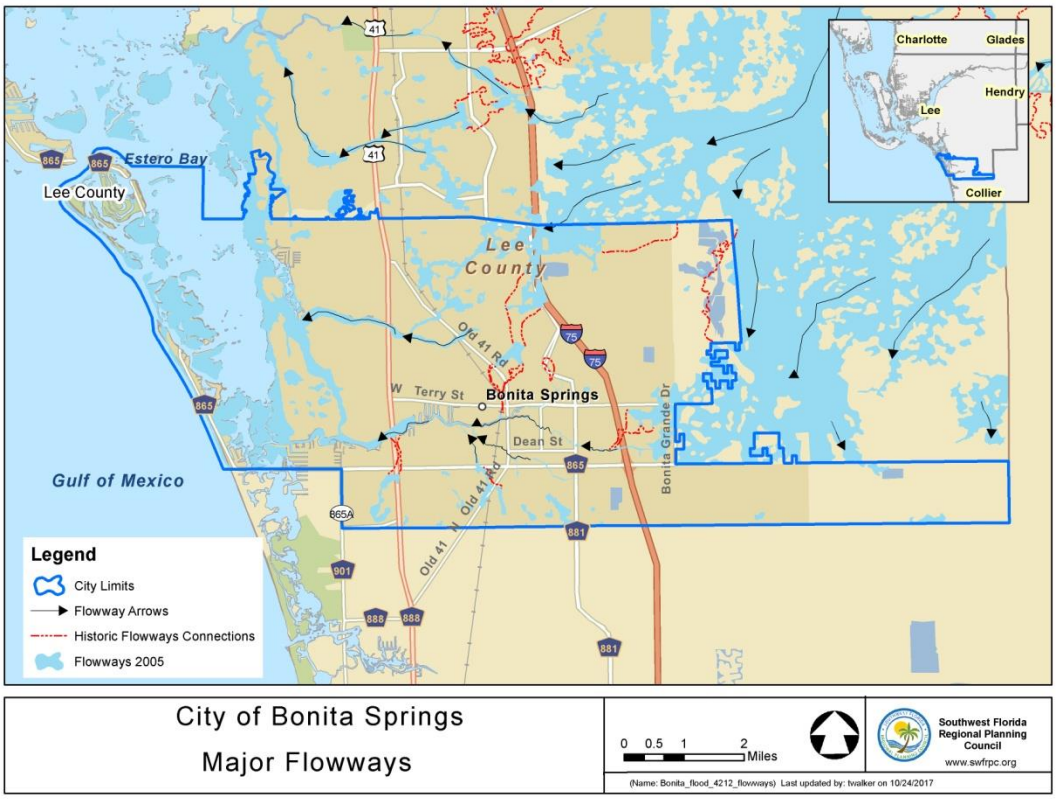
# City of Bonita Springs Flood Reduction and Watershed Restoration Plan




Source: SWFRPC 2017

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All recommendations regarding potential flooding reduction solutions are based on the author's observations and experience, but not based on an engineering feasibility or cost reasonableness analysis normally down by engineering firms. Extensive engineering feasibility analysis and cost reasonableness analysis could not be provided within the available funding and time allotted for this Study requested by Bonita Springs City Council.

Potential Solutions for flooding reduction need to be analyzed for engineering feasibility by neighborhood to determine the cost reasonableness and the actual likely contribution for reduction of flooding in that neighborhood; and potential solutions which by engineering analysis appear to be feasible and cost reasonable need to be evaluated in a water model created and validated to accurately predict extent of flooding from various storm events such as 25 yr, 50 yr., 100 yr., IRMA 100 yr. est. at 150 yr. flooding and higher storm events such as 200 yr. storm to determine if the potential solution when applied to a neighborhoods) reduces extend of flooding (flooding reduction %) and /or improves flooding levels in other areas or has little effect on overall flooding or actually contributes to worsening flooding in some areas. Model should be developed ASAP using latest GIS topo elevations, finer grid and more accurate boundary conditions with ability to vary 5 of ground saturation and depth of surficial water table.



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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 Wesley Kayne, P.E., Barraco and Associates, Councilman Fred Forbes, Deputy Mayor Peter O'Flinn, City Manager Carl Schwing, Assistant City Manager Arleen Hunter, Director of Public Works Matt Feeney and Atkins Engineering.

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 WITH FUNDING FROM THE CITY OF BONITA SPRINGS

# Abstract

The Southwest Florida Regional Planning Council (SWFRPC) assisted the City of Bonita Springs in developing a City of Bonita Springs Flood Reduction and Watershed Restoration Plan that includes proposals for projects to reduce flooding in the City of Bonita Springs suitable for legislative funding support and plans for reduction of flooding, restoration of functional healthy hydrology, and subsequent improvements in water quality and habitat. The project encompasses the Imperial River Watershed, the Spring Creek Watershed and the Coastal Island Watershed within the City of Bonita Springs

In the development of this plan 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 multiple citizens from Cedar Creek, Imperial Harbor, Worthington, Morton Groves, Pelican Landing, neighborhoods along the Imperial River, and Spring Creek. We confirmed the scope of work and selected protocols. We assisted in the selection of Atkins Engineering for planning level cost estimates of plan recommendations. We met with Lee County staff and with their contracted study engineers. 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.



The City of Bonita Springs selected by interviewing three major nationally recognized engineering firms with significant storm water and flooding control experience a companion engineering firm, Adkins Engineering. Adkins Engineering was used to provide approximate costs estimates for various potential solutions discussed herein. Appendix A contains the work of Adkins Engineering which was done to support this effort.

Potential solutions to provide flood reduction were then developed to address city-wide and specific area flooding reduction. A total of 15 potential solutions are provided.

Potential Solution 1: Removing impediments to flows within the existing system. This includes debris, sediments, and trash that has accumulated or that is storm related. Evaluate existing constrictions in flow in the system including lack of drainage features; small culverts; culverts with inverts set too high; causeways constructed across floodplains; unpermitted intrusions into the floodplains; and locations where variances allowed intrusions into the floodplains.

Potential Solution 2: Replace substandard culverts and bridges with new structures of increased size, correct inverts, and a design that plans for future sea level rise and increased future storm surge. Where possible and feasible replace multiple culverts with an open span of box culverts or a bridge. improves flows and may enhance recreational navigability. Repair damaged, degraded and vandalized permitted dikes and berms

Potential Solution 3: Retrofit older communities which lack any true surface water management system to have a basic system of swales with collection in storm water retention systems with a point or points of positive discharge to a larger receiving flowway These systems need not be restricted to a single named neighborhood but may best be constructed in several adjacent neighborhoods that all feed a regional storm water collection and treatment system.

Potential Solution 4: Collect flows in the watersheds east of I-75 into a very large Regional Storm water Management System (RSMS) with associated filter marsh water quality treatment located in the eastern area of the Bonita Springs DRGR on mine lands and agricultural lands This will serve neighborhood flows east of I-75 and collect flows from the north into a new flowway connection across native lands for discharge to correct watershed destination (Spring Creek, Imperial River, Cocohatchee River).

Potential Solution 5: Change the design of the Kehl Canal to retain and treat more water rather than quickly discharge it to the Imperial River proper. Add adjacent water storage features to collect flows from the Kehl Canal that incorporate filter marshes (examples: Ten-Mile Canal filter marsh; North Colonial Waterway; Freedom Park filter marsh) Install a series of step up weirs to hold additional water within with increasing control elevations from west to east (this will aid storage and provide improved groundwater levels during dry season in the DRGR)

Potential Solution 6: Reconnect and/or improve the connection of the upper watersheds of Half-Way Creek, Spring Creek, and the Cocohatchee River to carry their original natural flows and not unnaturally contribute excess flows to the Imperial River. The Bloomberg Grant application is for the beginning of this planning effort. The reconnection design will be designed to restore the natural hydroperiod and capacity of Half-Way Creek, Spring Creek, and the Cocohatchee River and not exceed their carrying capacity. Imperial River flooding will not be reduced by transferring flooding t another watershed (as has been done by other to the Imperial River.



Potential Solution 7: Where available obtain unoccupied lands including native lands, exotic infested lands, mine lands, agricultural lands, rural lands, and otherwise vacant lands that are in existing floodplains or immediately adjacent to existing floodplains. This includes SFWMD “Surplus Lands” currently available in the DRGR. Request that the SFWMD not auction these lands but transfer them to the City of Bonita Springs for water management projects or sell them at simple cost to the City.

Potential Solution 8: Establish a better/higher storm water retention standard for all new development including residential, commercial, industrial, recreational, and agricultural in the City of Bonita Springs. These standards will retain and manage more water on-site and provide for a gradual release in a natural hydroperiod; not a system of no discharge and then sudden high volume discharge. Amount for the City will be dependent on the administrative process to implement and then legal costs to defend the higher standard

Potential Solution 9: If an existing building in a floodplain is to be replaced or retro-fitted to more than 50% of its above foundation area then the building would have to meet the current flood elevation standards (no exemptions). Given the on-going rate of sea-level rise for the City of Bonita Springs an additional 3 feet over current elevations

would be recommended for building expected to last for more than 100 years. Amount will depend upon the number of buildings that will need to be elevated.

Potential Solution 10: If an area has been intentionally designed in its Surface Water Management System, (SWMS) and permitted to use its roadways as flowways during temporary flow events this information must be legally disclosed to the community and all new buyers and/or renters. Such roads should be posted that they will function that way with appropriate signage as is done in the western United States.

Potential Solution 11: Emergency Sluice Gates proved effective in communities like Pelican Landing. Determine where existing modern SWMS do not have them but could be redesigned for their use. Assist those communities in putting in Emergency Sluice Gates. Work with the SFWMD to allow greater flexibility in operating existing and future emergency sluice gates in response to storms occurring in a changing climate

Potential Solution 12: Establish a Storm water/Flood Reduction Utility Fee to assist in funding the necessary projects Fee would include a base city-wide assessment to cover City-Wide projects and activities and as needed an additional MSTU assessed for specific developments/neighborhoods when a retro-fit or project only affects it.

Potential Solution 13: Complete the Southern CREW Restoration Project. The purpose of the Southern Corkscrew Regional Ecosystem Watershed Critical (CREW) Project, aka Southern CREW Project (Project), is to restore hydrology and ecology to an environmentally sensitive natural area encompassing 4,150 acres, located along Bonita Beach Road, just east of Bonita Springs . It is estimated that construction costs associated with implementing the recommended improvements will be approximately $4.3 million.



Potential Solution 14: Some property owners who have experienced flooding in multiple flooding events on a repetitive basis over the years have indicated an interest in selling their property to the public sector to become part of the river floodplain unimpaired by structures.

Potential Solution 15: Prepare for the Effects of Climate Change on Flooding From Changes in Precipitation Rates, Storm Surge Events, and Sea Level Rise

Atkins Engineering was selected to provide support to SWFRPC in developing this report. This included developing planning-level project concepts and cost estimates for selected ideas developed by the SWFRPC, as well as, providing input as to the viability and permitability for the various types of projects. The support also includes providing input on City initiatives recommended by the SWFRPC. Information in Appendix I is intended to provide the City with planning-level information that can aid in high level decision making and prioritizing federal and state funding options for future project implementation.

# INTRODUCTION

## *The Estero Bay Watershed Landscape*

The Estero Bay Watershed is located on the lower west coast of Florida, on the Gulf of Mexico. The Estero Bay basin encompasses 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.

The Estero Bay Watershed is roughly bounded by Summerlin Road-McGregor Boulevard (CR 869) east to 6$^{the}$ Street north to 24$^{th}$ Street east to Lee Boulevard east to Immokalee Road (SR82) southeast to Wildcat Road, south on TPI Road, west to Six Ls Farm Road, south to Pioneer Road, south to the Bird Rookery Swamp, west to Interstate 75, north to Tuscany Reserve, west to new US 41, north to Bonita Beach Road, west to the Gulf of Mexico Beach of Bonita Beach, north and northwest along the beaches of Bonita Beach, Big Hickory Island, Black Island, Lovers Key, Estero Island, Bunche Beach and on a northwest bearing from Bodwitch Point to the landward end of the Sanibel Causeway at Summerlin Road.



Three different methodologies have produced estimates of the impervious surface of the watershed in 2000 (7% to 13%), 2025 (13% to 31%) and 2050 (15% to 32%). Population growth for the period between 1950 and 1980 was a nearly a 100% average increase per decade while 1980 to 2000 had almost 50% average increase per decade. By 2000, the area qualified as an urbanized area, as the population density had exceeded 1,000 people per square mile, with a population of 121,923. Historically, the watershed encompassed more than 75,000 acres of wetlands. Over 28 percent or 19,143 acres of wetlands have been lost in the Estero Bay Watershed. This study will focus on the currently undeveloped acreage including the approximately 60,000 wetland acres within the watershed that are under pressure for development.

All of the Estero Bay tributaries have the Outstanding Florida Waters designation and Estero Bay itself was the first estuary in the Florida to receive the Aquatic Preserve designation. The Estero Bay Watershed is within the South Florida Water Management District's (SFWMD) Lower Charlotte Harbor Surface Water Improvement Management (SWIM) program.

In 1999, the South Florida Water Management District completed the Estero Bay and Watershed Management and Improvement Plan. The plan developed land and water management strategies to achieve water quality and quantity objectives for Estero Bay. More recently, in 2003 the SFWMD Governing Board designated Lower Charlotte Harbor a priority SWIM Program water body, which includes Estero Bay. The SFWMD also received delegated authority to issue Environmental Resource Permits (ERP) from the State of Florida Department of Environmental Protection (FDEP).

The Estero Bay Watershed area is composed of a variety of landscapes with urban development comprising approximately 26% of the total watershed area in 2003. The urban development is primarily concentrated in the western portion of the Estero Bay basin. Interspersed between these urbanized areas are sections of public conservation land, agricultural land, other native land habitats, uplands, floodplain and riverine wetlands, tidal marsh and open water. Estero Bay Watershed includes almost 32,000 acres of managed public conservation areas, or 17.4% of the SWFRPC land area, including the western part of the Corkscrew Regional Ecosystem Watershed (CREW). Agriculture and rangeland covers approximately 5%, native upland habitats 16.4%, open water 19.2%, native wetlands 28.5% and barren lands (principally in conversion to development) 4%.

Southwest Florida rainfall is seasonal with a late-Winter/Spring drought and a Summer/Autumn monsoon. Southwest Florida is sub-tropical; not tropical and, not temperate

Southwest Florida is flat. The Estero Bay Watershed is a series of relatively flat plateaus with intervening old shoreline ridges ranging in elevation from sea level to a natural maximum of 50 feet NGVD in the eastern portion of Lee County. The Hendry Creek basin is low and does not exceed 5 feet National Geodetic Vertical Datum (NGVD) throughout, while elevations in basins farther south, Spring Creek, Estero River, and Imperial River, increase closer to the coast due to a xeric ridge of relic prehistoric beaches.

The higher elevations in the eastern part of the watershed are associated with the Immokalee Rise, and increase relatively steeply from 15 feet to over 40 feet in elevation. The Immokalee Rise separates the flowways of the Big Cypress and the Everglades from the Estero Bay Watershed.



Sheet-flow is a normal, natural path of gradual broad-front delivery of precipitation driven freshwater to streams and estuaries. Blocking sheet-flow, collecting and concentrating water flows into drainage ditches and canals creates flash water flows that alter the natural hydroperiod and enhance flooding, Sheet-flow directed into channels does extend the period from when the River flood crests to when it starts receding. Contrary to some past media statements sheet-flow does not cause flooding and there is no “deadly sheet-flow”.

There are several documented, predicted, and perceived problems in the Estero Bay watershed. The problems are primarily related to: 1.) conversion of natural habitats to agricultural, commercial, and residential land uses; 2.) the construction of canals, ditches, and road beds; and 3.) filling, dredging, and draining of wetlands water bodies that occur in association with the previous two factors. The watershed problems for the City of Bonita Springs include:

- increased watershed size- affects flooding ,
- increased freshwater inflows,- affects flooding,
- increased nutrient and total suspended solids loading- affects water quality
- lowered water tables water quality, but might create more absorptive ground reducing sheet flow and flooding

- altered wetland and aquatic hydroperiods - affects water quality,
- loss of wetland, upland, and aquatic habitats- affects water quality'
- downstream flooding

**Increased watershed size**

The constituent basins of the Estero Bay watershed were delineated as early as 1962 (Smalley, Welford, and Nalven, 1962). Even in 1962, these constituents had been altered from their predevelopment condition by canals and roadbeds. The size of the effective watershed for Estero Bay has increased since pre-development and presumed 1962 conditions as a result of several factors. Prominent among these factors are constrictions or blocks in historic flowways that formerly allowed water from the watershed's eastern basins to flow south through Collier County.

**Increased freshwater inflows**

Residential, commercial, and agricultural development has changed and will continue to change the natural landscape within the study area. These changes have and will result in changes in the physical manner in which runoff responds to rainfall. Replacement of wetlands and forests with impervious surfaces, like asphalt pavement, rooftops, and concrete sidewalks, produces increased runoff rates from the land surface. Likewise, ditching and pumping increase runoff rates from agricultural and mining areas. These increases have the potential to produce both an increase in the total freshwater discharges to the streams and estuary and increase the magnitude of individual discharge events. On-site and regional storm water management systems have been and continue to be constructed within the study area in an effort to ameliorate the impacts of these changes to the land surface. Insufficient data are available to determine the effect of both development and existing storm water management practices on freshwater discharges.



**Increased nutrient and total suspended solids loading**

Increases in nutrient and total suspended solids loads are a frequent concern in watersheds undergoing significant urban and agricultural development. Implementing "best management practices" in new development is a frequent solution. However best management practices minimize but do not necessarily eliminate the effect of new development on the watershed. The cumulative effects of several new development projects or the effects of new and old development combined, may degrade downstream water bodies and estuaries.

**Lowered water tables**

The construction of canals and channelization of existing waterways has lowered the surficial water table in many portions of the study area. Tabb et al. (1976) describe the pre-development watersheds immediately south of Estero as areas where evaporation exceeds transpiration in many years and drought-conditions are averted by storage of water in shallow, sand filled basins during wet years. Tabb et al. describe a scenario in

which canals breach these shallow basins and dissipate water reserves. This shallow-basin characterization applies to much of the Estero Bay watershed. It is because the watershed is a series of shallow basins, that the watershed size has been significantly increased by seemingly minor alterations in topography and conveyance. Water table declines have been purported causes for excessive wildfires (Tabb et al., 1976), melaleuca (Melaleuca quinquenervia) invasion patterns (Myers, 1983), and salinity intrusions in aquifers. Duever et al. (1978) suggested water-table declines might exacerbate winter freeze damage after observing regional, frost-damage patterns that mirrored regional, water table decline patterns.

**Altered wetland hydroperiods**

Ditching, filling, road beds, and urban and agricultural development have altered the hydroperiod of many of the wetlands in the study area. Most wetlands have been excessively drained, though a few may be over-hydrated. Duever et al. (1978) documented the negative effects of over-hydration. They found decreases in cypress growth as a result of excessive, prolonged flooding caused by berms in Corkscrew Swamp.

**Loss of wetland, upland, and aquatic habitats**

A large amount of upland and wetland habitat in the watershed has been converted to agricultural, residential, and commercial uses. Conversion appears to be continuing at equal or increasing rates. This habitat loss has the potential to affect several regionally or globally threatened or endangered species including the Florida panther (Felis concolor coryi), Florida black bear (Ursus americanus floridanus), red cockaded woodpecker (Picoides borealis), Big Cypress fox squirrel (Sciurus niger avicennia), wood stork (Mycteria americana), Southeastern American kestrel (Falco sparverius paulus), and Florida sandhill crane (Grus canadensis pratensis).



**Downstream flooding**

The 1995 wet season produced severe flooding in Bonita Springs located in the downstream reaches of the Imperial River sub-basin. This flooding was particularly notable given that high flows were not documented in the adjacent, Estero River sub-basin (Johnson Engineering Inc. et al., 1995). The South Lee County Watershed Study (Johnson Engineering Inc. et al., 1998) was conducted in response to this flooding. This flooding has been attributed to development in historic floodplains, land use changes, flowway constrictions, sub-basin reconfiguration, and agricultural pumping practices (Johnson Engineering Inc. et al., 1998).

In 2002, the City of Bonita Springs completed a Storm water 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 Storm water 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 Storm water Utility. The report for the Feasibility Study of a Storm water 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 Storm water 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

The South Lee County Watershed Update Plan, was completed January 20, 2011 for the South Florida Water Management District and Lee County January 20,2011 by Boyle Engineering. The following actions are recommended for implementation, in order of decreasing priority: 1) Increasing conveyance in the North Branch Estero River at Rivers Ford Road. 2) Increasing conveyance in the South Branch Estero River at Country Creek Drive near Split Oak Way. 3) Connection of Halfway Creek to the Rapallo Lake west of Via Coconut Point and east of Via Villagio. 4) Improve vegetation maintenance in Halfway Creek east and west of U.S. 41. Vegetation removed east of U.S. 41 should be removed from the flood way and not stacked in "tee-pees". Fallen vegetation and dense brush west of U.S. 41 should be removed and any recently deposited sediment should be removed. 5) Improve conveyance through the emergency by-pass gate and channel from the Brooks to the South Branch Estero River without decreasing groundwater elevations in the vicinity of Three Oaks Parkway and Williams Road. 6) Ensure that accumulated sediments are removed in the culverts under I-75 at Halfway Creek and maintained as required to meet design capacity. 7) Consideration of construction of weirs upstream of I-75 for Halfway Creek and South Branch Estero River to maintain adequate wet and dry season water levels consistent with wetland hydroperiod needs. Additional modeling is needed using more accurate topographic data east of I-75 to determine the invert elevation and the size of the weirs. 8) Construction of up to two 60" diameter culverts under I-75 to Bonita Bill Canal in the Spring Creek watershed. The culverts should either be: a) capped with concrete until conveyance improvements downstream have been implemented to a sufficient degree to allow for delivery of storm flows to the Spring Creek watershed, or b) controlled by a gate to only allow flows when water levels at the upstream side of the Moriah weir are less than 10.8 ft-NAVD and water depths upstream of the gate are greater than 1.5 feet. 9) Enlargement of culverts downstream of the Old U.S. 41 culverts in the Spring Creek tributary that receive flows from the Moriah weir. The capacity of the downstream culverts at the railroad, FPL crossing, and Cedar Lane should be at least as large as the Old U.S. 41 culverts (two 8' x 4' box culverts). 10) Enlargement of the Countess Lane culverts to be at least as large as the Old U.S. 41 culverts in Spring Creek at the USGS gaging station (two 8' x 4' box culverts). 11) Further evaluation of restoration of flood flow deliveries from the Kehl Canal watershed

to wetlands south of Bonita Beach Road and east of I-75 for ultimate conveyance to Cocohatchee Canal. The maximum flood flow deliveries are only necessary for the 25- and 100-year design storm events, and the peak flow is expected to be in the range of 200 cfs. Additional modeling and evaluation is needed to assure that the wetlands south of Bonita Beach Road (east of I-75) and the Cocohatchee Canal can safely receive these flows.

In addition to the above Mr. Roger Copp has also recommended that:

- Additional storage is needed in the DR/GR area
- Additional storage would be beneficial for a number of purposes, including augmentation of public water supplies, holding back wet season flows for subsequent release during the dry season, and water quality treatment
- The area east of I-75 has historically been an area that experiences extended periods of flooding
- Realtors are normally quiet about how much flooding one can expect, so further development east of I-75 may result in more complaints to City Council

The City of Bonita Springs City Council approved their DRGR Task Force's recommendation to hire Kevin Erwin to conduct an ecological assessment of the Bonita DRGR . The report included ecological mapping, a summary of existing and historical conditions and recommendations. Erwin recommended that the Ecological Report (2014) was first step, to be followed by additional surface and subsurface water monitoring This information could then be included in a model to be used as a decision-making tool to understand how changes on the surface landscape will impact both surface and subsurface water resources. The Erwin Ecological Report identified, "significant potential water storage capacity that exists within the DRGR if appropriate management and restoration techniques are implemented."



The work products included with this report are designed to be useful planning tools for staff, policy makers, and the public when considering future activities within the DRGR. These recommendations are time-sensitive. While there is considerable habitat fragmentation and over-drainage there still exists significant opportunities for hydroecological restoration and properly planned low-impact development as long as these activities receive priority action and public support. Delayed implementation of appropriate plans could complicate restoration opportunities resulting from further development and fragmentation.

The lack of hydropattern data is the most significant information gap requiring immediate attention in the DRGR and is prominent among recommended future activities. Understanding the dynamic nature of the ecosystems and the consequences of human interventions is essential for making management decisions aimed to maintain, enhance or restore the ecological integrity of the DRGR and to avoid, minimize or mitigate future ecological threats to the system.
The proper implementation of these recommended restoration scenarios will

improve the sustainable integrity of the community by setting proper goals and objectives.

Erwin recommend that the City initiate regular programs and discussions with all stakeholders in the DRGR as a critical part of the restoration and habitat management objectives. Open communications between all stakeholders is a key component to undertaking successful restoration and management projects. The City should implement a comprehensive surface and groundwater monitoring network that includes; shallow wells, deep wells, staff gauges, flow gauges and rain gauges. In addition, the collection of historic water level data should be pursued by identifying artifacts in the study area and verifying the accuracy of the LiDAR data for the study area. It will be necessary to extend the collection of hydrological data onto adjacent Lee County DRGR lands where some degree of restoration may be appropriate.

In order to commence the preparation of detailed restoration plans and make appropriate decisions on future land-use within the DRGR the Erwin report recommended that the City should model the existing and future hydrological conditions. The data and information collected in the recommended monitoring network, along with the infrastructure information identified in Task 1 could be used by the ecologist and modeler to calibrate existing conditions within the DRGR. It will then be possible to model the expected conditions for those future development and restoration scenarios chosen by the City.



## *The Fifteen City Watersheds (AKA Sub-basins)*

For the purposes of this study we are using the SFWMD basin and sub-basin designations. SFWMD has delineated basins in Estero Bay Watershed differently than FDEP. Compared to FDEP's Plan Units, the northern headwaters of the Cocohatchee River are in the Estero Bay Plan Unit. As a result of flooding in 1995, SFWMD determined that Trafford basin flows west to the Estero Bay or south depending on the amount of rainfall.

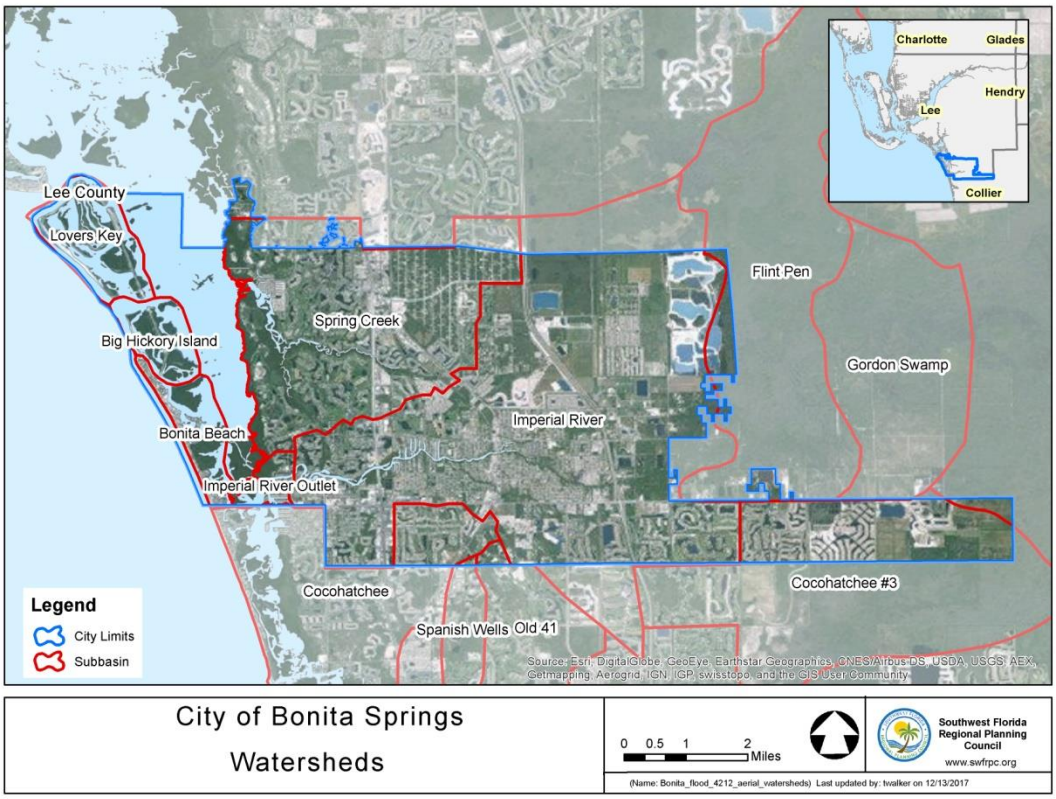


Figure 1: The Fifteen Sub-basins (15) in the City of Bonita Springs

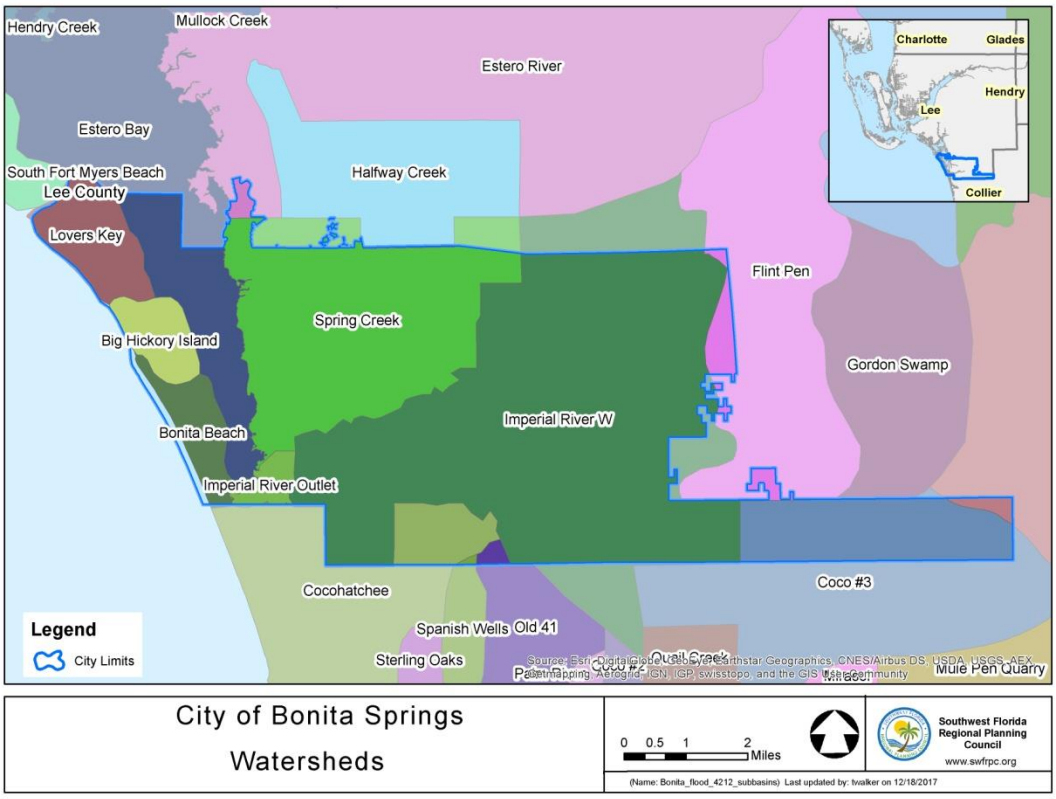




Figure 2: The Fifteen Sub-basins (15) Watersheds in the City of Bonita Springs (color coded)

Sub-basins That Occur Within the Boundaries of the City of Bonita Springs

| SUB-BASIN | BASIN | Total Acres | Total Acres within the City of Bonita Springs | Percent of the sub-basin in the City of Bonita Springs |
|---|---|---|---|---|
| Bird Rookery Swamp | Trafford | 16,585.70 | 133.48 | 0.80% |
| Gordon Swamp | Estero Bay | 4,806.00 | 13.84 | 0.29% |
| Flint Pen Strand | Estero Bay | 9,009.12 | 536.73 | 5.96% |
| Cocohatchee River East | Cocohatchee | 8,536.70 | 2,418.58 | 28.33% |
| Old 41 | Cocohatchee | 1,889.32 | 88.58 | 4.69% |
| Spanish Wells | Cocohatchee | 781.45 | 19.24 | 2.46% |
| Cocohatchee River West | Cocohatchee | 5,932.83 | 825.56 | 13.92% |
| Imperial River | Estero Bay | 16,336.90 | 13,721.65 | 83.99% |
| Spring Creek | Estero Bay | 7,084.01 | 6,343.77 | 89.55% |
| Imperial River Outlet | Estero Bay | 341.70 | 336.26 | 98.41% |
| Lovers Key | Estero Bay | 1,348.77 | 1,348.77 | 100.00% |
| Big Hickory Island | Estero Bay | 758.55 | 758.55 | 100.00% |
| Bonita Beach | Estero Bay | 837.69 | 837.69 | 100.00% |
| Estero River | Estero Bay | 39,168.80 | 118.96 | 0.30% |
| Estero Bay | Estero Bay | 10,910.80 | 2,205.76 | 20.22% |

Table 1: The Area and Percentage within the City of Bonita Springs of the Fifteen Sub-basins

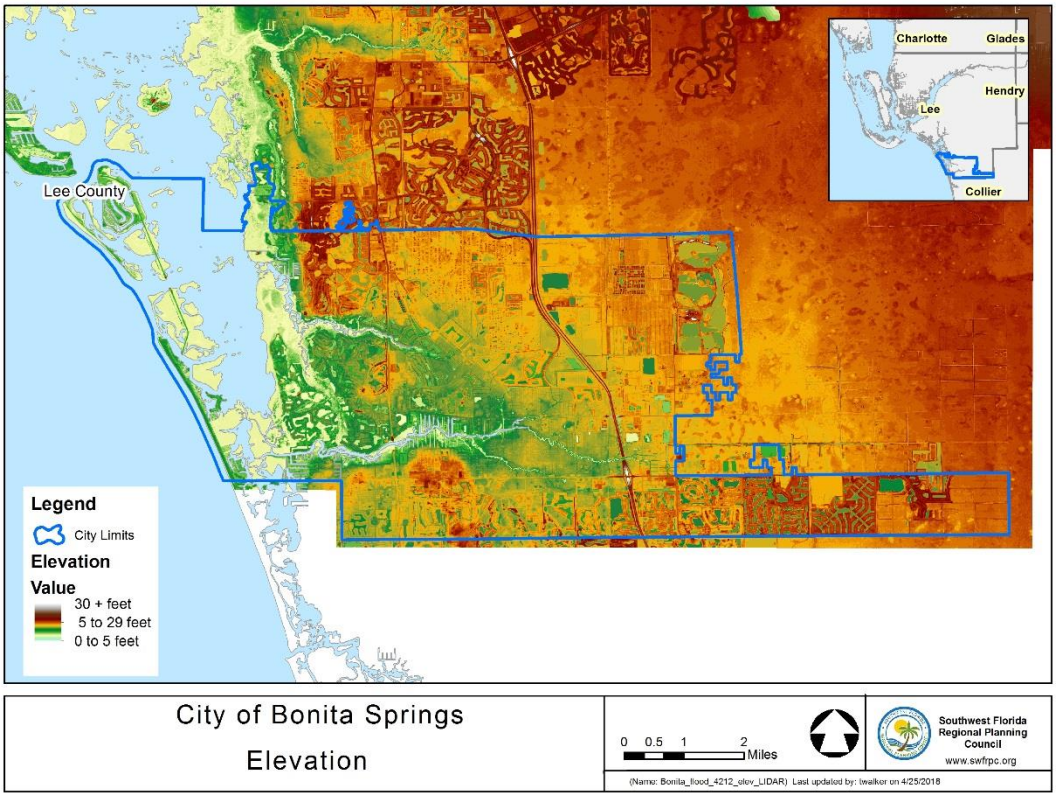


Figure 3: The Elevations in the City of Bonita Springs.
Note the very flat terrain and the highest areas are the Interstate 75 overpasses and a high mound in the DRGR mine.

The Estero Bay region is generally characterized by slow, sheet-flow drainage patterns that are typical of the flat, wetland-dominated, southern Florida landscape. In the past, the naturally dispersed water patterns distributed nutrients over broad areas of wetland vegetation. Seasonal fluctuations in flow from rainfall created the necessary salinity regime in Estero Bay for good estuarine productivity. Increased development since the 1960s has led to changes in the natural river systems around Estero Bay, altering freshwater inflow patterns (Florida Department of Environmental Protection, 2003).

Bird Rookery Swamp

Only 133.48 acres (0.8 %) of the 16,585.7 acre Bird Rookery Swamp sub-basin is in the far eastern end of the City of Bonita Springs. This where the connection between The Lake Trafford Basin and the Cocohatchee Basin occurs that can sometimes move water

that should go to Lake Trafford to instead flow westward into the Kehl Canal and then into the Imperial River. Bird Rookery Swamp is a large cypress/ mixed hardwood swamp forest with associated hydric pine flatwoods. It is part of the acquired public lands of the Corkscrew Regional Ecosystem Watershed (CREW) and protects numerous species of plants and wildlife. The CREW project began in 1989 after several years of drought caused wells to go dry in southern Lee County. The Lee County Commission applied for the Save Our Rivers Program, asking the South Florida Water Management District (SFWMD) to buy Flint Pen Strand for a water recharge area to ensure a better water supply for southern Lee County. At the same time Audubon Corkscrew Swamp and the Conservancy of Naples applied to the Save Our Rivers Program asking the SFWMD to buy Bird Rookery Swamp to protect the southern and western edges of the Corkscrew Sanctuary. The SFWMD looked at both applications and noticed that the two parcels of land were near each other. They studied the area further, discovered there was an entire undisturbed watershed system there and determined that the whole system needed to be protected. However, the SFWMD could not afford to purchase the whole project at one time. Concerned citizens and agencies formed the CREW Land & Water Trust. The Trust was formed as a private, non-profit organization – in partnership with public agencies – whose mission was to coordinate and oversee the purchase and management of the Corkscrew Regional Ecosystem Watershed (CREW) project. With determination and through partnerships with state and local governments, private landowners and businesses, environmental organizations and interested citizens, the first parcels of land were bought in 1990. Today, over 50,000 acres of the 60,000-acre project have been protected for conservation through acquisition or conservation easement. Protecting this land provides a place for water to slowly seep in to the ground, recharging the aquifer with drinking water. It also allows water to spread out and flow across the land where vegetation can filter pollutants out of the water before it reaches the Gulf. In addition to providing for clean water, protecting this land also makes available habitat for wildlife and recreation lands for the public.

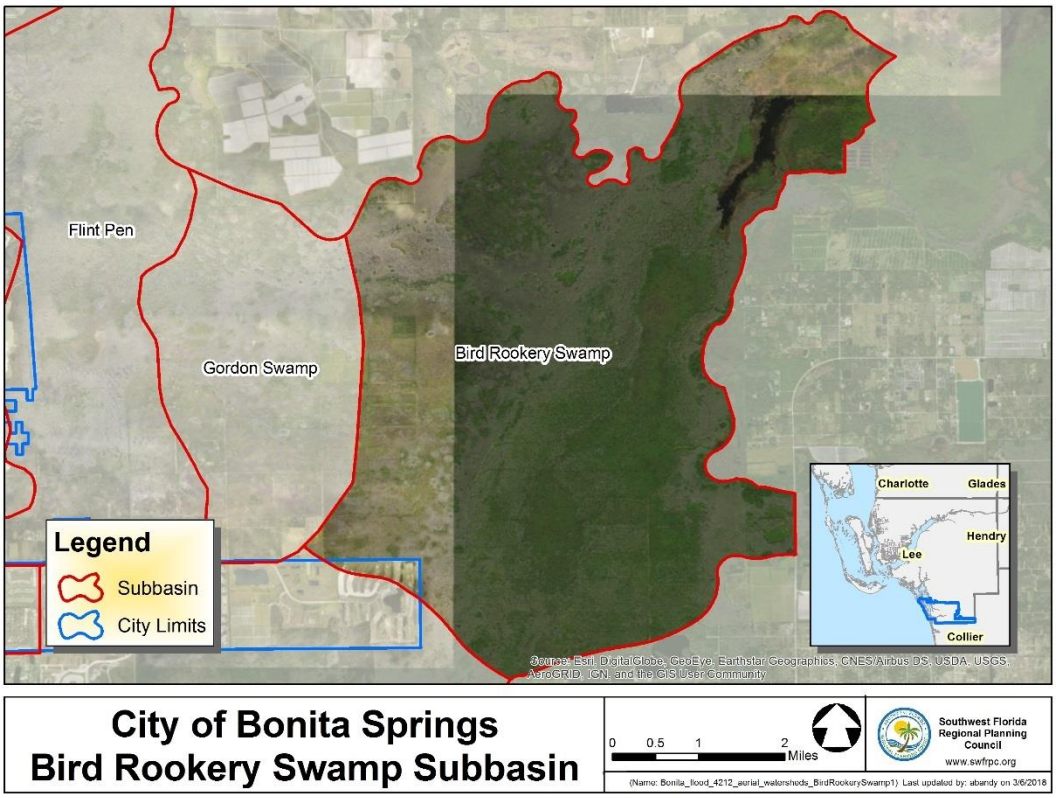




Figure 4: Aerial of the Bird Rookery Swamp Sub-basin

Gordon Swamp

Only 13.84 acres (0.29%) of the 4,806 acre Gordon Swamp are in the boundary of the City of Bonita Springs. It is a cypress/mixed hardwood swamp strand located between the Bird Rookery Swamp and the Flint-Pen Strand that sheet flowed historically southwestward into the Cocohatchee River East sub-basin and was part of the Cocohatchee River Watershed. However today the water is captured by the Kehl Canal and shunted eastward toward the Imperial River and Estero Bay. Gordon Swamp is within CREW.

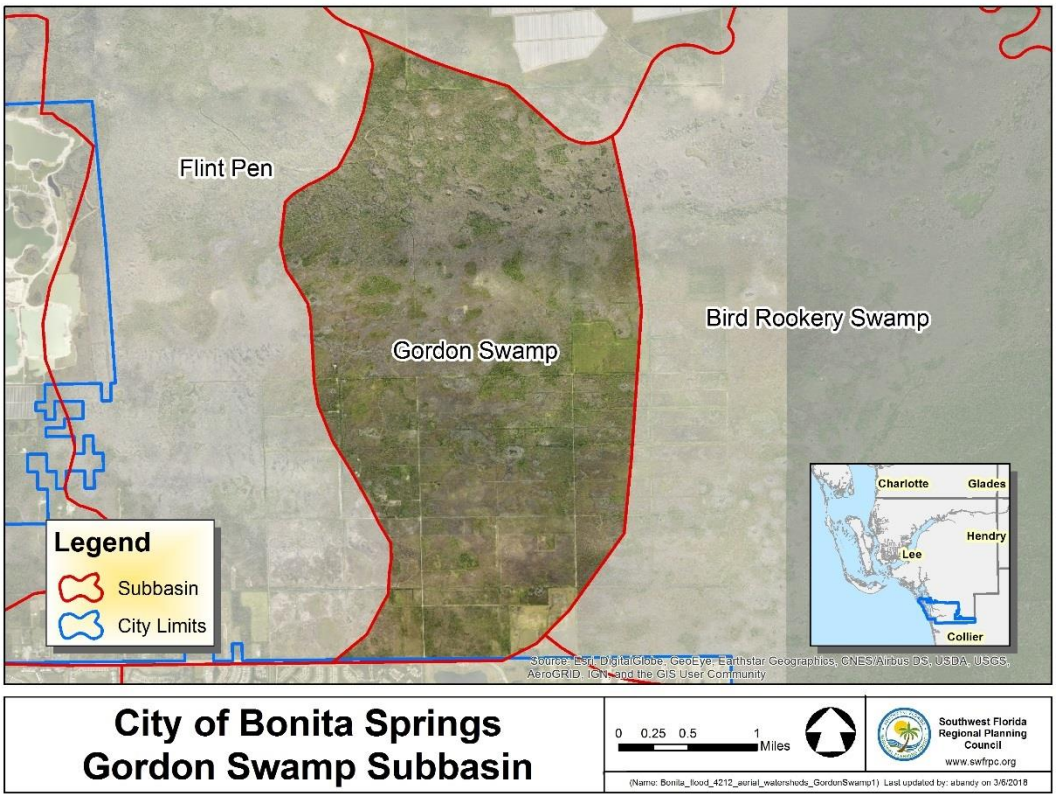




Figure 5: Aerial of the Gordon Swamp Sub-basin

Flint Pen Strand

Only 536.73 acres (5.96%) of the 9,009.12 acre Flint Pen Strand is in the boundary of the City of Bonita Springs. Flint Pen Strand provides part of the headwaters of the Estero River, Halfway Creek, Spring Creek, and the Imperial River.

The southwestern portion of the Flint Pen Strand flows southwestward into the Imperial River sub-basin. None of the flows of the northern and northwestern Flint Pen Strand should be entering into the Imperial River sub-basins but the blockage of flows to Spring Creek and the redirection on flows in canals oriented north to south move waters from the headways of Halfway Creek and Spring Creek east of Interstate 75 into the Imperial River. This is a substantial addition of water into the Imperial River that does not belong there and can contribute to flooding.

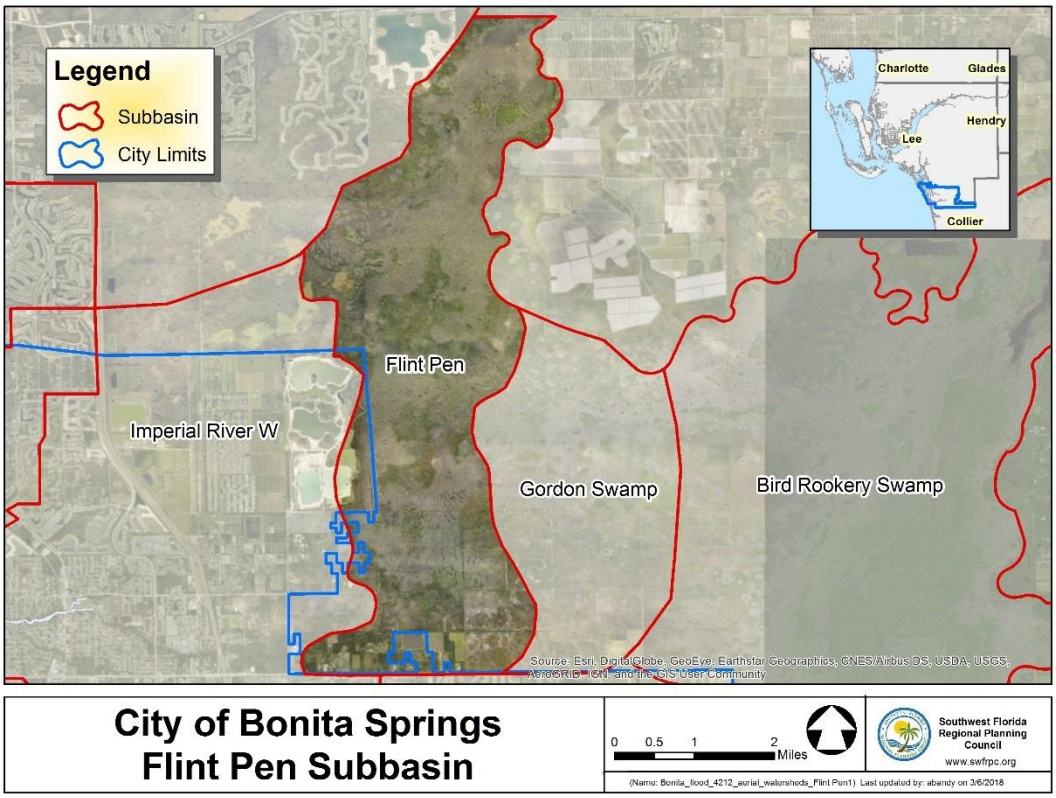




Figure 6: Aerial of the Flint Pen Strand Sub-basin

Cocohatchee River East (AKA Coco #3)

There are 2,418.58 acres (28.33%) of the 8,536.7 acre Cocohatchee River East sub-basin in the boundary of the City of Bonita Springs. This sub-basin is part of the Cocohatchee River Basin.

The waters in this sub-basin should be flowing south into the Cocohatchee River basin but the area within the City of Bonita Springs is instead captured by storm water management systems within developments and agricultural areas and directed to roadside canals of Bonita Beach Road. This then flows westward to connect with the Imperial River for flows into the Estero Bay. This is a substantial addition of water into the Imperial River that does not belong there and can contribute to flooding.

Water in areas of the sub-basin south of the Lee County Line-City of Bonita Springs boundary within Collier County flow south and south westward to be captured by the Cocohatchee/ Immokalee Road Canal which connects westward to the Cocohatchee River West sub-basin.

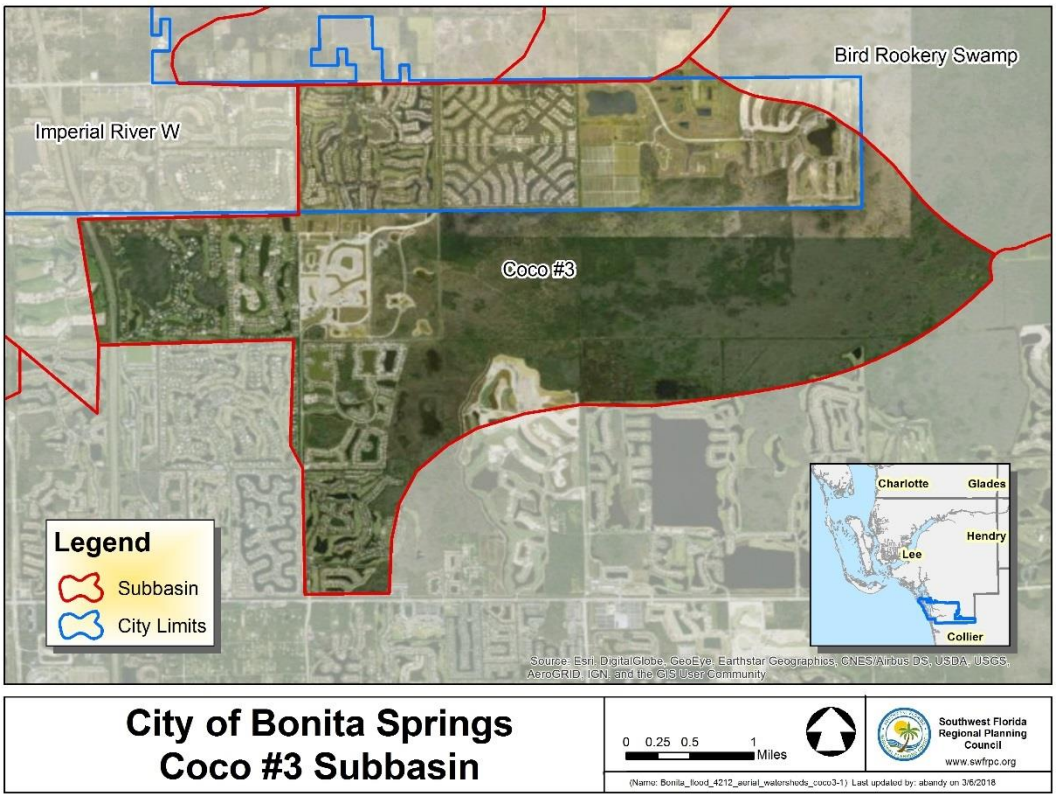




Figure 7: Aerial of the Cocohatchee West (#3) Sub-basin

Old US 41

There are 88.58 acres (4.69%) of the 1,889.32 acre Old US 41sub-basin in the boundary of the City of Bonita Springs. This sub-basin is part of the Cocohatchee River Basin. Water in this sub-basin flows southward to be collected in surface water management systems and canals that connect westward to Cocohatchee River sub-basin.

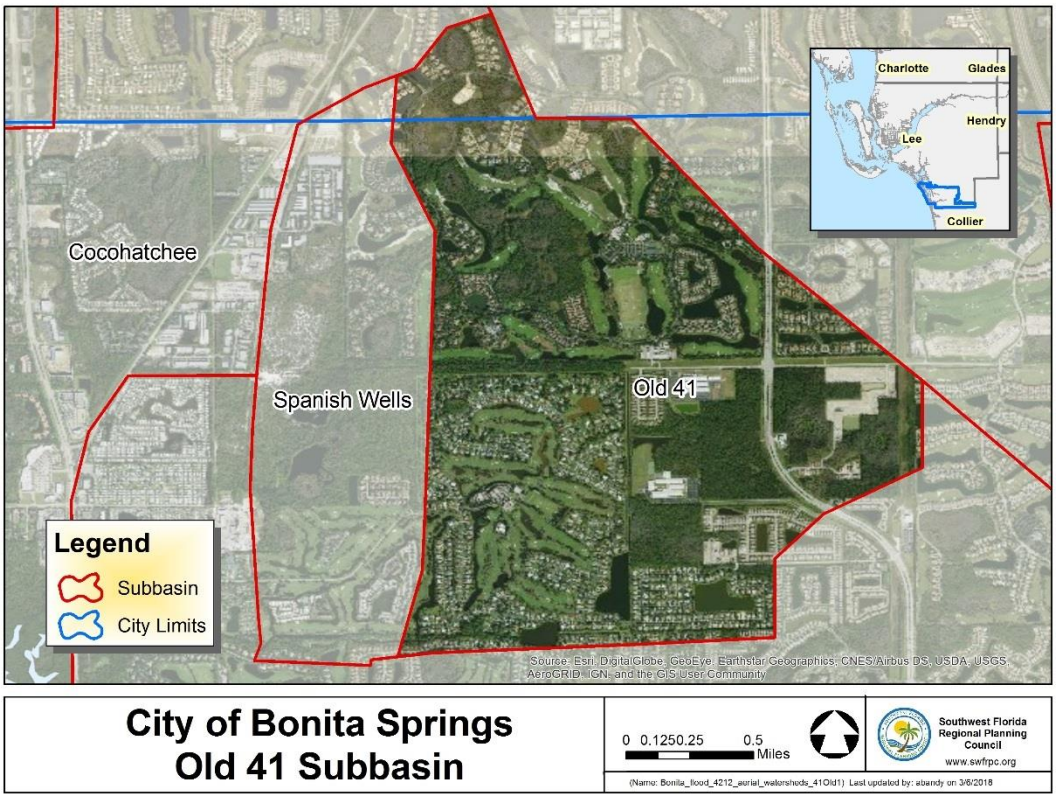




Figure 8: Aerial of the Old 41 Sub-basin

Spanish Wells

There are 19.24 acres (2.46%) of the 781.45 acre Spanish Wells sub-basin in the boundary of the City of Bonita Springs. This sub-basin is part of the Cocohatchee River Basin. Water in this sub-basin is collected within the Spanish Wells water management system (WMS) and is discharges to canals that connect westward to Cocohatchee River sub-basin.

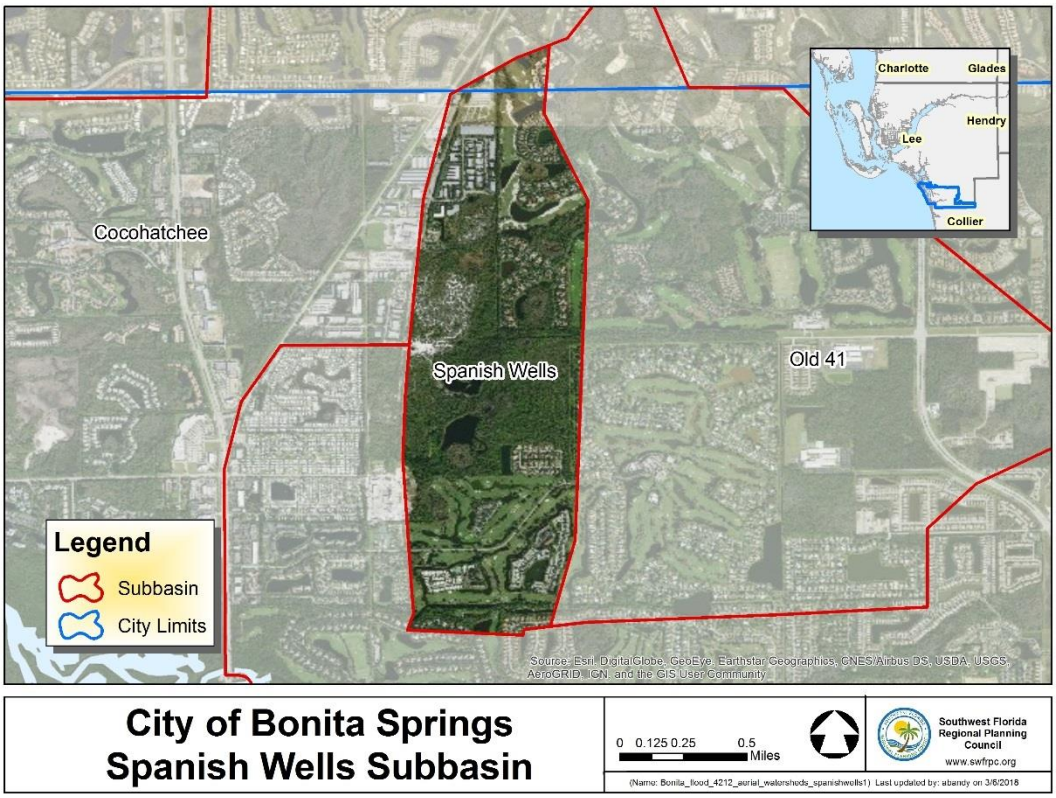




Figure 9: Aerial of the Spanish Wells Sub-basin

Cocohatchee River West

There are 825.56 acres (13.92%) of the 5,932.83 acre Cocohatchee River West sub-basin in the boundary of the City of Bonita Springs. This sub-basin is part of the Cocohatchee River Basin.

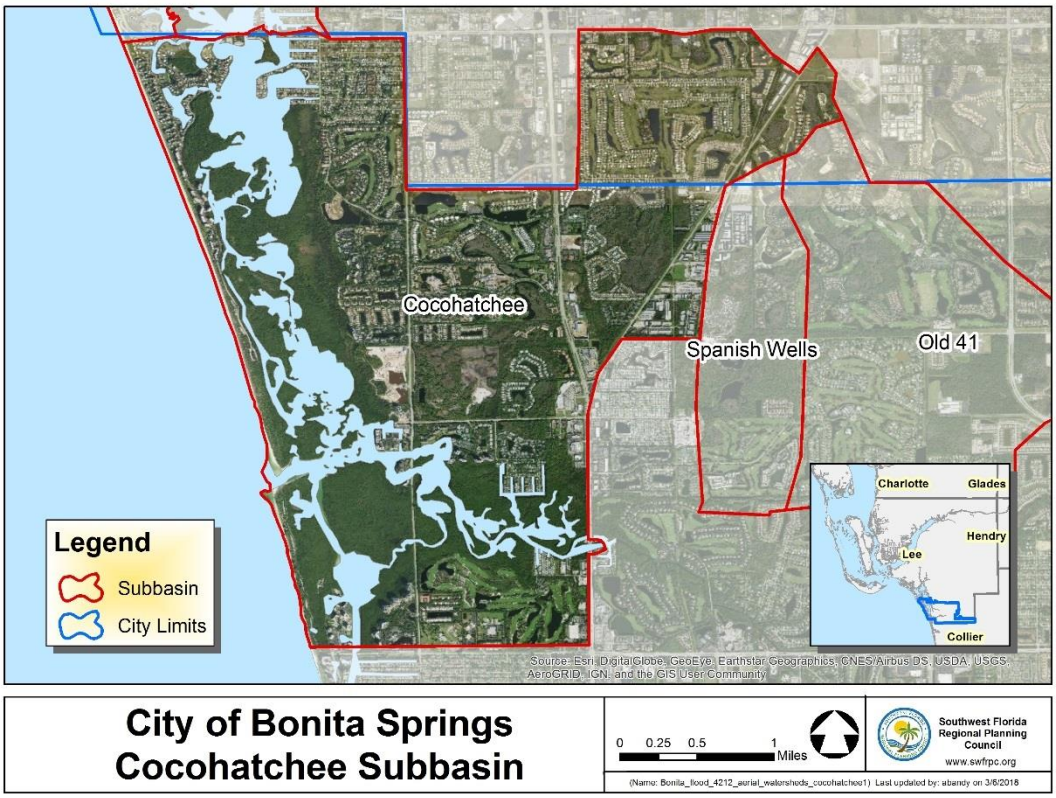




Figure 10: Aerial of the Cocohatchee River West Sub-basin

Imperial River West

There are 13,721.65 acres (83.99%) of the 16,336.9 acre Imperial River West sub-basin in the boundary of the City of Bonita Springs. This sub-basin is part of the Estero Bay Basin.

The Imperial River is fed by the Kehl Canal and marshland at 26°22′16″N, 81°41′23″W, just east of the city limits of Bonita Springs in unincorporated southwest Lee County. It is approximately 9.3 miles (15.0 km) long, from its headwaters just east of I-75 in the Flint Pen Strand, through downtown Bonita Springs and to its mouth at the north end of Fishtrap Bay, near the southern end of Estero Bay. It was originally named Surveyors Creek before the city was developed. The watershed is approximately two miles wide and five miles long. This watershed is generally located south of the Spring Creek Basin and north and north of the Cocohatchee River Basin, in Collier County.

Oak Creek and Leitner Creek flow into the upstream portion of the Imperial River. As the Imperial River runs adjacent to the City of Bonita Springs, it receives extensive amounts of urban runoff along the majority of its length (FDEP, 2003).

The topography of the Imperial River watershed reflects its location within the Southwestern Florida Flatwoods ecological region. Elevations range from around 5 to 10 feet above sea level in the western part of the watershed near the coast and around 10 to 15 feet above sea level in the eastern part of the watershed. The predominant soil type is shelly sand and clay, which exhibits moderate to good natural drainage (Department, 2003). The Imperial River watershed is rapidly being developed in response to a continuing influx of new residents. Land use in interior areas primarily consists of cattle, vegetable, and citrus farms. Retirement, tourism, health care and the service industries drive the economy. Additional information about the river's hydrology and geology are available in the Basin Status and Assessment Reports for the Everglades West Coast Basin Watershed Planning and Coordination Section. Bureau of Watershed Management (FDEP 2003).



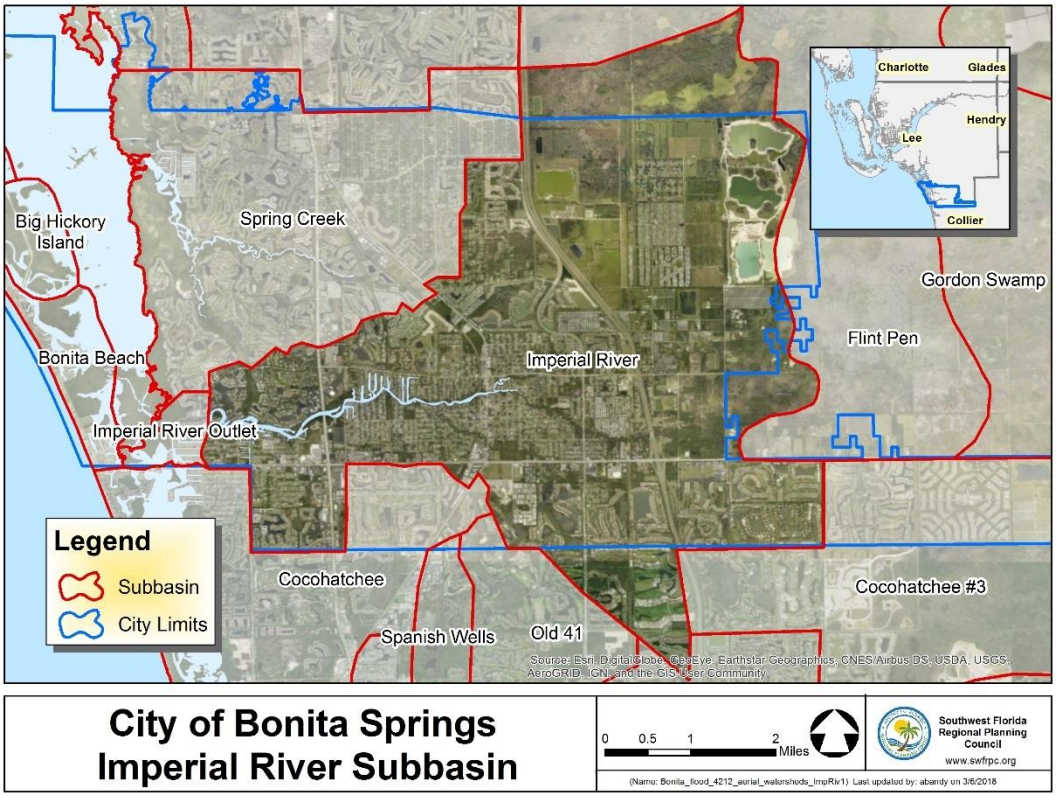


Figure 11: Aerial of the Imperial River Sub-basin

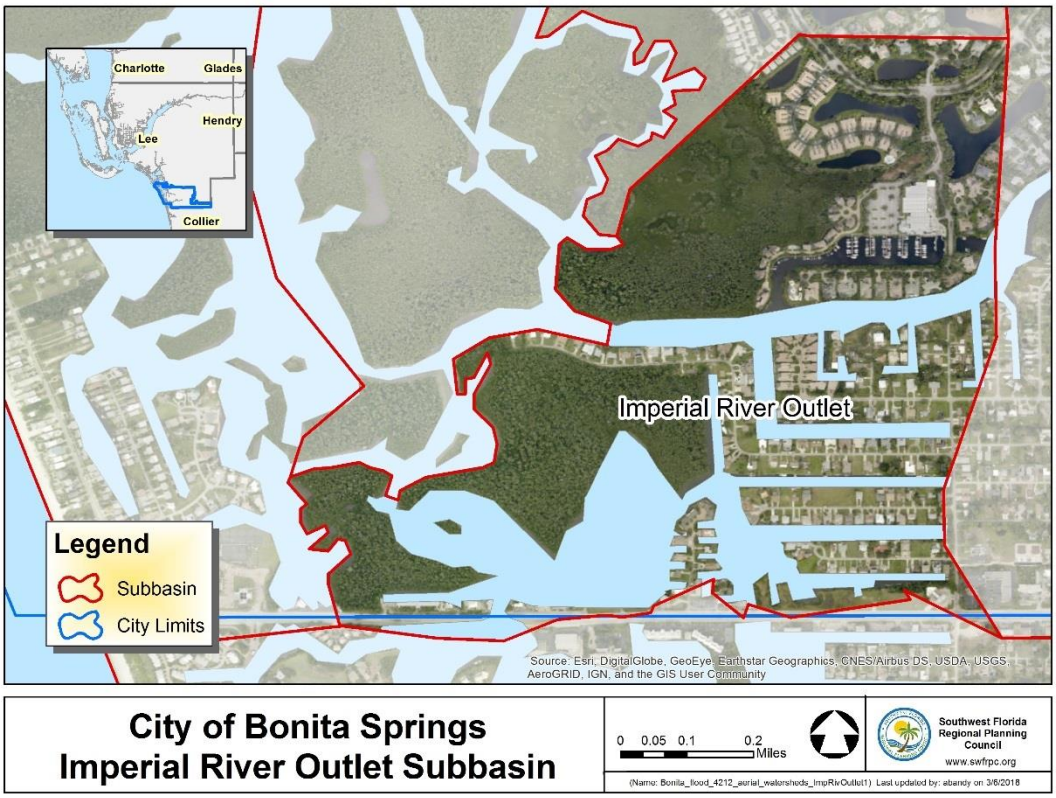




Figure 12: Aerial of the Imperial River Outlet Sub-basin

Spring Creek

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There are 6,343.77 acres (89.55%) of the 7,084.01-acre Spring Creek sub-basin in the boundary of the City of Bonita Springs. This sub-basin is part of the Estero Bay Basin.

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 composite runoff curve number (Cubic Meters per Second -cms) for the 3 day – 25 year event.

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.



It is a highly modified watershed and probably was at least twice the size of what it is today before Interstate 75 was constructed. Those former Spring Creek headwaters are now included in the Imperial River flows via the Flint Pen Strand. 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.

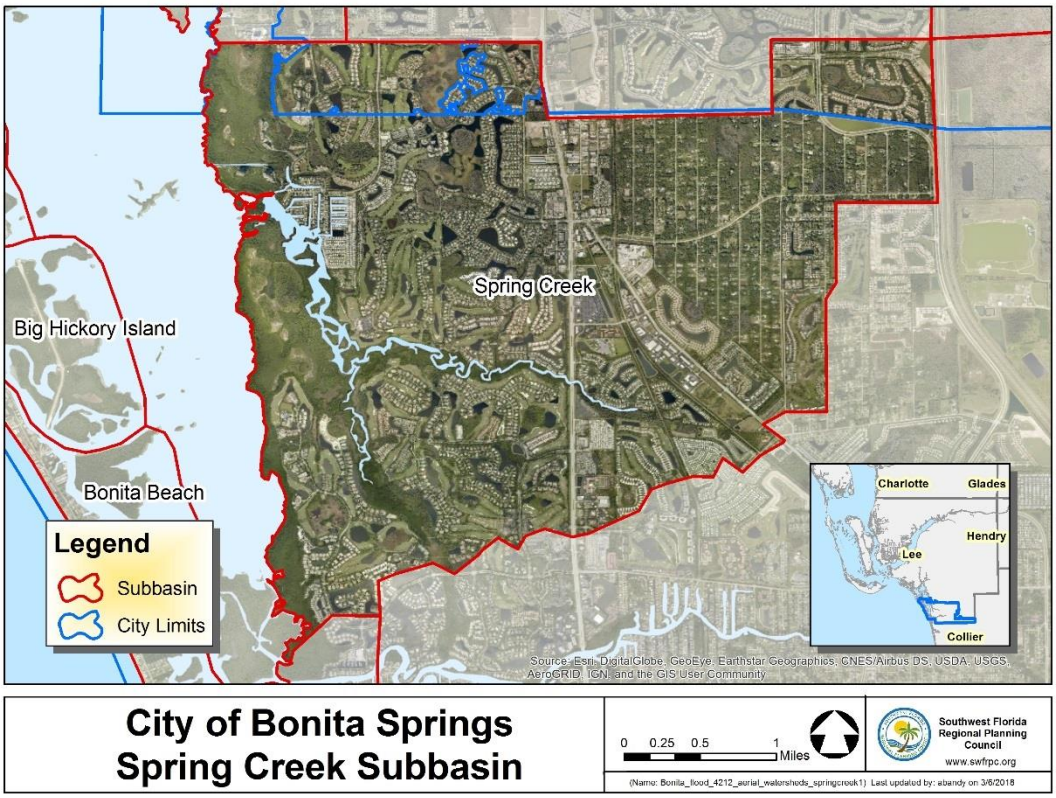




Figure 13: Aerial of the Spring Creek Sub-basin

Estero River

Only 0.3 % (118.96 acres) of the 39,168.8 acre Estero River sub-basin is located within the city of Bonita Springs boundary. This small area is part of the coastal mangrove forest and saltmarshes extending north to Coconut Point on Estero Bay. The Estero River is a 6.4-mile-long (10.3 km) waterway with headwaters that extend as far east and north as SR 82 and includes most of the western portion of the northern DRGR.

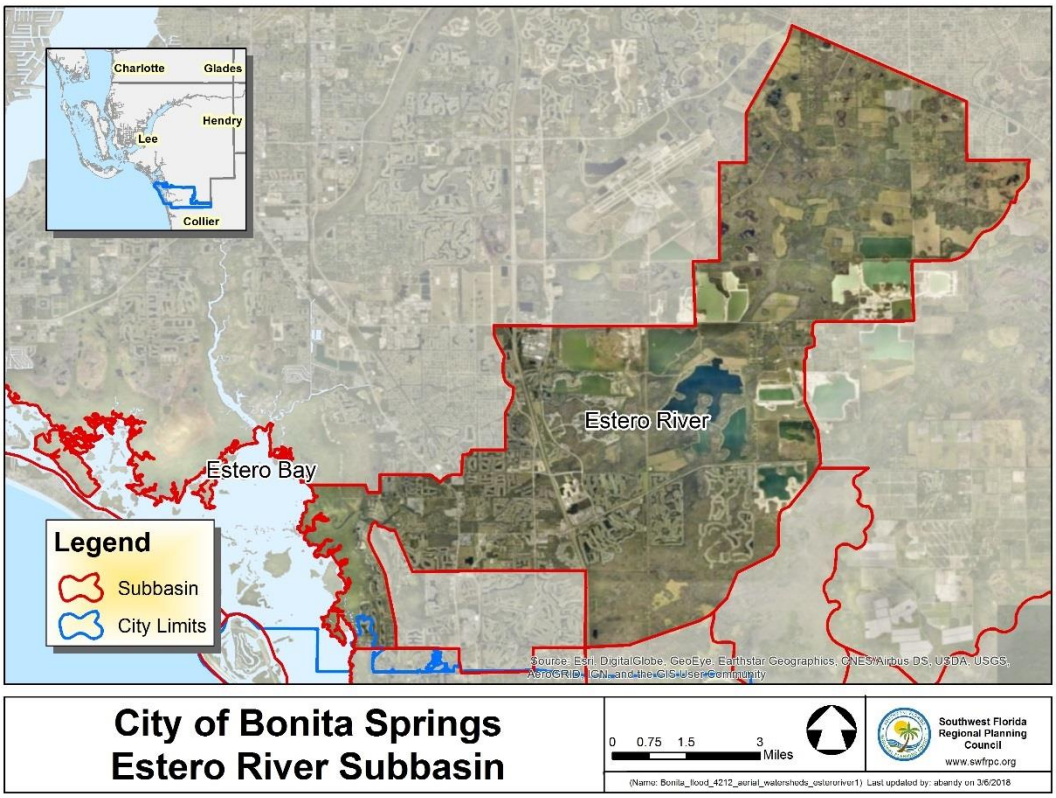




Figure 14: Aerial of the Estero River Sub-basin

The Coastal and Barrier Islands Watersheds

The Coastal and Barrier Islands sub-basins of the City of Bonita Springs are all within the city boundaries and include Lovers Key (1,348.77 acres), Big Hickory Island sub-basin (758.55 acres), Bonita Beach sub-basin (837.69 acres), and the Imperial River Outlet sub-basin (341.7 acres). All these coastal sub-basins connect directly to Estero Bay (98.19 %) or to the Gulf of Mexico (1.81%).

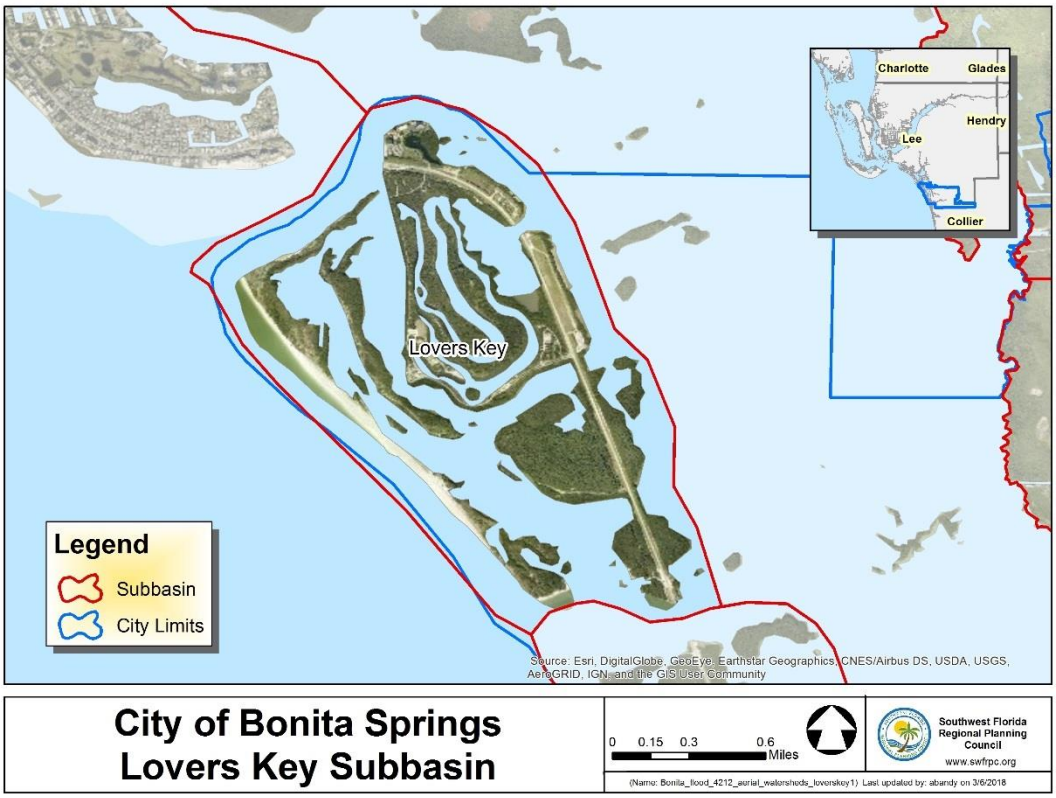




Figure 15: Aerial of the Lovers Key Sub-basin

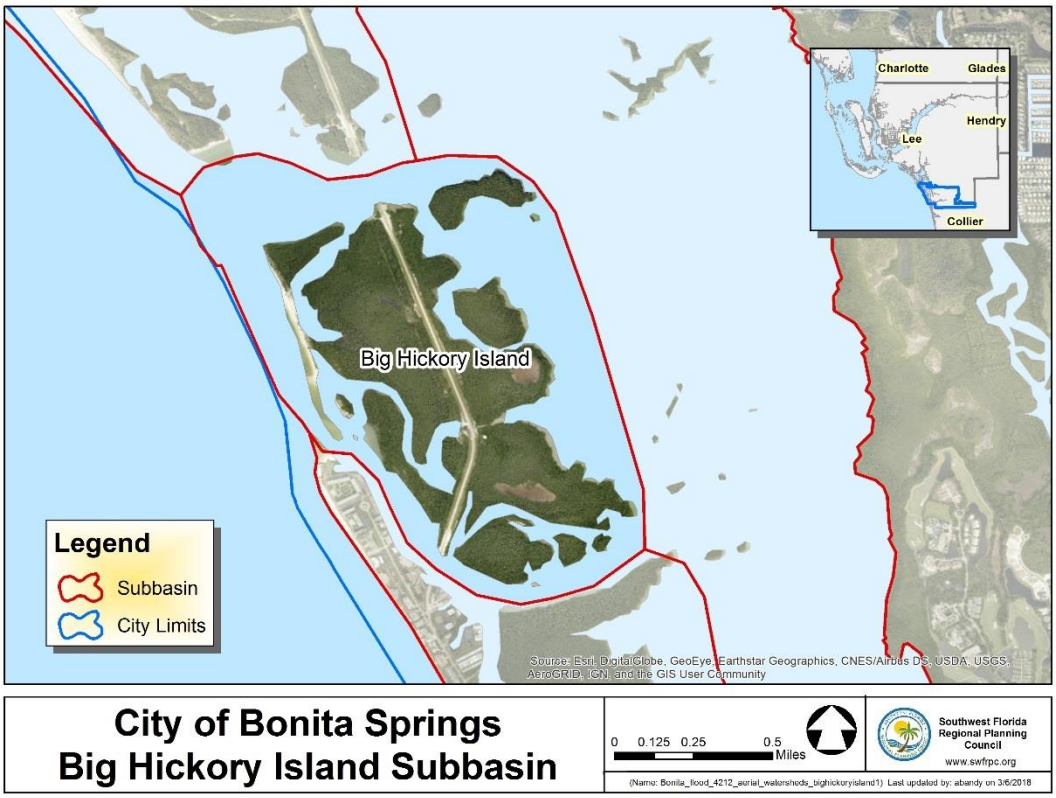




Figure 16: Aerial of the Big Hickory Island Sub-basin

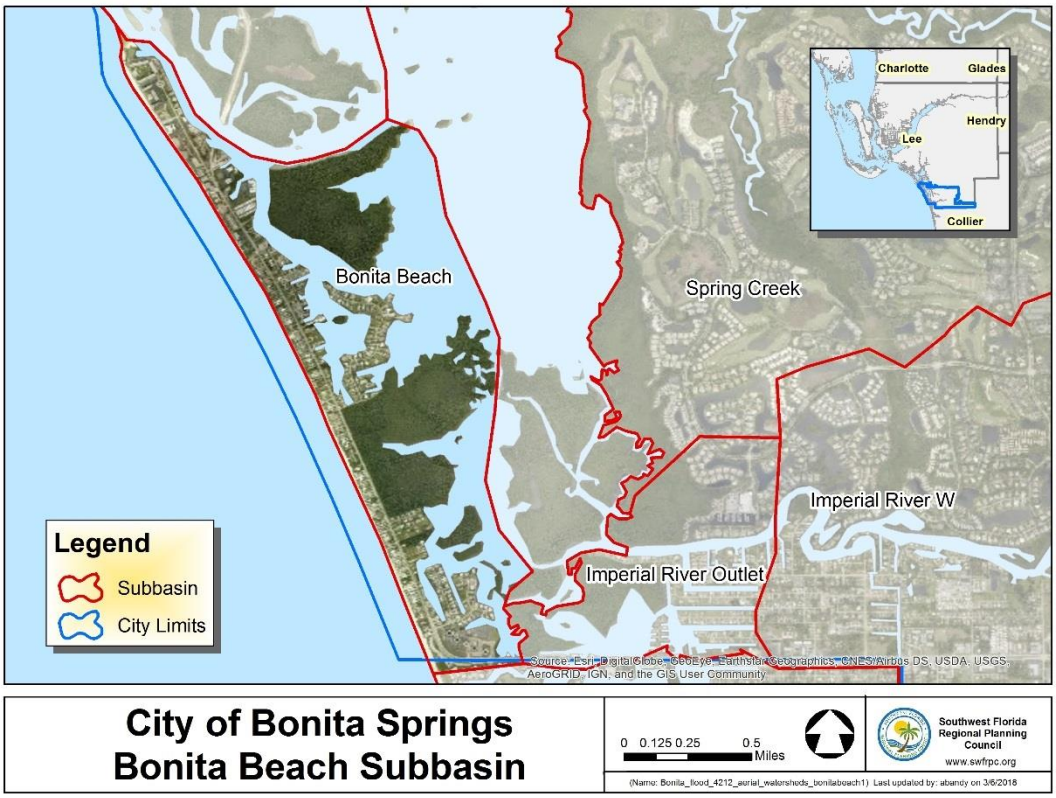




Figure 17: Aerial of the Bonita Beach Sub-basin

Estero Bay

Estero Bay is a long and very shallow estuary with an area of about 15 square miles (39 $km^2$). Estero Bay is bordered on the west by a chain of barrier islands: Estero Island, Long Key, Lovers Key, Black Island, Big Hickory Island, and Little Hickory Island. Four pass outlets give access to the Gulf of Mexico: (from north to south) Matanzas Pass, Big Carlos Pass, New Pass, and Big Hickory Pass. Four tributaries the Imperial River, Spring Creek, Estero River, and Hendry Creek along with coastal sub-basin sheet-flow bring freshwater into the estuary. In December 1966, the northern half of Estero Bay was designated as the state's first Aquatic Preserve, the Estero Bay Preserve State Park. The southern half of the bay was added to the preserve during the 1983 Florida Legislature session.

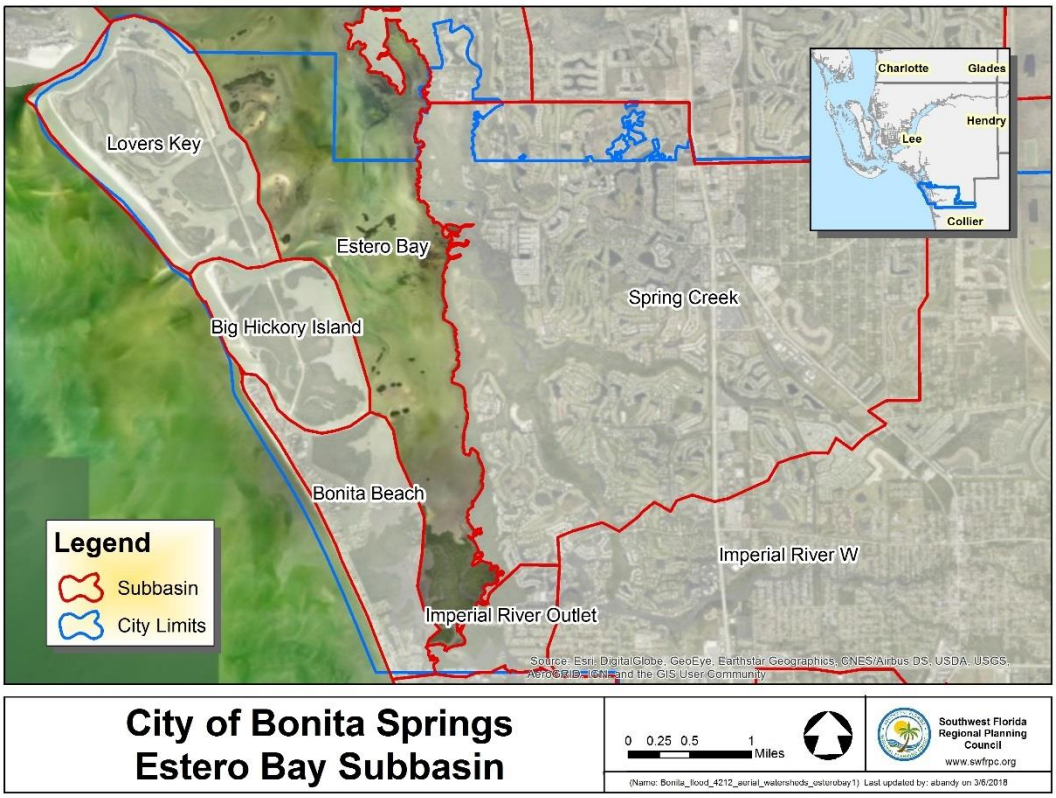




Figure 18: Aerial of the Estero Bay South Sub-basin

Estero Bay Preserve State Park encompasses approximately 10,000 acres, and continues to grow as more environmentally sensitive land is acquired. Originally called the Estero Bay State Buffer Preserve, the land was purchased to protect the Estero Bay Aquatic Preserve from the impacts associated with development. The Department of Environmental Protection, Office of Coastal and Aquatic Managed Areas (CAMA) managed the aquatic and buffer preserves initially. On January 1, 2004, the preserve became known as the Estero Bay Preserve State Park and is managed in conjunction with Koreshan State Historic Site and Mound Key Archeological State Park, under the Department of Recreation and Parks (DRP). The aquatic preserve is still managed by CAMA. Preservation and the protection of Estero Bay's water quality is a primary focus of the managing partnership between CAMA and DRP.

# PROJECT GOALS

This is a project with the goal of achieving flood reduction throughout the City of Bonita Springs. It is not a total flood elimination project. No one can guarantee the elimination of all flooding under all potential future conditions. No one should expect that if they

have a road or building located in an existing unmodified floodplain set at ground level elevation that they will not be flooded when the floodplain floods.

# ANATOMY OF THE FLOODS

Peninsular Florida has a very distinct wet season that can be objectively defined with onset and demise dates based on daily rainfall. The dramatic onset of rains and its retreat coincides with the seasonal cycle of the regional scale atmospheric and upper ocean circulations and upper ocean heat content of the immediate surrounding ocean. The gradual warming of the Intra-Americas Seas (IAS; includes Gulf of Mexico, Caribbean Sea and parts of northwestern subtropical Atlantic Ocean) with the seasonal evolution of the Loop Current and increased atmospheric heat flux in to the ocean eventually enhance the moisture flux into terrestrial PF around the time of the onset of the Rainy Season of Peninsular Florida (RSPF). Similarly, the RSPF retreats with the cooling of the IAS that coincides with the weakening of the Loop Current and reduction of the upper ocean heat content of the IAS. There has been an increasing frequency of anomalous onset and demise dates of the RSPF which is generating seasonal rainfall anomalies resulting in more intense wet seasons and drier dry seasons (Misra et al 2017).

In a continuation of Florida's growing pattern of monsoon-like weather during summer months, a trough of low pressure developed over the eastern Gulf of Mexico and passed east across the Florida Peninsula on the 26th through 28th of August, bringing abundant tropical moisture into the area. Heavy rain started to fall over southern Lee County during the evening of the 27th over already saturated ground and continued through the 28th. Lee County received 11.23 inches of rain from August 25th-28th 2017, easily exceeding the qualifications for a 25-year flood event.



After just the first day, overflows from the Imperial River began to result in flood watches for the surrounding areas In Bonita Springs. This burst of rainfall compounded on the fact that the Imperial River watershed has absorbed the flows of up to 3 other rivers as river lands have been filled in and developed upon and resulted in widespread flooding throughout the rivers once undeveloped flood plains. As this river water begins to flood into residential areas, it finds itself trapped in neighborhoods such as the Dean Street area. Localized flooding was reported, with water entering mobile homes in Estero and Bonita Springs. A total of 70 people evacuated a mobile home park in Estero, and another 116 people evacuated a mobile home park in Bonita Springs due to rising water on the Imperial River. Trailer parks have a relatively low off-season occupancy rate of between 30-40%. Heavy rain fell across the area each day, with some areas seeing over 16 inches of rain totals throughout the event. Flood waters entered numerous homes in Hillsborough, Manatee, Sarasota, and Lee counties, as well as making numerous roads impassable and stalling vehicles. The flooding also caused two separate drowning deaths in the area. In addition to the flooding, the storms produced some wind damage and a brief EF-0 tornado in Manatee County.

With the water unable to drain properly due to continuous flows, including sheet-flow and canal flows from the Imperial River's unnaturally enlarged watershed and sub-

standard or absent storm water management systems, it was just below two weeks after these water levels began to subside that the still water-logged soil of Southwest Florida faced the imposing figure of Hurricane Irma off of Florida's coastline.

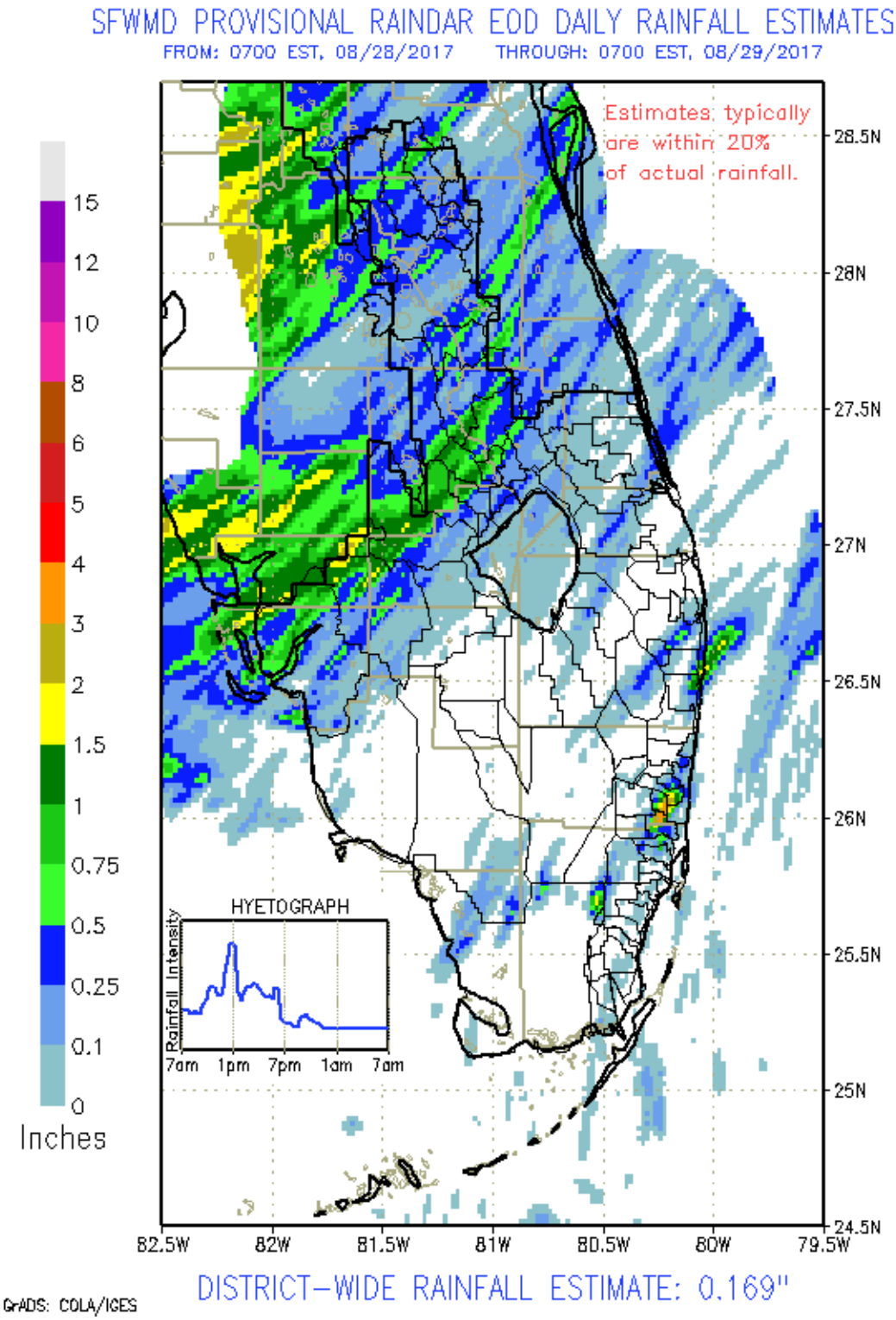

Figure 19: Rainfall through August 28th

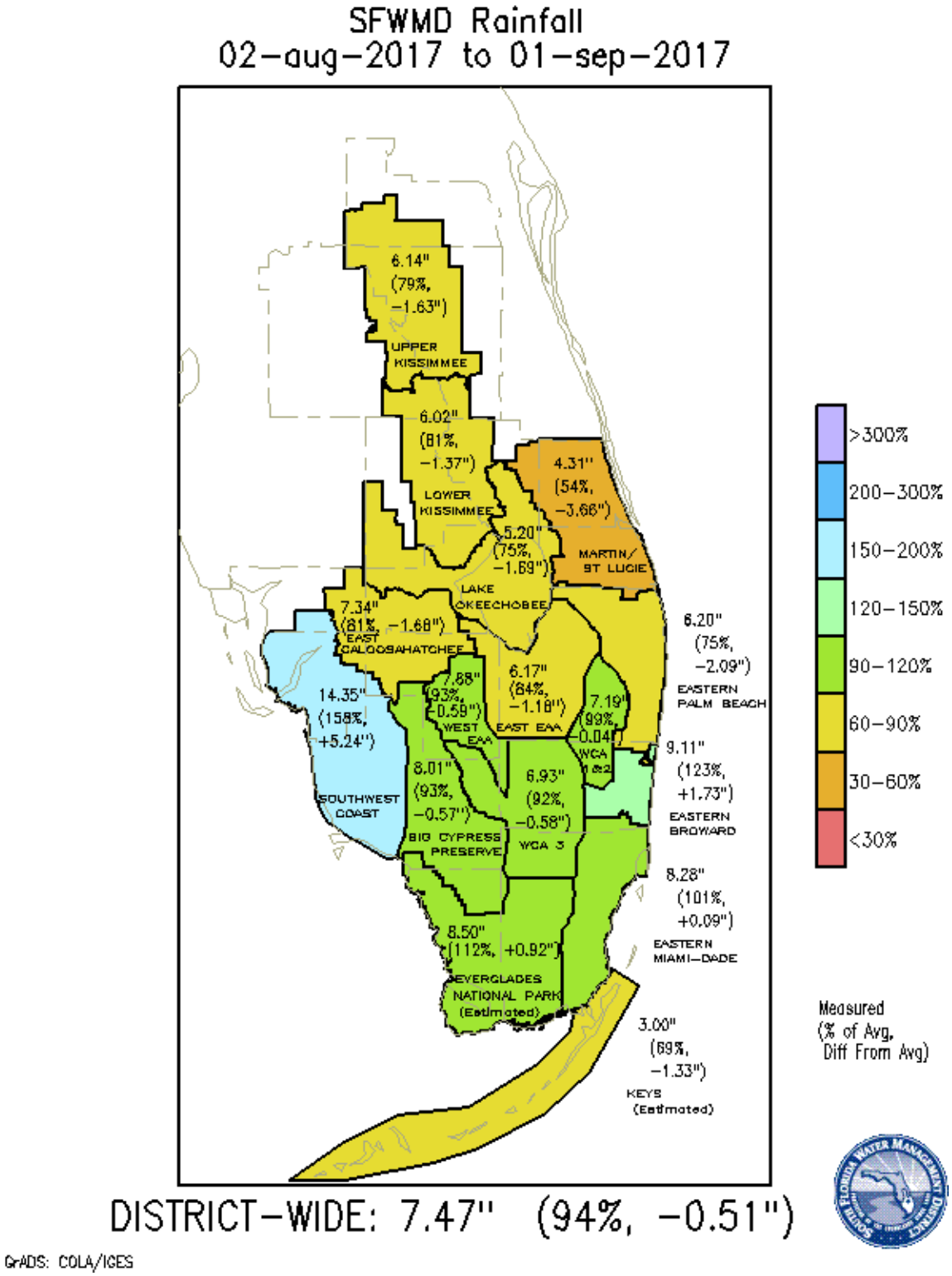


Figure 20: SFWMD Rainfall graphic portrays the above average rainfall for SWF in August 2017.

As Hurricane Irma made landfall in Florida for the second time in Collier County, it brought with it 110 mph wind speeds, and a deluge of rainfall that refilled the Imperial River's watershed that had just begun to lower towards normality. With both the soil and vegetation in the area already waterlogged, the 8-10 inches of rain (average 9.92 inches) delivered by Irma was all that was necessary for the banks of the Imperial River to overflow for the second time within thirteen days, and at a far more imposing scale. Mayor Peter Simmons reported after the storm that the entire city was affected by power outages, and over half of the city was affected by flooding. (Buchanan and Saget 2017) Reported storm surge at the Gulf of Mexico beaches attained 3.88 feet NGVD and left wrack lines on streets. Multiple places in mainland Bonita Springs felt the consequences of the rainwater floods. The residents who remained in place or returned to their homes after the rains subsided, found the water in their neighborhoods up to their waists or higher. Many residents were unable to reach their homes at all except by canoe or other vessel. Following this, we see a repeat of the flood patterns that took place during the late August events. With the size of the Imperial River watershed and the Imperial River itself as the main drainage point, the floodwaters continued to flow through Bonita Springs for days before finally beginning to retreat. (Viloria 2017) Even though Irma only rained about 8-10 inches on Bonita Springs, the consequences of more *frequent* flooding is clear. When floods follow one another too closely, the environment and the storm water management systems' ability to mitigate flooding is drastically diminished, and the likelihood of damage to infrastructure and homes significantly increases.

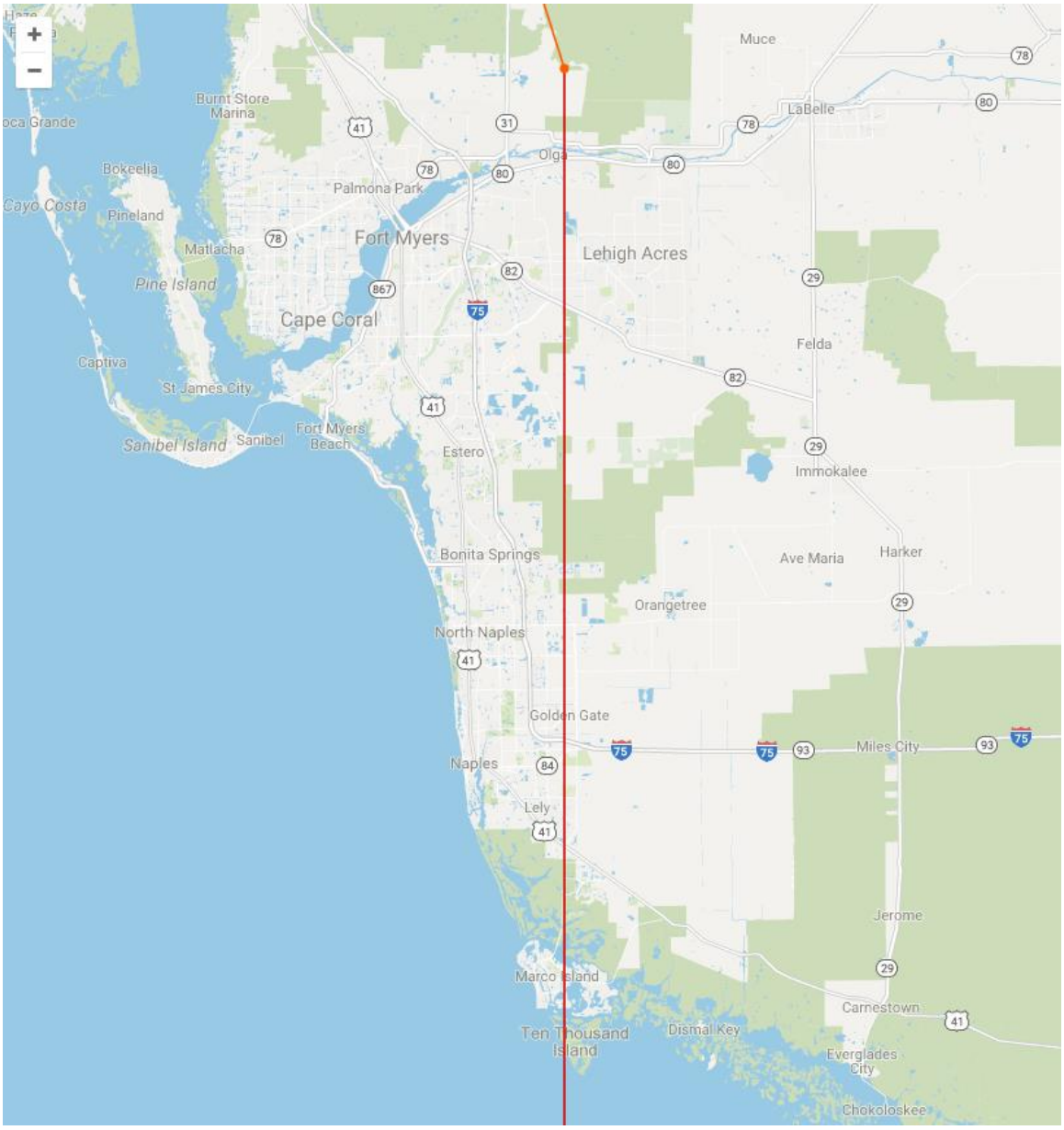


Figure 21: Path of Hurricane Irma as represented by the New York Times

Source: Almukhtar, Sarah, et al. "Maps: Tracking Hurricane Irma's Path Over Florida." *The New York Times*, The New York Times, 5 Sept. 2017, www.nytimes.com/interactive/2017/09/05/us/hurricane-irma-map.html?mcubz=0.

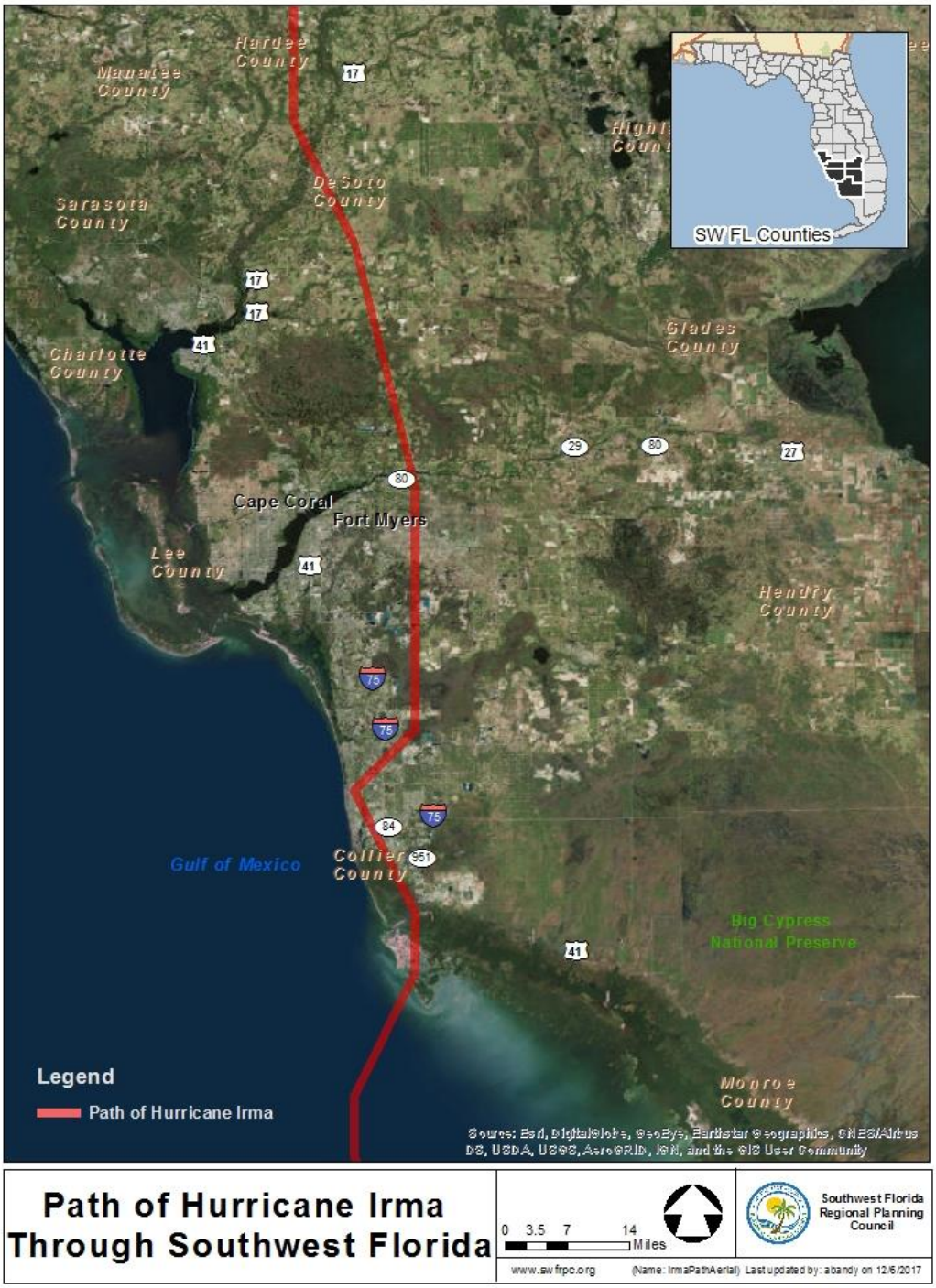


Figure 22: Path of Hurricane Irma 2017 on an aerial based upon center point reports form NOAA


Figure 23: Path of Hurricane Irma 2017 on an aerial based upon center point reports form NOAA

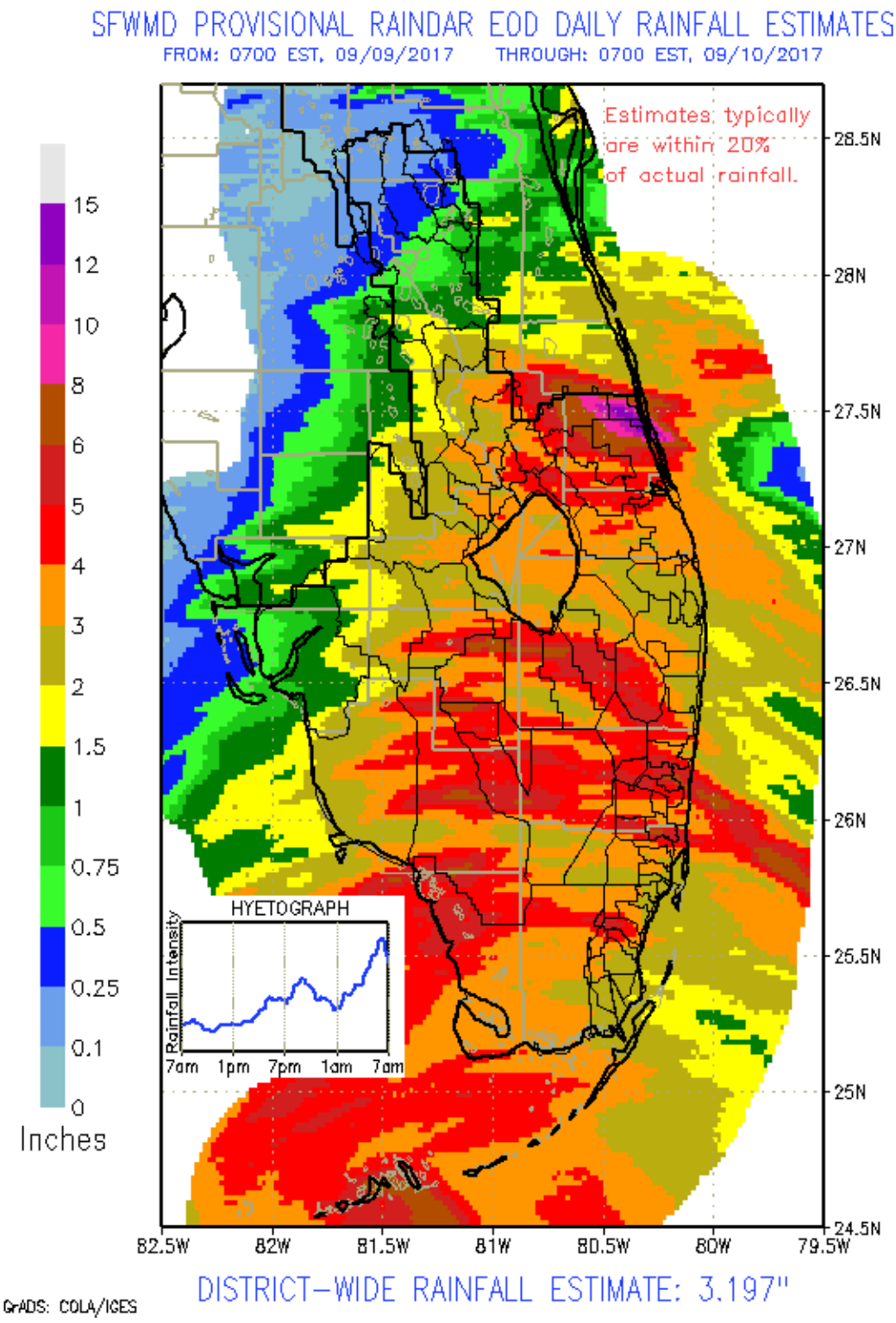


Figure 24: SFWMD Rainfall graphic shows Hurricane Irma threatening off the coast on September 9th, and increasing rainfall intensity.

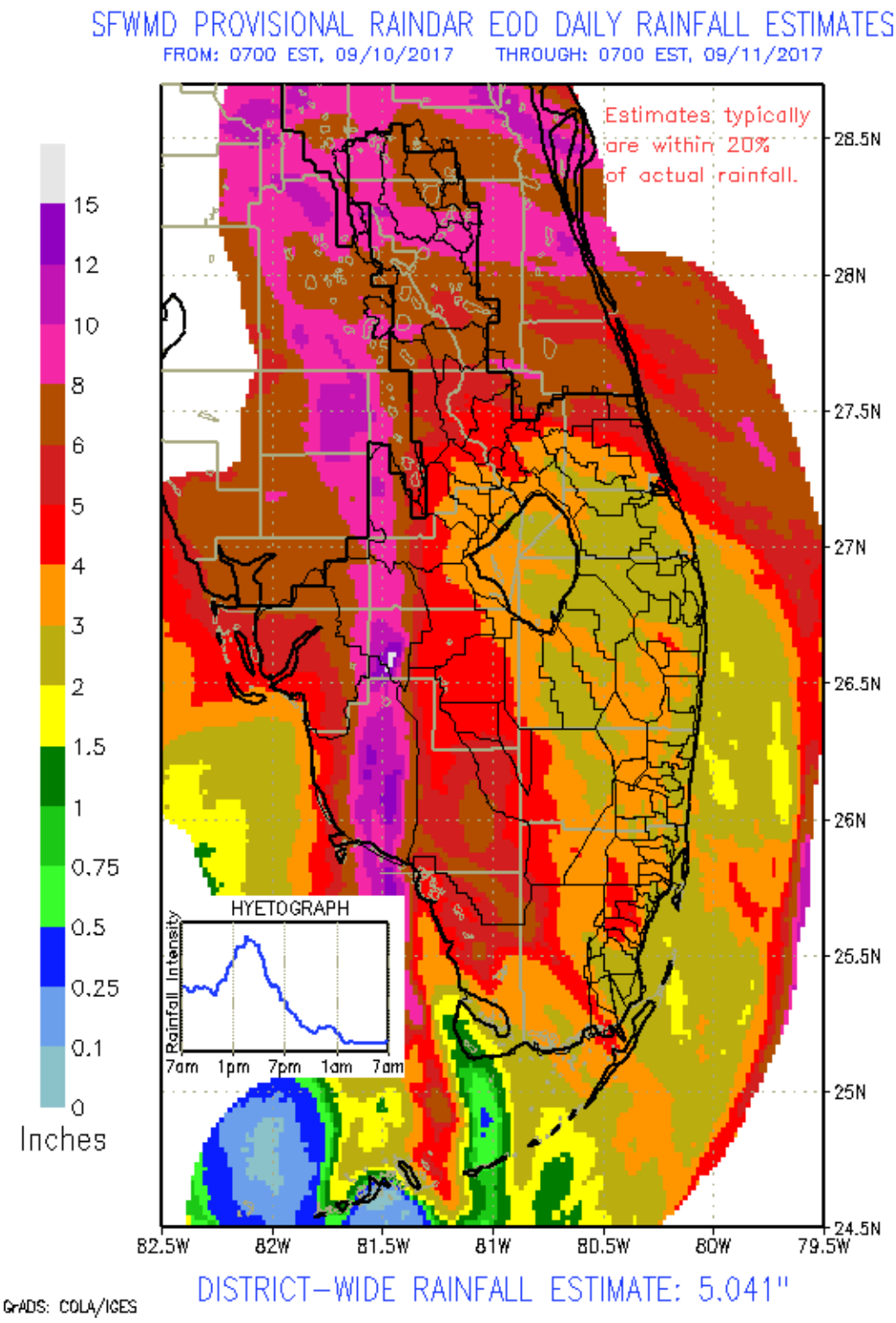


Figure 25; SFWMD Rainfall graphic shows Hurricane Irma reaching peak intensity September 10 over SWF, with some areas receiving 15 inches of predicted rainfall.

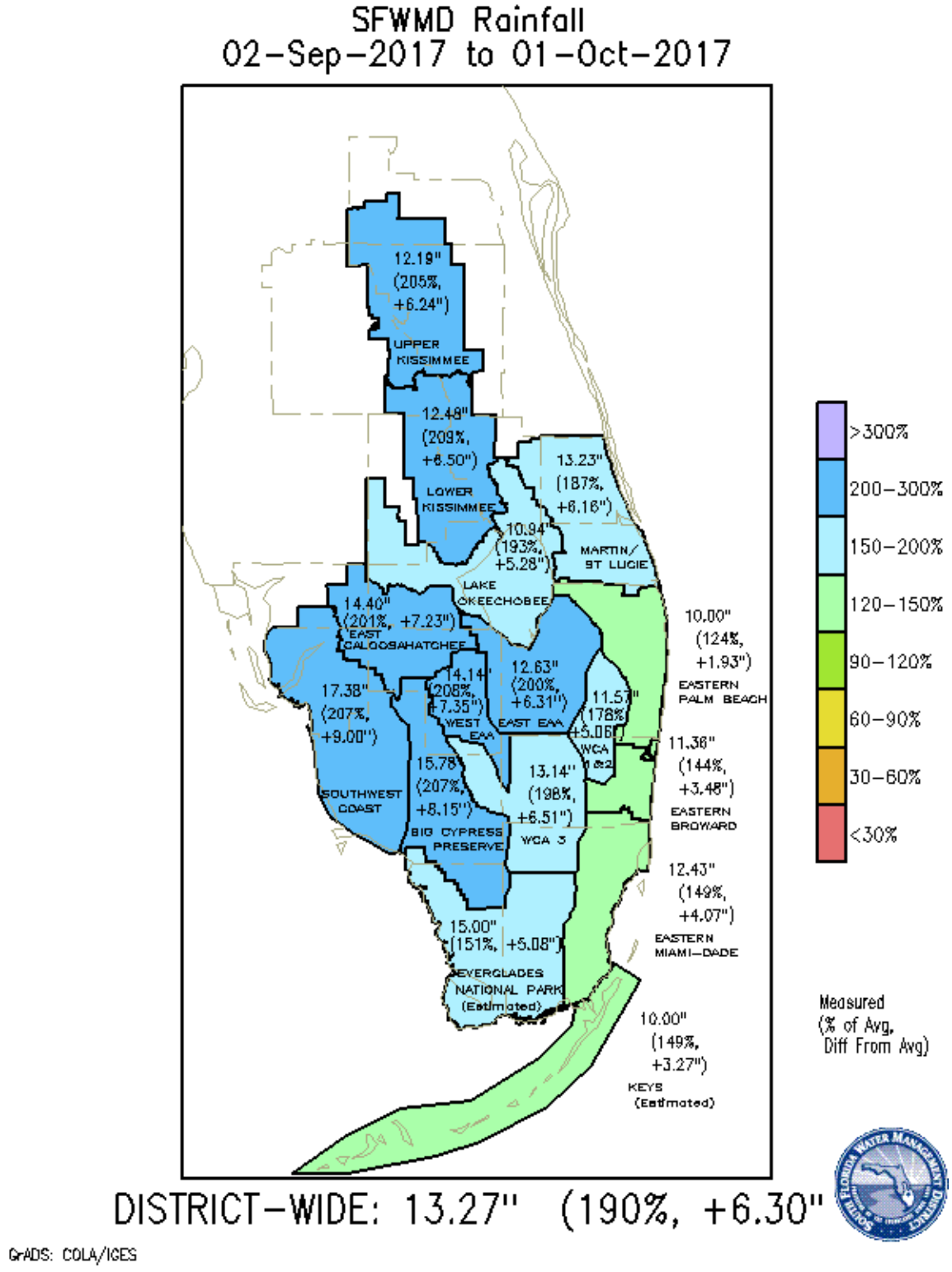


Figure 26: SFWMD Rainfall graphic portrays the well above average rainfall for SWF in Sept 2017

As of October 31, 2017 there had been 78.3: inches of rain (6.5 feet) in 2017 which is 26: inches of rain above average for the year as 68.9: inches of rain of that rain fell between June and Hurricane Irma with 4 major rain events (*South Florida Water Management District 2017).* Nearly 54 inches of rain, on average, fell across the 16-county district between May 21 and Oct. 28, which is the wettest 161 days on SFWMD records. District records started in 1932. The past 24 months are the wettest 24 months (125 inches of rainfall) in more than two decades.

The Invest 93 Four-Day Storm Event exceeded the 5-year storm and 25-year storm standards. Hurricane Irma rains exceeded these and the 100-year storm standards. The two storm events combined exceed all previous documented floods in the City of Bonita Springs

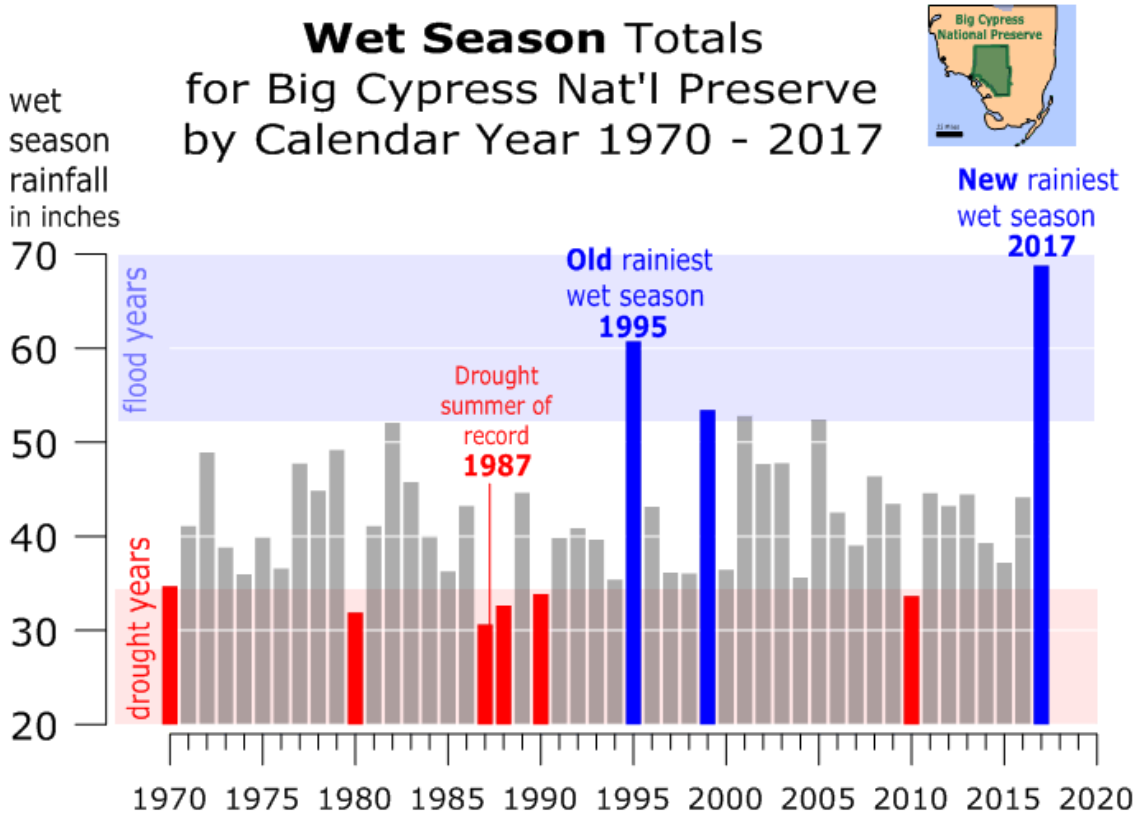


Figure 27: Wet Season Rain Totals for the Big Cypress
Source: GoHydro 2018

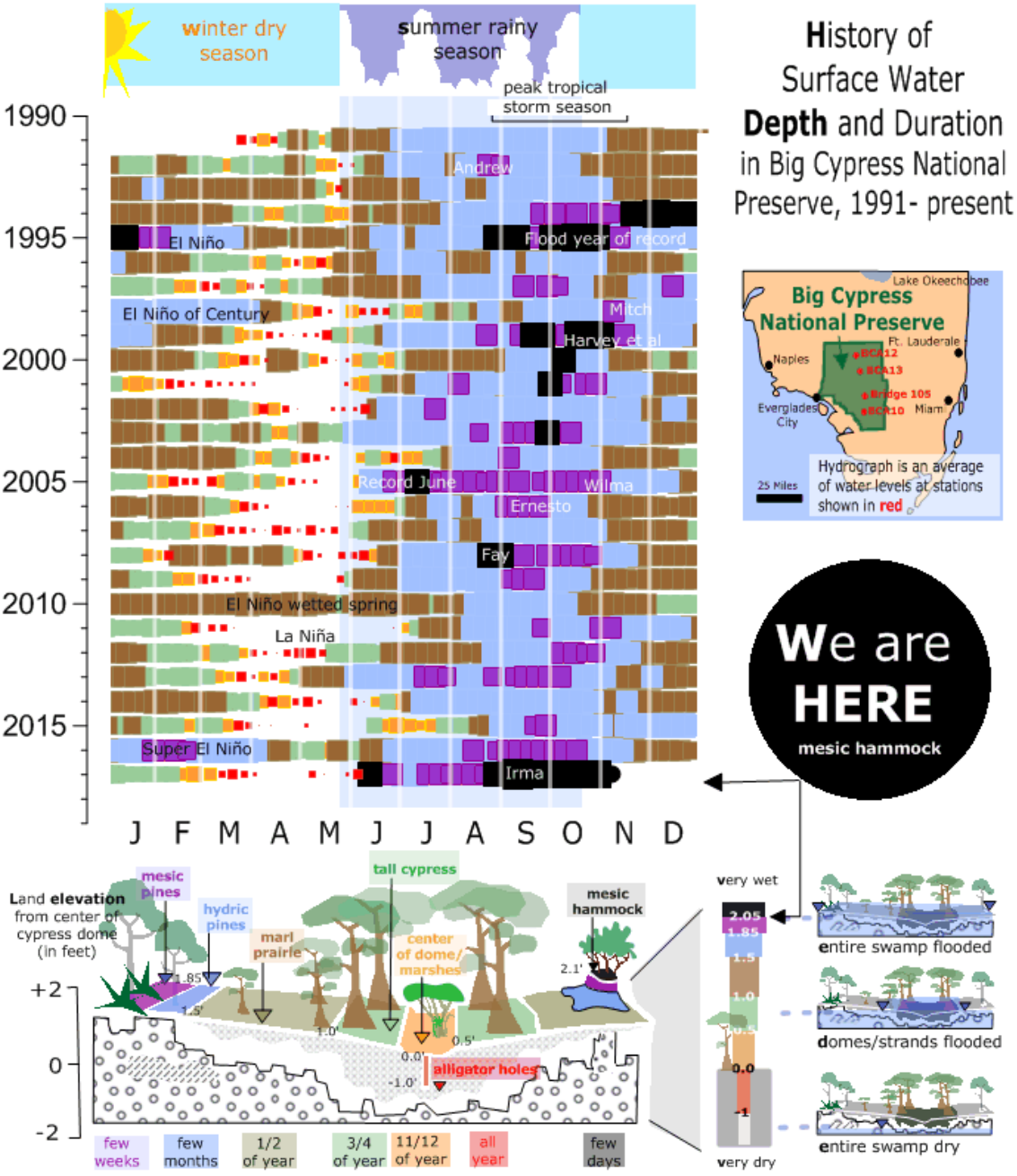


Figure 28: The history of Surface water Depth and Duration in the Big Cypress Watershed at Nov 2017 from 1990-2017.
Source: GoHydro, 2018

The Historic Period of Record for discharge rates in storm water system design does not account for climate change in precipitation rates and delivery. Control structure size and inverts do not account for climate change considerations. The “pond/lake borrow pits”,

golf courses (if any) and road system are expected to provide flood storage during the most extreme storm events. Under such conditions road flooding is planned for.

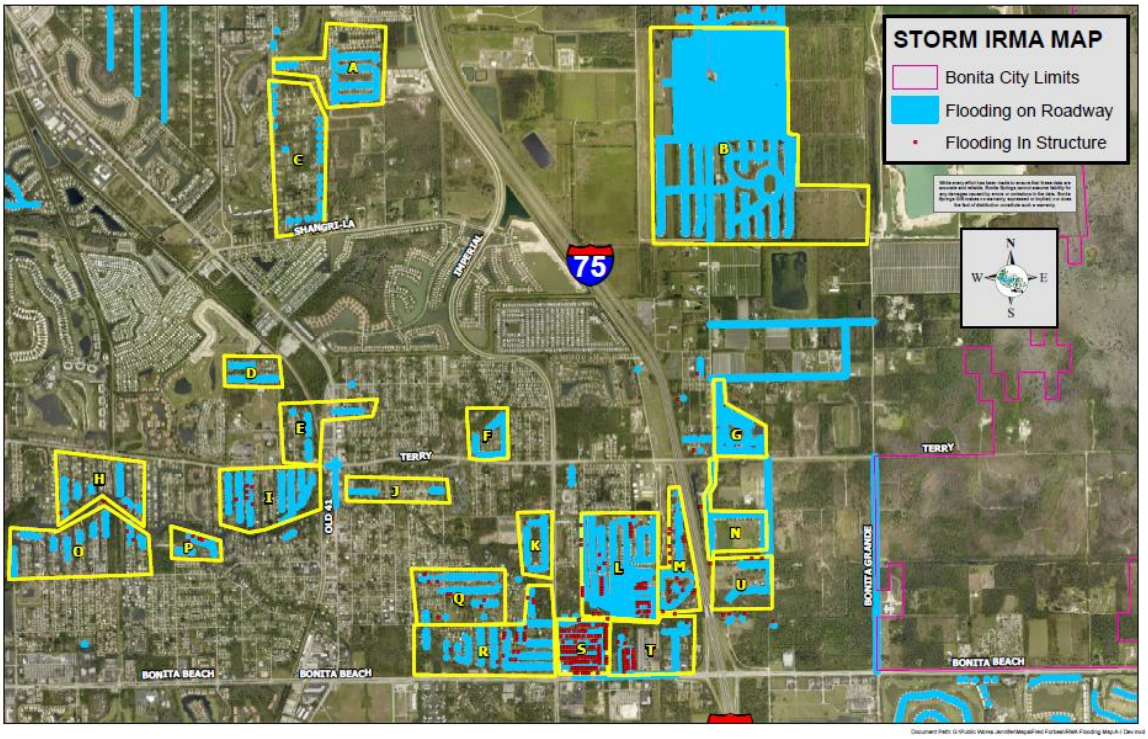


Figure 29: Flooded Area A-U City of Bonita Springs

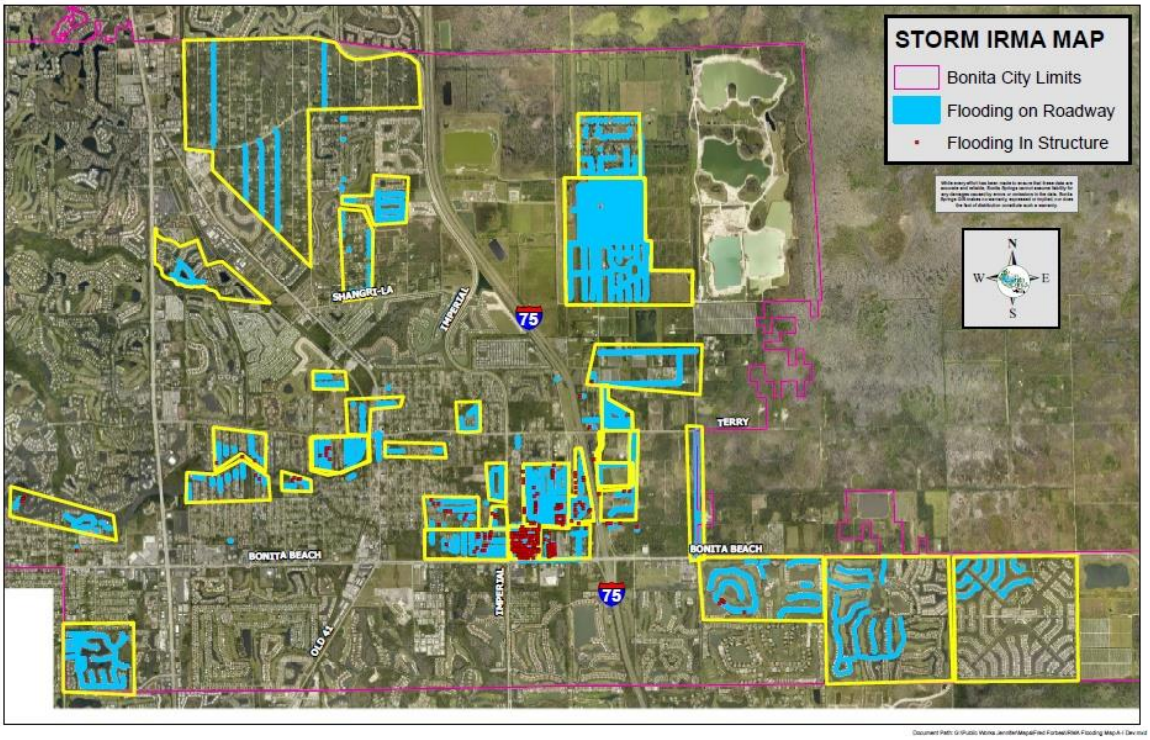


Figure 30: Additional Flooded Areas City of Bonita Springs

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The Imperial River overflowed its banks during Hurricane Irma, flooding Bonita Springs and impacting 4,775 individual residences and inundating 430 homes with up to a maximum of 5 ft of water. Some neighborhoods remained with roads under standing waters for up to 4 - 5 weeks after Hurricane Irma.




Figure 31: View East of Bonita Beach Road at the Flea Market Entrance.
Source: USA Today




Figure 32: View North of the Dean Street, Quinn Street/Oakland Drive and Imperial Bonita Estates Areas.
Source: SFWMD




Figure 33: View North of the Dean Street and Imperial Bonita Estates with the Bourbonnais Bridge shown.
Source: SFWMD




Figure 34: View North of the Pinecrest and Imperial Bonita Estates Areas with the Terry Street Overpass of I-75 in the distance and the I-75 Imperial River Bridge in the lower right.
Source: SFWMD




Figure 35: View North of Kent Road, and San Soucci Areas with Morton Groves and Citrus park in the distance.
Source: SFWMD




Figure 36: Flooded Areas City of Bonita Springs at Bonita Grande Road and the Kehl Canal Weir.
Source: SFWMD

Figure 37: Flooded Areas City of Bonita Springs, Close view of Worthington
Source: City of Bonita Springs




Figure 38: Flooded Areas City of Bonita Springs at Worthington and Bonita Beach Road East.
Source: City of Bonita Springs

# PROJECTS ALREADY STARTED

- Spring Creek Shoal Dredging (Spring Creek Restoration Plan)
- NOAA Grant for Spring Creek Culvert Improvements at the CSX Railroad and Milagro Road (Spring Creek Restoration Plan)

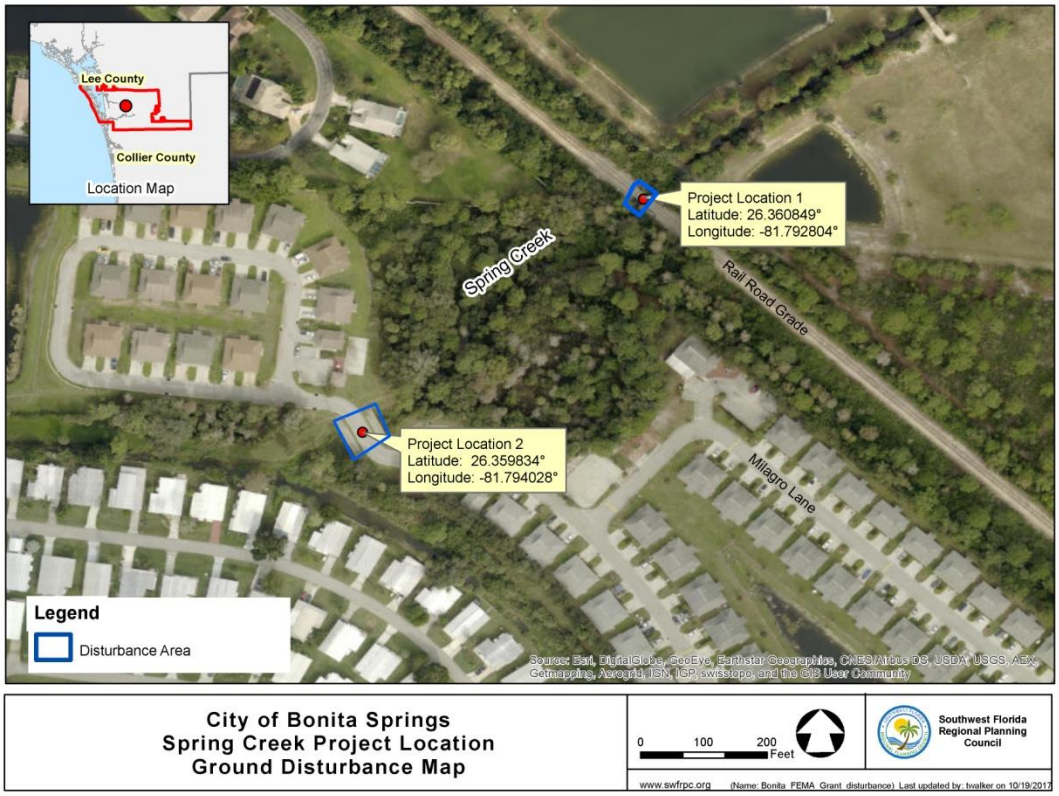


Figure 39: Spring Creek Project Location

- Bloomberg Grant (Taking Back the Watersheds) This is a very large water modeling study which includes the areas outside of city, with an estimated total cost of $5 million dollars, that will determine the hydrology within the DRGR and the proper allocation of flows to all the receiving watersheds in the Estero Bay and Cocohatchee River systems..
- Selection of Atkins as Engineering Firm to assist in Flood Reduction Plan technical engineering assistance.

- List of legislative initiative funding projects for the next upcoming legislative session
- To date FDEP and SFWMD have committed approximately $1.2 Million to cleanup efforts in the Imperial River from the bay to its headwaters at the Kehl Canal. In addition, Oak Creek has been identified for future cleanup efforts in the 2018/19 timeframe.
- SFWMD is working with the City to water model potential flow of storm water south rather than into Imperial River to determine quantities of storm water which could be diverted to the south based on historical flow patterns.

**LEGISLATIVE INITIATIVES for the Next (2018) Florida Legislative Session**

The City identified and submitted legislative funding requests to the Florida State Legislature based on post storm observations and previous engineering studies the requests are identified below:

1. Inspection of all culvert and tributary systems, replacement of crushed and/or substandard culvert conveyances on all flowways including residential yard conveyances; improvements to all systems; Conduct detailed engineering studies of hardest hit flooded neighborhoods in City including, but not limited to: Quinn area streets, Imperial Bonita Estates, Citrus Park, South Dean Street area, Morton Grove, Lake Shalimar, and Pinecrest area.



2. Construct Logan Boulevard and other potential conveyance systems from Bonita Beach Road south to the Cocohatchee

**3.** Land acquisition for more retention In the Bonita DR/GR for regional scale retention treatment and at smaller scales along the course of the Imperial River and Spring Creek. Initially target parcels identified in the C2020 program, Lee County Master Mitigation Program and Southwest Florida Watershed Study. Partner with adjacent jurisdictions and N.G.O.s

4. Pine Lake Preserve Conveyance and Restoration with retention opportunities

# POTENTIAL SOLUTIONS FOR FLOOD REDUCTION IN THE CITY OF BONITA SPRINGS

This is a project with the goal of achieving flood reduction throughout the City of Bonita Springs. It is not a total flood elimination project. No one can guarantee the elimination of all flooding under all potential future conditions No one should expect that if they have a road or building located in an existing unmodified floodplain set at ground level elevation that they will not be flooded when the floodplain floods.

Potential Solutions can be:

Short-term, implemented or started in this year and relatively immediate.

Moderate-term already planned and ready for funding for design and build.

Longer –term with planning needed in the two to five-year time frame for design and build.

On-going and paradigm changing into the foreseeable future including changes in building codes, land use plans, and climate change adaptation.

Preventative maintenance will generally allow flood water to recede quicker, but will in most cases not prevent flooding of areas and neighborhoods which have a record of historical flooding.



Potential Solutions can also be defined in two categories as corrective, preventive/conservation. Corrective options are management tools that serve to correct problems that already exist. Preventative/Conservation options are tools to prevent future problems that will result as the area of developed land in the watershed increases and the amount of generated flood run-off increases while more development is put in harm's way of flooding.

## *Potential Solution 1: Remove Blockages to Flow (short-term corrective/preventative)*

- Remove impediments to flows within the existing system.
- This includes debris, sediments, and trash that has accumulated or that is storm related
- Evaluate existing constrictions of the flow in the drainage system including lack of drainage features; small culverts; culverts with inverts set too high; causeways constructed across floodplains; unpermitted intrusions into the floodplains; and locations where variances allowed intrusions into the floodplains.

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

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

Removing muck and debris in the freshwater portions of Spring Creek, Imperial River, Leitner Creek, Oak Creek, Kehl Canal and collector canals including roadside canals 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 Harbor 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: 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: 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.

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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 Cubic feet per second (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 storm water 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.



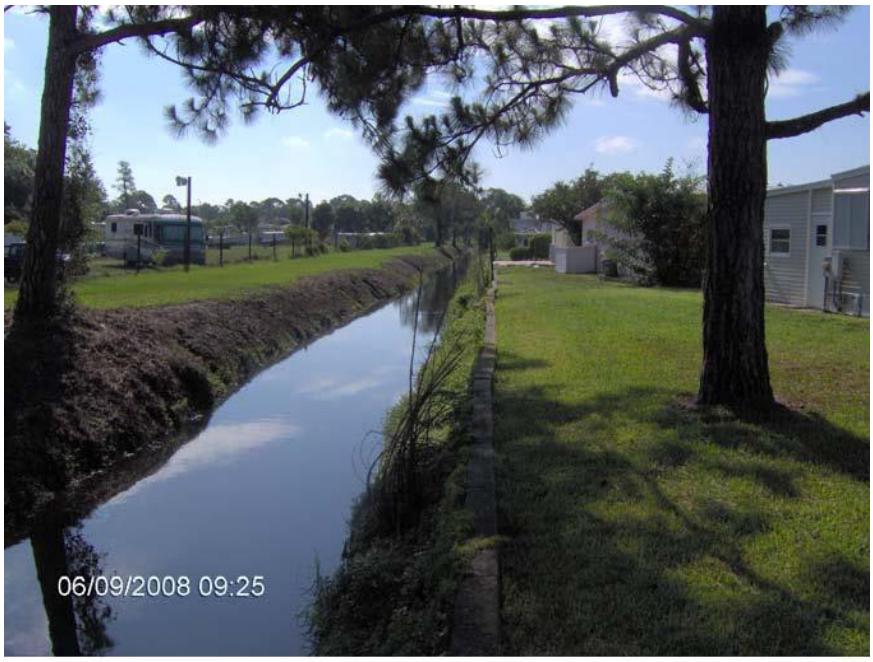

Figure 44: Bernwood Business Park upstream to Old US 41
Source: 2008, Exceptional Engineering, Inc.

Pic 10. Spring Creek Tributary inside Bernwood Business Park



Figure 45: 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: Canal inside Imperial Harbor
Source: 2008, Exceptional Engineering, Inc.




Pic 16. Downstream of Imperial Harbor
Figure 47: 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: 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


Figure 50: Phase I project limits for the SFWMD clearing and snag process: Old US 41 to Matheson Avenue


Figure 51: Phase II project limits for the SFWMD clearing and snag process; I-5 to Bonita Grande Drive

In 2001 the Lee County Division of Natural Resources requested an increase in the annual contract amount for cleaning and snagging maintenance from $200,000.00 to $650,000.00, due to additional maintenance agreements being, executed with the South Florida Water Management District for work on the Halfway Creek, Estero River and Imperial River and additional funding to be provided in the new fiscal year for the Neighborhood Improvement Program. This would be $633,929.47 in 2017 dollars.



The post Hurricane Irma cleanup of the Imperial River by state agencies is planned to include the entire River with FEP phase clearing the navigable channel from Estero Bay to the Old US 41 bridge, and the SFWMD clearing from the shore to the edge of the navigable channel. The overall cost of FDEP and SFWMD river cleanup is approximately $1.2 M

## *Potential Solution 2: Replace Substandard Culverts and Bridges*

- Replace substandard culverts and bridges with new structures of increased size, correct inverts, and a design the plans for future sea level rise and increased future storm surge.
- Where possible and feasible replace multiple culverts with an open span of box culverts or a bridge. Improves flows and may enhance recreational navigability.
- Repair damaged, degraded and vandalized permitted dikes and berms

- 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 hydraulic performance and improved maintenance while reducing backwater.

Identified Vulnerabilities for the Spring Creek Watershed include:

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

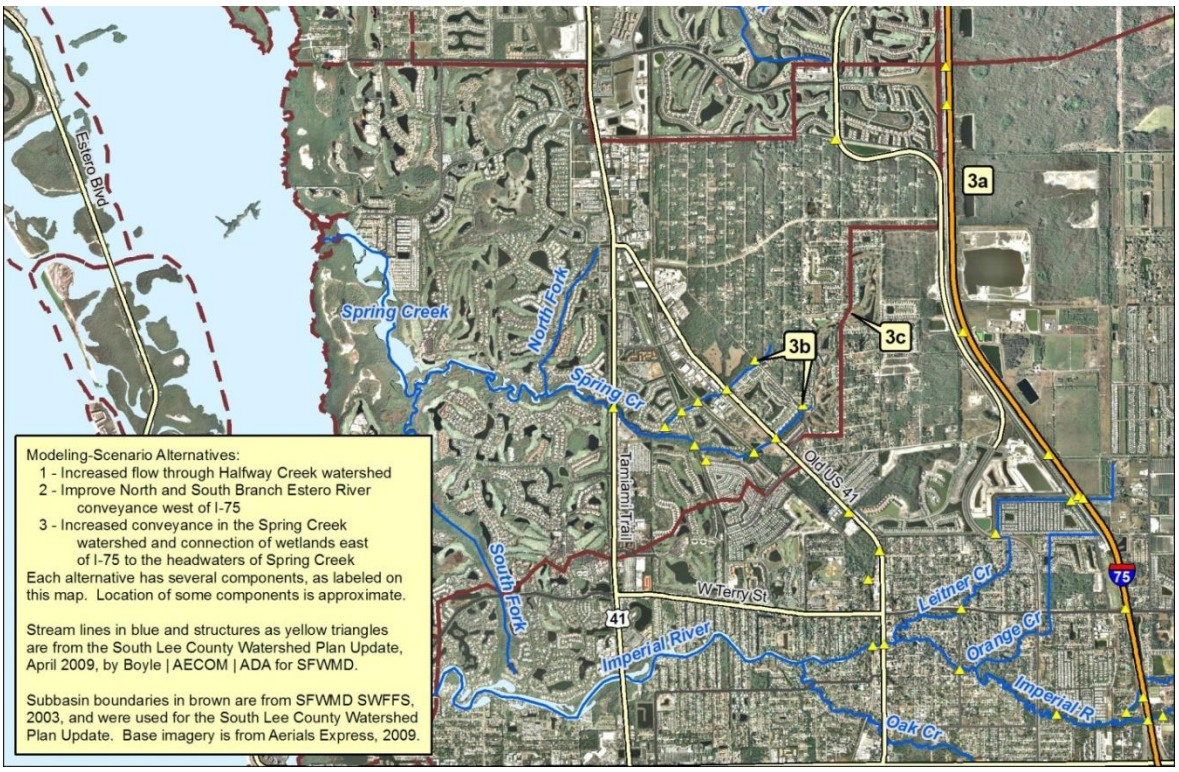



Figure 52: Locations of areas needing increased conveyance in Spring Creek (indicated by a yellow triangle with the number 3)
Source: South Lee County Watershed Plan Update 2009

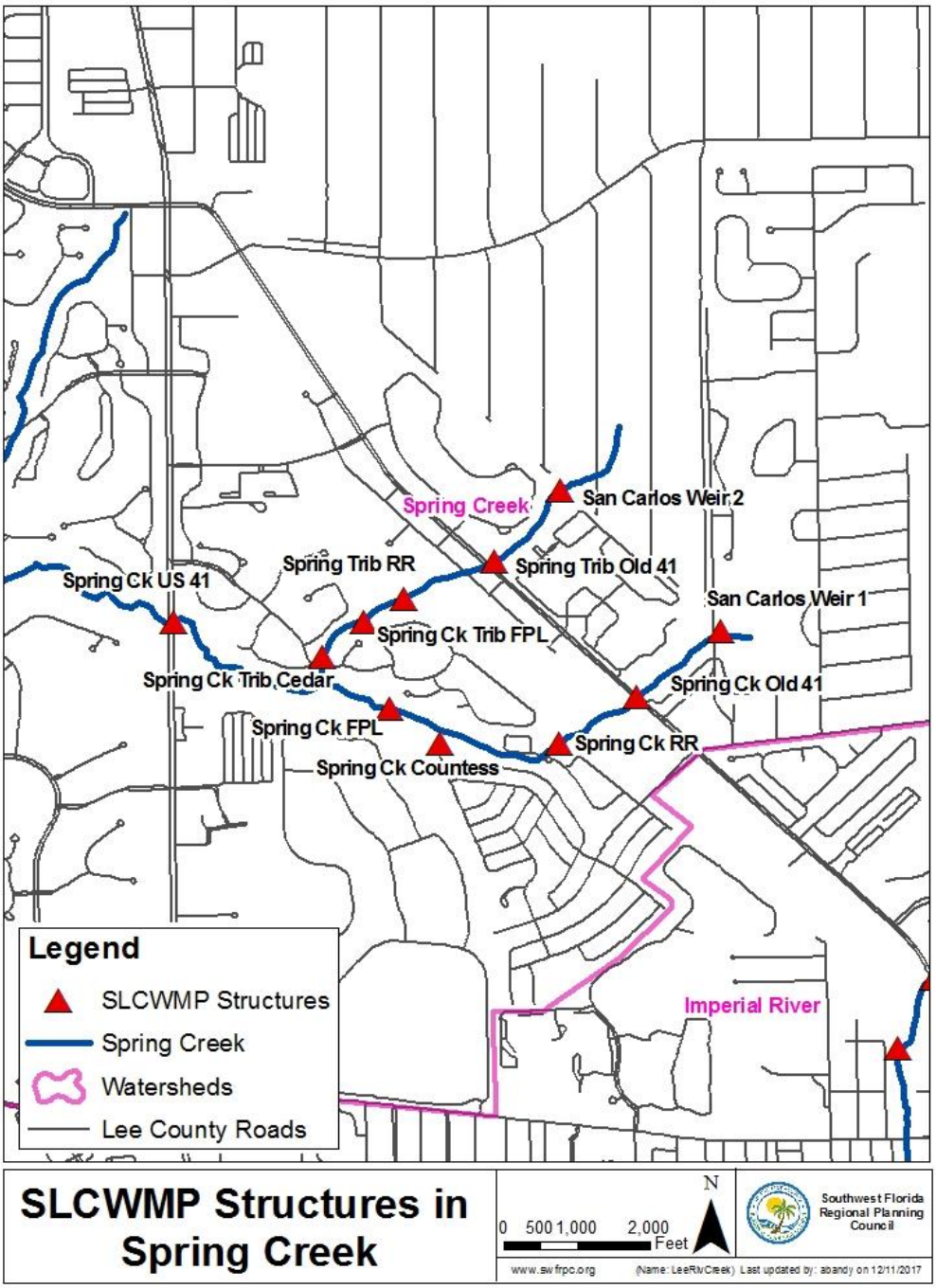



Figure 53: Locations of SLCWMP Structures in Spring Creek.

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 54).


Figure 54: Box Culvert at Three Oaks Parkway Extension east side
Source: 2008, Exceptional Engineering, Inc.

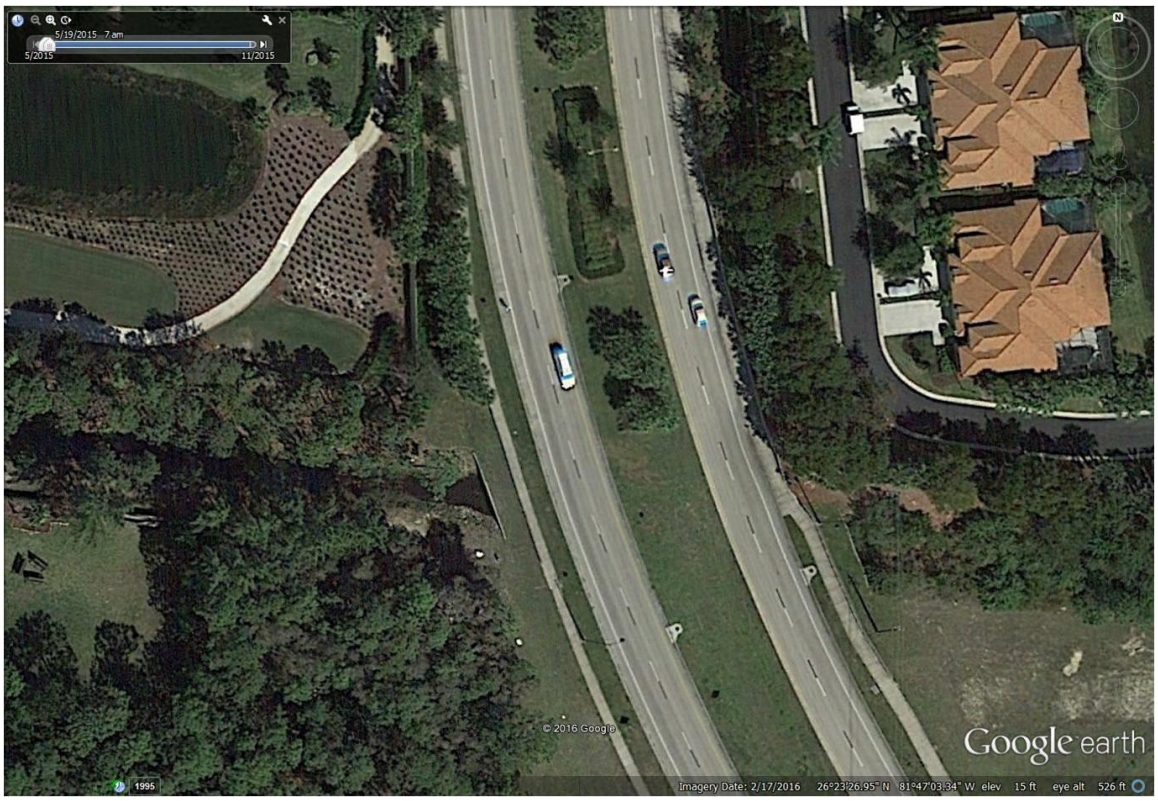





Figure 55 Box Culvert at Three Oaks Parkway Extension east side
Source: Google Earth 2016

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.

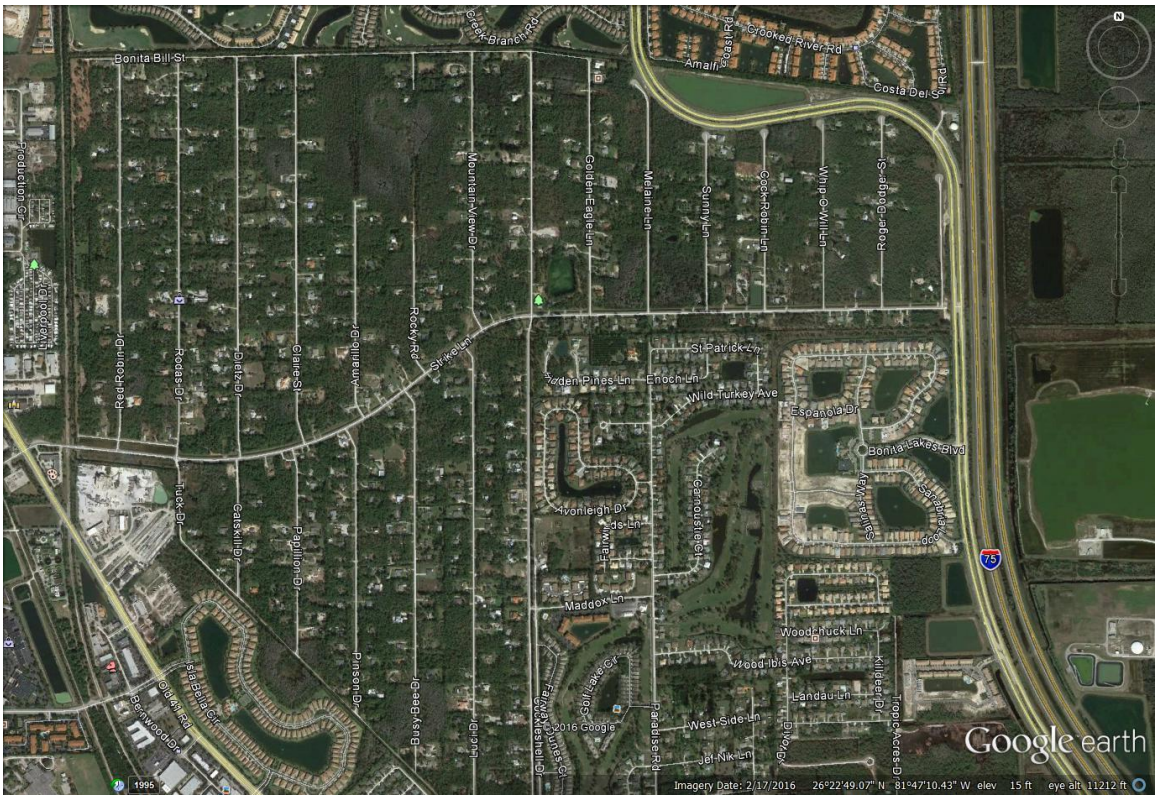





Figure 56: San Carlos Estates canals and road system. Note central Strike Lane and north and south roads that are very different from denser flanking developments. Source: Google Earth 2016

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 installation of culverts and/or bridges 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 57: 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 58 to the railroad right-of-way.

Pic 20. Culvert in Bernwood Business Park – North Branch

Figure 58 North Branch Culvert in Bernwood Business Park – North Branch
Source: 2008, Exceptional Engineering, Inc.

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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 59: 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 53. 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 60:  48” RCP at FPL easement
Source: 2008, Exceptional Engineering

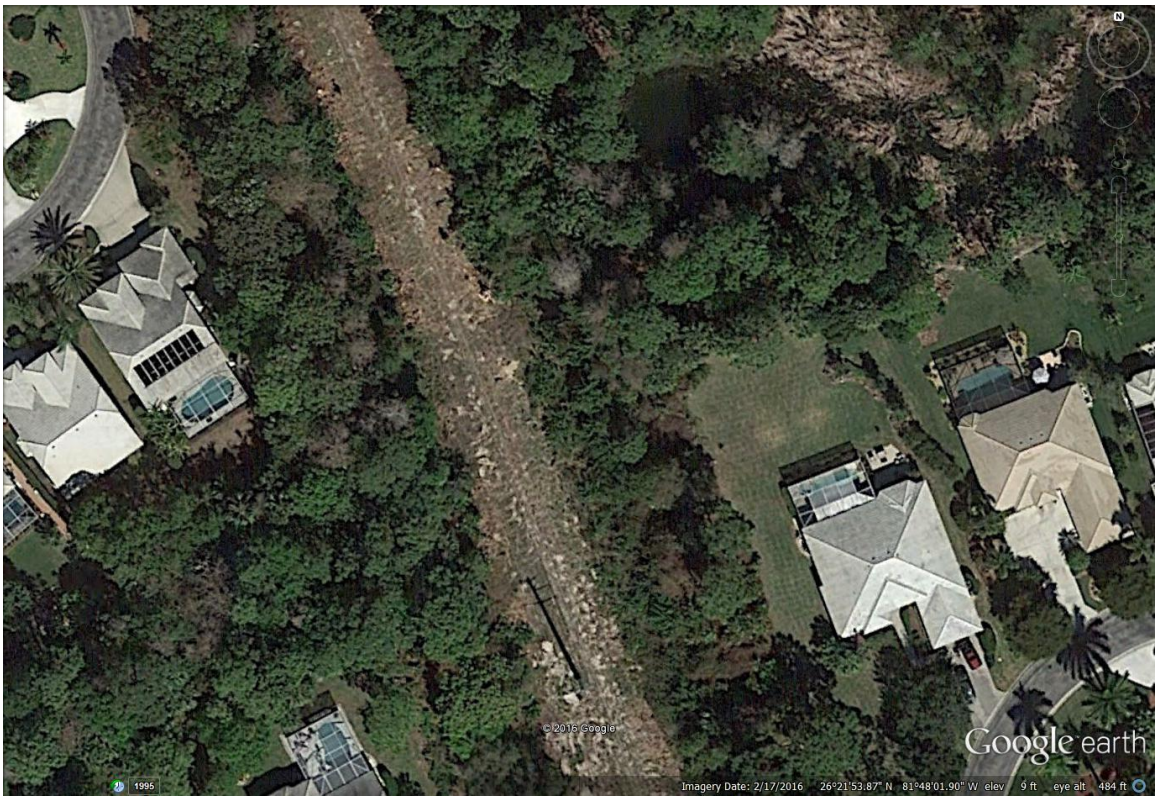




Figure 61: North Branch of Spring Creek at the FPL easement
Source: Google Earth 2016

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 62: 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.

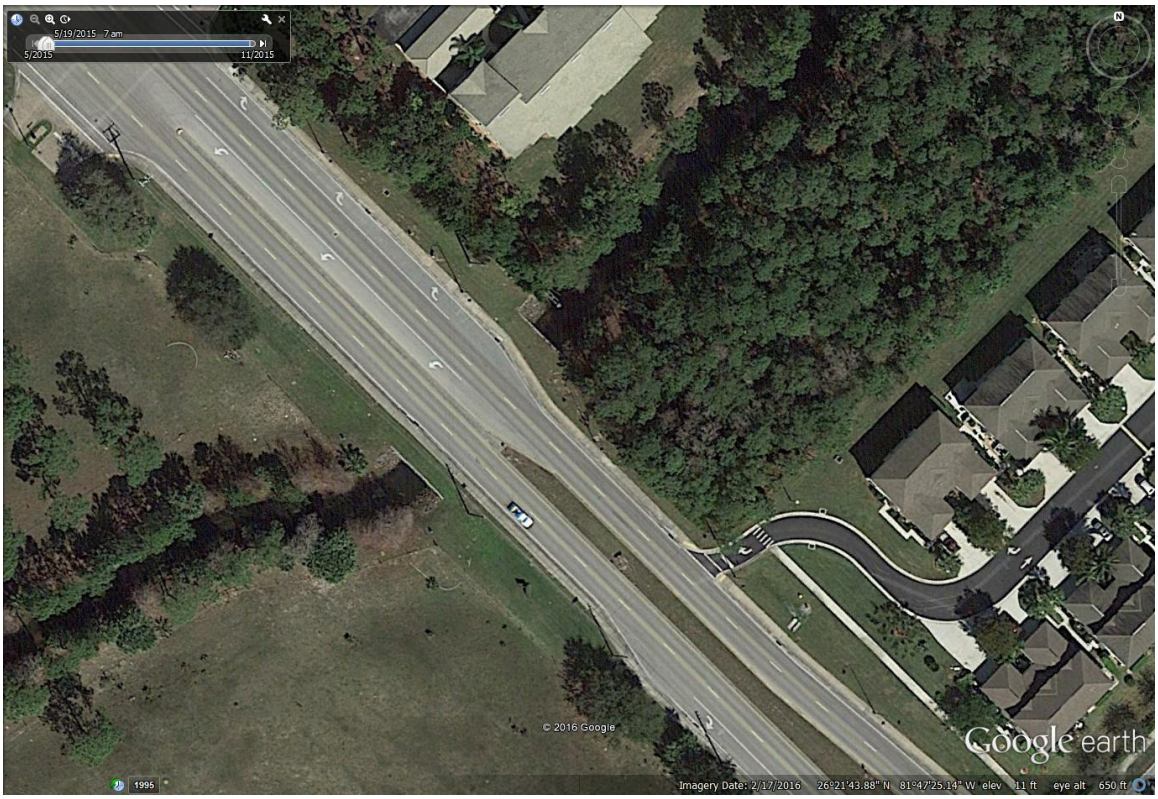




Figure 63: Old US41 Box Culvert on the South Branch of Spring Creek entering Bernwood Business Park
Source 2008: Google Earth 2016

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 64: Cattle Crossing of the South Branch inside Bernwood Business Park in 2008
Source: 2008, Exceptional Engineering, Inc.



Figure 65: 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 66: Seminole Gulf Railroad Crossing
Source: Google Earth 2016


Pic 12. Seminole Gulf Railroad Crossing

Figure 67: Seminole Gulf Railroad South Branch Crossing
Source: 2008, Exceptional Engineering, Inc.


Pic 13. Additional Pipe at Railroad Crossing

Figure 68: 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.




Figure 69: 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 70: FPL Easement Bridge Crossing
Source: 2008, Exceptional Engineering, Inc.



Figure 71: 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

- Improvement of undersized culverts to larger capacity
- Modifications of weirs and causeway barriers impeding flow in the upper and middle reaches of the creek

## *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 72: 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 hydraulic performance and improved maintenance while reducing backwater. Depending on the design this may allow passage of canoes/kayaks.

Modifications of weirs and causeway barriers impeding flow in the upper and middle reaches of the Spring Creek


Figure 73. San Carlos Estates southernmost weir. Note: flow from erosion.
Source: 2008, Exceptional Engineering, Inc.




Figure 74: 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 hydraulic 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 hydraulic performance and improved maintenance while reducing backwater. The San Carolos Drainage District (A Florida Special Tax District) covers a large part of San Carlos Estates and San Carlos Park communities. The City of Bonita Springs could do projects if the City owns the land that the project is on, or if the City has entered into some type of Cooperative Agreement with the San Carlos Estates Water Control District. Otherwise the City of Bonita Springs is unable to do a project relating to the drainage ways since it would not have jurisdiction even if the channel or structure that is part of the San Carlos Drainage District is within the city limits.

Figure 75: Adjustable weir design at outlet of Suncoast Estates to Powell Creek, Lee County



Figure 76: Other adjustable weir designs with a fish chute.

Figure 77: Other adjustable weir designs with side flap gates.

Figure 78: Other adjustable weir designs with lift gates.

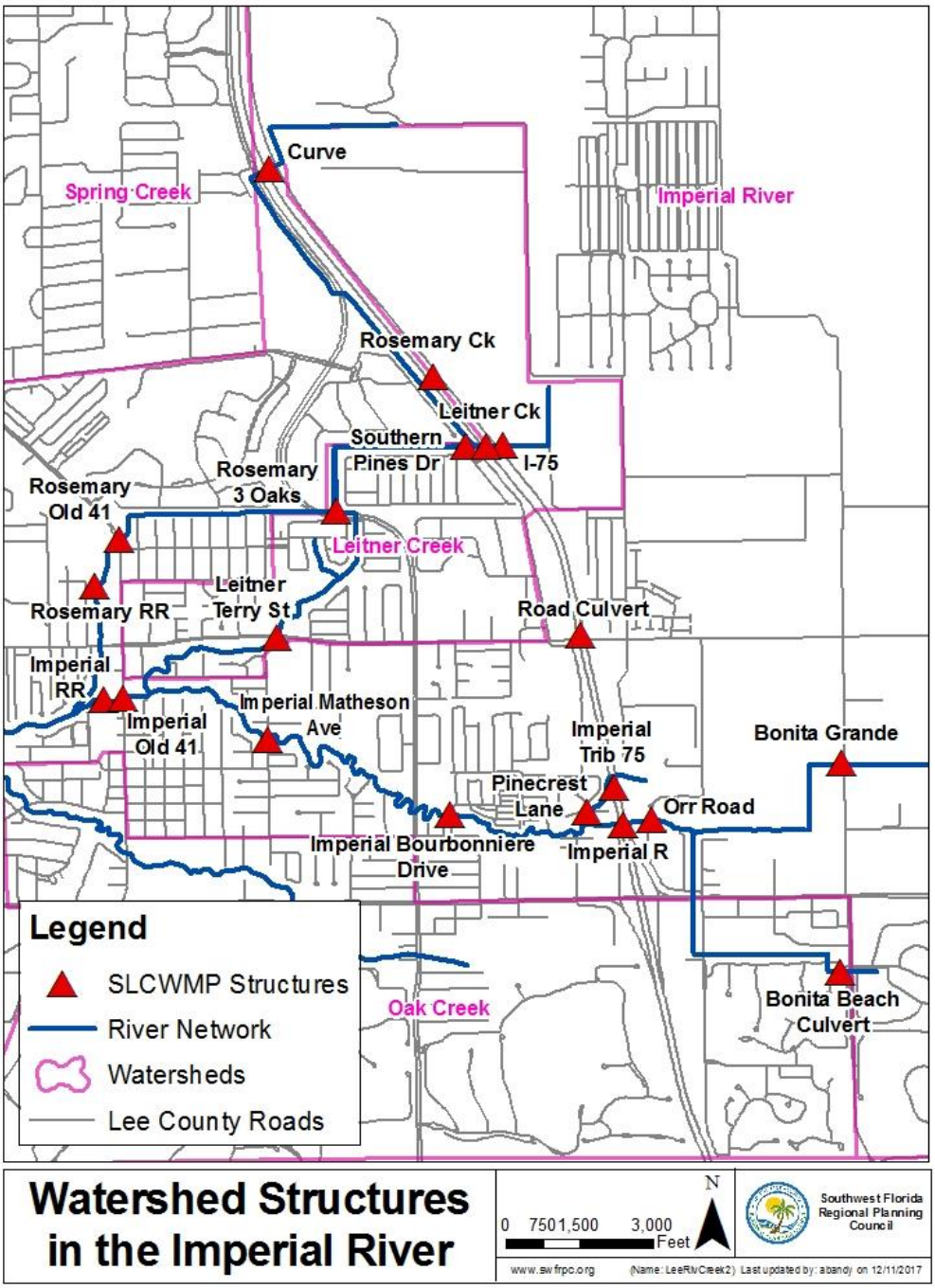


Figure 79: Watershed Structures in the Imperial River

The headwaters of the Imperial River originally were restricted to its own watershed in the central part of the DRGR Today they are composed of parts of the Cocohatchee, the Spring Creek, and the Estero River headwaters as well as the Imperial headwaters of the Flint Pen Strand. The Kehl Canal intercepts waters flowing from the northeast to southwest from the Lake Trafford, Gordon Swamp. Flint Pen and the northern part of the Cocohatchee Watershed and shunts it west to pass the Kehl Canal Weir. Immediately west of the weir is the Bonita Grande Boulevard Bridge. In parallel the south side Bonita Beach Boulevard canal collects waters of the Cocohatchee Watershed and directs them east under Bonita Grande Boulevard through 3 seventy two inch diameter culverts , to a canal north of Bonita Beach Road that turns north to intersect with the other Kehl canal flows in an area known as Surveyor's Creek (the original name for the Imperial River). Lee County cleaned these culverts out after Hurricane Irma.




Figure 80: Bonita Beach Road Culvert Undercrossing


Figure 81: Imperial River Canal at Bonita Grande Boulevard

The Imperial River proper then flows east past the site of the former Kent/Orr road bridge, which was removed by the SFWMD. The main South Branch of the imperial River flows under I-75 under large bridges.



Figure 82: Removal of the Kent/Orr Bridge by the SFWMD
Sources: Naples Daily News


Figure 83: Crossing of I-75 at the South Branch of the Imperial River

In contrast the smaller North Branch of the Imperial River crosses under a small vegetation blocked culvert that collects waters from areas south and north of East Terry Street including Morton Groves, the YMCA, Pine Preserve, Rue de Paix and Kent Road. The North Branch then flows through a small culvert at Pinecrest and Riverview Lane to make connection with the larger South Branch of the Imperial River.



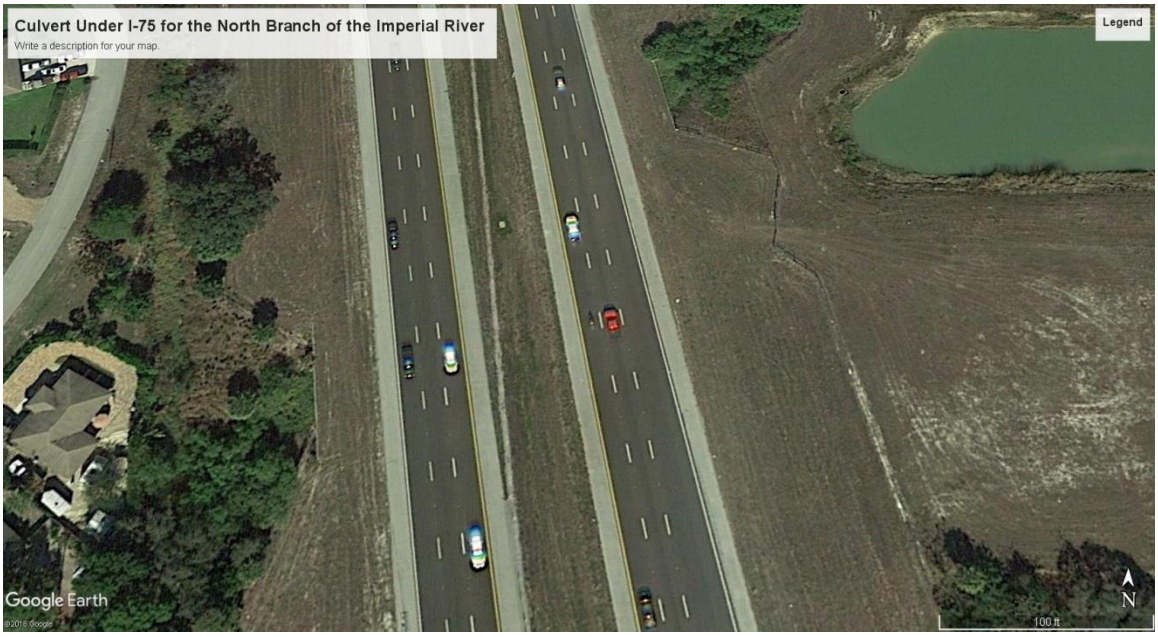


Figure 84: I-75 culvert crossing of the North Branch of the Imperial River.

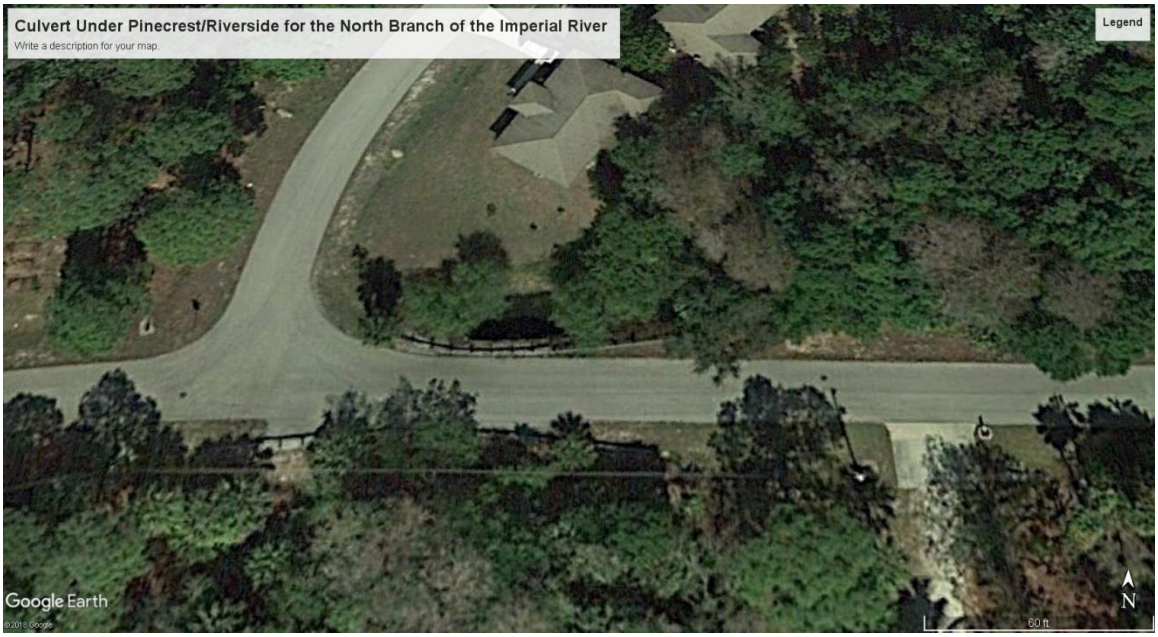


Figure 85: Culvert under Pinecrest/Riverside of the North Branch of the Imperial River

The combined Imperial River then flows west to the Bourbonnierre Bridge. While designed for spanning the basic river profile this bridge does not span the whole floodplain.




Figure 86: Bourbonnierre Bridge crossing of the Imperial River

The Imperial River then begins a series of multiple ox-bow serpentine turns. At Imperial Parkway the large bridge crossing area straightens the River for a short distance and then

pushes the River against an upland essentially making the river turn 90 degrees to the north to continue following the ox-bows.


Figure 87: Imperial Parkway Bridge crossing of the Imperial River



The Imperial River then proceeds westward to flow under the small Matheson Avenue Bridge.

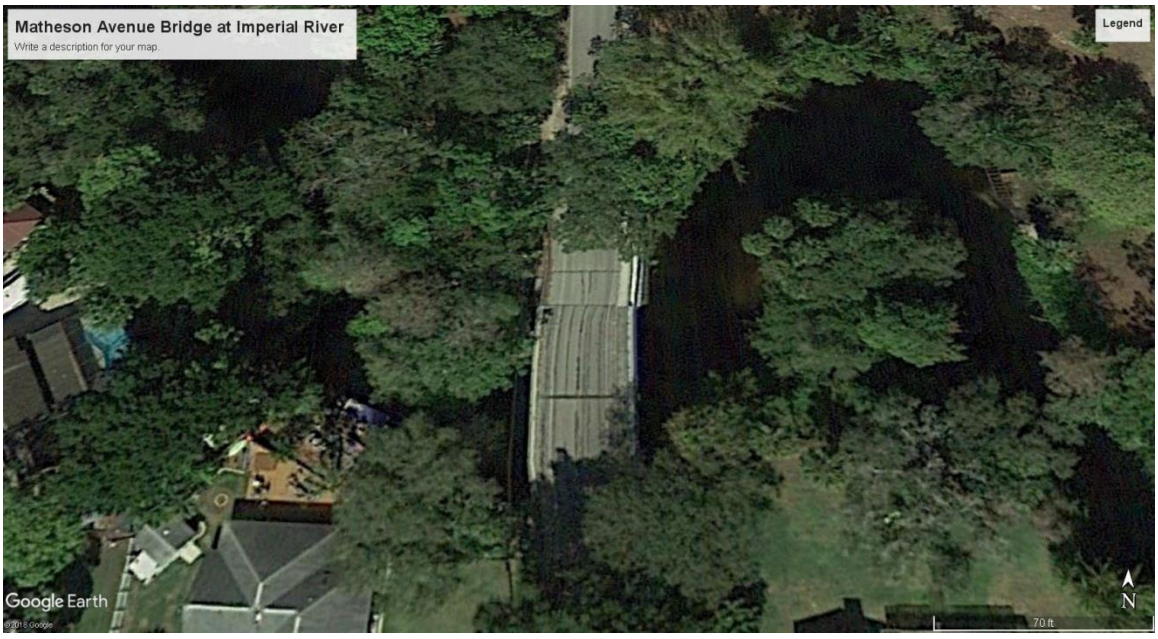


Figure 88: Matheson Avenue Bridge crossing of the Imperial River

Further west the Imperial River is joined by the tributary Leitner Creek. Leitner Creek was essentially converted to a canal in its headwaters east of Interstate 75 in the Citrus Park area. Leitner Creek crosses under I-75 in a set of two culverts and then through a culvert under Southern Pines Drive.


Figure 89: Leitner Creek Canal culvert crossing at I-75

The Leitner Creek Canal then proceeds west to turn south and cross under Imperial Parkway.


Figure 90: Leitner Creek Canal culvert crossing at Imperial Parkway

At this point flows split south into Leitner Creek Proper and west as the Rosemary Canal. Leitner Creek then takes on a more natural profile and cross under Wagon Trail, Torchfire Trail, Goodwin Street, and Terry Street at which point it turns west to its confluence with the Imperial River.




Figure 91: Leitner Creek culvert crossing at Terry Street

The waters that enter the Rosemary Canal originate at their furthest headwaters at the BSU site east of I-75 and includes parts of the former headwaters of Spring Creek these flow under I-75 through culverts and then go south along the west side of I-75 in a vegetated canal.

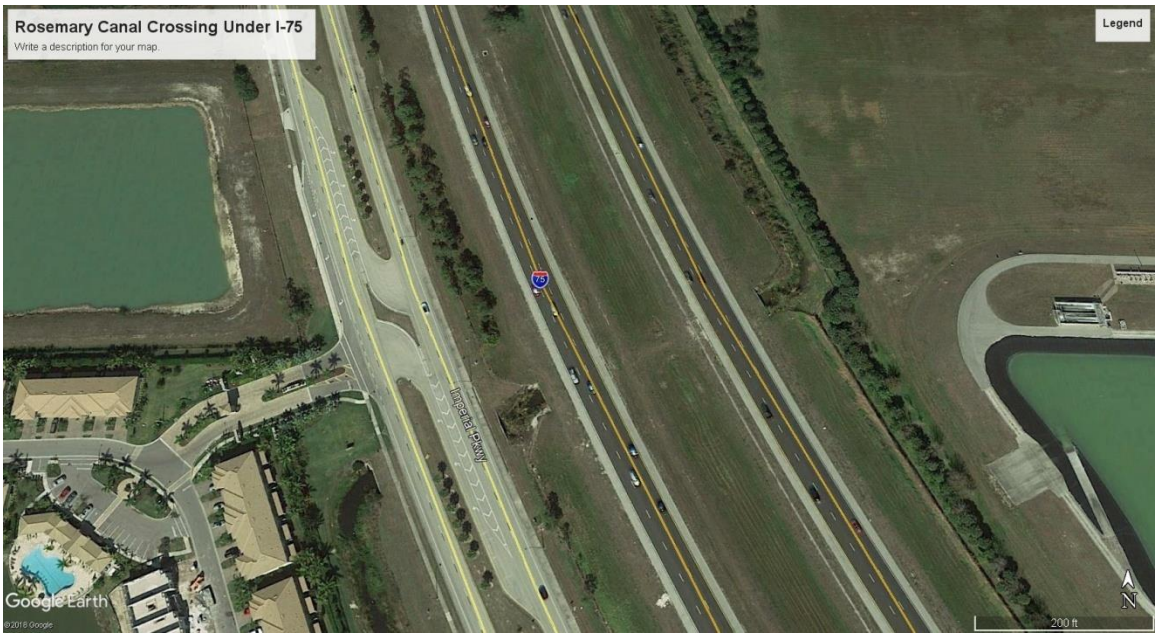




Figure 92: I-75 culvert crossing form BSU property to Rosemary Canal

This canal flows though culverts under Imperial Parkway and is then joined by the waters of a eastern canal that has culverts under I-75 that collects waters from west of Citrus Park.


Figure 93: Culvert crossing of Rosemary Canal under Imperial Parkway

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The Canal continues south along the west side of I-75 and then takes an acute turn west around the De Milano cul-de-sac. At this point it combines with the Leitner Creek Canal flowing from under I-75. The Rosemary Canal flows westward to cross under Old US 41 and turns south to cross under the railroad.


Figure 94: Culvert crossing of Rosemary Canal under Old US 41


Figure 95: Culvert crossing of Rosemary Canal under the Railroad

Rosemary Canal then parallels the railroad on its west side flowing southward to make confluence with the Imperial River immediately west of the railroad bridge across the Imperial River.




Figure 96: Railroad Bridge and Pedestrian Bridge Crossings of the Imperial River

The Imperial River then receives flows from Oak Creek a tributary entering from the south near Tennessee Street. The Imperial River widens and flows under the large New US 41 bridges. From this point westward there are no other crossings of the Imperial River as it flows into Fish-Trap Bay.




Figure 97: New US 41 Bridge Crossing of the Imperial River

Bridges that need to be made larger and culverts that need to be replaced by large culverts or new bridges to prevent stacked up flooding on the upstream sides of the roads.

**For Spring Creek sub-basin**

Three Oaks Parkway/Imperial Parkway box culvert

North Branch and South Branch Old US 41 box culverts

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

Spring Creek North Branch Railroad Crossing

Spring Creek South Branch Railroad Crossing (has already been applied for with FEMA)

The Milagro Lane Culvert on the South Branch of Spring Creek (has already been applied for with FEMA)

The FPL right-of-way bridging and pipes on the North and South Branches Spring Creek.

The culvert at Cedar Creek Drive

The cattle crossing bridge inside Bernwood Business Park on the South Branch

**For Imperial River sub-basin**

It is recommended that SFWMD or another competent organization run their water model on the Imperial River after updating to flooding depth of August 2017 'little flood" and the IRMA flood of September 2017 the following bridges which visual observations indicate some of these have spans too short to accommodate the floodway resulting in a damming up of the flood waters making the flooding worse and causing a longer time for the flood waters to recede.

Bonita Grande Boulevard



Pinecrest/Riverside Lane

Bourbonnierre Drive Bridge

Matheson Avenue

Rosemary Canal at I-75

Leitner Creek at I-75

Leitner Creek at Terry Street

Southern Pines Drive

Rosemary at Old 41

Rosemary at Railroad

Rosemary Canal at Imperial Parkway

Atkins Engineering has provided for Potential Solution 2 a planning level concept and cost estimate for upsizing, expanding or replacing an existing storm water culvert or bridge crossing. with six different examples of bridge or culvert replacement projects,

for converting an existing bridge with insufficient flowway size and fill causeways that act as a dike during flood events with a bridge that span a riverine floodplain allowing full flow passage.

## *Potential Solution 3: Retrofit Older Residential Communities*

- Retrofit older communities which lack any true surface water management system to have a basic system of swales with collection in storm water retention systems with a point or points of positive discharge to a larger receiving flowway
- These systems need not be restricted to a single named neighborhood but may best be constructed in several adjacent neighborhoods that all feed a regional storm water collection and treatment system.

Designing safer and smarter communities that can cope with flooding and other extreme weather is cost-effective and often easier than we assume. By taking meaningful steps to protect themselves, these vulnerable cities and states became more resilient to storms, while saving tax dollars long-term.



After the destruction from Hurricane Andrew in 1992, Florida became the nation's leader for implementing and enforcing superior building codes to reduce the impact of hurricanes. These codes proved their worth during Hurricane Irma this September when buildings were better able to withstand the storm, likely savings millions in damages. Elevating new buildings, as the Florida codes require in flood-prone areas, typically costs less than 1 percent of the total new building cost for each foot a building is raised. Such investments pay for themselves in as little as one or two years in areas with the highest risk of flooding, the Federal Emergency Management Agency has found.

There is an opportunity for regional storm water management and filter marsh system in the Spring Creek sub-basin at the currently dormant and unused Bonita Springs Golf and Country Club golf course. This site could provide storm water retention and treatment and a non-intense use public park similar in design to facilities like Freedom Park in Collier County, Billy Creek Preserve and Filter Marsh in Fort Myers, and Powell Creek Preserve Filter Marsh in North Fort Myers.

There are other locations for filter marshes in the Spring Creek watershed that have been identified in the Spring Creek Restoration Plan (2016)

Atkins Engineering has provided in Appendix 1 for Potential Solution 3 a planning level cost estimates for retrofitting an older neighborhood with a new storm water conveyance system (swales/culverts) and creating a storm water treatment/attenuation facility (pond).

### *Potential Solution 4: Large Regional Storm water Management System (RSMS) in the Density Reduction/ Groundwater Recharge Zone (DRGR)*

- Collect flows in the watersheds east of I-75 into a very large Regional Storm water Management System (RSMS) with associated filter marsh water quality treatment located in the eastern area of the Bonita Springs DRGR on mine lands and agricultural lands
- This will serve neighborhood flows east of I-75 and collect flows from the north into a new flowway connection across native lands for discharge to correct watershed destination (Spring Creek, Imperial River, and Cocohatchee River).

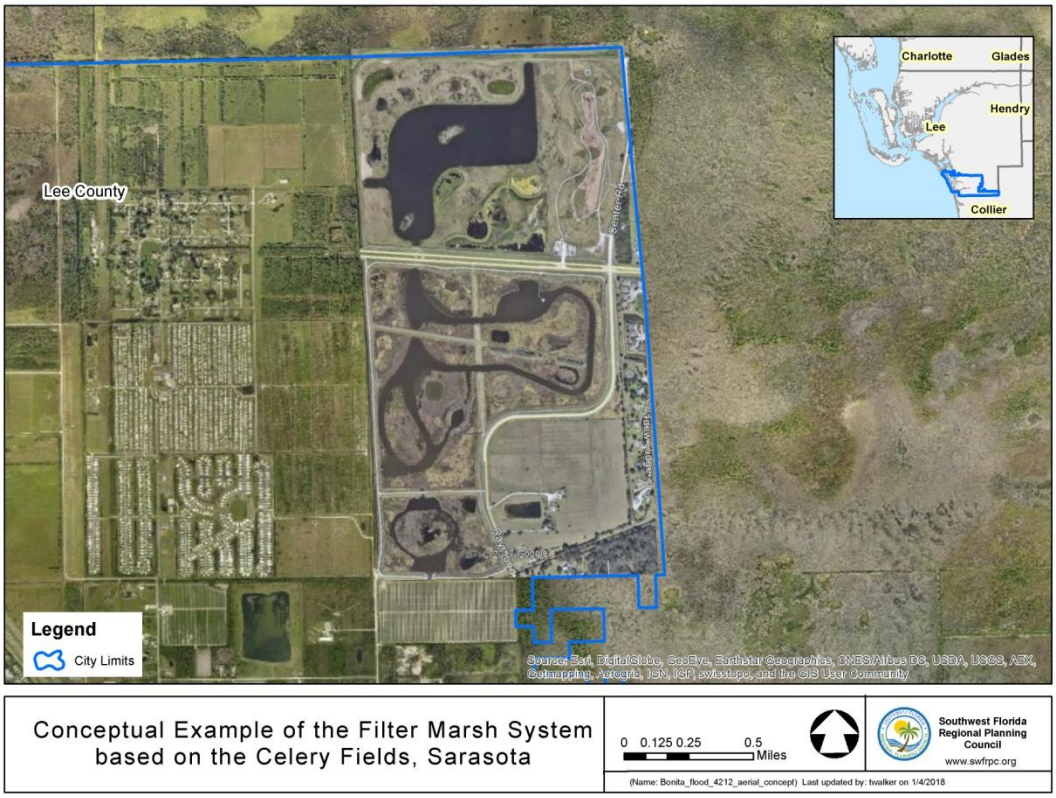


Figure 98: Initial conceptual example of the Filter Marsh System based on overlaying the Celery Fields in Sarasota County at the Mine Site in the DRGR

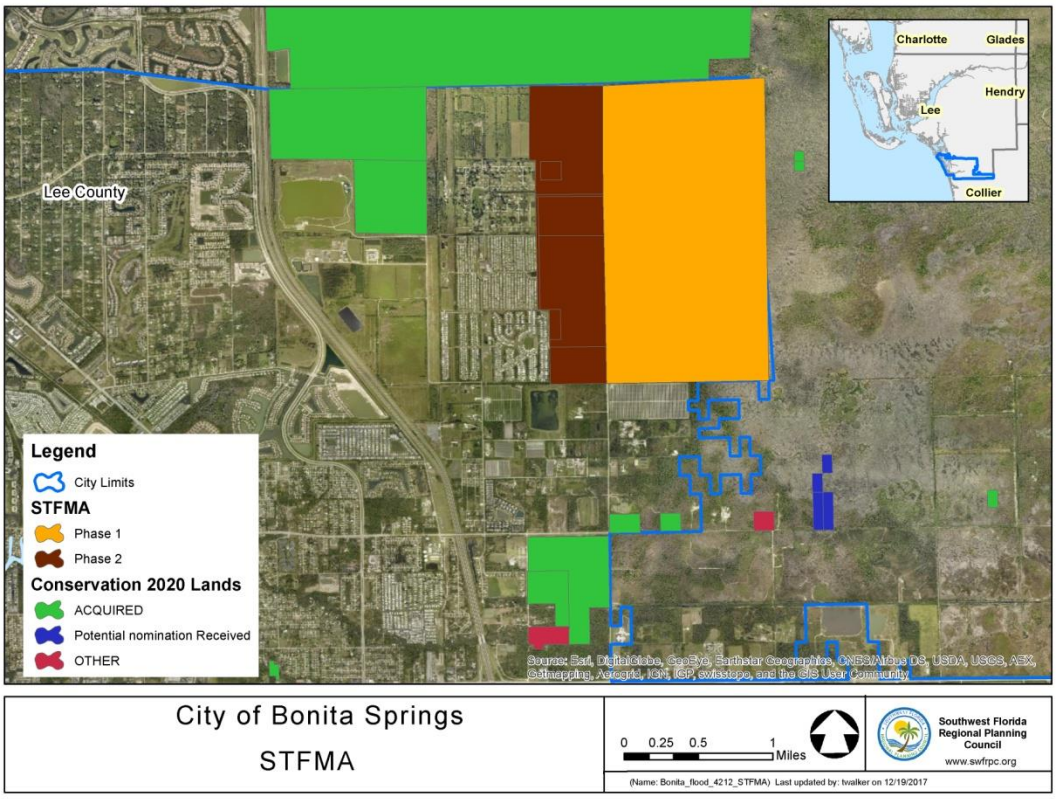




Figure 99: Storm water Treatment and Filter Marsh
DRGR of the City of Bonita Springs

Land acquisition to create additional storm water retention in the upper reaches of the Imperial River Basin, known locally as the DR/GR, to create regional scale Storm water Storage Treatment Area (STA) and to acquire lands downstream to create smaller scales treatment area along the courses of the Imperial River and Spring Creek. This project will slow the delivery of the storm water sheetflow into the developed areas of Bonita Springs and help to prevent flooding along the rivers course. Additionally the treatment areas will aide in removing nitrogen from the watershed and achieving the adopted Basin Management Action Plan's (BMAP) .74 mg/L Total Maximum Daily Load (TMDL) for Nitrogen.

Initial cost estimates for Bonita Springs Storm water Storage and Treatment Land Acquisition is $6,200,000. There will be additional expense for engineering construction and operation and maintenance of the facility.

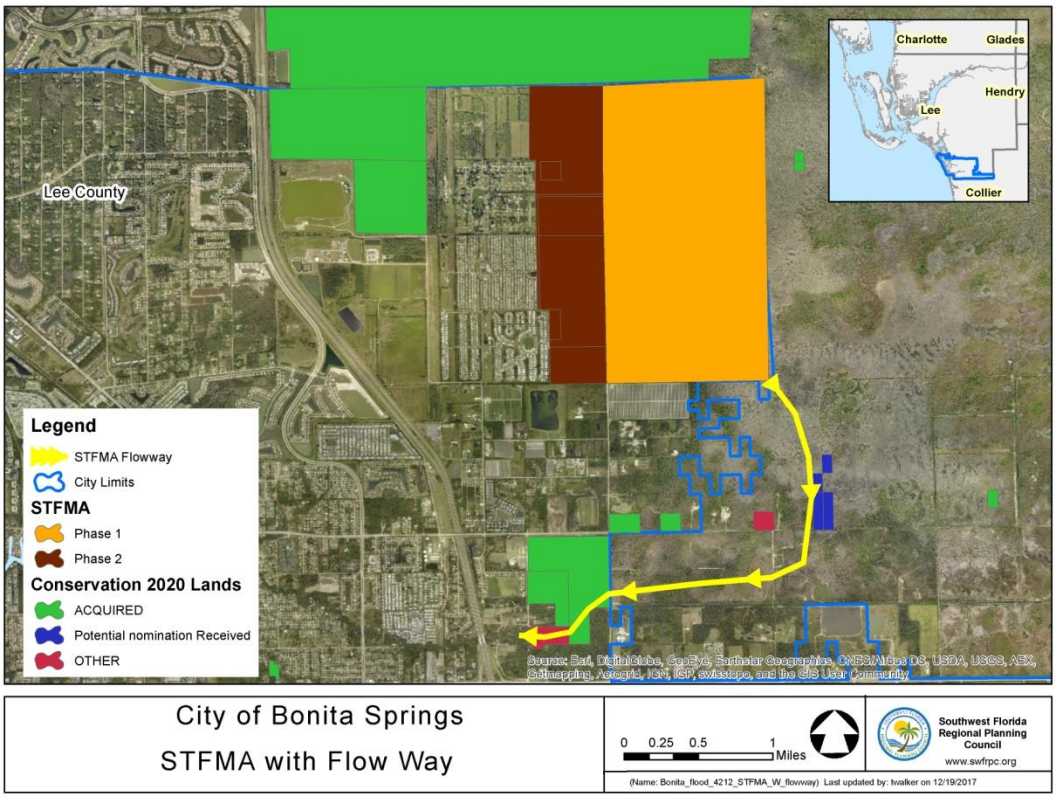




Figure 100: Storm water Treatment and Filter Marsh with Flowway Location through CREW, DRGR of the City of Bonita Springs

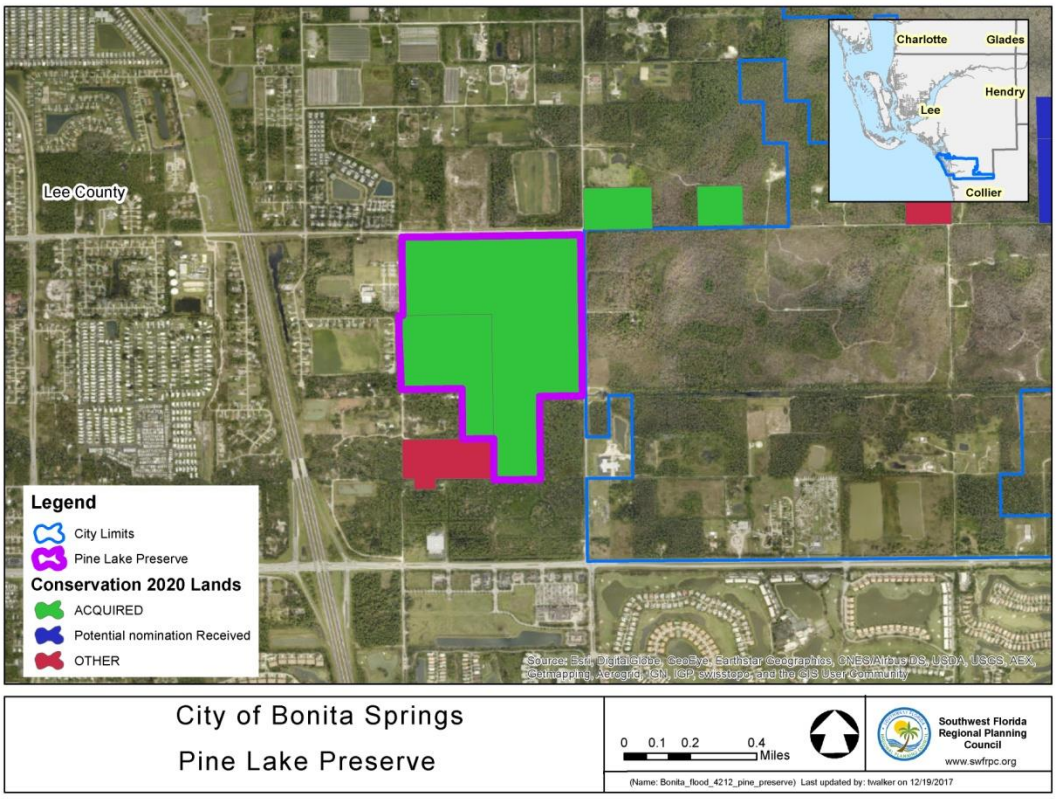




Figure 101: Pine Lake Preserve, DRGR of the City of Bonita Springs

The outflow of the RSWFMTS will be as sheetflow which will connect to the Pine Lake Preserve restoration flowway of the Imperial River.

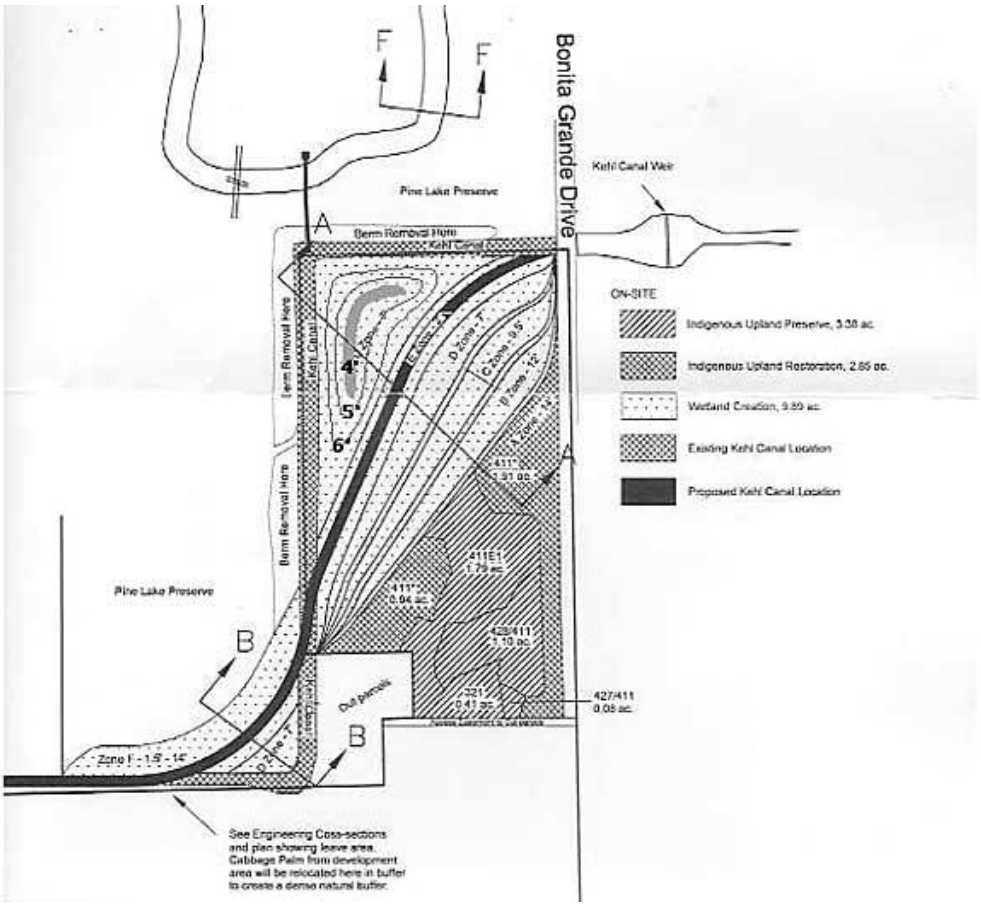




Figure 102: Pine Lake Preserve channel restoration

The proposed RSWFMTS could be built in two phases. Phase 1 which would encompass the existing mine site is 1,260 acres. Phase 2 which consists of the agricultural fields west of the mine site is 510.8 acres. By comparison the existing Celery Fields area in Sarasota County is 406 acres

Atkins Engineering has provided in Appendix 1 for **Potential Solution 4** a planning level concept and cost estimate for creating a Regional Storm water Management Facility within the in the Density Reduction/ Groundwater Recharge Zone (DRGR).

## *Potential Solution 5: Improve Design and Retention in the Kehl Canal*

- Change the design of the Kehl Canal to retain and treat more water rather than quickly discharge it to the Imperial River proper.

- Add adjacent water storage features to collect flows from the Kehl Canal that incorporate filter marshes (examples: Ten-Mile Canal filter marsh; North Colonial Waterway; Freedom Park filter marsh)

- Install a series of step-up weirs to hold additional water within with increasing control elevations from west to east (this will aid storage and provide improved groundwater levels during dry season in the DRGR)

The Kehl Canal was constructed in 1962 to capture flows coming from the northeast in the Flint-Pen Strand and flows from the grid of agricultural and dirt road drainage ditches north of it that serve 15 square mile area. The Kehl Canal is approximately 4.2 miles long. The width in the canal varies along its length and the more easterly parts are shallower with some vegetation n the channel. The construction of the Kehl Canal combined with the construction of roadways, altered the sheet flow pattern into the smaller canals and ditches that feed into the Kehl Canal. One account states that the Kehl Canal was created to drain land to the east of the Preserve for the failed Suncoast Acres residential community.

The easternmost part of the Kehl Carnal is found slightly east of Poor Man's Pass Road. It flows east and crosses under Vincent Road with several branch canals that extend south west of Vincent Road. It continues west crossing under Faygin Lane. It then encounters the Kehl Canal gate structure with a reported invert elevation of 13.0 ft NGVD29 located just east of Bonita Grande Road. This weir was first installed in the mid-1990s to raise the water table, increase wetland hydroperiods and reduce the draining of wetlands to the east.



The Kehl Canal continues to extend approximately 1/4 mile east of the weir and then the canal turns south. The canal then turns west and continues straight until it intersects with the Imperial River at Kent Road.

This canal blocks the original channel of the Imperial River that once flowed through the southern arm of the Pine Lake Preserve. In October 2004, a cut in the berm of the Kehl Canal was made where the original Imperial riverbed once flowed and another cut was made on the western boundary through an elevated roadbed. These berm cuts were made to restore flow through the original channel of the Imperial River. Water occasionally flows through the historic riverbed during heavy rain events, but the Kehl Canal is 4-5feet lower than the historic channel, so the majority of the time the level of the Kehl Canal is not high enough to allow water to flow through.

Kehl Canal is the source of flow to the Imperial River upstream of I-75, along with flows from a drainage canal south of Bonita Beach Road. There are two sets of culverts in the upper reaches of Kehl Canal that are located at Poorman’s Pass Road (3 X 42” CMPs, Inv 12.5 ft-NGVD) and Vincent Road (30”, 32”, and 42” CMPs, unknown invert). Kehl Canal water levels are controlled by a gate and weir at the downstream end of Kehl Canal just east of Bonita Grande Drive. The Kehl Canal gate consists of two steel plates that

have an elevation of 12 ft-NGVD when closed. The invert elevation is 3 ft NGVD, and the gates open during the wet season. Opening criteria vary depending upon a variety of factors, and gate operations are therefore based on gate operation records. There is a 100-foot weir at the Kehl Canal gate with an invert elevation equal to 10 ft-NGVD. Bonita Grande Drive consists of a box opening that is 49 feet wide, 12 feet high, with the invert elevation equal to 4 ft-NGVD. Imperial River road crossings are all bridges from I-75 to U.S. 41, and all bridges except the railroad bridge and the Bourbonnierre Street Bridge appear to be new. These older bridges do not appear to be a significant constraint, however no detailed cross sections of these bridges were found. Dimensions were obtained from existing HEC-RAS files. Rosemary Canal and Leitner Creeks enter Imperial River from the north, and the drainage areas for these two creeks have been substantially modified since construction of Three Oaks Parkway (called Imperial Boulevard within Bonita Springs).

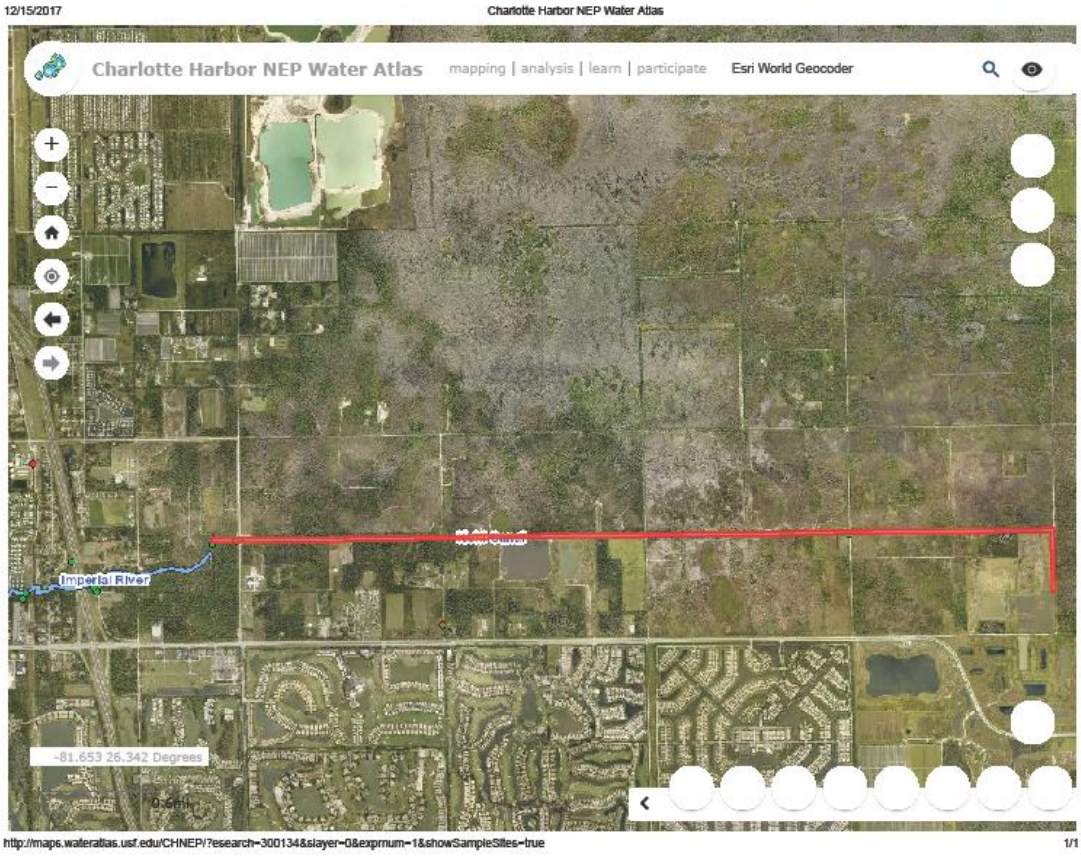




Figure 103; Kehl Canal Extents

Kehl Canal (as defined by the SFWMD is indicated in red. Imperial River Path is in blue. Note that there is a canal that runs around the perimeter of the Pine Preserve that carries the majority of the Kehl Canal flows to the Imperial River after making two turns.


Figure 104: Kehl Canal Weir

Atkins Engineering has provided in Appendix 1 for Potential Solution 5a a planning level concept and cost estimate for creating step weirs within the Kehl Canal to slow water discharge from the canal and for Potential Solution 5b a planning level concept and cost estimate for storing water south of the Kehl Canal by pumping water from the canal to an impoundment.

## *Potential Solution 6: Restore the Watershed Connections*

- Reconnect and/or improve the connection of the upper watersheds of Half-Way Creek, Spring Creek, and the Cocohatchee River to carry their original natural flows and not unnaturally contribute excess flows to the Imperial River.
- The Bloomberg Grant application is for the beginning of this.

- The reconnection design will be designed to restore the natural hydroperiod and capacity of Half-Way Creek, Spring Creek, and the Cocohatchee River and not exceed their carrying capacity. Imperial River flooding will not be reduced by transferring flooding to another watershed (as has been done by other to the Imperial River.

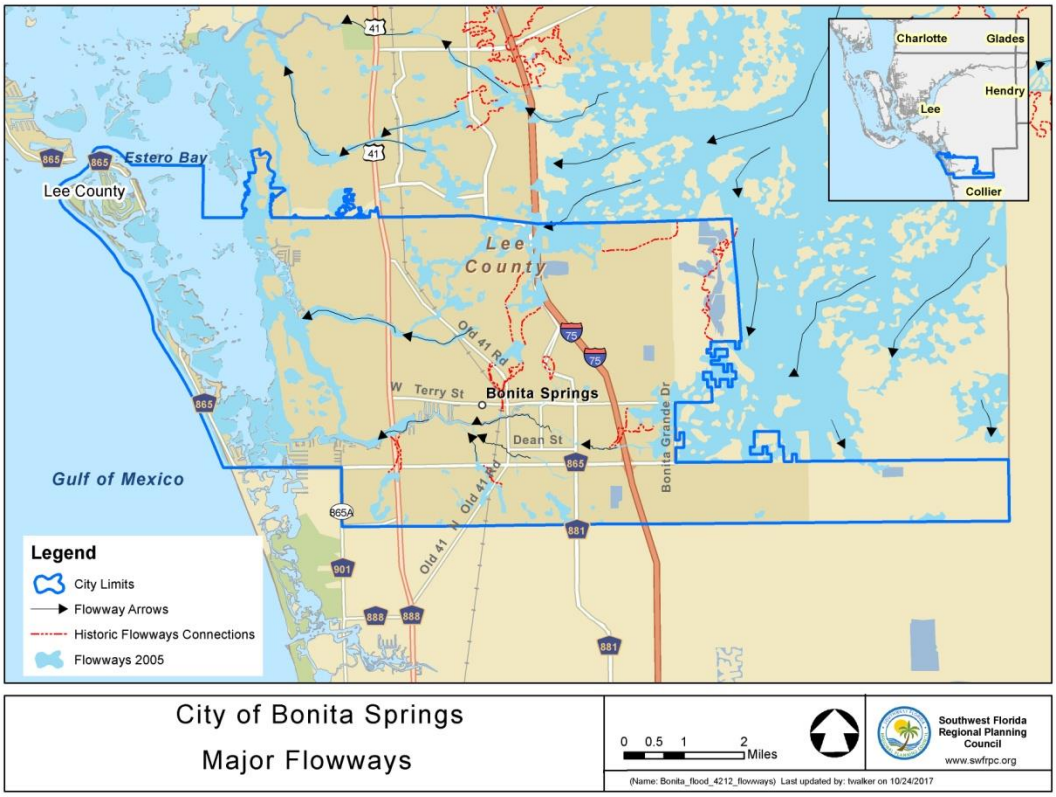


Figure 105: Major Flowways of the City of Bonita Springs

Note that Interstate 75 has blocked flow to parts of Spring Creek and the Kehl Canal captures flows that should go south.

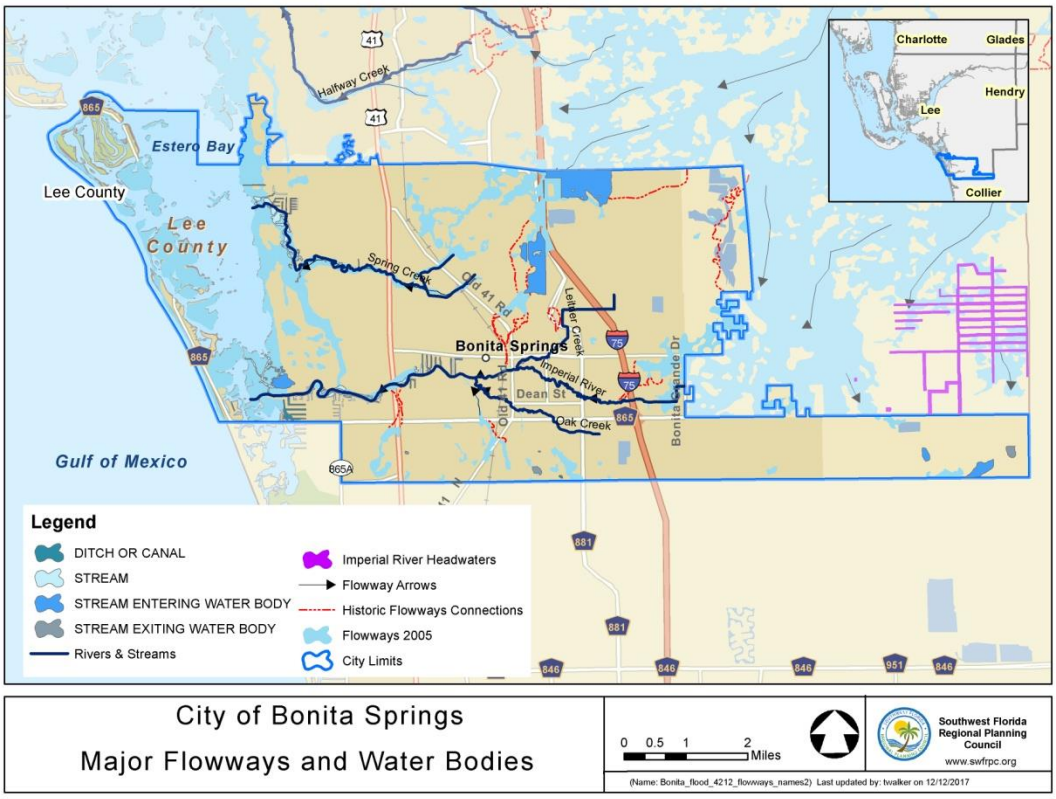




Figure 106: Major Flowways of the City of Bonita Springs with eastern canals of the Imperial River headwaters and stream channels features

Identified for the Spring Creek Watershed include:

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. 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 hydraulically 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 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 hydraulically 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.



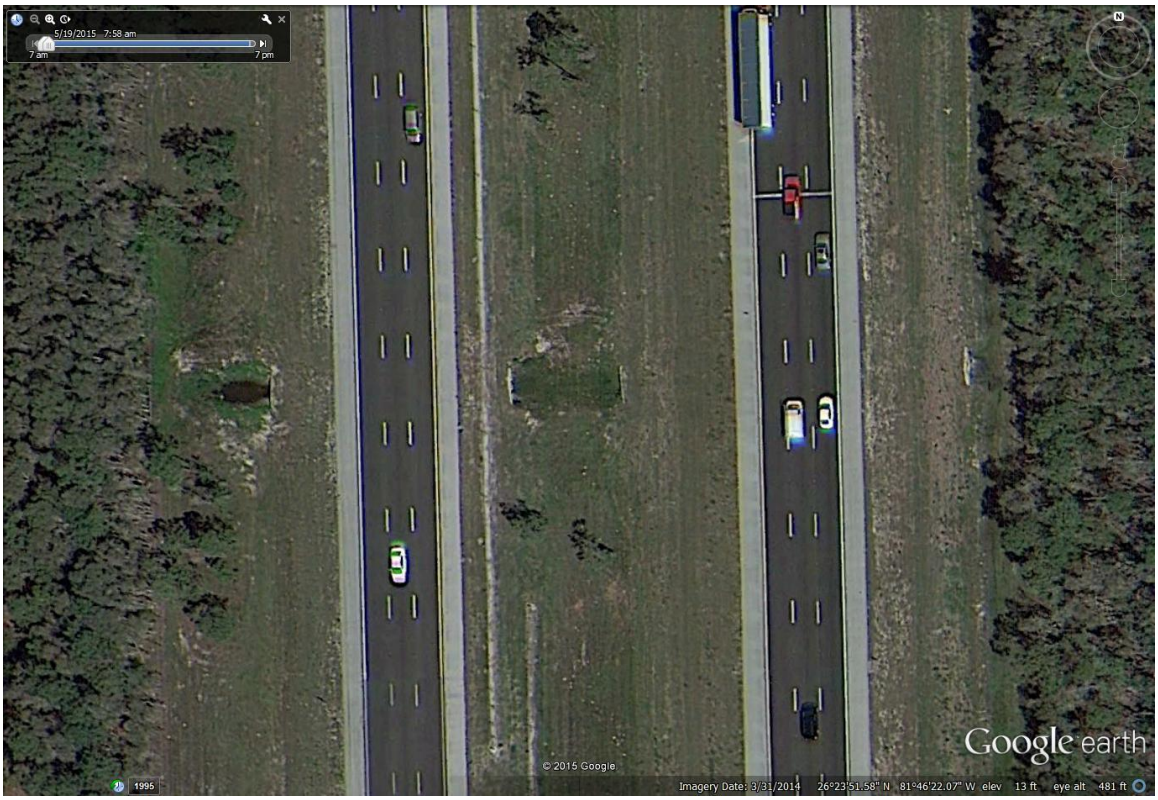


Figure 107: Culvert between Flint Penn Strand (Edison Farms) and The Brooks crossing under Interstate 75.
Source Google Earth 2015

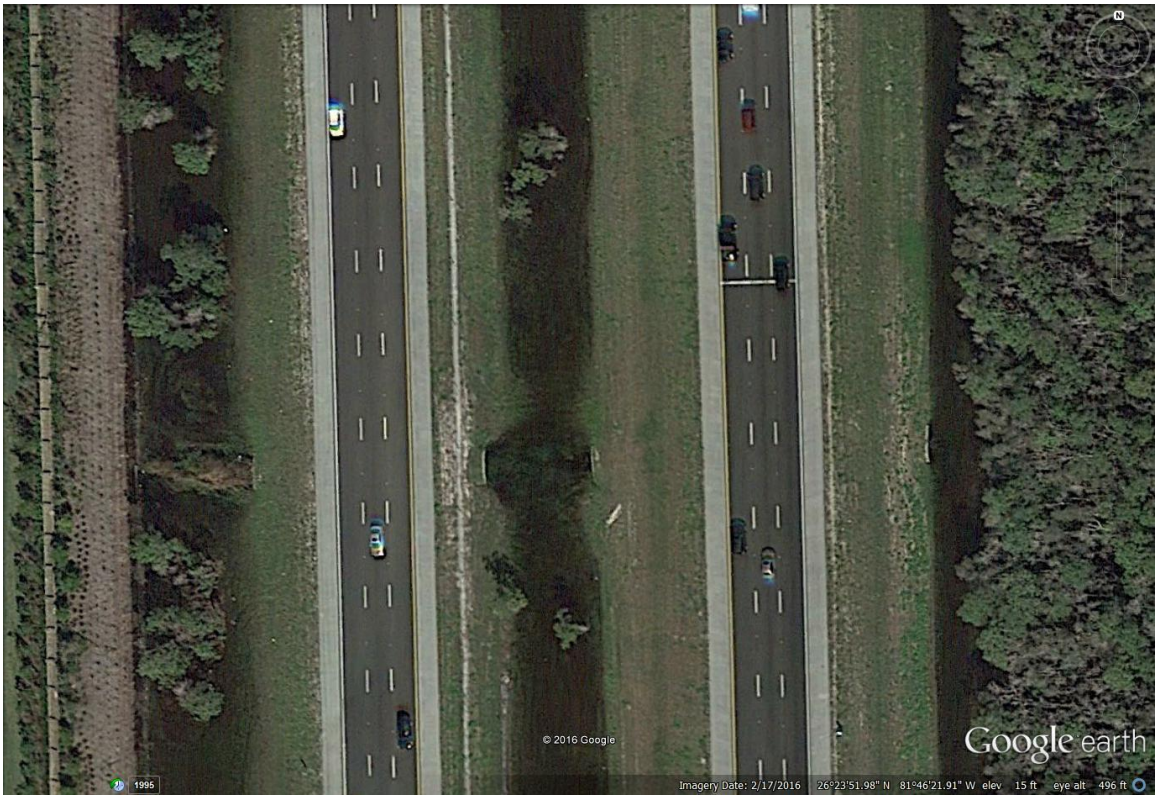


Figure 108: Culvert between Flint Penn Strand (Edison Farms) and The Brooks crossing under Interstate 75.
Source Google Earth 2016

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 Springs 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.

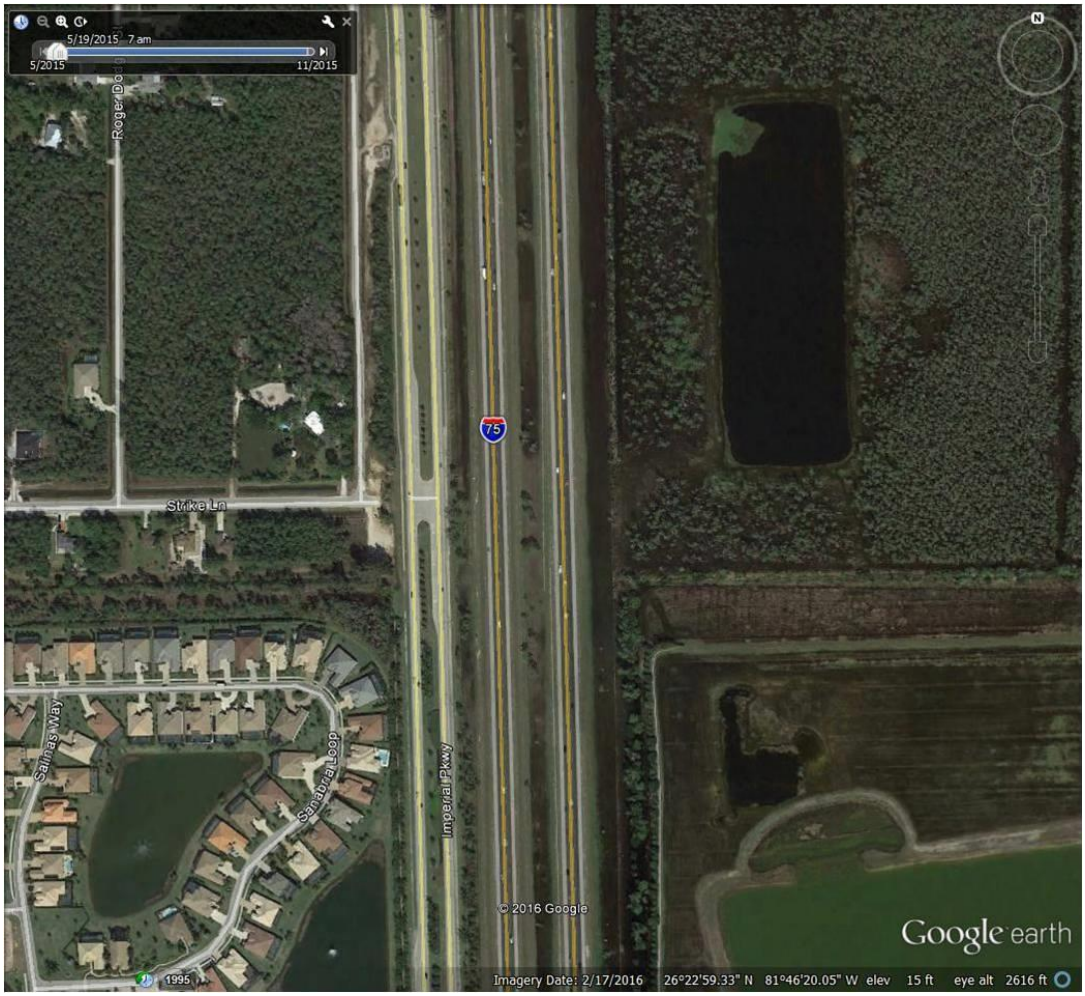


Figure 109: Former location of where the south branch of Spring Creek would have crossed between Flint Penn Strand (Edison Farms) and area west of Interstate 75. Source Google Earth 2016

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.

Identified for the Imperial River Watershed include:

Bonita Springs Southern Flowways Construction AKA Logan Boulevard Flowway

This project is for the Design and Construction of multiple flowways to reconnect the regional historic southern storm water sheet flow to the Cocohatchee watershed. Because of previous land development, sheet flows have been redirected westerly into the Imperial River's watershed that historically has flown south into the Cocohatchee watershed. As an emergency measure, pumps were set by the South Florida Water Management District to send water down the unimproved Logan Boulevard Right of Way. The Logan Boulevard roadway is currently under design with construction scheduled for the summer of 2018; this project involves evaluation, design, and construction of 2 southern flowways, to include gated structures.

The estimated cost of this project is $7,350,000

## *Potential Solution 7: Acquire and Restore Floodplain Areas*

- Where available obtain unoccupied lands including native lands, exotic infested lands, mine lands, agricultural lands, rural lands, and otherwise vacant lands that are in existing floodplains or immediately adjacent to existing floodplains. This includes SFWMD "Surplus Lands" currently available in the DRGR. Request that the SFWMD not auction these lands but transfer them to the City of Bonita Springs for water management projects or sell them at simple cost to the City.

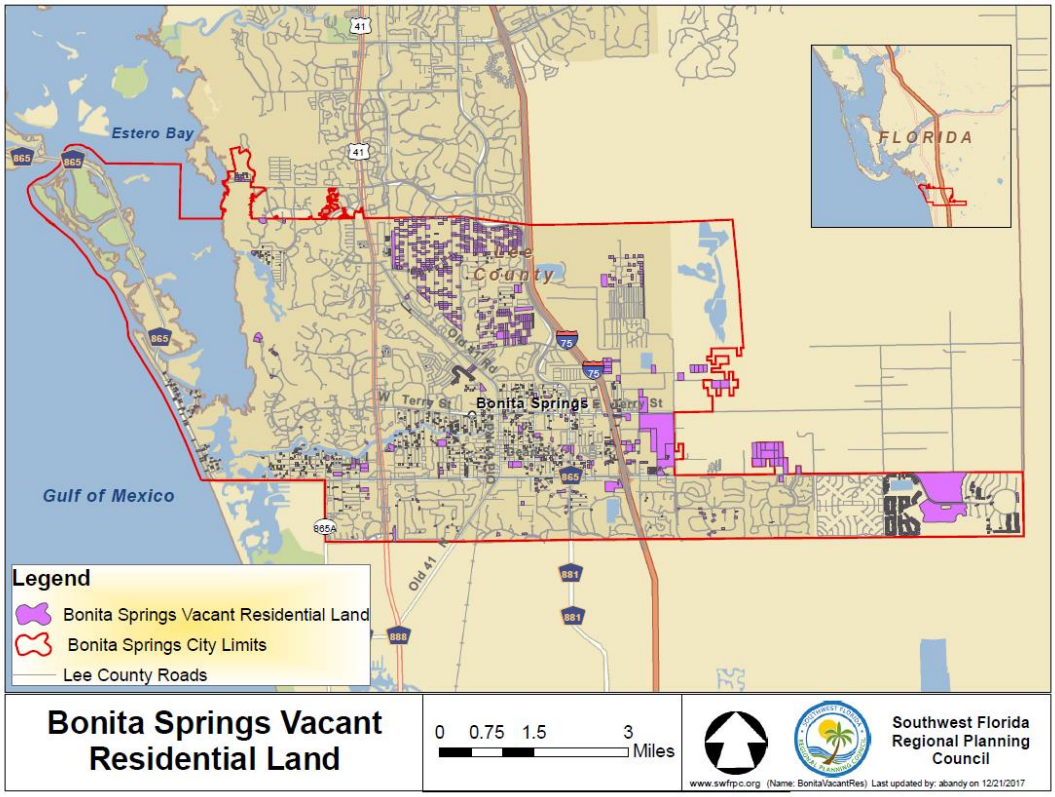




Figure 110: Map of existing Vacant Lands that could potentially be used for storm water retention or floodplain restoration.

Since 1999, the City of Charlotte and Mecklenburg County in North Carolina have gradually removed 400 homes, apartment buildings and businesses from flood-prone areas, saving taxpayers $25 million in the process. The voluntary buy-out program has created a safer building stock in the area while recreating an open floodplain. This, in turn, expanded recreation and public space in the rapidly growing Charlotte metropolitan area. By making room for rivers to expand temporarily during heavy rains, these actions reduce downstream flooding. Such investments, expected to help the community avoid $300 million in future flooding costs, will boost Charlotte-Mecklenburg's economic competitiveness long-term.

## *Potential Solution 8: Establish a better/higher storm water retention standard for all new development*

- Establish a better/higher storm water retention standard for all new development including residential, commercial, industrial, recreational, and agricultural in the City of Bonita Springs.

These standards will retain and manage more water on-site and provide for a gradual release in a natural hydroperiod; not a system of no discharge and then sudden high-volume discharge.

One model for these better storm water standards is the set 9of storm water resolutons estalished by the SWFRPC with reccomendations for locsal governemnts on how they can improve and retrofit their sotrmwater managment system standrads.

Atkins Engineering has provided in Appendix 1 for Potential Solution 8 input on the City's storm water regulatory standards for new development.

### *Potential Solution 9: Rebuild To Better Current Flood Elevation Standards*

- If an existing building in a floodplain is to be replaced or retro-fitted to more than 50% of its above foundation area then the building would have to meet the current flood elevation standards (no exemptions).
- Given the on-going rate of sea-level rise for the City of Bonita Springs an additional 3 feet over current elevations would be recommended for building expected to last for more than 100 years.

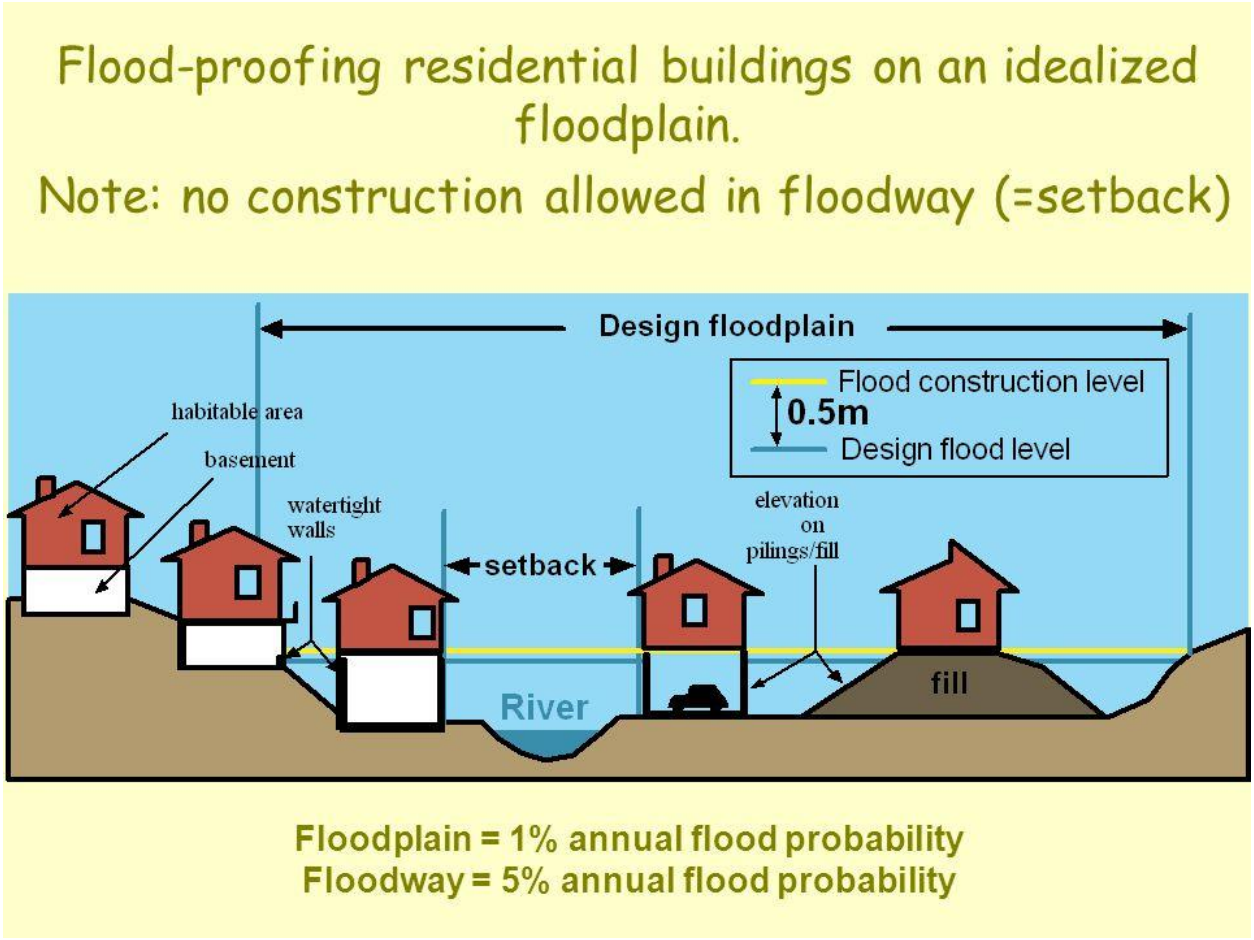




Figure 111: Flood-proofing residential buildings on an idealized floodplain
Source: FEMA

Louisiana's Jefferson Parish invested $2.4 million to elevate 23 homes after Hurricane Katrina – a significant, but worthwhile, investment. When Hurricane Isaac struck in 2012, none of these homes were flooded, avoiding some $2.2 million in losses. The upgrades to these homes nearly paid for themselves after a single storm event. With more storms in the offing, the return on investment will continue to grow.

Figure 112: Elevating a House Out of a Floodplain in Louisiana

Homeowner or non-resident property owners rebuilding after Hurricane Irma you may have to elevate buildings to meet community floodplain management regulations. Communities participating in the National Flood Insurance Program (NFIP) require all homes being substantially improved, or homes that have sustained substantial damage, to be built or elevated to or above the Base Flood Elevation (BFE). Substantial Improvement is a term used by NFIP and refers to the reconstruction or improvement of a structure that has been substantially damaged. Substantial damage is also a term used by NFIP.



Following floodplain ordinance requirements and getting the proper permits are required when rebuilding. This will not only makes the new home safer and will save money on their federal flood insurance premiums. Before rebuilding in a Special Flood Hazard Area (SFHA), it is necessary to check with local building officials. They are responsible for enforcing local elevation requirements, even in areas where the BFE has not been established. Rebuilding higher than the minimum requirement is always a wise decision and saves on flood insurance premiums.

There are programs available to assist with construction costs. If a person lives in an SFHA and is a homeowner with an NFIP policy whose home was substantially damaged they may be eligible for Increased Cost of Compliance (ICC) coverage of up to $30,000. This can pay all or part of the cost to elevate the home to the current effective BFE.

A building may be eligible for ICC coverage if the local floodplain building official determines either:

1. The structure is substantially damaged, meaning the cost to repair the flood damaged structure is 50 percent or more of its pre-disaster market value; or
2. The property sustained repetitive damage, meaning that flood damage has occurred twice in the past 10 years, and the cost of repairing the flood damage, on

average, equaled or exceeded 25 percent of the property market value at the time of each flood.

Those two flood damage events must have resulted in flood insurance claim payments, and the community's floodplain management ordinance must have a repetitive loss provision.

An in-depth FEMA booklet about the process of elevating your home is available online." FEMA's Homeowner's Guide to Retrofitting" provides further information about elevating the house.

FEMA's Hazard Mitigation Grant Program, Flood Mitigation Assistance Program and Pre-Disaster Mitigation Grant Program all include property elevations as an eligible project type. The local community, not individual survivors, must apply for mitigation grants. To qualify, they must meet all eligibility criteria and then apply through the local community, which applies to the State. The State subsequently submits applications to FEMA for review and approval. Project approval is necessary before construction can begin. Mitigation information from Florida's Division of Emergency Management is available online at: https://floridadisaster.org/Mitigation/index.htm.

The U.S. Small Business Administration (SBA) is the federal government's primary source of funding for the long-term rebuilding of disaster-damaged private property. SBA helps businesses of all sizes, private non-profit organizations, homeowners and renters fund repairs or rebuilding efforts with low-interest disaster loans. These loans cover losses not fully compensated by insurance or other sources and do not duplicate benefits of other agencies or organizations. Loans can be increased by up to 20 percent of the verified physical loss for mitigation measures (not to exceed $200,000) including: building elevation, retaining walls, seawalls, sump pumps; and relocating utilities.



For more information, applicants may contact SBA's Disaster Assistance Customer Service Center by calling 800-659-2955, emailing disastercustomerservice@sba.gov, or visiting SBA's website at•https://www.sba.gov/disaster-assistance/hurricane-irma. Deaf and hard-of-hearing individuals may call 800-877-8339

Atkins Engineering has provided in Appendix 1 for Potential Solution 9 planning level cost estimates for elevating existing residential structures to an elevation above the floodplain

## *Potential Solution 10: Educate the Public on What Existing SWM Systems and Standards Can Do and Do Not Do.*

- If an area has been intentionally designed in its Surface Water Management System, (SWMS) and permitted to use its roadways as flowways during temporary flow events this information must be legally disclosed to the community and all new buyers and/or renters.

- Such roads should be posted that they will function that way with appropriate signage as is done in the western United States.

## *Potential Solution 11: Emergency Sluice Gates for Some SWMS*

- Emergency Sluice Gates proved effective in communities like Pelican Landing
- Determine where existing modern SWMS do not have them but could be redesigned for their use
- Assist those communities in putting in Emergency Sluice Gates
- Work with the SFWMD to allow greater flexibility in operating existing and future emergency sluice gates in response to storms occurring in a changing climate

***Storm water Management Gate Operation Rules:***



1. All storm water gates are to be fitted with a lock and chain. All locks to be keyed alike. Only the District Manager and District Engineer shall maintain possession of a key.
2. All storm water gates to be inspected and maintained annually. The District Engineer shall maintain a written inspection log. Annual inspections shall be made on or about May 1st of each year.
3. The District Engineer shall maintain a full written log of all inspections and precautions (open storm water gates) in accordance with established storm water gate operation procedures.
4. The District engineer shall submit the written log of each Storm water gate opening event to the South Florida Water Manager District (SFWMD) within 30 days of the Storm water gate operation.
5. If the site is not subject to a tropical storm or hurricane watch, the gates may not be opened until SFWMD representatives provide written permission to the District.

***Storm water Gate Operation Procedures***

1. The District Engineer may open storm water gates as needed, downstream to upstream, in order to lower all lake elevations to their respective control elevation when the development is subject to a tropical storm or hurricane watch;

otherwise, written permission from SFWMD must be provided prior to storm water operation.

2. The District Engineer may, if deemed warranted by a tropical storm or hurricane watch, lower the water surface elevation 1’ below the control elevation of a basin if this basin is determined to have limited vertical storage available; otherwise, written permission from SFWMD must be provided prior to storm water gate operation.
3. The District Engineer shall maintain a written log of the beginning water surface elevation, times of storm water gate operation (open and closed) including information which documents the elevation at which each storm water gate was closed. The District Engineer shall record elevations at all staff gauges immediately following the forecasted event. Such information shall be included in the event log.
4. The District Engineer shall submit all written logs of each event in which a storm water gate was operated to the SFWMD within 30 days of the end of the event.
5. The District Engineer shall perform a post-event inspection of all structures and conveyances and document requirements for any maintenance work needed.



Figure 113: Emergency Sluice Gate at Pelican Landing

Atkins Engineering has provided in Appendix 1 for Potential Solution11 planning level cost estimates for retrofitting an existing storm water outfall structure with an operable sluice gate.

## *Potential Solution 12: Storm water/Flood Reduction Utility Fee*

- Establish a Storm water/Flood Reduction Utility Fee to assist in funding the necessary projects
- Fee would include a base city-wide assessment to cover City-Wide projects and activities and as needed an additional MSTU assessed for specific developments/neighborhoods when a retro-fit or project only affects it.

Funding sources for storm water projects traditionally come from general revenue funds. During the past few years the entire country has faced new economic hardships which have resulted in many programs being altered and in some cases eliminated. Local governments have experienced new pressures finding sources of funding for projects. Many agencies are finding new limitations that make the search for new funding sources a great deal more challenging.

Since 1984 the State of Florida has gone through several large scale changes of policy regarding storm water and pollution control. Most recently, in 2009, new regulations for monitoring Total Maximum Daily Loads (TMDL) in storm water have become policy.

Each new change in regulation adds complexities and costs to new storm water management projects. With oversight from both State and Federal agencies, local governments are held more accountable and are requiring that all projects be compliant with current policy and regulation.

With the increased focus at the State and Federal level, supplemental funding sources are being made available to local governments to share the costs of new projects. Customary funding sources such as property taxes (millage rates), one cent gas tax referendums, and bonding are now being supplemented with Federal grant program cost sharing (historically recognized as Joint Party Agreements-JPAs).



Since these programs are continuously changing, it is entirely possible that a single project may have more than one source as a funding option. All funding sources may not necessarily be suitable for specific projects. Careful evaluation by legal teams, agency staff, and public endorsement should be conducted before choosing a funding source.

Operating costs, direct capital costs, and cost benefits may be factors in choosing or declining funding options. Projects can also meet criteria for funding sources through demonstrations of secondary impacts. For example, if a project is addressing flooding concerns, the flooding could generate risk to water quality to adjacent lands or ecosystems making flooding projects eligible for water quality funding.

### 12.1.1 Local Funding Sources – City of Bonita Springs

#### 12.1.1.1 Ad Valorem

Funds are collected through Ad Valorem are taxes assessed on property ownership for all non-exempt real and personal property. The funds collected through Ad Valorem are the primary sources of revenue for the City. Revenues collected through property taxes are determined by a millage rate, and are collected from individual property owners. The millage rate is determined by a ratio calculated from comparing the total taxable property value with the deficit in the projected City budget.

For the fiscal year 2010/2011, the projected Ad Valorem revenue is expected to be $5,740,000. The revenue from this funding source represents 41% of the City's general fund revenue stream. The City of Bonita Springs Public Works forecasted budget for this timeframe is approximately $3,515,280, which includes the implementation of storm water CIP projects as recommended in the existing SMP and approved by the city council.

12.1.1.2 Municipal Services Benefit Taxing Unit (MSBU/MSTU)

Several of Lee County's storm water projects are paid for by "Taxing Authorities". For example a Municipal Services Taxing Unit (MSTU) or Municipal Services Benefit Unit (MSBU) is a Taxing Authority which has its own budget that is typically approved at a public hearing.

In the City of Bonita Springs there are specific geographic areas determined by ordinance that define specific areas of improvement. The benefits are structured to improve public infrastructure such as roads, sidewalks, drainage, and lighting. The revenue source collection method determines whether it is a MSBU and MSTU.

A MSBU is authorized by Florida Statutes as a special assessment district providing improvements and/or services to a specific geographic area. The MSBU is financed by an assessment specific to those properties receiving the benefit. The revenue funds services performed by the MSBU come from non-ad valorem assessments (not tied to property values).



A MSTU is authorized by the State constitution and Florida Statues as a taxing district. The MSTU performs as a legal financial mechanism for providing specific services based on geographic locations. The MSTU can impose ad valorem taxes to fund improvement projects.

Daryl Walk with the City of Bonita Springs was contacted to discuss the City's use of MSBU's or MSTU's. Mr. Walk confirmed that the City would consider the option of implementing MSBU/MSTU funding to assist CIP projects for those projects demonstrating benefit requirements. The benefit must be justified and documented before implementation for a specific region or project. Although this remains an option, the City does not pursue this funding frequently and other funding sources would likely be preferred.

12.1.1.3 Private Community Funding

Many local community and residential developments collect private funding through home owner association fees and/or CDD dues. Revenues collected from home owners through these sources can be allocated for flooding improvements within that community. The associations are independent from each other and will have varying quantities of available revenue for use within each community.

12.1.2 State Funding Sources

12.1.2.1 Clean Water Act Section 319 (h)

The Clean Water Act (CWA) was established in 1987 to address non-point source efforts. The CWA Section 319 is an opportunity for federal funding provided to the State and administered through the office of Florida Department of Environmental Protection (FDEP). Under this section, states, territories and tribes have funding options that are divided into components that include:

- Technical assistance
- Financial assistance
- Education
- Training
- Technology transfer
- Example projects
- Regulatory programs

Projects that are eligible for Section 319 funding must meet the criteria for mitigating nonpoint source pollution. Applications must be submitted to the Environmental Protection Agency for review and approval of funding.

The EPA was contacted and the discussion regarding this funding source was confirmed. It is an active program and used by many agencies at the District level to fund projects demonstrating need and benefit. The contact person for the Florida program is Dave Worley. Mr. Worley can assist with all questions, appropriate forms, and required documentation for eligibility of Clean Water Act 319 funding.

Website information: http://www.epa.gove/owow_keep/NPS/cwact.html



12.1.2.2 Community Budget Issue Request (CBIR)

The Florida legislature created the Surface Water Improvement and Management (SWIM) program to address non-point pollution sources. The program is intended to improve water quality, specifically under the provisions of the Florida Watershed Restoration Act of 1999. The Lower Charlotte Harbor is listed as a priority water management system by the SFWMD. The City of Bonita Springs is therefore in position to participate in Community Budget Issue Requests (CBIRs) for projects qualifying for restoration funding.

Although CBIRs specify water quality improvement parameters, flooding projects that adversely affect the water quality under the Florida Watershed Restoration Act could be eligible for funding. A water quality benefit must be demonstrated and the project should be “dirt ready”, meaning ready to go. Local participation is typically expected to be about 50% and completed permits are recommended.

The SFWMD convenes each August to prioritize each City and county’s project requests. The SFWMD continuously evaluates criteria in effort to achieve consistency of project requirements and selection processes. Projects with multiple component

benefits score the highest and get a higher priority. For example a project having a water quality benefit, a flood mitigation component, and recreational components may have an advantage over a single component water quality project.

SFWMD subdivides its jurisdiction into regions to manage CBIR funding and project eligibility. The City of Bonita Springs falls under the jurisdiction of the SFWMD Central District.

### 12.1.3 Federal Funding Sources

#### 12.1.3.1 Florida Forever Act

The Florida Forever Act was legislation passed in 1999 to provide funding for restoration projects. The projects are typically larger in size and dollar value and must meet criteria set forth by Florida Department of Environmental (FDEP) Office of Environmental Services Division of State Lands. Projects in pursuit of qualifying for this funding are projects that:

- Enhance the coordination and completion of land acquisition projects
- Protect bio-diversity at the species, natural community and landscape levels
- Protect, restore, and maintain the quality and functions of land, water, and wetland systems of the state
- Ensure sufficient quantities of water are available to meet current and future needs of natural systems
- Increase natural resource based public recreation or educational opportunities
- Preserve archaeological sites
- Increase the amount of forestland available for sustainable management of natural resources
- Increase the amount of open space available for urban areas



The Florida Forever Act is a funding source provided at the federal level through grants managed at the state level by the Florida Department of Environmental Protection in Tallahassee. The proctor for this program is Paula Allen. Ms. Allen was contacted with regards to this funding program and she was able to verify the procedures set forth at the state and federal levels. Ms. Allen discussed the key focus of the funding was to target restoration of Florida conservation areas. The projects are typically larger in nature in terms of acreage. The 2010 funding cycle had provisions for $15M in project funds, which is the smallest amount of annual funding available in recent years.

Website information: http://www.dep.state.fl.us/lands/links.htm

#### 12.1.3.2 Community Development Block Grant Program

The Community Development Block Grant Program is a federal program targeted to provide funding for community development, including housing projects. Congress created the program in 1974 by passing the Housing and Community Development Act, Title I. The program is federally funded and administered at the

state level through the Florida Department of Community Affairs (DCA). The objectives of the program at the national level are:

- Projects that provide benefit to low and moderate-income community areas
- Prevent and/or reduce slums or blighted areas
- Specifically target urgent community development needs

The program is an excellent opportunity for projects that are in smaller communities (population less than 200,000), in cities that cannot afford projects affecting housing or low income areas, or under the jurisdiction of local governments who do not have the staff to complete projects without assistance. Eligibility is classified into three categories:

1. Low-Moderate National Objective – where a minimum of 51% of the beneficiaries income is below 80% of the area's median income.
2. Slum-Blight National Objective – the area or community must meet the requirements set forth by local and state definitions as a slum or blighted area.
3. Urgent Needs National Objective – the project must mitigate existing conditions that pose a serious and immediate threat to local residents.

Candidates who receive grants are required to maintain records and documentation to fulfill eligibility requirements.

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Roger Doherty was contacted to discuss the Block Grant program. Mr. Doherty explained the program remains completely funded and all projects are considered. The goal of the program is to provide funding for projects that are found in geographic regions considered to be slums and/or blighted areas. Applications for projects located in these areas can be made through the Division of Housing, and must be accompanied by documentation showing that the project meets the requirements of this grant program.

Website information: http://www.dca.state.fl.us/fhcd/cdbg/index.cfm

12.1.3.3 Federal Emergency Management Agency (DHS/FEMA)

The Federal Emergency Management Agency has developed a Hazard Mitigation Grant Program (HMGP). The HMGP is set up to assist communities to fund projects that mitigate threats resulting from natural and man-made hazards. HMGP funds can be used for projects that will help reduce or eliminate the losses and threats associated with future disasters. Projects applications must clearly demonstrate a long-term solution to a potential threat, such as, the elevation of a building to reduce the risk of flood damages in lieu of buying sandbags and pumps to combat the flood. Also, a project's cost benefit must demonstrate that the potential savings due to project implementation are greater than the cost of implementing the project. Funds can be used for projects on either public or private property or to purchase property that in danger of continuous damage. The following list provides some examples of suitable projects:

- Acquiring property for sale resulting in the demolition or clearing of infrastructure, resulting in usable open space
- Retrofitting infrastructure to defend against flooding, wind, fire, or other hazards
- Elevating structures to reduce flood risks
- Vegetative management programs
- Flood projects that are not repetitive flood projects of other Federal agencies
- Local flood projects; i.e. construction of levees, floodwalls, or other storm water management infrastructure
- Post disaster activities to retrofit or reconstruct existing buildings

FEMA was contacted regarding this grant program to determine requirements, documentation, forms, and procedures. Miles Anderson oversees the FEMA program funding for the State of Florida. Mr. Anderson explained the program was funded in 2010 and will also be funding projects in 2011. Projects demonstrating eligibility for this grant money are automatically funded. The funding targets infrastructure upgrades that mitigate potential threats to public safety and both public and private property resulting from storms and natural disasters. Miles Anderson reviews application packages and can assist in answering questions regarding application procedures.

Website information: http://www.fema.gov/government/grant/hmgp



## *Potential Solution 13: Complete the Southern CREW Restoration Project*

**CREW (~24,972 acres) Lee and Collier Counties**

CREW is a regionally significant wetland system. It lies in a large topographic basin and serves as the headwaters to the Imperial River and to Picayune Strand. The Southern CREW critical project is intended to aid water storage, natural systems restoration and flood control. Staff recognizes the benefits that the property has contributed towards the District's core missions, as evident from the comments, and the value as a popular public use area. There are a few small parcels that lie outside the project boundary that do not support the project mission. SFWMD Staff recommends that the use and management of the property within the project boundaries continue as-is.

The further evaluation of those few small parcels lying outside the project boundary will consider the exchange or surplus of the District's fee interest in those sites.

The purpose of the Southern Corkscrew Regional Ecosystem Watershed Critical (CREW) Project, aka Southern CREW Project (Project), is to restore hydrology and ecology to an environmentally sensitive natural area encompassing 4,150 acres, located along Bonita Beach Road, just east of Bonita Springs (Figure 114).

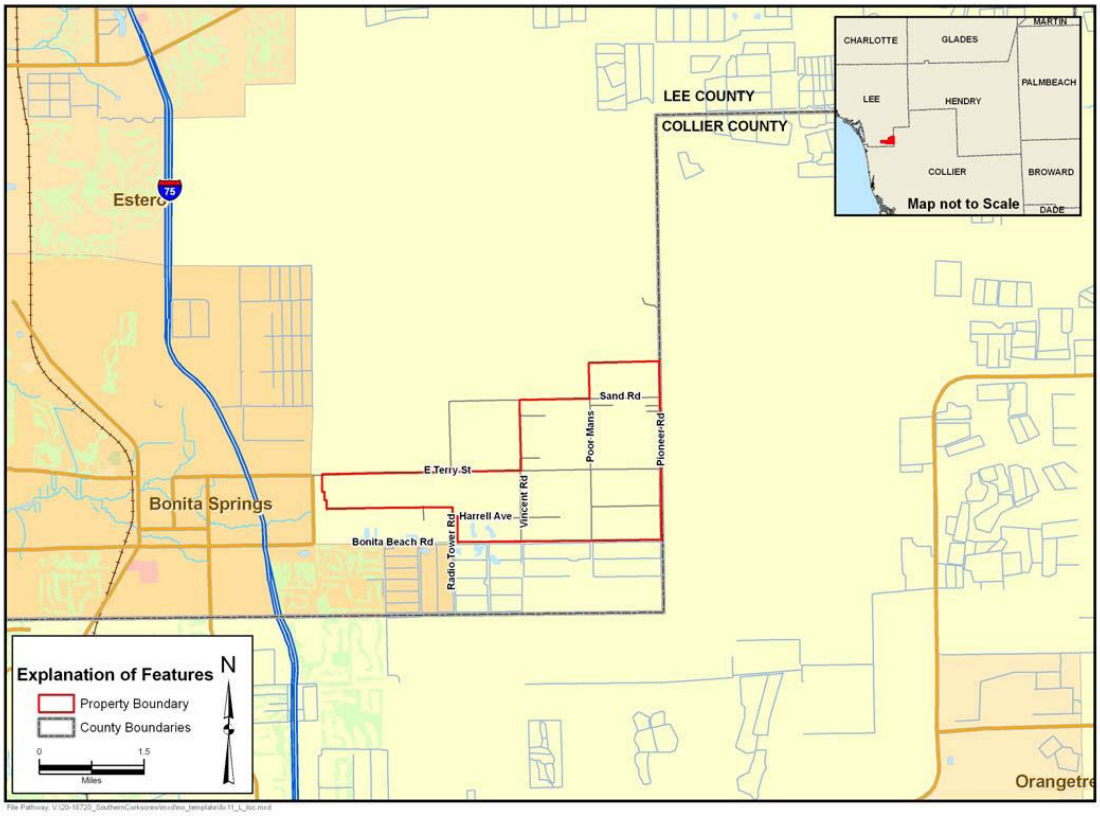


Figure 114 –Project Location Map

Forming a part of Lee County's Imperial River Watershed, the Project was initiated as a Critical Project in the Comprehensive Everglades Restoration Plan.

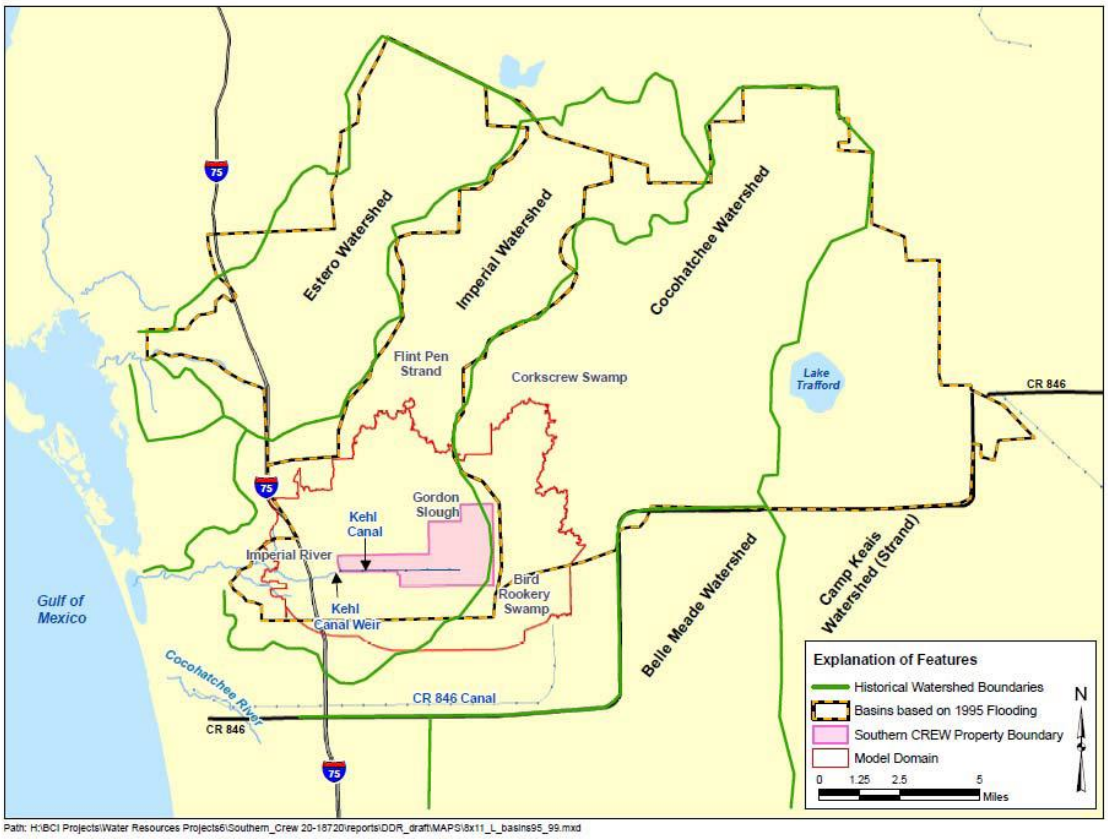




Figure 115 - South Lee County Conceptualized Watershed Boundaries
[Adapted from Johnson Engineering (1999)]

The area comprising the Project is a former residential development having numerous dirt roads, agricultural ditches, and canals that have over the years, altered the historical sheet flow patterns within the region. The Project's objective is to restore the hydrology and ecology of the area without significant adverse impacts to offsite properties. The U.S. Army Corps of Engineers prepared an Environmental Assessment (EA) in1999, stating this objective and several recommendations to achieve this objective. The Project has been designed to implement the following objectives: watershed restoration, reduction of nutrient and pollutant loads to the Imperial River, land acquisition, protection, and restoration of wetland habitat targeted for housing and commercial development, and protection of listed species and other fish and wildlife resources.

To accomplish the Project's objective, the South Florida Water Management District (District) selected TKW Consulting Engineers, Inc. (TKW), which includes TKW sub-consultant AMEC Environmental Infrastructure, Inc. (AMEC), to provide professional survey, design, and modeling services. Achieving the Project's objective is considered a critical need of the District's plan for regional prosperity and quality of life benefits in Lee County. The initial design phase of this Project entailed evaluating various restoration scenarios based on two model simulations that were developed by AMEC.

The first model was a short duration simulation (order of days to months) for analyzing large rainfall events and corresponding flooding, and the second model was a long-term simulation (~ years) to analyze hydro-ecological benefits that need to be implemented.

The Project area presently consists of dirt roadbeds, canals, ditches, embankments, and berm areas, which need to be graded, degraded, excavated, and/or filled in order to allow restoration of a more natural, northeast to southwest sheet flow and shallow groundwater flow pattern. Several different restoration improvement options were considered, individually as well as in conjunction with one another. These options included constructing ditch blocks to impede flow, making road cuts and adding conveyances to redirect the flow, constructing weirs with fixed elevation and time-varying-crest to control water-levels, and also constructing or removing berms as a way to control the flow of water. The initial study phase concluded with the preferred restoration improvement option being the East and West Restoration Scenario (EWRS), which recommended the following:

- Remove all or portions of the berm around the Grant Parcel (west of Poor Man's Pass);
- Remove all or portions of the berm around Lee County's Tomato Farm (north of Sand
- Road);
- Fill ditches and cut roads on the east side of the property north of the Kehl Canal in Sections 24, 25, 26, 35, and 36;



- Degrade approximately 4,200 feet of Pioneer Road from the northern project boundary (Tomato property), south to approximately 500 feet north of the Kehl Canal; the intent is to use the degraded material to fill ditches along both sides of Pioneer Road;
- Provide new culvert under East Terry Street; and
- Provide a ditch plug in the ditch located approximately ½-mile west of Vincent Road, just north of the Kehl Canal.
- Fill approximately one mile of the Kehl Canal.

To address the recommended EWRS improvement option, TKW created 26 project alignments beginning with Alignment A to the north, also known as Sand Road, and ending with Alignment Z to the west, which is a new culvert installation. Of the 26 alignments, 25 involve earthwork degrading operations; Alignment Z is the only alignment that does not require earthwork degrading operations. The project also includes constructing a 300' x 300' Construction Staging Area near the Vincent Road/Bonita Beach Road entrance. The District will ultimately convert this staging area to a parking area for recreational purposes at the completion of the project. Drawing No. G105 (Sheet 5), Master Site Plan, depicts the 26 project alignments and the Construction Staging area site. Drawing No. G105 is included in this report as Figure 116.

TKW's design approach considered evaluating each of the project alignments with the goal of developing cost-effective earthwork improvements with respect to the following earthwork operation options:

• Cutting/degrading berms;
• Constructing 12-foot minimum wide roadbeds along alignments A and Q where existing roadbeds are located within a cut section (degrade berm section) and the roadbed section is less than 12 feet wide; and
• Filling ditches/canals composed of native Unclassified Fill material to create the following features:
  - New Canal Plugs;
  - New Ditch Plugs;
  - New Lengthened Canal Plugs;
  - New Low-Water Crossings along ditch alignments A and Q; and
• New Wood Stork Foraging Areas at canal plugs along alignments C, E, and G.
• Constructing a temporary Construction Staging Area to be converted to a permanent District parking area by the District after completion of the Project; and
• Installing New 18-inch RCP at alignments Z and R, and New 24-inch RCP at the Construction Staging Area site.

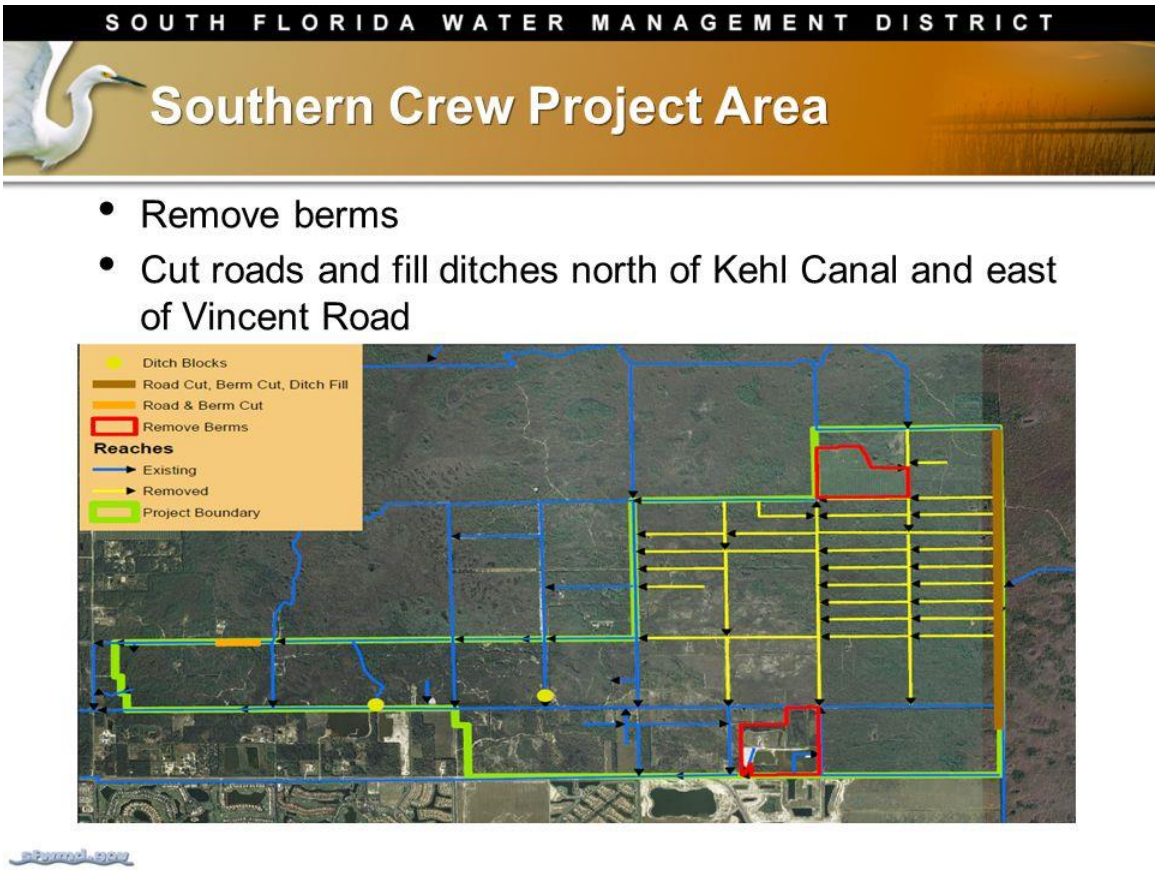




Figure 116: Southern CREW Project Area restoration plans.

Selection of the optimal earthwork design improvement for each of the alignments required investigating existing terrain conditions and evaluating the various earthwork operations involved with respect to constructability, effectiveness, transporting logistics, and cost. It is noted that earthwork operations must only employ backfilling ditches and

canals using “native "excavated material from local cutting, degrading, and excavation operations; no off-site fill or borrow excavation is permitted on this project, except where Select Fill may be required to fill roadbed areas to accommodate pipe cover requirements. The term “local” refers to available Unclassified Fill earthwork materials generated within the immediate vicinity of the earthwork operations. However, there will likely be Surplus Fill material generated from alignments R, U, and V, which will require transporting the Unclassified Fill or Random Fill materials to several alignment locations where adequate local earthwork material may not be available.

Ultimately, upon completion, this Project will reflect an overall improvement that restores site conditions, to the degree possible, back to predevelopment conditions, while improving ecological hydrology through new water conveyance crossings. The Project achieves its objective of restoring the hydrology and ecology of the region without significant adverse impacts to offsite properties.

It is estimated that construction costs associated with implementing these recommended improvements will be approximately $4.3 million. The estimated construction time is anticipated to be between 18 months and 2 years.

**CREW Background**

Water once flowed freely across the natural landscape of what is now Bonita Springs in Lee County. Historic water sheetflow in the Corkscrew Regional Ecosystem Watershed was later blocked by dirt roads, agricultural ditches and several home sites. This altered the ecosystem and has contributed to flooding in residential and other areas. Floods in 1995 led the SFWMD to develop the Southern CREW Restoration Project to restore the ecosystem while protecting area residents and properties. With work spanning more than a decade, the SFWMD acquired approximately 4,000 acres for this project, cleared exotic vegetation from more than 2,500 acres, removed roads and plugged agricultural ditches on more than 600 acres. To date, the SFWMD and State have invested more than $32 million to conserve the lands, with the U.S. Department of the Interior contributing another $7 million to the restoration effort.



When completed, the restoration project will provide significant benefits to the Southwest Florida ecosystem, including:

• Restoring wetlands and the historic sheetflow of water

• Improving regional flood protection and drainage

• Increasing water storage and aquifer recharge capability

The South Florida Water Management District (SFWMD) awarded a $2.9 million construction contract for work that will restore the hydrology and ecology on more than 1,000 acres within the Southern Corkscrew Regional Ecosystem Watershed (CREW) Project. The SFWMD and its partners — representing businesses, environmental groups,

landowners and governmental agencies — manage the watershed for its numerous benefits to water storage and wildlife preservation. The 60,000-acre watershed spanning Lee and Collier counties includes a 5,000-acre marsh at its headwaters and the famous Audubon Corkscrew Swamp Sanctuary.

This project is the essence of restoration taking out roads and plugging ditches will continue a transformation back to a more natural environment while also maintaining flood control by providing water storage for nearby residents.

The contract covers a variety of restoration work, including:

• Degrading approximately 10 miles of dirt roads
• Removing spoil piles
• Plugging or filling ditches and canal drainage systems no longer needed
• Degrading existing berms within the project area

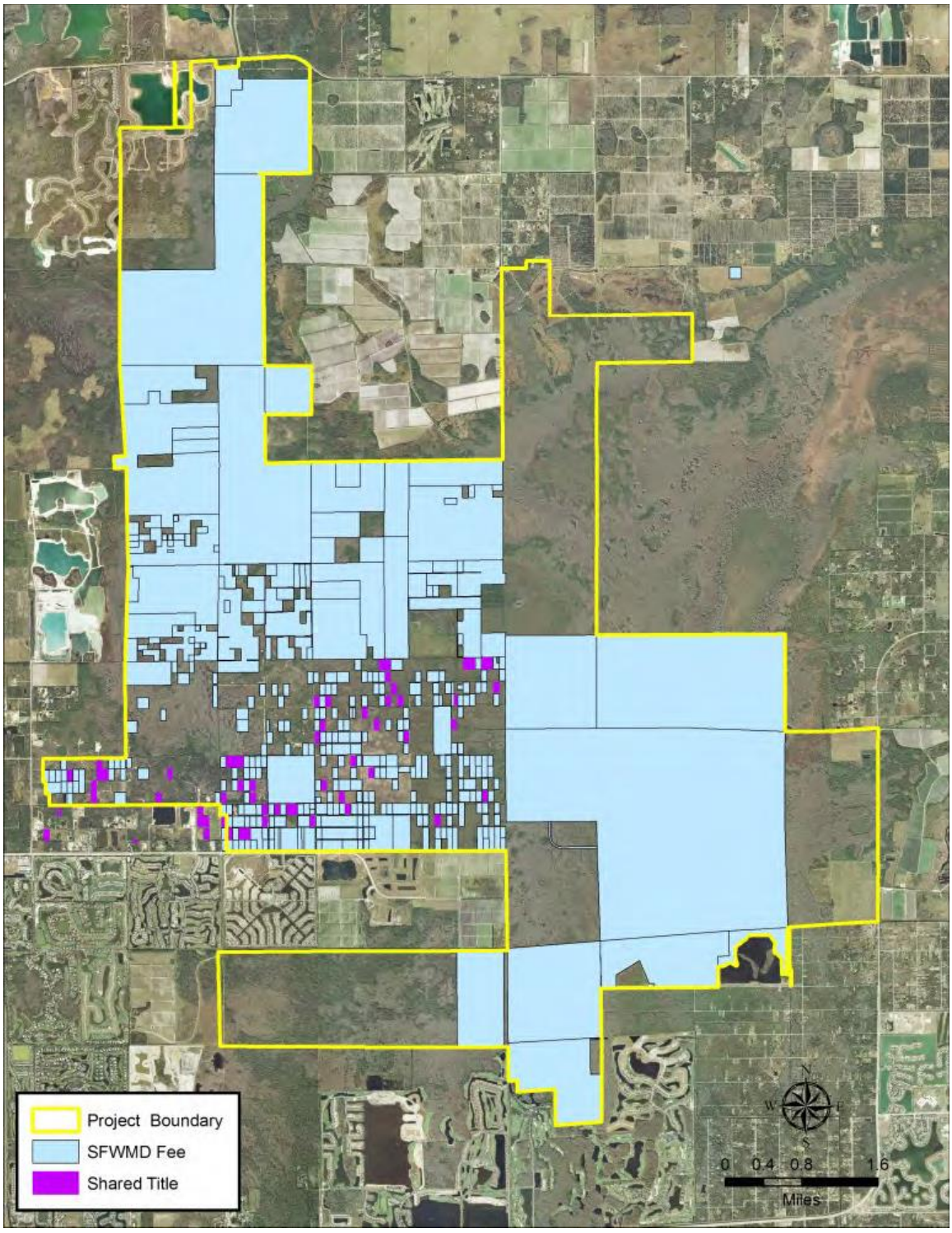


Figure 117: Existing CREW lands.
Source SFWMD 2017

## *Potential Solution 14: Voluntary Seller Floodplain Restoration*

In the course of field review and discussions with citizens of Bonita Springs the concept of a willing seller program to restore the floodplain areas with some of the largest amount of flooding was proposed. Some property owners who have experienced flooding in multiple flooding events on a repetitive basis over the years have indicated an interest in selling their property to the public sector to become part of the river floodplain unimpaired by structures.

The interest has been on the Imperial River in areas east of Interstate 75 above and below the Kehl Canal weir; real estate offerings flanking Imperial Parkway and areas north and south of the river between Imperial Parkway and Interstate 75.

The concept would be to establish a mechanism for willing sellers to approach city staff with an offering of sale. The individual property could then be evaluated for its floodplain position, cost/benefit in flood reduction, and other real estate issues. The city could then determine which properties it would want to buy or option.

Atkins Engineering has provided in Appendix 1 for Potential Solution 14 planning level cost estimates and guidance for voluntarily buying out structures and property in repetitive flooding areas.



## *Potential Solution 15: Prepare for the Effects of Climate Change on Flooding From Changes in Precipitation Rates, Storm Surge Events, and Sea Level Rise*

Southwest Florida, including the City of Bonita Springs, 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.

Craig Fugate the former director of the Federal Emergency Management Agency and the Florida Division of Emergency Management said changes in the earth's climate may not be increasing the number of storms, but their features are getting more intense. Fugate said that Floridians must brace for storms that will be stronger, have longer periods at top speeds and bring more rain than in the past because of the changing climate. Fugate, who addressed reporters during a conference call hosted by the National Hurricane Survival Initiative about a new website and year-round awareness campaign titled "Get Ready, Florida!," said people are expecting a level of forecasting that "isn't there yet." Instead, people should continue to anticipate some uncertainty in forecasting, he said.

Erik Salna, associate director and meteorologist at Florida International University's hurricane research center, said "more and more" research supports that climate change is causing increasingly intense hurricane rainfall. "It is a situation, moving forward for Florida, we being the hurricane capital of the country, not only storms that could come each and every year, but more storms and more damaging storms," Salna said.



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

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.

# SUMMARY OF FLOOD REDUCTION AND WATERSHED RESTORATION RECOMMENDATIONS

Potential solutions to provide flood reduction were then developed to address city-wide and specific area flooding reduction. A total of 15 potential solutions are provided.

1: Removing impediments to flows within the existing system. This includes debris, sediments, and trash that has accumulated or that is storm related. Evaluate existing constrictions in flow in the system including lack of drainage features; small culverts; culverts with inverts set too high; causeways constructed across floodplains; unpermitted intrusions into the floodplains; and locations where variances allowed intrusions into the floodplains.

2: Replace substandard culverts and bridges with new structures of increased size, correct inverts, and a design the plans for future sea level rise and increased future storm surge. Where possible and feasible replace multiple culverts with an open span of box culverts or a bridge. Improves flows and may enhance recreational navigability. Repair damaged, degraded and vandalized permitted dikes and berms



3: Retrofit older communities which lack any true surface water management system to have a basic system of swales with collection in storm water retention systems with a point or points of positive discharge to a larger receiving flowway These systems need not be restricted to a single named neighborhood but may best be constructed in several adjacent neighborhoods that all feed a regional storm water collection and treatment system.

4: Collect flows in the watersheds east of I-75 into a very large Regional Storm water Management System (RSMS) with associated filter marsh water quality treatment located in the eastern area of the Bonita Springs DRGR on mine lands and agricultural lands. This will serve neighborhood flows east of I-75 and collect flows from the north into a new flowway connection across native lands for discharge to correct watershed destination (Spring Creek, Imperial River, and Cocohatchee River).

5: Change the design of the Kehl Canal to retain and treat more water rather than quickly discharge it to the Imperial River proper. Add adjacent water storage features to collect flows from the Kehl Canal that incorporate filter marshes (examples: Ten-Mile Canal filter marsh; North Colonial Waterway; Freedom Park filter marsh). Install a series of step up weirs to hold additional water within with increasing control elevations from west to east (this will aid storage and provide improved groundwater levels during dry season in the DRGR).

6: Reconnect and/or improve the connection of the upper watersheds of Half-Way Creek, Spring Creek, and the Cocohatchee River to carry their original natural flows and not unnaturally contribute excess flows to the Imperial River. The Bloomberg Grant application is for the beginning of this planning effort. The reconnection design will be designed to restore the natural hydroperiod and capacity of Half-Way Creek, Spring Creek, and the Cocohatchee River and not exceed their carrying capacity. Imperial River flooding will not be reduced by transferring flooding to another watershed (as has been done by other to the Imperial River.

7: Where available obtain unoccupied lands including native lands, exotic infested lands, mine lands, agricultural lands, rural lands, and otherwise vacant lands that are in existing floodplains or immediately adjacent to existing floodplains. This includes SFWMD "Surplus Lands" currently available in the DRGR. Request that the SFWMD not auction these lands but transfer them to the City of Bonita Springs for water management projects or sell them at simple cost to the City.

8: Establish a better/higher storm water retention standard for all new development including residential, commercial, industrial, recreational, and agricultural in the City of Bonita Springs. These standards will retain and manage more water on-site and provide for a gradual release in a natural hydroperiod; not a system of no discharge and then sudden high volume discharge. Amount for the City will be dependent on the administrative process to implement and then legal costs to defend the higher standard

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9: If an existing building in a floodplain is to be replaced or retro-fitted to more than 50% of its above foundation area then the building would have to meet the current flood elevation standards (no exemptions). Given the on-going rate of sea-level rise for the City of Bonita Springs an additional 3 feet over current elevations would be recommended for building expected to last for more than 100 years. Amount will depend upon the number of buildings that will need to be elevated.

10: If an area has been intentionally designed in its Surface Water Management System, (SWMS) and permitted to use its roadways as flowways during temporary flow events this information must be legally disclosed to the community and all new buyers and/or renters. Such roads should be posted that they will function that way with appropriate signage as is done in the western United States.

11: Emergency Sluice Gates proved effective in communities like Pelican Landing. Determine where existing modern SWMS do not have them but could be redesigned for their use. Assist those communities in putting in Emergency Sluice Gates. Work with the SFWMD to allow greater flexibility in operating existing and future emergency sluice gates in response to storms occurring in a changing climate

12: Establish a Storm water/Flood Reduction Utility Fee to assist in funding the necessary projects Fee would include a base city-wide assessment to cover city-wide projects and activities and as needed an additional MSTU assessed for specific developments/neighborhoods when a retro-fit or project only affects them.

13: Complete the Southern CREW Restoration Project. The purpose of the Southern Corkscrew Regional Ecosystem Watershed Critical (CREW) Project, aka Southern CREW Project (Project), is to restore hydrology and ecology to an environmentally sensitive natural area encompassing 4,150 acres, located along Bonita Beach Road, just east of Bonita Springs . It is estimated that construction costs associated with implementing the recommended improvements will be approximately $4.3 million.

14: Some property owners who have experienced flooding in multiple flooding events on a repetitive basis over the years have indicated an interest in selling their property to the public sector to become part of the river floodplain unimpaired by structures.

15: Prepare for the effects of climate change on flooding from changes in precipitation rates, storm surge events, and sea level rise

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# Appendix II: Cross-reference of areas and potential solutions

| | | | | Potential Solution | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | Name Identifier | Water body | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| A | Divot Drive/ Ankeny | Spring Creek | X | X | | | | X | X | X | X | | | X | | X | X |
| B | Citrus Park | Flint Pen Strand | X | | X | x | | X | X | X | X | X | X | X | | X | X |
| C | Paradise Lane/ Shangri-La | Spring Creek | X | X | | | | X | X | X | X | | | X | | X | X |
| D | Sunshine/ North Pine Avenue | Rosemary Canal | X | X | | | | X | | X | X | | | X | | X | X |
| E | Riverside/ Terry Street | Rosemary Canal | X | X | | | | X | | X | X | | | X | | X | X |
| F | Spanish Gardens | Leitner Creek | X | X | | | | X | | X | X | | | X | | X | X |
| G | Morton Groves | Flint Pen Strand | X | | X | x | | X | X | X | X | X | X | X | X | X | X |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | Flamingo to Harbor | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| I | Old 41 to Richview | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| J | Wilson Street | Imperial River | X | X | | | X | X | X | X | X | | X | X | X | X |
| K | Preservation and Tortoise | Imperial River | X | X | | | X | X | X | X | X | | X | X | X | X |
| L | Imperial Bonita Estates | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| M | Pinecrest Area | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| N | San Souci Rue de Paix/ Kent | North Imperial | X | X | | x | | X | X | X | X | | X | | X | X |
| O | Johnson to Gasparilla | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| P | Mouth of Oak Creek | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| Q | Tangelo/ Matheson | Imperial River | X | X | | | X | X | X | X | X | | X | X | X | X |
| R | Imperial Parkway to Matheson | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| S | Dean Street Area East | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| T | Oakland Drive/ Quinn Street | Imperial River | X | X | X | | X | X | X | X | X | | X | X | X | X |
| U | Kent Road/ Jefferson | North Imperial | X | X | | | X | X | X | X | X | | X | X | X | X |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| v | Hunters Ridge | Imperial River | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| x | Worthington | Imperial River | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| y | Palmira | Imperial River | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| z | Village Walk | Imperial River | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |

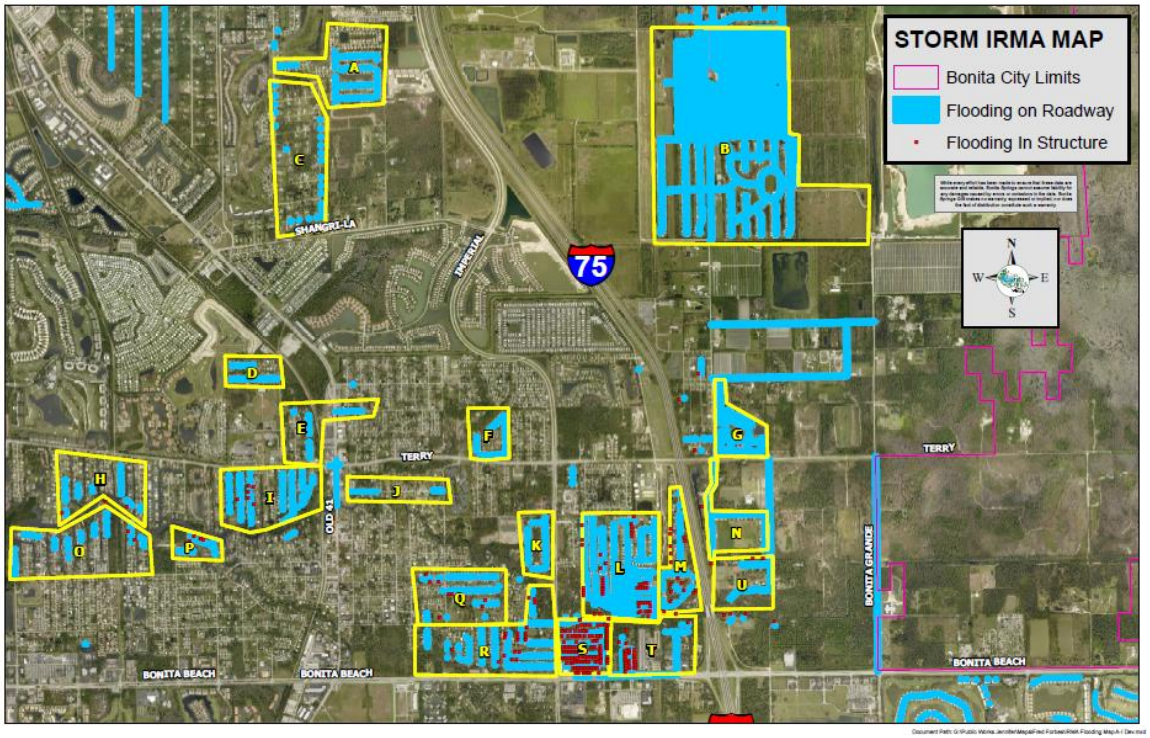


Figure 118: Flooded Area A-U City of Bonita Springs

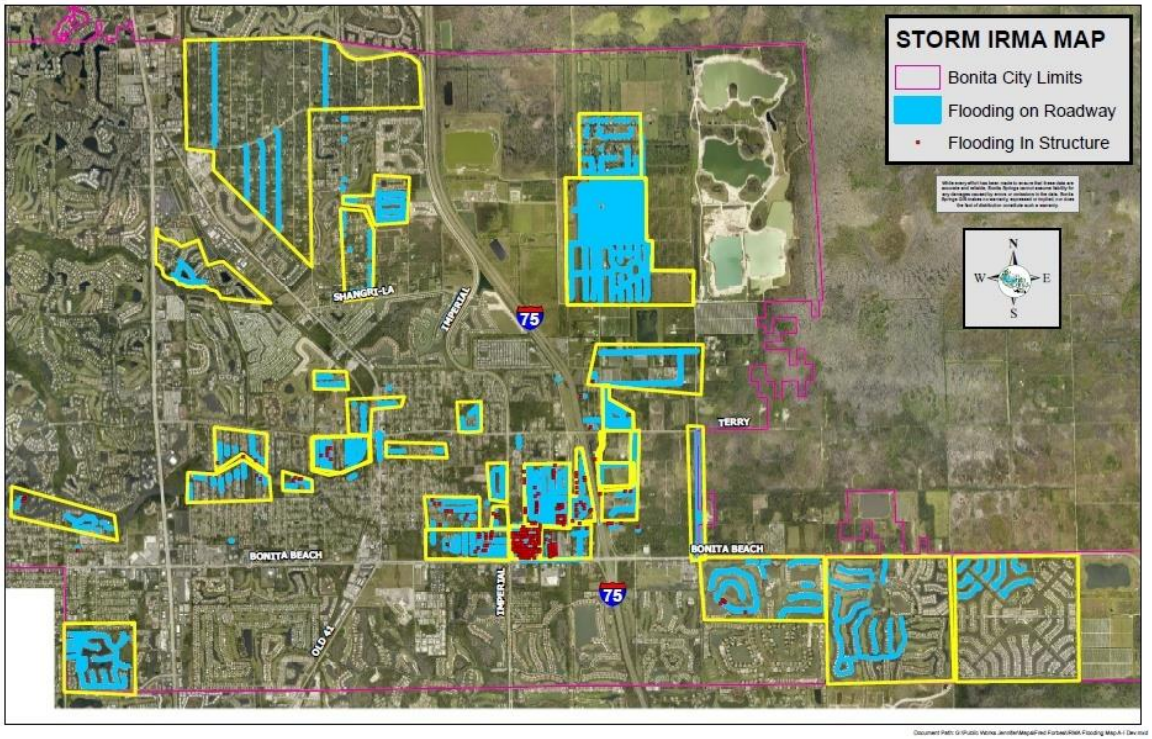


Figure 119: Additional Flooded Area including V-Z, City of Bonita Springs

# Appendix III: Definitions

**CFS**

(acronym) Cubic Feet per Second, a measure of flow

**CMS**

(acronym) Cubic Meters per Second, a measure of flow

**Evaporation**

**(**noun*)* the process of turning from liquid into vapor.

**Evapotranspirated**

(noun)
the process of transferring moisture from the earth to the atmosphereby evaporatio n of water and transpiration from plants.

**Hydric**

(adjective) (of an environment or habitat) containing plenty of moisture; very wet.



**Hydroperiod**

(noun) the seasonal pattern of water levels.

**Purported**

(verb) appear or claim to be or do something, especially falsely; profess.

**Riverine**

(adjective technical; literary) relating to or situated on a river or riverbank; riparian. "a riverine forest"

**Ruderal Lands**

(adjective; botany*);* lands with plants growing on waste ground or among refuse.

**Transpiration**

(noun; botany) the passage of water through a plant from the roots through the vascular system to the atmosphere.