutional officers. The purpose of the survey was to gather baseline data on key staff members' perceptions and experiences with respect to weather, climate, storm events and climate

change. The survey results were compiled and used to inform follow-up in-person interviews. Results from both the surveys and the interviews provided a wealth of information *from Lee County personnel* about the ways in which County programs and assets might be made more resilient to the effects of climate change in the near-, middle- and long-term. Literature review pertinent to Lee County provided additional alternatives.

Resiliency strategies are alternatives to consider. In this document, resiliency strategies are organized according to groups of identified vulnerabilities. The strategies are not prioritized; prioritization should be the work of a full adaptation planning process. Some areas have many resiliency strategies, and some have few. It is noted throughout the resiliency strategy lists that Lee County has already made great strides in its efforts to increase energy efficiency, fuel economy, and water efficiency. These efforts are noted with a special symbol in the tables. None of the lists of possible strategies should be taken to be all inclusive, or exclusive, but should represent a place at which to begin discussion.

Resiliency strategy areas included in the document address the following:
- County buildings and infrastructure
- Policy and program-related resiliency strategies
- Coastal erosion and sea level rise
- Emergency and hazard planning
- Health and human services
- Land use planning
- Urban, suburban, and rural land use
- Public water supply and domestic self-supply projections of population
- Water and wastewater
- Waste management
- Natural systems and resources
- Renewable, green energy
- Transportation
- County vehicle fleet
- Education and outreach
- Historic preservation and historic districts

Restoration recommendation 18: The City of Bonita Springs should develop a climate change adaptation plan to address the future conditions and vulnerabilities of the City in response to ongoing climate change. In the interim it can utilize applicable components of the Lee County Climate Change Vulnerability Assessment and the Lee County Climate Change Resiliency Strategy.

# List of Restoration Recommendations for Spring Creek

Restoration recommendation 1a : At this time there is no need to change the existing culvert under I-75 for the North Branch of Spring Creek. If development occurs east of the Interstate then this may significantly change to the detriment of the hydrology of Spring Creek. If those lands are conserved and sheetflow restored, Spring Creek hydrology will improve.

Restoration recommendation 1b : At this time there is no viable opportunity to make a restoration of the flows of the headwaters of the South Branch of the Spring Creek watershed. While this had been identified in the P D & E with the U.S. Highway Administration during the I-75 Improvement planning process, those agencies chose to take no action in that project.

Restoration recommendation 2: It would be best for future culverting and/or bridging to span the entire floodplain rather than constrict it with smaller minimum requirement conveyance. Future repair or redesign should include engineering that provides an additional 1 foot of downstream water elevation from sea level rise and a regular 100-year event occurring in a 10-year to 15-year return rate from future changes in seasonal hydrology. The following culverts need to be improved to provide safe passage for exiting base flows and in anticipation of future hydroperiod changes which will include more extreme rain events:

1) Three Oaks Parkway box culvert
2) North Branch and South Branch Old US 41 box culverts
3) The culvert within Bernwood Business Park on the North Branch of Spring Creek
4) The cattle crossing inside Bernwood Business Park on the South Branch
5) The several 48” RCP pipes along the railroad right-of-way which convey water from the east side ditch to the west side ditch that runs parallel to the tracks on the North Branch and the bridge and pipes on the South Branch
6) The Milagro Lane Culvert on the South Branch of Spring Creek
7) The FPL right-of-way bridging and pipes on the North and South Branches
8) The culvert at Cedar Creek Drive

Restoration recommendation 3: The existing crossing should be replaced with a culvert bridge with a cross-section spanning of the entire tributary. This will provide improved hydrologic performance and improved maintenance while reducing backwater. Depending on the design this may allow passage of canoes/kayaks.

Restoration recommendation 4a: The existing pipe and fill crossings should be replaced with a culverts with a cross-section spanning of the entire tributary extents. This will provide improved hydrologic performance and improved maintenance while reducing backwater.

Restoration recommendation 4b: The existing weirs at the outlet of San Carlos Estates should be repaired/rebuilt to a modern adjustable weir design with the potential increase of invert to increase retention time, and pipe and fill crossings should be replaced with culverts with a cross-section spanning of the entire tributary extents. This will provide improved hydrologic performance and improved maintenance while reducing backwater.

Restoration recommendation 5: There are opportunities for the placement of ditch block/ structures within San Carlos Estates to delay and control runoff before runoff reaches the canal system proper. These can take the form of backyard lipped swales and grassed spreaders swales flanking the Strike Lane Canal.

Restoration recommendation 6: The City of Bonita Springs is addressing the navigation restoration need with the current dredging proposal and no additional work is needed in the near future if this project is implemented. If erosion control is properly applied in the watershed and stormwater management of solids, including total suspended solids (TSS), is improved the amount and frequency of maintenance dredging can be minimized. Potentially as sea level rise occurs in the future the lower watershed of Spring Creek will become deeper in the central channel at the base rate of approximately 1 foot per 100 years.

Restoration recommendation 7: It is recommended that exotic and nuisance vegetation and muck be removed to natural creek/sheet flow depths in the following areas:

1) Headwaters within The Brooks (sheetflow area)
2) North Branch
    i. Villages of Bonita subdivision perimeter ditch
    ii. Canals of San Carlos Estates Drainage
    iii. Railroad Right-Of-Way Canal-Ditches East and West
    iv. FPL Right-Of-Way Canal-Ditches East and West
    v. Within Cedar Creek Subdivision
3) South Branch
    i. Canals of San Carlos Estates Drainage
    ii. Within Bernwood Business Park
    iii. Railroad Right-Of-Way Canal-Ditches East and West
    iv. FPL Right-Of-Way Canal-Ditches East and West
    v. Downstream of Imperial Harbor Subdivision
4) Juncture of North Branch and South Branch of Spring Creek

Restoration recommendation 8: At this time, because of state preemption of copper sulfate regulation the most likely approach to address copper pollution in the Spring Creek Watershed would be to enter into a Basin Management Action Plan (BMAP) with FDEP in coordination with the FDACS that would allow for a copper use reduction plan for the watershed.

Restoration recommendation 9: The best approaches to address fecal coliform pollution in Spring Creek are the following;

1) Adoption and Implementation of a model resolution based on the **Managed Care Model Guidance for Onsite Wastewater Systems Planning, Treatment and Management #2008-02** adopted by the SWFRPC
2) Adoption and Implementation of a model resolution based on the **Wastewater Package Treatment Plant #2007-5** adopted by the SWFRPC
3) Fencing of livestock from the sections of Spring Creek providing a minimum distance of 30 feet from the Creek banks an any channels leading into the Creek-note that 100 feet would be optimal
4) An education program for residents on the importance of picking up after pet waste for human and pet health as well as water quality

Restoration recommendation 10: The best approaches to address nitrogen pollution in Spring Creek are the following;

1) Continued implementation and enforcement of the existing local fertilizer restrictions adopted by the City of Bonita Springs
2) Work with the local golf course managers in the Spring Creek Watershed to move toward improved fertilizer management on their golf courses utilizing the City of Sanibel Golf Course Nutrient and Lake Management Recommendations (BMPs)
3) Fencing of livestock from the sections of Spring Creek providing a minimum distance of 30 feet from the Creek banks and any channels leading into the Creek-note that 100 feet would be optimal
4) Work with local stormwater pond managers to install and operate littoral shelves vegetated with emergent vegetation, aerators to keep water moving in a system, and floating island filter vegetation mats in a program similar to that utilized by the City of Naples
5) Continue the education program for residents on the importance of fertilizer management for good water quality in Spring Creek

Restoration recommendation 11: The best approaches to address low dissolved oxygen levels in the Spring Creek watershed are:

1) Implementation of the restoration recommendations 1 through 7 and implementation of the water quality recommendations 8 through 10 of this report
2) Work with local stormwater pond managers to install and operate littoral shelves vegetated with emergent vegetation, aerators to keep water moving in a system, and floating island filter vegetation mats in a program similar to that utilized by the City of Naples

Restoration recommendation 12: The City of Bonita Springs should work with the FDEP, the Lee County Conservation 2020 program, and interested non-governmental conservation organizations to explore the use of transfer of development rights to secure the remaining unprotected properties in the Florida Forever Acquisition area at the mouth of Spring Creek. The best agreed-upon tool for protection should be utilized for each property and property owner.

Restoration recommendation 13: The City of Bonita Springs should consider an exotic plant program similar to that utilized by the City of Sanibel in supporting the removal of exotic vegetation from the jurisdictional area of that City. This program could achieve removal of exotics from conservation easements as well as removal of sources of exotics during new construction, retro-fits and general landscape maintenance.

Restoration recommendation 14: The City of Bonita Springs should work with Lee County to implement a Clean and Snag project on Spring Creek from its headwaters west of Interstate 75 to the juncture of the North and South Branches of the Creek . Where the exotic vegetation is located beyond the creek floodplain the City should work with the adjacent property owners to obtain permission to further remove exotics in those areas so as to achieve elimination of future sources of re-infestation.

Restoration recommendation 15: The City of Bonita Springs should work with the communities with stormwater management systems that discharge to Spring Creek to determine who is responsible for maintenance and removing exotic vegetation from their stormwater management systems. Where it is determined that the City is responsible it can implement its programs to address this. Where it is determined that the property owners are responsible, then these communities may require assistance in organizing and identifying how they can implement a cleanup of their stormwater management system.

Restoration recommendation 16: The City of Bonita Springs should consider establishing filter marshes for water quality and habitat improvement in the location identified in the west outflow of Strike Canal south of Red Robin Drive and the south branch within Bernwood Business Park.

Restoration recommendation 17: Based upon analysis of the navigable portion of Spring Creek there are two remaining locations for a pubic kayak/canoe launch with limited parking They are the northwest corner of the Bonita Commons Realty site and the Thomas and Vida Orr site.. Given the commercial nature of the Bonita Commons site it is the recommended site since an opportunity for associated business and a parking situation less disruptive to a community neighborhood can be found there.

Restoration recommendation 18: The City of Bonita Springs should develop a climate change adaptation plan to address the future conditions and vulnerabilities of the City in response to ongoing climate change. In the interim it can utilize applicable components of the Lee County Climate Change Vulnerability Assessment and the Lee County Climate Change Resiliency Strategy.

# Sources and Citations Utilized in This Document and the Vulnerability Assessment

This list includes both literature cited and literature utilized in original analysis and writing.


Alber, M. 2002. A conceptual model of estuarine freshwater inflow management. *Estuaries* 25(6), 1246-1261.

Antonini, Gustavo A.; 1999 A historical geography of Southwest Florida waterways

Antonini, Gustavo, David A. Fann, Paul Roat. 2002. A Historical Geography of Southwest Florida Waterways, Vol 2. West Coast Inland Navigation District, page 21.

Atlas of Florida, 1992. Edward A. Fernald and E. D. Purdum Editors, University Press of Florida, 1992, page 37.

Balogh, Frank.; 1977 Effects of point source pollutants in a semi-tropical estuarine environment

Bamberg, M. 1980. Climate. Pages 32-46 in Water use and development plan, Volume III C, lower west coast. South Florida Water Management District. West Palm Beach, Florida.

Bates, N.R. 2007. Interannual variability of the oceanic CO2 sink in the subtropical gyre of the North Atlantic Ocean over the last 2 decades. *Journal of Geophysical Research* 112: 1-26.

Beever III, J.W. 2008. Growth Management Regulation, Public Investment and Resource Implications for the Estero Bay Watershed 2006-2007– Southwest Lee County, Florida. SWFRPC, 490 pages.

Beever III, J.W. and K. Dryden 1992. Hydric slash pine flatwoods: a community profile. Florida Game and Fresh Water Fish Commission. 118 pp.

Beever III, J.W., W. Gray, D. Trescott, D. Cobb, J. Utley, D. Crawford, and D. Hutchinson 2010. Lee County Climate Change Vulnerability Assessment. Southwest Florida Regional Planning Council. 226 pp.

Beever III, J.W., W. Gray, D. Trescott, J. Utley, D. Hutchinson, Tim Walker, D. Cobb 2010. Lee County Climate Change Resiliency Strategy. Southwest Florida Regional Planning Council. 163 pp.

Beever III, J.W., W. Gray, L. Beever, and D. Cobb 2011. A Watershed Analysis of Permitted Coastal Wetland Impacts and Mitigation Methods within the Charlotte Harbor

National Estuary Program Study Area. Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program. USEPA CE- 96484907-0. 391 pp.

Beever, III, J.W., W. Gray, D. Trescott, D. Cobb, J. Utley and L. B. Beever 2009. Comprehensive Southwest Florida/ Charlotte Harbor Climate Change Vulnerability Assessment. Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program, Technical Report 09-3, 298 pages.

Beever, III, J.W., W. Gray, D. Trescott, D. Cobb, J. Utley, and L. B. Beever 2009 City of Punta Gorda Climate Change Adaptation Plan. SWFRPC/CHNEP, 267 pp.

Beever, III, J.W ,and L. Beever. State of the Bay 2014, Estero Bay Agency on Bay Management .

Bell, T.L., D. Rosenfeld, K.-M. Kim, J.-M Yoo, M.-I. Lee and M. Hahnenberger. 2008. Midweek increase in U.S. summer rain and storm heights suggests air pollution invigorates rainstorms. *Journal of Geophysical Research (Atmospheres)* 113:D02209, doi: 10.1029/2007JD008623.

Bollman, Nick. 2007. Florida's resilient coasts: a state policy framework for adaptation to climate change. Ft. Lauderdale, FL: Florida Atlantic University Center for Urban and Environmental Solutions. 38pp.

Bradley, J.T. 1972. Climate of Florida. Pages 45-70 in Climate of the States. Environmental Data Service, No. 60-8. Silver Springs, Md.

Brooks, N., R. Nicholls and J. Hall 2006. Sea Level Rise: Coastal Impacts and Responses. Berlin, WBGU: 49.

Brown, Mark T.; 1976 Lee County : an area of rapid growth.

Bruun, Per. 1962. Sea Level Rise, as a Cause of Shore Erosion. *Journal of the Waterways and Harbors Division*, Proceedings of the American Society of Civil Engineers, 88(WW1):117-130.

Bruun, Per. 1986. Worldwide Impacts of Sea Level Rise on Shorelines. In *Effects of Changes in Stratospheric Ozone and Global Climate*, Vol. 4: Sea Level Rise, edited by James G. Titus, 99-128. Washington, DC, U.S. Environmental Protection Agency.

Bureau of Coastal and Aquatic Managed Areas, Division of Marine Resources, Department of Environmental Protection. 2002 Land management plan for the Estero Bay State Buffer Preserve, Lee County, Florida : for the period May 1997 through May 2002 Tallahassee, Fla. : Bureau of Coastal and Aquatic Managed Areas

Bureau of Economic and Business Research (BEBR). 2003. Florida State and County Population Estimates, April 1, 2003 and Projections for 2005-2030. University of Florida, Gainesville, Florida.

Calusa Group, Sierra Club, Environmental Confederation of SWFL. 1987. Petition for Outstanding Florida Waters designation for the Imperial River, Spring Creek, the Estero River, Mullock and Hendry Creek

Castaneda, H., and F.E. Putz. 2007. Predicting sea level rise effects on a nature preserve on the Gulf Coast of Florida: A landscape perspective. *Florida Scientist* 70(2): 166-175.

CBO Testimony, 2005: *Macroeconomic and Budgetary Effects of Hurricanes Katrina and Rita.* Statement of Douglas Holtz-Easkin, Director, before the Committee on the Budget, U.S. House of Representatives. Congressional Budget Office, Washington, DC, 21pp. http://www.cbo.gov/doc.cfm?index=6684

Ceilley, David W.; 1990 South Estero Bay - Big Hickory Pass : report on water quality monitoring, September 1990

Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation and Management Plan 2008. 1926 Victoria Avenue, Fort Myers, Florida 33901

Clark, Roger S.; 1987. Water quality, circulation and patterns and sediment analysis of the Estero Bay estuarine system, 1986

Coastal Coordinating Council. 1974. Florida coastal zone management atlas. State of Florida, Tallahassee, Florida.

Coastal States Organization Climate Change Work Group. 2007. The role of coastal zone management programs in adaptation to climate change. B. Davis, chair. 30 pp.

Committee on Environment and Natural Resources. 2008. Scientific assessment of the effects of global change on the United States. Washington, D.C.: National Science and Technology Council. 271 pp.

Covington, James W. 1958. Life at Fort Brooke, 1824-1836. The Florida Historical Quarterly, volume XXXVI, Number 4. pp 319-330. http://fulltext6.fcla.edu/DLData/CF/CF00000036/CF00154113/36_4/36no4.pdf.

Cox, J., Kautz, R., MacLaughlin M., and Gilbert, T. 1994. Closing the Gaps in Florida's Wildlife Habitat Conservation System. Office of Environmental Services, Florida Game and Fresh Water Fish Commission, 620 South Meridian Street, Tallahassee, Florida 32399-1600.

Daltry, Wayne E. and David Y. Burr. CHNEP 1998 Base programs analysis. North Ft. Myers, Fla. : Charlotte Harbor National Estuary Program.

Department of Natural Resources. 1983. Estero Bay Aquatic Preserve Management Plan. Tallahassee, FL. http://www.dep.state.fl.us/coastal/sites/estero/info.htm.

Doyle, T.W., G.F. Girod, and M.A. Brooks. 2003. Chapter12: Modeling mangrove forest migration along the southwest coast of Florida under climate change. In *Integrated assessment of the climate change impacts on the Gulf Coast region.* Gulf Coast Climate Change Assessment Council and Louisiana State University.

Drew, R.D. and N.S. Schomer 1984. An Ecological Characterization of the Caloosahatchee River/Big Cypress Watershed. U.S. Fish and Wildlife Service. FWS/OBS-82/58.2. 225 pp.

Dryden, K.A. and J. W. Beever III 1994 Regional protection of listed wildlife species and other wildlife resources in the greater Charlotte Harbor ecosystem. Office of Environmental Services, Florida Game and Fresh Water Fish Commission, 29200 Tuckers Grade, Punta Gorda, FL 33955).

Easterling, D.R., G.A. Meehl, C. Parmesan, S.A. Changnon, T.R. Karl, and L.O. Mearns. 2000. Climate extremes: observations, modeling and impacts. *Science,* v. 289, 2068-2074.

Elsner, James B. 2006. Evidence in support of the climate change-Atlantic hurricane hypothesis. Geophysical Research Letters 33 (L16705): 1-3.

Enfield, D.B., A.M. Mestas-Nuñez, and P.J. Trimble. 2001. The Atlantic multidecadal oscillation and its relation to rainfall and river flows in the continental U.S. *Geophysical Research Letters* 28 (10), 2077-2080.

Environmental Protection Agency. 2003. Monitoring and Assessing Water Quality. http://www.epa.gov/owow/monitoring/volunteer/stream/vms52.html.

Environmental Regulation Commission. 1990. Report to the Environmental Regulation Commission on the proposed designation of the Estero Bay tributaries as Outstanding Florida Waters

Estero Bay and Watershed Management and Improvement Plan Workshop (1996 : Ft. Myers, Fla.); 1996 Estero Bay and Watershed Management and Improvement Plan Workshop

Estevez, E.D. 1988. Implications of sea level rise for wetlands creation and management in Florida. *Proceedings, Annual Conference on Wetlands Restoration and Creation* 103-113.

Exceptional Engineering, Inc 2008. Pring Creek Watershed Drainage Study. 31 pp.

Federal Emergency Management Agency. *Florida Disaster History*. June 12, 2009. www.fema.gov/news/disasters_state.fema?id=12 (accessed June 29, 2009).

Florida Center for Environmental Studies, Florida Climate Change Conference, 9-11 May 2007. Climate Change Conference Summary. Tampa, Florida.

Florida Cooperative Fish and Wildlife Research Unit. 2000. "FLORIDA LAND COVER". gap_lcov. Raster Digital Data. Florida: Florida Fish and Wildlife Conservation Commission. May 2000. (gap_lcov).

Florida Department of Environmental Protection 1994. *Approach to the assessment of sediment*

Florida Department of Environmental Protection 2007a. Drinking Water Database, Florida DEP

Florida Department of Environmental Protection 2008. *Integrated water quality assessment for Florida: 2008 305(b) report and 303(d) list update*. Tallahassee, FL: Division of Environmental Assessment and Restoration, Bureau of Watershed Management. http://www.dep.state.fl.us/water/tmdl/docs/2006_Integrated_Report.pdf.

Florida Department of Environmental Protection 2008. LABINS. Land Boundary Information System. http://data.labins.org/2003/

Florida Department of Transportation. 1999. Florida Land Use, Cover and Forms Classification System. Third Edition. Tallahassee, Florida

Florida Division of Emergency Management 2004. Hurricane Impact Report, A Summary, Florida Division of Emergency Management.

Florida Division of Emergency Management 2007. Draft Hurricane Impact Report, Florida Division of Emergency Management.

Florida Fish and Wildlife Institute 2006 Florida Fish and Wildlife Conservation Commission Florida Statewide Environmental Sensitivity Index Maps, http://ocean.floridamarine.org/esimaps/

Florida Natural Areas Inventory 1989. Natural Communities. in Guide to the Natural Communities of Florida. 111 pp.

Florida Oceans and Coastal Council (FOCC) 2009. The effects of climate change on Florida's ocean and coastal resources. A special report to the Florida Energy and Climate Commission and the people of Florida. Tallahassee, FL. 34 pp.

Florida State Legislature 2014. The 2006 Florida Statutes.

Florida. Bureau of Environmental Land Management.; 1983 Charlotte Harbor aquatic preserves management plan : adopted May 18, 1983 by the Board of Trustees of the Internal Improvement Trust Fund .

Florida's Geological History and Geological Resources 1994. Florida Department of Environmental Protection, Florida Geological Survey, Special Publication No. 35, 1994, pages 17-26, including Figure 10, Sea level changes during the Cenozoic Era (after Haq et al., 1987) and Figure 16, Pleistocene Shoreline in Florida. Illustrated by Frank R. Rupert. .

Forstall, Richard. 1995. Population of Counties by Decennial Census: 1900 to 1990. Population Division, US Bureau of the Census, Washington, DC. http://www.census.gov/population/cencounts/fl190090.txt

Fraser, Thomas H.; 1997 Compendium of existing monitoring programs in the greater Charlotte Harbor watershed

Gazelles, B., M. Chavez, A. J. McMichael, and S. Hales. 2005. Non-stationary influence of El Nino on the synchronous dengue epidemics in Thailand. PLoS Medicine 2313-318.

GeoPlan Center at the University of Florida 2006.FLORIDA 2060: A POPULATION DISTRIBUTION SCENARIO. A Research Project Prepared for 1000 Friends of Florida by the GeoPlan Center at the University of Florida December 2006

Gilman, E.L Joanna Ellison b, Norman C. Duke c, Colin Field 2008. Threats to mangroves from climate change and adaptation options, Aquatic. Bot. doi:10.1016/j.aquabot.2007.12.009 14 pp.

Gleason, P.J., and Stone, P., 1994, Age, origin and landscape evolution of the Everglades peatland, *in* Davis, S.M., and Ogden, J.C., Everglades: The ecosystem and its restoration: Delray Beach, Florida, St. Lucie Press, p. 149-197.

Glick, P. 2006. Application of SLAMM 4.1 to Nine Sites in Florida, National Wildlife Federation, Climate Change Specialist, 6 Nickerson Street, Suite 200, Seattle, WA 98109, February 16, 2006. 27 pp.

Glick, P., and J. Clough. 2006. *An unfavorable tide: Global warming, coastal habitats and sportsfishing in Florida.* National Wildlife Federation and Florida Wildlife Federation. http://www.nwf.org/news/story.cfm page Id=867DBCA1-F1F6-7B10-369BEE5595525202.

Goldenberg, S.B., C.W. Landsea, A.M. Mestaz-Nunez, and W.M. Gray. 2001. The recent increase in Atlantic hurricane activity: Causes and implications. *Science* 293, 474-479.

GoogleEarth 2015. 26 degrees 23' 52.55" by 81 degrees 46' 21.48"

Gruber, A. 1969. Energy budget and climatology of the atmosphere over the Florida peninsula. Final rep. to the U.S. Army Elect. Commission. Tech. rep. ECOM-04367-F. 64 pp.

Hansen, J.E., 2007. Scientific reticence and Sea Level Rise. *Environmental Research Letters*, Vol. 2, 024002. doi:10.1088/1748-9326/2/2/024002.

Harvell, C. D., C. E. Mitchell, J. R. Ward, S. Altizer, A. Dobson, R. S. Ostfeld, and M. D. Samuel. 2002. Climate warming and disease risks for terrestrial and marine biota. Science 2962158-2162.

Harvell, C.D., C.E. Mitchell, J.R. Ward, S. Altizer, A.P. Dobson, R.S. Ostfeld, and M.D. Samuel. 2002. Climate warming and disease risks for terrestrial and marine biota. *Science* 296:2158–62.

Harvell, C.D., K. Kim, J.M. Burkholder, R.R. Colwell, P.R. Epstein, D.J. Grimes, and E.E. Hofmann et al. 1999. Emerging marine diseases— Climate links and anthropogenic factors. *Science* 285, 1505-1510.

Hela, I. 1952. Remarks on the climate of southern Florida. Bull. Mar. Sci. 2(2):438-447.

Henderson-Sellers, A., H. Zhang, G. Berz et al. (1998). "Tropical Cyclones and Global Climate Change: A Post-IPCC Assessment." *Bulletin of the American Meteorological Society* 79(1).

Hine, A.C., and D.F. Belknap. 1986. *Recent geological history and modern sedimentary processes of the Pasco, Hernando, and Citrus County coastlines: West central Florida.* Florida Sea Grant Report No. 79. http://www.priweb.org/ed/TFGuide/SE/se_geohist/se_geohist_pdfs/geo_history_se.pdf.

Intergovernmental Panel on Climate Change (IPCC) (2001a). *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Cambridge UK, Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC) (2007a). *Climate Change 2007: Summary for Policy Makers. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK, Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC) 2001: *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Houghton, J.T.,Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp.

Intergovernmental Panel on Climate Change (IPCC) 2007b. *Climate change 2007: The physical science basis. Contribution of Working Group I to the fourth assessment report*

*of the Intergovernmental Panel on Climate Change* (S. Solomon, S., D. Qin, M. Manning., Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, Eds.). Cambridge, UK, and New York: Cambridge University Press. http://www.ipcc.ch.

Intergovernmental Panel on *Climate Change* (IPCC) *2007c. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (M.L. Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson, eds.). Cambridge, UK: Cambridge University Press.

Intergovernmental Panel on Climate Change. (IPCC) *2007a. Climate change 2007: Synthesis report* (L. Bernstein, P. Bosch, O. Canziani, C. Zhenlin, R. Christ, O. Davidson, and W. Hare et al., CoreWriting Team). Geneva, Switzerland. http://www.ipcc.ch/pdf/assessmentreport/ar4/syr/ar4_syr.pdf.

Intergovernmental Panel on Climate Change. 2008. *About Intergovernmental Panel on Climate Change.* http://www.ipcc.ch/about/index.htm.

Jane Anderson Jones. SIXTEENTH CENTURY SPANISH ENCOUNTERS WITH THE CALUSA Great Events from History: North America. *Rev. ed. Salem Press, 1996.* http://faculty.mccfl.edu/JonesJ/flbib/CALUSAS.html.

Jimerfield, S., M. Waage, and W. Snape, 2007: Global Warming Threats and Conservation Actions in Endangered Species Recovery Plans: a Preliminary Analysis. Center for Biological Diversity.

Jones, C.S., J.F. Shriver, and J.J. O'Brien. 1999. The effects of El Niño on rainfall and fire in Florida. *Florida Geographer* 30, 55-69.

Jordan, C. L. 1973. Climate. Pages IIA-1 to IIA-14 in J. I. Jones, R. E. Ring, M. O. Rinkel, and R. E. Smith, (eds.) A summary of knowledge of the eastern Gulf of Mexico. State University System of Florida, Institute of Oceanography.

Karl, T. R., J. M. Melillo, and T. C. Peterson, (eds.) Global Climate Change Impacts in the United States, Cambridge University Press, 2009.

Knutson, T.R., J.J. Sirutis, S.T. Garner, G.A. Vecchi, and I.M. Held.2008. Simulated reduction in Atlantic hurricane frequency under twenty-first-century warming conditions. *Nature Geoscience,* 18 May, doi: 10.1038/ngeo202.

Landsea, C.W., W.M. Gray, P.W. Mielke, Jr., and K.J. Berry.1994. Seasonal forecasting of Atlantic hurricane activity. *Weather* 49, 273-284.

Lane, Ed, ed. 1994. Florida's Geological History and Geological Resources. Florida Geological Survey, Special Publication No. 35. Tallahassee, Florida. http://www.clas.ufl.edu/users/guerry/GLY4155/sp35/Fgs35.HTM.

Layne, J. N. 1974. The land mammals of south Florida. Pages 386-413 in P. J. Gleason, (ed.) Environments of South Florida: present and past. Miami Geol. Soc. Mem. 2.

Layne, J.N. and M.N. McCauley. 1976. Biological overview of the Florida panther. Pages 5-45 *in* P.C.H. Pritchard ed., Proceedings of the Florida panther conference. Florida Audubon Society. 121 pp.

Lee County Environmental Services Dept., Natural Resources Division, [2000] Surface water master plan [Fort Myers, Fla.] :

Lee, J. K., R. A. Park, P. W. Mausel, and R. C. Howe. 1991. GIS-related Modeling of Impacts of Sea Level Rise on Coastal Areas. Pages 356-367. *GIS/LIS '91 Conference*, Atlanta, Georgia.

Levina, E., J. S. Jacob, L. E. Ramos and I. Ortiz 2007. Policy Frameworks for Adaptation to Climate Change in Coastal Zones: The Case of the Gulf of Mexico. Paris, Organization for Economic Co-operation and Development:

Library of Congress. 2004. Map Collections: 1500-2004. Washington D.C. http://lcweb2.loc.gov/ammem/gmdhtml/gmdhome.html.

Lugo, A.E., and S.C. Snedaker. 1974. The ecology of mangroves. Annual Review of Ecology and Systematics 5:39-64.

Martel Laboratories, Inc. and Mangrove Systems, Inc, ed. 1984. Southwestern Florida ecological characterization : an ecological atlas : map narratives Washington, D.C. : U.S. Dept. of the Interior, Fish and Wildlife Service : Minerals Management Service.

Maul, G.A., and D.M. Martin. 1993. Sea level rise at Key West, Florida, 1846–1991: America's longest instrument record? *Geophysical Research Letters* 20 (18): 1955-1958.

Maul, G.A., and H.J. Sims. 2007. Florida coastal temperature trends: Comparing independent datasets. *Florida Scientist* 70(1): 71-82.

McCormick, Paul V. and James A. Laing. "Effects of increased phosphorus loading on dissolved oxygen in a subtropical wetland, the Florida Everglades." Wetlands Ecology and Management. 11:199-216, 2003.

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver, and Z.-C. Zhao, 2007: Global climate projections. In: *Climate Change 2007: The Physical Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK, and New York, pp. 747-845.

Miller, James A. 1990. Groundwater Atlas of the United States, Segment 6, Alabama, Florida, Georgia, and South Carolina. U.S Geological Survey Hydrological Investigations Atlas 730-G. http://capp.water.usgs.gov/gwa/ch_g/index.html.

Mitchell-Tapping, H.J., A.M. Mitchell- Tapping, et. al. Research studies in Estero Bay Aquatic Preserve, Lee County Florida Estero Bay Marine Laboratory, Fort Myers Beach, Fla

Mitsch, William J. and James G. Gosselink. Wetlands. New York: Van Nostrand Reinhold Company; 1986.

Mulkey, S. 2007. Climate Change and Land Use in Florida. Gainesville, FL: Century Commission.

Mulvania, M. 1931. Ecological survey of a Florida scrub. Ecology 12: 528-540.

O'Brien, J. and D. Zierden 2001. Climate of Florida. NCDC, NOAA.

Odum, W.E., and C.C. McIvor. 1990. Mangroves. Pages 517-548 *in* R.L. Myers and J.J. Ewel, (eds.), Ecosystems of Florida. University Press of Florida, Gainesville, Florida.

Odum, W.E., and E.J. Heald. 1972. Trophic analysis of an estuarine mangrove community. Bulletin of Marine Science 22:671-738.

Odum, W.E., C.C. McIvor, and T.S. Smith. 1982. The ecology of mangroves of South Florida: a community profile. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS - 81/24.

Oetting, J and T Hoctor. 2007. CLIP _ Critical lands & waters Identification project. Phase I report to the Century Commission for a Sustainable Florida. www.centurycommission.org

Park, R. A., M. S. Trehan, P. W. Mausel, and R. C. Howe. 1989a. The Effects of Sea Level Rise on U.S. Coastal Wetlands. Pages 1-1 to 1-55. in J. B. Smith and D. A. Tirpak, eds. *The Potential Effects of Global Climate Change on the United States, Appendix B - Sea Level Rise*. U.S. Environmental Protection Agency, Washington, D.C.

PBS&J, Inc. 1999. Estero Bay watershed assessment South Florida Water Management District. West Palm Beach.

Peterson, C.H., R.T. Barber, K.L. Cottingham, H.K. Lote, C.A. Simenstad, R.R. Christian, M.F. Piehler, and J. Wilson. 2008. National estuaries. In *Preliminary review of adaptation options for climate-sensitive ecosystems and resources: A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research.* Washington, DC: U.S. Environmental Protection Agency.

Pielke, R (Sr.). 2005. Land use and climate change. *Science* 310:1625.

Pielke, R.A., R.L. Walko, L. Steyaert, P.L. Vidale, G.E. Liston, and W.A. Lyons. 1999. The influence of anthroprogenic landscape changes on weather in south Florida. *Monthly Weather Review*127, 1663-1673.

Rahmstorf, S. 2007. A semi-empirical approach to projecting future sea level rise. *Science* 315:368-370.

Sallenger, A.H., H.F. Stockdon, L. Fauver, M. Hansen, D. Thompson, C.W. Wright, and J. Lillycrop. 2006. Hurricanes 2004: An overview of their characteristics and coastal change. *Estuaries and Coasts* 29(6A), 880-888.

Savage T. 1972. Florida mangroves as shoreline stabilizers. Florida Department of Natural Resources professional paper 19.

Savarese, M., L. P. Tedesco, C. Mankiewicz and L. Shrake 2002. *Late Holocene Sea Level Rise in Southwest Florida: Implications for Estuarine Management and Coastal Evolution*. Fifteenth Keck Research Symposium in Geology Proceedings, Amherst College, Amherst, Massachusetts.

Seaman, W. 1985. Introduction to the aquatic resources of Florida. Pages 1-19 *in* W. Seaman (ed.), Florida aquatic habitat and fishery resources. American Fisheries Society.

Seminole Nation, I.T.: The People who never surrendered. http://www.seminolenation-indianterritory.org/.

SFWMD. 2005. Caloosahatchee River/Estuary Nutrient Issues. South Florida Water Management District.

SFWMD. 2004. Draft C-43 Existing Conditions Report. West Palm Beach, Florida. http://www.evergladesplan.org/pm/pm_docs/rpdt/south_docs/081904_srpdt_ram_c43_exist_conds.pdf.

Shepherd, J.M., A. Grundstein, and T.L. Mote. 2007. Quantifying the contribution of tropical cyclones to extreme rainfall along the coastal southeastern United States. *Geophysical Research Letters* 34: L23810, doi: 10.1029/2007GL031694.

South Florida Water Management District (SFWMD) and U.S. Army Corps of Engineers (COE). 2002. Southwest Florida Feasibility Study Project Management Plan. http://www.evergladesplan.org/pm/program/program_docs/pmp_study_swfl/pmp_swfl_main_final.pdf.

South Florida Water Management District. 2000. District Water Management Plan (DWMP). South Florida Water Management District, West Palm Beach, Florida. http://www.sfwmd.gov/org/wrm/dwmp/dwmp_2000/.

Southwest Florida Regional Planning Council (SWFRPC), 2001. Southwest Florida Regional Hurricane Evacuation Study 2001 Update, Table 2 Land falling Category 2 Storm Surge Vulnerable Population Estimates.

Southwest Florida Regional Planning Council (SWFRPC). 2004. SWFRPC website. http://www.swfrpc.org/About/TheCouncil.htm.

Squillace, A. E. 1966. Geographic variation in the slash pine. For. Sci. Monogr. 10, 56p.

Stanton, E.A., and F. Ackerman. 2007. *Florida and climate change: The costs of inaction.* Tufts University Global Development and Environment Institute and Stockholm Environment Institute–US Center.

Straile, D., and N.C. Stenseth. 2007. The North Atlantic Oscillation and ecology: Links between historical time-series, and lessons regarding future climate warming. *Climate Research* 34(3): 259-262.

Tetra Tech, Inc and Janicki Environmental, Inc. 2004. Compilation, Evaluation, and Archiving of Existing Water Quality Data for Southwest Florida. Department of the Army, Jacksonville District Corps of Engineers. Jacksonville, Florida.

Thomas, T.M. 1974. A detailed analysis of climatological and hydrological records of south Florida, with reference to man's influence upon ecosystem evolution. Pages 82-122 in P.J. Gleason, (ed.) Environments of south Florida: present and past. Miami Geol. Soc. Mem. 2.

Titus, J. G. 1998. "Rising seas, coastal erosion, and the takings clause: how to save wetlands and beaches without hurting property owners". *Maryland Law Review* 57 (4) 1279-1399.

Titus, J. G. 2000. Does the U.S. Government Realize that the Sea Is Rising? Golden Gate University Law Review, Vol. 30:4:717-778

Titus, J.G. and C. Richman, 2001: Maps of lands vulnerable to sea level rise: modeled elevations along the U.S. Atlantic and Gulf coasts. *Climate Research*, 18(3): 205-228.

Titus, J.G. and Narayanan, V.K. 1995. The Probability of Sea Level Rise. Washington D.C. Environmental Protection Agency.

Torrence, Corbett McP.; 1994 Topographic mapping and archaeological reconnaissance of Mound Key State Archaeological Site (8LL2), Estero Bay, Florida

Treaty with the Florida Tribes of Indians, 1823. http://digital.library.okstate.edu/kappler/vol2/treaties/sem0203.htm.

Trescott, D. and T. Walker. 2009. Land use impacts and solutions to sea level rise in southwest Florida, Southwest Florida Regional Planning Council, Fort Myers, Florida. *www.swfrpc.org*

Turner, R.E, N.N. Rabalais, B. Fry, N. Atilla, C.S .Milan, J.M. Lee, and C. Normandeau et al. 2006. Paleo-indicators and water quality change in the Charlotte Harbor Estuary (Florida).*Limnology and Oceanography*, v. 51, no. 1, pp. 518-533.

Twilley, R. 1980. Organic exports from black mangrove forests in south Florida. PhD dissertation (unpublished). University of Florida, Gainesville, Florida.

Twilley, R.R., E. Barron, H.L. Gholz, M.A. Harwell, R.L. Miller, D.J. Reed, J.B. Rose, E. Siemann, R.G. Welzel and R.J. Zimmerman. 2001. Confronting Climate Change in the Gulf Coast Region: Prospects for Sustaining Our Ecological Heritage. Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC. 82 pp.

U.S. Army Corps of Engineers. 2003. Record of Decision. Jacksonville, Florida. http://www.saj.usace.army.mil/permit/hot_topics/SFLAEIS/contents.htm.

U.S. Department of Agriculture, Natural Resources Conservation Service. Soil Data Mart. http://soildatamart.nrcs.usda.gov/State.aspx. Note: All but Collier information present.

United States Army Corps of Engineers 2000. Environmental Impact Statement on Improving the Regulatory Process in Southwest Florida, Lee and Collier Counties, Florida, U.S. Army Corps of Engineers, Jacksonville District.

United States Census Bureau (2004a). State Interim Population Projections by Age and Sex: 2004 – 2030; Table 1: Interim Projections: Ranking of Census 2000 and Projected 2030 State Population and Change: 2000 to 2030.Washington DC, United States Census Bureau.

United States Census Bureau (2015). U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin; Table 1a. Projected Population of the United States, by Race and Hispanic Origin: 2000 to 2050, United States Census Bureau.

United States Census Bureau 2007. 2002 Economic Census, United States Census Bureau.

United States Coast Survey.; [map]; 1998. Florida, Fort Myers to Charlotte Harbor and Wiggins Pass .

United States Congress, Office of Technology Assessment, 1993. Preparing for an Uncertain Climate--Volume I, OTA-O-567 (Washington, DC: U.S. Government Printing Office, October 1993).

United States Congress, Office of Technology Assessment, 1993. Preparing for an Uncertain Climate--Volume II, OTA-O-568 (Washington, DC: U.S. Government Printing Office, October 1993).

United States Department of Commerce (USDC), 1981. Local climatological data 1980 - Fort Myers - annual summary with comparative data. U.S. Dep. Comm., National Oceanic and Atmospheric Administration (NOAA).

United States Environmental Protection Agency 1997.Climate Change and Florida Office of Policy, Planning and Evaluation (2111) EPA 230-F-97-008i September 1997. 4 pp

United States Environmental Protection Agency Climate Ready Estuaries 2008. *Draft synthesis of adaptation options for coastal areas.* Distributed at NEP National Meeting, 26 February 2008. 26 pp.

United States Geological Survey 2000. National Assessment of Coastal Vulnerability to Future Sea level Rise. Washington, D.C., United States Geological Survey: 2.

United States Geological Survey 2007. *NOAA Medium Resolution Digital Vector Shoreline*, Coastal and Marine Geology Program Internet Map Server—Atlantic and East Coast USGS.

United States Geological Survey, Biological Resources Division [USGS-BRD]. 1996.Classification of 1993/94 Landsat TM Imagery. Florida Cooperative Fish and Wildlife Research Unit, University of Florida; Gainesville, Florida.

United States Global Change Research Program 2001. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. Washington D.C., National Assessment Synthesis Team, United States Global Change Research Program: Updated in 2004. www.usgcrp.gov/usgcrp/nacc/

United States National Oceanic and Atmospheric Administration (USNOAA), Climatic Data Center. 2008. Draft Climate Change handbook. Asheville, NC: NOAA Climatic Data Center.

United States Streets Dataset. Environmental Systems Research Institute 2009.

United States. Congress. Senate. Committee on Energy and Natural Resources. Subcommittee on National Parks, Historic Preservation, and Recreation.; 1999 South Florida ecosystem restoration : joint hearings before the Subcommittee on National Parks, Historic Preservation, and Recreation of the Committee on Energy and Natural Resources, and the Subcommittee on Interior and Related Agencies of the Committee on Appropriations, United States Senate, One Hundred Sixth Congress, first session ... April 29, 1999.

United States. Soil Conservation Service.; 1992 Flood prone areas of Lee County, Florida : flood plain management study, phase I : Estero Bay area

University of Florida Bureau of Economic and Business Research, (UFBEBR) Warrington College of Business. 2008. Florida Statistical Abstract 2008. Gainesville, Florida: University of Florida.

University of Florida: GeoPlan 2007 1:250,000 Digital Elevation Model

University of Florida: GeoPlan 2007 Historic and Projected Populations of Florida Counties

University of South Florida FCCDR 2015. Spring Creek Stream Assessment. *West-Central Florida Tidal Stream Assessment Study p129-138.*

US Bureau of the Census. 2003. State and County QuickFacts. Washington, DC. http://quickfacts.census.gov/qfd/states/12000.html

US Bureau of the Census. 2015. State and County QuickFacts. Washington, DC.

US Fish and Wildlife Service, Southeast Region. 1999. South Florida Multi-Species Recovery Plan.

Vecchi, G.A., and B.J. Soden. 2007. Increased tropical Atlantic wind shear in model projections of global warming. *Geophysical Research Letters* 34, L08702, doi: 10.1029/2006GL028905.

Virmani, J.I., and R.H. Weisberg. 2006. The 2005 hurricane season: An echo of the past or a harbinger of the future? *Geophysical Research Letters* 33, L05707, doi: 10. 1029/2005GL025517.

Volk, Michael. 2008a. An analysis of strategies for adaptation to sea level rise in Florida. Gainesville, FL: University of Florida. 143 pp.

Walton, Todd L. Jr._ 2007. Projected sea level rise in Florida, Ocean Engineering 34 (2007) 1832–1840

Wang, C., and S.-K. Lee. 2008. Global warming and United States land falling hurricanes. *Geophysical Research Letters* 35, L02708, doi: 1029/ 2007GL032396.

Wanielista, M. 2006 An Evaluation of Southwest Florida Basin Rule BMP Efficiencies SFWMD Report published August 31, 2006

Wanless, H.R. 1998. Mangroves, hurricanes, and sea level rise. South Florida Study Group, The Conservancy, Naples, Florida.

Ward, Gerald M.; 1990 Imperial River / Fishtrap Bay / Big Hickory Bay channels and navigation : Bonita Springs, Lee County, Florida

Webster, P.J., G.J. Holland, J.A. Curry, and H.-R. Chang. 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309 (5742), 1844-1846.

Williams, K., K.C. Ewel, R.P. Stumpf, F.E. Putz, and T.W. Workman. 1999. Sea level rise and coastal forest retreat on the west coast of Florida, USA. *Ecology* 80 (6): 2045-2063.

Yonge, Julius C., editor. 1927. The Quarterly Periodical of the Florida Historical Society. Volume V, Number 3.
http://fulltext6.fcla.edu/DLData/SN/SN00154113/0005_003/5no3.pdf