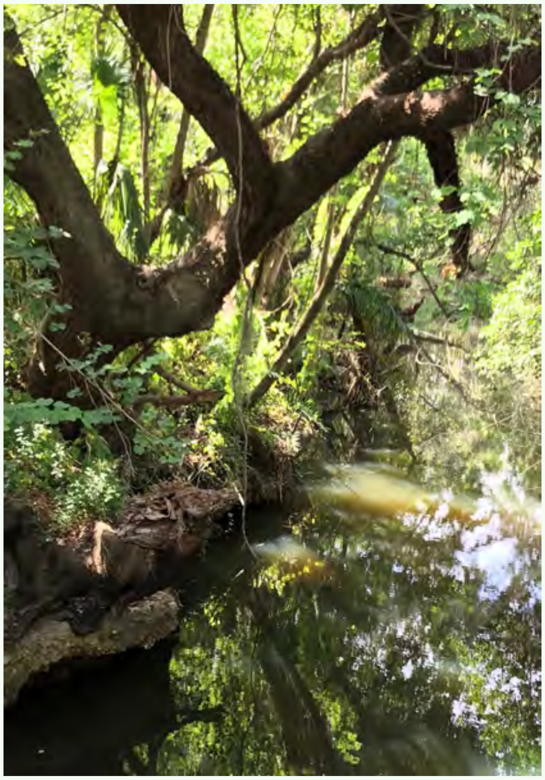
ATTACHMENT 2

the Village of ESTERO

Village of Estero Stormwater Master Plan

October, 2018



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Stormwater Master Plan

October, 2018

Volume 1

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Table of Contents

VOLUME 1

TABLE of FIGURES

LIST of TABLES

LIST of MAPS (11x17)

VOLUME 2

APPENDIX B

Executive Summary

Executive Summary

This Stormwater Master Plan provides the details of the current regional hydrology affecting the Village and the current conditions of stormwater/surface water networks within the Village. The important benefit of this Master Plan is the development of an updated regional-scale model and detailed local-scale model. Both models can be utilized to evaluate the impacts of infrastructure projects or development projects on the existing stormwater system. Additional goals of the Stormwater Master Plan project are as follows:

- Provide a framework for evaluating Stormwater improvement projects and new developments;
- Identify drainage issues;
- Identify flood mitigation projects;
- Identify locations where additional water level/flow monitoring stations should be installed; and
- Develop regulatory standards and guidelines.

The initial task of the project included an evaluation of the existing data available for the stormwater facilities within the Village of Estero, verifying the data and obtaining new/updated data. The collected data provides an accurate record of the physical properties and conditions of the system and a record of more recent surface water levels and flows within the system. The data collected included the following:

- Inventory of all structures (culverts, bridges, pipes) located within the main conveyances;
- Flow and Stage Data from USGS Gages, The Brooks system gages and other surface water observation stations within the study area;
- Surveyed cross-section data;
- Soil Data;
- Current Land Use/Land Cover Data;
- 2007 LiDAR (Topographic) Data;
- Existing vegetation and site conditions; and
- High-water Mark Surveys and Documentation for the August/September 2017 Rainfall Events.

The data is a vital component of the project and provides a basis of established existing conditions to properly create and calibrate the master surface water management model. As previously mentioned, the latest regional study that includes the Estero River and Halfway Creek watersheds is the 2008 Update to the South Lee County Watershed Master Plan. The 2008 Update study reviewed the findings of the original 1999 South Lee County Watershed Master Plan and provided additional recommendations to address concerns with surface water flow and flooding within the study area. Numerous recommendations were provided from the 2008 Update and a portion have been implemented since the completion of the study.

There are four (4) distinct sub-watershed areas located within the Village of Estero jurisdiction. The watersheds within the Village are predominantly natural stream conveyances. The two (2) major natural conveyances within The Village are the Estero River and Halfway Creek. The Estero River is divided into two (2) branches at the location of Bamboo Island just west of the Villages at Country Creek development, the North Branch and South Branch. Each of these creek conveyances travel through the Village, meandering through residential and commercial developments, community parks, conservation areas, etc. and into the main branch of the Estero River. Halfway Creek is also a tributary to the Estero River Main Branch, connecting to the River at approximately 2.5 miles from Estero Bay.

From a regional perspective, the overall Estero River watershed covers approximately 39,163 acres. The watershed includes quarries, Florida Gulf Coast University, Gulf Coast Town Center, Miromar Outlet Mall, and numerous residential communities. The Estero River North Branch sub-watershed begins at State Road 82 and extends southwest towards I-75 and then westward until it reaches the junction with the Estero River (Main Branch). The Estero River South Branch sub-watershed (South Branch) extends east of I-75 along the Corkscrew Road corridor, south of the Stoneybrook development and west to the junction point with the North Branch sub-watershed. The Halfway Creek main stream originates in a broad marsh system located east of I-75. The watershed boundary for Halfway Creek extends to the southern boundary of The Brooks, runs west of US-41, extends north at El Dorado Acres and continues north containing portions of West Bay Club and Pelican Sound before reaching the limits of the Estero River Main Branch watershed. The eastern southern boundary of the Estero River watershed is adjacent to the Imperial River watershed. Based on conditions east of I-75 and south of Corkscrew Road, there are no known barriers or structures to separate the flow. Surface water can interact between the Estero River/Halfway Creek and Imperial River watersheds.

Once the data collection was completed, the project focused on preparing updates to the Regional-Scale model that was developed for the 2008 South Lee County Watershed Master Plan Update (SLCWM). The purpose of the modeling assessment was to evaluate the regional hydrology and provide the conditions that will be used in the detailed local-scale modeling assessment. The regional model used the integrated surface and ground water model MIKE SHE/MIKE 11. The updates to the Regional-Scale model included recently acquired data sources, recalibration of the model to known hydrologic data, and development of boundary conditions for the Village ICPR model based on the updated SLCWM. The model contains over 400 square miles and includes the drainage basins of the Estero River, Halfway Creek, Spring Creek, and the Imperial River.

Outlined below is the purpose and main goals of the Regional-Scale model.

The Regional-Scale model:

- Provides boundary conditions from the regional model calibrated to over 200 calibration stations for the local-scale modeling effort;
- Provides base information for the development of a local-scale ICPR model to be utilized as an appropriate tool for evaluating development proposals located west of I-75;
- Utilized recent information from two large rainfall events in 2017, including Hurricane Irma, to support the calibration effort;
- Was used to identify areas with regional drainage problems; and
- Can be used to evaluate proposed improvement projects and impact of drainage changes on wet season water levels near the area of the proposed improvements.

west of Interstate I-75.

The main goals of the Local-Scale model include the following:

- Assess the existing conditions of the stormwater facilities;
- Identify stormwater deficiencies;
- Provide a framework for evaluating projects and new developments; and

The Local-Scale model was created using Interconnected Channel and Pond Routing (version 4.03.02), known as ICPR4. ICPR is a widely used and accepted modeling platform throughout Florida for hydrologic and hydraulic analyses. The ICPR4 platform is also integrated with GIS (Graphical Information System) data so that the model is properly geo-referenced and can be easily updated with new data as it becomes available. The Local-Scale model includes the contributing watersheds for all four (4) main waterways: Estero River Main Branch, Estero River North Branch, Estero River South Branch and Halfway Creek. The Local-Scale model also includes secondary conveyances, other critical major conveyances, discharge control structures from permitted developments, overland flow from uncontrolled parcels and major network components such as culverts, bridges, and weirs. The secondary conveyances include critical roadways or ditch systems with known drainage issues, such as: Three Oaks Parkway, River Ranch Road, Estero Parkway, Corkscrew Road, Broadway Avenue, and the Seminole Gulf Railroad ditch system. The Local-Scale model is an accurate representation of the stormwater network located within the Village and the contributing watershed areas adjacent to the Village.

The Local-Scale model of the study area considers the data collected from available plans, permits, record information, ground surveys, and field reconnaissance. The hydrologic and hydraulic parameters used to develop the Local-Scale ICPR model included the following:

- Assess the existing conditions of the stormwater facilities;
- Identify stormwater deficiencies;
- Provide a framework for evaluating projects and new developments; and

The Local-Scale model was created using Interconnected Channel and Pond Routing (version 4.03.02), known as ICPR4. ICPR is a widely used and accepted modeling platform throughout Florida for hydrologic and hydraulic analyses. The ICPR4 platform is also integrated with GIS (Graphical Information System) data so that the model is properly geo-referenced and can be easily updated with new data as it becomes available. The Local-Scale model includes the contributing watersheds for all four (4) main waterways: Estero River Main Branch, Estero River North Branch, Estero River South Branch and Halfway Creek. The Local-Scale model also includes secondary conveyances, other critical major conveyances, discharge control structures from permitted developments, overland flow from uncontrolled parcels and major network components such as culverts, bridges, and weirs. The secondary conveyances include critical roadways or ditch systems with known drainage issues, such as: Three Oaks Parkway, River Ranch Road, Estero Parkway, Corkscrew Road, Broadway Avenue, and the Seminole Gulf Railroad ditch system. The Local-Scale model is an accurate representation of the stormwater network located within the Village and the contributing watershed areas adjacent to the Village.

The Local-Scale model of the study area considers the data collected from available plans, permits, record information, ground surveys, and field reconnaissance. The hydrologic and hydraulic parameters used to develop the Local-Scale ICPR model included the following:

- Topographic Data/Terrain Data: 2007 LiDAR data with a 0.5 ft contour resolution;
- Land Use/Land Cover: Updated to reflect current conditions;
- Soil Data;
- Runoff Curve Numbers: Categorized per Land Use and Soil Combination;
- Time of Concentration (Tc): Applied for each sub-basin;
- Rainfall Data and Design Storms: Obtained for the 5-year, 1-day; 10-year, 1-day; 25-year, 3-day; and 100-year, 3-day events;
- Upstream Boundary Conditions (Flow and Stage) from Regional-Scale Model;
- Downstream Boundary Condition (Stage) from Regional-Scale Model; and
- Structure Inventory.

Utilizing the collected data, including permit records, as-built plans, and field visits, a delineation of the overall contributing areas to each main stream was prepared. Within each of the four (4) watersheds, sub-basins were defined, and the network of the stormwater infrastructure was detailed. For the hydraulic network, model links were used to connect the sub-basin nodes and nodes along the conveyances. The links were in the form of pipes, weirs, control structures, etc. based upon the structure inventory and record information.

At the completion of the Local-Scale ICPR4 model development, the calibration process was conducted. The calibration process consisted of making slight changes to model inputs, iteratively, until the simulated peak stages of the 25-year, 3-day and 100-year, 3-day design storms were reasonably close to the observed peak stages during the late August 2017 and early September 2017 rainfall events. The amount of rainfall during these significant events varied across the Lee County area. Within the Estero River watershed, the August 2017 storm event resulted in an estimated total of 11.4 inches of rainfall over a 5-day period, which is similar to the 11.2 inches of rainfall used in the 25-year, 3-day design storm.

For the Local-Scale ICPR4 model calibration effort, a comparison was made between the simulation results of the 25-year, 3-day and 100-year, 3-day events to the recorded values at key locations. The goal of the calibration effort was to achieve peak stages that were reasonably close, within 1 foot, of the observed/recorded values.

The observed/recorded data include the following sources of data:

- USGS Gage Stations - North Branch and South Branch;
- USGS Gage Stations - North Branch and South Branch;
- The Brooks Gage Stations - North and South Outfall Weirs;
- South Florida Water Management (SFWMD) High Water Mark Report, Post Irma (12/8/17);
- Lee County Post-Irma Assessment Report (02/28/18); and
- Field Observations and Data Collection by J. R. Evans Engineering (8/29/17 and 09/18/17)

Model inputs that were considered for adjustment in the calibration process to achieve results consistent with the observed late August 2017 and early September 2017 observed data were the following:

- Upstream and downstream boundary conditions, both stage and flow;
- Roughness coefficients (Manning's n) for the conveyance links;
- Runoff curve numbers per drainage basin;
- Time of concentration per drainage basin; and
- Initial conditions within the main conveyance channels, both stage and flow.

To aid in the calibration process, the model simulations were setup so that the initial stages within the main conveyances during the model simulations were approximately equal to the typically observed wet season stages. Data from the Estero River North Branch USGS gage and the Estero River South Branch USGS gage were used for calibrating the initial stage parameters. The calibration effort also included adjusting the roughness coefficients, Manning's "n" values, within the main conveyance routes. Particularly, the Manning's "n" values for the channel and overbank areas of the Estero River Main Branch, North Branch and South Branch were adjusted to reflect conditions favorable to achieve peak water surface stages closer to the observed/recorded stages.

Once the Local-Scale model calibration was concluded, performance evaluations were conducted for each of the sub-watershed areas for each design storm event. In each of the evaluations, the main conveyance was analyzed in sections for each design storm, attention given to average channel velocities, maximum flow rates, peak water surface stages and any significant increases in peak stages along the channel or conveyance. In addition, for each design storm peak water surface stages were evaluated at key locations within the network and compared with existing elevations of roadways, homes, etc. to determine the level of flooding risk. The performance evaluations of the main conveyance system were beneficial in identifying locations of potential issues and providing a basis for evaluating mitigation and improvement projects.

For the Halfway Creek existing conditions analysis, the critical portion of the creek is the area located between the south end of the West Bay Club community and the U.S 41 crossing. This portion of the creek is a large natural area containing wetlands and uplands and the creek is not well-defined. The model results reflect significant increases in peak water surface elevations within this area. This is an area of concern since there are residential communities, such as Marsh Landing and Fountain Lakes, that discharge to this portion of Halfway Creek. The analyses of the other portions of Halfway Creek did not present any concerns.

For the Estero River South Branch existing conditions analysis, the most critical portion of the waterway is the area located upstream of the Three Oaks Parkway crossing to the Sanctuary Drive crossing. Within this portion, the waterway channel becomes narrower, forcing water to flow within the over banks that contain more vegetation and debris. The existing conditions model results reflect significant increases in peak water surface elevations within this area.

The existing conditions analysis for the Estero River North Branch identified several areas of concern within the waterway. One of the areas of concern is located within the Villages at Country Creek community. Within this area, there are significant increases in water levels along the river. Another portion of the North Branch that presented concerns is the section located between the north boundary of Villages at Country Creek and the Rookery Drive crossing. The model indicates significant increases in water levels through this portion of the North Branch. Within the north diversion portion of the North Branch, which extends from Rookery Pointe, under Three Oaks Parkway and along the north side of Villagio, the model presents another condition of significant increases in water levels. Specifically, the increases in peak stages occur in the section of the north diversion that travels through the natural area north of Villagio.

The existing conditions analysis for the Estero River Main Branch identified a couple of concerns. During the 25-year and 100-year design storm simulations, the model indicates moderate velocities of flow within the channel, located downstream of the U.S. 41 crossing. The high velocities allow the potential of the flow to transport sediments from upstream and into the Bay. During all four (4) design storm simulations, the model indicates significant increase in water levels within the section of the river located between the Seminole Gulf Railroad crossing and the Sandy Lane crossing. This is an area where the river channel begins to change, becoming narrower, which cause water to flow within and above the banks of the river where there is more vegetation.

In addition to performance evaluations for the existing surface water system, an evaluation of build-out conditions was conducted. Consideration was given to the vacant parcels that could potentially be developed. The selection of vacant, to-be-developed parcels did not include government-owned or public parcels, conservation parcels, State-owned lands, or out-parcels that were already part of a master plan development. The goal of the Build-out scenario was to evaluate the potential impacts on the main conveyance systems within The Village with the development of the build-out parcels under the current design criteria. An evaluation was conducted which simulated discharge rates from each build-out parcel, based on the current regionally accepted design criteria for the 25-year, 3-day storm event. The results of the evaluation and comparison of peak stages indicate that the development of the vacant parcels does impact the existing conveyance systems in varying ways. Existing low-lying areas with uncontrolled discharge may have a lower discharge rate when developed. Conversely, vacant areas of higher elevation and less connectivity to the main conveyance systems may have a higher discharge rate once developed. This evaluation of the build-out conditions supports the aspect that plans for development of vacant parcels within The Village should be reviewed thoroughly with respect to the impacts to the existing stormwater facilities. The ICPR4 Local-Scale model is a tool that can be utilized to conduct the evaluations of proposed development projects within The Village.

As part of this Stormwater Master Plan, the existing stormwater infrastructure conditions were evaluated to determine potential improvement projects. Local flooding during the late August and early September 2017 rainfall events aided in the identification of areas in need of improvements. The evaluation resulted in the identification of a total of ten (10) potential improvement projects. Eight (8) of the projects were evaluated through additional hydraulic modeling. The improvement projects were grouped by the sub-watershed in which they are located. The projects are as follows:

Estero River Main Branch
- Project Seven: Estero River Side Bank Sediment Removal
- Project Eight: Broadway Ave. Main Tributary
- Project Ten: Maintenance of the Seminole Gulf Railroad Ditch
- Project Nine: U.S. 41 Roadside Drainage Modifications

Estero River North Branch
- Project One: Villages at Country Creek Bypass Swale
- Project Two: Three Oaks Parkway Drainage Improvements
- Project Three: Villagio / Estero Parkway Drainage Improvements
- Project Four: Estero Parkway Culvert
- Project Six: Dry Creek Bed Sediment Removal

Estero River South Branch
- Project Five: River Ranch Road Drainage Improvements
- Project Ten: Maintenance of the South Branch south of Corkscrew Road

Halfway Creek
- Project Ten: Maintenance of Halfway Creek West of U.S. 41

The potential projects include improvements to portions of the North Branch channel, re-establishing the Bamboo Island bypass to provide better flow distribution, and improving the River Ranch road drainage system with additional cross-culverts. One of the recommended projects includes a regular maintenance program for portions of the Halfway Creek, Estero River North Branch and South Branch waterways. Keeping these conveyances maintained with minimal vegetation debris and exotics will improve flow conveyance, capacity and distribution. The proposed projects were further evaluated with preliminary costs, including construction, permit and engineering/design costs. The projects were ranked by priority, with the highest priority being a project to be implemented within 1-5 years. The ranking of the projects was based upon the following factors:

- Magnitude of Potential Benefits to the Overall System;
- Estimated Construction Cost for the Improvements or Activities;
- Ease or Difficulty of Implementing the Improvements or Activities: Permit Requirements, Coordination with Other Entities, etc.

In addition to recommended improvement projects, there are other activities the Village can implement to mitigate issues with negative impacts on the stormwater management system and damages related to flooding. These activities include placing language within the Land Development Code and Comprehensive

Plan documents to establish policies and guidelines with respect to stormwater management. The recommended rule changes include minimum finished floor elevation criteria and setting a criterion for allowable discharge rates for new development projects. All the recommended rule changes and improvement projects will further aid the Village in addressing current and potential stormwater system issues.

In March 2017, the Village of Estero officially became a participating community in the National Flood Insurance Program (NFIP). As a new community within the NFIP, the Village is responsible for maintaining floodplain management policies and flood mapping products. To better understand the effects of potential riverine flooding within the Village, the 100-year riverine floodplain associated with the Estero River and Halfway Creek waterways were evaluated as part of the Master Plan. The Local-Scale ICPR model was used to support the riverine floodplain analyses. The floodplain analyses were created in the modeling programs HEC-RAS (Hydrologic Engineering Center's River Analysis System) and GeoHECRAS. The HEC-RAS program is designed to perform hydraulic calculations for a full network of natural and manmade channels. The GeoHECRAS software allows the user to properly geo-reference the HEC-RAS model. Halfway Creek was modeled as one (1) stream and Estero River was modeled as one (1) stream with two (2) branches, North and South Branch, connecting at a common junction along the river.

Using the Local-Scale ICPR model and the flow results from the 100-year, 3-day design storm, flow values were selected at specific locations along the main waterway and provided as input for the HEC-RAS model. The floodplain was delineated using the available Digital Elevation Model (DEM) prepared for the ICPR Local-Scale model along with additional as-built data for newly developed properties. The riverine floodplain delineation is based upon the peak 100-year water surface elevations determined in the HEC-RAS analysis and were determined as reasonably consistent with the peak 100-year design stages in the Local-Scale ICPR model.

The preparation of the Stormwater Master Plan successfully resulted in a greater understanding of the regional hydrology affecting the Village of Estero and the existing stormwater facilities within the Village. Collecting data of the Village's existing land uses, soil types, main drainage conveyance systems, conveyance structures and the conditions of the Estero River and Halfway Creek, allowed for the creation of the Local-Scale ICPR4 model.

Introduction

Introduction

Estero, where the river meets the sea. The Village of Estero is known for the beauty of the meandering Estero River, the history of the early pioneers, and for high development standards. The Village of Estero municipal boundary consists of approximately 30 square miles within the southern portion of Lee County. The Village became incorporated in December of 2014. Prior to that date, the Village had experienced a significant amount of growth with new residential and business communities. The Village continues to be an epicenter for growth in Southwest Florida.

The two (2) major watersheds affecting the Village of Estero are the Estero River Watershed and Halfway Creek Watershed. Both watersheds connect prior to entering Estero Bay. The headwaters of both systems originate east of Interstate 75 and traverse through the Village of Estero as predominately natural conveyances. The last major hydrologic study conducted for the area was the 2008 Update to the South Lee County Watershed Master Plan. This study evaluated the findings in the original 1999 South Lee County Watershed Master Plan study and provided new recommendations for the various watersheds.

After incorporation, the Village of Estero recognized the importance of understanding regional drainage patterns and the local drainage infrastructure network and system behavior within the Village. The Village of Estero Stormwater Master Plan is a focused study on the regional and local stormwater systems affecting the Village. This will help better understand the hydrologic and hydraulic behavior and provide a basis for evaluation of drainage improvement projects.

One of the most important aspects of the Village's infrastructure is the storm water management facilities. Understanding how the hydrologic and hydraulic networks function is crucial for maintaining and developing an effective water management system. The surface water conveyance system within the Village is unique when compared to some adjoining communities. The main waterways are predominately natural conveyances, compared to manmade canals. Natural waterway systems often have limited conveyance and capacity due to vegetation within the flow paths, and curvilinear alignments and geometric conditions. Based on past records and observed conditions, there are areas within the Village that experience flooding conditions due to factors such as a lack of storage and conveyance ability. Therefore, it is important to understand how the surface water and stormwater facilities are connected by way of a focused evaluation to identify feasible improvement projects and support a plan for implementation.

The entire watershed extends outside the Village boundary and these land areas located contribute surface water to the main streams within the Village. As those land uses change, there are potential impacts to the stormwater facilities within the Village. Therefore, it is also important to understand the hydrologic behavior of the region surrounding the Village. As a result, the Village Council took the initiative to engage a consulting team to prepare a Stormwater Master Plan. The Village of Estero Stormwater Master Plan project involves a focused study on the regional and local stormwater systems affecting the Village to better understand the hydrologic and hydraulic behavior and provide a basis for evaluation of drainage improvement projects.

Purpose

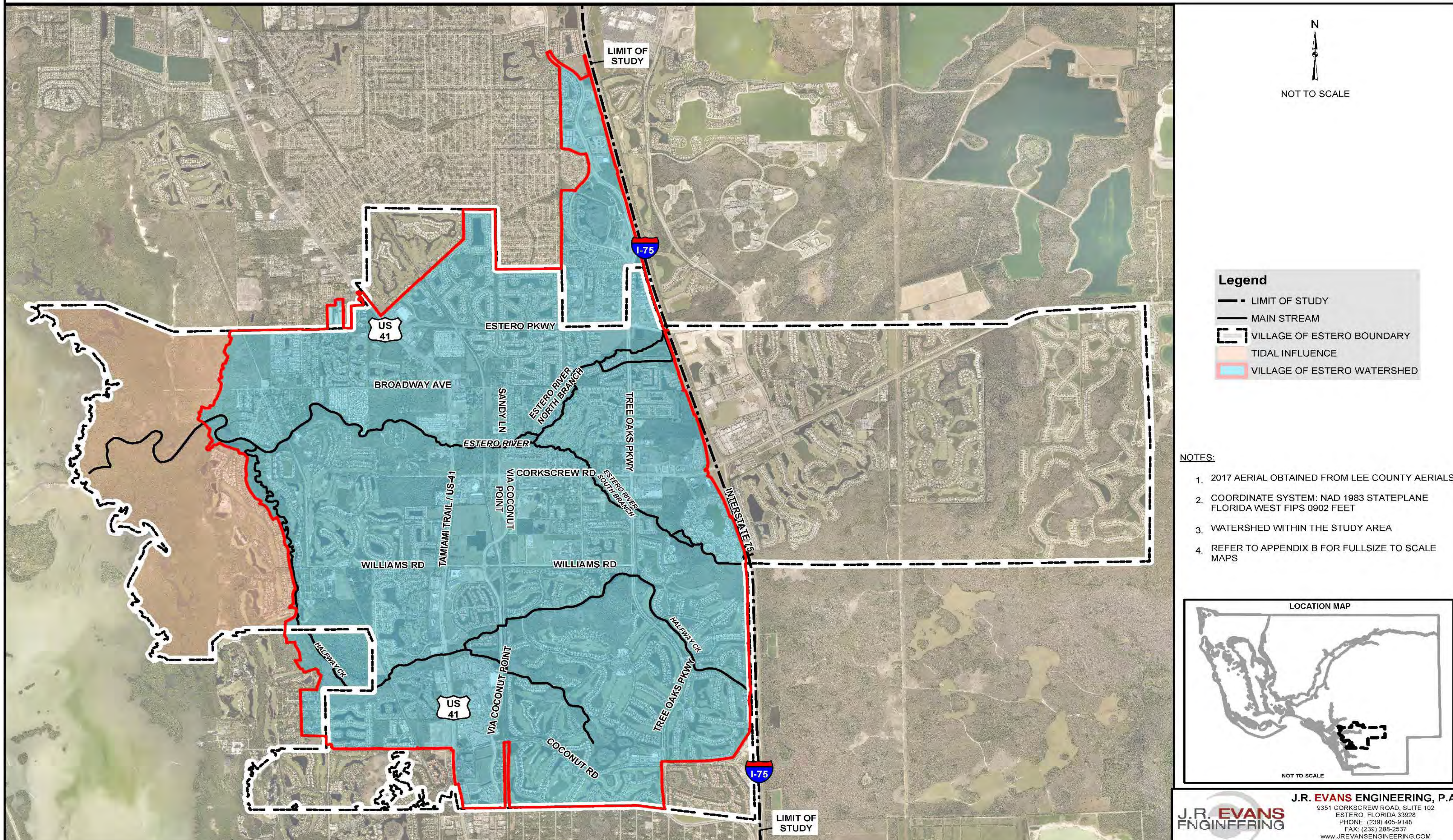
Purpose

The purpose of the Stormwater Master Plan report is to present the details and findings of a focused study to understand the current regional hydrology affecting the Village and understand the current conditions of stormwater/surface water networks within the Village. The purpose of the report is to assess regional drainage issues affecting the Village, assess the behavior of the current system, identify areas of flooding or drainage deficiencies, and recommend improvement projects and other mitigation activities for consideration. A significant benefit of the project is the development of an updated regional-scale model and detailed local-scale model, with which both can be utilized to evaluate and/or assess the impacts of infrastructure projects or development projects on the existing stormwater system. Likewise, the local-scale models can be continually updated as projects are implemented so that the model remains current and reflective of current conditions. Additional goals of the Stormwater Master Plan are as follows:

- Provide a framework for evaluating Stormwater improvement projects and new developments;
- Identify flood mitigation projects;
- Identify locations where additional water level/flows monitoring should be installed; and
- Develop regulatory standards and guidelines.

The following sections of the report describe all the tasks involved with the Project, from data collection, to regional-scale model updates, to development of a detailed local-scale model for a detailed study area located west of Interstate 75 to the watershed limits. Map 1-1 depicts the boundary for the local-scale model study. The report begins with a description of past studies and previously recommended improvements proposed for the area, followed by a discussion on the collection and verification of data for the current study, followed by a description of the updates performed to the regional-scale MIKE SHE/MIKE 11 model and the development of the local-scale ICPR model, followed by a presentation of the local-scale performance evaluations for the existing conditions and built-out conditions within the Village. The last sections of the report take the areas of concern identified in the performance evaluations and reviews potential improvement projects with a description of the hydraulic improvements, permitting requirements and overall costs involved. Based on evaluations of the project, the report provides a plan for implementing the most beneficial projects and recommendations for other mitigation activities, such as regulatory guidelines, protection of the natural conveyances and additional monitoring. Lastly, the report discusses the Village's participation within the National Flood Insurance Program and the importance for maintaining the Villages' floodplain management practices and mapping. The report describes the details of the re-evaluation of the 100-year riverine floodplain analysis based upon the results of the Local-Scale ICPR model and development of an open-channel flow model to delineate a revised riverine floodplain for the Estero River and Halfway Creek, west of the Interstate. The updated riverine 100-year floodplain analysis which can be used by the Village to pursue a revision to the Federal Emergency Management Agency (FEMA) Flood study and maps for the Village community

Map 1-1: Study Area



Data Collection

1. Data Collection

The initial task to support the Stormwater Master Plan project included an evaluation of the existing data available for the stormwater facilities within The Village of Estero jurisdictional boundary, verifying the data and obtaining new/updated data. The collected and verified data provides a more accurate record of the physical properties and conditions of the system and a record of more recent surface water levels and flows within the system. The data is a vital component of the study, especially with respect to the calibration and validation processes. The data provides a basis of confirmed existing conditions to property evaluate improvement projects with attainable results.

1.1. Requirements

The data collection effort conducted for the Village of Estero Stormwater Master Plan took place from April 2017-July 2017. Additional data collection needs were identified during subsequent phases of the project, particularly after the major rain events in late August 2017 and with the passing of Hurricane Irma in September 2017. Outlined below is a list of the specific data collection tasks conducted:

Table 1-1: Data Collection Activities

No.	Description of Task
1	Obtain and review previous.
2	Collect/Obtain existing Survey data and determine need for additional cross-section information.
3	Collect GIS data for the watershed areas.
4	Collect and compile historic (flow and stage) data for Estero River and Halfway Creek.
5	Verify implementation status of recommendations per the 1999 South Lee County Watershed Plan and 2009 South Lee County Watershed Plan Update.
6	Collect current information for structures located within the Estero River (North and South Branches) and Halfway Creek. Verify physical conditions of structures/crossings/bridges.
7	Collect permit data for all permitted surface water management systems and verify as-built conditions.
8	Collect information and records on previously identified problem areas (as reported by residences, community stakeholders, Lee County representatives, etc.).
9	Conduct meetings with Village staff and community residents to identify and document persistent drainage issues/flood issues.
Due to major rain events in August/September 2017, the additional data collection tasks were conducted.	
10	Collect and compile high water marks and flow data.
11	Collect additional survey data and cross-sections.

1.2. Previous Studies/Data Sources

There have been numerous hydrologic and hydraulic studies conducted within the study area, ranging from large-scale to individual development areas. Information from these studies were reviewed and utilized where appropriate for this Stormwater Master Plan. Table 1-2, located below, provides a list of the known studies and data sources that were considered.

Table 1-2: Previous Studies/Data Sources

No.	Description
1	South Lee County Watershed Plan (SLCWP) - 1999
2	South Lee County Watershed Pan (SLCWP) Update – Report and MIKE SHE Model 2008
3	South Florida Water Management District (SFWMD) Permits, permit boundaries, staff reports, as-built information for individual projects located within Study Area.
4	New cross-section data for the South Branch of Estero River per changes resulting from adjacent developments (Estero Place and Villa Palmeras).
5	2007/2008 LiDAR Elevation Data (NAVD 88)

1.3. Discussion of SLCWP Recommendations and Implementation Status

In 1992 and 1995, a series of significant rainfall events occurred within the Bonita Springs area and resulted in wide-spread flood damages and prolonged displacement of many residences. In response to those events, a study (South Lee County Watershed Plan or SLCWP) was initiated to identify the causes of flooding, recommend improvements and reduce future flooding. The SLCWP was completed in July 1999 and most notably identified for Estero the loss of historic flows within the Estero River and Halfway Creek watersheds. The SLCWP identified the construction of Interstate, I-75, as one of causes for the loss of historic flows. Numerous recommendations were provided as a result of the SLCWP study and a portion were implemented as of 2008.

In February of 2008, the South Florida Water Management District issued a permit for the widening of I-75 from four (4) lanes to six (6) lanes for the segment located between the Collier/Lee County line to Corkscrew Road. The project included installing additional culverts under I-75 south of Corkscrew Road to covey flows from east of I-75 to west of I-75. The project raised several concerns from adjacent property owners and stakeholders in the area. Therefore, the South Florida Water Management District (District) and Lee County (County) cost shared and collaborated on a study known as the South Lee County Watershed Plan Update (SLCWP Update). The objective of this update was to verify and validate the findings and material assumptions of the original 1999 SLCWP for the Halfway Creek, Spring Creek, South Branch of the Estero River, and Imperial River region. If conditions changed in these areas that required revisions to the recommendations in the 1999 SLCWP, then new recommendations were to be provided.

The following actions were recommended for implementation in the 2008 SLCWP Update, in order of decreasing priority:

1. Increasing conveyance in the North Branch Estero River at Rivers Halfhitch 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.

Since the issuance of the recommendations, some of the activities have been implemented. The below Table 1-3 provides the outline of the recommended activities and status of implementation.

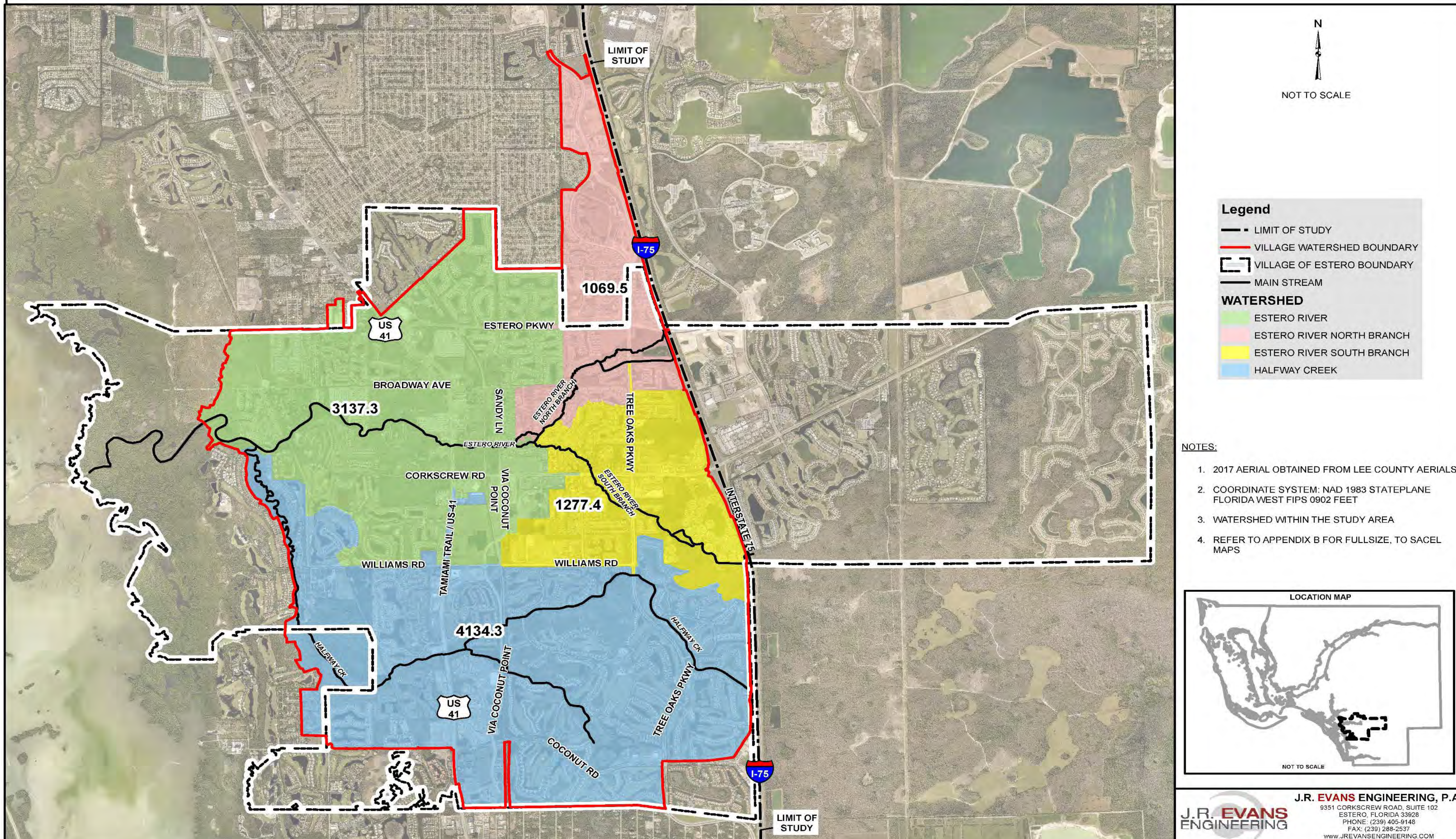
Table 1-3: SLCWP Update Final Recommendations Implementation Status

No.	Proposed Recommended Improvement	Status
1	Increasing conveyance in the North Branch Estero River at Rivers Ford Road.	Completed
2	Increasing conveyance in the South Branch Estero River at Country Creek Drive near Split Oak Way.	Completed
3	Connection of Halfway Creek to the Rapallo Lake west of Via Coconut Point and east of Via Villagio.	Not Implemented
4	Improve vegetation maintenance in Halfway Creek east and west of U.S. 41. Vegetation should be removed from the flood way and not stacked in "tee-pees" east of U.S. 41	Implemented. Requires continued maintenance.
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.	Implemented
6	Ensure that accumulated sediments are removed in the culverts under I-75 at Halfway Creek and maintained as required to meet design capacity.	Implemented
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.	Not Implemented
8	Construction of up to two 60" diameter culverts under I-75 to Bonita Bill Canal in the Spring Creek watershed.	Not Implemented
9	Enlargement of culverts downstream of the Old U.S. 41 culverts in the Spring Creek tributary that receive flows from the Moriah weir.	Completed
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)	Status Unknown. Does not impact Village of Estero
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.	Status Unknown. Does not impact Village of Estero

1.4. Descriptions of Watersheds

There is one (1) main watershed and four (4) distinct sub-watershed areas located within and affecting the Village of Estero jurisdiction. The watersheds within the Village are comprised of predominantly natural stream conveyances. The two (2) major natural conveyances within The Village are the Estero River and Halfway Creek. The Estero River is divided into two (2) branches at the location of bamboo island just west of the Villages at Country Creek development, the North Branch and South Branch. Each of these creek conveyances travel through the Village, meandering through residential and commercial developments, community parks, conservation areas, etc. and into the main branch of the Estero River which ultimately outfalls into Estero Bay. Halfway Creek is also a tributary to the Estero River Main Branch, connecting to the River at approximately 2.5 miles from Estero Bay. Provided below are detailed descriptions of each sub-watershed and their distinguishing features. Maps 1-2, 1-3, 1-4, 1-5 and 1-6 provide a graphical view of the combined watersheds and each of the watershed boundaries.

Map 1-2: Overall Estero River and Halfway Creek Watersheds



1.4.1. Estero River, North Branch

The Estero River North Branch (also referred as North Branch through this report) is a perennial waterway with a generally well-defined channel within the downstream section, segments of mild to abrupt meanders and profiles slopes ranging from mild to moderate. Upstream portions of the North Branch sub-watershed area extend through wetland slough areas. The entire waterway length (including natural and channel sections) up to I-75 is approximately 2.15 miles measured from its confluence with the Estero River (Main Branch). The Estero River North Branch confluence is located at approximately 0.13 miles northeast of the intersection of Sandy Lane and Corkscrew Road (near the downstream end of “Bamboo Island”). The contributing sub-watershed west of I-75 of the North Branch is approximately 1,069.5 acres, with limits of the overall Estero River watershed that extend well beyond the Village of Estero jurisdiction. The North Branch sub-watershed generally begins at State Road 82 and extends southwest towards I-75 and westward until it reaches the junction with the Estero River (Main Branch) and the Estero River South Branch. The overall Estero River watershed encompasses approximately 39,163 acres and includes contributing lands east of I-75, which include mines, Florida Gulf Coast University, Gulf Coast Town Center, Miromar Outlet Mall, and numerous residential communities.

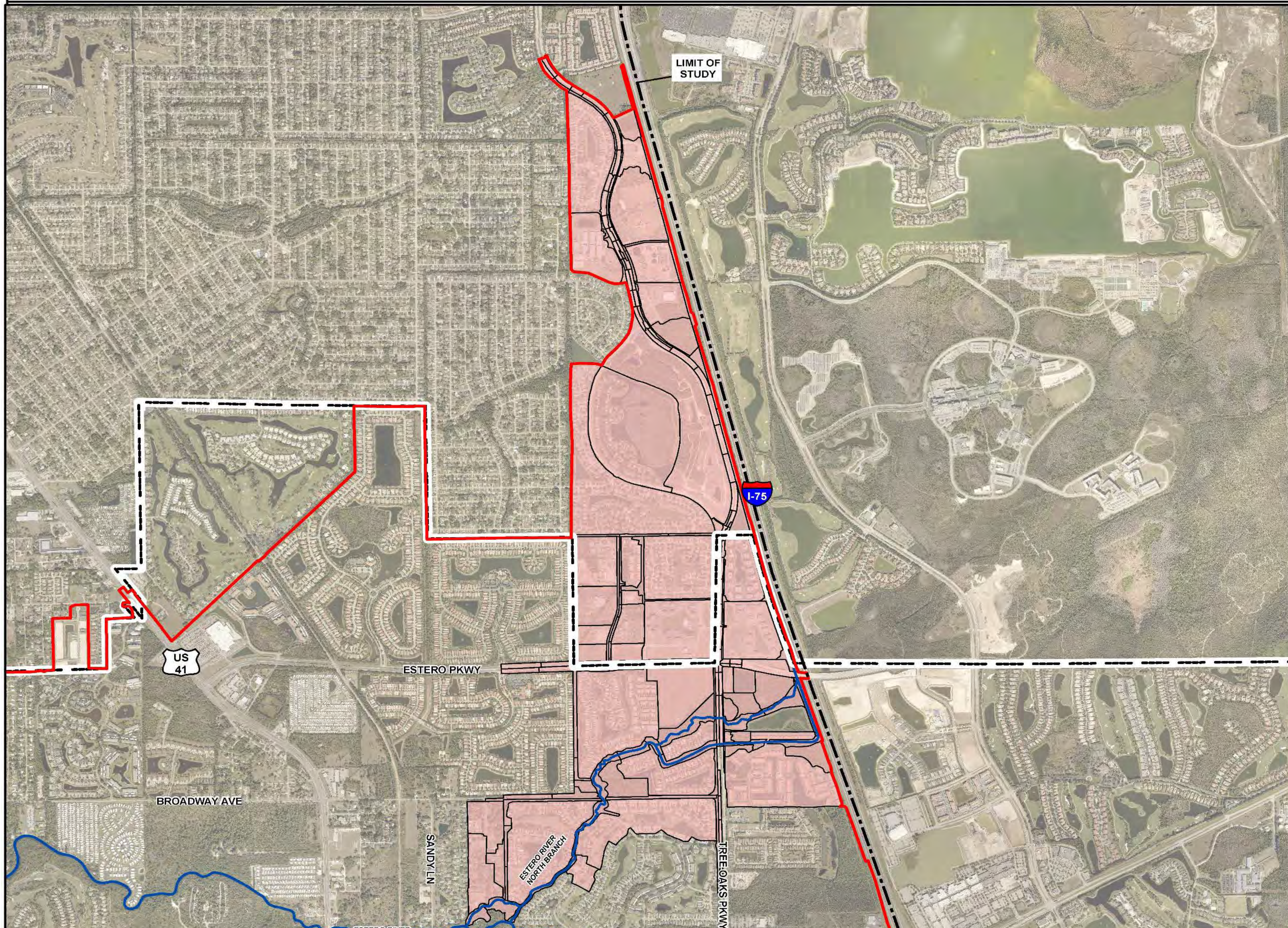
The existing land uses within the North Branch watershed consists of: residential and commercial developments, institutional sites, agricultural sites, golf courses, public infrastructure, mines, park areas and wetlands and upland areas. Prior to and over the past 10 years, an increase in development has occurred within this watershed, particularly with the residential and commercial land uses. With the changes in land uses, historical flow patterns have been altered, and flows have been conveyed to the North Branch using secondary conveyance systems, however those flows do not necessarily reach the original confluence point and/or follow the original hydraulic behavior. The most significant changes in land use within the North Branch watershed have occurred with the extension of Estero Parkway East from Three Oaks Parkway, across the I-75 and connecting to Ben Hill Griffin Parkway. The Estero Parkway corridor has experienced an increased level of development activity, with the Tidewater development (located east of I-75), and Estero Oaks Apartments and The Reef Student Living developments (located west of I-75). This area is adjacent to a location of significant North Branch’s inflow (crossing the I-75); and the change in land has altered the previous sheet flow conditions for the flowing waters within the North Branch during significant rainfall events.

The North Branch’s defined creek receives flows from a series of wetlands located east of I-75, under I-75 north of Corkscrew Road and traverses in a southwesterly direction through residential communities of Villagio, Rookery Pointe and The Villages at Country Creek. The North Branch receives flows from secondary conveyances, which include but is not limited to: the Three Oaks Parkway drainage system, the Estero Parkway drainage system, a generally parallel channel (concrete and bare earth) along the west side of I-75, a conveyance system that begins south of Rookery Pointe crosses the Estero Parkway and continues west of the Three Oaks Elementary School and South of Pine Glen, and the Cypress View Road drainage system. Most of these conveyances are comprised of ditches and culverts, and some inline structures (such as the ones found at: Three Oaks Parkway, Estero Parkway, Cypress View Road and the drainage system that begins south of Rookery Pointe). The North Branch also receives controlled discharges from the developed areas. It should be noted that the North Branch may also experience some shared flows with the South Branch when water levels reach certain levels. This behavior is suggested along the Three Oaks Parkway drainage system.

As the North Branch heads west of I-75, there are two (2) routes that the water may follow. One route is north of the Villagio development through a conservation area, crossing the Three Oaks Parkway and traversing another natural area (just north of Rookery Drive). The other branch travels through the Villagio residential development, under the Three Oaks Parkway, crosses the Rookery

Pointe residential community through an initial linear flow-way system to where it meets with the northern branch and flows toward The Villages at Country Creek. As the North Branch reach enters The Villages at Country Creek, it becomes more curvilinear and narrow with steeper side slopes and rocky bottom, which results in greater opportunity for erosion and sediment during significant flow conditions. A reach segment that runs southeast bordering the northern portion of "Bamboo Island", from the confluence of the North Branch and the South Branch to a point 0.25 mile downstream (where it meets the Estero River Main Branch) contains milder profile slopes until it reaches the Main Branch. In addition, there is a historic creek segment located between the North Branch and South Branch, along the east side of Bamboo Island which has been filled in with sediment and vegetation over time. The profile slopes within this historic segment are also very shallow.

Map 1-3: Estero River- North Branch Watershed Boundary



N

NOT TO SCALE

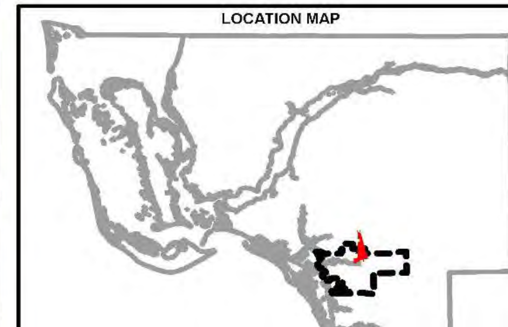
Legend

- LIMIT OF STUDY
- VILLAGE WATERSHED BOUNDARY
- VILLAGE OF ESTERO BOUNDARY
- MAIN STREAM
- ESTERO RIVER NORTH BRANCH BASIN
- SUB-BASIN BOUNDARY

NOTES:

1. 2017 AERIAL OBTAINED FROM LEE COUNTY AERIALS
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE FLORIDA WEST FIPS 0902 FEET
3. WATERSHED WITHIN THE STUDY AREA
4. REFER TO APPENDIX B FOR FULL SIZE, TO SACLE MAPS.

LOCATION MAP



NOT TO SCALE

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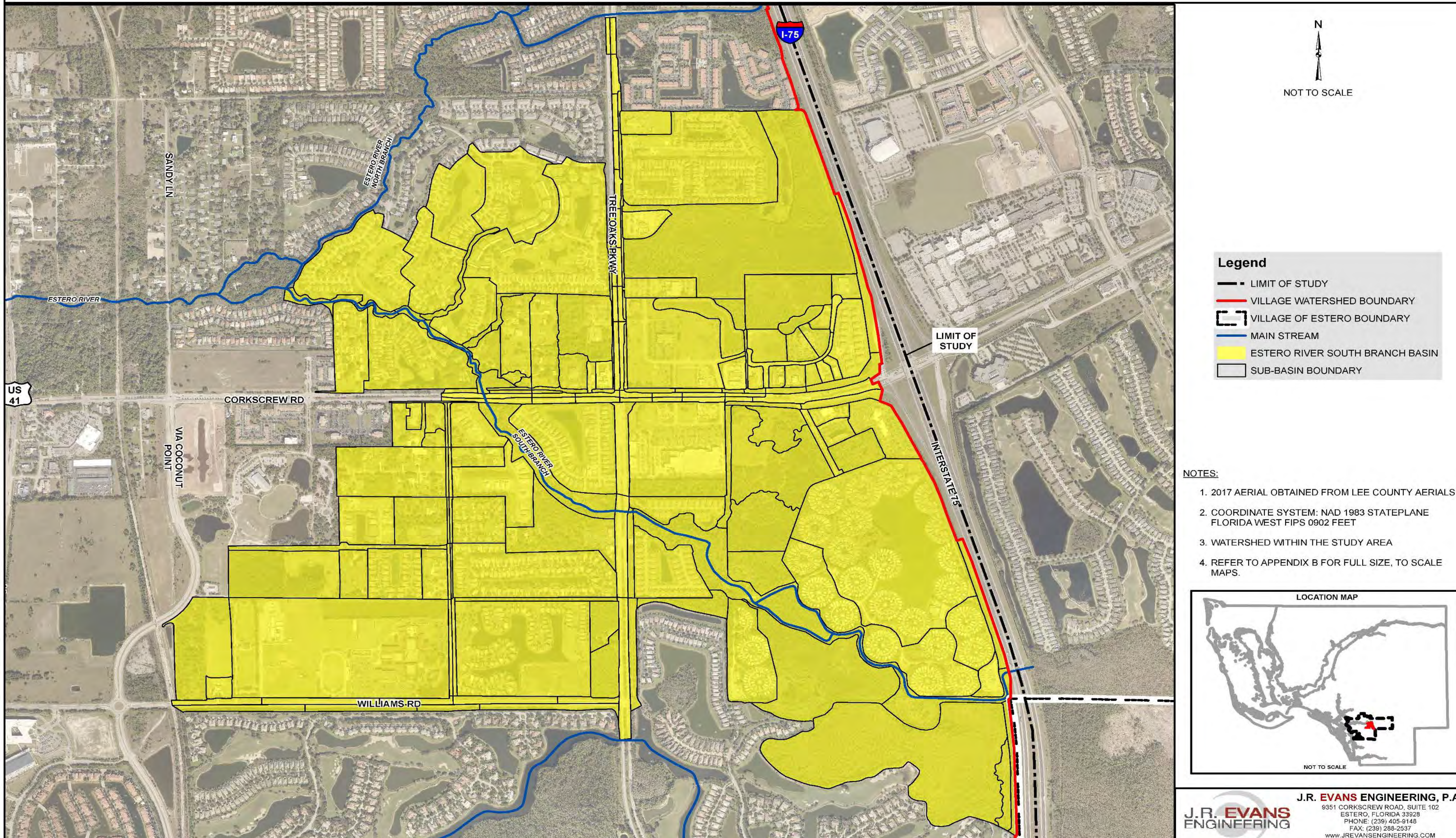
1.4.2. Estero River South Branch

The contributing watershed to the South Branch, west of I-75 is comprised of 1,277 acres. However, the entire sub-watershed, including lands east of I-75, is comprised within the overall Estero River watershed boundary. The Estero River South Branch sub-watershed (South Branch) extends east of I-75 along the Corkscrew Road corridor, south of the Stoneybrook development and west to the junction point with the North Branch sub-watershed. The length of the defined waterway from the confluence with the North Branch to I-75 is 2.36 miles. The land uses within the South Branch watershed include residential, commercial, educational facilities, conservation areas, public park, and public infrastructure (main arterial roadways). Throughout the past 10 years, an increase in development activity has occurred, especially with commercial and residential developments.

The South Branch receives flows from I-75 conveyances consisting of a bridge, three (3) 8' x 8' box culverts and one (1) 10' x 6' box culvert. There is small channel through dense vegetation that restricts flows downstream of the 8' x 8' box culverts. The South Branch main stream also receives flow from secondary conveyances including the Three Oaks Parkway system, Corkscrew Road ditch, and Williams Road swale. The South Branch watershed, west of I-75, consists of a mixture of permitted/regulated developments with controlled discharges, and uncontrolled developed areas, such as older subdivisions located along River Ranch Road.

As the South Branch main stream heads west of I-75, the creek meanders along the southwest side of Corkscrew Woodlands, under a small bridge crossing for Sanctuary Road, through the Villa Palmeras development, under Three Oaks Parkway, through the Estero Place development, under Corkscrew Road and connecting with the North Branch, along the south side of "Bamboo Island". The South Branch main stream is a predominately natural waterway with a narrow bottom width and dense vegetation along the banks and overbank areas, where not located next to developed properties.

Map 1-4: Estero River- South Branch Watershed Boundary



NOTES:

1. 2017 AERIAL OBTAINED FROM LEE COUNTY AERIALS
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE FLORIDA WEST FIPS 0902 FEET
3. WATERSHED WITHIN THE STUDY AREA
4. REFER TO APPENDIX B FOR FULL SIZE, TO SCALE MAPS.

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1.4.3. Halfway Creek

The Halfway Creek main stream originates in a broad marsh system located east of I-75. As with the South Branch sub-watershed, the portion of Halfway Creek sub-watershed located east of I-75 is comprised within the overall Estero River watershed area, which is approximately 39,163 acres. The southern boundary of the Estero River watershed is adjacent to the Imperial River watershed. Based on conditions east of I-75 and south of Corkscrew Road, there are no known barriers or structures to separate the flow and surface water can flow between the Estero River/Halfway Creek and Imperial River watersheds. The Halfway Creek specific sub-watershed area within this study area, located east of I-75, is approximately 4,134 acres. The length of the Halfway Creek waterway from the confluence with the Main Branch of the Estero River to I-75 is 7.18 miles. The land uses within the Halfway Creek watershed include commercial, residential, medical facilities, golf course, conservation and park use. Over the past ten (10) years, there has been a significant increase in development with commercial and medical uses and along the U.S. 41 (Tamiami Trail) corridor. The watershed boundary for Halfway Creek extends to the southern boundary of The Brooks (at Bonita Bill Street), follows U.S. 41 to Coconut Road, runs along the north side of Coconut Road, extends north at El Dorado Acres, and continues north containing portions of West Bay Club and Pelican Sound before reaching the limits of the Estero River Main Branch watershed.

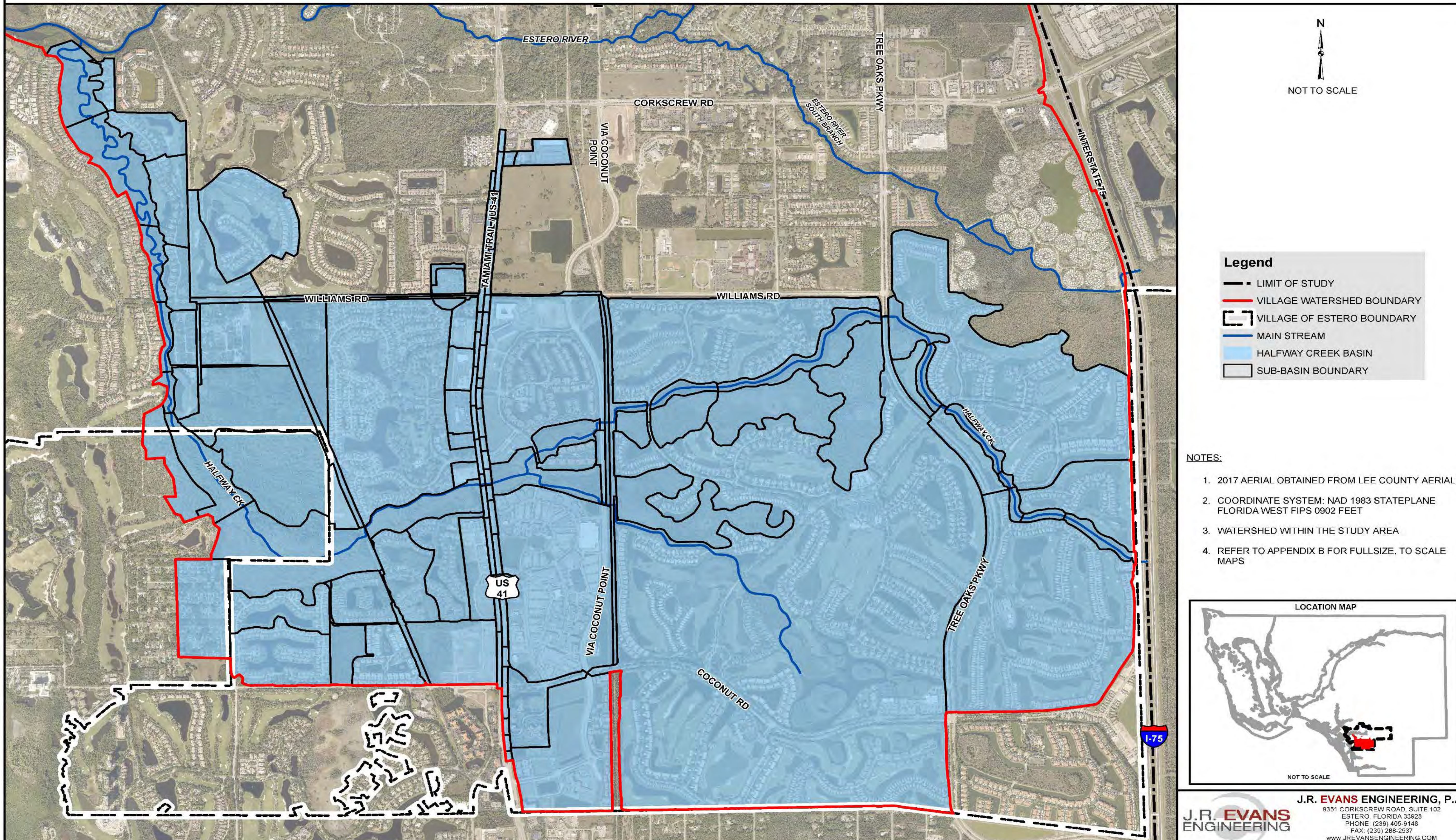
Stormwater from east of I-75 pass under the Interstate through two (2) 9’ x 8’ box culverts and then proceeds through The Brooks development as large flow-way lakes. Each of the flow-way lakes are connected by box culverts. Halfway Creek leaves The Brooks development through two (2) weir control structures, one located at the west end of the north preserve area, just north of Falling Leaf Drive. The second outfall weir is located on the west side of the southern preserve area, north of Rosedale Drive. After leaving The Brooks, Halfway Creek flows under the Seminole Railroad and under Via Coconut Point roadway, reaching the Rapallo and Enclave at Rapallo developments. At this point, the creek contains two (2) branches through wetland flow-way systems until reaching Via Villagio. Each branch of the Halfway Creek travels through culverts under Via Villagio and then merge at the location of a 200 ft long weir with an invert elevation of 10.82 FT NAVD. This weir was installed in the 1980’s as part of the initial development of The Brooks. The creek continues as one branch from Via Villagio westward over through another wetland system and then reaching U.S. 41. Once the Halfway Creek flows under U.S. 41, it meanders along the southern boundary of the Fountain Lakes community into a large marsh system located east of the FP&L easement. The creek then heads north, meandering through the West Bay Club development and ultimately joining the Estero River Main Branch at approximately 2.3 miles upstream of Estero Bay.

Halfway Creek receives flow from secondary conveyances that include the Seminole Gulf Railroad ditch system, U.S. 41 storage/conveyance system, FP&L Easement ditch system, and other smaller roadway conveyance and ditch systems. The Halfway Creek system receives flow from a mixture of permitted/regulated developments with controlled discharges and uncontrolled developed areas, such as older residential areas located along Williams Road, west of U.S. 41. Many of the regulated developments, such as Marsh Landing and Forest Lakes, discharge to the FP&L ditch before reaching the main stream. As with the Estero River secondary conveyances, this is an important aspect of the system’s function since the level of maintenance of these secondary conveyances has a direct impact on the discharge ability for the regulated developments.

Halfway Creek receives flow from secondary conveyances that include the Seminole Gulf Railroad ditch system, U.S. 41 storage/conveyance system, FP&L Easement ditch system, and other smaller roadway conveyance and ditch systems. The Halfway Creek system receives flow from a mixture of permitted/regulated developments with controlled discharges and uncontrolled developed areas, such as older residential areas located along Williams Road, west of U.S. 41. Some of the regulated developments, such as Marsh Landing and Forest Lakes, discharge to the FP&L ditch before reaching the main stream. As with the Estero River secondary conveyances, this is an important aspect of the system's function since the level of maintenance of these secondary conveyances has a direct impact on the discharge ability for the regulated developments.

Halfway Creek shares a controlled connection with the Estero River South Branch watershed through a by-pass structure location along the east side of Three Oaks Parkway, at the intersection with Williams Road. The intent of the by-pass structure is to serve as an emergency overflow opportunity when water levels reach a certain elevation in Halfway Creek. This structure and its operation guidelines are defined in more detail within the following report sections.

Map 1-5: Halfway Creek Watershed Boundary



1.4.4. Estero River Main Branch

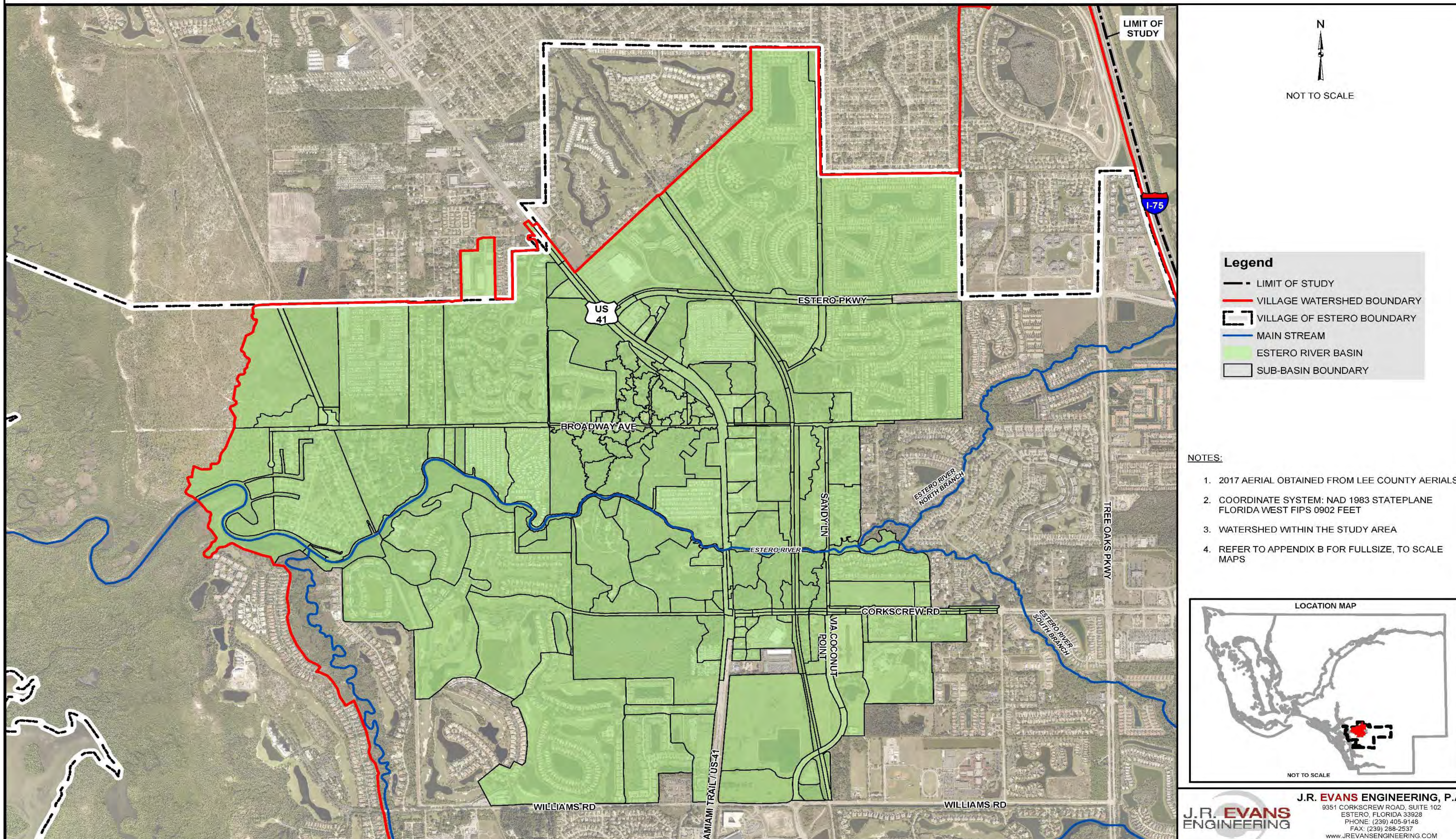
The Estero River Main Branch (also referred as Estero River through this report) is a perennial waterway with a well-defined channel, segments of mild to abrupt meanders and profiles slopes ranging from mild to moderate. The entire waterway length is approximately 3.34 miles, measured from its confluence with Estero Bay to the confluence of the Estero River North Branch and 3.51 miles measured to the confluence with the Estero River South Branch. The Estero River specific watershed area (not including the North and South Branch watersheds) is approximately 3,137 acres, with limits that are generally located within the Village of Estero jurisdiction.

The existing land uses within the Estero River watershed consists of: commercial and residential developments, institutional sites, golf courses, mines, conservation (including wetlands and uplands) and park areas. Most of the recent development over the last five (5) years has been commercial uses and development along the U.S. 41 (Tamiami Trail) corridor.

The Estero River receives flows from secondary and main conveyance systems. The main conveyances contributing to the Estero River are: North Branch, South Branch, and Halfway Creek. Secondary conveyance systems include: the Seminole Gulf Railroad ditch system, Sandy Lane drainage system, the drainage system that crosses the Broadway West and US-41, the FP&L Easement ditch system, and the U.S. 41 drainage system. The Estero River (and its secondary conveyances) receive flows from a mixture of permitted/regulated developments with controlled discharges and uncontrolled developed areas (such as: older subdivisions located along East and West Broadway Avenue and Highlands Avenue). The secondary conveyances include the Seminole Railroad ditch and the FP&L ditch facilities which are maintained and/or managed by the pertaining organization/company; meaning that neither the State, County nor the Village of Estero have rights to those areas. This condition is very important as the maintenance of these secondary conveyances have a direct impact to the overall system's function and the ability for the regulated developments to effectively discharge to them.

As the Estero River heads west from the confluence of the North and South Branch, it travels under Sandy Lane, under the Seminole Gulf Railroad crossing, under U.S. 41 and meanders along the Koreshan State Park property continuing until reaching the Tahiti Mobile Home Park and other residential developments before entering the Estero Bay. The Estero River channel sections are generally described as narrow and deep as it heads west of Bamboo Island and reaches the bridge at U.S. 41. From that point and downstream, the main stream begins to widen to larger cross-sections with vegetated overbank areas (where not developed) until it reaches the Estero Bay. The section of the River from the Estero Bay to The Villages at Country Creek is used for recreation and is frequented by many visitors for kayaking, canoeing and paddle boarding.

Map 1-6: Estero River Main Branch Watershed Boundary



1.5. Main Structures - Estero River (all branches) & Halfway Creek

As mentioned in the previous sections, the headwaters of the Estero River are located east of I-75 in a broad system of wetlands. The entire Estero River watershed encompasses 39,163 acres. East of I-75, flows are conveyed through overland sheet flow, flow through wetlands, roadway crossings in the form of brides and/or box culverts, and roadside ditches. Flows from this area flow under I-75, north of Corkscrew Road to the North Branch system and south of Corkscrew Road to the South Branch system. The North Branch receives flows from three (3) conveyances under I-75: One (1) bridge, two (2) 10’X6’ box culverts and two (2) 10’X7’ box culverts. As flows enter the North Branch, there are two (2) flow-ways leading from I-75. One flow-way path travels under the recent extension of Estero Parkway, through a conservation area, and under Three Oaks Parkway through three (3) 9’x 4’ box culverts and through another natural/forested area north of the Rookery Point development. The second flow-way path travels through the Villagio development in a more channelized system, then under Three Oaks Parkway through four (4) 10’ x 5’ box culverts, into the Rookery Point development. The second flow-way path continues through Rookery Point and goes through two (2) bridge crossings before joining the first flow-way path coming from the northeast. The North Branch main stream leaves Rookery Point and enters The Villages of Country Creek, and traverses through one (1) golf-cart bridge, one (1) vehicular bridge and one (1) pedestrian bridge before joining with the South Branch main stream. Each of these main conveyance structures for the North Branch are detailed in Table 1-4 and depicted in Map 1-7 following this section.

The South Branch of the Estero River receives flows from three (3) I-75 conveyances which consist of: a bridge, three (3) 8’ x 8’ box culverts, and one (1) 10’ x 6’ box culvert. There is a small channel with dense vegetation that restricts flows downstream of the three (3) 8’ x 8’ box culverts. The South Branch then flows under a bridge at Sanctuary Road, under a pedestrian bridge within the Villa Palmeras development and under Three Oaks Parkway through a set of four (4) 10’ x 6’ box culverts. As the South Branch travels northwest from Three Oaks Parkway, it crosses under another pedestrian bridge located within the Estero Place development and reaches Corkscrew Road and a set of three (3) box culverts. As the South Branch enters the Villages of Country Creek development, it flows under four (4) additional bridges and then merges with North Branch. There is also a tributary ditch to the South Branch located along the east side of Three Oaks Parkway from the limits of The Brooks development. At the north boundary of The Brooks, there is a diversion gate that controls flow from the Halfway Creek system to the South Branch. It is intended to serve as an emergency date to divert flow from The Brooks to the north to the South Branch There are two weir openings in a concrete box structure; the east opening includes a vertical lift gate that can operate as an overflow or underflow gate. The operation of the gate was permitted under ERP Application 140506-12. The overflow gate is typically left closed (lowered) with a weir crest at 12.42 FT NAVD. The gate opens (raises) only when the headwater elevation exceeds 12.92 FT NAVD and the water surface elevation at the Corkscrew Road crossing of the South Branch is lower than 10.82 FT NAVD. The weir gate is also opened (raised) when the site is in the cone of an approaching storm and the South Branch is lower than 10.82 FT NAVD. Each of these main conveyance structures for the South Branch are detailed in Table 1-4 and depicted in Map 1-7 following this section.

At the confluence of the North Branch and South Branch, the Estero River Main Branch commences. As the Main Branch travels west from the Villages of Country Creek development, it crosses under Sandy Lane through a roadway bridge and then the Seminole Gulf Railroad bridge. The next and last major structure within the Main Branch is the US 41 roadway bridge. Each of these main conveyance structures for the Main Branch detailed in Table 1-4 and depicted in Map 1-7 following this section.

As mentioned in the previous section, Halfway Creek originates in a broad marsh system located east of I-75. Flows pass under I-75 through two (2) 9’ x 8’ box culverts and then flow into The Brooks development. Flows pass through the flow-way lakes within The Brooks and the lakes are connected via six (6) sets of four (4) submerged 10’ x 6’ box culverts. There are also four (4) pedestrian/golf cart bridges that cross the flow-way lakes within The Brooks and have been considered in the local-scale ICPR model for this study. The flow out of The Brooks are controlled by two (2) weir structures at an invert of 12.42 FT NAVD, each located along the west property line and approximately 1,700 LF apart. The crest of the north Brooks Outfall weir has a length of 200 feet and a weir width (parallel to the flow direction) of 16 feet. The south Brooks Outfall weir has a crest length of 11.4 ft and width of 24 inches (2 feet). Halfway Creek then flows through the Seminole Gulf Railroad culverts and the culverts under Via Coconut Point. On the west side of Via Coconut Point, there is an equalizer ditch that connects the main (north) branch of Halfway Creek and the south (diversion) branch of Halfway Creek. The flows travel through the wetland/marsh areas located between/around the Rapallo and Enclave at Rapallo developments before reaching the Via Villagio roadway. Within the main (north) branch of Halfway Creek, there is a pedestrian bridge that crosses the wetland/marsh area, which was considered in the local-scale ICPR model for this study. Each branch of the Halfway Creek travels through culverts under Via Villagio and then merge at the location of a 200 ft long weir with an invert elevation of 10.82 FT NAVD. This weir was installed in the 1980’s as part of the initial development of The Brooks. Halfway Creek then flows through a natural/wetland area before reaching the U.S. 41 roadway crossing, which consists of three (3) 10’ x 7’ box culverts. Just west of the U.S. 41 roadway crossing, there is a pedestrian boardwalk bridge that connects the north and south sidewalks along U.S. 41 across the Creek. After the U.S. 41 crossing, the next structures crossing the waterway are located within the West Bay Club development. These structures include three (3) pedestrian/golf cart crossing bridges and one (1) vehicular bridge. Each of these main conveyance structures for the South Branch are detailed in Table 1-4 and depicted in Map 1-7 following this section.

Table 1-4: Structure Inventory

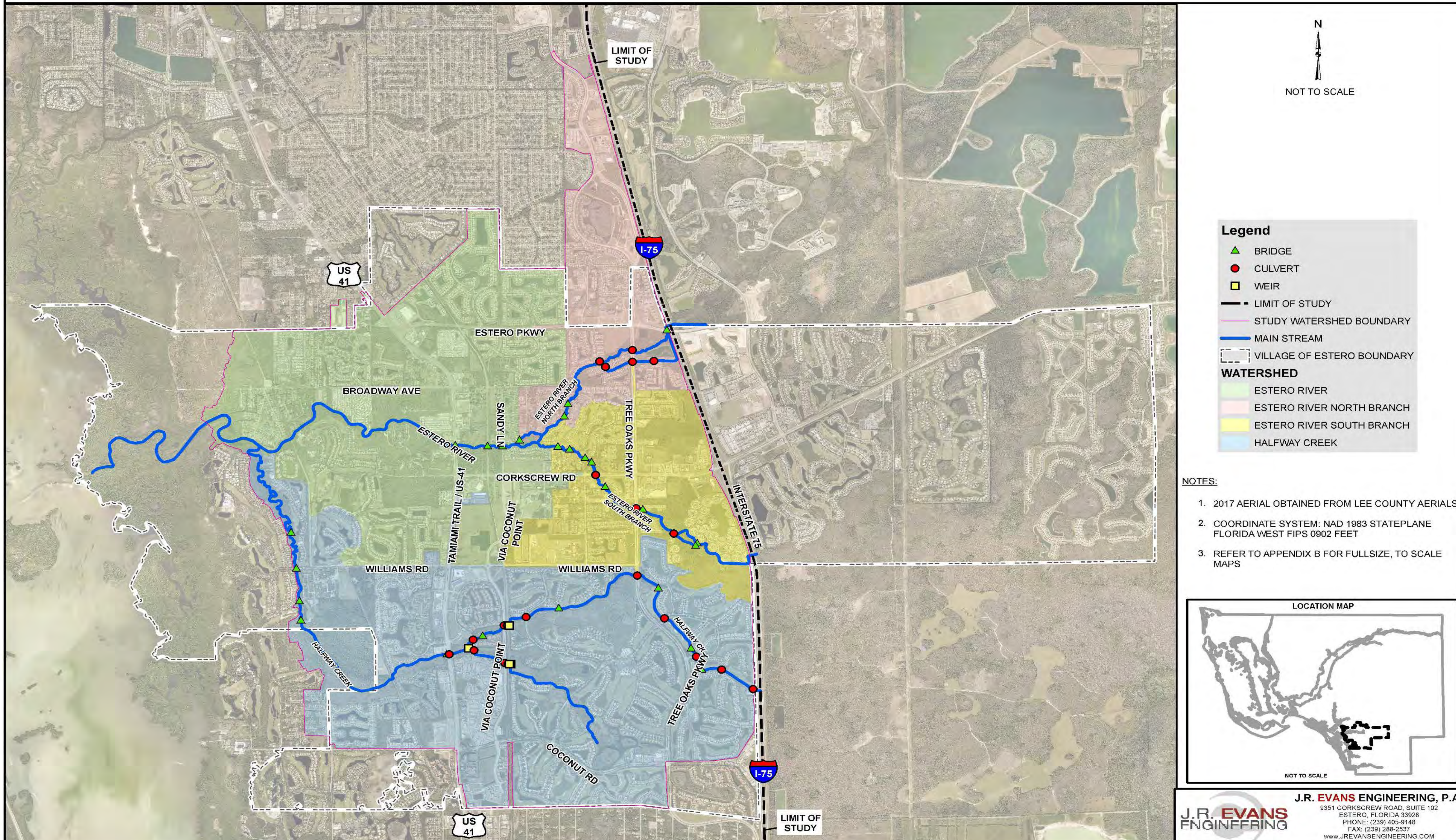
Structure Inventory					
Waterway	**Station**	**ICPR4 ID**	**Location Description**	**Type**	**Structure Geometry**
Estero River	14,436	ER-RC2	US-41	Bridge	150 feet Bridge Opening/Width = 90 feet/4 Piers
	15,813	ER-RC2-1	Railroad Crossing	Rail-Road Bridge	64 feet Bridge Opening/Width = 42 feet/1 Pier
	16,442	ER-RC3	Sandy Lane	Bridge	63.3 feet Bridge Opening/Width = 31 feet/2 Piers
Estero River North Branch	189	ERNBD1-RC1	South of Tanglewood Lane	Access Bridge	45.1 feet Bridge Section/Width = 14.15 feet
	1,676	ERNB-RC1	The Village at Country Creek at Halfhitch Road	Bridge	40 feet Bridge Opening/Width = 46 feet
	2,276	ERNB-RC2	The Village at Country Creek - Golf Cart Bridge	Access Bridge	40 feet Bridge Section/Width = 9 feet
	5,330	ERNB-P1	Rockery Drive	Pipe	4 Rectangular Cells/Depth = 8 feet and Width = 27 feet/Length = 45 feet
	5,721	ERNB-P2	Rockery Drive	Pipe	1 Rectangular Cell/Depth = 8 and Width 27/Length = 39.5 feet
	7,033	ERNB-P3	Three Oaks	Pipe	4 Rectangular Cells/Depth = 10 feet and Width = 5 feet/Length = 129 feet
	7,892	ERNB-P4	Villagio Gardens Court	Pipe	1 Rectangular Cell/Depth = 8 and width 24/Length = 63 feet
	10,197	ERNB-RC3	I-75	Bridge	287 feet Bridge Span/Width = 126 feet
	1,515	ERNBD2-P1	Three Oaks Pkwy.	Pipe	3 Rectangular Cells/Depth = 9 feet and Width = 4 feet/Length = 126 feet

Structure Inventory					
Waterway	**Station**	**ICPR4 ID**	**Location Description**	**Type**	**Structure Geometry**
Estero River South Branch	973	ERSB-RC1	Cypress Park Circle	Access Bridge	37.7 feet Bridge Section/Width = 10 feet
	1,615	ERSB-RC2	Country Creek Dr. at Split Oak Way	Bridge	72 feet Bridge Opening/Width = 40 feet/1 Pier
	2,460	ERSB-RC3	The Village at Country Creek	Golf Cart Bridge	51 feet Bridge Section/Width = 10 feet
	2,803	ERSB-RC4	Country Creek Dr. at Olde Oak Place	Bridge	39 feet Bridge Opening/Width = 44 feet
	3,421	ERSB-P1, ERSB-P1-2	Corkscrew Road	Pipe	2 Rectangular Cell/Depth = 5.5 feet and Width 10.5 feet / 1 Rectangular Cell/Depth = 8 feet and Width = 10.5 feet
	4,148	ERSB-RC5	Estero Place	Access Bridge	340 feet Bridge Opening/Width = 8 feet/18 Piers
	5,899	ERSB-P2	Three Oaks Parkway	Pipe	4 Rectangular Cells/Depth = 8 feet and Width = 10 feet
	6,189	ERSB-RC6	Villa Palmeras	Access Bridge	225 feet Bridge Opening/Width = 8 feet/27 Piers
	8,003	ERSB-P3	Sanctuary Drive	Pipe	10 Rectangular Cells/Depth = 4.5 feet and Width = 7 feet
	9,400	ERSB-RC7, ERSB-RC8	Corkscrew Woodlands	Access Bridges	76 feet Bridge Opening/Width = 7.4 feet/7 Piers
Halfway Creek Diversion	325	HCD1-PU3	Via Villagio South of Enclave at Rapallo	Pipe	3 Rectangular Cells/Depth = 6 feet and Width = 10 feet/Length = 70 feet
	1,781	HCD1-PU1	Via Coconut Point	Pipe	2 Rectangular Cells/Depth = 6 feet and Width = 10 feet/Length = 137 feet
	1,913	HCDI-PU2	Railroad Crossing	Pipe	2 Rectangular Cells/Depth = 4 feet and Width = 7 feet/Length = 60 feet
	1,973	HCD1-W1, HCD1-W2	The Brooks, South Outfall	Weir	Rectangular Weir Invert Elevation = 12.42 feet/Depth = 2.41 feet/Width = 11.4 feet and Rectangular Weir Invert Elevation 14.83 feet/Width 35 feet
Halfway Creek	7,366	HC-RC1	West Bay Club	Access Bridge	285 feet Bridge Opening/Width = 12 feet/17 Piers
	9,418	HC-RC2	West Bay Boulevard	Bridge	94 feet Bridge Opening/Width = 45 Feet/8 Piers
	10,918	HC-RC3	West Bay Club	Access Bridge	130 feet Bridge Opening/Width = 38 feet/9 Piers
	11,801	HC-RC4	West Bay Club	Access Bridge	101 feet Bridge Opening/Width = 12 feet/5 Piers
	20,153	HC-RC5	West US-41	Pedestrian Bridge	446 feet Bridge Opening/Width = 7 feet/44 Piers
	20,248	HC-P101	US-41	Pipe	3 Rectangular Cells/Depth = 7 feet and Width = 10 feet/Length = 150 feet
	21,119	HC-W3	West Via Villagio	Weir	200 feet long Broad crested Weir, Invert = 10.82 FT-NAVD
	21,581	HC-P1	Via Villagio	Pipe	3 Rectangular Cells/Depth = 6 feet and Width = 10 feet/Length = 70 feet
	22,006	HC-RC7	South of Rapallo	Access Bridge	243 feet Bridge Opening/Width = 6 feet/21 Piers
	23,140	HC-P2	Via Coconut Point	Pipe	4 Rectangular Cells/Depth = 6 feet and Width = 10 feet/Length = 123 feet

Structure Inventory					
Waterway	**Station**	**ICPR4 ID**	**Location Description**	**Type**	**Structure Geometry**
Halfway Creek – Continued	23,270	HC-P3	Rail Road East Via Coconut Point	Pipe	4 Rectangular Cells/Depth = 4 feet and Width = 10 feet/Length = 48 feet
	23,345	HC-W1, HC-W10	The Brooks, North Outfall	Weir	Trapezoidal Weir with Invert Elevation = 12.42 feet/Bottom Width = 200 feet/Side Slopes 2 and Rectangular Weir with Invert Elevation 15.02 feet/Width 250 feet
	24,305	HC-P4	Knollview Blvd.	Pipe	4 Rectangular Cells/Depth = 6 feet and Width = 9 feet/Length = 100 feet
	25,731	HC-RC8	The Brooks	Access Bridge	125 feet Bridge Opening/12 feet Wide/13 Piers
	29,659	HC-P5	Three Oaks Parkway	Pipe	4 Rectangular Cells/Depth 6 feet and Width = 10 feet/Length 100 feet
	30,760	HC-RC9	The Brooks	Access Bridge	120 feet Bridge Opening/12 feet Wide/11 Piers
	32,288	HC-P6	Oakwilde Blvd.	Pipe	4 Rectangular Cells/Depth = 6 feet and Width = 10 feet/Length = 100 feet
	34,077	HC-RC10	The Brooks	Access Bridge	120 feet Bridge Opening/12 feet Wide/11 Piers
	34,489	HC-P7	The Brooks	Pipe	4 Rectangular Cells/ Depth = 6 feet and Width = 10 feet/Length = 100 feet
	35,163	HC-RC11	The Brooks	Access Bridge	149 feet Bridge Opening/12 feet Wide/15 Piers
	35,996	HC-P10	Whispering Ridge Drive	Pipe	4 Rectangular Cells/Depth = 6 and Width = 10 feet/Length = 57 feet
	37,555	HC-P8	The Brooks Berm at I-75	Pipe	4 Rectangular Cells/Depth = 6 and Width = 10 feet/Length = 80 feet

***- STATION: Refers to location measured in linear feet from beginning (mouth) of main stream.**

Map 1-7: Main Streams with Major In-Line Structures

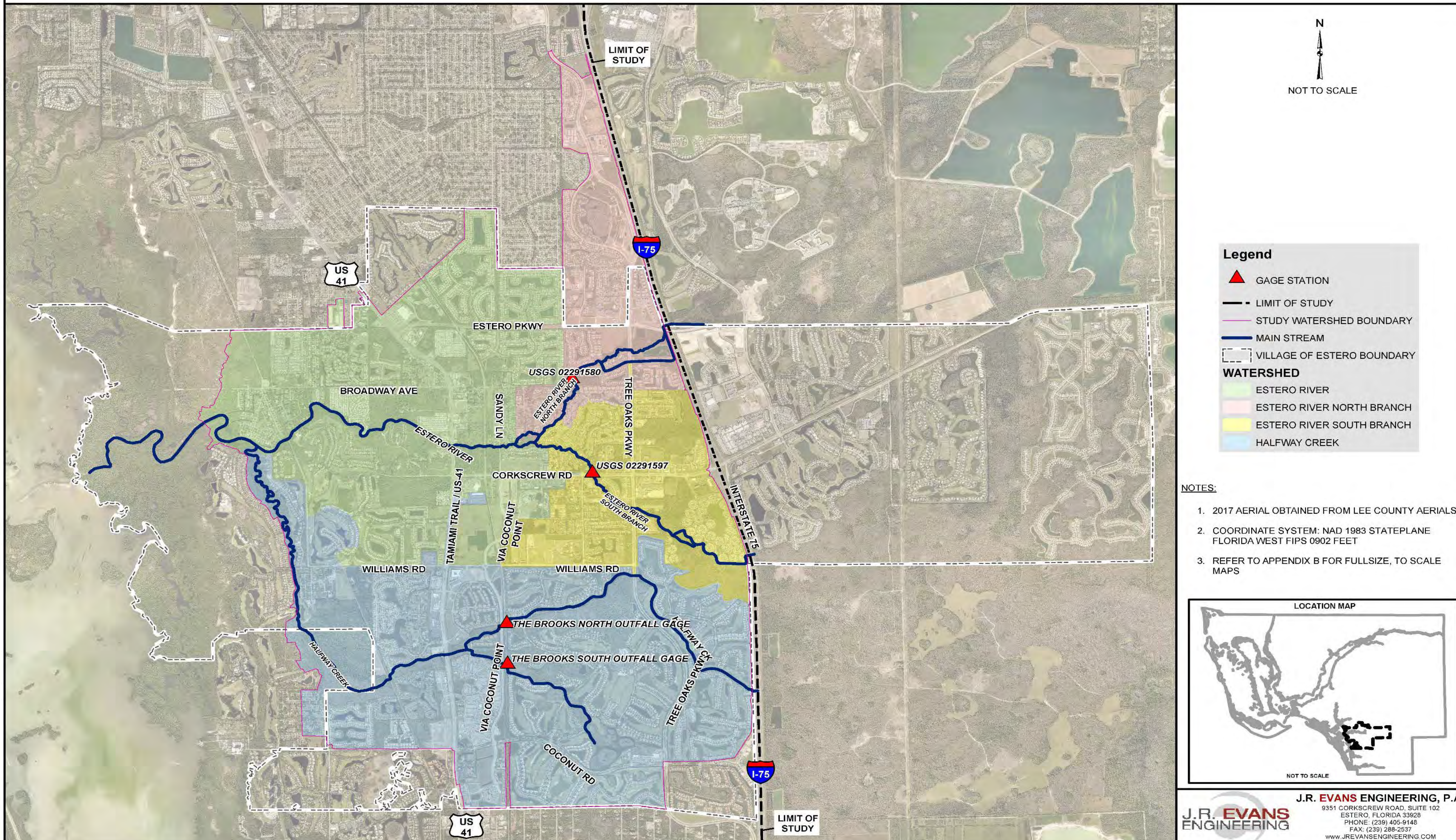


1.6. Calibration Data

Flow and stage data are available from the SFWMD DBHYDRO database for the South Branch at Corkscrew Road (north side), and the North Branch at the east end of Broadway Avenue, near the south boundary of Rookery Pointe. The gages are USGS devices and are continually recorded flow and stage data. There are also stage recorders along Halfway Creek located within The Brooks development. The Brooks gages are located (1) along the north side of Copperleaf community in the eastern section of the Brooks, (2) at the North Brooks Outfall Weir and (3) at the South Brooks Outfall Weir. The recorded data has been provided by The Brooks Community Development District's Engineer. Map 1-8 depicts a map of these stream gaging stations located within the Village Local-Scale model study area.

There are also numerous surface water observation stations (43), providing flow and stage data, located outside the Village of Estero boundary. In addition to the surface water gaging stations, there are 158 groundwater monitoring stations located within the domain of the Regional-Scale model study which were also used in the calibration efforts. Observation station data were adopted from recent models or compiled otherwise for years 2013 and 2014. Data through 2015 for all stations were added to existing databases that include data from 2006, thereby providing data for the continuous period of 2006 to 2015. The simulation period for calibration was initially set to January 1, 2013 through December 30, 2014. The calibration period was then reduced to the 2013 wet season since the primary focus of this project was to provide boundary conditions for a local-scale detailed ICPR flood simulation model for the Village, west of I-75. Therefore, the available gage and observation station data sufficiently covered the calibration period. Additional details regarding the groundwater observation stations utilized in the updates to the Regional-Scale model is provided within the Integrated Surface/Groundwater Modeling for the Village of Estero Watershed report, prepared by Water Science Associates and located within Appendix A.

Map 1-8: Stream Gaging Stations (USGS and Others)



1.7. Record Flows/Stages (since 2013) & Peak Stages/Flows 2017 Wet Season

A review of the recorded/measured flows and stages for the available observation stations was conducted as one of the initial steps in this study to support the updates for the Regional-Scale model and development of the Village Local-Scale model. Map 1-8 above depicts the location of the gaging stations. Figures 1-9a and 1-9b, depict the measured water levels, Datum NAVD 88, for the North and South Branches of the Estero River over the last 16 years. Figures 1-10a and 10b depicts the measured surface water flows within the North and South Branches of the Estero River. Figure 1-11 depicts the Halfway Creek measured water levels, Datum NAVD 88, for the Brooks gaging stations.

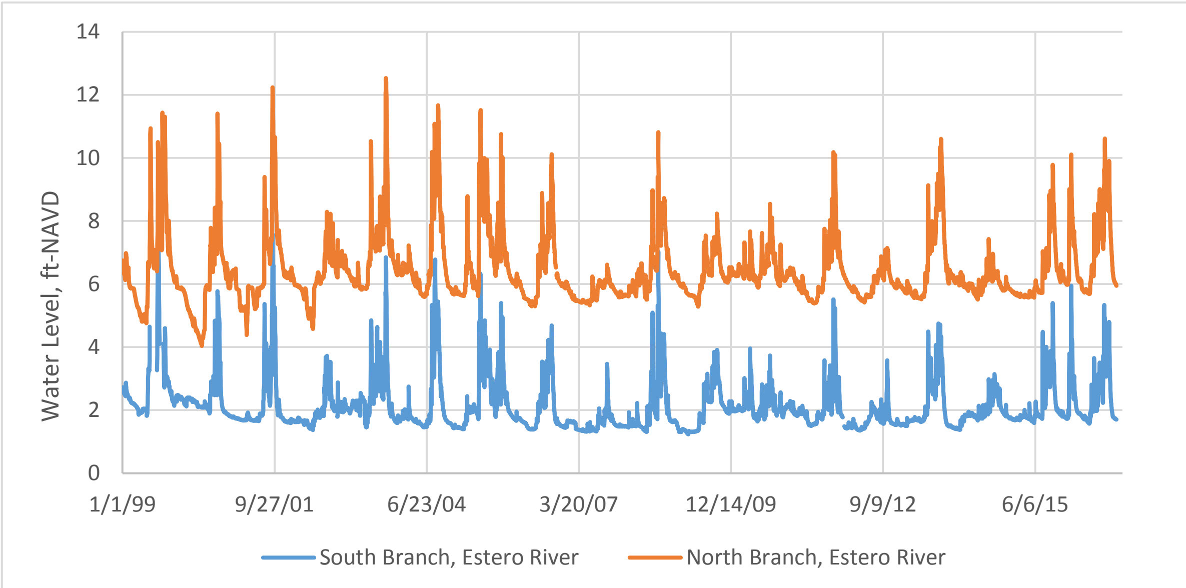


Figure 1-1: Estero River Water Levels
January 1, 1999 thru June 6, 2015

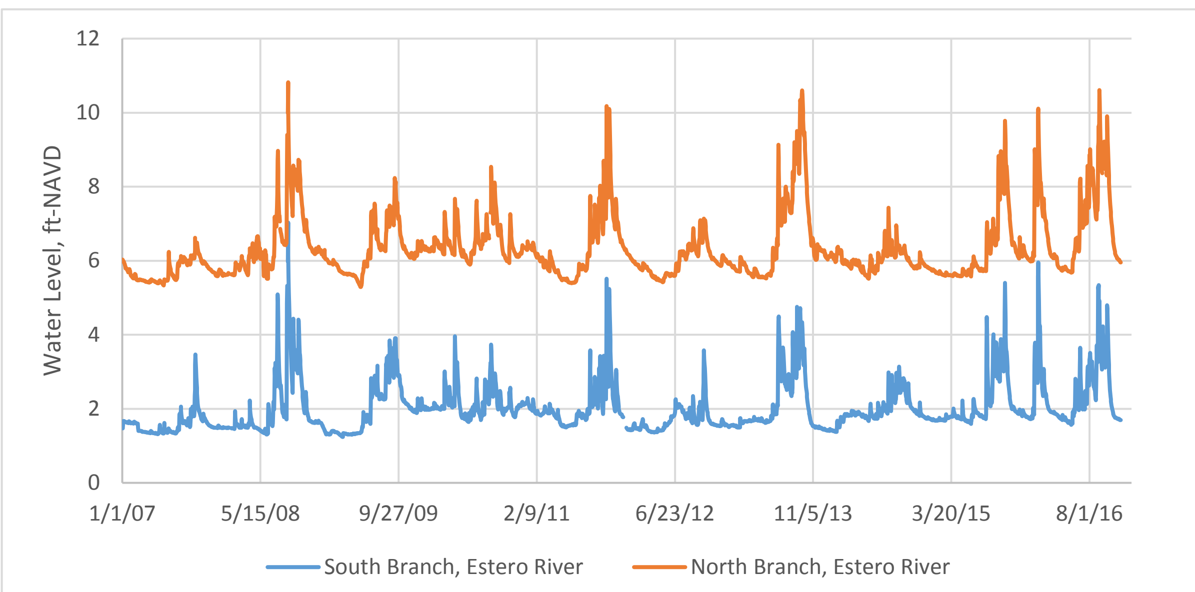


Figure 1-2: Estero River Water Levels
January 1, 2007 thru August 1, 2016

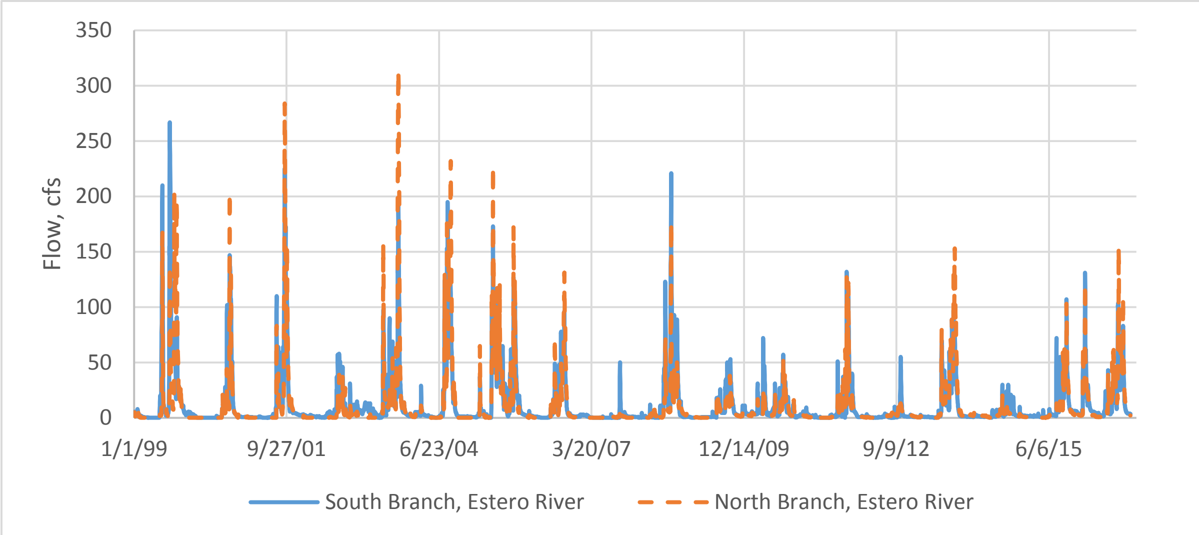


Figure 1-3: Estero River Flow Rates
January 1, 1999 thru June 6, 2015

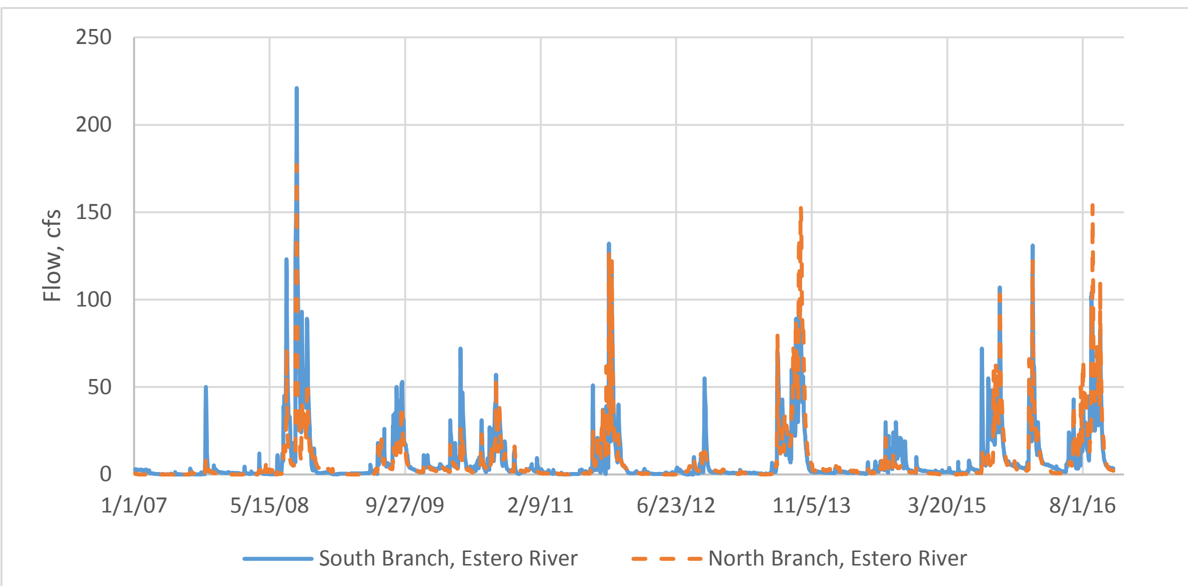


Figure 1-4: Estero River Flow Rates
January 1, 2007 thru August 1, 2016

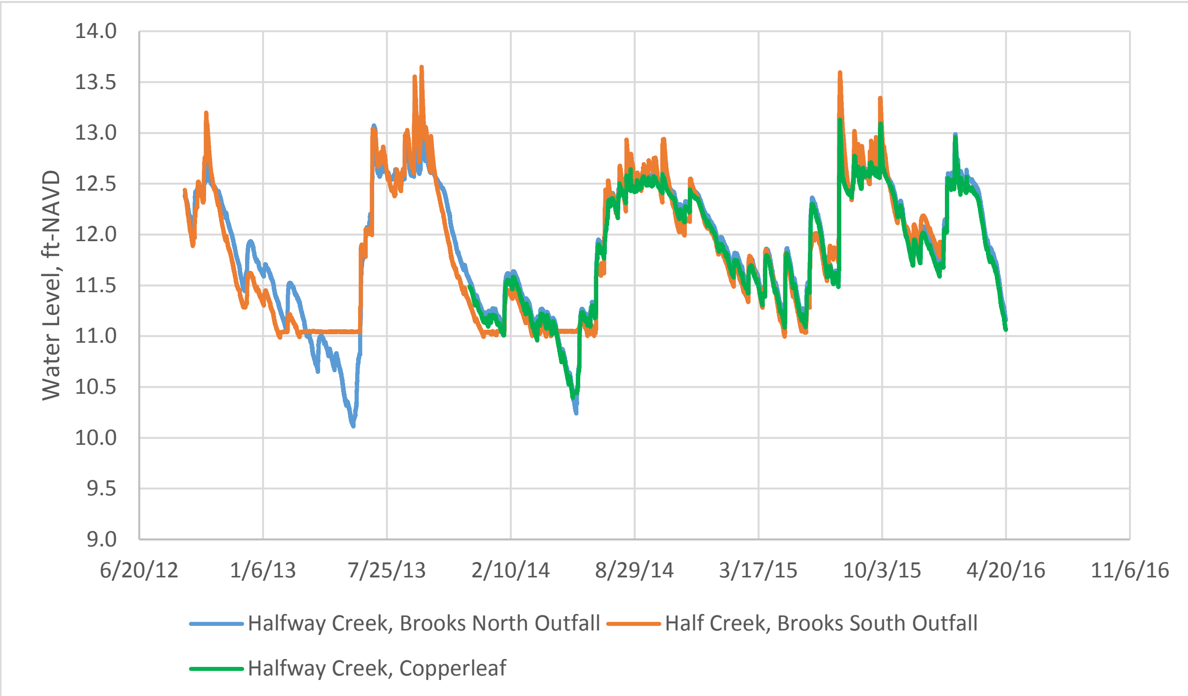


Figure 1-5: Halfway Creek Water Levels
June 20, 2012 thru November 6, 2016

<u>2017 Peak Flows and Stages</u>

In late August 2017, the southwest Florida region experienced a very heavy rainfall event, Invest 92L, that lasted five (5) days. The event occurred August 23rd through August 27th and delivered approximately 11.6 inches of rainfall on the Village of Estero. Shortly following the late August event, Hurricane Irma passed over the region, from September 9th-10th. Hurricane Irma delivered another 9.4 inches of rainfall on the Village of Estero. Two (2) events of this magnitude within a three-week period is extremely rare and resulted in the new peak stage and flow records for the gages within the North and South Branches of the Estero River. The back-to-back events resulted in flooding of major arterial roadways, such as Three Oaks Parkway and prolonged flooding of roadways within residential communities within The Village. Due to the significance of the August/September 2017 events, the calibration efforts of the Regional-Scale model were revisited, and the input data and model parameters were adjusted so that the 100-year design storm peak stages were in the range of the 2017 observed values. Because the field investigations for the August and September 2017 events provided high water marks at more locations than were available for the original calibration period (wet season 2013), the model input files were modified to better represent conditions during flood events.

Figures 1-6 and 1-1 depict the recorded stage and flow values for the gages within the North and South Branches of the Estero River during the period of 6/2017-10/2017. Figure 1-8 depicts the recorded stage values for the Halfway Creek gages. Map 1-9 provides a map of the recorded high-water marks for the 2017 rainfall events.

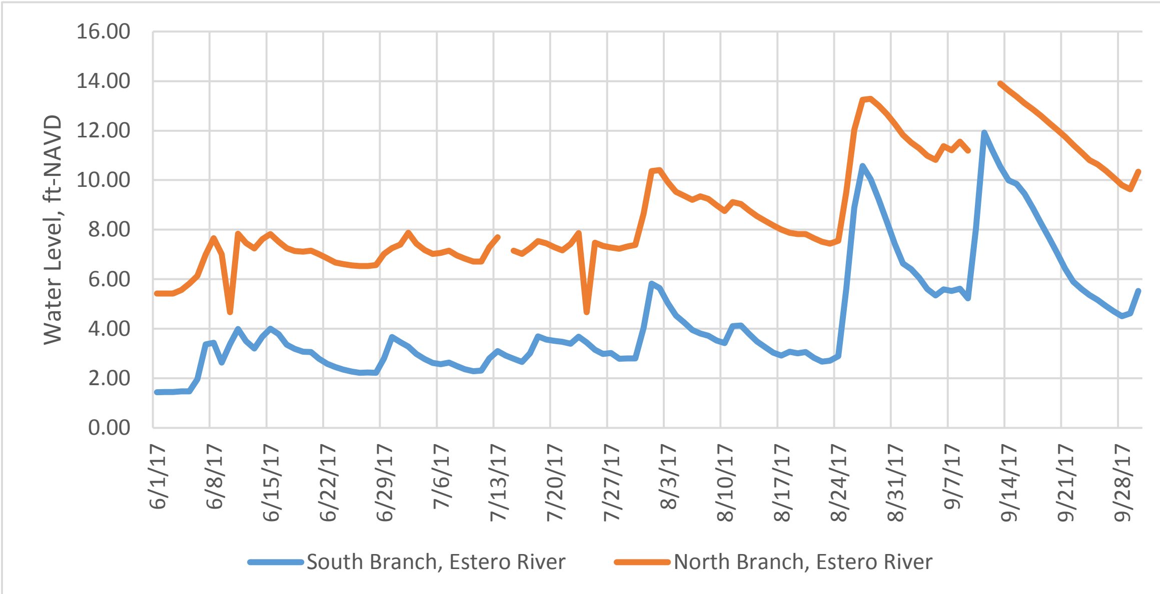


Figure 1-6: Estero River Water Levels
Wet Season 2017

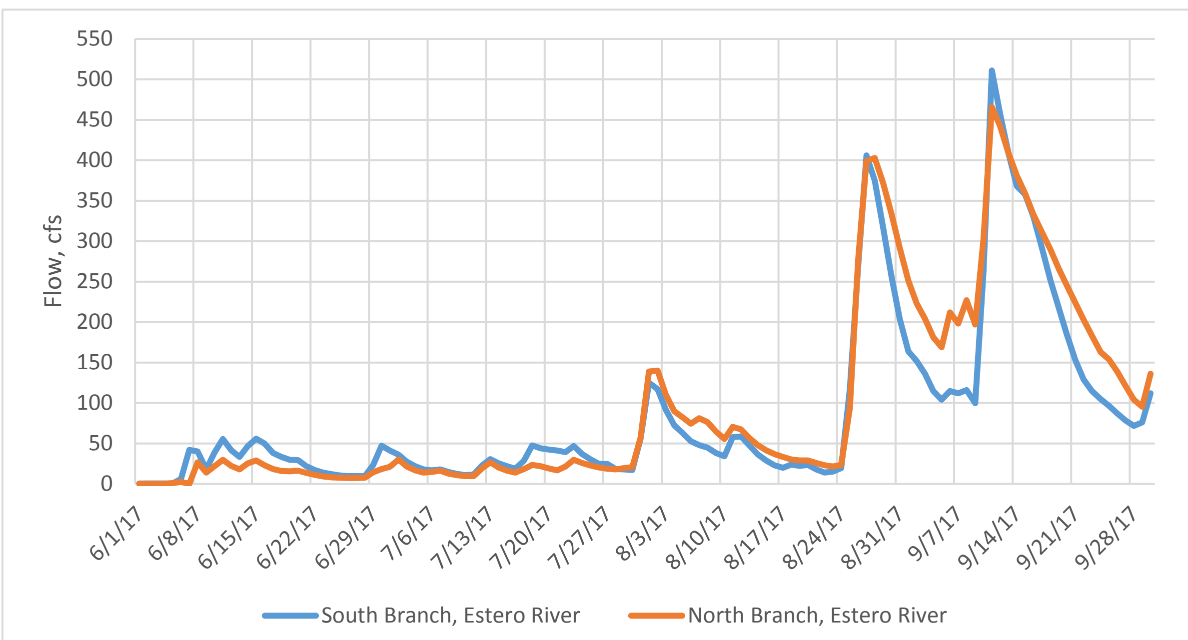


Figure 1-7: Estero River Flow Rates
Wet Season 2017

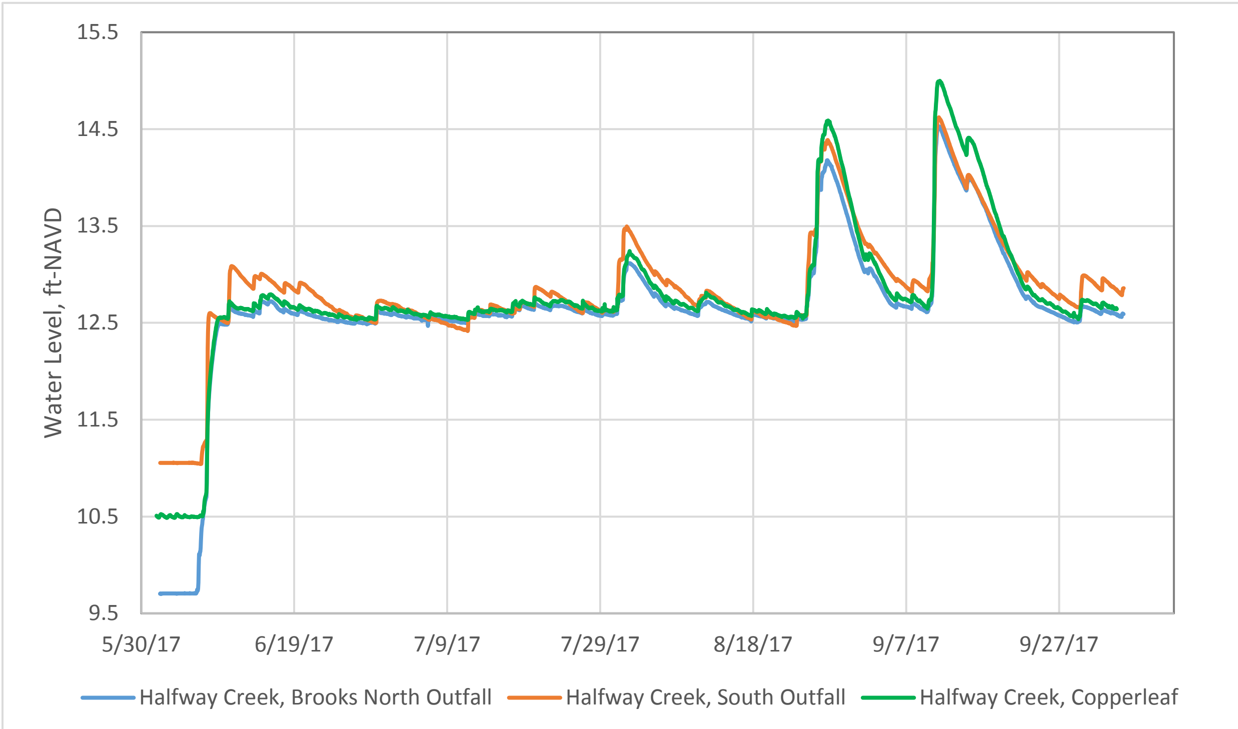
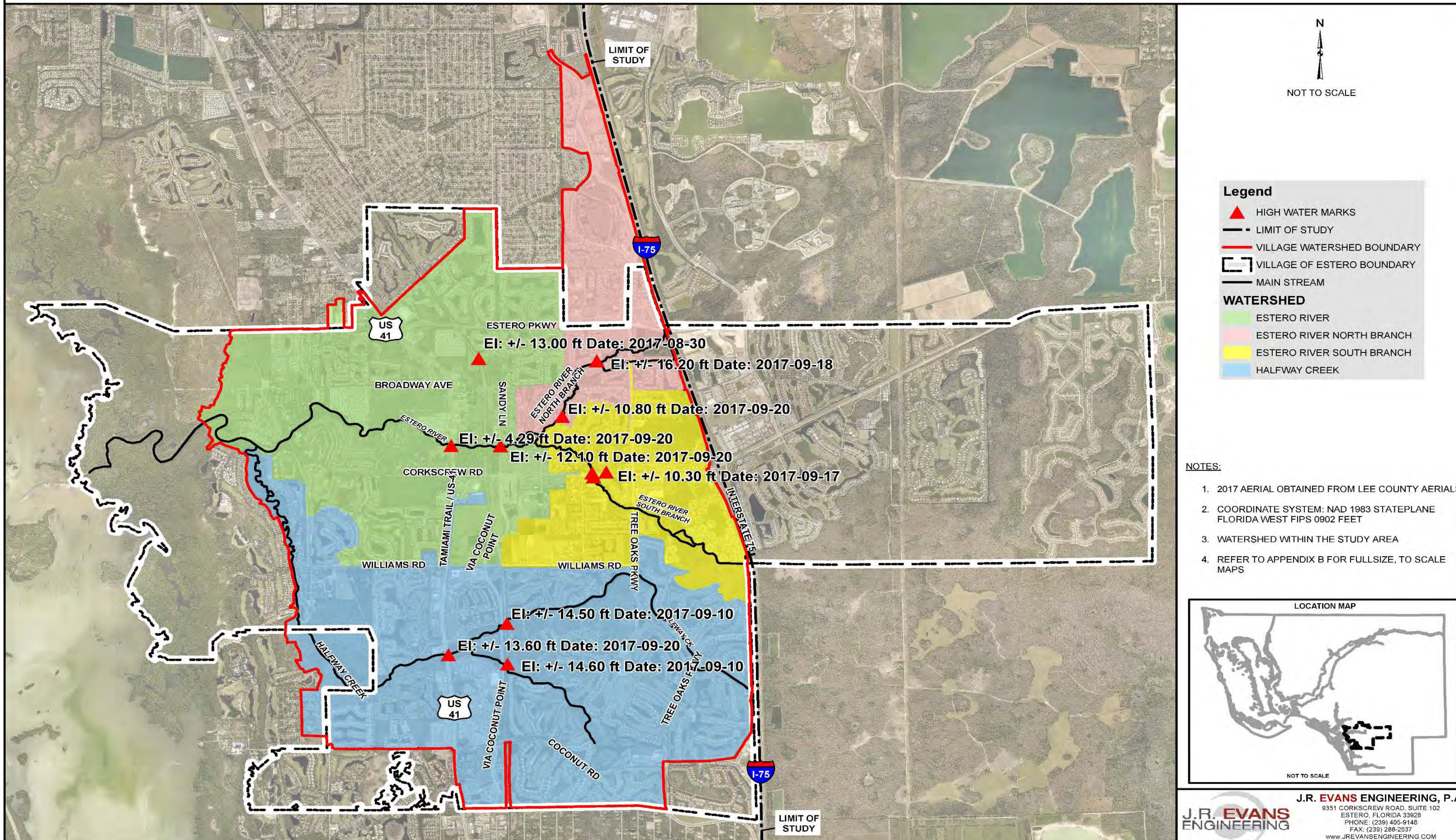


Figure 1-8: Halfway Creek Water Levels
Wet Season 2017

Map 1-9: Recorded High-Water Marks of August/September 2017 Wet Season Event

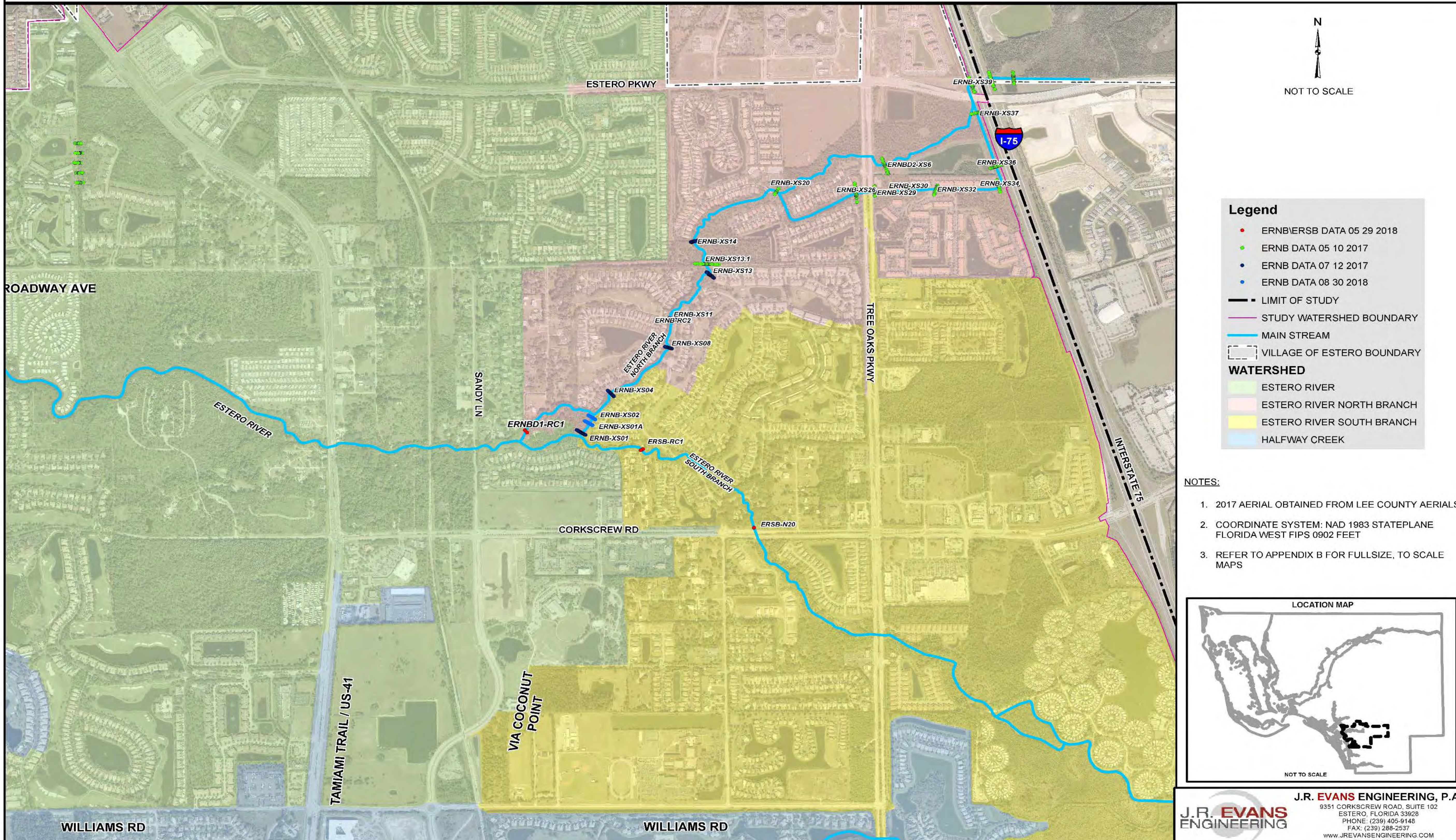


1.8. Surveyed Cross-Sections

To support the Regional-Scale and Local-Scale modeling efforts, a review of the existing cross-section information within the Regional-Scale model domain was conducted. Based on this review, additional cross-sections were surveyed to accurately represent the more current conditions of the study area, particularly of the main stream conveyances. The cross-section data was collected by Dagostino & Wood, Inc. Surveyed cross-sections were taken along the North Branch of the Estero River, within the Villages at Country Creek, Rookery Pointe, and Villagio communities. In addition, as-built survey cross-sections were obtained for portions of the South Branch of the Estero River where changes occurred with the recent development of the Estero Place and Villa Palmeras residential communities. The surveyed cross-sections and additional data were obtained in 05/2017, 07/2017, and 5/2018. The surveyed cross-sections were utilized in both the Regional-Scale and Local-Scale models. For the Local-Scale ICPR model, more channel cross-sections were defined for the main conveyances and secondary conveyances utilizing the following sources for the geometry and conditions: Existing cross-sections from MIKE SHE/MIKE 11 model, surveyed data, as-built information, field visits, current HEC-RAS models from Federal Emergency Management Agency (FEMA), and the Digital Elevation Model (DEM) per 2008 data.

Map 1-10 depicts the locations of where the additional cross-sections were surveyed by Dagostino & Wood, Inc.

Map 1-10: Additional Surveyed Cross-sections and Structures (Per Main Stream)

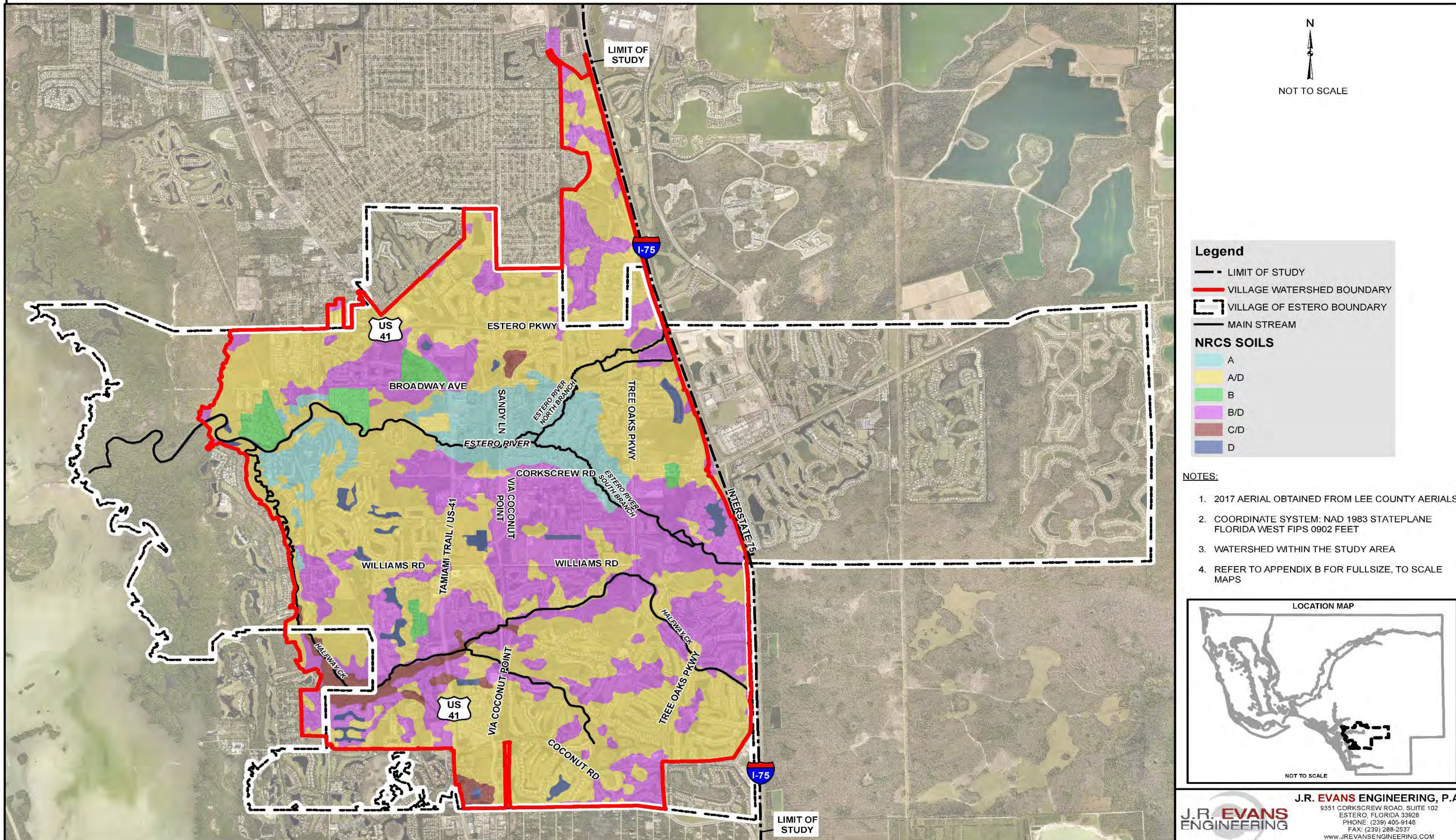


1.9. Soil Data

To support the Local-Scale modeling efforts, the most recent available soil data was obtained for the main conveyance watersheds within the Village of Estero study area. The soil data source is the National Resources and Conservation Services (NRCS), dated August 8, 2017. The soil data was processed as needed to be properly incorporated into the Local-Scale ICPR mode and result in a better evaluation of run-off characteristics for basin areas.

Map 1-11 depicts a map of the soil data utilized in the Local-Scale ICPR model.

Map 1-11: Soil Data

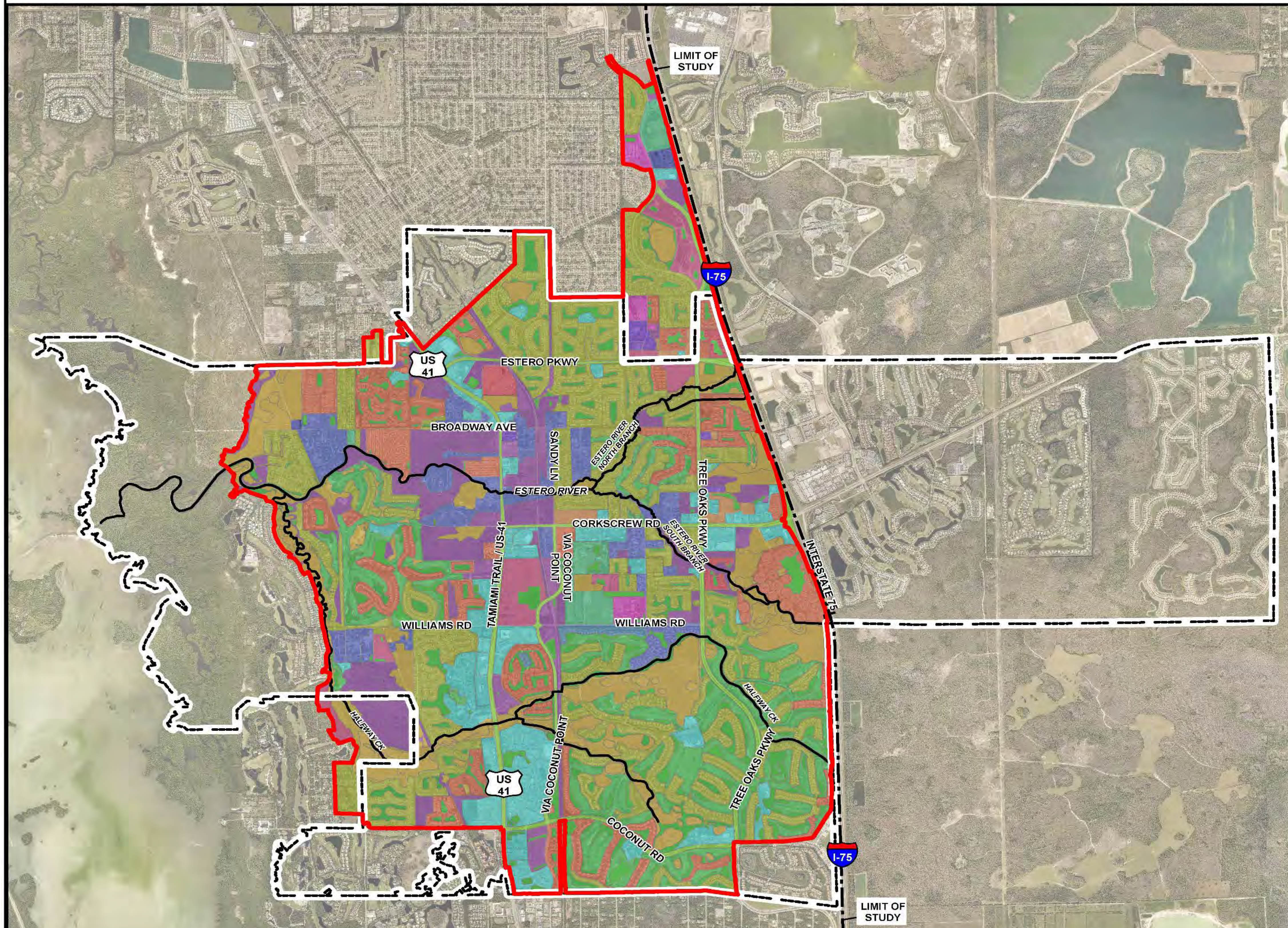


1.10. Land Use/Land Cover Data (Local-Scale ICPR4 Model)

To support the Regional-Scale and Local-Scale modeling efforts, the previous Land Use/Land Cover data was reviewed and updated to reflect the changes in land use since the 2009 South Lee County Watershed Master Plan Update project. The most significant changes included areas along the Estero Parkway, Three Oaks Parkway, Corkscrew Road and U.S. 41 corridors. In each of the modeling efforts, the land use/land cover data influences the rainfall runoff process. For the Regional-Scale MIKE SHE model, a detailed description of the updates and how the MIKE SHE model utilizes the information is provided in Section 2 of this report and within the Integrated Surface/Ground Water Modeling for the Village of Estero Watershed report contained in Appendix A. For the Local-Scale Village ICPR model, the land use/land cover data file was furthered refined for the specific study area to reflect current conditions. For the Local-Scale model the land use/land cover was adjusted where needed to be consistent with more current 2017 conditions. In both modeling efforts, the land use/land cover influences how stormwater runoff is handled on different types of properties. Based upon the type of land use/land cover, the rate at which the stormwater discharges from the land to storage areas is affected.

Map 1-12 depicts the final Land Use/Land Cover data and designations utilized in the Local-Scale model for the evaluation of existing conditions.

Map 1-12: Land Use/Land Cover Data (Local-Scale ICPR Model)



Legend

- LIMIT OF STUDY
- VILLAGE WATERSHED BOUNDARY
- VILLAGE OF ESTERO BOUNDARY
- MAIN STREAM

LAND COVER/LAND USE

- 1 Acre Lots
- 1/4 Acre Lots
- 1/8 Acre Lots
- Commercial
- Educational Facilities
- Golf Course
- Grass
- Homes
- Institutional
- Pasture
- Paved Roads
- Recreational
- Upland
- Urban High Density
- Utilities Facilities
- Water
- Wetland

NOTES:

1. 2017 AERIAL OBTAINED FROM LEE COUNTY AERIALS
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE FLORIDA WEST FIPS 0902 FEET
3. WATERSHED WITHIN THE STUDY AREA
4. REFER TO APPENDIX B FOR FULLSIZE, TO SCALE MAPS

LOCATION MAP

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Regional-Scale Model Update (MIKE SHE/MIKE 11)

2. Regional-Scale Model Update (MIKE SHE/ MIKE 11)

2.1. Model Description and Update Focus

Water Science Associates, Inc. (WSA) was contracted by J.R. Evans Engineering, P.A. to provide a regional modeling assessment for the Estero River and Halfway Creek watersheds. The purpose of the modeling assessment was to provide regional hydrology and surface water boundary conditions to J.R. Evans Engineering that will be used in The Village Local-Scale, detailed modeling assessment. The regional model used the integrated surface/ground water model MIKE SHE/MIKE 11, and the input files are based on files used in the Lee County Density Reduction/Groundwater Recharge project and the South Lee County Watershed Plan Update (SLCWMP). The model covers over 400 square miles and includes the drainage basins of the Estero River, Halfway Creek, Spring Creek, and the Imperial River. The model extends north of SR 82 into Lehigh Acres, east of SR 29 in Hendry County, and south of Bonita Beach Road in Bonita Springs, Florida. The area of study is shown graphically on Figure 2-1.

The model includes groundwater pumpage from the Green Meadows, Corkscrew, Pinewoods, and Bonita Spring Utilities wellfields. Irrigation from both agricultural and residential areas are also represented. The model has overland flow routines for the large wetlands east of I-75 and has hydrologic routines established for mining areas. Major road culverts and/or bridges are represented in the model for the North and South Branches of the Estero River and Halfway Creek, including The Brooks by-pass gate and the outflow weirs located along the west side of The Brooks.

The scope of work included incorporation of numerous model improvements with more recently acquired data sources, calibration of the model to known hydrologic data, and development of boundary conditions for the Village Local-Scale ICPR model based on the updated SLCWM (South Lee County Watershed Model).

The Regional-Scale Model:

- Provides boundary conditions from the regional model calibrated to over 200 calibration stations for the local scale modeling effort;
- Provides base information for the development of a local scale ICPR model to be utilized as an appropriate tool for evaluating development proposals located west of I-75.;
- Utilized recent information from two large rainfall events in 2017, including Hurricane Irma, to support the calibration effort;
- Was used to identify areas with regional drainage problems;
- For proposed regional-scale projects, it can be used to evaluate the impact of drainage changes on wet season water levels in the vicinity of the proposed improvements.

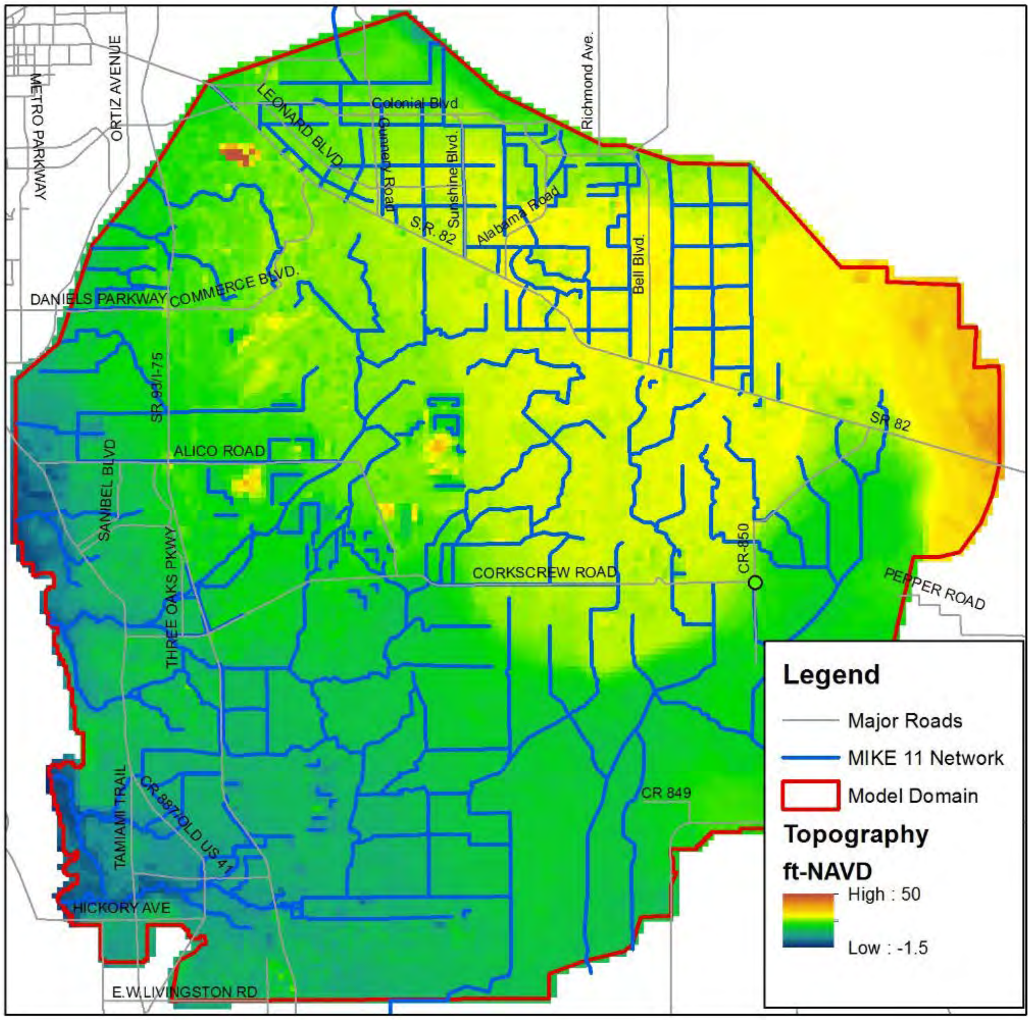


Figure 2-1: Regional-Scale Model Study Area (MIKE SHE)

2.2. Regional Drainage Points of Discussion

Based on the results of this modeling study and previous studies, there has been a considerable amount of evaluation of the Estero River and Halfway Creek watersheds with respect hydrology and flow patterns. The Village of Estero is located within each of these two (2) watersheds and it is important for The Village to understand and take into consideration regional-scale activities that could positively or negatively impact the flooding behavior within the waterways of The Village. Through this study, the specific sub-watershed areas for each of the main conveyances have been delineated west of I-75. Based on the delineation, the North Branch of the Estero River receives contributing flows from properties located as far north as Alico Road. Therefore, it is important to look at regional improvements within the Alico Road corridor and south towards Corkscrew Road, east of I-75.

The Regional-Scale model was used to identify areas of regional drainage problems and determine potential actions that could be taken to reduce flooding conditions. Observations made during previous major flooding events in 2017 were also considered. Based on a review of modeling results and flooding problems observed in late 2017, the following activities are recommended for consideration:

- Increased storage is needed in the North Branch Estero River for large rain events. High water levels were observed in September 2017, both east and west of I-75, therefore storage of floodwaters during large rainfall events would benefit multiple developments along the North Branch.
  - Lee County already owns an inactive mining pit south of Alico Road that could be converted to an off-line reservoir for temporary storage during major floods. Numerous other mining pits could also be used for storage if a private-public arrangement could be established (the SFWMD Water Farming Program is an example of how this can be implemented).
- If additional storage is provided, consideration should be given to decreasing or eliminating flows along the north side of Alico Road east of I-75 that are conveyed west to Ten Mile Canal. Surveying of channel dimensions and roadway culverts would be required along with flow measurements during flooding events to better understand the potential impacts of capturing flows that currently flow west.
- Between I-75 and Alico Road, direct more flow south of Corkscrew Road. Flow pathways for the area south of Corkscrew Road and east of I-75 are shown below in Figure 2-2. Flow pathways for the area north of Corkscrew Road and south of Alico Road are shown in Figure 2-3.
- Re-establish historic flow-ways across Corkscrew Road east of the intersection with Alico Road. This could include public-private partnerships.
- Promote more groundwater recharge in the headwaters of the Estero River, Halfway Creek, and Imperial River watersheds.

Water depths relative to land surface south of Corkscrew Road east of I-75 are presented in Figure 2-2. In the areas south of Corkscrew Road, flow is to the south and west towards the South Branch Estero River (point 4) and Halfway Creek (point 5), as indicated by the arrows on Figure 2-2. Figure 2-3 presents a map of wet season water depths relative to land surface for areas east of I-75 in the area of Corkscrew Road and Alico Road. Flows in cubic feet per second for September 8, 2013 are shown in yellow.

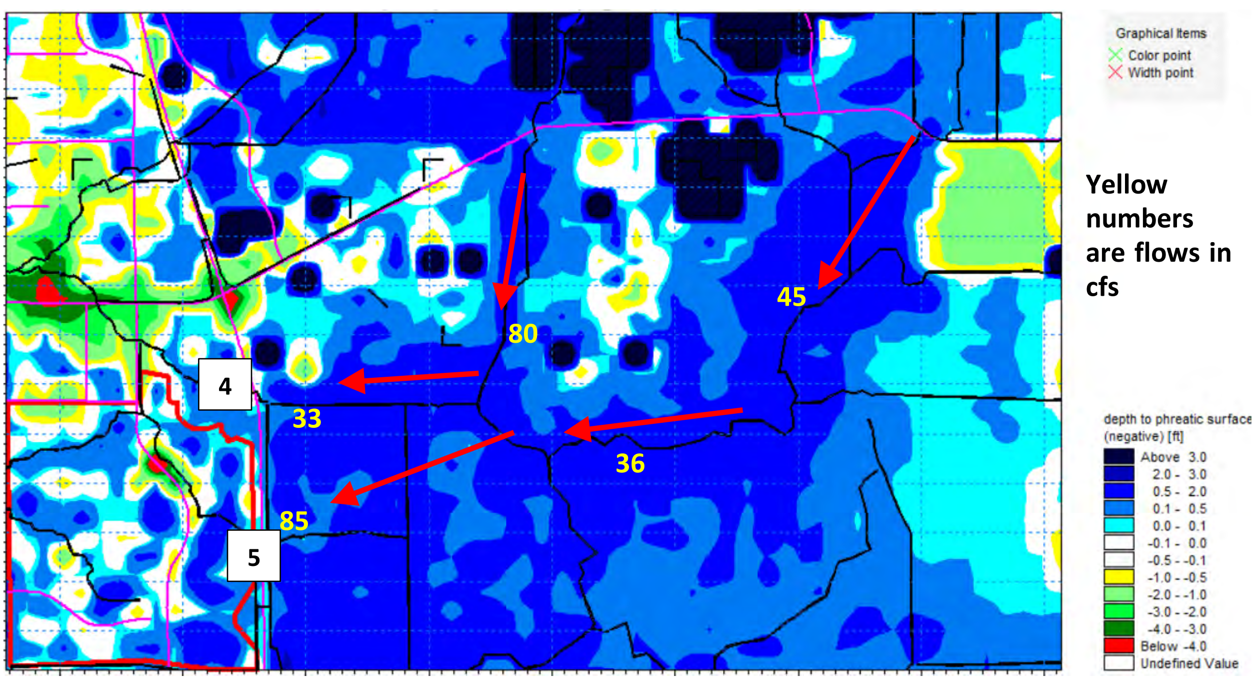


Figure 2-2: Wet Season Flow Depths Relative to Land Surface Areas South of Corkscrew Road and East of 1-75

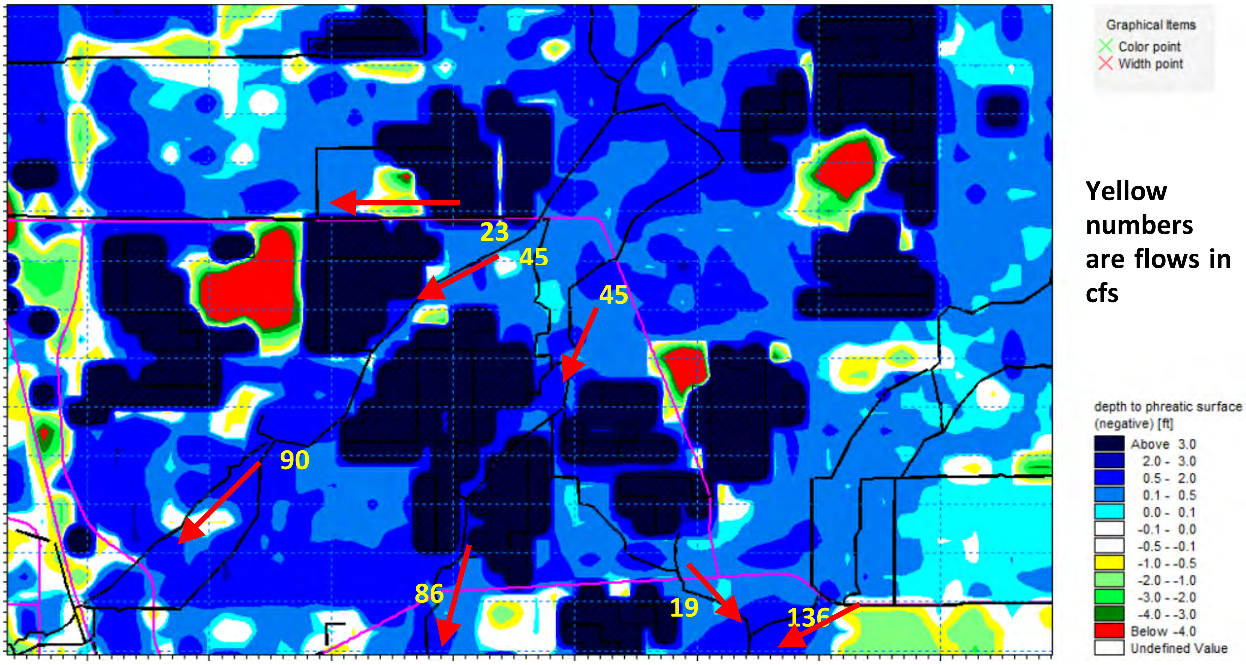


Figure 2-3: Wet Season Flow Depths (9-8-13) Relative to Land Surface Areas North of Corkscrew Road and East of I-75 (red arrows indicate flow direction)

2.3. MIKE SHE/MIKE 11 Updates

The updates to the MIKE SHE/MIKE 11 model included more recent topography, climate data, land use/land cover data, hydrogeology, surface water information in the form of recent surveyed cross-sections, new weirs, culverts, gates, etc., water use records and calibration data. Within the following paragraphs, the specific updates are summarized. A more detailed discussion of the updates is provided within the Integrated Surface/Groundwater Modeling for the Village of Estero Watershed report, prepared by Water Science Associates located in Appendix A.

Topography: The latest LiDAR data for Lee, Collier and Hendry Counties was obtained from the South Florida Water Management District (SFWMD) database, dated 2007/2008. The new data was incorporated into the MIKE SHE/MIKE 11 model using a 750-ft sampling of resolution. The elevations range from +50 FT NAVD in the eastern portion of the model study area to -1.0 FT NAVD at the coast, on the west side of the model study area. Figure 2-1 depicts a graphical view of the digital elevation model generated from the LiDAR data.

Rainfall Data: Hourly NEXRAD rainfall data was obtained from SFWMD for a period from January 1996 to November 2016. In addition, Daily reference ET (RET) data was downloaded from the USGS website from the years 1995 through 2015 and processed.

Land Use/Land Cover Data: The previous data used in the 2008/2009 SLCWMP project was updated within the MIKE SHE graphical user interface to better represent several developments that were constructed between 2009 and 2013, including eastern portions of Miromar, the Preserve, southern portions of Bella Terra, and Corkscrew Shores. In addition, changes were made in several agricultural areas that were abandoned between 2009 and 2013. The crop development was extended up to year 2016 to cover the long-term simulation period. The vegetation database from the most recent model developed for the Collier County was used.

Irrigation: Irrigation was specified for land use types based on SFWMD water use irrigation permit records. MIKE SHE uses an irrigation command area file to define which areas are irrigated, how irrigation is applied (sprinkler, drip, or sheet), and the irrigation source (river, single well, shallow well, or external). For this model update, irrigation command areas file was carefully checked within the Estero River watershed to assure that irrigated lands were represented in the model. Also, the type of irrigation and the water sources were checked and modified as necessary.

Surface Water Components: The MIKE 11 network was modified in the Corkscrew Swamp area in accordance with the new flow paths from the most recent Collier County Model. In the area located North from SR-80, the branches and structures were replaced from the ones in the most recent model that is being used for watershed evaluations of the Lehigh Acres Municipal Services Improvement District (A.D.A. Engineering, Inc., 2016). In addition, the path of some branches in the western part of the model were redrawn, and other small branch segments added to represent stormwater detention facilities that attenuate wet season runoff. The cross sections were set to be consistent with the combined area within a development, and an outflow weir was added based on permit files for the developments. The network updates also include updating the cross-sections of the MIKE11 branches and incorporating recently surveyed cross-sections for the North and South Branches of the Estero River, which are described in Section 1.9 of this report.

Water Use/ Observation Wells: The data was adopted from recent models and/or compiled for years 2013 and 2014. The data through year 2015 for all observation stations were added to the existing database, which included data from 2006. In addition, the model data for municipal potable water supply wells was also updated to include the information from the Water Supply Permitted Facility Site shape file (imerrwuf.shp) as on October 21, 2015. The monthly pumping extraction data reports for all the wells was obtained from the SFWMD for years 2006 throughout 2015.

2.4. Regional-Scale Model Calibration Efforts

Model calibration is a process of developing an input data set that allows the model to simulate changes in water levels and river flows over a specified period of time that is a close approximation of observed conditions. The calibrated model is a simplification of actual conditions because it is not possible to fully represent the numerous factors that dictate the behavior of both surface and ground water flow in a 418-square mile area. Applying changes to model inputs is a key calibration process and allows reasonable estimation of unknown conditions. For the Regional-Scale Model, simulation results at the calibration stations were compared to recorded water levels and flows, and adjustments were applied to the input data to improve calibration. The simulation period for calibration was initially set to January 1, 2013 through December 30, 2014. The calibration period was then reduced to the 2013 wet season since the primary focus of this project was to provide regional hydrology and surface water boundary conditions for a local-scale detailed ICPR model for the Village of Estero west of I-75. As mentioned in previous sections, significant rain events occurred in late August 2017 and early September 2017, during the later phases of the calibration effort. Based on the observed peak water levels in the North and South Branches of the Estero River and the resulting flooding conditions throughout the Village, it was determined to further adjust the input data for the Regional -Scale model to be reasonably consistent for the 100-year design storm peak stages and better represent wet season peak conditions within the Village. Details on the calibration efforts are provided within the Integrated Surface/Groundwater Modeling for the Village of Estero Watershed report, prepared by Water Science Associates located in Appendix A of this report.

For the calibration of the Regional-Scale model, the three (3) primary statistical measures utilized were mean error, mean absolute error, and correlation coefficient. Mean error (ME) is the arithmetic average of the difference between the simulated and measured water levels or flows during the calibration period. Mean error can be 0.0 (perfect calibration) if half of the differences are -1.0 foot and the other half of the differences are +1.0 foot, therefore this calibration parameter needs to be complimented with other calibration metrics. The mean error statistic is an effective statistic to quantify the overall model performance relative to measured data. Mean absolute error (MAE) is the arithmetic average of the absolute difference between the simulated and measured water levels or flows during the calibration period. The correlation coefficient (r) is used to measure the strength and direction of the linear relationship between the measured data and the results at that location in the model. A value of 0 indicates no correlation, a value of 1 indicates an exact correlation. For the purpose of this Regional-Scale study, the thresholds for each of the calibration measures were as follows:

Table 2-1: Calibration Performance Metrics

Performance	Mean Error (ME)	Mean Absolute Error (MAE)	Correlation Coefficient (r)
Good	-0.5 to 0.5 ft	<0.75 ft	>0.80
OK	-1.0 to -0.5 or 0.5 to 1.0	>0.75 and < 1.0 ft	>0.65 and < 0.80
Poor	<-1.0 or >1.0	>1.0 ft	<0.65

Calibration, as measured strictly by the calibration statistics, was considered good in 37 of 74 stations for MAE and 52 of 74 stations for correlation coefficient. Model performance considered both good and OK for 48 of 74 stations for MAE and 63 of 74 stations for correlation coefficient. In all the stations where calibration was considered to be OK, the calibration was very good in the wet season, which is the primary focus of the study. The adjustments made to the Regional-Scale model during the calibration process are detailed within the Integrated Surface/Groundwater Modeling for the Village of Estero Watershed report, prepared by Water Science Associates located in Appendix A of this report. The adjustments included improved cross-section parameters, updates to the water use parameters, detention storage areas, hydraulic conductivity within the surficial aquifer, and cross-section roughness coefficient changes.

After completion of the initial calibration, the simulated water stages were compared with the peak stages resulting from the August/September 2017 events. Additional adjustments were made to certain input parameters and model runs were executed with the intent to achieve peak stages during the 100-year, 3-day event reasonably close to the observed and recorded 2017 peak stages, while maintaining the calibration performance for the 2013 wet season. These changes within the Regional-Scale model involved roughness coefficient (Manning's "n") value adjustments and initial stages. Based on the results, the comparison of the simulated stages, the results are in range of the observed peak stages and provides confidence that the calibrated model is a valuable tool for providing wet season boundary conditions for the Village Local-Scale model, west of I-75. Details and comparison tables resulting from the calibration efforts are provided within the Integrated Surface/Groundwater Modeling for the Village of Estero Watershed report, prepared by Water Science Associates located in Appendix A of this report.

2.5. Local-Scale Model Boundary Conditions

The Regional-Scale model results for the nodes located at I-75 culverts and bridges were isolated for discharge and stage. The locations for the boundary conditions were selected based upon locations of significant inflow into the system. A total of five (5) upstream boundary condition locations were selected which are described as follows:

- Location #1: I-75 bridge crossing located just north of Estero Parkway overpass
- Location #2: I-75 culvert crossing located 0.23 miles south of Estero Parkway overpass
- Location #3: I-75 culvert crossing located 0.40 miles north of Corkscrew Road
- Location #4: I-75 bridge crossing located 0.77 miles south of Corkscrew Road
- Location #5: I-75 culvert crossing located 1.90 miles south of Corkscrew Road

For the downstream boundary condition, one (1) location was selected since Halfway Creek joins the Estero River Main Branch approximately 2.0 miles downstream of the U.S. 41 bridge crossing. The downstream boundary location is approximately 0.63 miles downstream of the confluence of the Halfway Creek and Estero River.

The times series for the five (5) input locations into the Village of Estero from East of I-75 were used as the incoming boundary conditions for the Local-Scale model. The locations of the upstream boundary conditions were selected based upon known conditions and locations where significant flows occur. There is a crossing under I-75 coming from Stoneybrook that flows into the lakes located within the Corkscrew Woodlands community. Based on a previous evaluation of flows through that culvert, it was determined that there is minimal flow through that culvert due to the management of flows from the Stoneybrook community. All the discharge flows from the Stoneybrook development are directed towards the wetlands located south of the development. Therefore, this culvert crossing was not included in the regional model and not considered for a boundary condition for the local-scale model. A map of the upstream boundary conditions is shown in Figure 2-4.

Boundary Condition Location #4 includes a bridge (dimensions obtained from FDOT files) and four 8' x 8' box culverts that are physically located south of the I-75 bridge and are included as part of the South Branch Estero River MIKE 11 branch. Therefore, Location #4 include two (2) crossings under I-75 as being connected and flowing into the South Branch of the Estero River.

The boundary condition files included the downstream boundary condition for the Estero River. Tidal water level data from the NOAA Naples tidal station 8725110 were used as the downstream boundary condition.

The boundary conditions were a results of design storm simulations in the Regional-Scale model, which included the 5-, 10-, 25- and 100-year design storms. The 5-, 10-, 25-year and 100-year simulations were executed using initial condition ground water levels from July 15, 2013 and surface water levels from August 20, 2013. Surface water levels were revised to August 20th after a review of observed water levels from large rainfall events in late August and early September 2017. The design storm rainfall amounts were 5.5, 6.5, 11.2, and 13.2 inches, respectively for the 5-, 10-, 25- and 100-year events. The rainfall distribution applied to the entire model domain was as defined in the SFWMD Applicants Handbook. Simulated stages and flows were extracted from the MIKE 11 result files at locations along I-75 where culverts or bridges allow for conveyance west of I-75. Figure 2-4 illustrates these boundary condition locations. Peak stages and flows for the 5-, 10-, 25- and 100-year design storms are shown in Table 2-2.

1	North Branch Estero River
2	Culv 1200 ft S of Estero Pkwy
3	Culv 2350 ft N of Corkscrew Rd
4	South Branch Estero River
5	Halfway Creek

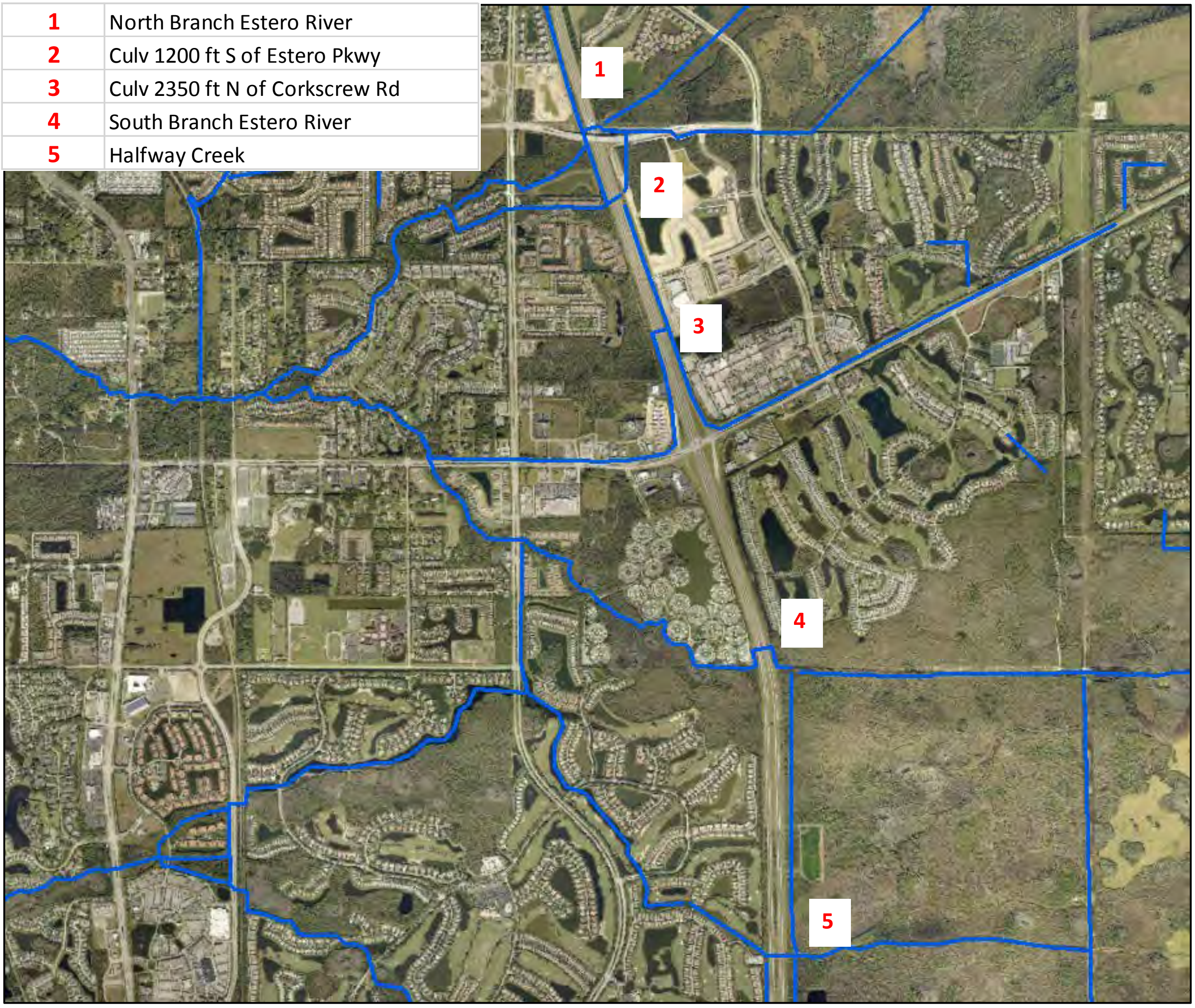


Figure 2-4: Location of Boundary Conditions Used from MIKE SHE Model

Map 2-1: Location of Boundary Conditions Used from MIKE SHE Model

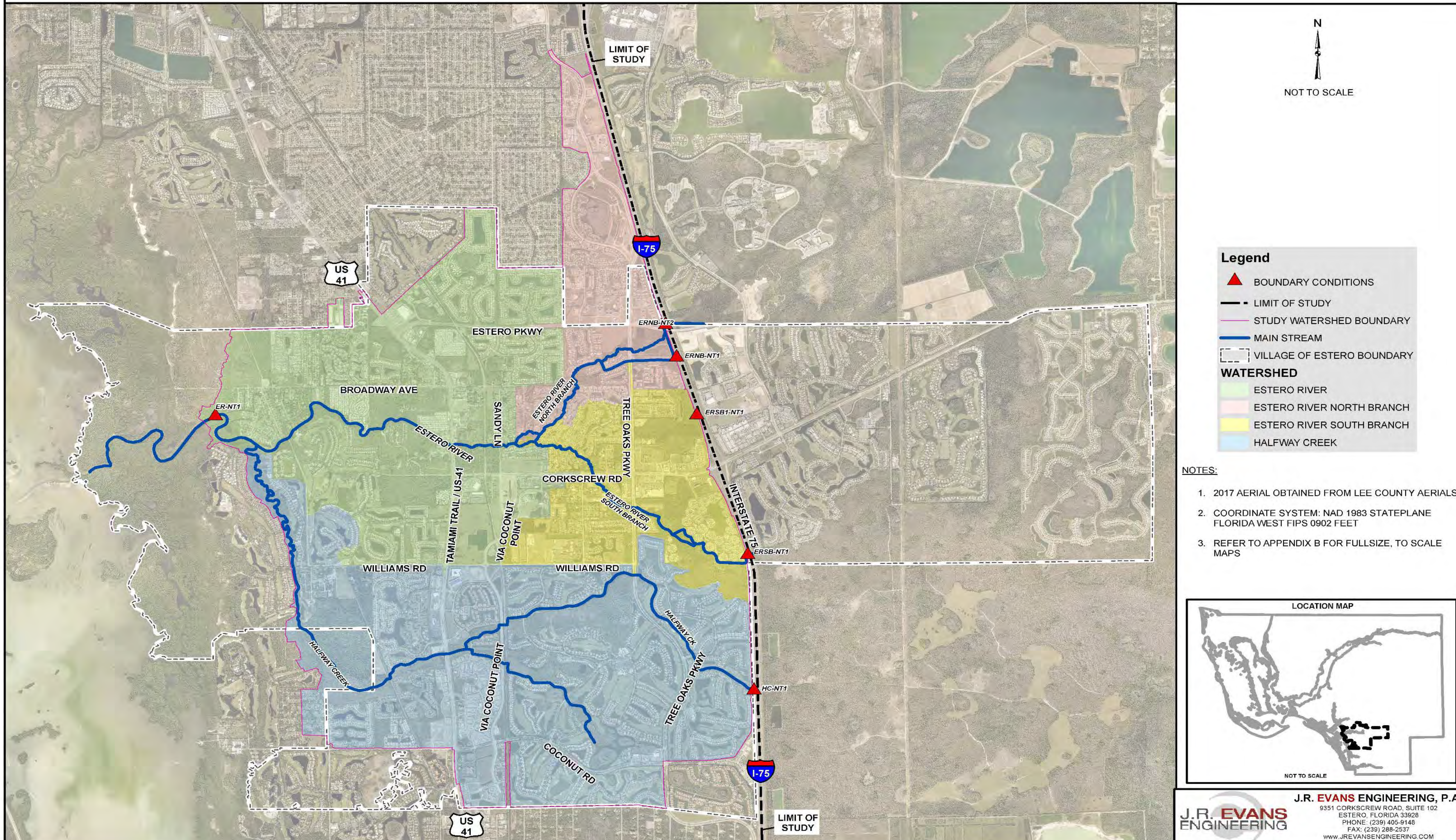


Table 2-2: Simulated Peak Boundary Stages and Flows

Location	5-Year, 1-Day Design Storm		10-Year, 1-Day Design Storm	
	ft-NAVD	cfs	ft-NAVD	cfs
1 - North Branch at I-75	15.4	121.6	15.6	141.8
2 - Culvert 1200 ft S of Estero Pkwy	13.2	18.4	13.4	23.7
3 - Culvert 2350 ft N of Corkscrew Rd	14.6	33.3	14.8	41.1
4 - South Branch Estero River	14.4	62.1	14.6	94.7
5 - Halfway Creek at I-75	13.1	133.3	13.4	155.1

Location	25-Year, 3-Day Design Storm		100-Year, 3Day Design Storm	
	ft-NAVD	cfs	ft-NAVD	cfs
1 - North Branch at I-75	15.9	181.5	15.9	187.3
2 - Culvert 1200 ft S of Estero Pkwy	14.2	46.4	15.2	135.0
3 - Culvert 2350 ft N of Corkscrew Rd	15.2	64.3	15.7	104.0
4 - South Branch Estero River	14.8	127.5	15.0	167.5
5 - Halfway Creek at I-75	14.1	209.3	14.4	251.2

Village of Estero
Local Scale Model
(ICPR 4)

3. Village of Estero Local-Scale Model (ICPR V4)

3.1. Model Description and Focus

Once the Regional-Scale model updates and the data collection tasks were completed, work began on creating a more detailed Local-Scale model specific to the Village watershed boundaries, located west of Interstate I-75. The main goals of the Local-Scale model include the following:

- Develop and assess the existing inventory of the stormwater facilities within the Village;
- Identify deficiencies within the systems - flooding/conveyance issues;
- Provide a framework for evaluating stormwater improvement projects and new developments; and
- Identify and evaluate flood mitigation projects.

The software utilized to create the Local-Scale model is Interconnected Channel and Pond Routing (version 4.03.02), known as ICPR4. ICPR4 is a fully integrated 1D/2D surface and groundwater model platform. ICPR is a widely used and accepted modeling platform throughout Florida for simulating hydrologic and hydraulic analyses and similar studies. The ICPR4 platform is also integrated with GIS (Graphical Information System) data so that the model is properly geo-referenced and can be easily updated with new data as it becomes available. The ICPR4 is not limited with the number of model elements and is therefore well suited to utilize for a detailed model of the local stormwater infrastructure system within The Village of Estero.

The Local-Scale model includes the contributing watersheds for all four (4) main waterways: Estero River Main Branch, Estero River North Branch, Estero River South Branch and Halfway Creek. The Local-Scale model includes the main waterways, secondary conveyances, other major conveyances considered critical, discharge control structures from permitted developments, overland flow from uncontrolled parcels and major network components such as culverts, bridges, and weirs. The secondary conveyances include critical roadways or roads with known drainage issues, such as: Three Oaks Parkway, River Ranch Road, Estero Parkway, Corkscrew Road, U.S. 41, Broadway Avenue, and the Seminole Gulf Railroad ditch system. The Local-Scale model represents a reasonably accurate depiction of the stormwater network located within The Village and within contributing watershed areas adjacent to The Village. The following report sections will review the input data and parameters defined for the model as well as an evaluation of the results from the existing conditions and build-out scenarios.

3.2. Description of Input Data and Parameters

3.2.1. Model Link Element Parameters (Manning's N, Entrance and Exit Losses, etc.)

The hydrologic/hydraulic analysis of the study area considers all the data collected from available plans, permits, record information, ground surveys, and field recognizance. Both the hydrology and the hydraulics of the overall system were evaluated using the Interconnected Channel and Pond Routing Model (ICPR4) software (version 4.03.02). In consideration of the main waterways, the available cross-section data from the FEMA hydraulic HEC-RAS models and the Regional-Scale MIKE 11 model were evaluated and cross-sections were further defined within the Local-Scale model utilizing the most appropriate data. Both sources of the cross-section definition were considered with the final determination of cross-section location and alignment. In areas of low-confidence, additional cross-sections were surveyed in the field and incorporated into the model input data. The surveyed cross-sections are depicted on Map 1-10, in Section 1. Overall, cross-sections were aligned considering the characteristic of the channel/swale and predominant flow change locations.

The Manning's "n" values for the main waterways (streams) and secondary conveyance channel links were determined using acceptable values (such as: Chow's book "Open-Channel Hydraulics" - Chow, 1959). Higher Manning's "n" values where used during the Existing Conditions Scenario to represent the areas of vegetation overgrowth (within the channel), negative slopes, flow impingement, etc. Each of the main streams contain different characteristics with respect to slope, vegetation, meandering, etc. For example, the Estero River Main Branch is a wide, clean waterway extending from the Bay upstream to U.S. 41. From the crossing at U.S. 41, the River conditions begin to change to a narrower stream with steeper side slopes, more vegetation growth and a meandering alignment. Based on the evaluation of each main stream, a range of Manning's "N" values were utilized to represent the conditions at certain locations. Table 3-1 defines the ranges used per main stream and per channel and overbank areas.

Table 3-1: Manning's "N" Values – Main Stream

Main Stream	Manning's "N" Value Range		
	Channel	Left Overbank	Right Overbank
Main Branch West of U.S. 41	0.03-0.05	0.06-0.12	0.03-0.10
Main Branch East of U.S. 41	0.09-0.12	0.14-0.16	0.12-0.14
North Branch, Up to Rookery Circle	0.09-0.12	0.12-0.16	0.12-0.16
North Branch, From Rookery Circle to I-75	0.04-0.065	0.08-0.12	0.06-0.12
South Branch, From Confluence to Sanctuary Drive	0.05-0.10	0.08-0.17	0.12-0.17
South Branch, From Sanctuary Drive to I-75	0.04-0.07	0.10-0.15	0.06-0.14
Halfway Creek	0.04-0.06	0.06-0.14	0.06-0.12

For the secondary conveyances that are open swales or ditches, the following Table 3-2 defines the Manning's "N" values used per observed condition of the conveyance.

Table 3-2: Manning's "N" Values – Secondary Channels

Secondary Channels Conditions	Manning's "N" Value Range
Well-Maintained / Short Grass / No Trees	0.035-0.04
Not Maintained / Weed and Brush Present	0.05-0.08
Not Maintained / Dense Brush at High Flow Stage	0.08-0.14

For the secondary conveyances that are piped and for piped network elements, the following Table 3-3 defines the Manning's "N" values used.

Table 3-3: Manning's "N" Values – Piped Conveyance

Pipe Material	Manning's "N" Value Range
Reinforced Concrete Pipe (RCP)	0.013
Corrugated Metal Pipe (CMP)	0.023
Polyvinyl Chloride Pipe (PVC)	0.01

For the culverts, pipes, discharge control structures, and weirs defined within the model network, appropriate structure Entrance and Exit Loss coefficients were applied based on the alignment of the culvert and end treatment, whether connected to a structure or open channel. Provided in Table 3-4 are the ranges of the Entrance and Exit Loss coefficients used per configuration.

Table 3-4: Entrance/Exit Loss Coefficients

Structure Type	Entrance/Exit Loss Coefficient
Manhole and Catch Basins	0.5
Mitered End Sections	0.7
Connection Type	Exit Loss Coefficient
Straight	0.25
Pipe Entering Pond	1.0

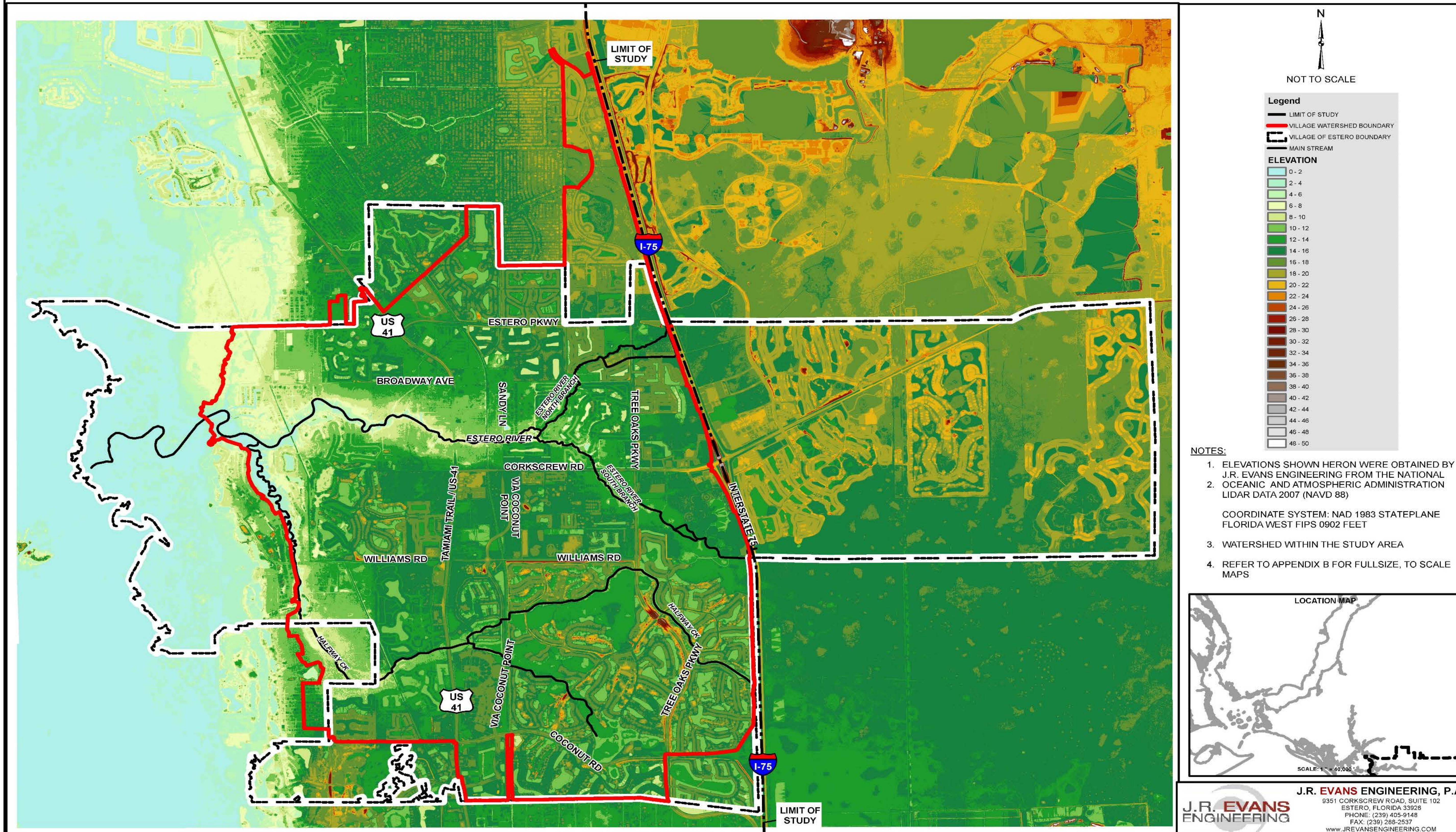
3.2.2. Hydraulic and Hydrologic Parameters

This section of the report will discuss the other hydraulic and hydrologic parameters established and used within the Local-Scale ICPR4 model.

Topographic Data/Terrain Data

The first parameter to review is the topographic data available and used for the modeling study. For the more detailed Local-Scale model, the latest LiDAR data for Lee, Collier and Hendry Counties was obtained from the South Florida Water Management District (SFWMD) database. The new data was incorporated into the ICPR4 model using a 1 foot x 1 foot cell size for topographic sampling. The elevations range from +22 FT NAVD in the eastern portion of the Local-Scale model study area to -1.0 FT NAVD at the coast, on the west side of the Local-Scale model study area. Map 3-1 depicts a graphical view of the digital elevation model (DEM) generated from the LiDAR data. The resolution for the DEM to support the Local-Scale ICPR4 model is detailed enough to provide 0.5 ft contours meeting acceptable accuracy thresholds.

Map 3-1: Digital Elevation Model (DEM)



Land Use/Land Cover Data

As previously mentioned, the previous Land Use/Land Cover data was reviewed and updated to reflect the changes in land use since the 2009 South Lee County Watershed Master Plan Update project. The most significant changes included areas along the Estero Parkway, Three Oaks Parkway, Corkscrew Road and U.S. 41 corridors. For the Local-Scale Village ICPR model, the land use/land cover data file was furthered refined for the specific study area to reflect current conditions. Since the Local-Scale model is considered to reflect existing conditions and is to be verified with the 2017 wet season event water stages, the land use/land cover data was analyzed and adjusted where needed to be consistent with more current 2017 conditions.

Soil Data

In addition to the Land Use/Land Cover, the most recent available soil data was obtained for the main conveyance watersheds within the Village of Estero study area. The soil data source is the National Resources and Conservation Services (NRCS), dated August 8, 2017. The soil data was processed as needed to be properly incorporated into the Local-Scale ICPR mode and result in a better evaluation of run-off characteristics for basin areas.

Delineation of Sub-Basins

Utilizing all the collected data, including permit records, as-built plans, field visits and observations, a delineation of the overall contributing areas to each main stream was prepared. Within each of the four (4) watersheds, sub-basins were defined and the network of the stormwater infrastructure was detailed. The approach to defining the sub-basins involved the following steps:

- Review available permit records, including plans and as-built information (South Florida Water Management District, Lee County, FDOT, etc.).
- For undeveloped areas, evaluate DEM and Flow Accumulation tools to determine flow patterns.
- Conduct field recognizance to confirm current flow patterns/directions, locations and conditions of outfall structures and control structures, etc.

For each of the sub-basins, a node was defined as either a Stage/Area or Stage/Volume node based upon the specific location and basin information. The node information within the ICPR4 model defines how much surface storage is available within the sub-basin before discharging off-site either through a control structure or overland weir/sheet flow. For the developed and permitted sub-basins that were developed prior to the date of the LiDAR (2007), the DEM was used to generate the stage-storage information applicable to that basin. For permitted developments that were developed after 2007, the available permit/as-built data was used to define the stage-storage relationship for the basin. For the unpermitted/uncontrolled basins, the DEM was also used to generate the stage-storage data. Once the stage-storage data was generated with ICPR4, the team furthered reviewed the data and adjusted where needed to more reasonably reflect the available storage area. For instance, the automatically generated stage-storage data may provide storage up to the highest elevation within the basin, however it is not reasonable to utilize that data point in the analysis. Therefore, adjustments were conducted to provide reasonable assumptions for available storage.

Runoff Curve Number

Another parameter specific to the basins is the run-off curve number, known as the CN. The curve number method is a simple, widely used and efficient method for determining the approximate amount of runoff from a rainfall even in a particular area. Determination of the CN depends on the watershed's soil and cover conditions, which the model represents as hydrologic soil group, cover type, treatment, and hydrologic condition. For the Local-Scale ICPR4 model, all the different combinations of land use/land cover and soil types were tabulated with a CN assigned to each combination. As the sub-basins were processed in ICPR4, the program uses the CN table and calculates a composite CN specific to each sub-basin depending on the specific land cover and soil types contained in the basin area. Therefore, the determination of the runoff CN value is more detailed with less assumptions or generalizing. The following Table 3-5 provides the defined CN for each of the land cover/soil types contained within the ICPR4 model.

Table 3-5: CN Table for ICPR4

CN Table for ICPR4		
Land Cover Zone	**Soil Zone**	**Curve Number**
1/8 Acre Lots - Residential	A	77
	B	85
	D	92
	A/D	92
	B/D	92
	C/D	92
1/4 Acre Lots - Residential	A	61
	B	75
	D	87
	A/D	87
	B/D	87
	C/D	87
1/3 Acre Lots - Residential	A	57
	B	72
	D	86
	A/D	86
	B/D	86
	C/D	86
1/2 Acre Lots - Residential	A	54
	B	70
	D	85
	A/D	85
	B/D	85
	C/D	85
1 Acre Lots - Residential	A	51
	B	68
	D	84
	A/D	84
	B/D	84
	C/D	84

CN Table for ICPR4		
Land Cover Zone	**Soil Zone**	**Curve Number**
Bare Ground	A	77
	B	86
	D	91
	A/D	94
	B/D	94
	C/D	94
Commercial	A	89
	B	92
	D	95
	A/D	95
	B/D	95
	C/D	95
Educational Facilities	A	81
	B	88
	D	93
	A/D	93
	B/D	93
	C/D	93
Grass	A	49
	B	69
	D	84
	A/D	84
	B/D	84
	C/D	84
Golf Course	A	39
	B	61
	D	80
	A/D	80
	B/D	80
	C/D	80
Institutional	A	81
	B	88
	D	93
	A/D	93
	B/D	93
	C/D	93

CN Table for ICPR4		
Land Cover Zone	**Soil Zone**	**Curve Number**
Pasture	A	49
	B	69
	D	84
	A/D	84
	B/D	84
	C/D	84
Paved Road	A	83
	B	89
	D	93
	A/D	93
	B/D	93
	C/D	93
Recreational	A	49
	B	69
	D	84
	A/D	84
	B/D	84
	C/D	84
Upland	A	35
	B	56
	D	77
	A/D	77
	B/D	77
	C/D	77
Utility Facilities	A	81
	B	88
	D	93
	A/D	93
	B/D	93
	C/D	93
Water	A	100
	B	100
	D	100
	A/D	100
	B/D	100
	C/D	100

CN Table for ICPR4		
Land Cover Zone	**Soil Zone**	**Curve Number**
Wetland	A	98
	B	98
	D	98
	A/D	98
	B/D	98
	C/D	98

Time of Concentration (Tc)

Another parameter to review for the sub-basins is the Time of Concentration, Tc. Time of concentration (Tc) is the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet. Time of concentration will vary depending upon slope and character of the watershed and the flow path.

For the developed/permitted sub-basins, the Tc defined within the permit records for the development was used. For the undeveloped/unpermitted sub-basins, a unique time of concentration was calculated for each of those sub-basins. Time of concentration was calculated as the duration required for the most hydraulically isolated runoff within each sub-basin to reach the outfall location for that basin. Three components of time of concentration were estimated and summed to form the time of concentrations; the duration of sheet flow, shallow concentrated flow and channel flow. Equations from the Technical Report 55 (TR-55) were utilized to calculate the three components of time of concentration.

A maximum length of sheet flow was estimated for each applicable sub-basin based upon the following equation:

$$\ell = \frac{100\sqrt{S}}{n} \qquad \text{(eq. 15–9)}$$

n = Manning's roughness coefficient
t = limiting length of flow, ft
S = slope, ft/ft

Shallow concentrated flow travel lengths were based on the projected distance to the sub-basin outfall location, starting from the point at which runoff transitioned from sheet flow to shallow concentrated flow. Specific travel lengths of shallow concentrated flow were calculated for each of the applicable sub-basins. The following equation was utilized to calculate the shallow concentrated flow travel time:

$$T_{SC} = \frac{L}{3600 * \frac{1.49 * r^{2/3} * s^{1/2}}{n}}$$

T_{SC} = shallow concentrated flow travel time, hr
L = flow length, ft
r = hydraulic radius, ft
n = Manning's roughness coefficient for open channel flow

Source: NRCS TR-55: CHAPTER 3 Time of Concentration and Travel Time

Any channelized flow for a sub-basin was assumed to begin at the point at which surface flow may enter a channel prior to reaching the outfall location for the sub-basin. The following equations were utilized to calculate the channel flow travel time:

$$T_{CF} = \frac{L}{3600 * V}\ ,\ V = \frac{1.49 * r^{2/3} * s^{1/2}}{n}$$

T_{CF} = channel flow travel time, hr
L = flow length, ft
r = hydraulic radius, ft
n = Manning's roughness coefficient for open channel flow
V = average velocity, ft/s

Source: NRCS TR-55: CHAPTER 3 Time of Concentration and Travel Time

3.2.3. Rainfall Data and Design Storms

Precipitation depths for the 5-, 10-, 25- and 100-year design storm events were obtained specifically for the subject watershed area using the South Florida Water Management District's (SFWMD) Applicant's Handbook and applicable Isohyet Curves. The rainfall distribution applied to the entire model domain was as defined in the SFWMD Applicants Handbook. The design storm rainfall amounts are depicted in the following Table 3-6.

Table 3-6: Rainfall Data per Design Storm

Design Storm Interval	Rainfall Depth (inches)
5-Year, 1-Day	5.5
10-Year, 1-Day	6.5
25-Year, 3-Day	11.2
100-Year, 3 Day	13.2

3.2.4. Boundary Conditions from Regional-Scale Model MIKE SHE/MIKE 11)

Once the Regional-Scale model was calibrated to the August-September 2017 rainfall, the model results for the nodes located at I-75 culverts and bridges were isolated for discharge and stage. The times series for the five (5) input locations into the Village of Estero from East of I-75 were used as the incoming boundary conditions for the Local-Scale model. The boundary conditions were a results of design storm simulations in the Regional-Scale model, which included the 5, 10, 25 and 100-year design storms.

A dataset, in 1-hour increments, for each upstream boundary node per design storm simulation was provided consisting of the Regional-Scale Model calibration period of June- August 2013. From that dataset, a selection of the data was used to define the time-stage and time-flow conditions for each of the upstream boundary nodes. The selected range for the data represents the lower stages/flows at the beginning of the design storm up to the peak stages/flows and the receding of both values. The selected range includes a total of 7 days of data. Figures 3-1 thru 3-7 provide a graph of the Boundary Nodes and the selected time versus flow data per design storm. Figure 3-8 depicts a graph of the Boundary Nodes and the selected time versus stage data.

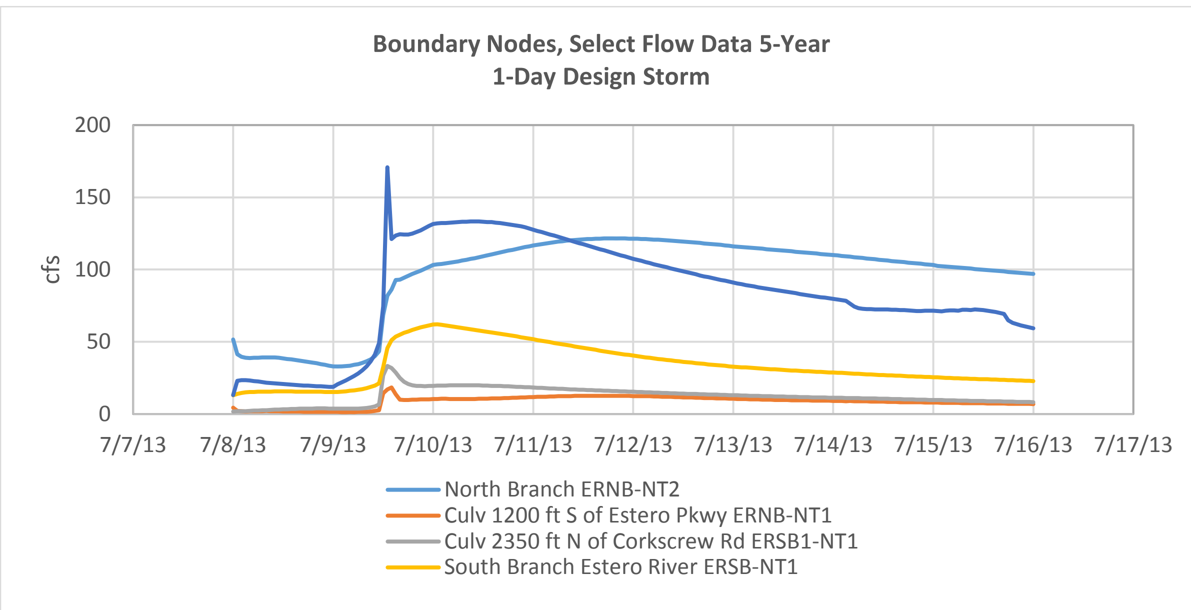


Figure 3-1: Boundary Nodes, Select Flow Data 5-Year 1-Day Design Storm

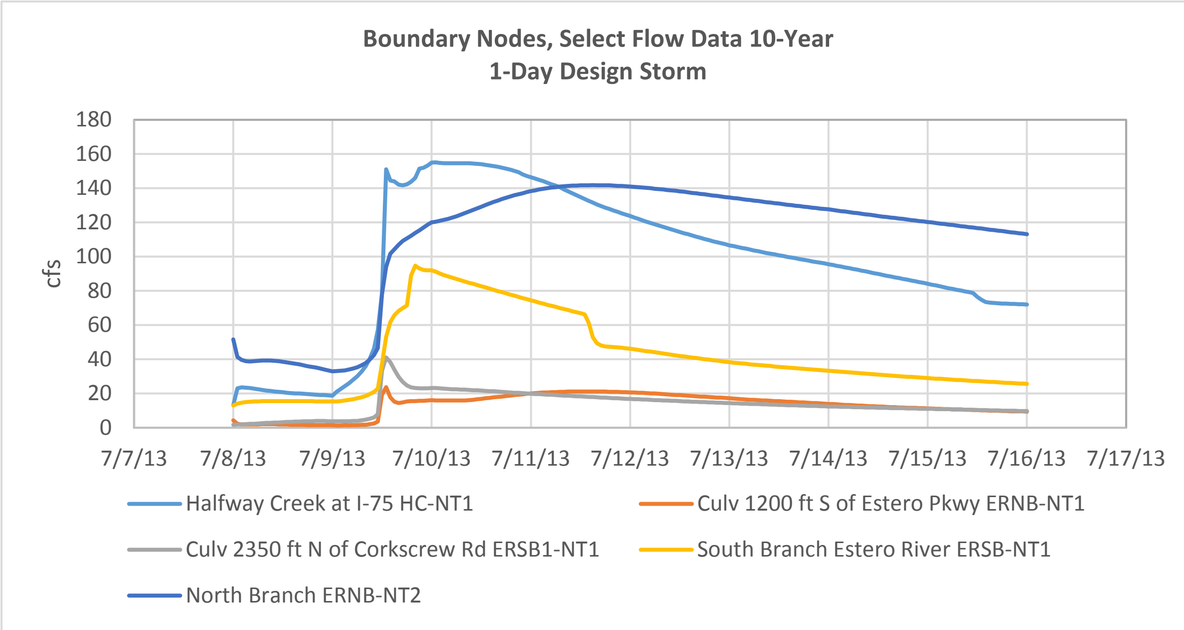


Figure 3-2: Boundary Nodes, Select Flow Data 10-Year 1-Day Design Storm

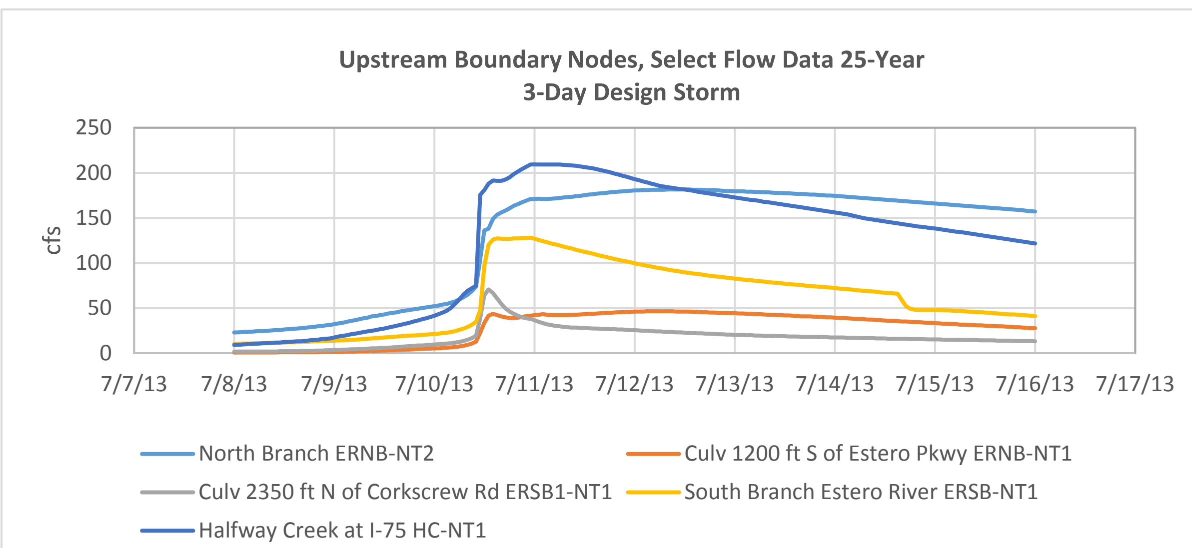


Figure 3-3: Boundary Nodes, Select Flow Data 25-Year 3-Day Design Storm

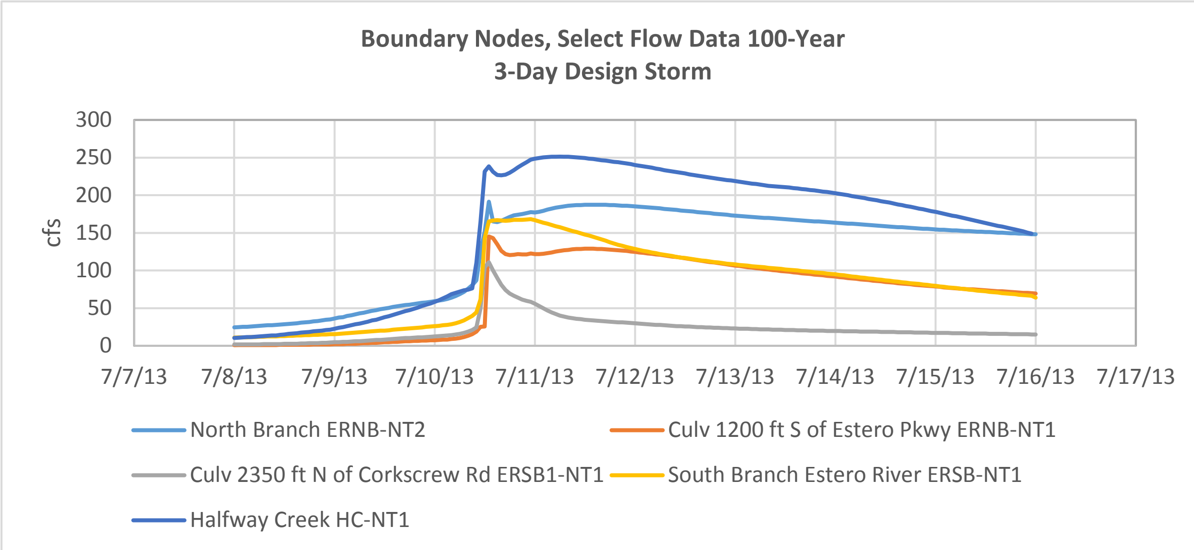


Figure 3-4: Boundary Nodes, Select Flow Data 100-Year 3-Day Design Storm

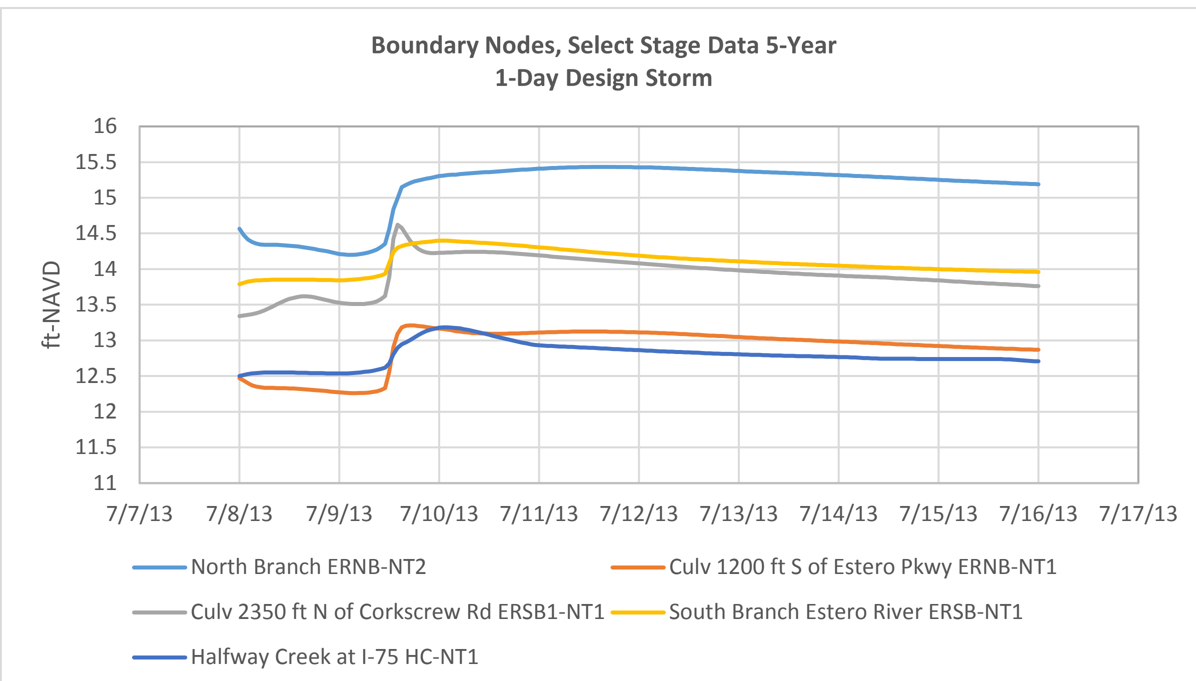


Figure 3-5: Boundary Nodes, Select Stage Data 5-Year 1-Day Design Storm

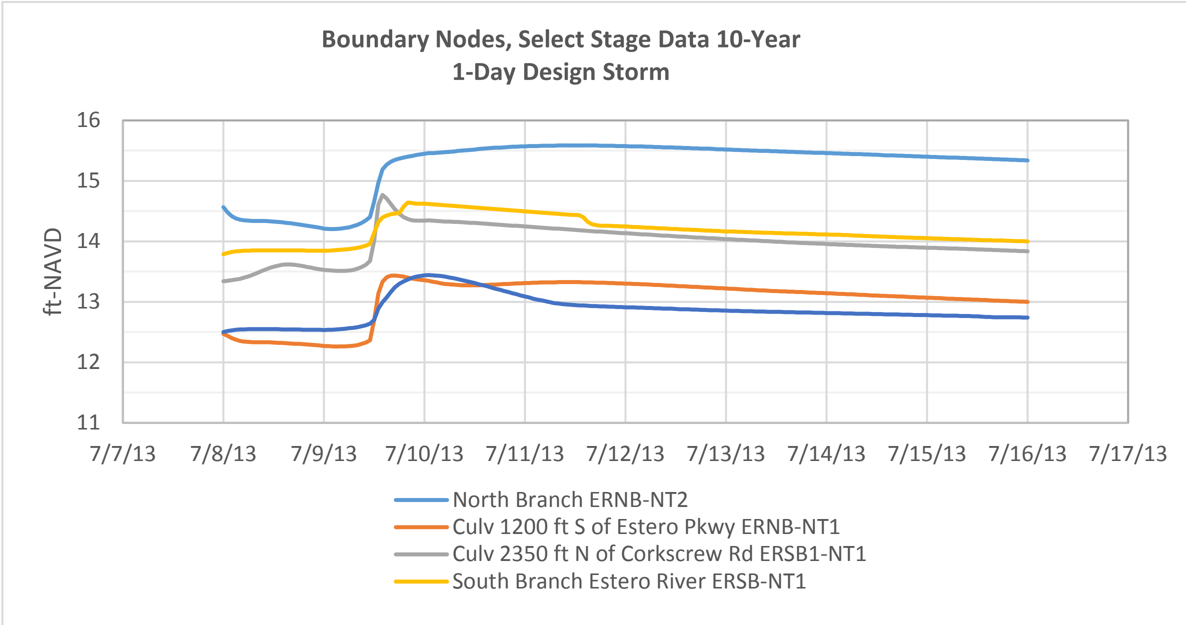


Figure 3-6: Boundary Nodes, Select Stage Data 10-Year 1-Day Design Storm

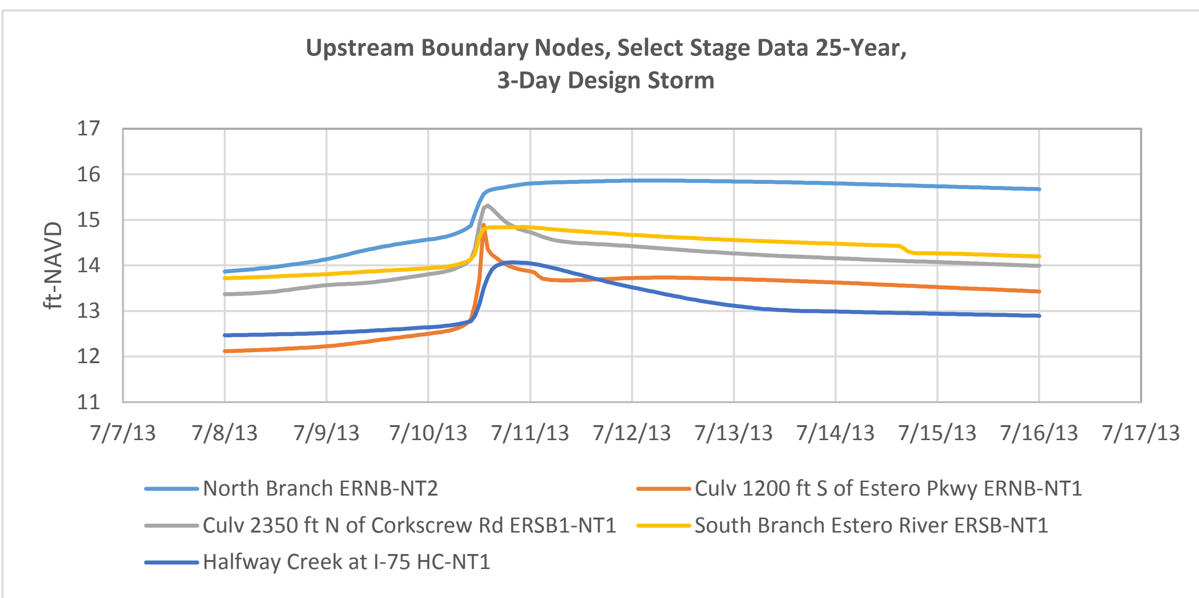


Figure 3-7: Boundary Nodes, Select Stage Data 25-Year 3-Day Design Storm

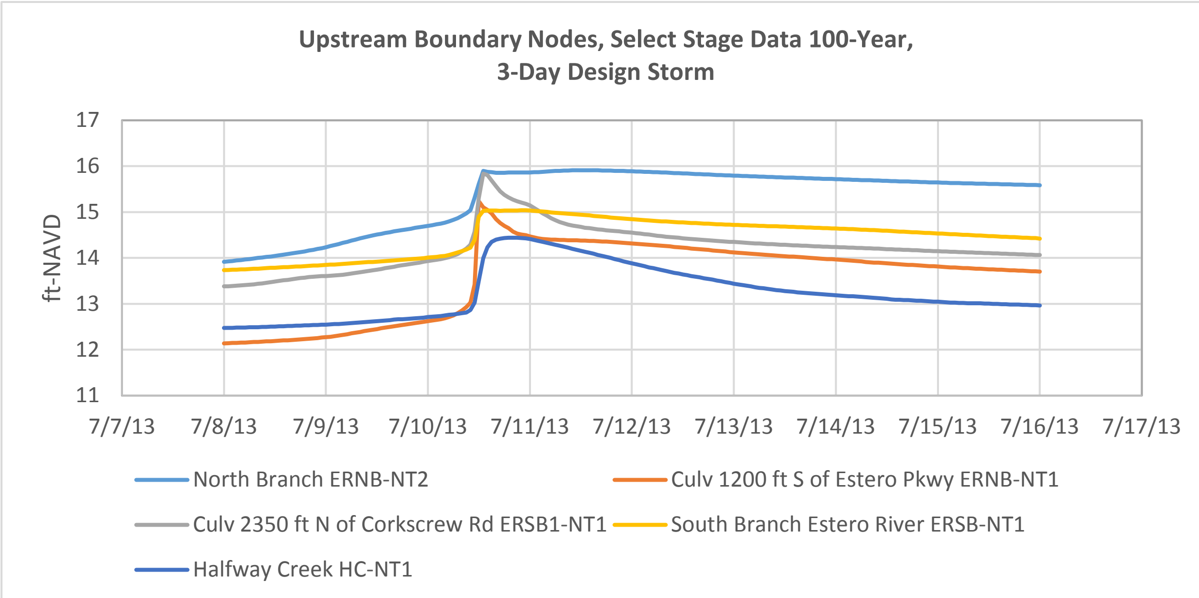


Figure 3-8: Boundary Nodes, Select Stage Data 100-Year 3-Day Design Storm

For the downstream boundary node, ERNT1, the dataset in 1-hour increments was also provided and a selection of that dataset was made to represent the time-stage conditions for each of the respective design storms. Figure 3-9 represents the selected time/stage data for the downstream boundary node ER-NT1 per design storm.

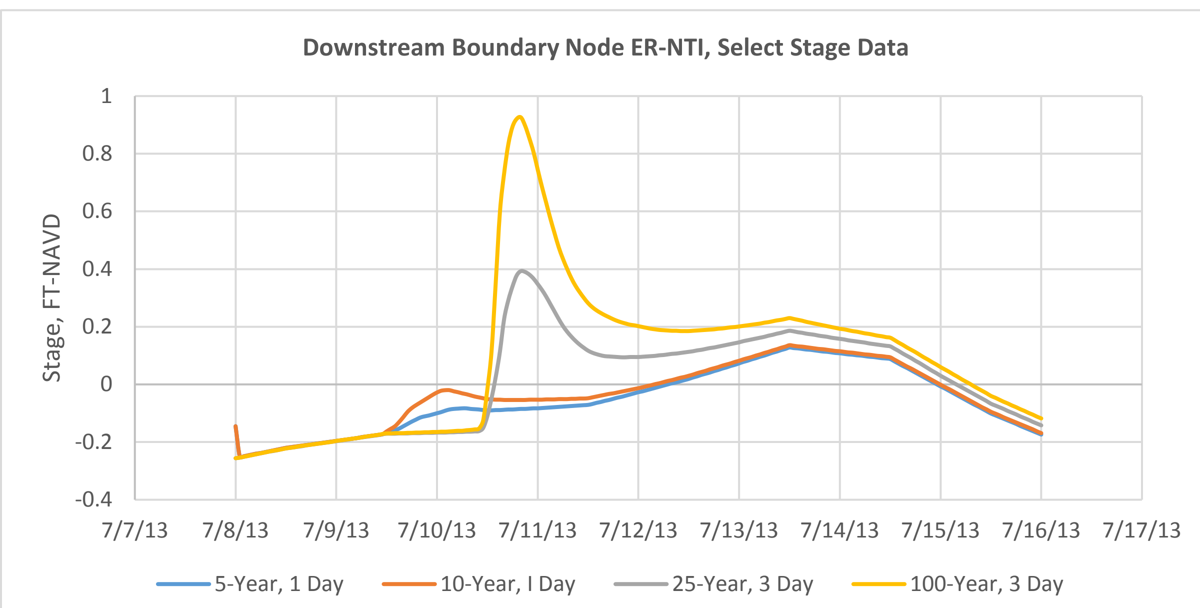


Figure 3-9: Downstream Boundary Node ER-NTI Select Stage Data

3.2.5. Local-Scale ICP4 Model Nomenclature

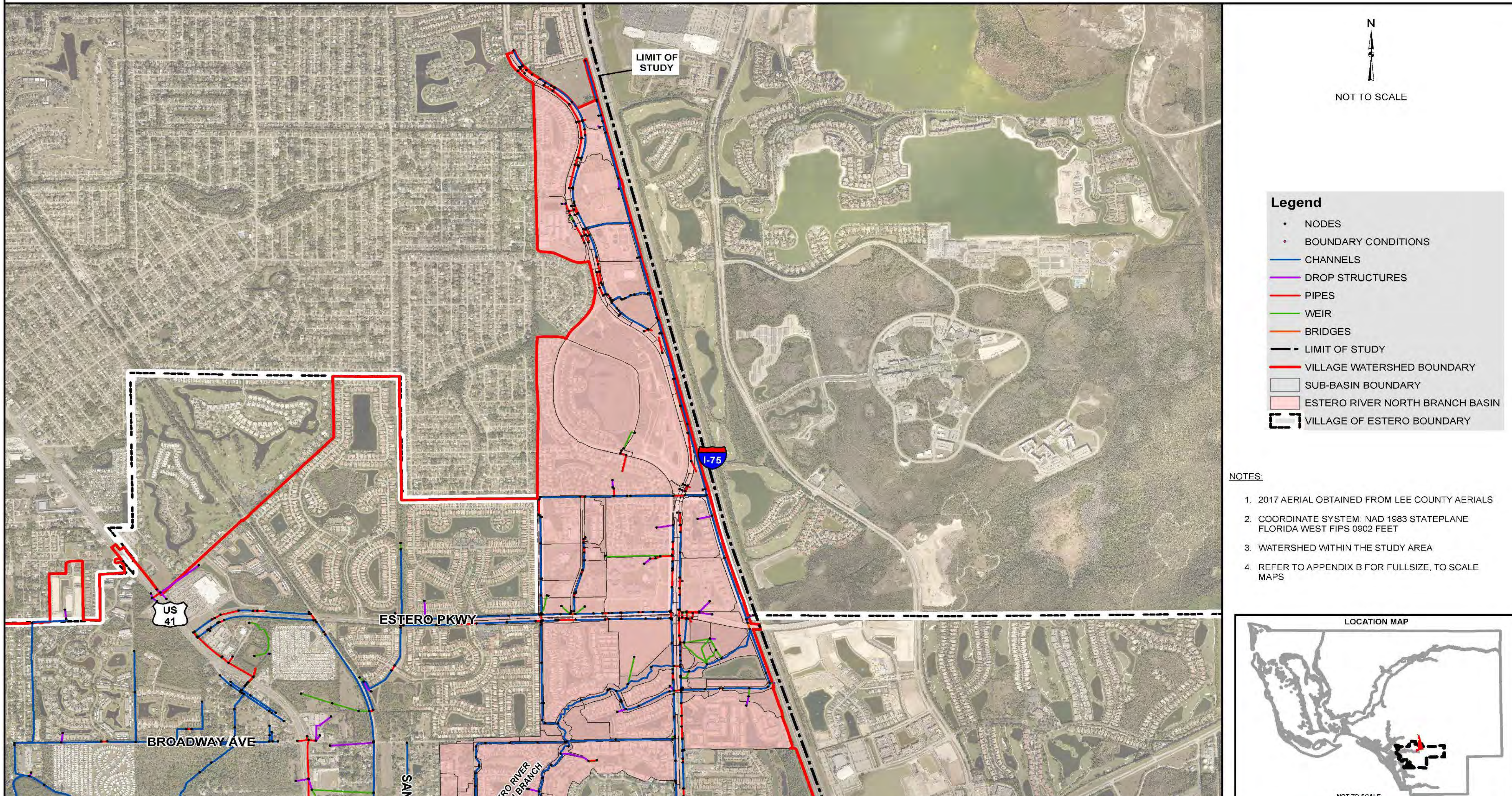
In the development of the Local-Scale ICPR4 model, specific naming conventions were applied to the different model elements based upon the watershed they were in and the conveyance route. As updates are conducted to the Master ICPR4 model, the recommended nomenclature should be followed. Please see the outline below for the guidance on the ICPR4 Model Nomenclature. The following pages include maps (Map 3-2 through Map 3-5) of the ICPR4 network for each of the watershed areas.

Waterway Acronyms
• Estero River → ER
o Secondary Conveyance System of Estero River (if not named in hydrography layers) → *e.g. ER1, ER2, etc.*
• Estero River North Branch → ERNB
o Secondary Conveyance System of Estero River North Branch (if not named in hydrography layers) → *e.g. ERNB1, ERNB2, etc.*
• Estero River South Branch → ERSB
o Secondary Conveyance System of Estero River South Branch (if not named in hydrography layers) → *e.g. ERSB1, ERSB2, etc.*
• Halfway Creek → HC
o Secondary Conveyance System of Halfway Creek (if not named) → *e.g. HC1, HC2, etc.*

Modeling Elements
• Stage Area Nodes: e.g. ERNB-N1, ERSB-N2, HC-N1, ERNB1 N5…
• Time Series Nodes: e.g. ERNB-NT1, ERSB-NT2, HC-NT1, ERNB1-NT5…
• Channel Links: e.g. ERNB-C1, ERSB-C2, HC-C1, ERNB1-C5…
• Pipe Links (on Surface): e.g. ERNB-P1, ERSB-P2, HC-C1, ERNB1-P5…
• Pipe Links (Underground): e.g. ERNB-PU1, ERSB-PU2, HC-C1, ERNB1-PU5…
• Weir Links: e.g. ERNB-W1, ERSB-W2, HC-W1, ERNB1-W5…
• Drop Structure Links: e.g. ERNB-DS1, ERSB-DS2, HC-DS1, ERNB1-DS5…
• Rating Curve Links: e.g. ERNB-RC1, ERSB-RC2, HC-RC1, ERNB1-RC5…
• Channel Cross Sections: e.g. ERNB-CX1, ERSB-CX2, HC-CX1, ERNB1-CX5…
• Weir Cross Sections: e.g. ERNB-WX1, ERSB-WX2, HC-WX1, ERNB1-WX5…
• Basins: e.g. ERNB-B1, ERSB-B2, HC-B1, ERNB1-B5…

Please Note: For the portion of the ICPR4 model detailing the Broadway Ave. tributary to the Estero River, this system was previously modeled under a separate study effort to evaluate potential improvements. The naming convention for this portion of the Local-Scale Master ICPR4 model will differ from the typical naming convention provided above.

Map 3-2: ICPR Network - Estero River North Branch



NOTES:

1. 2017 AERIAL OBTAINED FROM LEE COUNTY AERIALS
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE FLORIDA WEST FIPS 0902 FEET
3. WATERSHED WITHIN THE STUDY AREA
4. REFER TO APPENDIX B FOR FULLSIZE, TO SCALE MAPS

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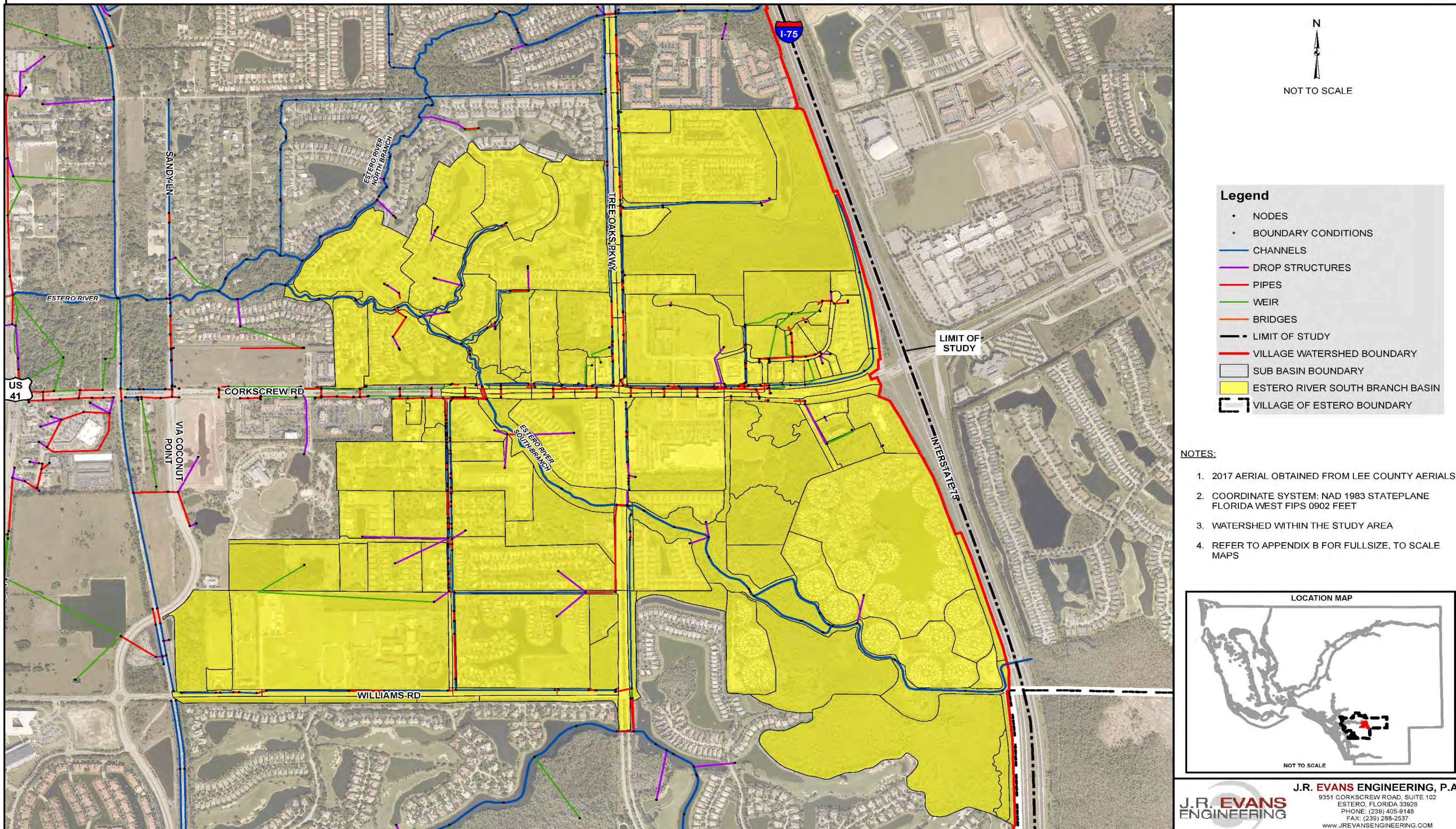
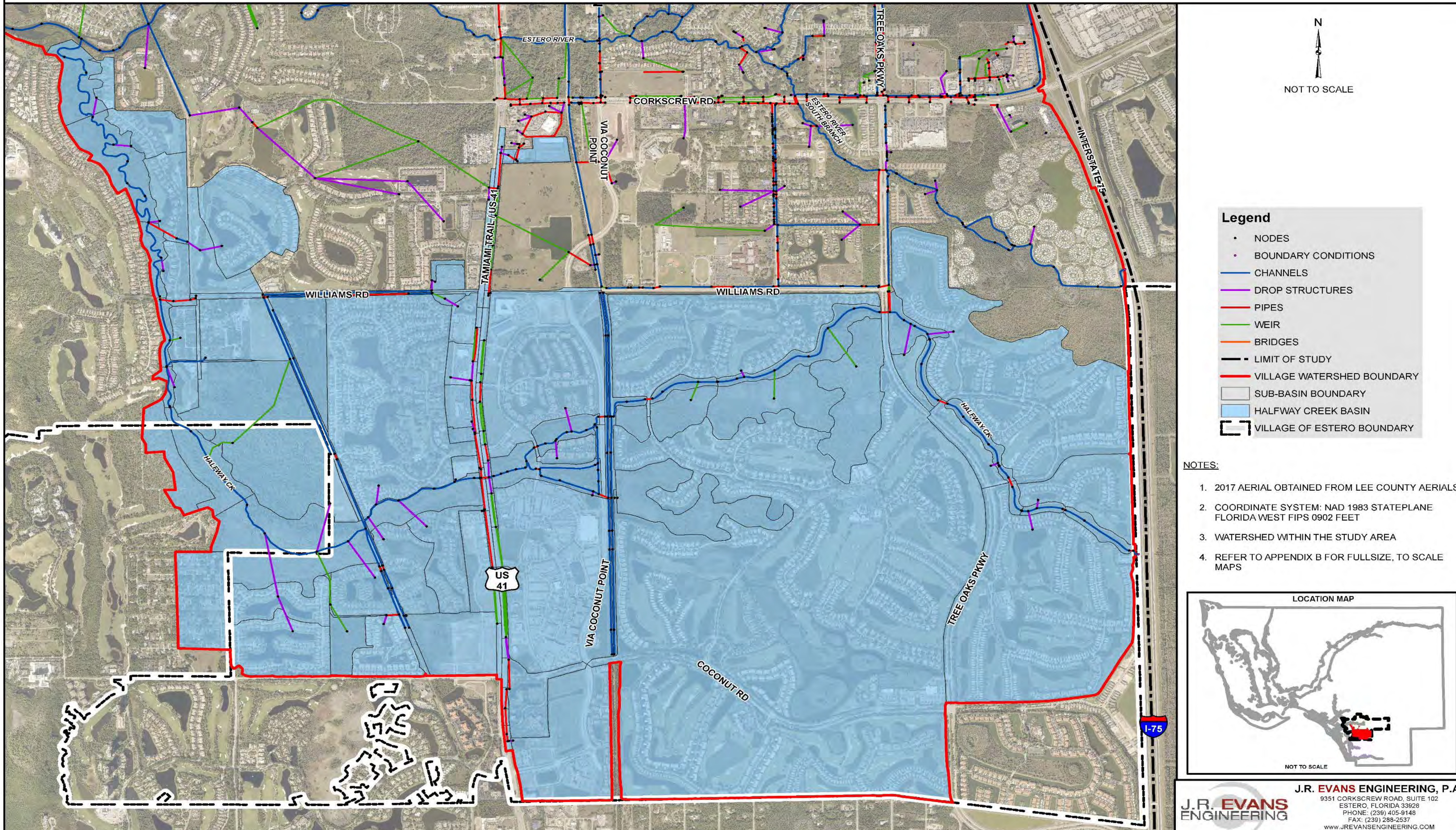
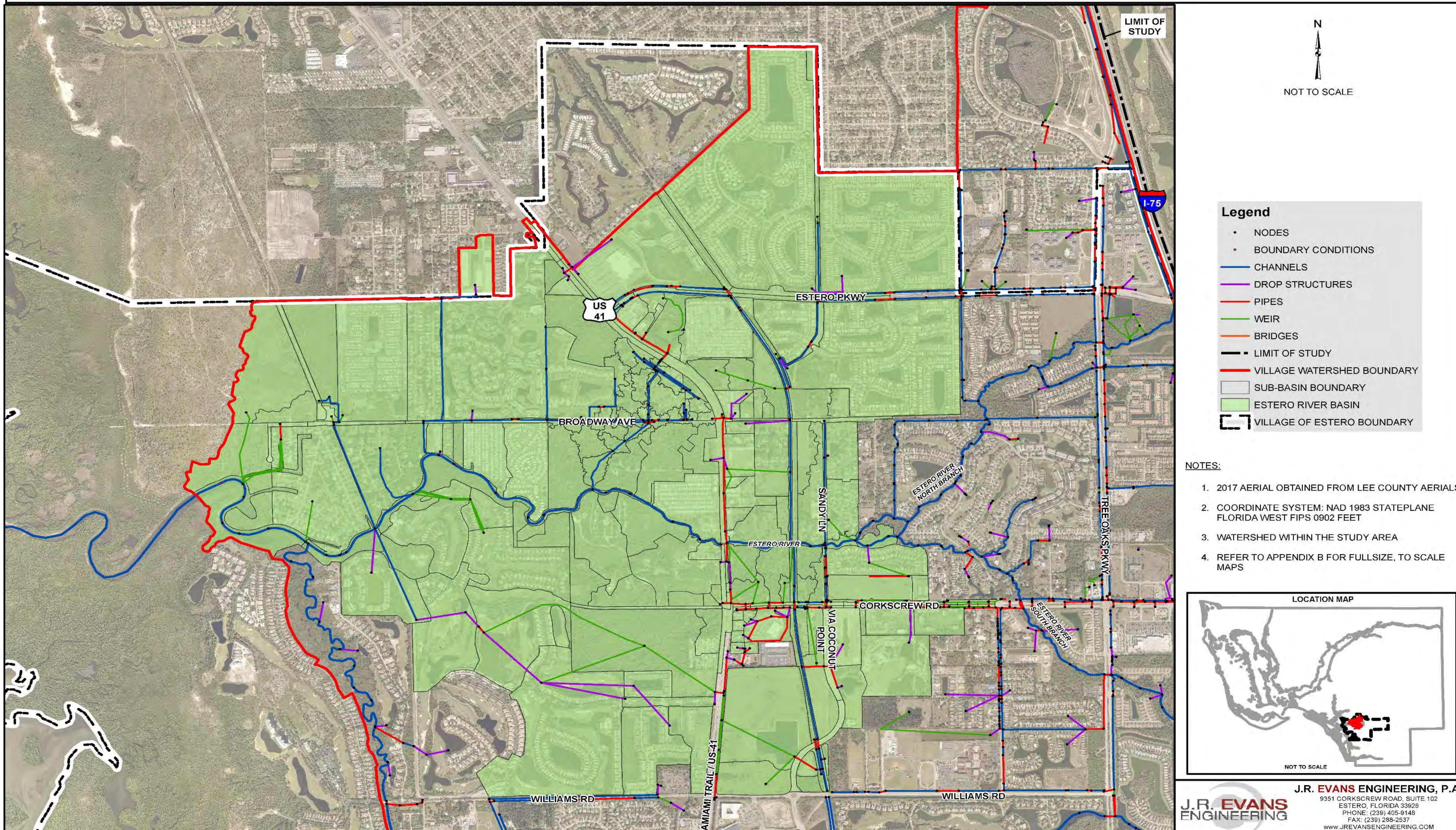
Map 3-3: ICPR Network - Estero River South Branch



Map 3-4: ICPR Network – Halfway Creek



Map 3-5: ICPR Network – Estero River Main Branch



3.3. Calibration/Validation Process

Model calibration is a process of developing an input data set, often by a series of iterative adjustments to input values, that allows the model to simulate changes in water levels and river flows over a specified period of time that is a close approximation of observed conditions. The calibrated model is a simplification of actual conditions because it is not possible to fully represent the numerous factors that dictate the behavior of both surface and ground water flow in a large study area, such as with this study. Applying changes to model inputs is a key calibration process and allows reasonable estimation of unknown conditions.

For the Local-Scale model, the calibration effort was concluded by validating that the simulated peak stages of the 25-year, 3-day and 100-year, 3-day design storms were reasonably close to the recorded and observed peak stages during the late August 2017 and early September 2017 rainfall events.

For the Local-Scale ICPR4 model calibration and validation effort, a general comparison was made between the simulation results of the 25-year, 3-day and 100-year, 3-day events to the observed/recorded values at key locations, including the USGS gages and The Brooks gages, throughout the study area with the goal to achieve peak stages that were reasonably close, within 1 foot, of the observed/recorded value. The observed/recorded data include the following sources of data:

- USGS Gage Stations - North Branch and South Branch
- The Brooks Gage Stations - North and South Outfall Weirs
- South Florida Water Management (SFWMD) High Water Mark Report, Post Irma (12/8/17)
- Lee County Post-Irma Assessment Report (02/28/18)
- Field Observations and Data Collection by J. R. Evans Engineering (8/29/17 and 09/18/17)

Model inputs that could be adjusted in the calibration process to achieve results consistent with the observed late August 2017 and early September 2017 observed data were:

- Upstream and downstream boundary conditions, both stage and flow
- Rainfall intensity and duration
- Roughness coefficients (Manning's n) for the conveyance links
- Runoff curve numbers per drainage basin
- Time of concentration per drainage basin
- Initial conditions within the main conveyance channels, both stage and flow

The amount of rainfall during these significant events varied across the entire Lee County area. Rainfall data for the August 2017 rainfall event was available from four (4) Lee County rain gages with rainfall totals that varied from 9.3 to 13.5 inches over a 5-day period. The September event (Hurricane Irma) rainfall totals from three (3) Lee County rain gages varied from 6.3 to 12.3 inches over a 2-day period (the Three Oaks rainfall gage did not have a total rainfall amount for the September event due to equipment failure at the gage station).

When looking at the specific region of the Estero River watershed, the August 2017 storm event resulted in a total of 11.4 inches of rainfall over a 5-day period. The 25-year 3-day precipitation used in the 25-year, 3-day design storm is 11.2 inches, which is also consistent with what NOAA (National Oceanic and Atmospheric Administration) established for the 25-year 3-day storm: 11.2 inches of precipitation for the subject area. Therefore, it is reasonable to estimate that a rainfall depth of 11.4 inches over a 5-day rain event will produce similar peak stages within the Estero River watershed as that of an 11.2 inches rainfall over a 3-day storm event. Due to the quick onset of Hurricane Irma after the August 2017 event, the August peak stages were further exacerbated because water levels within the main streams and ponds did not have the opportunity to recede back to normal wet season levels. In addition, the storms introduced more vegetation debris and potential for obstructions within the main streams and waterways, which also contributed to the peak water levels experienced throughout the area. Due to the numerous factors that dictated the behavior of the surface water conditions throughout the study area, a direct comparison between the observed and simulated values is not reasonable because the design storm simulation assumes a uniform rainfall amount and intensity for the entire watershed, while the actual watershed response to the two 2017 events is dependent upon rainfall intensities and amounts that varied across the watershed.

The "Hot Start" tool of the ICPR4 program was utilized to establish initial stages at nodes within the model. At the start of a simulation run in ICPR4, the water surface elevation at each node is based on a manually input initial stage or is set at the lowest elevation within the node's stage-area or stage-area table. A simulation run mode called "Hot Start" can also be used for setting the initial stage at each node. The "Hot Start" run is a separate simulation that has its own run time, rainfall depth and distribution, boundary stage set, and external hydrograph set. When running a full design storm simulation, the simulation can set initial stages based on the stages established in the "Hot Start" simulation at a specified time.

The Master Model's Hot Start simulations were setup so that the initial stages within the main conveyances during the design storm simulations were approximately equal to the typically observed wet season stages. Data from the Estero River North Branch USGS gage and the Estero River South Branch USGS gage were used for calibrating the "Hot Start" parameters.

A test simulation with the 25-year, 3-day design storm boundary stage set and external hydrograph set, with no rainfall was ran to determine at what time the nodes near the two USGS stream gages reached the typical wet season stage (water surface elevation). Once the time was determined, a new boundary stage set and external hydrograph set was created with constant stage and flow at the determined time. The two stream USGS gage nodes reached a steady-state condition at the approximate typical wet season elevations at hour 30 when the boundary stage set and the external hydrograph set were ran with the hour 60 boundary conditions. Therefore, the 25-year and 100-year, 3-day design storm simulations were executed to reference the "Hot Start" simulation of the Base Run at hour 30, to set the initial stages. The similar approach was applied to the 5-year and 10-year design storm simulations in which the "Hot Start" base runs use the boundary stage and external hydrograph at hour 40. Utilizing the "Hot Start" mode to execute the design storm simulations ensures that the initial stages of nodes within the main conveyances are representative of typical wet season water surface levels and antecedent conditions.

The calibration of the local scale model was accomplished by making adjustments to Manning's "n" values and initial conditions within the main conveyance routes. Particularly, the roughness coefficient values for the channel and overbank areas of the Estero River Main Branch, North Branch and South Branch were adjusted to reflect conditions favorable to achieve peak water surface stages closer to the actual recorded data.

Provided in Table 3-7 are the comparison results of the observed/recorded peak water surface stages and the simulated values for the 25-year and 100-year design storms.

Table 3-7: Calibration/Validation Comparison Table
Key Locations within Study Area

Calibration/Validation Comparison Table Key Locations within Study Area								
Node	**Location**	**ICPR4 25-Year (NAVD)**	**ICPR4 100-Year (NAVD)**	**Reported/ Observed Stage (NAVD)**	**Permitted 25yr Stage (NAVD)**	**25yr Diff.**	**100yr Diff.**	**Notes**
ER-N16	ER at Broadway Conveyance Connection	3.34	3.94					
ER-N21	ER & US-41 Downstream	3.91	4.53	4.29		-0.38	0.24	SFWMD High Water Mark Report, Collected 9/20/2017
ER-N23	Rail Road - Downstream	4.63	5.30					
ER-N24	Rail Road - Upstream	4.64	5.31					
ER-N26	ER & Sandy Lane Bridge	6.01	6.70	12.1				SFWMD High Water Mark Report, Collected: 09/20/17 - Not Considered Due to Discrepancies with Surrounding Elevations
ER-N27	West side of Bamboo Island	6.58	7.33	7.5		-0.92	-0.17	Lee County Post-Irma Assessment Report
ER1-N18	Corkscrew to Sandy Lane	15.14	15.42		15.13	0.01		
ER1-NC57	Estero Community Park	15.34	15.57					
ER4N-N12	SGLR Ditch & Estero Pkwy US	14.40	14.86	14.77		-0.37	0.09	JRE Observation
ER4N-NC19	Cascades	14.32	14.60		14.36	-0.04		
ER4N-NC23	Belle Lago	14.61	15.14		14.98	-0.37		
ER4N-NC24	The Reserve	15.71	16.04		15.68	0.03		
ER4N-N6	Cascades Outfall/ SGLR Ditch	13.69	13.90	13		0.69	0.9	High Water Elevation per Hole Montes Survey
ER4S-N3	SGLR Ditch Upstream of Corkscrew Road	15.71	16.05					
ER6-N1	Walmart Ultimate Outfall	14.70	15.01		15.18	-0.48		
ER6-NC3	Walmart/Osprey Cove	14.37	14.61					
ER804-N1	Pineland Preserve Outfall	12.30	12.32					
ER804-NC1	Pineland Preserve	15.99	16.44		16.44	-0.45		
ERNB-N1	East side of Bamboo Island	7.83	8.37					
ERNB-N17	USGS Gage-South of Rookery Point	12.44	13.01	14		-0.16	0.41	Post Irma estimate; Regional-Scale Model = 12.6 FTNAVD
ERNB-N20	Rookery Point Cir. Bridge	14.66	15.04	15.3		-0.64	-0.26	Lee County Post-Irma Assessment Report (residents observed 16.3'±)

Node	Location	ICPR4 25-Year (NAVD)	ICPR4 100-Year (NAVD)	Reported/ Observed Stage (NAVD)	Permitted 25yr Stage (NAVD)	25yr Diff.	100yr Diff.	Notes
ERNB-N30	D/S Three Oaks Pkwy Crossing	14.83	15.19					
ERNB-N6	Villages of Country Creek - Halfhitch Rd Bridge	9.98	10.56	10.8		-0.82	-0.24	Lee County Post- Irma Assessment Report SFWMD High Water Mark Report, Collected: 9/20/2017
ERNB-NC05	The Villages at Country Creek Basin 3	10.28	10.92		9.02	1.26		
ERNB-NC25	Rookery Basin 2	16.16	16.41		15.73	0.43		
ERNB-NC46	Villagio	16.66	16.94		16.42	0.24		
ERNB1-NC018	Waste Water Treatment Plant	19.60	20.33	N/A	N/A			
ERNB1-NC022	Three Oaks Community Park (Park)	17.60	17.93		16.24	1.36		
ERNB1-NC025	Three Oaks Community Park (Pond)	17.58	17.91		17.41	0.17		
ERNB2-NC23	Country Oaks	17.34	17.68		16.48	0.86		
ERNB2E-N13	Estero Pkwy & 3Oaks	15.35	15.63	16.4		-1.05	-0.77	Lee County Post- Irma Assessment Report
ERNB2E-N24	End nodes Three Oaks near Coastal Villages	17.92	18.28	N/A	N/A			
ERNB2N-NC20	Three Oaks Town Center	16.79	17.01		17.32	-0.53		
ERNB2N-NC59	Three Oaks Middle School	18.15	18.44		16.79	1.36		
ERNB2W-NC22	Estero Oaks	16.37	16.55		16.59	-0.22		
ERNB2W-NC24	Rookery Basin 3	17.43	17.58		17.07	0.36		
ERNB3-NC16	Somerset	17.41	17.53		17.4	0.01		
ERNB4-N10	U/S Estero Parkway Culvert	15.88	16.33					
ERNB4-NC14	Our Lady Of Light	17.11	17.25		16.37	0.74		
ERNB4-NC4	Rookery Basin 1	16.60	16.83		16.19	0.41		
ERNB5E-NC7	Pond 100 Estero Parkway	19.38	19.65		19.01	0.37		
ERNB5E-NC8	The Reef	16.82	17.08		17.04	-0.22		
ERNBD2-N4	ERNB at 3Oaks Crossing N (US)	14.77	15.16	16.72		-1.95	-1.56	8/29/2017 JRE observation
ERSB-N20	USGS Gage - ERSB at Corkscrew Rd	9.92	10.66	10.4		-0.48	0.26	8.91 FT NAVD - 8/29/2017 JRE observation SFWMD High Water Mark Report, Collected: 9/20/2017

Calibration/Validation Comparison Table
Key Locations within Study Area

Calibration/Validation Comparison Table Key Locations within Study Area								
Node	**Location**	**ICPR4 25-Year (NAVD)**	**ICPR4 100-Year (NAVD)**	**Reported/ Observed Stage (NAVD)**	**Permitted 25yr Stage (NAVD)**	**25yr Diff.**	**100yr Diff.**	**Notes**
ERSB-N32	ERSB Downstream of Sanctuary Rd	13.89	14.06					
ERSB-N34	ERSB at Sanctuary Road Crossing	13.94	14.13	14		-0.06	0.13	Interview with Residents - JRE Observation
ERSB-NC05	The Villages at Country Creek Basin 7	10.33	11.01		11.02	-0.69		
ERSB1-N2	See See St. - Downstream	10.04	10.81	10.3		-0.26	0.51	SFWMD High Water Mark Report, Collected: 9/20/2017
ERSB1-NC534	Courtyard Apartments	16.62	16.76		15.94	0.68		
ERSB2E-N14	Post Office on 3Oaks	15.32	15.50	15.6		-0.28	-0.1	Lee County Post- Irma Assessment Report
ERSB2E-N7	3 Oaks at Quente Way	15.34	15.44	15.5		-0.16	-0.06	Lee County Post- Irma Assessment Report
ERSB2E-NC37	Copper Oaks	16.95	17.17		17.03	-0.08		
ERSB5-N05	ERSB5-N05	13.74	14.31		13.42	0.32		
ERSB6-NC03	The Villages at Country Creek Basin 10	12.66	12.95		12.92	-0.26		
ERSB6-NC06	The Villages at Country Creek Basin 5	11.42	11.89		12.02	-0.6		
ERSB9-N12	River Ranch at Block Lane	15.12	15.38	14.5		0.62	0.88	Flow observed ±0.5' above road after August 2017 Storm - JRE Observation
HC-N22	HC Downstream of FPL Crossing	9.93	10.17					
HC-N34	Halfway Creek at U.S. 41 - U/S	13.53	13.79	13.6		-0.07	0.19	SFWMD High Water Mark Report, Collected: 9/20/2017
HC-N35	Halfway Creek at U.S. 41 - U/S (+100 FT)	13.53	13.79	13.6		-0.07	0.19	SFWMD High Water Mark Report, Collected: 9/20/2017
HC-N55	The Brooks North Outfall Gage	13.86	14.18	14.5		-0.64	-0.32	Recorded Gage Data - Peak Stage
HCD1-NC10	Coconut Point Mall- North Outfall	15.54	15.77		15.5	0.04		
HCD1-NC3	The Brooks South Outfall Gage	14.61	14.92	14.6		0.01	0.32	Recorded Gage Data - Peak Stage
HC-NC17	Marsh Landing Basin 2 Outfall	12.72	12.89		13	-0.28		
HC-NC24	Fountain Lakes Basin 1 Outfall	13.78	14.05		13.65	0.13		
HC4-NC1	Coconut Shores Basin Outfall	15.90	16.14		15.65	0.25		
NS-052	Broadway Ave., North Side	13.48	13.79					

Calibration/Validation Comparison Table Key Locations within Study Area								
Node	**Location**	**ICPR4 25-Year (NAVD)**	**ICPR4 100-Year (NAVD)**	**Reported/ Observed Stage (NAVD)**	**Permitted 25yr Stage (NAVD)**	**25yr Diff.**	**100yr Diff.**	**Notes**
N-010	North Side of Broadway Ave. Tributary/ Trailside Dr.	13.69	13.95					
NC-100	Terra Vista	13.55	13.88		12.92	0.63		
ER802-N5	Breckenridge	13.27	13.47		12.92	0.35		
NS-473	Trailside Dr., North End	13.88	14.03					
NS-476	Trailside Dr., South End	14.29	14.30					
ER802-N3	North Side of Broadway Ave. at Sherrill Lane	11.24	11.56					

3.4. Modeling Results – Existing Conditions Scenario

Provided in the following sections is a discussion about what the hydraulic analysis indicates for specific areas of the stormwater management system within The Village. Per each design storm and each sub-watershed, a detailed review of the model results is presented along with noted areas of concern, such as high velocities within channels or significant increases in water stages across culvert or bridge crossings. Based on the hydraulic evaluations, potential improvement projects are identified and further explored within Section 4 of this report. In addition to evaluating the performance of the conveyances per design storm, an evaluation was conducted of the peak stage results for key locations within the study are along with a discussion of notable conditions.

3.4.1. 5-Year, 1-Day Design Storm Analysis and Results

The 5-year, 1-day design storm utilizes a total rainfall depth of 5.5 inches distributed over a period of 24 hours, or 1 day. In the past, many jurisdictions such as Lee County have regulated that the minimum road elevations for new developments shall be at the design water elevation resulting from a 5-year, 1—day storm event. Thus, there are many older residential developments within the Village where the roadway elevations may be consistent with this antiquated requirement. In recent years, jurisdictions have revised the regulation and many now require that the minimum roadways for new developments be set at the design water elevation based upon the 25-year, 3-day storm event. For the hydraulic analysis of the 5-year, 1-day design storm, the main conveyances of each sub-watershed are evaluated below to provide an overall description of system performance and to note areas of concern and/or candidates for improvement properties.

3.4.1.a. Halfway Creek Watershed Hydraulic Analysis

As mentioned in the previous section, Halfway Creek originates in a broad marsh system located east of I-75. Flows pass under I-75 through two box culverts and then flow into The Brooks development. Flows pass through the flow-way lakes within The Brooks and the lakes are connected via six (6) sets of four (4) submerged box culverts. The flow out of The Brooks are controlled by two (2) weir structures at an invert of 12.42 FT NAVD, each located along the west property line and approximately 1,700 LF apart. Halfway Creek then flows through the Seminole Gulf Railroad culverts and the culverts under Via Coconut Point. On the west side of Via Coconut Point, there is an equalizer ditch that connects the main (north) branch of Halfway Creek and the south (diversion) branch of Halfway Creek. The flows travel through the wetland/marsh areas located between/around the Rapallo and Enclave at Rapallo developments before reaching the Via Villagio roadway. Each branch of the Halfway Creek travels through culverts under Via Villagio and then merge at the location of a 200 ft wide broad-crested weir. Halfway Creek then flows through a natural/wetland area before reaching the U.S. 41 roadway crossing. After U.S. 41, it meanders along the southern boundary of the Fountain Lakes community into a large conservation/marsh system located east of the FP&L easement. The conservation/wetland area is very large and heavily vegetated throughout. Through this area, there is no defined channel section and majority of the flow occurs within the wetlands/upland conservation areas. There are concerns with the potential for high water elevations within this portion of the creek based upon the conditions of the wetlands/uplands area and level of vegetative debris. There are several residential communities that discharge to this portion of Halfway Creek and are directly impacted by the water levels within this section. Beyond the wetland/upland conservation area, the creek becomes more defined and heads north, meandering through the West Bay Club development and ultimately joining the Estero River Main Branch at approximately 2.3 miles upstream of Estero Bay. The creek receives flows from regulated developments, such as Fountain Lakes, Marsh Landing, Coconut Shores, West Bay Club and Coconut Point Mall. Provided below is an outline of the model results for the main conveyances within the Halfway Creek watershed. The creek was evaluated in “sections” as described below.

Section 1: Main Stream from Confluence with Estero River upstream to U.S. 41

- o Maximum average channel velocities are low to mild, ranging from 0.19 fps to a maximum of 2.44 fps at the most downstream end (entering Estero River).
- o Maximum Flow rates within this section of the creek range from 241 cfs to 261 cfs at the downstream connection to Estero River.
- o From the downstream boundary to U.S. 41, the peak water surface elevations range from 2.37 ft-NAVD to 12.77 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ HC-N7 to HC-N8: Increase of 0.62 feet located within the West Bay Club, north of West Bay Boulevard, just north of the most northern golf cart bridge crossing.
  - ➢ HC-N15 to HC-N16: Increase of 1.34 feet located within southern portion of West Bay Club, south of the last golf cart bridge crossing. This can be attributed to change in profile slope of channel bottom and decrease in defined channel section – increasing in elevation upstream and increase in roughness coefficient on the overbank areas.
  - ➢ HC-N17 to HC-N18: Increase of 0.67 feet located just outside south boundary of West Bay Club and into large conservation/wetland area. This is attributed to shallower channel section with high roughness factors within majority of flow area cross-section.
  - ➢ HC-N19 to HC-N20: Increase of 0.94 feet located within large conservation/wetland area between West Bay Club and FPL Crossing. This is attributed to shallower channel section with high roughness factors within majority of flow area cross-section.
  - ➢ HC-N22 to HC-N23: Increase of 1.26 feet located within large conservation/wetland area between West Bay Club and FPL crossing, just downstream of FPL crossing. This is attributed to shallower channel section at upstream end and high roughness factors within majority of flow area cross-section for entire segment.
  - ➢ HC-N25 to HC-N26: Increase of 0.53 feet located within large conservation/wetland area, just upstream of FPL crossing. This is attributed to shallower channel section at upstream end and high roughness factors within majority of flow cross-section for entire segment. The surface water elevations within this portion of Halfway Creek affects Marsh Landing Basin 3 Outfall and properties upstream, specifically Fountain Lakes Basin 1, Marsh Landing Basins 1 and 2.
  - ➢ See Figure 3-10 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- o ***To lessen the hydraulic jump within the large conservation/wetland area located between West Bay Club and FPL crossing, conduct routine/regular maintenance to reduce roughness factor within flow area.***
- o ***Work with the West Bay Club community on a regular maintenance program for the upstream portions of Halfway Creek located within their property.***

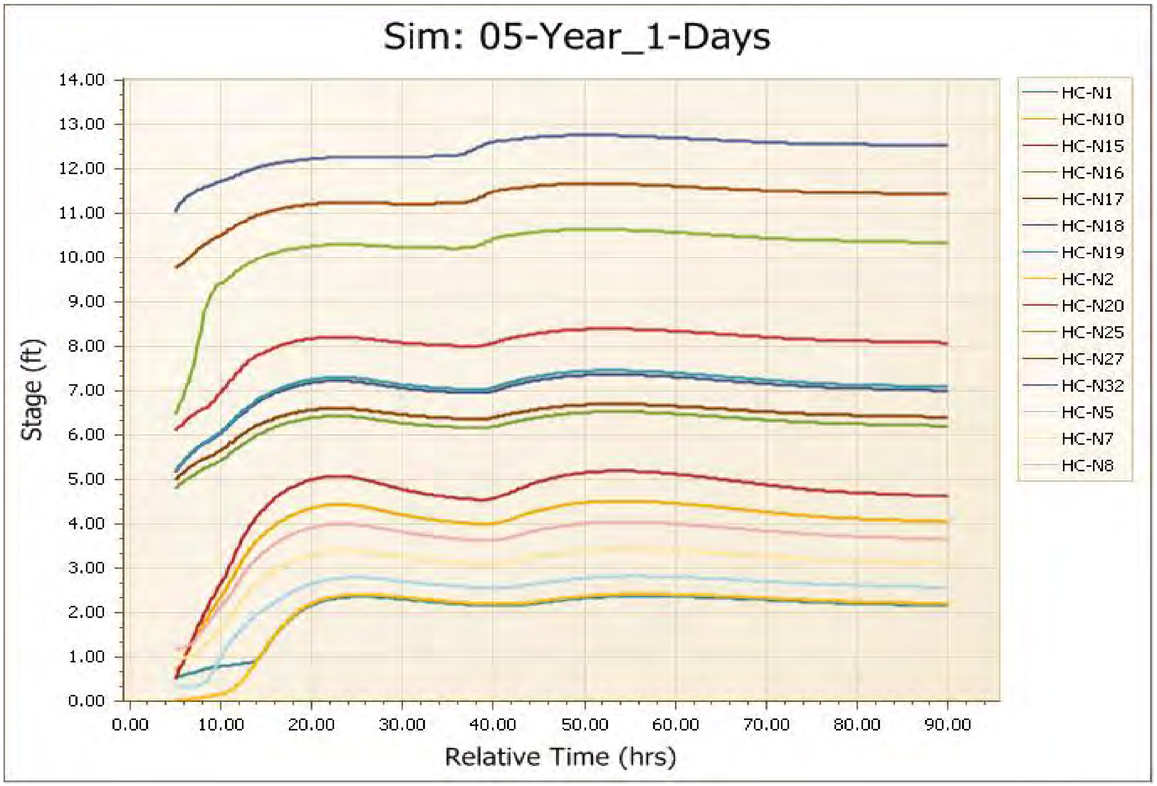


Figure 3-10: Halfway Creek Section 1 -
5-Year, 1-Day Stage Time Series

<u>Section 2: Main Stream from Downstream U.S. 41 to Railroad Crossing/Brooks North Outfall</u>

- o Maximum average channel velocities are low to mild, ranging from 0.15 fps to a maximum of 1.01 fps at the downstream end of the U.S. 41 crossing.
- o Maximum flow rates within this section of the creek range from 229 cfs coming from the Brooks North Outfall to 322 cfs at the downstream side of the U.S. 41 crossing.
- o From the downstream side of U.S. 41 to the Railroad Crossing/Brooks North Outfall, the peak water surface elevations range from 12.77 ft-NAVD to 13.02 ft-NAVD.
- o The average velocity through the U.S 41 culvert crossing is 1.15 fps and the culverts are flowing completely full during the peak of the event. The bottom invert is 4.62 ft-NAVD with a top elevation of 11.62 ft-NAVD.
- o There are no significant increases, being an increase of 6 inches or greater between nodes, in surface water levels for this section of Halfway Creek.
- o See Figure 3-11 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Halfway Creek during 5-year, 1-day design storm.

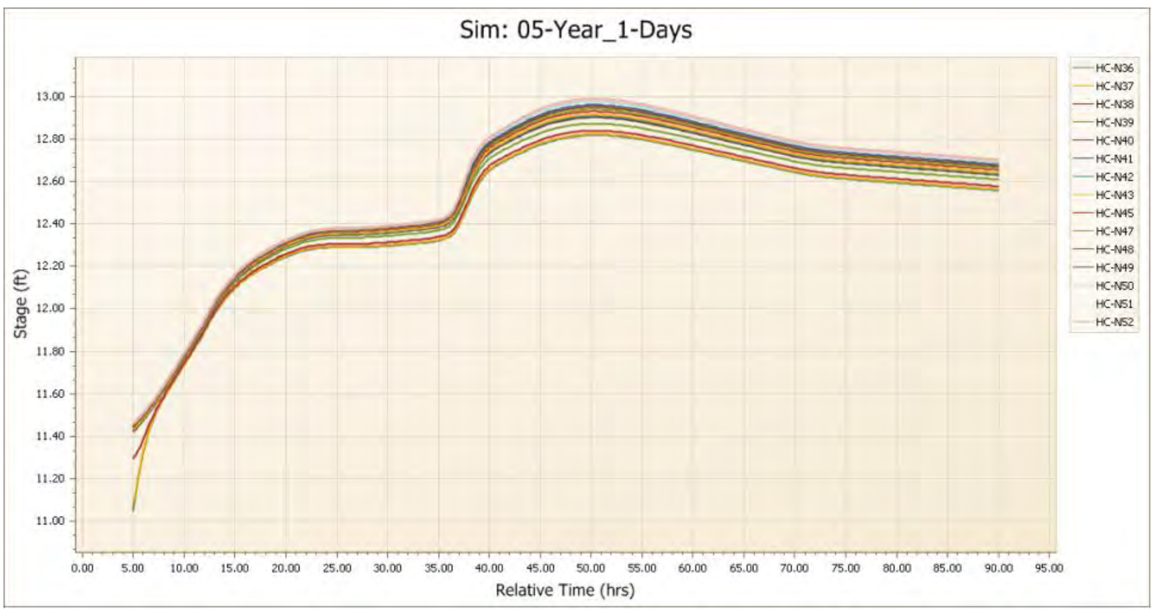


Figure 3-11: Halfway Creek Section 2 -
5-Year, 1-Day Stage Time Series

Section 3: Main Stream from Upstream Side of Brooks North Outfall to I-75

- Average channel velocities are very low, ranging from 0.12 fps to a maximum of 0.15 fps at the downstream end of the Railroad crossing. This is attributed to the nature of the flow-way lake system within The Brooks community, which is controlled by the outfall weir. All the flow-way lakes behave as a level pool, connected by a system of submerged culverts.
- Flow rates within this section of the creek range from 133 cfs coming from the I-75 culverts to 267 cfs at the upstream side of the Brooks North Outfall.
- From the upstream side of the Brooks North Outfall to the I-75 culverts, the peak water surface elevations range from 13.02 ft-NAVD to 13.18 ft-NAVD.
- There are no significant increases, being an increase of 6 inches or greater between nodes, in surface water levels for this section of Halfway Creek
- See Figure 3-12 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Halfway Creek during 5-year, 1-day design storm.

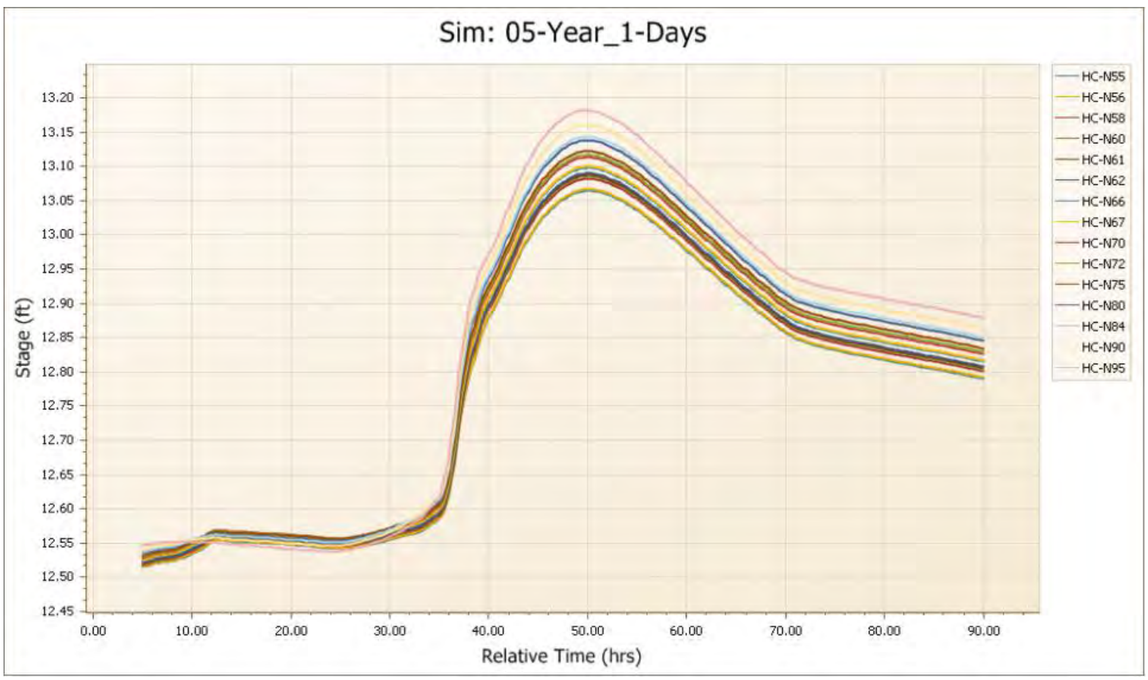


Figure 3-12: Halfway Creek Section 3 -
5-Year, 1-Day Stage Time Series

Section 4: Diversion Streams from Weir Downstream of Via Villagio to The Brooks South Outfall

- Maximum average channel velocities are mild, ranging from 0.19 fps to a maximum of 0.54 fps within the south diversion portion, just north of Coconut Point Mall.
- Peak flow rates within the north diversion portion (HCD2) range from 86 cfs to 100 cfs at the upstream side of the Via Villagio culvert crossing. Peak flow rates within the south diversion portion (HCD1) range from 51 cfs to 67 cfs at the upstream side of the Via Villagio culvert crossing. The two (2) diversion join at the upstream side of the Via Villagio culvert crossing and become one channel on the downstream side. The maximum flow rate in the channel leaving the Via Villagio culvert is 148 cfs.
- In the railroad ditches that traverse north and south on the east side of Via Coconut, there is very little flow.
- From the upstream side of the weir located downstream from Via Villagio to the Brooks South Outfall, the peak water surface elevations range from 12.90 ft-NAVD to 12.96 ft-NAVD.
- There are no significant increases, being an increase of 6 inches or greater between nodes, in surface water levels for this section of Halfway Creek
- See Figure 3-13 below for the Node time series results for the diversion stream Nodes.

No major issues identified for this section of Halfway Creek diversion during 5-year, 1-day design storm.

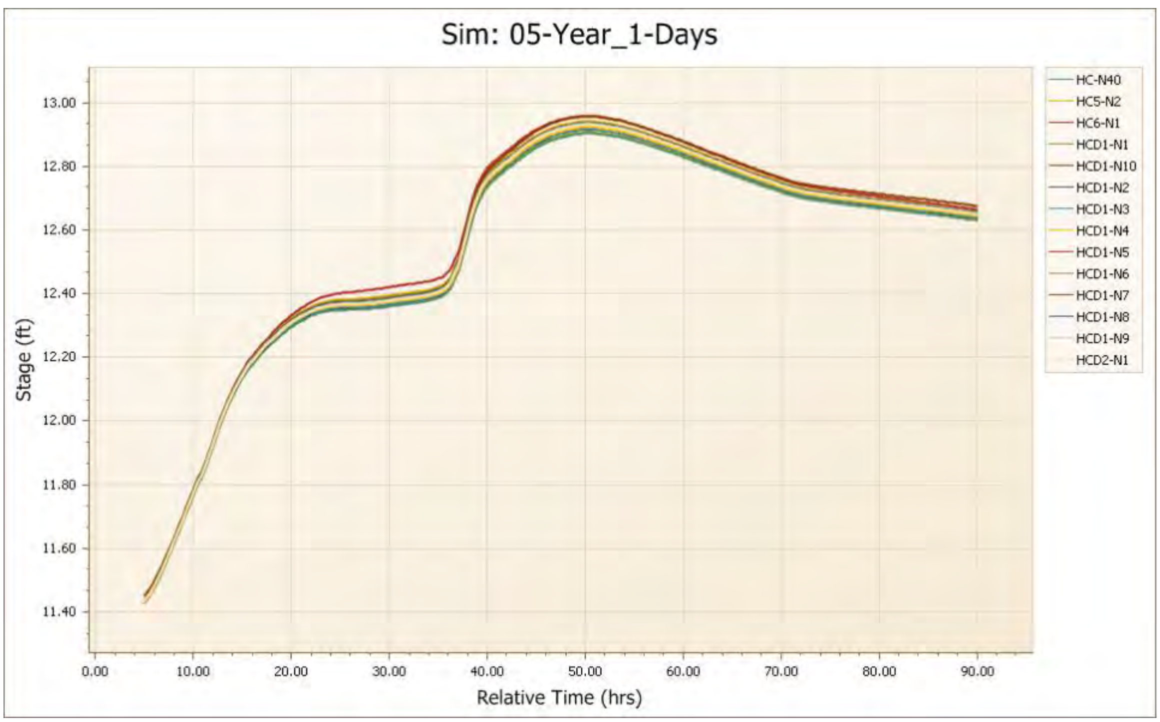


Figure 3-13: Halfway Creek Section 4 -
5-Year, 1-Day Stage Time Series

3.4.1.b. <u>South Branch Sub-Watershed Hydraulic Analysis</u>

As mentioned in the previous section, the South Branch receives flows from I-75 conveyances consisting of a bridge, three (3) 8’ x 8’ box culverts and one (1) 10’ x 6’ box culvert. There is small channel through dense vegetation that restricts flows downstream of the 8’ x 8’ box culverts. The South Branch receives flow from secondary conveyances such as the Three Oaks Parkway system, Corkscrew Road ditch, and Williams Road swale. As the South Branch creek heads west of I-75, it meanders along Corkscrew Woodlands, under a small bridge crossing for Sanctuary Road, through the Villa Palmeras development, through the Three Oaks Parkway culvert crossing, through the Estero Place development, through the Corkscrew Road crossing and connecting with the North Branch, along the south side of “Bamboo Island”. The South Branch main stream is a predominately natural waterway with a narrow bottom width and dense vegetation along the banks and overbank areas, where not located next to developed properties.

<u>Section 1: South Branch from Confluence with Main Branch upstream to Corkscrew Road:</u>

- o Average maximum channel velocities are mild, ranging from 0.69 fps to a maximum of 2.09 fps at just upstream from the confluence with the Main Branch.
- o Peak flow rates within this section of the River range from 152 cfs at the downstream side of the Corkscrew Road crossing to 238 cfs at the connection to the main branch of the Estero River.
- o From the confluence with the Main Branch to Corkscrew Road, the peak water surface elevations range from 3.72 ft-NAVD to 5.89 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ There are no significant increases in water levels between nodes along this section of the Estero River South Branch.
  - ➢ See Figure 3-14 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of the South Branch during 5-year, 1-day design storm.

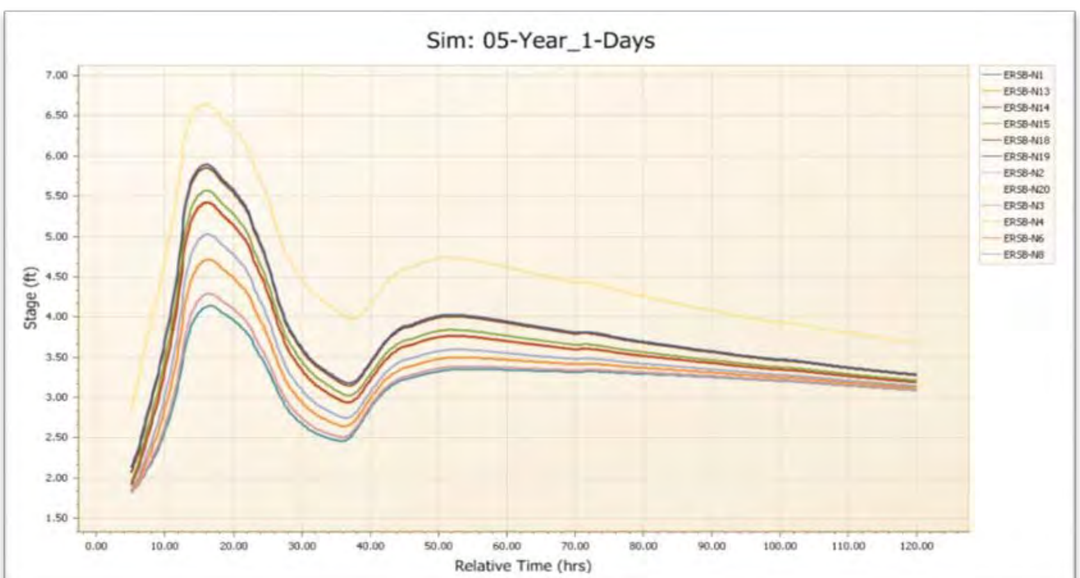


**Figure 3-14: South Branch Section 1 -
5-Year, 1-Day Stage Time Series**

Section 2: South Branch from Corkscrew Road to Three Oaks Parkway

- o Average maximum channel velocities are low to mild, ranging from 0.46 fps to a maximum of 0.87 fps.
- o Peak flow rates within this section of the River range from 122 cfs to 129 cfs. The most upstream portion of this section of the South Branch has the highest flow rate, coming from the culverts under Three Oaks Parkway. Typically, the flow rate of a river increases from upstream to downstream. This section of the South Branch has an increase in vegetation, and thus the Manning's n value, which could account for the decrease in the flow rate from upstream to downstream.
- o From the downstream side of Corkscrew Road to the downstream side of Three Oaks Parkway, the peak water surface elevations range from 6.64 ft-NAVD to 7.16 ft-NAVD.
- o Significant increases in peak water levels between nodes:
  - ➢ There are no significant increases in water levels between nodes along this section of the Estero River South Branch.
  - ➢ See Figure 3-15 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of the South Branch during 5-year, 1-day design storm.

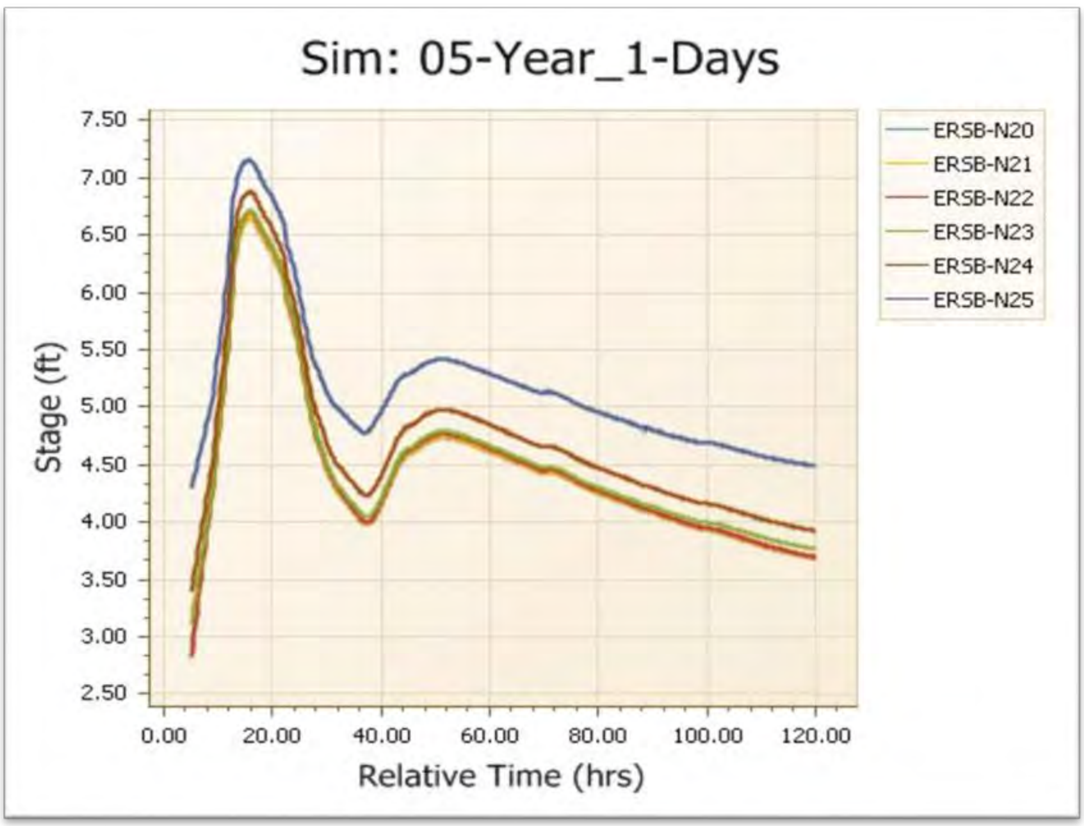


Figure 3-15: South Branch Section 2 -
5-Year, 1-Day Stage Time Series

Section 3: South Branch from Three Oaks Parkway to the I-75 Culvert Crossing

- Average maximum channel velocities are low to mild, ranging from 0.30 fps to a maximum of 1.13 fps.
- Maximum flow rates within this section of the South Branch range from 25 cfs to 148 cfs, with the greatest flow rate occurring just upstream of the Three Oaks Parkway culvert crossing. The lowest flow rates occur in the portion which separates into two (2) distinct channels located near Corkscrew Woodlands; each channel conveying a portion of the total flow.
- From the downstream side of the Three Oaks Parkway crossing to the downstream side of the I-75 culverts, the peak water surface elevations range from 7.21 ft-NAVD to 14.40 ft-NAVD.
- Significant increases in peak water levels between nodes:
  - ERSB-N28 to ERSB-N29: Increase of 2.53 feet across a pedestrian bridge crossing located in Villa Palmeras. This is attributed to the change in cross-section of the River – the bottom becomes narrower, forcing water to flow more in the banks with a much higher roughness. In addition, the available flow area at the lower water surface elevations is more limited through the bridge crossing.
  - ERSB-N29 to ERSB-N31: Increase of 0.55 feet from the upstream side of the pedestrian bridge crossing to upstream. This attributed to a narrow channel section.
  - ERSB-N30 to ERSB-N31: Increase of1.87 feet located within the creek section at the east side of Villa Palmeras. This is attributed to the change in cross-section of the River – the bottom becomes narrower, forcing water to flow more in the banks with a much higher roughness. Furthermore, this section of the River has a large drainage basin contributing flow to it, much of which is wetlands and residential developments. See Figure 3-16 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jump within the area located upstream of Villa Palmeras, conduct routine/regular maintenance to reduce roughness factor within flow area.***

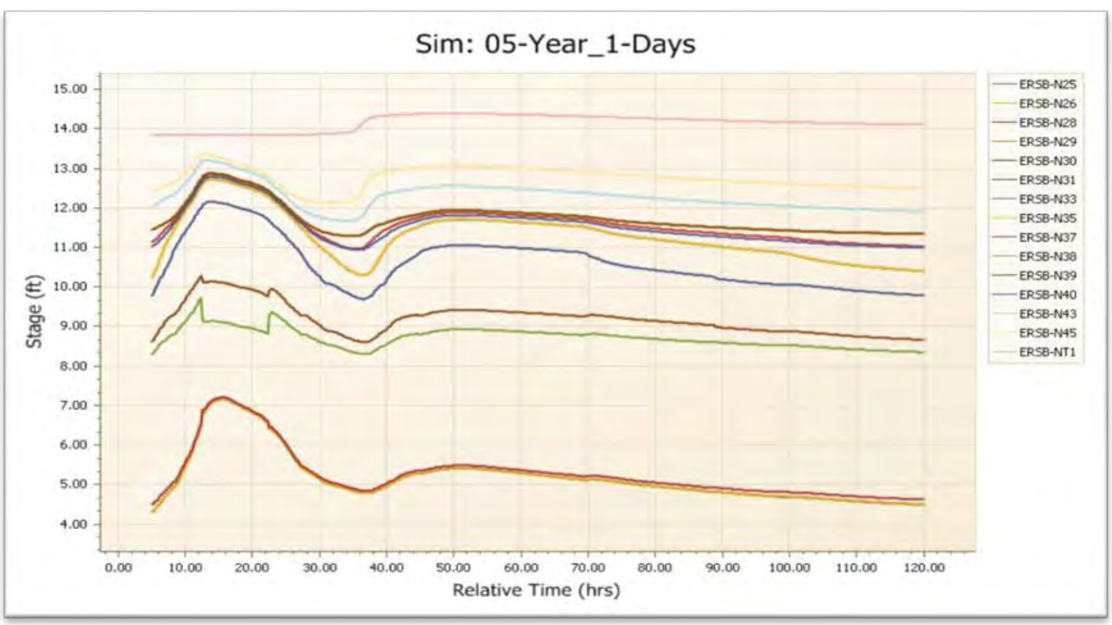


Figure 3-16: South Branch Section 3 -
5-Year, 1-Day Stage Time Series

3.4.1.c. North Branch Sub-Watershed Hydraulic Analysis

As mentioned in the previous section, the North Branch is a perennial waterway with a generally well-defined channel within the downstream section, segments of mild to abrupt meanders and profiles slopes ranging from mild to moderate. The defined creek section receives flows from a series of wetlands located east of I-75, flows under I-75 north of Corkscrew Road and traverses in a southwesterly direction. The North Branch receives flows from secondary conveyances, which include but is not limited to: the Three Oaks Parkway drainage system, the Estero Parkway drainage system, a channel (concrete and bare earth) along the west side of I-75, a conveyance system that begins south of Rookery Pointe crosses the Estero Parkway and continues west of the Three Oaks Elementary School and South of Pine Glen, and the Cypress View Road drainage system. As the North Branch heads west of I-75, there are two (2) routes that the water may follow. One route is north of the Villagio development through a conservation area, crossing the Three Oaks Parkway and traversing another natural area (just north of Rookery Drive). The other route travels through the Villagio residential development, under the Three Oaks Parkway, crosses the Rookery Pointe residential community through an initial linear flow-way system to where it meets with the northern branch and flows toward The Villages at Country Creek. As the creek enters The Villages at Country Creek, it becomes more curvilinear and narrower with steeper side slopes and rocky bottom. A segment of the creek that runs southeast bordering the northern portion of "Bamboo Island" contains milder profile slopes until it reaches the confluences with the Main Branch. In addition, there is a historic creek segment located between the North Branch and South Branch, along the east side of Bamboo Island which has been filled in with sediment and vegetation over time.

Section 1: From Junction with River to North Boundary of VCC

- Maximum average channel velocities are mild to moderate, ranging from 0.71 fps to a maximum of 3.34 fps at just upstream of the junction with Estero River.
- Peak flow rates within this section of the creek range from 265 cfs at the north boundary of Villages at Country Creek to 266 cfs at the location of where the North Branch enters a slight change in direction to the west, along the north side of Bamboo Island. At this point, there is a split in the flow. The maximum flow coming out of the westward diversion into the junction with the River is 153 cfs.
- From the junction node to the north Villages at Country Creek boundary, the peak water surface elevations range from 3.72 ft-NAVD to 10.63 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - From ERNBD1-N2 to ERNBD1-N3: There is 0.66 feet of rise between peak water surface elevations. This is located within the westward diversion section of the North Branch and can be attributed to more shallow channel sections within this area.
  - From ERNBD1-N3 to ERNBD1-N4: There is 1.17 feet of rise between peak water surface elevations. This is located within the westward diversion section of the North Branch and can be attributed to more shallow channel sections within this area.
  - From ERNBD1-N4 to ERNB-N1: There is 1.06 feet of rise between peak water surface elevations. This is located at the interface between the North Branch and westward diversion of the North Branch. This can be attributed to the change in channel cross-section at this location.
  - From ERNB-N8 to ERNB-N10: There is 0.60 feet of rise between peak water surface elevations. This is located just downstream of the golf cart bridge located north of Halfhitch Road.

➢ See Figure 3-17 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jumps within the section of the branch that travels along the north side of Bamboo Island, provide a better distribution of flow by improving the bypass section that travels along the east and south side of Bamboo Island.***
- ***Work with the Villages at Country Creek community on a regular maintenance program for the portions of the North Branch located within their property.***

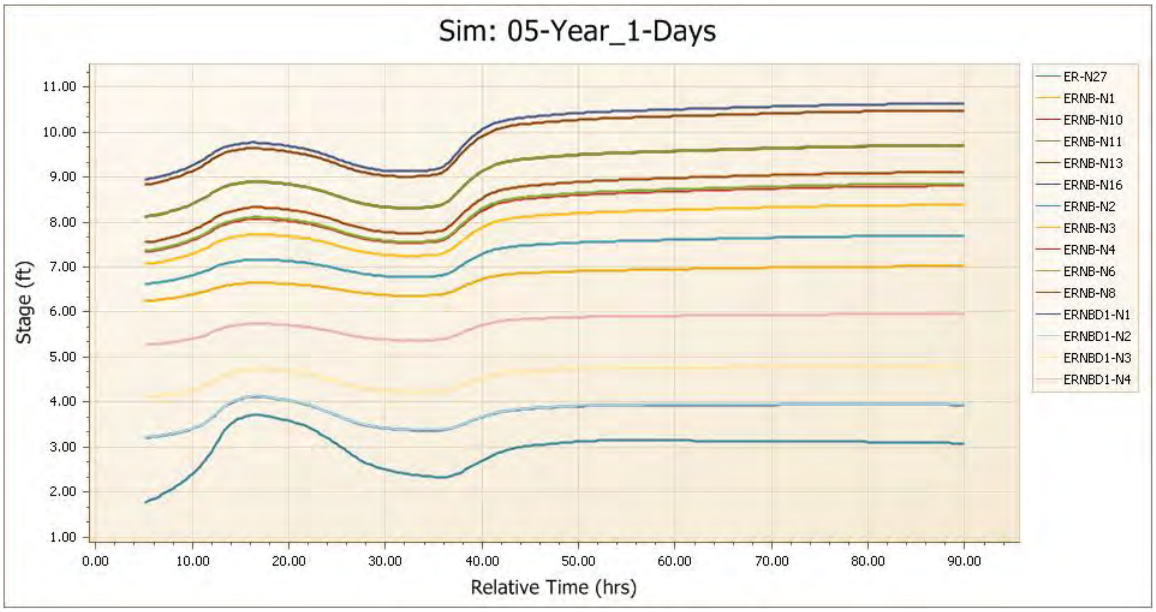


Figure 3-17: North Branch Section 1 - 5-Year, 1-Day Stage Time Series

Section 2: North Branch from North Boundary of Villages at Country Creek through Rookery Pointe to I-75 Boundary (ERNB-NT2)

- Average maximum channel velocities are mild to moderate, ranging from 0.54 fps to a maximum of 2.57 fps at the most downstream end.
- Maximum Flow rates within this section of the creek range from 252 cfs to 266 cfs at northern boundary of Villages at Country Creek
- From the downstream boundary to I-75 boundary node, the peak water surface elevations range from 10.63 ft-NAVD to 15.43 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ERNB-N16 to ERNB-N17 Increase of 0.65 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area.
  - ERNB-N17 to ERNB-N18: Increase of 1.92 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area. There is also a steeper slope in the bottom elevation of the channel, which increase velocities.
  - ERNB-N18 to ERNB-N19: Increase of 0.72 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area.
  - See Figure 3-18 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jumps within the section of the branch that travels between Villages at Country Creek and Rookery Drive, conduct improvements to the channel cross-section to achieve a more gradual slope from north to south and conduct routine maintenance to remove vegetation debris and exotics.***

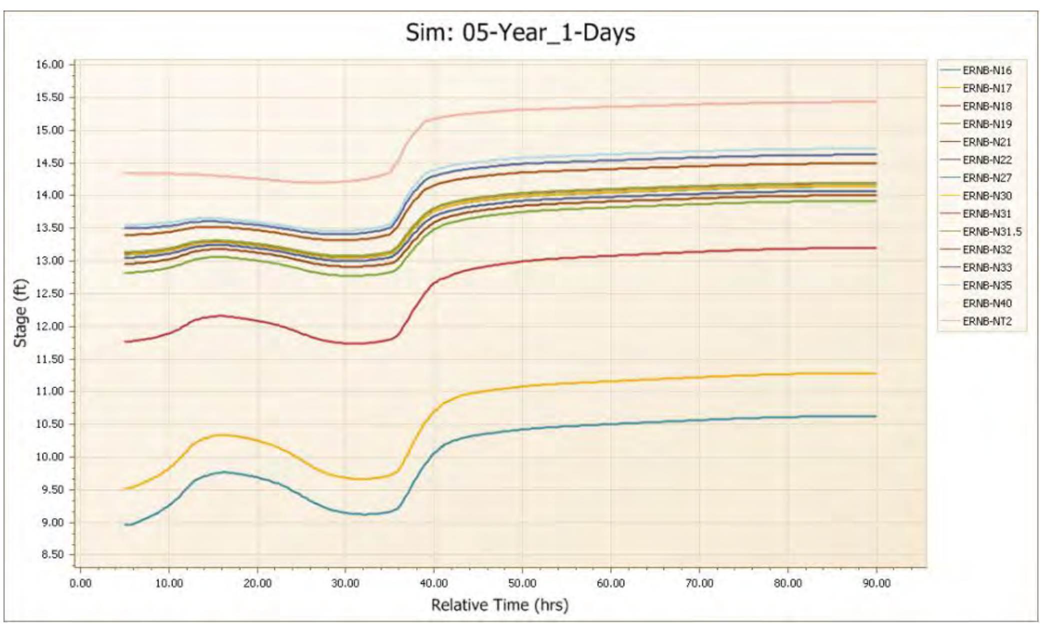


Figure 3-18: North Branch Section 2 - 5-year, 1-Day Stage Time Series

Section 3 North Branch North Diversion through Rookery Pointe, North of Villagio to I-75 Boundary (ERNB-NT2)

- o Average maximum channel velocities are very low, ranging from 0.11 fps to a maximum of 0.30 fps at the most downstream end.
- o Peak flow rates within this diversion section of the creek range from 14.5 cfs to 27.5 cfs at the point of connection with the main stream of the North Branch.
- o From the downstream boundary to I-75 boundary node, the peak water surface elevations range from 14.01 ft-NAVD to 15.37 ft-NAVD at the junction with the I-75 parallel swale.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ ERNBD2-N8 to ERNB-N39: Increase of 1.29 feet located within the within the diversion section just before connecting to the I-75 parallel swale. This is attributed to a change in the channel section – more narrow width, higher bottom elevation and heavy vegetation within the flow area.
  - ➢ See Figure 3-19 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- o ***To lessen the hydraulic jumps within the section of the branch that travels north of Villagio, conduct improvements to the channel to achieve a more open cross-section and conduct routine maintenance to remove vegetation debris and exotics.***

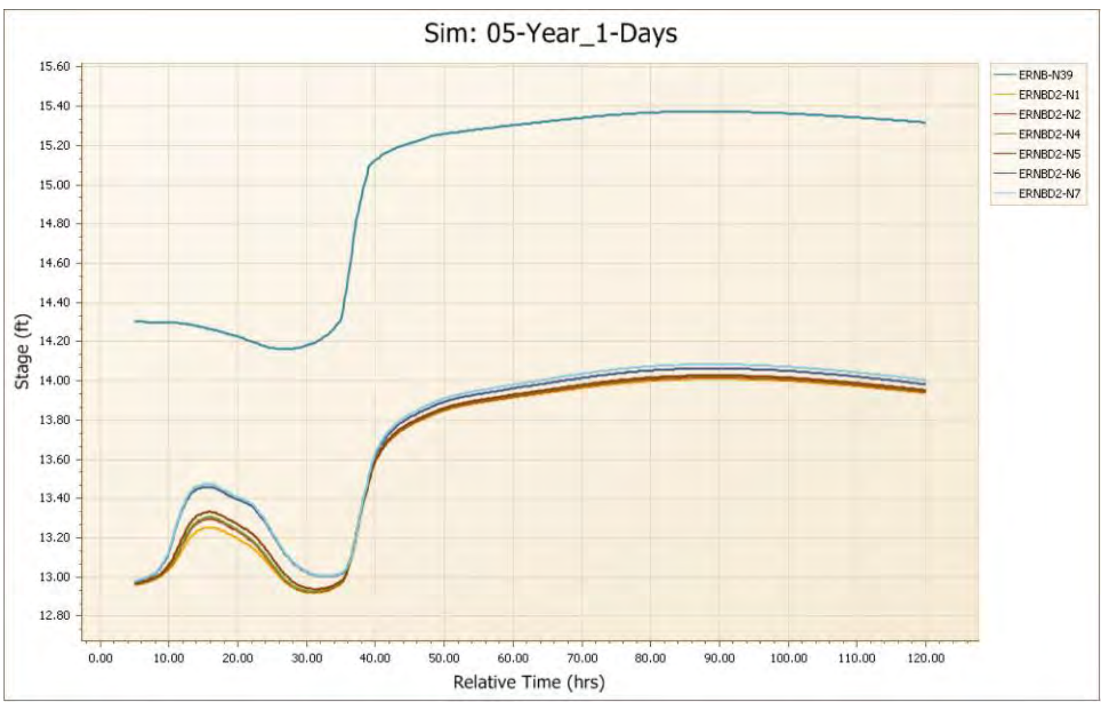


Figure 3-19: North Branch North Diversion Section - 5-Year, 1-Day Stage Time Series

3.4.1.d. Estero River, Main Branch Sub-Watershed Hydraulic Analysis

As mentioned in the previous section, the Estero River is a perennial waterway with a well-defined channel, segments of mild to abrupt meanders and profiles slopes ranging from mild to moderate. The Estero River receives flows from secondary and main conveyance systems. The main conveyances contributing to the Estero River are: North Branch, South Branch, and Halfway Creek. Secondary conveyance systems include: the Seminole Gulf Railroad ditch, Sandy Lane, the drainage system Broadway West and US-41, the FP&L Easement ditch, and the U.S. 41 drainage system. As the Estero River heads west from the confluence of the North and South Branches, it travels under Sandy Lane, under the Seminole Gulf Railroad crossing, under U.S. 41 and meanders along the Koreshan State Park property continuing until reaching the Tahiti Mobile Home Park and other residential developments before entering the Estero Bay. Main concerns to be evaluated for the River include the railroad and Sandy Lane crossings and conveyance conditions within the River.

Section 1: Main Stream from Confluence with Estero Bay upstream to U.S. 41

- o Maximum average channel velocities are mild, ranging from 0.90 fps to a maximum of 1.93 fps at just upstream from the confluence with Estero Bay.
- o Peak flow rates within this section of the River range from 431 cfs at the downstream side of U.S. 41 crossing to 791 cfs at the downstream connection to Estero Bay.
- o From the downstream boundary node to U.S. 41, the peak water surface elevations range from -0.04 ft-NAVD to 1.49 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ There are no significant increases in water levels between nodes along this section of the Estero River.
  - ➢ See Figure 3-20 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Estero River during 5-year, 1-day design storm

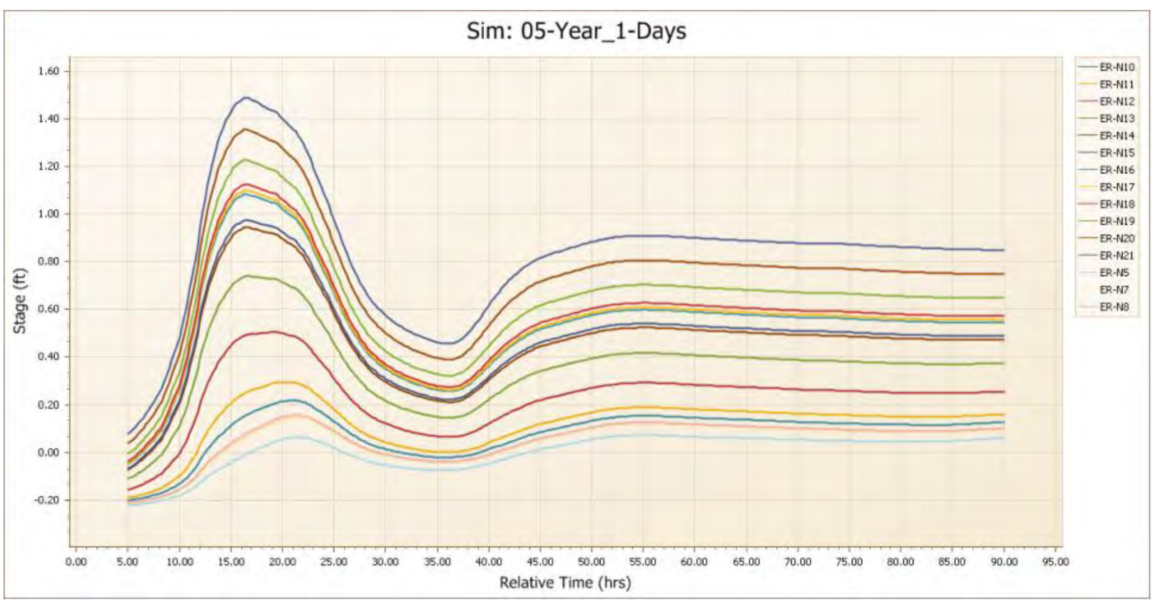


Figure 3-20: Estero River Section 1 -
5-Year, 1-Day Stage Time Series

Section 2: Main Stream from Downstream U.S. 41 to Connection with North and South Branch

- Maximum average maximum channel velocities are mild, ranging from 1.05 fps to a maximum of 2.07 fps at the downstream end of the railroad crossing.
- Peak flow rates within this section of the River range from 372 cfs coming from the junction with the North and South Branches to 431 cfs at the downstream side of the U.S. 41 crossing.
- From the downstream side of U.S. 41 to the junction with the North and South Branches, the peak water surface elevations range from 1.49 ft-NAVD to 3.72 ft-NAVD.
- Significant increases in peak water levels between nodes:
  - ER-N24 to ER-N24.5: Increase of 0.99 feet located just upstream of the railroad crossing. This is attributed to the change in cross-section of the creek as the bottom is becoming narrow, forcing water to flow more in the banks of the River with a higher roughness. In addition, the average channel velocities upstream of ER-N24.5 are higher than the downstream channel.
  - See Figure 3-21 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To reduce the hydraulic jump located between the railroad crossing and the Sandy Lane crossing, it is recommended that the River channel be modified with a more consistent cross-section, including wider bottom and milder side slopes.***

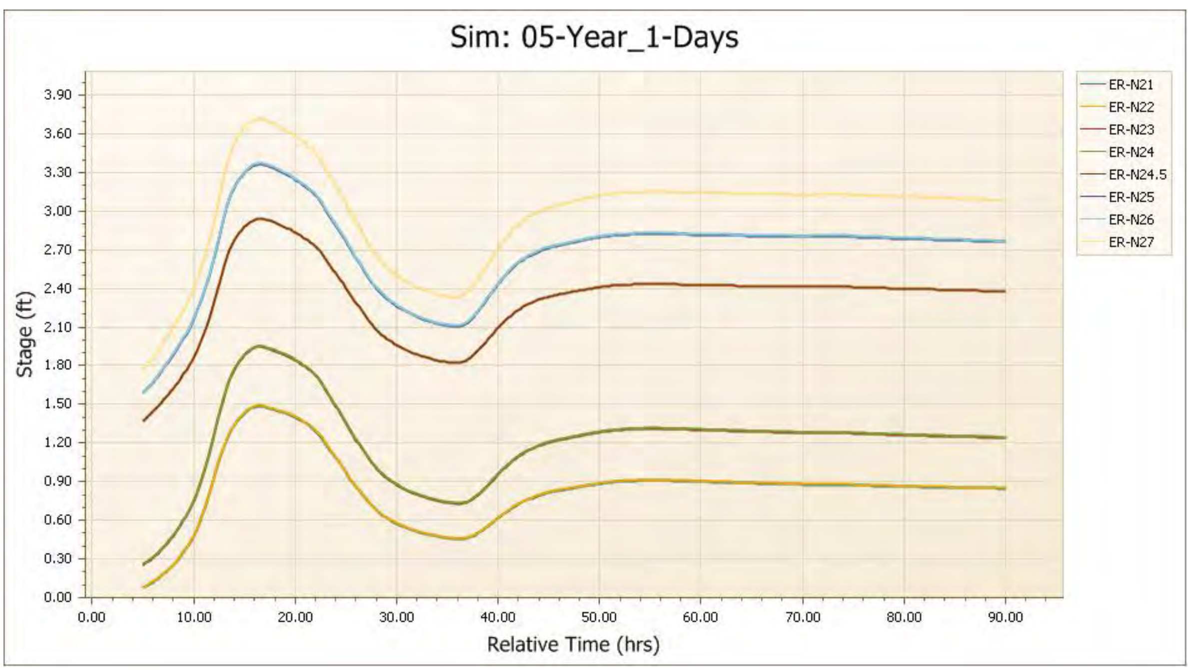


Figure 3-21: Estero River Section 2 - 5-Year, 1-Day Stage Time Series

Table 3-8 provides the node maximum stage results for the 5-Year, 1-Day design storm within the Local-Scale ICPR4 Model. An assessment was conducted within the ICPR4 model at key locations to evaluate the potential for roadway flooding or access flooding, particularly for residential communities. The yellow-highlighted rows within Table 3-8 represent locations that the model results indicate potential for flooding of roadways within the subject development. For example, within the Marsh Landing Basin 2 community (HC-NC17), the existing lowest roadway elevations are around 12.20 FT-NAVD and the 5-year design stage is very close at 12.18 FT-NAVD. In addition, the 5-year design stage for the Trailside Dr. area is not high enough to exceed the roadway pavement elevations, however it is high enough to exceed the limits of the adjacent roadside drainage swale and lower adjacent residential properties.

Table 3-8: Existing Conditions 5-Year, 1-Day ICPR4 Model Results at Key Locations

Existing Conditions 5-Year, 1-Day ICPR4 Model Results at Key Locations		
Node	**Location**	**ICPR4 5-Year, 1-Day Peak Stage (FT-NAVD)**
ER-N16	ER at Broadway Conveyance Connection	1.08
ER-N21	ER & US-41 Downstream	1.49
ER-N23	Rail Road - Downstream	1.95
ER-N24	Rail Road - Upstream	1.95
ER-N26	ER & Sandy Lane Bridge	3.37
ER-N27	West side of Bamboo Island	3.72
ER1-N18	Corkscrew to Sandy Lane	14.31
ER1-NC57	Estero Community Park	14.09
ER4N-N12	SGLR Ditch & Estero Pkwy US	13.12
ER4N-N19	Cascades	13.26
ER4N-N23	Belle Lago	13.06
ER4N-N24	The Reserve	14.14
ER4N-N6	Cascades Outfall / SGLR Ditch	12.63
ER4S-N3	SGLR Ditch Upstream of Corkscrew Road	14.76
ER6-N1	Walmart Ultimate Outfall	13.74
ER6-N3	Walmart/Osprey Cove	13.64
ER804-N1	Pineland Preserve Outfall	12.20
ER804-NC1	Pineland Preserve	14.23
ERNB - N1	East side of Bamboo Island	7.02
ERNB-N17	USGS Gage-South of Rookery Point	11.28
ERNB-N20	Rookery Point Cir. Bridge	13.93

Existing Conditions 5-Year, 1-Day ICPR4 Model Results at Key Locations		
Node	**Location**	**ICPR4 5-Year, 1-Day Peak Stage (FT-NAVD)**
ERNB-N30	D/S Three Oaks Pkwy Crossing	14.15
ERNB-N6	Villages of Country Creek - Halfhitch Rd Bridge	8.85
ERNB-NC05	The Villages at Country Creek Basin 3	8.80
ERNB-NC25	Rookery Basin 2	14.92
ERNB-NC46	Villagio	15.76
ERNB1-NC018	Waste Water Treatment Plant	18.41
ERNB1-NC022	Three Oaks Community Park (Park)	16.41
ERNB1-NC025	Three Oaks Community Park (Pond)	16.32
ERNB2-NC23	Country Oaks	16.68
ERNB2E-N13	Estero Pkwy & 3Oaks	14.17
ERNB2E-N24	End nodes Three Oaks near Coastal Villages	16.06
ERNB2N-NC20	Three Oaks Town Center	16.09
ERNB2N-NC59	Three Oaks Middle School	17.22
ERNB2W-NC22	Estero Oaks	15.86
ERNB2W-NC24	Rookery Basin 3	16.91
ERNB3-NC16	Somerset	16.67
ERNB4-N10	U/S Estero Parkway Culvert	14.44
ERNB4-NC14	Our Lady Of Light	16.65
ERNB4-NC4	Rookery Basin 1	15.40
ERNB5E-NC7	Pond 100 Estero Parkway	18.66
ERNB5E-NC8	The Reef	16.04
ERNBD2-N4	ERNB at 3Oaks Crossing N (US)	14.02
ERSB-N20	USGS Gage - ERSB at Corkscrew Rd	6.64
ERSB-N32	ERSB Downstream of Sanctuary Rd	12.70
ERSB-N34	ERSB at Sanctuary Road Crossing	12.72
ERSB-NC05	The Villages at Country Creek Basin 7	7.97
ERSB1-N2	See See St. - Downstream	7.99
ERSB1-NC534	Courtyard Apartments	16.23
ERSB2E-N14	Post Office on 3Oaks	14.70
ERSB2E-N7	3 Oaks at Quente Way	14.69
ERSB2E-NC37	Copper Oaks	16.07

Existing Conditions 5-Year, 1-Day ICPR4 Model Results at Key Locations		
Node	**Location**	**ICPR4 5-Year, 1-Day Peak Stage (FT-NAVD)**
ERSB5-N05	ERSB5-N05	12.24
ERSB6-NC03	The Villages at Country Creek Basin 10	11.33
ERSB6-NC06	The Villages at Country Creek Basin 5	10.39
ERSB9-N12	River Ranch at Block Lane	14.17
HC-N22	HC Downstream of FPL Crossing	9.08
HC-N34	Halfway Creek at U.S. 41 - U/S	12.81
HC-N35	Halfway Creek at U.S. 41 - U/S (+100 FT)	12.82
HC-N55	The Brooks North Outfall Gage	13.06
HCD1-NC10	Coconut Point Mall- North Outfall	14.68
HCD1-NC3	The Brooks South Outfall Gage	13.72
HC-NC17	Marsh Landing Basin 2 Outfall	12.18
HC-NC24	Fountain Lakes Basin 1 Outfall	12.59
HC4-NC1	Coconut Shores Basin Outfall	15.19
HCD1-NC3	The Brooks South Outfall Gage	11.54
NS-052	Broadway Ave., North Side	13.14
N-010	North Side of Broadway Ave. Tributary/ Trailside Dr.	12.29
NC-100	Terra Vista	12.39
ER802-N5	Breckenridge	13.25
NS-473	Trailside Dr., North End	14.23
NS-476	Trailside Dr., South End	9.82
ER802-N3	North Side of Broadway Ave. at Sherrill Lane	1.08

3.4.2. 10-Year, 1-Day Design Storm Analysis and Results

The 10-year, 1-day design storm utilizes a total rainfall depth of 6.5 inches distributed over a period of 24 hours, or 1 day. In the past, many jurisdictions such as Lee County have regulated that the minimum road elevations for new developments shall be at the design water elevation resulting from a 5-year, 1—day storm event. Thus, there are many older residential developments within the Village where the roadway elevations may be consistent with this antiquated requirement. For the hydraulic analysis of the 10-year, 1-day design storm, the main conveyances of each sub-watershed are evaluated below to provide an overall description of system performance and to note areas of concern and/or candidates for improvement projects.

3.4.2.a. Halfway Creek Watershed Hydraulic Analysis

Section 1: Main Stream from Confluence with Estero River upstream to U.S. 41

- Maximum average channel velocities are mild or moderate, ranging from 0.22 fps to a maximum of 2.60 fps at the most downstream end.
- Peak flow rates within this section of the creek range from 297 cfs to 321 cfs at the downstream connection to Estero River.
- From the downstream boundary to U.S. 41, the peak water surface elevations range from 2.52 ft-NAVD to 12.95 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater, between nodes, in peak surface water levels occur at the following locations:
  - HC-N7 to HC-N8: Increase of 0.66 feet located within the West Bay Club, north of West Bay Boulevard, just north of the most northern golf cart bridge crossing.
  - HC-N15 to HC-N16: Increase of 1.22 feet located within southern portion of West Bay Club, south of the last golf cart bridge crossing. This can be attributed to change in profile slope of channel bottom, a decrease in defined channel section, and increase in roughness coefficient within the overbank areas.
  - HC-N17 to HC-N18: Increase of 0.70 feet located just outside south boundary of West Bay Club and into large conservation/wetland area. This is attributed to shallower channel section with high roughness factors within majority of flow cross-section.
  - HC-N19 to HC-N20: Increase of 0.89 feet located within large conservation/wetland area between West Bay Club and FPL Crossing. This is attributed to shallower channel section with high roughness factors within majority of flow cross-section.
  - HC-N22 to HC-N23: Increase of 1.19 feet located within large conservation/wetland area between West Bay Club and FPL crossing, just downstream of FPL crossing. This is attributed to shallower channel section at upstream end and high roughness factors within majority of flow cross-section for entire segment.
  - HC-N25 to HC-N26: Increase of 0.51 feet located within large conservation/wetland area, just upstream of FPL crossing. This is attributed to shallower channel section at upstream end and high roughness factors within majority of flow cross-section for entire segment. The surface water elevations within this portion of Halfway Creek affects Marsh Landing Basin 3 Outfall and properties upstream, specifically Fountain Lakes Basin 1, Marsh Landing Basins 1 and 2.
  - See Figure 3-22 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jump within the large conservation/wetland area located between West Bay Club and FPL crossing, conduct routine/regular maintenance to reduce roughness factor within flow area.***
- ***Work with the West Bay Club community on a regular maintenance program for the upstream portions of Halfway Creek located within their property.***

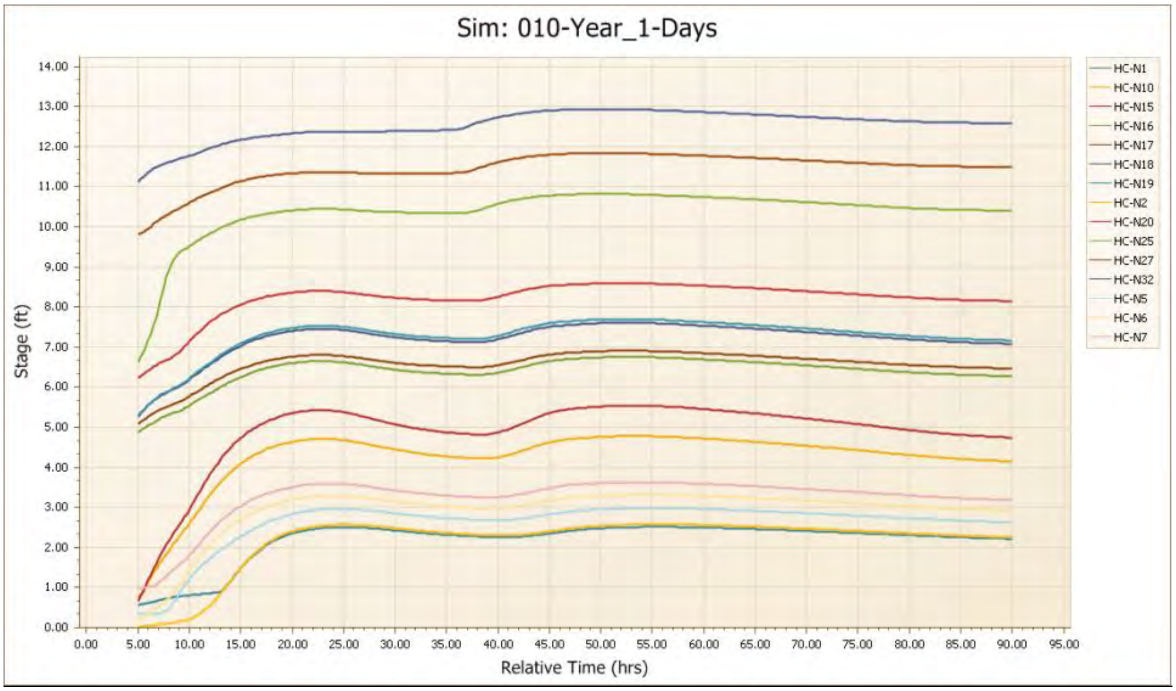


Figure 3-22: Halfway Creek Section 1 -
10-Year, 1-Day Stage Time Series

Section 2: Main Stream from Downstream U.S. 41 to Railroad Crossing/Brooks North Outfall

- o Maximum average channel velocities are mild, ranging from 0.17 fps to a maximum of 1.01 fps at the downstream end of the U.S. 41 crossing.
- o Peak Flow rates within this section of the creek range from 261 cfs coming from the Brooks North Outfall to 381 cfs at the downstream side of the U.S. 41 crossing. As the
- o From the downstream side of U.S. 41 to the Railroad Crossing/Brooks North Outfall, the peak water surface elevations range from 12.95 ft-NAVD to 13.24 ft-NAVD.
- o The average velocity through the U.S 41 culvert crossing is 1.41 fps and the culverts are flowing completely full during the peak of the event. The peak head-loss through the culvert crossing is 0.07 feet. The bottom invert is 4.62 ft-NAVD with a top elevation of 11.62 ft-NAVD.
- o See Figure 3-23 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Halfway Creek during 10-year, 1-day design storm.

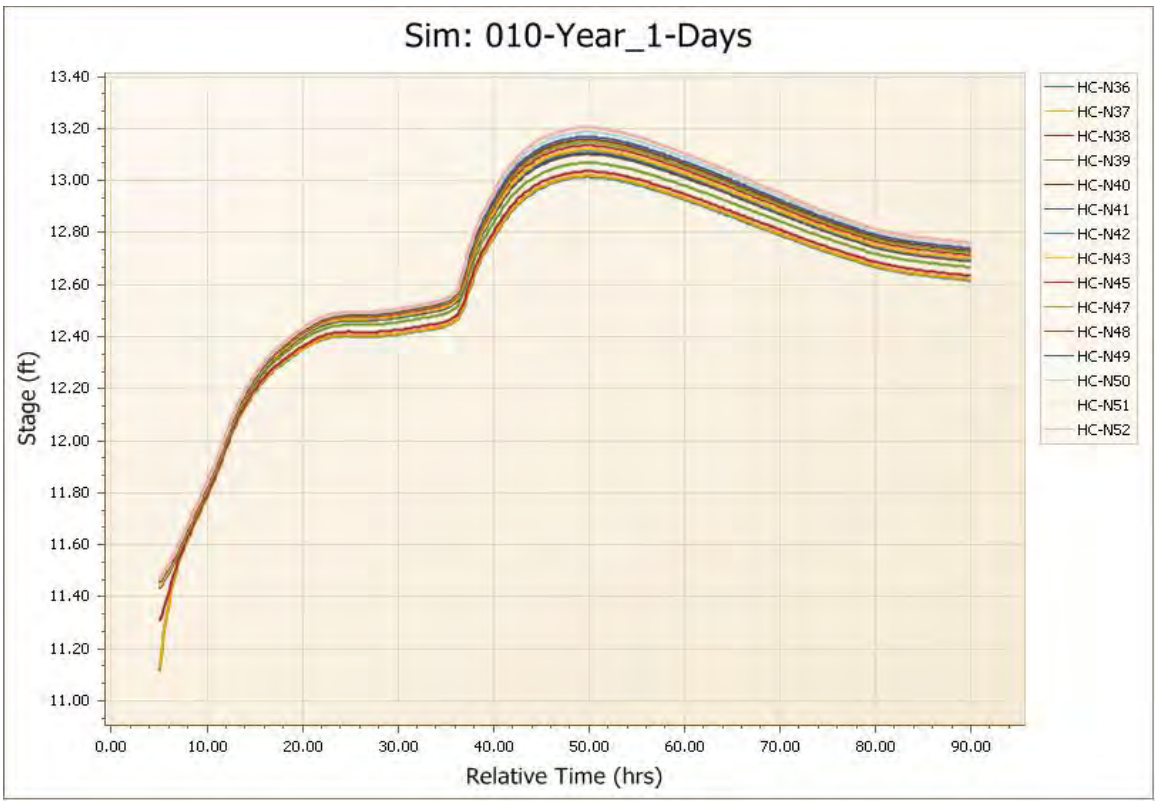


Figure 3-23: Halfway Creek Section 2 - 10-Year, 1-Day Stage Time Series

Section 3: Main Stream from Upstream Side of Brooks North Outfall to I-75

- o Maximum average channel velocities are very low, ranging from 0.16 fps to a maximum of 0.19 fps at the downstream end of the Brooks North Outfall. This is attributed to the nature of the flow-way lake system within The Brooks community, which is controlled by the outfall weir. All the flow-way lakes behave as a level pool, connected by a system of submerged culverts.
- o Peak flow rates within this section of the creek range from 155 cfs coming from the I-75 culverts to 225 cfs at the downstream side of the Brooks North Outfall.
- o From the downstream side of the Brooks North Outfall to the I-75 culverts, the peak water surface elevations range from 13.24 ft-NAVD to 13.44 ft-NAVD.
- o See Figure 3-24 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Halfway Creek during 10-year, 1-day design storm.

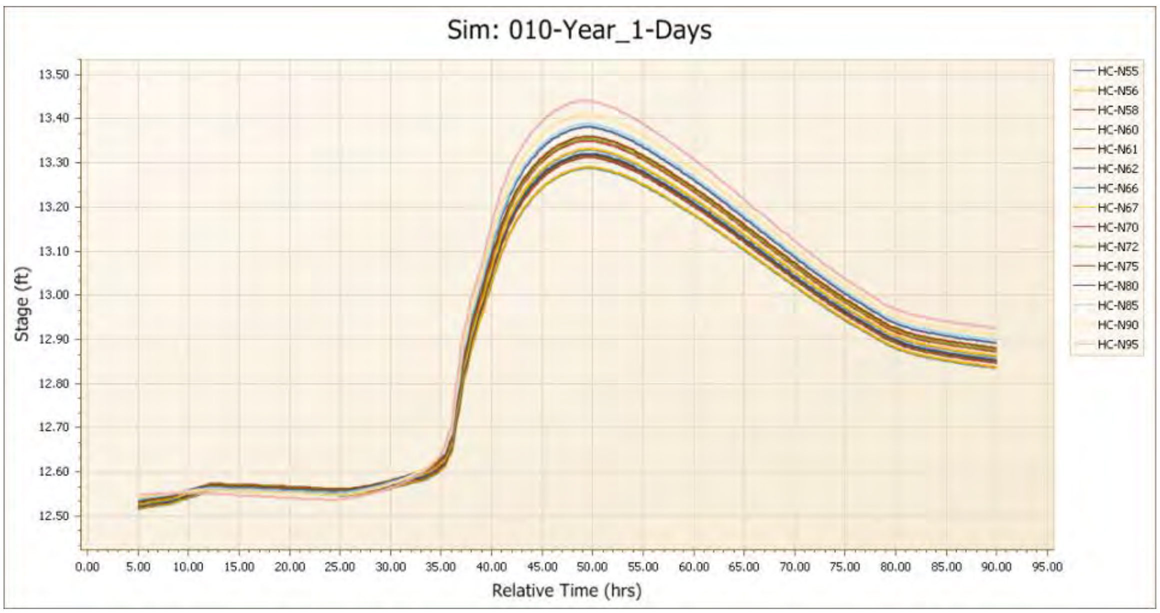


Figure 3-24: Halfway Creek Section 3 -
10-Year, 1-Day Stage Time Series

<u>Section 4: Diversion Streams from Weir Downstream of Via Villagio to The Brooks South Outfall</u>

- Maximum average channel velocities are mild, ranging from 0.22 fps to a maximum of 0.54 fps within the south diversion portion, just north of Coconut Point Mall.
- Peak flow rates within the north diversion portion (HCD2) range from 98 cfs to 118 cfs at the upstream side of the Via Villagio culvert crossing. Peak flow rates within the south diversion portion (HCD1) range from 64 cfs to 90 cfs at the upstream side of the Via Villagio culvert crossing. The two (2) diversion join at the upstream side of the Via Villagio culvert crossing and become one (1) channel on the downstream side. The maximum flow rate in the channel leaving the Via Villagio culvert is 179 cfs.
- In the railroad ditches that travel north and south of the Brooks South and North Outfall, there is very little flow.
- From the upstream side of the weir located downstream from Via Villagio to the Brooks South Outfall, the peak water surface elevations range from 13.10 ft-NAVD to 13.17 ft-NAVD.
- See Figure 3-25 below for the Node time series results for the diversion stream Nodes.

No major issues identified for this section of Halfway Creek during 10-year, 1-day design storm.

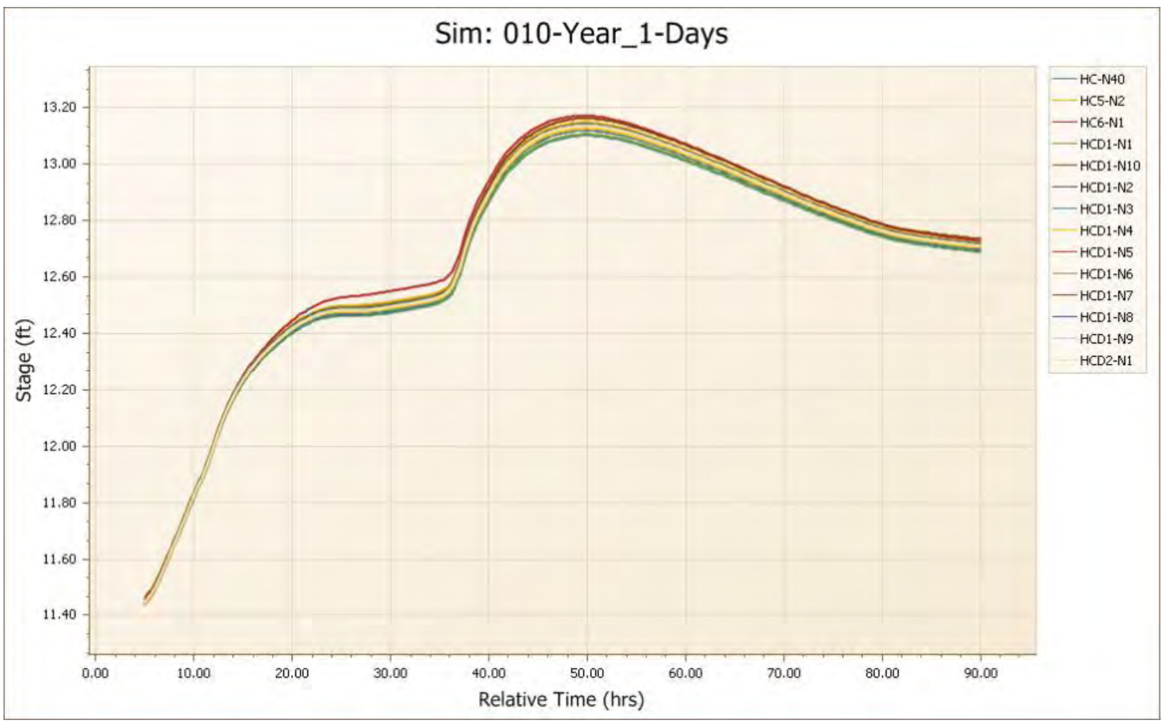


Figure 3-25: Halfway Creek Section 4 -
10-Year, 1-Day Stage Time Series

3.4.2.b. <u>South Branch Sub-Watershed Hydraulic Analysis</u>

<u>Section 1: South Branch from Confluence with Main Branch upstream to Corkscrew Road:</u>

- o Average channel velocities are mild, ranging from 0.77 fps to a maximum of 2.12 fps at just upstream from the confluence with the Main Branch.
- o Peak flow rates within this section of the River range from 185 cfs at the downstream side of the Corkscrew Road crossing to 284 cfs at the connection to the main branch of the Estero River.
- o From the confluence with the Main Branch to Corkscrew Road, the peak water surface elevations range from 4.10 ft-NAVD to 6.44 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ There are no significant increases in water levels between nodes along this section of the Estero River South Branch.
  - ➢ See Figure 3-26 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of the South Branch during 10-year, 1-day design storm.

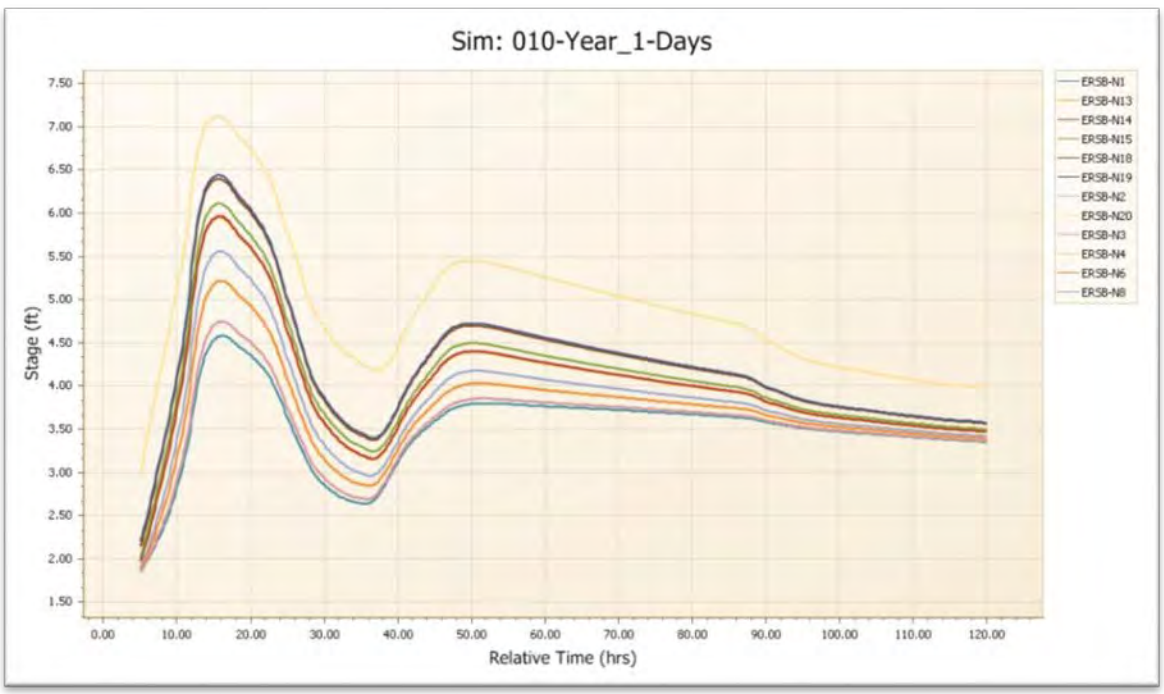


Figure 3-26: South Branch Section 1 -
10-Year, 1-Day Stage Time Series

Section 2: South Branch from Corkscrew Road to Three Oaks Parkway

- o Average maximum channel velocities are mild, ranging from 0.50 fps to a maximum of 0.87 fps.
- o Peak flow rates within this section of the River range from 138 cfs to 148 cfs. Unlike during the 5-Year, 1-Day simulation, the flow rate during the 10-Year, 1-Day simulation does increase as it goes downstream. 138 cfs enters Section 2 of the South Branch from the Three Oaks Parkway culverts, and 148 cfs leaves the section at the Corkscrew Road culverts.
- o From the downstream side of Corkscrew Road to the downstream side of Three Oaks Parkway, the peak water surface elevations range from 7.12 ft-NAVD to 7.65 ft-NAVD.
- o Significant increases in peak water levels between nodes:
  - ➢ There are no significant increases in water levels between nodes along this section of the Estero River South Branch.
  - ➢ See Figure 3-27 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of the South Branch during 10-year, 1-day design storm.

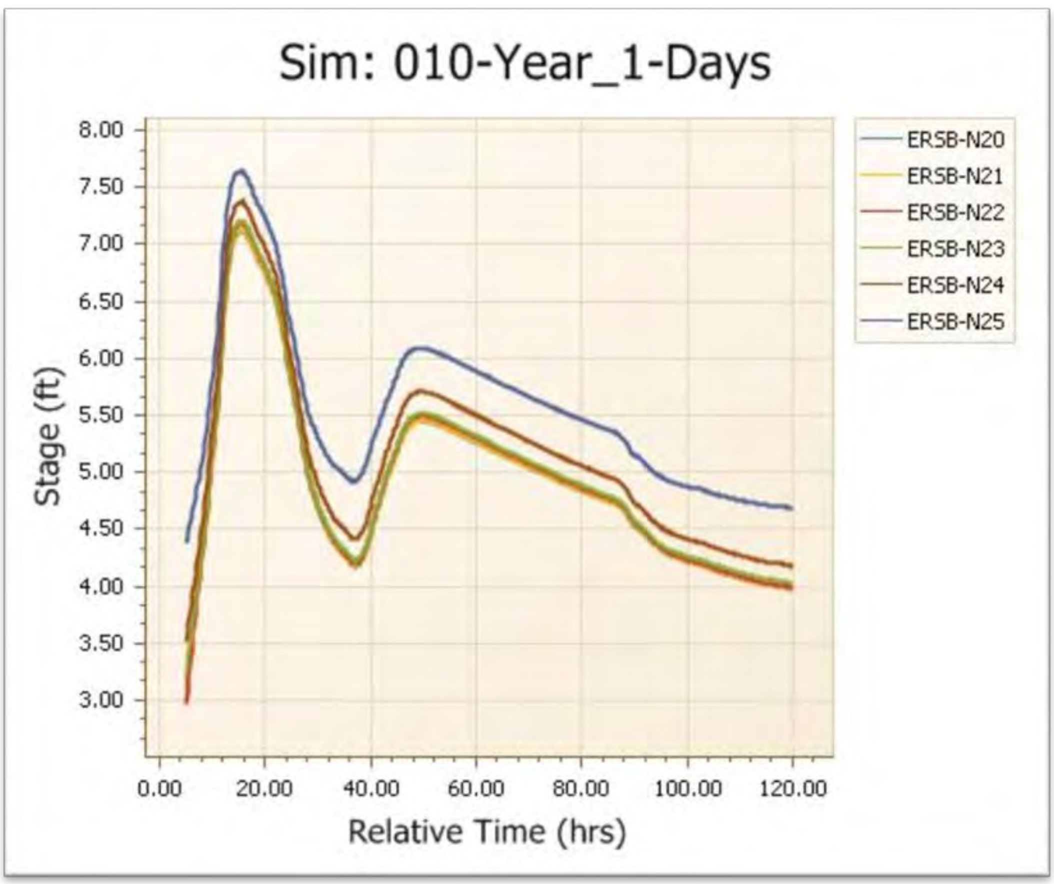


**Figure 3-27: South Branch Section 2 -
10-Year, 1-Day Stage Time Series**

Section 3: South Branch from Three Oaks Parkway to the I-75 Culvert Crossing

- o Average maximum channel velocities are mild, ranging from 0.31 fps to 1.16 fps.
- o Peak flow rates within this section of the River range from 30 cfs to 151 cfs, with the greatest flow rate occurring just downstream of where the split section of the river merges back into a single channel. The lowest flow rates occur in the portion which separates into two (2) distinct channels; each channel conveying a portion of the total flow.
- o From the downstream side of Three Oaks Parkway to the downstream side of the I-75 culverts, the peak water surface elevations range from 7.65 ft-NAVD to 14.64 ft-NAVD.
- o Significant increases in peak water levels between nodes:
  - ➢ ERSB-N28 to ERSB-N29: Increase of 2.05 feet across a pedestrian bridge crossing located in Villa Palmeras. This is attributed to the change in cross-section of the River – the bottom becomes narrower, forcing water to flow more in the banks with a much higher roughness. In addition, the available flow area at the lower water surface elevations is more limited through the bridge crossing.
  - ➢ ERSB-N29 to ERSB-N31: Increase of 0.57 feet from the upstream side of the pedestrian bridge crossing to upstream. This attributed to a narrow channel section.
  - ➢ ERSB-N30 to ERSB-N31: Increase of 2.04 feet located within the creek section at the east side of Villa Palmeras. This is attributed to the change in cross-section of the River – the bottom becomes narrower, forcing water to flow more in the banks with a much higher roughness. Furthermore, this section of the River has a large drainage basin contributing flow to it, much of which is wetlands and residential developments.
  - ➢ See Figure 3-28 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- o ***To lessen the hydraulic jump within the area located upstream of Villa Palmeras, conduct routine/regular maintenance to reduce roughness factor within flow area***

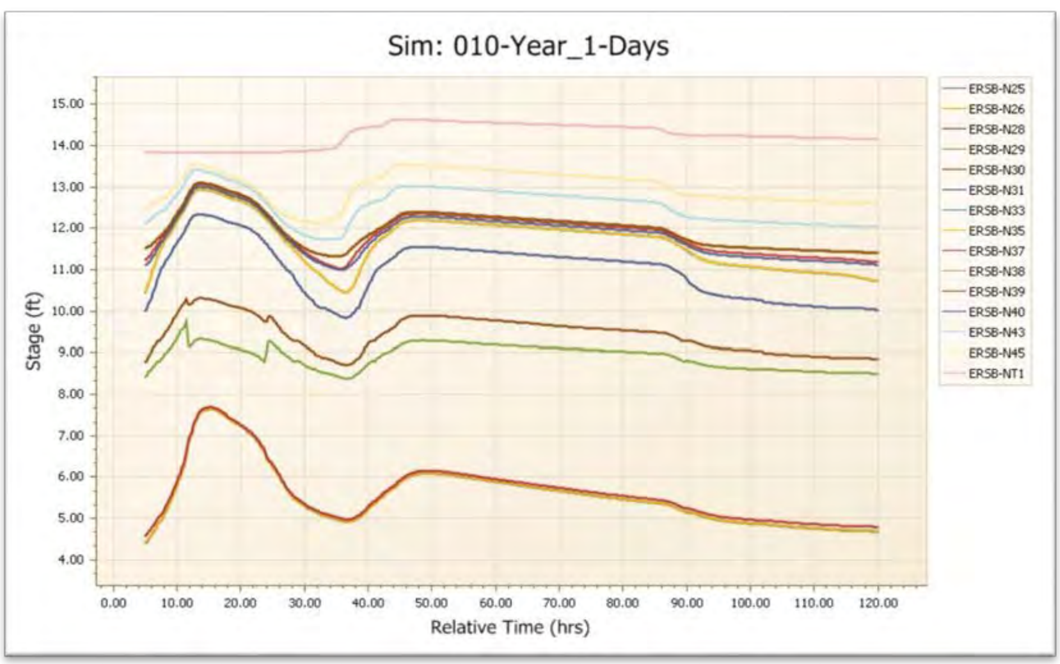


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Figure 3-28: South Branch Section 3 -
10-Year, 1-Day Stage Time Series

3.4.2.c. North Branch Sub-Watershed Hydraulic Analysis

Section 1: From Junction with River to North Boundary of VCC

- Maximum average channel velocities are mild to moderate, ranging from 0.72 fps to a maximum of 3.34 fps at just upstream of the junction with Estero River.
- Peak flow rates within this section of the creek range from 291 cfs at the north boundary of Villages at Country Creek to 292 cfs at the location of where the North Branch enters a slight diversion to the west. At this point, there is a split in the flow. The maximum flow coming out of the westward diversion into the junction with the River is 163 cfs.
- From the junction node to the north Villages at Country Creek boundary, the peak water surface elevations range from 4.10 ft-NAVD to 10.91 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - From ERNBD1-N3 to ERNBD1-N4: There is 1.14 feet of rise between peak water surface elevations. This is located within the westward diversion section of the North Branch and can be attributed to more shallow channel sections within this area.
  - From ERNBD1-N4 to ERNB-N1: There is 1.06 feet of rise between peak water surface elevations. This is located at the interface between the North Branch and westward diversion of the North Branch. This can be attributed to the change in channel cross-section at this location.
  - From ERNB-N8 to ERNB-N10: There is 0.60 feet of rise between peak water surface elevations. This is located just downstream of the golf cart bridge located north of Halfhitch Road.
  - See Figure 3-29 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jumps within the section of the branch that travels along the north side of Bamboo Island, provide a better distribution of flow by improving the bypass section that travels along the east and south side of Bamboo Island.***
- ***Work with the Villages at Country Creek community on a regular maintenance program for the portions of the North Branch located within their property.***

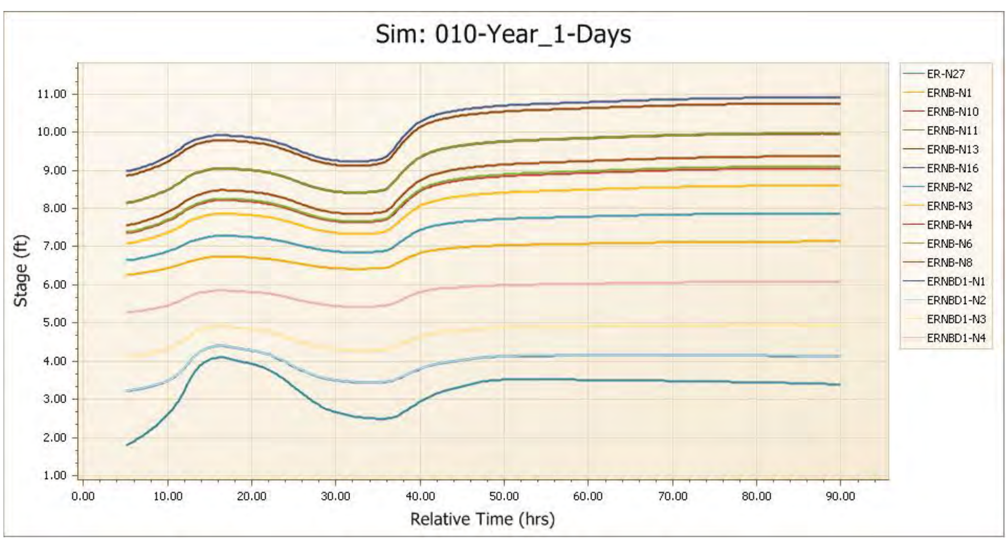


Figure 3-29: North Branch Section 1 - 10-Year, 1-Day Stage Time Series

Section 2: North Branch from North Boundary of Villages at Country Creek through Rookery Pointe to I-75 Boundary (ERNB-NT2)

- Average channel velocities are mild to moderate, ranging from 0.54 fps to a maximum of 2.57 fps at the most downstream end.
- Flow rates within this section of the creek range from 281 cfs to 292 cfs at northern boundary of Villages at Country Creek.
- From the downstream boundary to I-75 boundary node, the peak water surface elevations range from 10.91 ft-NAVD to 15.59 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ERNB-N16 to ERNB-N17 Increase of 0.66 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area.
  - ERNB-N17 to ERNB-N18: Increase of 1.94 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area. There is also a steeper slope in the bottom elevation of the channel, which increase velocities.
  - ERNB-N18 to ERNB-N19: Increase of 0.66 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area.
  - See Figure 3-30 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jumps within the section of the branch that travels between Villages at Country Creek and Rookery Drive, conduct improvements to the channel cross-section to achieve a more gradual slope from north to south and conduct routine maintenance to remove vegetation debris and exotics.***

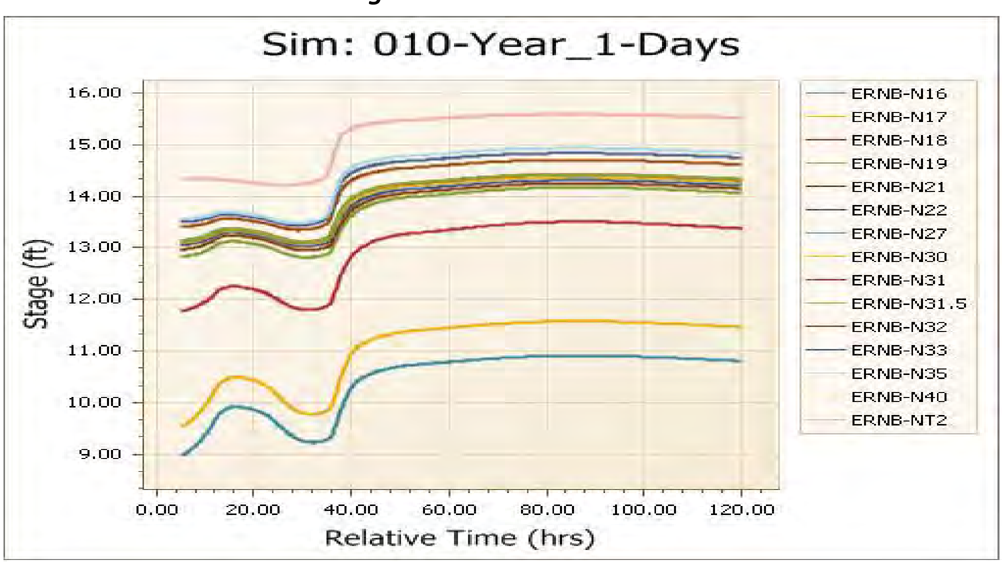


Figure 3-30: North Branch Section 2 -
10-Year, 1-Day Stage Time Series

Section 3: North Branch North Diversion from through Rookery Pointe, North of Villagio to I-75 Boundary (ERNB-NT2)

- o Maximum Average channel velocities are very low, ranging from 0.13 fps to a maximum of 0.34 fps at the most downstream end.
- o Peak flow rates within this diversion section of the creek range from 14.4 cfs to 33.7 cfs at the point of connection with the main stream of the North Branch.
- o From the downstream boundary to I-75 boundary node, the peak water surface elevations range from 14.25 ft-NAVD to 15.53 ft-NAVD at the junction with the I-75 parallel swale.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ ERNBD2-N7 to ERNB-N39: Increase of 1.20 feet located within the within the diversion section just before connecting to the I-75 parallel swale. This is attributed to a change in the channel section – more narrow width, higher bottom elevation and heavy vegetation within the flow area.
  - ➢ See Figure 3-31 below for the Node time series results for the stream Nodes in this segment.

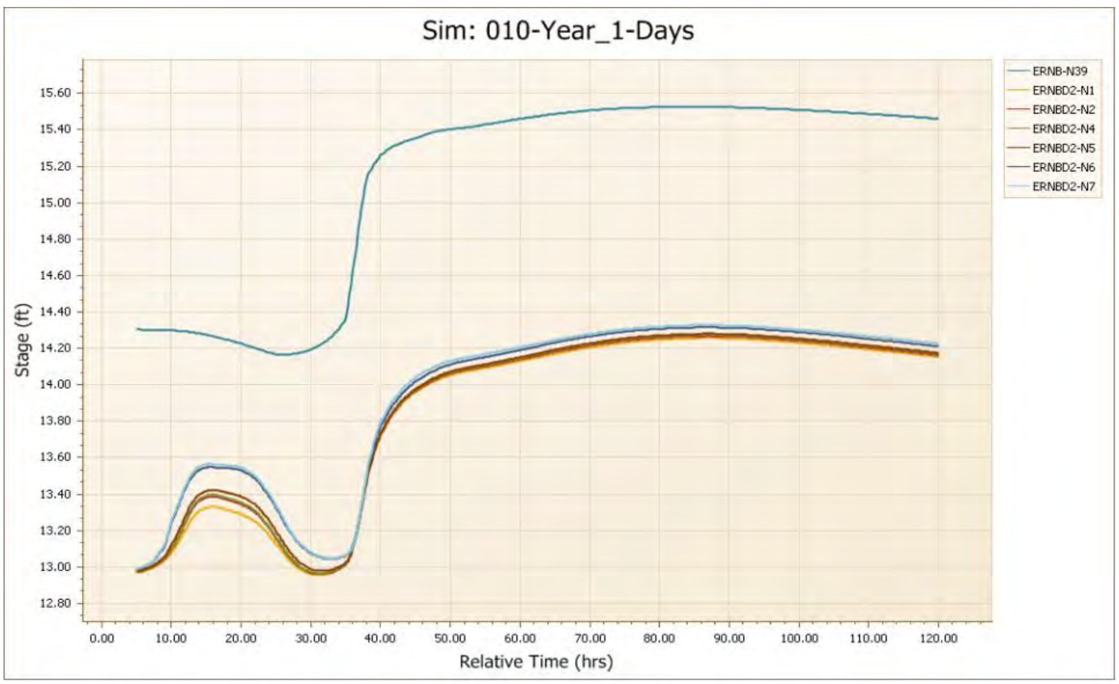


Figure 3-31: North Branch North Diversion Section
10-Year, 1-Day Stage Time Series

3.4.2.d. Estero River, Main Branch Sub-Watershed Hydraulic Analysis

Section 1: Main Stream from Confluence with Estero Bay upstream to U.S. 41

- Maximum Average channel velocities are mild, ranging from 1.16 fps to a maximum of 2.31 fps at just upstream from the confluence with Estero Bay.
- Peak flow rates within this section of the River range from 499 cfs at the downstream side of U.S. 41 crossing to 956 cfs at the downstream connection to Estero Bay.
- From the downstream boundary to U.S. 41, the peak water surface elevations range from -0.00 ft-NAVD to 1.83 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - The model does not indicate any significant increases in peak water levels between nodes for this section of the Estero River.
  - See Figure 3-32 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Estero River during 10-year, 1-day design storm.

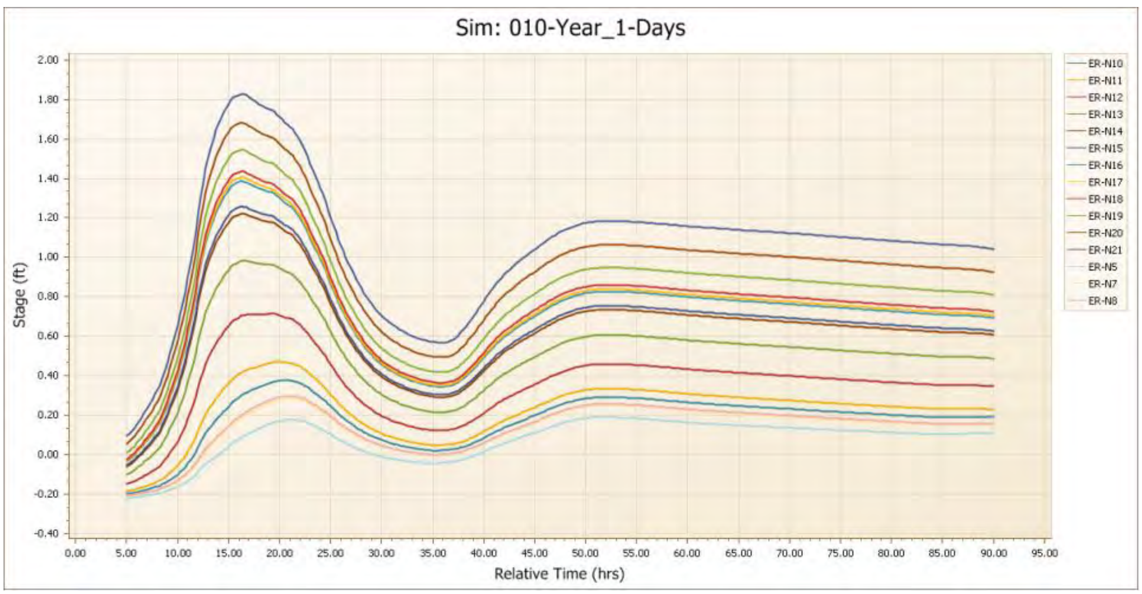


Figure 3-32: Estero River Section 1 - 10-Year, 1-Day Stage Time Series

Section 2: Main Stream from Downstream U.S. 41 to connection with North and South Branch

- Average maximum channel velocities are mild, ranging from 1.13 fps to a maximum of 2.16 fps at the downstream end of the railroad crossing.
- Peak flow rates within this section of the River range from 422 cfs coming from the junction with the North and South Branches to 499 cfs at the downstream side of the U.S. 41 crossing.
- From the downstream side of U.S. 41 to the junction with the North and South Branches, the peak water surface elevations range from 1.83 ft-NAVD to 4.10 ft-NAVD.
- Significant increases in peak water levels between nodes:
  - ER-N24 to ER-N24.5: Increase of 0.94 feet located just upstream of the railroad crossing. This is attributed to the change in cross-section of the creek – the bottom is becoming narrow, forcing water to flow more in the banks with a higher roughness. In addition, the average channel velocity upstream of ER-N24.5 are higher than the downstream channel.
  - See Figure 3-33 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***For the section of the River located upstream of the railroad crossing up to the downstream side of Sandy Lane, it is recommended that the channel be modified to be more consistent in size, bottom width and side slopes.***

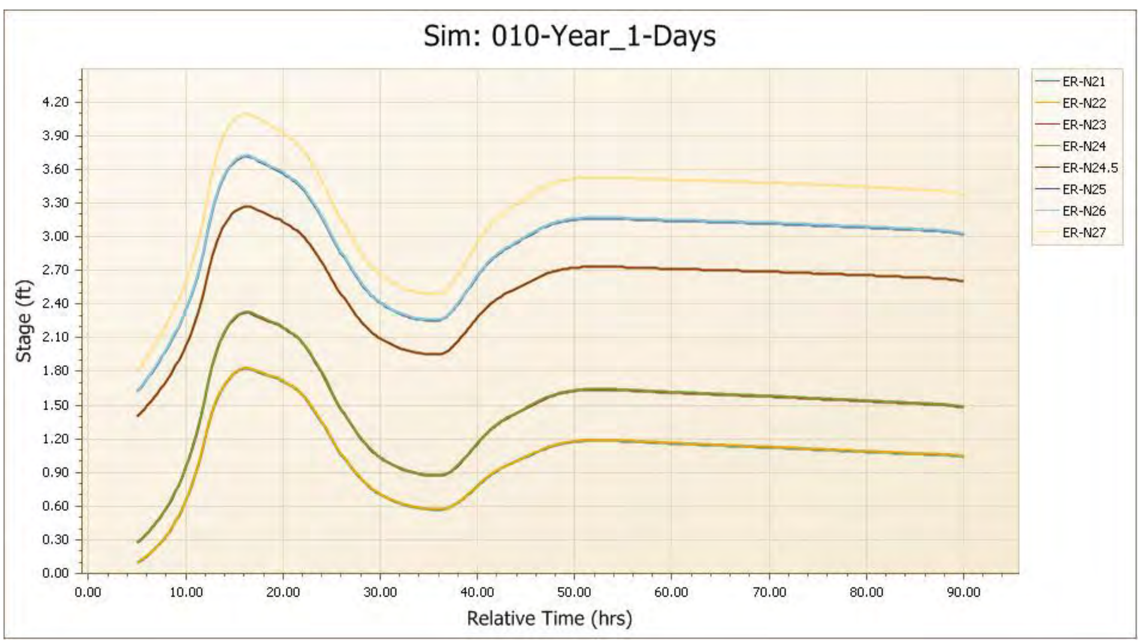


Figure 3-33: Estero River Section 2 - 10-Year, 1-Day Stage Time Series

Table 3-9 provides the node maximum stage results for the 10-Year, 1-Day design storm within the Local-Scale ICPR4 Model. An assessment was conducted within the ICPR4 model at key locations to evaluate the potential for roadway flooding or access flooding, particularly for residential communities. The results are similar to the 5-year design storm conditions, with the potential for more areas to experience localized flooding of low-lying land and roadways. This is particularly true for older residential communities or residential areas without a surface water management system. The yellow-highlighted rows within Table 3-9 represent locations that the model results indicate potential for flooding of roadways within the subject development.

For example, within the Marsh Landing Basin 2 community (HC-NC17), the existing lowest roadway elevations are around 12.20 FT-NAVD and the 10-year design stage is above that at 12.29 FT-NAVD. In addition, the 10-year design stage for the Trailside Dr. area is not high enough to exceed the roadway pavement elevations, however it is high enough to exceed the limits of the adjacent roadside drainage swale and lower adjacent residential properties. Similar conditions occur in the area of the intersection of River Ranch Road and Block Lane where the lower road elevations are at 14.0 FT-NAVD and the 10-year design storm peak stage is 14.33 FT-NAVD.

Table 3-9: Existing Conditions 10-Year, 1-Day ICPR4 Model Results at Key Locations

Existing Conditions 10-Year, 1-Day ICPR4 Model Results at Key Locations		
Node	**Location**	**ICPR4 10-Year, 1-Day Peak Stage (FT-NAVD)**
ER-N16	ER at Broadway Conveyance Connection	1.39
ER-N21	ER & US-41 Downstream	1.83
ER-N23	Rail Road - Downstream	2.33
ER-N24	Rail Road - Upstream	2.33
ER-N26	ER & Sandy Lane Bridge	3.72
ER-N27	West side of Bamboo Island	4.1
ER1-N18	Corkscrew to Sandy Lane	14.43
ER1-NC57	Estero Community Park	14.45
ER4N-N12	SGLR Ditch & Estero Pkwy US	13.39
ER4N-N19	Cascades	13.57
ER4N-N23	Belle Lago	13.39
ER4N-N24	The Reserve	14.57
ER4N-N6	Cascades Outfall / SGLR Ditch	12.87
ER4S-N3	SGLR Ditch Upstream of Corkscrew Road	14.95
ER6-N1	Walmart Ultimate Outfall	14
ER6-N3	Walmart/Osprey Cove	13.81
ER804-N1	Pineland Preserve Outfall	12.23
ER804-NC1	Pineland Preserve	14.65

Existing Conditions 10-Year, 1-Day ICPR4 Model Results at Key Locations		
Node	**Location**	**ICPR4 10-Year, 1-Day Peak Stage (FT-NAVD)**
ERNB - N1	East side of Bamboo Island	7.14
ERNB-N17	USGS Gage-South of Rookery Point	11.57
ERNB-N20	Rookery Point Cir. Bridge	14.18
ERNB-N30	D/S Three Oaks Pkwy Crossing	14.38
ERNB-N6	Villages of Country Creek - Halfhitch Rd Bridge	9.1
ERNB-NC05	The Villages at Country Creek Basin 3	9.05
ERNB-NC25	Rookery Basin 2	15.26
ERNB-NC46	Villagio	16.05
ERNB1-NC018	Waste Water Treatment Plant	18.53
ERNB1-NC022	Three Oaks Community Park (Park)	16.8
ERNB1-NC025	Three Oaks Community Park (Pond)	16.63
ERNB2-NC23	Country Oaks	16.82
ERNB2E-N13	Estero Pkwy & 3Oaks	14.32
ERNB2E-N24	End nodes Three Oaks near Coastal Villages	16.14
ERNB2N-NC20	Three Oaks Town Center	16.26
ERNB2N-NC59	Three Oaks Middle School	17.47
ERNB2W-NC22	Estero Oaks	16
ERNB2W-NC24	Rookery Basin 3	17.16
ERNB3-NC16	Somerset	16.86
ERNB4-N10	U/S Estero Parkway Culvert	14.67
ERNB4-NC14	Our Lady Of Light	16.77
ERNB4-NC4	Rookery Basin 1	15.81
ERNB5E-NC7	Pond 100 Estero Parkway	18.75
ERNB5E-NC8	The Reef	16.3
ERNBD2-N4	ERNB at 3Oaks Crossing N (US)	14.28
ERSB-N20	USGS Gage - ERSB at Corkscrew Rd	7.12
ERSB-N32	ERSB Downstream of Sanctuary Rd	12.92
ERSB-N34	ERSB at Sanctuary Road Crossing	12.94
ERSB-NC05	The Villages at Country Creek Basin 7	8.45
ERSB1-N2	See See St. - Downstream	8.14
ERSB1-NC534	Courtyard Apartments	16.28
ERSB2E-N14	Post Office on 3Oaks	14.86
ERSB2E-N7	3 Oaks at Quente Way	14.85

Existing Conditions 10-Year, 1-Day ICPR4 Model Results at Key Locations		
Node	**Location**	**ICPR4 10-Year, 1-Day Peak Stage (FT-NAVD)**
ERSB2E-NC37	Copper Oaks	16.33
ERSB5-N05	ERSB5-N05	12.64
ERSB6-NC03	The Villages at Country Creek Basin 10	11.7
ERSB6-NC06	The Villages at Country Creek Basin 5	10.57
ERSB9-N12	River Ranch at Block Lane	14.33
HC-N22	HC Downstream of FPL Crossing	9.26
HC-N34	Halfway Creek at U.S. 41 - U/S	13.01
HC-N35	Halfway Creek at U.S. 41 - U/S (+100 FT)	13.01
HC-N55	The Brooks North Outfall Gage	13.29
HCD1-NC10	Coconut Point Mall- North Outfall	14.94
HCD1-NC3	The Brooks South Outfall Gage	13.92
HC-NC17	Marsh Landing Basin 2 Outfall	12.29
HC-NC24	Fountain Lakes Basin 1 Outfall	12.92
HC4-NC1	Coconut Shores Basin Outfall	15.48
NS-052	Broadway Ave., North Side	11.92
N-010	North Side of Broadway Ave. Tributary/ Trailside Dr.	13.25
NC-100	Terra Vista	12.74
ER802-N5	Breckenridge	12.7
NS-473	Trailside Dr., North End	13.41
NS-476	Trailside Dr., South End	14.24
ER802-N3	North Side of Broadway Ave. at Sherrill Lane	10.03

3.4.3. 25-Year, 3-Day Design Storm Analysis and Results

The 25-year, 3-day design storm utilizes a total rainfall depth of 11.2 inches distributed over a period of 72 hours, or 3 days. The 25-year, 3-day design storm is the standard event used for development projects that contain a surface water management system. Developments are regulated to provide sufficient surface water storage to contain the 25-year, 3-day event. Therefore, for many of the regulated developments, the berms around the property are designed to be at the design high water elevation determined from the 25-year, 3-day event. Also, since some of the residential developments contain roadways elevations set at the 10-year, 1-day or 5-year, 1-day design stages, it is anticipated that there could be localized roadway flooding during the 25-year, 3-day storm event in those areas. For the hydraulic analysis of the 25-year, 3-day design storm, the main conveyances of each sub-watershed are evaluated below to provide an overall description of system performance and to note areas of concern and/or candidates for improvement projects.

3.4.3.a. Halfway Creek Watershed Hydraulic Analysis

Section 1: Main Stream from Confluence with Estero River upstream to U.S. 41

- Maximum average channel velocities are mild to moderate, ranging from 0.35 fps to a maximum of 3.05 fps at the most downstream end.
- Peak flow rates within this section of the creek range from 573 cfs to 720 cfs at the downstream connection to Estero River.
- From the downstream boundary to U.S. 41, the peak water surface elevations range from 3.18 ft-NAVD to 13.38 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater, between nodes, in peak surface water levels occur at the following locations:
  - HC-N7 to HC-N8: Increase of 0.85 feet located within the West Bay Club, north of West Bay Boulevard, just north of the most northern golf cart bridge crossing.
  - HC-N15 to HC-N16: Increase of 0.81 feet located within southern portion of West Bay Club, south of the last golf cart bridge crossing. This can be attributed to change in profile slope of channel bottom/ decrease in defined channel section – increasing in elevation upstream and increase in roughness coefficient on the overbank areas.
  - HC-N17 to HC-N18: Increase of 0.59 feet located just outside south boundary of West Bay Club and into large conservation/wetland area. This is attributed to shallower channel section with high roughness factors within majority of flow cross-section.
  - HC-N19 to HC-N20: Increase of 0.66 feet located within large conservation/wetland area between West Bay Club and FPL Crossing. This is attributed to shallower channel section with high roughness factors within majority of flow cross-section.
  - HC-N22 to HC-N23: Increase of 0.95 feet located within large conservation/wetland area between West Bay Club and FPL crossing, just downstream of FPL crossing. This is attributed to shallower channel section at upstream end and high roughness factors within majority of flow cross-section for entire segment. The surface water elevations within this portion of Halfway Creek affects Marsh Landing Basin 3 Outfall and properties upstream, specifically Fountain Lakes Basin 1, Marsh Landing Basins 1 and 2.
  - See Figure 3-34 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***Conduct Routine/regular maintenance of large conservation/wetland area located between West Bay Club and FPL crossing to reduce roughness factor within flow area.***
- ***Work with the West Bay Club community on a regular maintenance program for the upstream portions of Halfway Creek located within their property.***

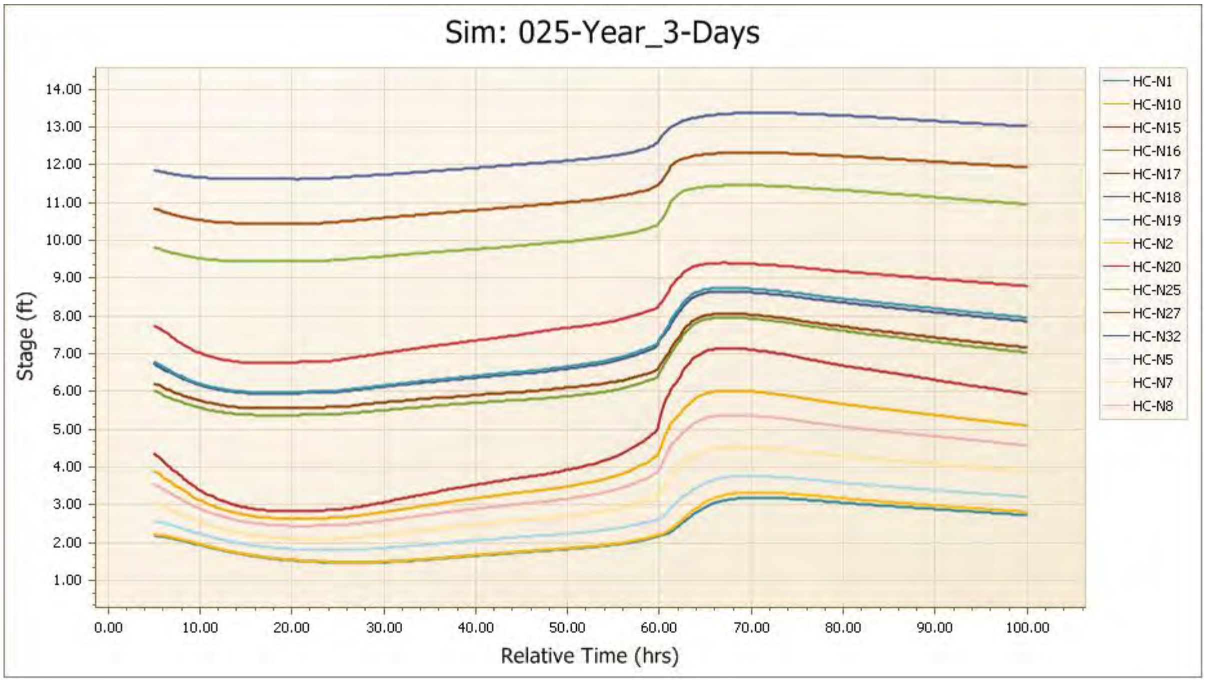


Figure 3-34: Halfway Creek Section 1 -
25-Year, 3-Day Stage Time Series

Section 2: Main Stream from Downstream U.S. 41 to Railroad Crossing/Brooks North Outfall

- Maximum average channel velocities are mild, ranging from 0.19 fps to a maximum of 1.05 fps at the downstream end of the U.S. 41 crossing.
- Maximum flow rates within this section of the creek range from 342 cfs coming from the Brooks North Outfall to 573 cfs at the downstream side of the U.S. 41 crossing. As the
- From the downstream side of U.S. 41 to the Railroad Crossing/Brooks North Outfall, the peak water surface elevations range from 13.38 ft-NAVD to 13.82 ft-NAVD.
- The maximum average velocity through the U.S 41 culvert crossing is 2.18 fps and the culverts are flowing completely full during the peak of the event. The peak head-loss through the culvert crossing is 0.15 feet. The bottom invert is 4.62 ft-NAVD with a top elevation of 11.62 ft-NAVD.
- See Figure 3-35 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Halfway Creek during 25-year, 3-day design storm.

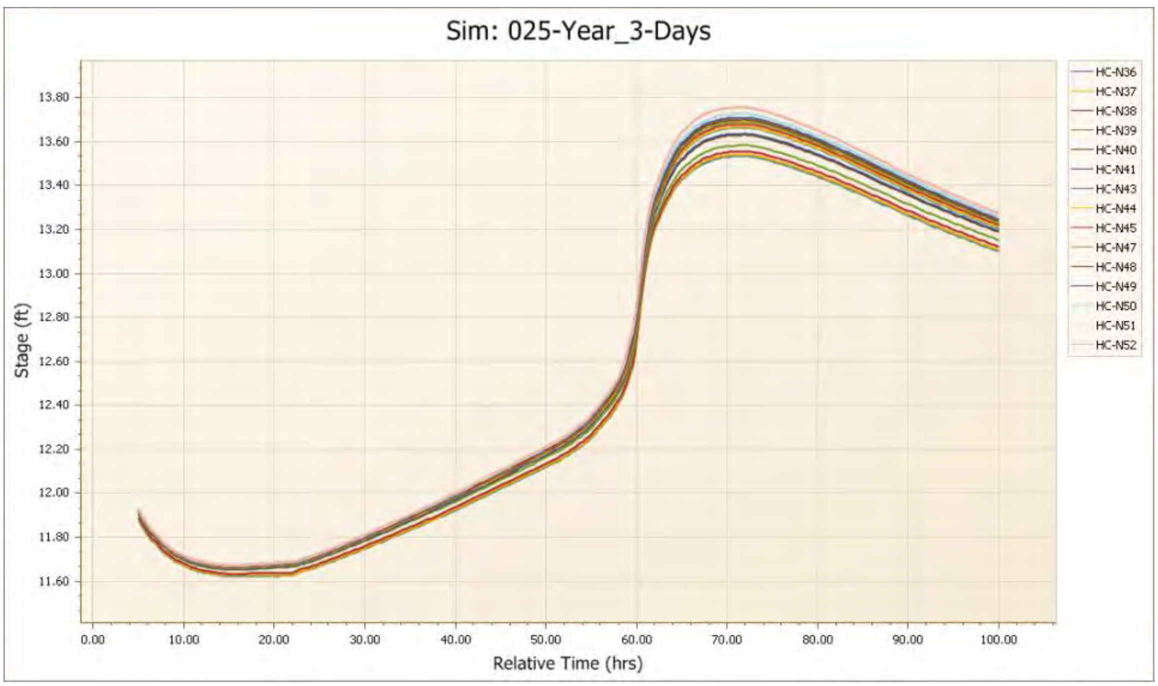


**Figure 3-35: Halfway Creek Section 2 -
25-Year, 3-Day Stage Time Series**

Section 3: Main Stream from Upstream Side of Brooks North Outfall to I-75

- o Average channel velocities are low, ranging from 0.18 fps to a maximum of 0.46 fps at the downstream end of the Brooks North Outfall. This is attributed to the nature of the flow-way lake system within The Brooks community, which is controlled by the outfall weir. All the flow-way lakes behave as a level pool, connected by a system of submerged culverts.
- o Maximum flow rates within this section of the creek range from 209 cfs coming from the I-75 culverts to 302 cfs at the downstream side of the Brooks North Outfall.
- o From the downstream side of the Brooks North Outfall to the I-75 culverts, the peak water surface elevations range from 13.82 ft-NAVD to 14.07 ft-NAVD.
- o See Figure 3-36 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Halfway Creek during 25-year, 3-day design storm.

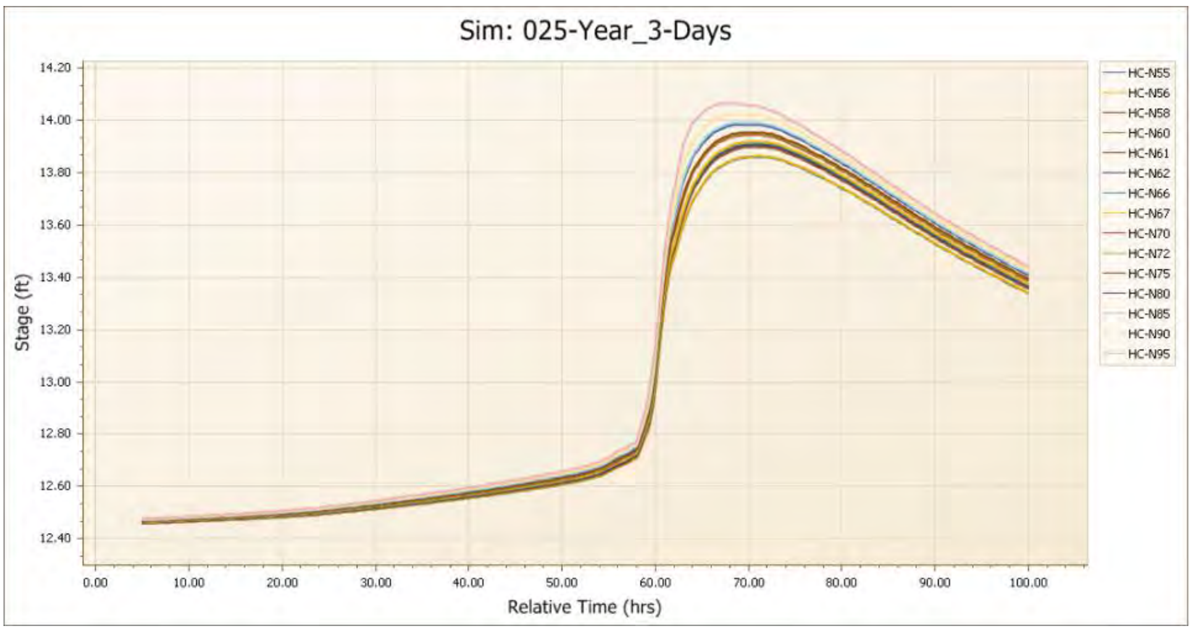


Figure 3-36: Halfway Creek Section 3 -
25-Year, 3-Day Stage Time Series

Section 4: Diversion Streams from Weir Downstream of Via Villagio to The Brooks South Outfall

- Maximum average channel velocities are low, ranging from 0.23 fps to a maximum of 0.33 fps within the south diversion portion, just north of Coconut Point Mall.
- Peak flow rates within the north diversion portion (HCD2) range from 128 cfs to 154 cfs at the upstream side of the Via Villagio culvert crossing. Peak flow rates within the south diversion portion (HCD1) range from 104 cfs to 142 cfs at the upstream side of the Via Villagio culvert crossing. The two (2) diversion join at the upstream side of the Via Villagio culvert crossing and become one channel on the downstream side. The maximum flow rate in the channel leaving the Via Villagio culvert is 256 cfs.
- In the railroad ditches that travel north and south of the Brooks South and North Outfall, there is very little flow.
- From the upstream side of the weir located downstream from Via Villagio to the Brooks South Outfall, the peak water surface elevations range from 13.63 ft-NAVD to 13.80 ft-NAVD.
- See Figure 3-37 below for the Node time series results for the diversion stream Nodes.

No major issues identified for this section of Halfway Creek during 25-year, 3-day design storm.

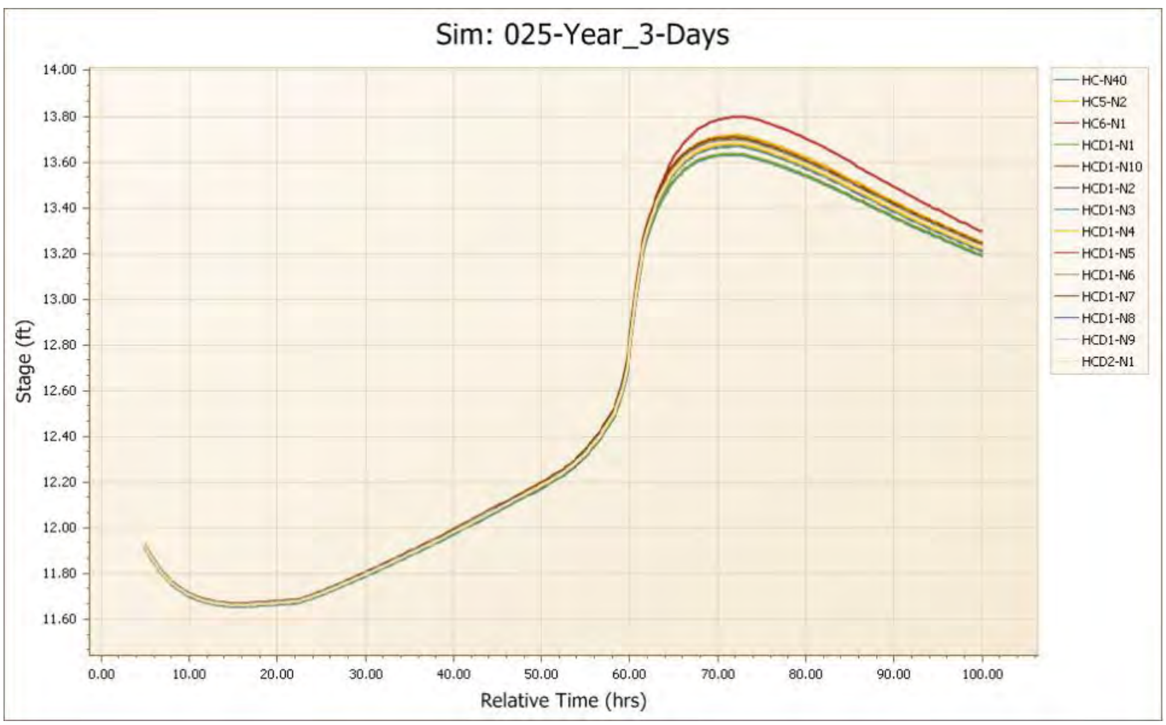


Figure 3-37: Halfway Creek Section 4 -
25-Year, 3-Day Stage Time Series

3.4.3.b. South Branch Sub-Watershed Hydraulic Analysis

Section 1: South Branch from Confluence with Main Branch upstream to Corkscrew Road:

- Average channel velocities are mild, ranging from 1.14 fps to a maximum of 2.32 fps just downstream of the southernmost bridge within the Villages at Country Creek, ERSB-RC4.
- Peak flow rates within this section of the River range from 448 cfs at the downstream side of the Corkscrew Road culvert crossing to 662 cfs at the connection to the main branch of the Estero River.
- From the downstream boundary node to Corkscrew Road, the peak water surface elevations range from 6.58 ft-NAVD to 9.92 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ERSB-N3 to ERSB-N4: There is an increase in peak stage of 0.59 feet between the two nodes. This can be attributed to the change in channel cross-section at this location, as well as the 1.37 foot difference in invert elevation of the two nodes.
  - See Figure 3-38 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of the South Branch during 25-year, 3-day design storm.

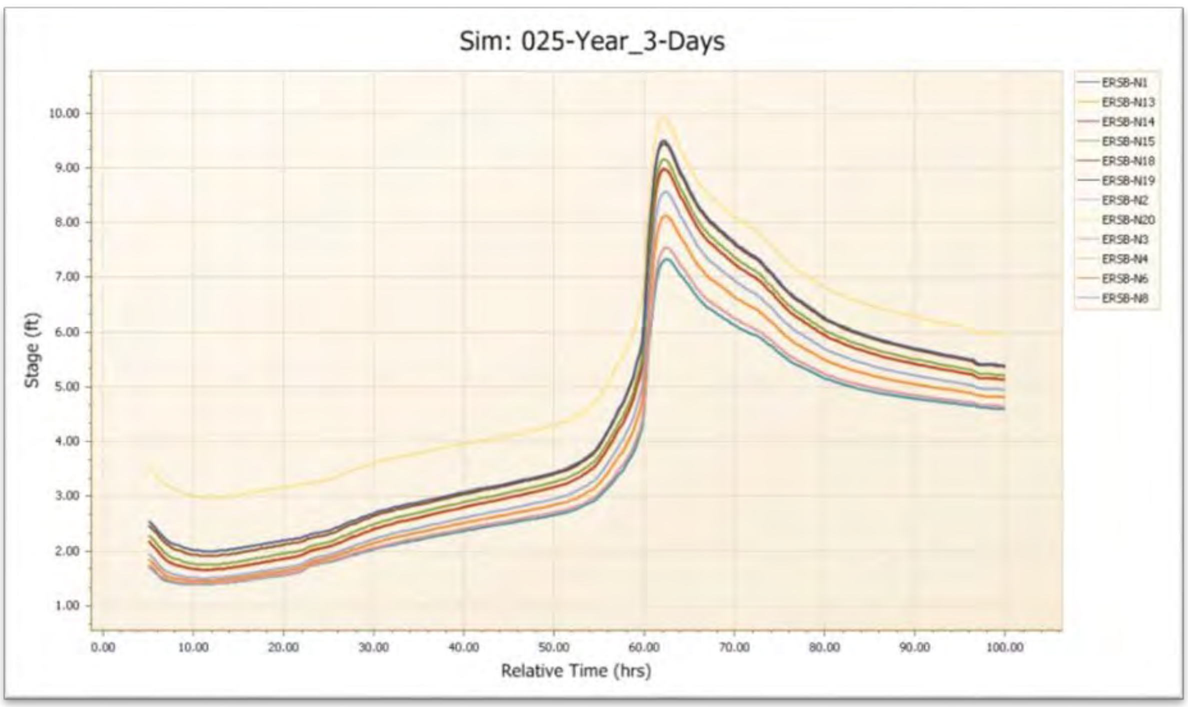


Figure 3-38: South Branch Section 1 -
25-Year, 3-Day Stage Time Series

Section 2: South Branch from Corkscrew Road to Three Oaks Parkway

- Average maximum channel velocities are mild, ranging from 0.77 fps to a maximum of 1.13 fps.
- Peak flow rates within this section of the River range from 347 cfs to 390 cfs. The most downstream portion of this section of the River has the highest flow rate.
- From the downstream side of Corkscrew Road to the downstream side of Three Oaks Parkway, the peak water surface elevations range from 9.92 ft-NAVD to 10.56 ft-NAVD.
- Significant increases in peak water levels between nodes:
  - There are no significant increases in water levels between nodes along this section of the Estero River South Branch.
  - See Figure 3-39 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of the South Branch during 25-year, 3-day design storm.

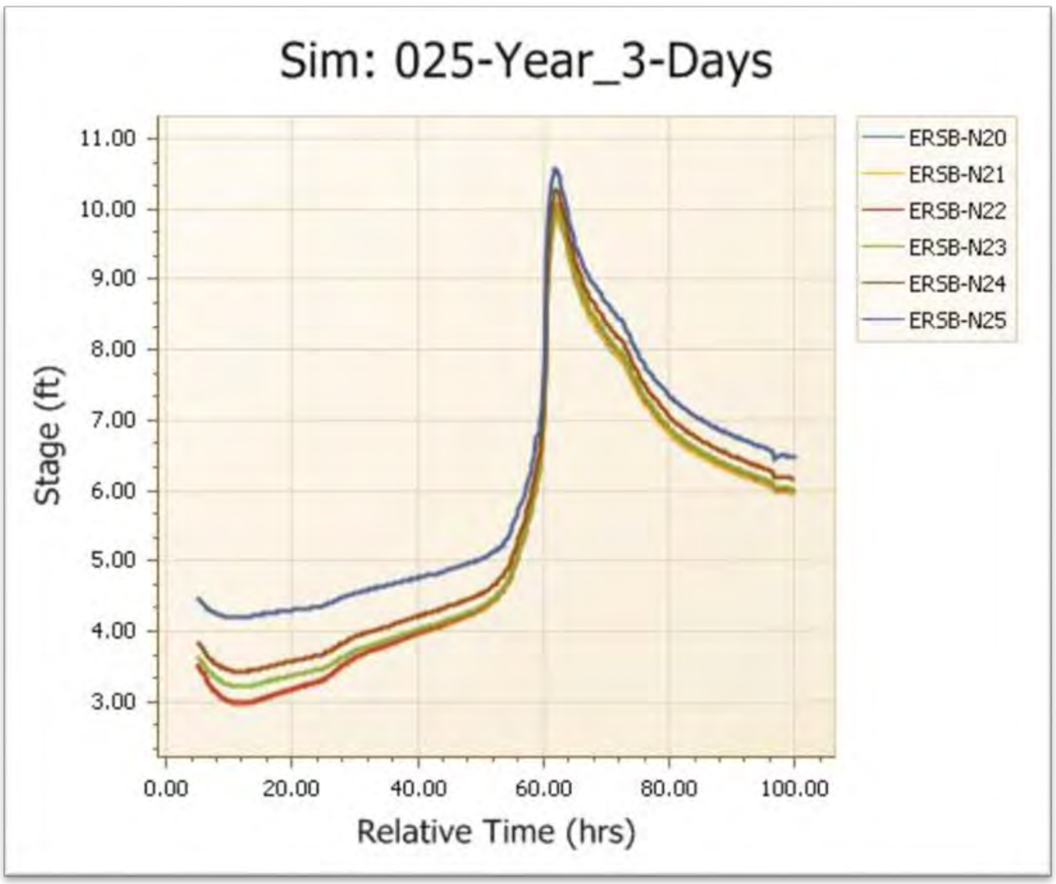


Figure 3-39: South Branch Section 2 - 25-Year, 3-Day Stage Time Series

Section 3: South Branch from Three Oaks Parkway to the I-75 Culvert Crossing

- Average maximum channel velocities are mild, ranging from 0.32 fps to a maximum of 2.80 fps.
- Peak flow rates within this section of the River range from 69 cfs to 347 cfs, with the greatest flow rates occurring in the Three Oaks Parkway culverts. The lowest flow rates occur within the river just downstream of the I-75 culverts.
- From the downstream side of Three Oaks Parkway to the downstream side of the I-75 culverts, the peak water surface elevations range from 10.58 ft-NAVD to 14.86 ft-NAVD.
- Significant increases in peak water levels between nodes:
  - ERSB-N29 to ERSB-N31: Increase of 0.63 feet from the upstream side of the pedestrian bridge crossing to upstream. This attributed to a narrow channel section.
  - ERSB-N30 to ERSB-N31: Increase of 1.97 feet located within the creek section at the east side of Villa Palmeras. This is attributed to the change in cross-section of the River – the bottom becomes narrower, forcing water to flow more in the banks with a much higher roughness. Furthermore, this section of the River has a large drainage basin contributing flow to it, much of which is wetlands and residential developments.
  - See Figure 3-40 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jump within the area located upstream of Villa Palmeras, conduct routine/regular maintenance to reduce roughness factor within flow area.***

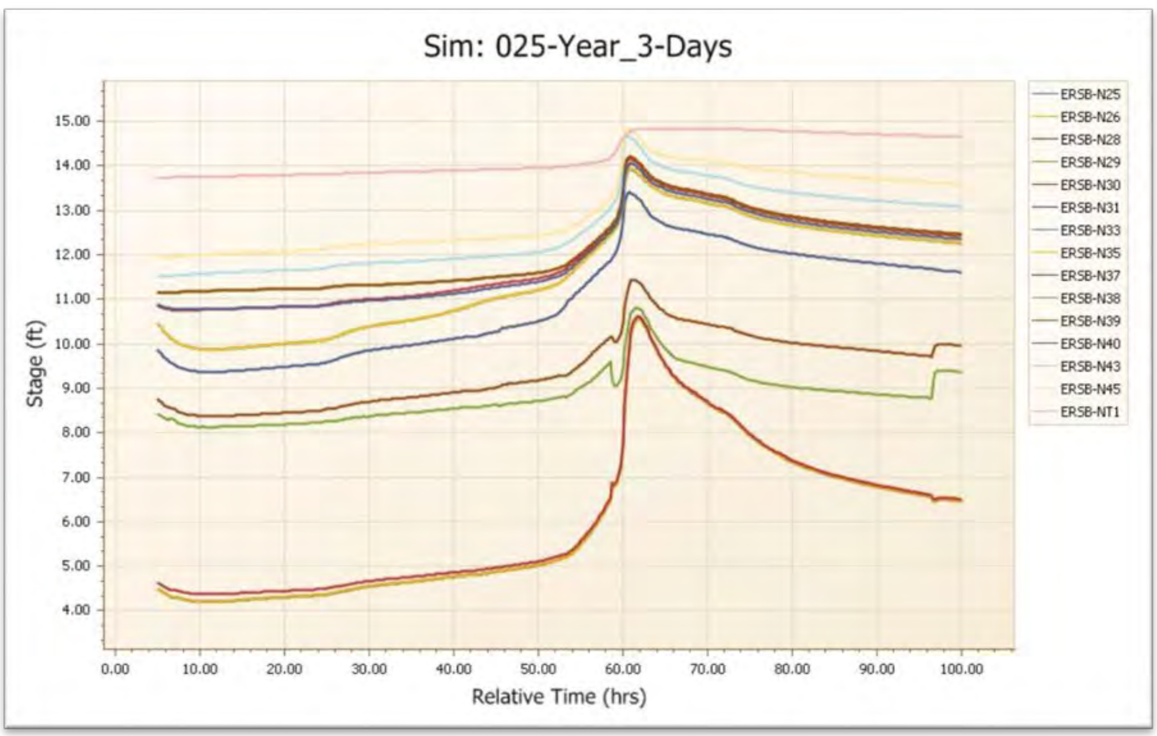


Figure 3-40: South Branch Section 3 - 25-Year, 3-Day Stage Time Series

3.4.3.c. North Branch Sub-Watershed Hydraulic Analysis

Section 1: From Junction with River to North Boundary of VCC

- o Maximum average channel velocities are mild to moderate, ranging from 0.74 fps to a maximum of 2.91 fps at just upstream of the junction with Estero River. It is important to note that some of the maximum average velocities are less with the 25-year event compared to the 10-year event. This is attributed to more flow within the bank/overbank area which is subject to the higher roughness (more vegetation, roots, trees, etc.). The flow is experiencing more friction and velocity is decreased.
- o Peak flow rates within this section of the creek range from 373 cfs at the north boundary of Villages at Country Creek to 383 cfs at the location of where the North Branch enters a slight diversion to the west. At this point, there is a split in the flow. The maximum flow coming out of the westward diversion into the junction with the River is 205 cfs.
- o From the junction node to the north Villages at Country Creek boundary, the peak water surface elevations range from 6.58 ft-NAVD to 11.80 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ From ERNB-N1 to ERNB-N2: There 0.78 feet of rise between peak water surface elevations. This is located just upstream from the slight diversion point.
  - ➢ From ERNB-N2 to ERNB-N3: There 0.86 feet of rise between peak water surface elevations.
  - ➢ From ERNB-N8 to ERNB-N10: There is 0.58 feet of rise between peak water surface elevations. This is located just downstream of the golf cart bridge located north of Halfhitch Road.
  - ➢ See Figure 3-41 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- o ***Work with the Villages at Country Creek community on a regular maintenance program for the portions of the North Branch located within their property.***

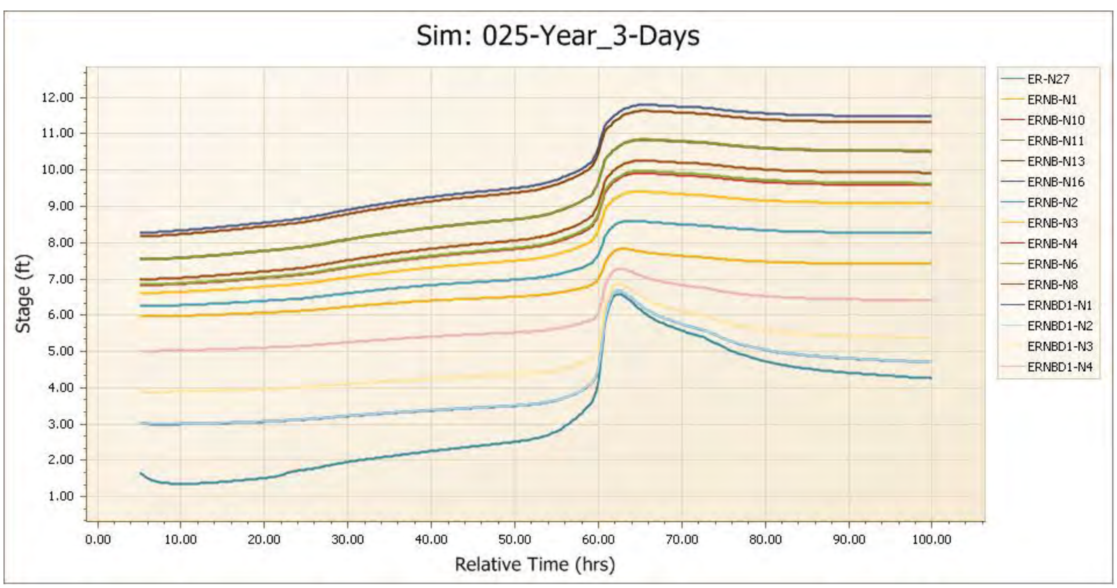


Figure 3-41: North Branch Section 1 - 25-Year, 3-Day Stage Time Series

Section 2: North Branch from North Boundary of Villages at Country Creek through Rookery Pointe to I-75 Boundary (ERNB-NT2)

- o Average channel velocities are mild to moderate, ranging from 0.79 fps to a maximum of 2.57 fps at the most downstream end.
- o Flow rates within this section of the creek range from 289 cfs to 376 cfs at northern boundary of Villages at Country Creek.
- o From the downstream boundary to I-75 boundary node, the peak water surface elevations range from 11.80 ft-NAVD to 15.86 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ ERNB-N16 to ERNB-N17 Increase of 0.64 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area.
  - ➢ ERNB-N17 to ERNB-N18: Increase of 1.64 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area. There is also a steeper slope in the bottom elevation of the channel, which increase velocities.
  - ➢ See Figure 3-42 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- o ***To lessen the hydraulic jumps within the section of the branch that travels between Villages at Country Creek and Rookery Drive, conduct improvements to the channel cross-section to achieve a more gradual slope from north to south and conduct routine maintenance to remove vegetation debris and exotics***.

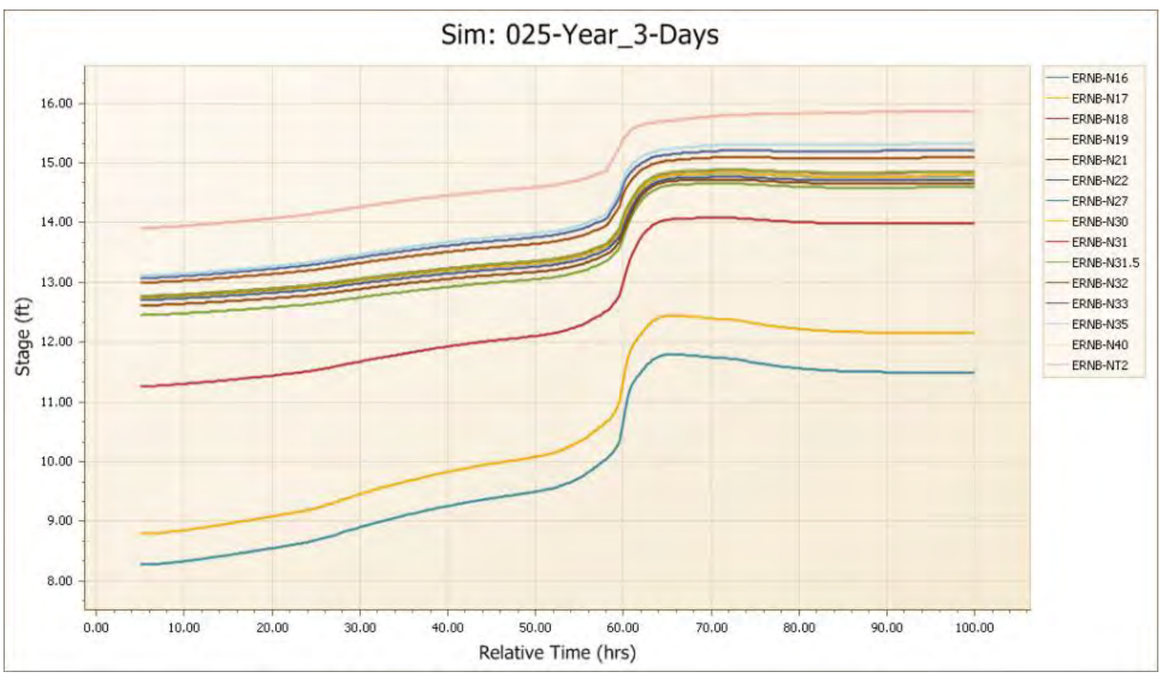


Figure 3-42: North Branch Section 2 - 25-Year, 3-Day Stage Time Series

<u>Section 3: North Branch North Diversion from through Rookery Pointe, North of Villagio to I-75 Boundary (ERNB-NT2)</u>

- o Maximum Average channel velocities are very low, ranging from 0.18 fps to a maximum of 0.58 fps at the most downstream end.
- o Peak flow rates within this diversion section of the creek range from 18.67 cfs to 76.6 cfs at the point just upstream of connection with the main stream of the North Branch.
- o From the downstream boundary to I-75 boundary node, the peak water surface elevations range from 14.25 ft-NAVD to 15.53 ft-NAVD at the junction with the I-75 parallel swale.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ ERNBD2-N7 to ERNB-N39: Increase of 1.00 feet located within the within the diversion section just before connecting to the I-75 parallel swale. This is attributed to a change in the channel section – more narrow width, higher bottom elevation and heavy vegetation within the flow area.
  - ➢ See Figure 3-43 below for the Node time series results for the stream Nodes in this segment.

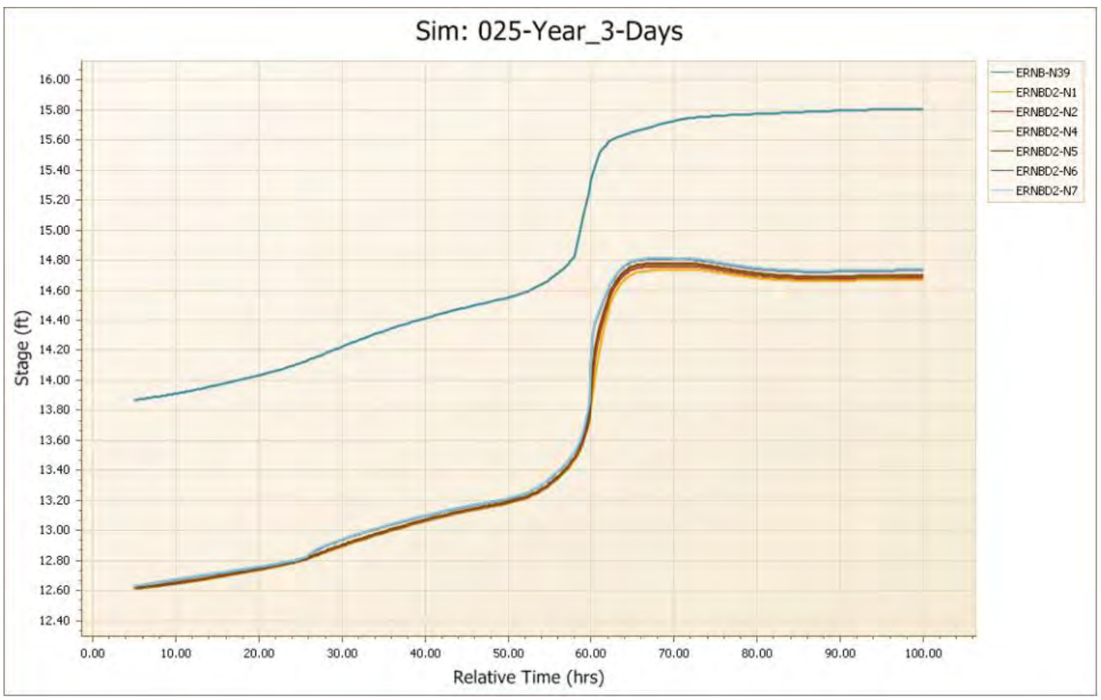


Figure 3-43: North Branch Section 3 - 25-Year, 3-Day Stage Time Series

3.4.3.d. Estero River Sub-Watershed Hydraulic Analysis

Section 1: Main Stream from Confluence with Estero Bay upstream to U.S. 41

- o Average maximum channel velocities are mild to moderate, ranging from 1.76 fps to a maximum of 4.13 fps at just upstream from the confluence with Estero Bay.
- o Peak flow rates within this section of the River are significantly greater than the 10-year event and range from 1043 cfs at the downstream side of U.S. 41 crossing to 1958 cfs at the downstream connection to Estero Bay.
- o From the downstream boundary to U.S. 41, the peak water surface elevations range from 0.48 ft-NAVD to 3.91 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ The model does not indicate any significant increases in peak water levels between nodes for this section of the Estero River.
  - ➢ See Figure 3-44 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Estero River during 25-year, 3-day design storm.

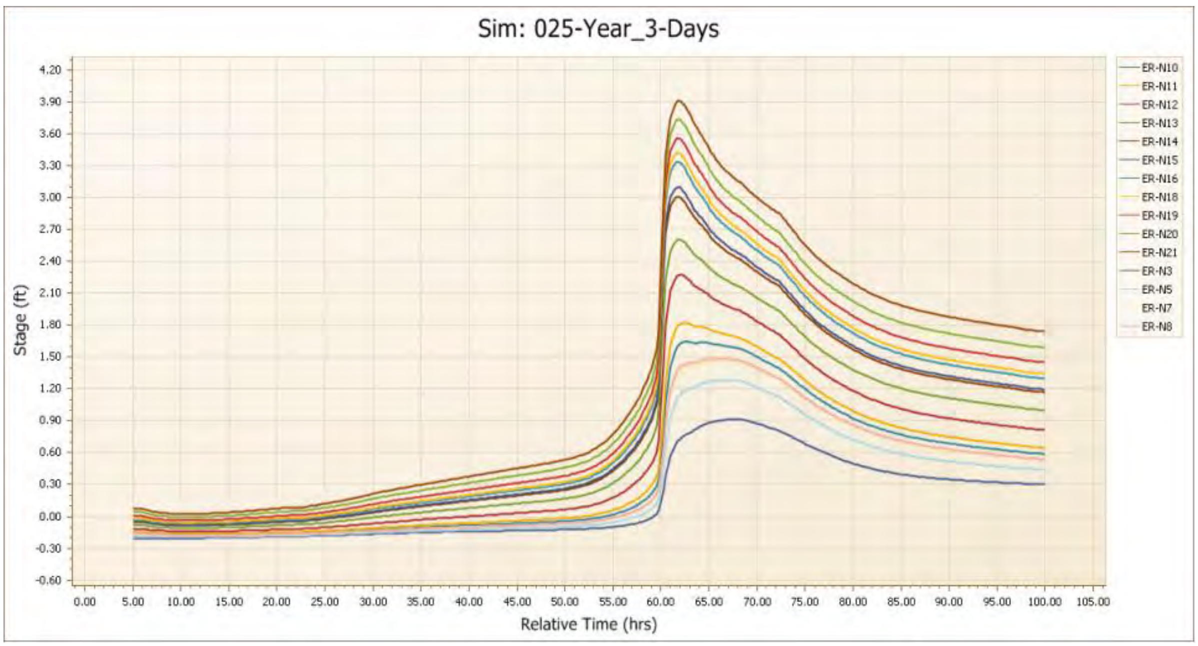


Figure 3-44: Estero River Section 1 -
25-Year, 3-Day Stage Time Series

Section 2: Main Stream from Downstream U.S. 41 to connection with North and South Branch

- o Average maximum channel velocities are mild to moderate, ranging from 1.59 fps to a maximum of 2.73 fps at the downstream end of the railroad crossing.
- o Peak flow rates within this section of the River range from 865 cfs coming from the junction with the North and South Branches to 1043 cfs at the downstream side of the U.S. 41 crossing.
- o From the downstream side of U.S. 41 to the junction with the North and South Branches, the peak water surface elevations range from 3.91 ft-NAVD to 6.58 ft-NAVD.
- o Significant increases in peak water levels between nodes:
  - ➢ ER-N22 to ER-N23: Increase of 0.71 feet located just upstream from US 41 crossing to the downstream end of the railroad crossing. This increase can be attributed to more flow occurring in the banks of the channel section with higher roughness values.
  - ➢ ER-N24 to ER-N24.5: Increase of 0.77 feet located just upstream of the railroad crossing. This is attributed to the change in cross-section of the creek as the bottom is becoming narrow, forcing water to flow more in the banks with a higher roughness. In addition, the average channel velocity upstream of ER-N24.5 are higher than the downstream channel.
  - ➢ See Figure 3-45 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- o ***For the section of the River located upstream of the railroad crossing up to the downstream side of Sandy Lane, it is recommended that the channel be modified to be more consistent in size, bottom width and side slopes.***

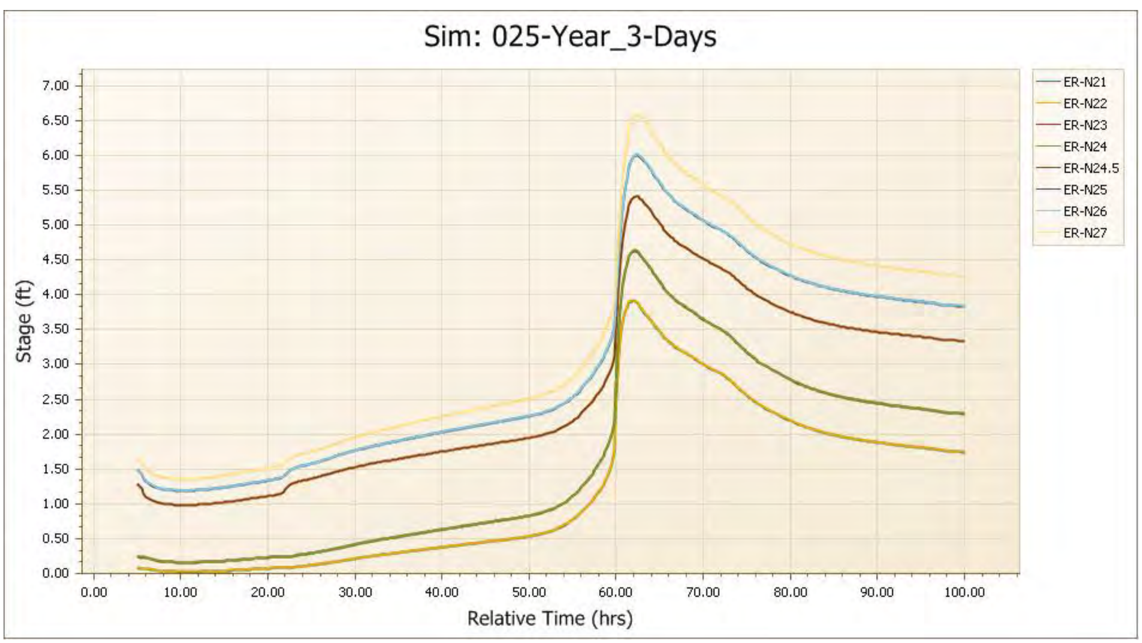


Figure 3-45: Estero River Section 2 -
25-Year, 3-Day Stage Time Series

Table 3-10 provides the node maximum stage results for the 25-Year, 3-Day design storm within the Local-Scale ICPR4 Model. An assessment was conducted within the ICPR4 model at key locations to evaluate the potential for roadway flooding or access flooding, particularly for residential communities. This is particularly true for older residential communities or residential areas without a surface water management system. The yellow-highlighted rows within Table 3-10 represent locations that the model results indicate potential for flooding of roadways within the subject development. Based on the model results, none of the major arterial roadways, such as Corkscrew Road, Three Oaks Parkway, and U.S. 41 should experience flooding.

Table 3-10: Existing Conditions 25-Year, 3-Day ICPR4 Model Results at Key Locations

Existing Conditions 25-Year, 3-Day ICPR4 Model Results at Key Locations			
Node	**Location**	**ICPR4 25-Year, 3-Day Peak Stage (FT-NAVD)**	**Permitted 25yr Stage (FT-NAVD)**
ER-N16	ER at Broadway Conveyance Connection	3.34	
ER-N21	ER & US-41 Downstream	3.91	
ER-N23	Rail Road - Downstream	4.63	
ER-N24	Rail Road - Upstream	4.64	
ER-N26	ER & Sandy Lane Bridge	6.01	
ER-N27	West side of Bamboo Island	6.58	
ER1-N18	Corkscrew to Sandy Lane	15.14	15.13
ER1-NC57	Estero Community Park	15.34	
ER4N-N12	SGLR Ditch & Estero Pkwy US	14.4	
ER4N-N19	Cascades	14.32	14.36
ER4N-N23	Belle Lago	14.61	14.98
ER4N-N24	The Reserve	15.71	15.68
ER4N-N6	Cascades Outfall / SGLR Ditch	13.69	
ER4S-N3	SGLR Ditch Upstream of Corkscrew Road	15.71	
ER6-N1	Walmart Ultimate Outfall	14.7	15.18
ER6-N3	Walmart/Osprey Cove	14.37	
ER804-N1	Pineland Preserve Outfall	12.3	
ER804-NC1	Pineland Preserve	15.99	16.44
ERNB - N1	East side of Bamboo Island	7.83	
ERNB-N17	USGS Gage-South of Rookery Point	12.44	
ERNB-N20	Rookery Point Cir. Bridge	14.66	
ERNB-N30	D/S Three Oaks Pkwy Crossing	14.83	
ERNB-N6	Villages of Country Creek - Halfhitch Rd Bridge	9.98	
ERNB-NC05	The Villages at Country Creek Basin 3	10.28	9.02

Existing Conditions 25-Year, 3-Day ICPR4 Model Results at Key Locations			
Node	Location	ICPR4 25-Year, 3-Day Peak Stage (FT-NAVD)	Permitted 25yr Stage (FT-NAVD)
ERNB-NC25	Rookery Basin 2	16.16	15.73
ERNB-NC46	Villagio	16.66	16.42
ERNB1-NC018	Waste Water Treatment Plant	19.6	
ERNB1-NC022	Three Oaks Community Park (Park)	17.6	16.24
ERNB1-NC025	Three Oaks Community Park (Pond)	17.58	17.41
ERNB2-NC23	Country Oaks	17.34	16.48
ERNB2E-N13	Estero Pkwy & 3Oaks	15.35	
ERNB2E-N24	End nodes Three Oaks near Coastal Villages	17.92	
ERNB2N-NC20	Three Oaks Town Center	16.79	17.32
ERNB2N-NC59	Three Oaks Middle School	18.15	16.79
ERNB2W-NC22	Estero Oaks	16.37	16.59
ERNB2W-NC24	Rookery Basin 3	17.43	17.07
ERNB3-NC16	Somerset	17.41	17.4
ERNB4-N10	U/S Estero Parkway Culvert	15.88	
ERNB4-NC14	Our Lady of Light	17.11	16.37
ERNB4-NC4	Rookery Basin 1	16.6	16.19
ERNB5E-NC7	Pond 100 Estero Parkway	19.38	19.01
ERNB5E-NC8	The Reef	16.82	17.04
ERNBD2-N4	ERNB at 3Oaks Crossing N (US)	14.77	
ERSB-N20	USGS Gage - ERSB at Corkscrew Rd	9.92	
ERSB-N32	ERSB Downstream of Sanctuary Rd	13.89	
ERSB-N34	ERSB at Sanctuary Road Crossing	13.94	
ERSB-NC05	The Villages at Country Creek Basin 7	10.33	11.02
ERSB1-N2	See See St. - Downstream	10.04	
ERSB1-NC534	Courtyard Apartments	16.62	15.94
ERSB2E-N14	Post Office on 3Oaks	15.32	
ERSB2E-N7	3 Oaks at Quente Way	15.34	
ERSB2E-NC37	Copper Oaks	16.95	17.03
ERSB5-N05	ERSB5-N05	13.74	13.42
ERSB6-NC03	The Villages at Country Creek Basin 10	12.66	12.92
ERSB6-NC06	The Villages at Country Creek Basin 5	11.42	12.02
ERSB9-N12	River Ranch at Block Lane	15.12	
HC-N22	HC Downstream of FPL Crossing	9.93	

Existing Conditions 25-Year, 3-Day ICPR4 Model Results at Key Locations			
Node	**Location**	**ICPR4 25-Year, 3-Day Peak Stage (FT-NAVD)**	**Permitted 25yr Stage (FT-NAVD)**
HC-N34	Halfway Creek at U.S. 41 - U/S	13.53	
HC-N35	Halfway Creek at U.S. 41 - U/S (+100 FT)	13.53	
HC-N55	The Brooks North Outfall Gage	13.86	
HCD1-NC10	Coconut Point Mall- North Outfall	15.54	15.5
HCD1-NC3	The Brooks South Outfall Gage	14.61	
HC-NC17	Marsh Landing Basin 2 Outfall	12.72	13
HC-NC24	Fountain Lakes Basin 1 Outfall	13.78	13.65
HC4-NC1	Coconut Shores Basin Outfall	15.9	15.65
NS-052	Broadway Ave., North Side	13.48	
N-010	North Side of Broadway Ave. Tributary/ Trailside Dr.	13.69	
NC-100	Terra Vista	13.55	12.92
ER802-N5	Breckenridge	13.27	12.92
NS-473	Trailside Dr., North End	13.88	
NS-476	Trailside Dr., South End	14.29	
ER802-N3	North Side of Broadway Ave. at Sherrill Lane	11.24	

3.4.4. 100-Year, 3-Day Design Storm Analysis and Results

The 100-year, 3-day design storm utilizes a total rainfall depth of 13.2 inches distributed over a period of 72 hours, or 3 days. The 100-year, 3-day design storm is the standard event used to establish the minimum finished floor elevations for habitable structures for developments that contain a surface water management system. Developments are regulated to provide flood protection of any habitable structures by setting the finished floor elevations to the greater of the 100-year, 3-day design water stage or the established base flood elevation per FEMA's flood maps. However, there are older residential areas which do not have surface water management system and were not required to build to current regulatory standards. These areas are expected to have floor elevations lower than the 100-year design stage for their respective area. Also, since some of the residential developments contain roadways elevations set at the 10-year, 1-day or 5-year, 1-day design stages, it is anticipated that there could be localized roadway flooding during the 100-year, 3-day storm event in those areas. The roadways designed to provide safe passage for the 100-year design, 3-day storm are typically major evacuation routes, such as U.S. 41 and Interstate-75 (I-75). For the hydraulic analysis of the 100-year, 3-day design storm, the main conveyances of each sub-watershed are evaluated below to provide an overall description of system performance and to note areas of concern and/or candidates for improvement projects.

3.4.4.a. Halfway Creek Watershed Hydraulic Analysis

Section 1: Main Stream from Confluence with Estero River upstream to U.S. 41

- Maximum average channel velocities are mild to moderate, ranging from 0.39 fps to a maximum of 2.74 fps at the most downstream end.
- Channel peak flow rates within this section of the creek range from 553 cfs to 874 cfs at the downstream connection to Estero River.
- From the downstream boundary to U.S. 41, the peak water surface elevations range from 3.27 ft-NAVD to 13.58 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater, between nodes, in peak surface water levels occur at the following locations:
  - HC-N7 to HC-N8: Increase of 0.90 feet located within the West Bay Club, north of West Bay Boulevard, just north of the most northern golf cart bridge crossing.
  - HC-N15 to HC-N16: Increase of 0.72 feet located within southern portion of West Bay Club, south of the last golf cart bridge crossing. This can be attributed to change in profile slope of channel bottom/ decrease in defined channel section – increasing in elevation upstream and increase in roughness coefficient on the overbank areas.
  - HC-N17 to HC-N18: Increase of 0.55 feet located just outside south boundary of West Bay Club and into large conservation/wetland area. This is attributed to shallower channel section with high roughness factors within majority of flow cross-section.
  - HC-N19 to HC-N20: Increase of 0.62 feet located within large conservation/wetland area between West Bay Club and FPL Crossing. This is attributed to shallower channel section with high roughness factors within majority of flow cross-section.
  - HC-N22 to HC-N23: Increase of 0.88 feet located within large conservation/wetland area between West Bay Club and FPL crossing, just downstream of FPL crossing. This is attributed to shallower channel section at upstream end and high roughness factors within majority of flow cross-section for entire segment. The surface water elevations within this portion of Halfway Creek affects Marsh Landing Basin 3 Outfall and properties upstream, specifically Fountain Lakes Basin 1, Marsh Landing Basins 1 and 2.
  - See Figure 3-46 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***Conduct Routine/regular maintenance of large conservation/wetland area located between West Bay Club and FPL crossing to reduce roughness factor within flow area.***
- ***Work with the West Bay Club community on a regular maintenance program for the upstream portions of Halfway Creek located within their property.***

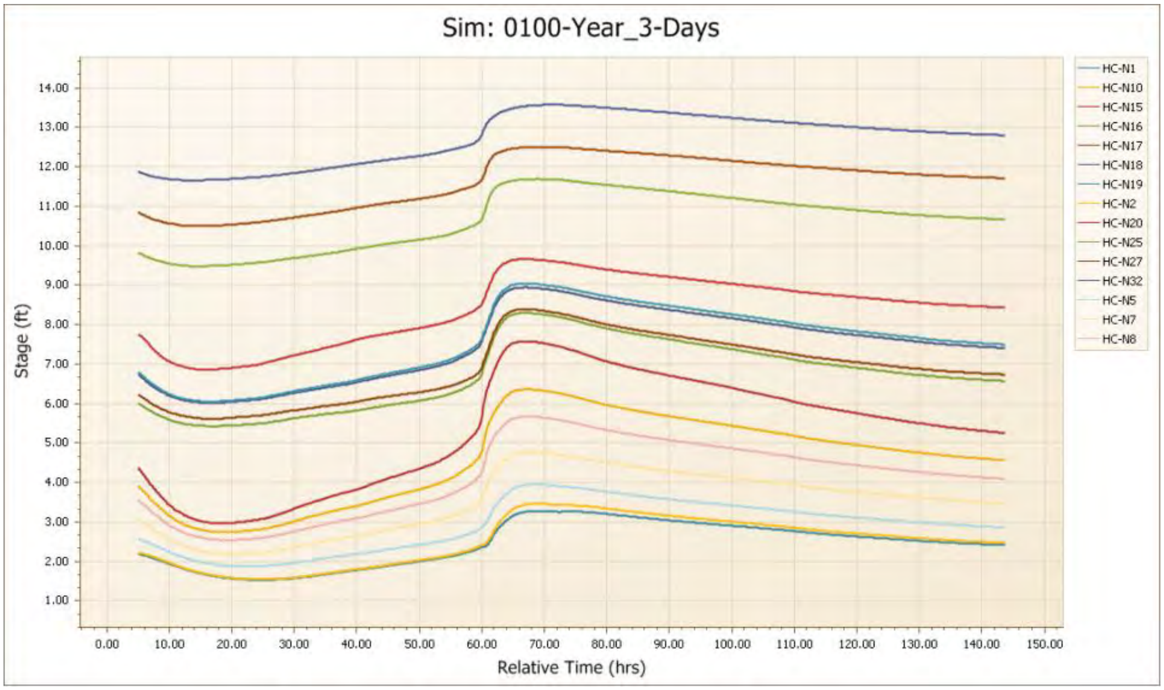


**Figure 3-46: Halfway Creek Section 1 -
100-Year, 3-Day Stage Time Series**

Section 2: Main Stream from Downstream U.S. 41 to Railroad Crossing/Brooks North Outfall

- Average maximum channel velocities are low to mild, ranging from 0.20 fps to a maximum of 1.06 fps at the downstream end of the U.S. 41 crossing.
- Maximum channel flow rates within this section of the creek range from 401 cfs coming from the Brooks North Outfall to 668 cfs at the downstream side of the U.S. 41 crossing.
- From the downstream side of U.S. 41 crossing to the Railroad Crossing/Brooks North Outfall, the peak water surface elevations range from 13.58 ft-NAVD to 14.13 ft-NAVD.
- The average velocity through the U.S 41 culvert crossing is 2.60 fps and the culverts are flowing completely full during the peak of the event. The peak head-loss through the culvert crossing is 0.21 feet. The bottom invert is 4.62 ft-NAVD with a top elevation of 11.62 ft-NAVD.
- See Figure 3-47 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Halfway Creek during 100-year, 3-day design storm.

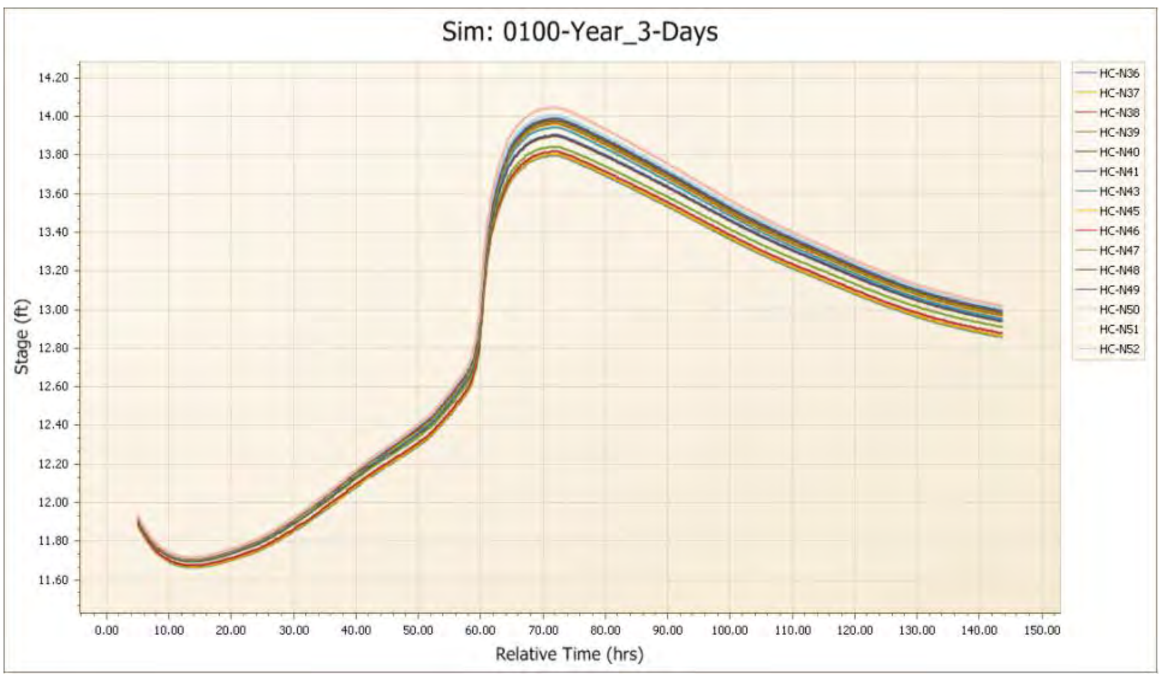


Figure 3-47: Halfway Creek Section 2 -
100-Year, 3-Day Stage Time Series

Section 3: Main Stream from Upstream Side of Brooks North Outfall to I-75

- o Average maximum channel velocities are low, ranging from 0.21 fps to a maximum of 0.50 fps at the downstream end of the Brooks North Outfall. This is attributed to the nature of the flow-way lake system within The Brooks community, which is controlled by the outfall weir. All the flow-way lakes behave as a level pool, connected by a system of submerged culverts.
- o Maximum channel flow rates within this section of the creek range from 251 cfs coming from the I-75 crossing to 353 cfs at the downstream side of the Brooks North Outfall.
- o From the downstream side of the Brooks North Outfall to the I-75 culverts, the peak water surface elevations range from 14.13 ft-NAVD to 14.44 ft-NAVD.
- o See Figure 3-48 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Halfway Creek during 100-year, 3-day design storm.

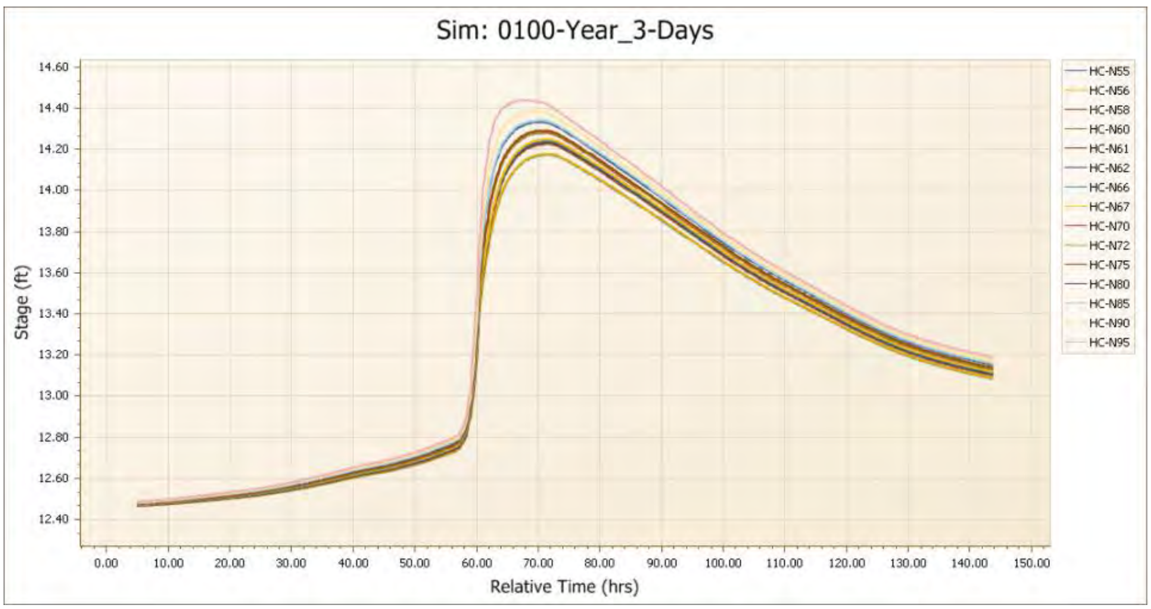


Figure 3-48: Halfway Creek Section 3 -
100-Year, 3-Day Stage Time Series

Section 4: Diversion Streams from Weir Downstream of Via Villagio to The Brooks South Outfall

- o Average channel velocities are low, ranging from 0.25 fps to a maximum of 0.36 fps within the south diversion portion, just north of Coconut Point Mall.
- o Peak flow rates within the north diversion portion (HCD2) range from 143 cfs to 158 cfs at the upstream side of the Via Villagio culvert crossing. Peak flow rates within the south diversion portion (HCD1) range from 150 cfs to 161 cfs at the upstream side of the Via Villagio culvert crossing.
- o In the railroad ditches that travel north and south of the Brooks South and North Outfall, there is very little flow.
- o From the upstream side of the weir located downstream from Via Villagio to the Brooks South Outfall, the peak water surface elevations range from 13.90 ft-NAVD to 14.12 ft-NAVD.
- o See Figure 3-49 below for the Node time series results for the diversion stream Nodes.

No major issues identified for this section of Halfway Creek during 100-year, 3-day design storm.

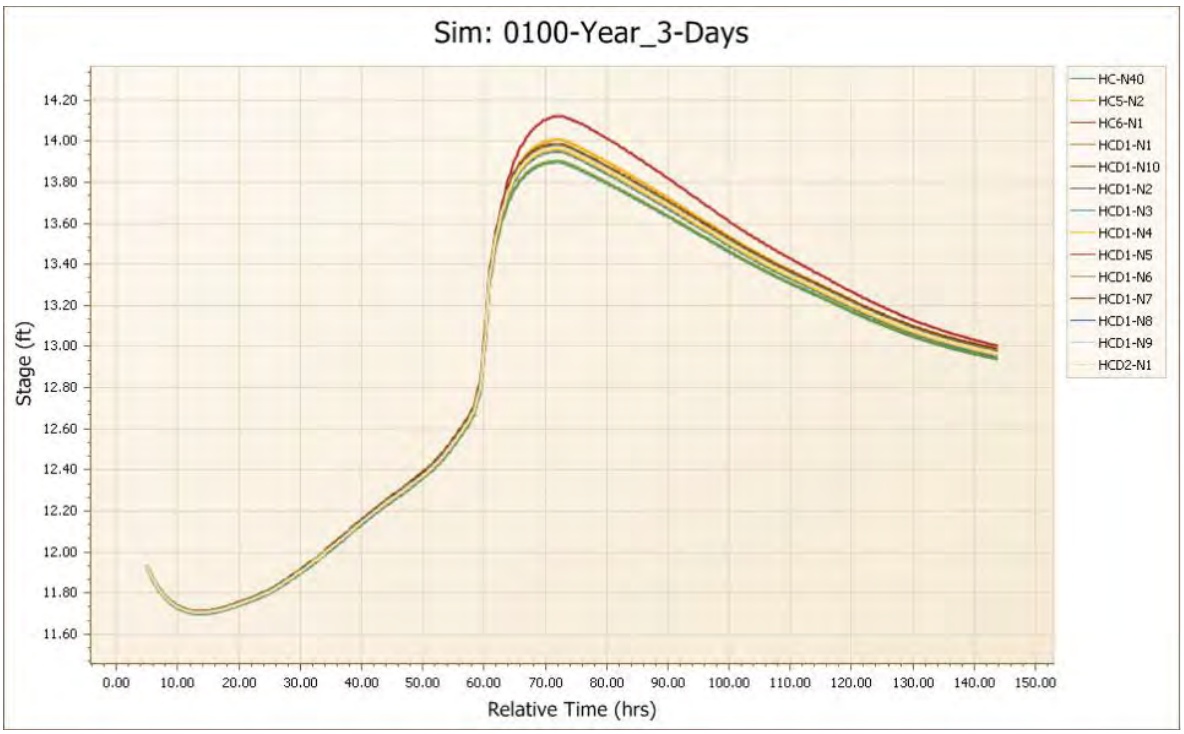


Figure 3-49: Halfway Creek Section 4 -
100-Year, 3-Day Stage Time Series

3.4.4.b. South Branch Sub-Watershed Hydraulic Analysis

Section 1: South Branch from Confluence with Main Branch upstream to Corkscrew Road:

- o Average channel velocities are mild, ranging from 1.15 fps to a maximum of 2.37 fps just downstream of the southernmost bridge within the Villages at Country Creek, ERSB-RC4.
- o Peak flow rates within this section of the River range from 536 cfs at the downstream side of the Corkscrew Road culvert crossing to 795 cfs at the connection to the main branch of the Estero River.
- o From the downstream boundary node to Corkscrew Road, the peak water surface elevations range from 7.33ft-NAVD to 10.28 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ ERSB-N3 to ERSB-N4: There is an increase in peak stage of 0.57 feet between the two nodes. This can be attributed to the change in channel cross-section at this location, as well as the 1.37 foot difference in invert elevation of the two nodes.
  - ➢ See Figure 3-50 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of the South Branch during 100-year, 3-day design storm.

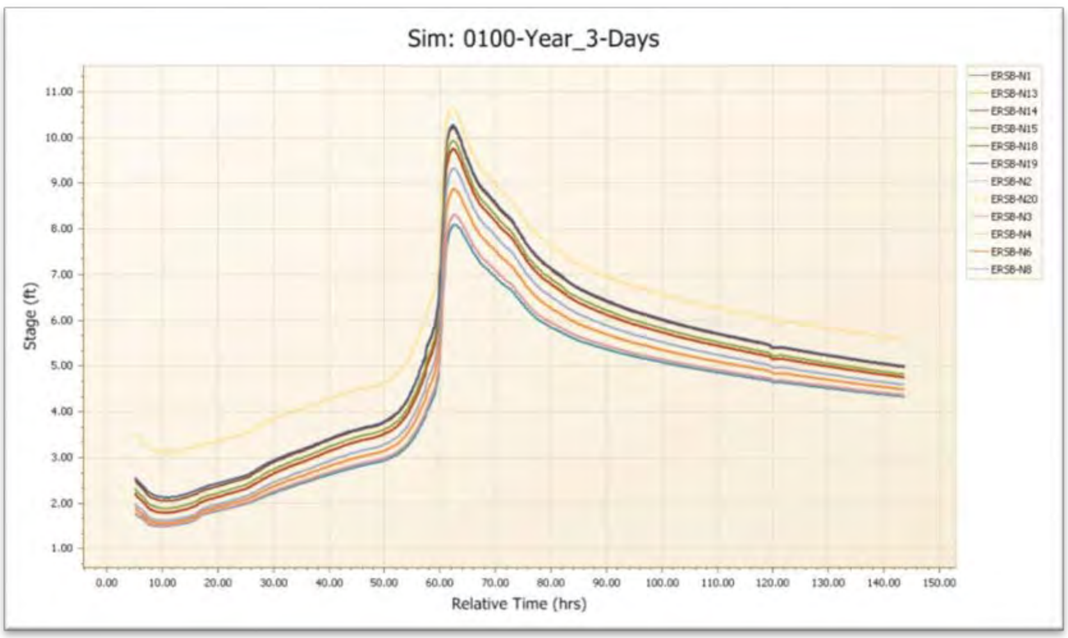


Figure 3-50: South Branch Section 1 - 100-Year, 3-Day Stage Time Series

<u>Section 2: South Branch from Corkscrew Road to Three Oaks Parkway</u>

- o Average maximum channel velocities are mild, ranging from 0.80 fps to a maximum of 1.45 fps.
- o Peak flow rates within this section of the River range from 414 cfs to 453 cfs. The most downstream portion of this section of river has a lower flow rate than the most upstream portion; therefore, this section of the South Branch is storing water.
- o From the downstream side of Corkscrew Road to the downstream side of Three Oaks Parkway, the peak water surface elevations range from 10.66 ft-NAVD to 11.28 ft-NAVD.
- o Significant increases in peak water levels between nodes:
  - ➢ There are no significant increases in water levels between nodes along this section of the Estero River South Branch.
  - ➢ See Figure 3-51 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of the South Branch during 100-year, 3-day design storm.

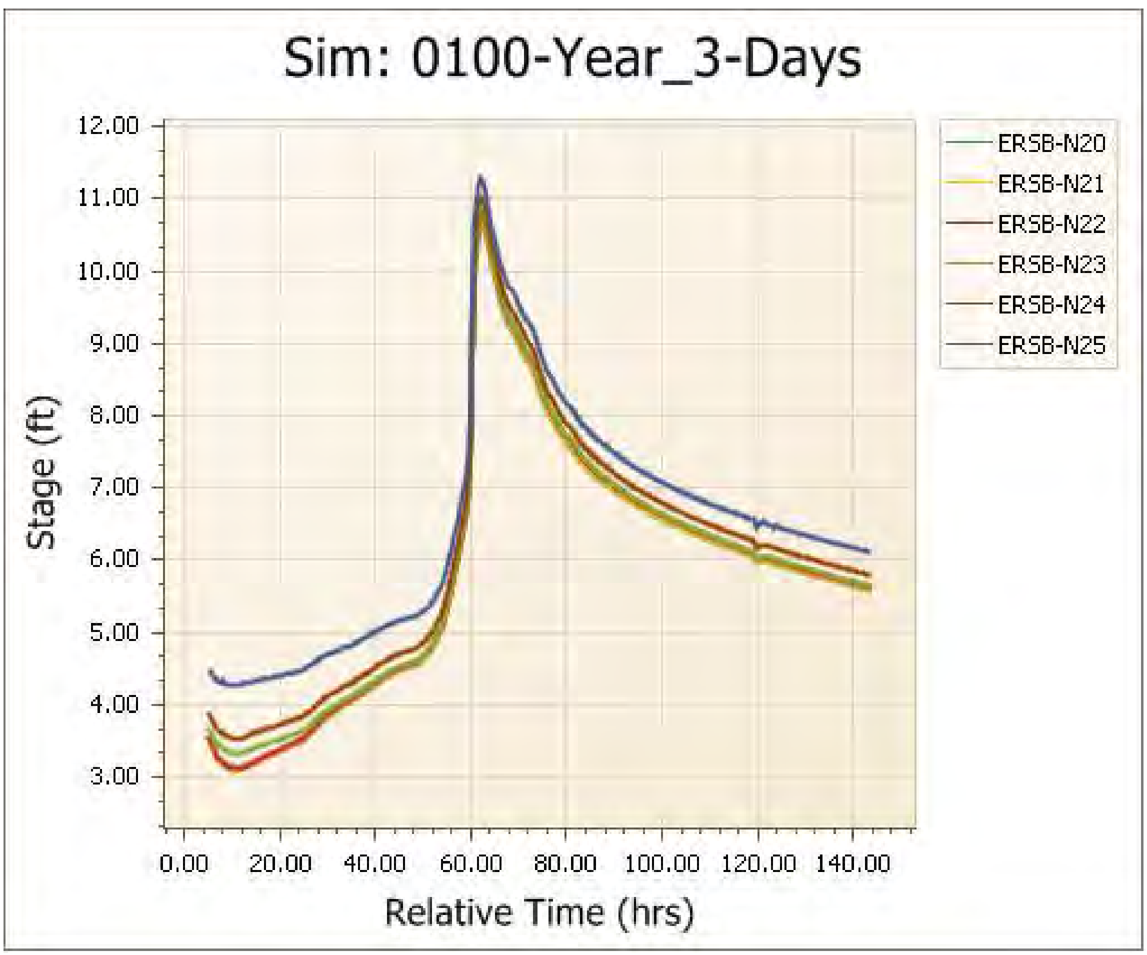


Figure 3-51: South Branch Section 2 - 100-Year, 3-Day Stage Time Series

Section 3: South Branch from Three Oaks Parkway to the I-75 Culvert Crossing

- Average maximum channel velocities are mild, ranging from 0.35 fps to a maximum of 2.71 fps.
- Peak flow rates within this section of the River range from 89 cfs to 414 cfs, with the greatest flow rate occurring through the Three Oaks Parkway culverts. The lowest flow rates occur at the most upstream portion of the section.
- From the downstream side of Three Oaks Parkway to the downstream side of the I-75 culverts, the peak water surface elevations range from 11.28 ft-NAVD to 15.14 ft-NAVD.
- Significant increases in peak water levels between nodes:
  - ERSB-N30 to ERSB-N31: Increase of 1.76 feet located within the creek section at the east side of Villa Palmeras. This is attributed to the change in cross-section of the River – the bottom becomes narrower, forcing water to flow more in the banks with a much higher roughness. Furthermore, this section of the River has a large drainage basin contributing flow to it, much of which is wetlands and residential developments.
  - See Figure 3-52 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jump within the area located upstream of Villa Palmeras, conduct routine/regular maintenance to reduce roughness factor within flow area***.

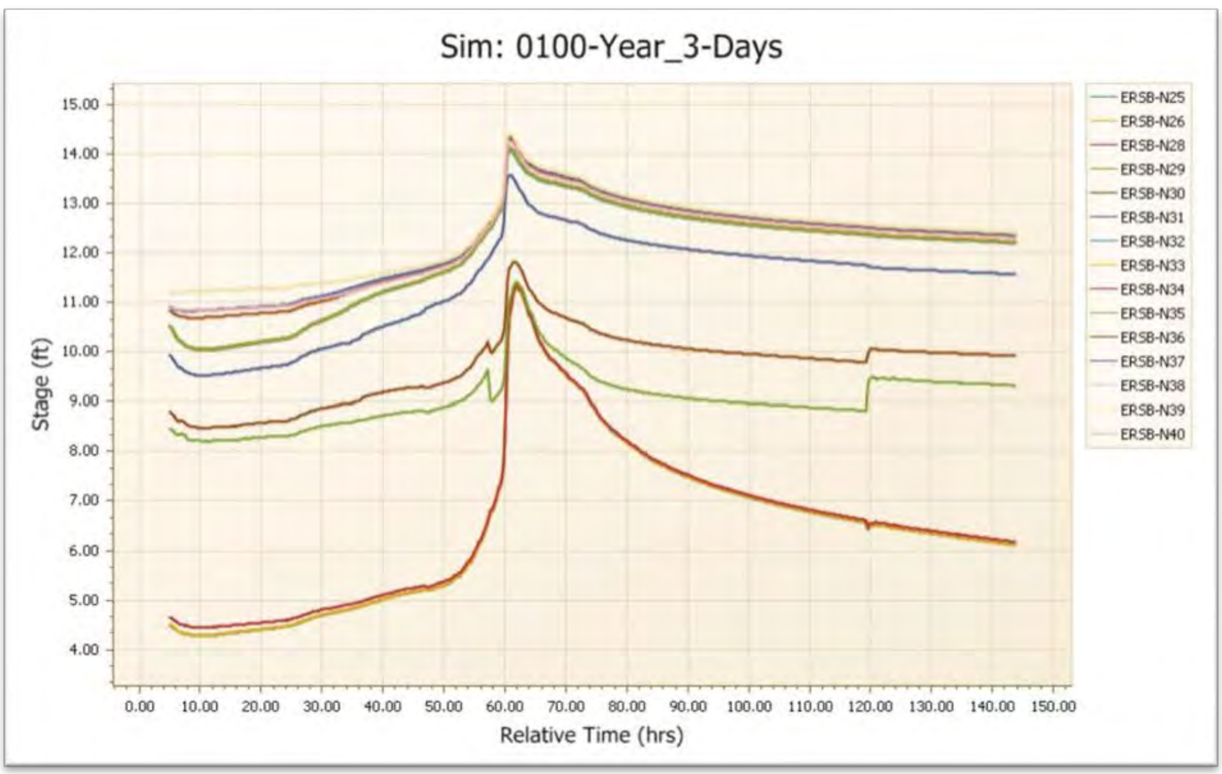


Figure 3-52: South Branch Section 3 - 100-Year, 3-Day Stage Time Series

3.4.4.c. North Branch Sub-Watershed Hydraulic Analysis

Section 1: From Junction with River to North Boundary of VCC

- o Maximum average channel velocities are mild to moderate, ranging from 0.75 fps to a maximum of 2.75 fps at just upstream of the junction with Estero River. It is important to note that some of the maximum average velocities are less with the 100-year event compared to the 10-year and 25-year events. This is attributed to more flow within the bank/overbank area which is subject to the higher roughness (more vegetation, roots, trees, etc.). The flow is experiencing more friction and velocity is decreased.
- o Peak flow rates within this section of the creek range from 435 cfs at the north boundary of Villages at Country Creek to 446 cfs at the location of where the North Branch enters a slight diversion to the west. At this point, there is a split in the flow. The maximum flow coming out of the westward diversion into the junction with the River is 239 cfs.
- o From the junction node to the north Villages at Country Creek boundary, the peak water surface elevations range from 7.33 ft-NAVD to 12.37 ft-NAVD.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ From ERNB-N1 to ERNB-N2: There 0.77 feet of rise between peak water surface elevations. This is located just upstream from the slight diversion point.
  - ➢ From ERNB-N2 to ERNB-N3: There 0.82 feet of rise between peak water surface elevations.
  - ➢ From ERNB-N8 to ERNB-N10: There is 0.56 feet of rise between peak water surface elevations. This is located just downstream of the golf cart bridge located north of Halfhitch Road.
  - ➢ See Figure 3-53 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- o ***Work with the Villages at Country Creek community on a regular maintenance program for the portions of the North Branch located within their property.***

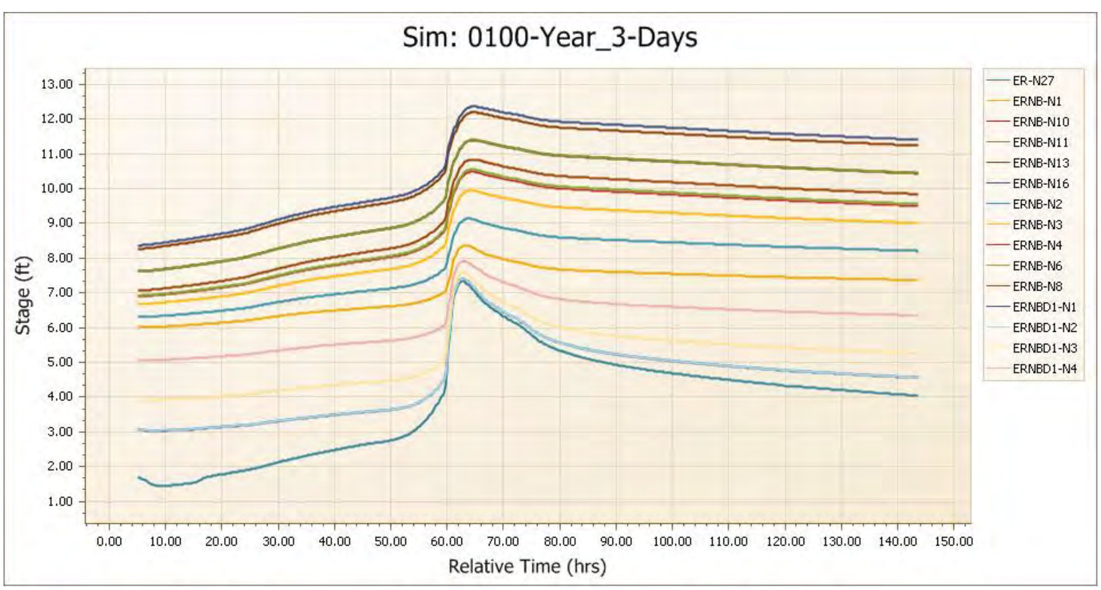


Figure 3-53: North Branch Section 1 - 100-Year, 3-Day Stage Time SerieS

Section 2: North Branch from North Boundary of Villages at Country Creek through Rookery Pointe to I-75 Boundary (ERNB-NT2)

- Average channel velocities are mild to moderate, ranging from 0.81 fps to a maximum of 2.57 fps at the most downstream end.
- Flow rates within this section of the creek range from 246 cfs to 444 cfs at northern boundary of Villages at Country Creek.
- From the downstream boundary to I-75 boundary node, the peak water surface elevations range from 12.37 ft-NAVD to 15.91 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ERNB-N16 to ERNB-N17 Increase of 0.64 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area.
  - ERNB-N17 to ERNB-N18: Increase of 1.50 feet located within the within the channel section just north of Villages at Country Creek. This is attributed to a change in the channel section – width, bottom elevation and heavy vegetation within the flow area. There is also a steeper slope in the bottom elevation of the channel, which increase velocities.
  - See Figure 3-54 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***To lessen the hydraulic jumps within the section of the branch that travels between Villages at Country Creek and Rookery Drive, conduct improvements to the channel cross-section to achieve a more gradual slope from north to south and conduct routine maintenance to remove vegetation debris and exotics.***

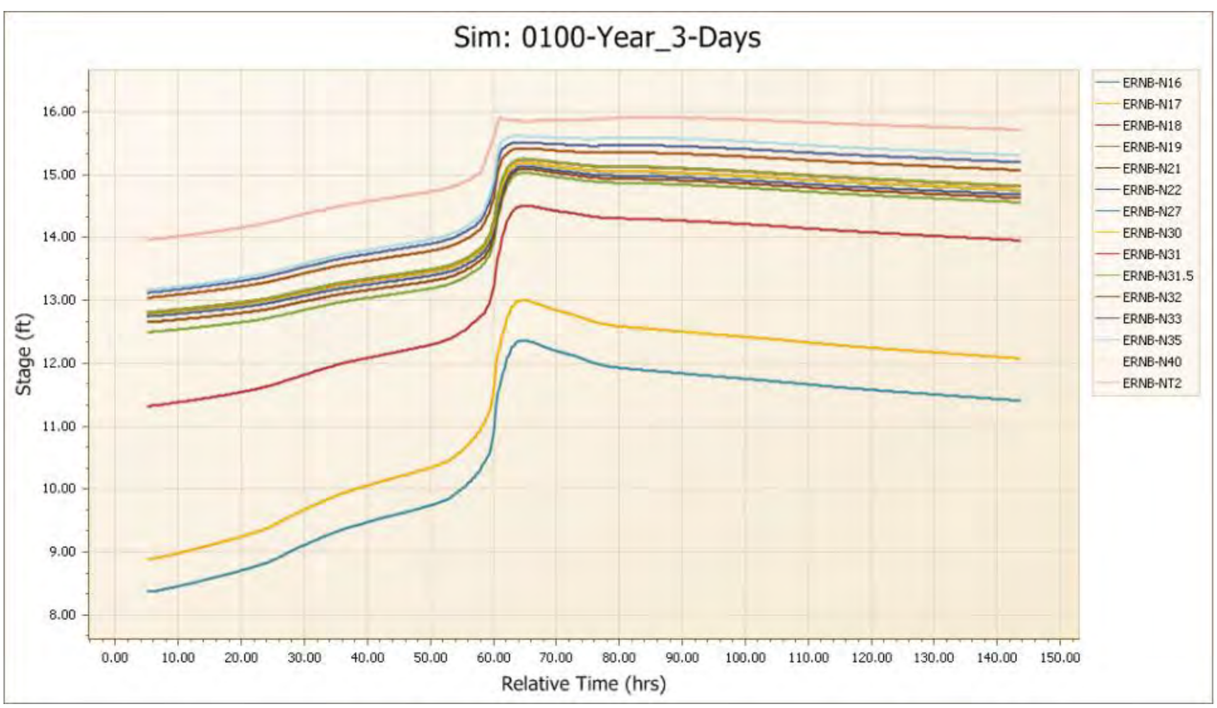


Figure 3-54: North Branch Section 2 - 100-Year, 3-Day Stage Time Series

Section 3: North Branch North Diversion from through Rookery Pointe, North of Villagio to I-75 Boundary (ERNB-NT2)

- o Maximum Average channel velocities are very low, ranging from 0.19 fps to a maximum of 0.69 fps at the most downstream end.
- o Peak flow rates within this diversion section of the creek range from 60 cfs to 65 cfs at the point just upstream of connection with the main stream of the North Branch.
- o From the downstream boundary to I-75 boundary node, the peak water surface elevations range from 15.10 ft-NAVD to 15.88 ft-NAVD at the junction with the I-75 parallel swale.
- o Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - ➢ ERNBD2-N7 to ERNB-N39: Increase of 0.69 feet located within the within the diversion section just before connecting to the I-75 parallel swale. This is attributed to a change in the channel section – more narrow width, higher bottom elevation and heavy vegetation within the flow area.
  - ➢ See Figure 3-55 below for the Node time series results for the stream Nodes in this segment.

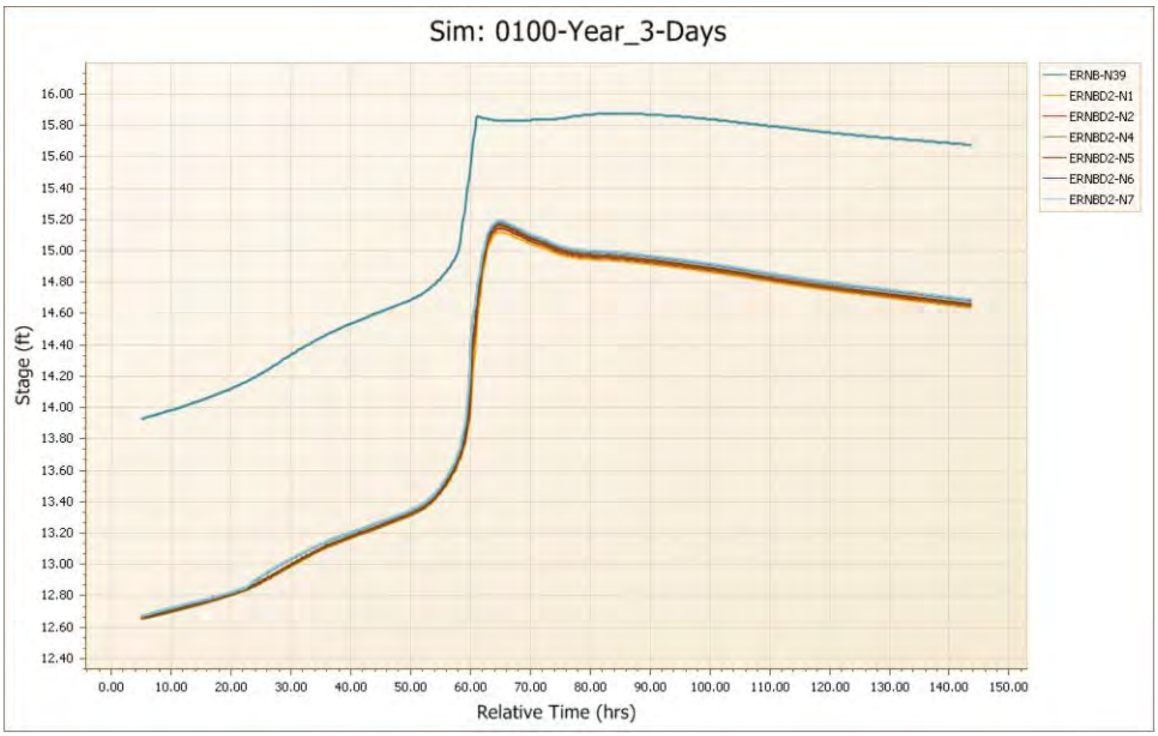


Figure 3-55: North Branch Section 3 - 100-Year, 3-Day Stage Time Series

3.4.4.d. Estero River Sub-Watershed Hydraulic Analysis

Section 1: Main Stream from Confluence with Estero Bay upstream to U.S. 41

- Average maximum channel velocities are moderate to fast, ranging from 1.89 fps to a maximum of 4.53 fps at just upstream from the confluence with Estero Bay. The higher velocities within this section of the river are indicative of the flow being able transport sediments during the larger storm events.
- Peak flow rates within this section of the River are significantly greater than the 25-year event and range from 1242 cfs at the downstream side of U.S. 41 crossing to 2375 cfs at the downstream connection to Estero Bay.
- From the downstream boundary to U.S. 41, the peak water surface elevations range from 1.03 ft-NAVD to 4.53 ft-NAVD.
- Significant increases, being an increase of 6 inches or greater between nodes, in surface water levels occur at the following locations:
  - The model does not indicate any significant increases in peak water levels between nodes for this section of the Estero River.
  - See Figure 3-56 below for the Node time series results for the stream Nodes in this segment.

No major issues identified for this section of Estero River during 100-year, 3-day design storm.

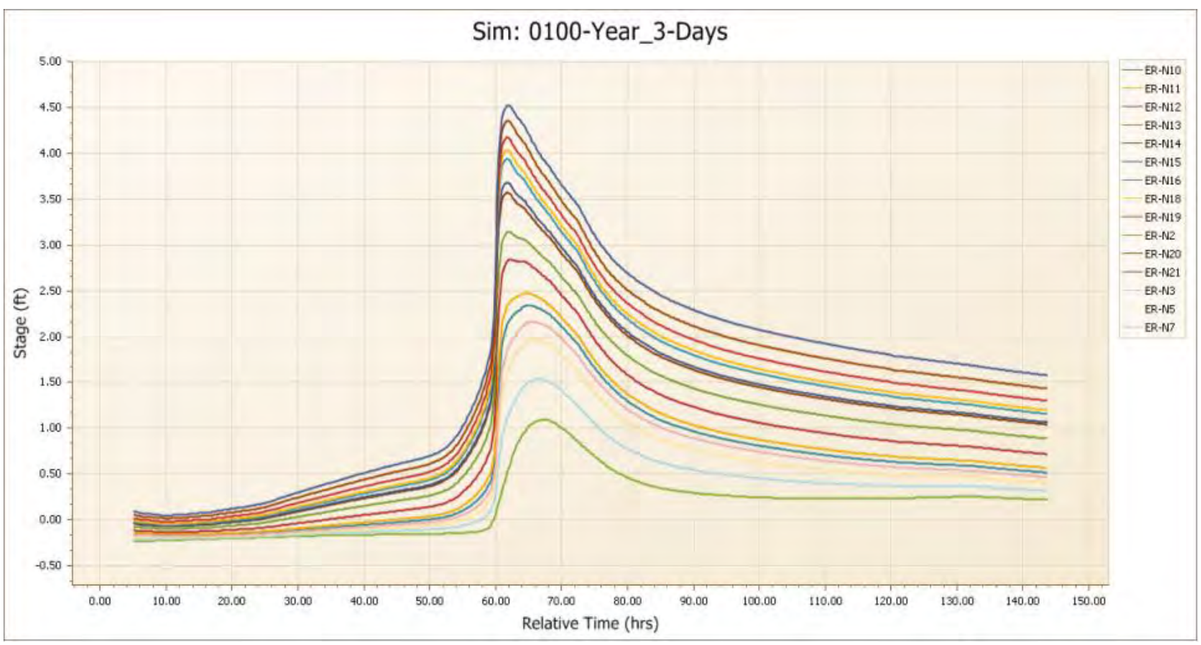


Figure 3-56: Estero River Section 1 - 100-Year, 3-Day Stage Time Series

Section 2: Main Stream from Downstream U.S. 41 to connection with North and South Branch

- Average maximum channel velocities are mild, ranging from 1.71 fps to a maximum of 2.88 fps at the downstream end of the railroad crossing.
- Flow rates within this section of the creek range from 1036 cfs coming from the junction with the North and South Branches to 1242 cfs at the downstream side of the U.S. 41 crossing.
- From the downstream side of U.S. 41 to the junction with the North and South Branches, the peak water surface elevations range from 4.53 ft-NAVD to 7.33 ft-NAVD.
- Significant increases in peak water levels between nodes:
  - ER-N22 to ER-N23: Increase of 0.76 feet located just upstream from US 41 crossing to the downstream end of the railroad crossing. This increase can be attributed to more flow occurring in the banks of the channel section with higher roughness values.
  - ER-N24 to ER-N24.5: Increase of 0.76 feet located just upstream of the railroad crossing. This is attributed to the change in cross-section of the creek – the bottom is becoming narrow, forcing water to flow more in the banks with a higher roughness. In addition, the average channel velocity upstream of ER-N24.5 are higher than the downstream channel.
  - See Figure 3-57 below for the Node time series results for the stream Nodes in this segment.

Recommended Improvements:

- ***For the section of the River located upstream of the railroad crossing up to the downstream side of Sandy Lane, it is recommended that the channel be modified to be more consistent in size, bottom width and side slopes.***

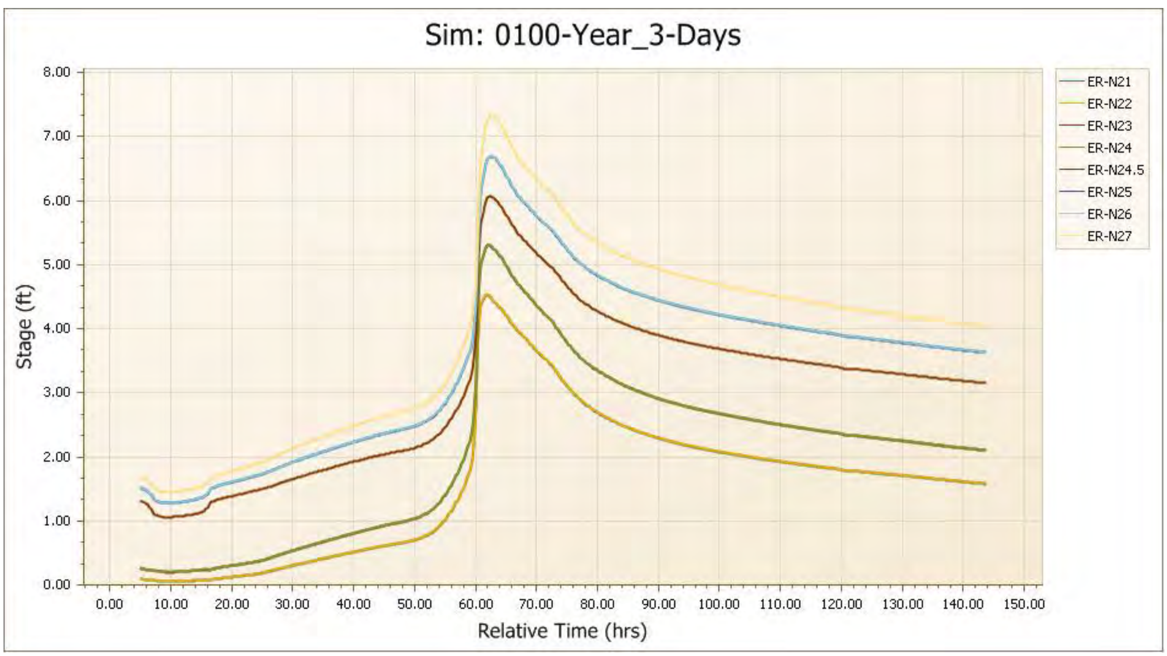


Figure 3-57: Estero River Section 2 -
100-Year, 3-Day Stage Time Series

Table 3-11 provides the node maximum stage results for the 100-Year, 3-Day design storm within the Local-Scale ICPR4 Model. An assessment was conducted within the ICPR4 model at key locations within the study area. Roadway flooding is anticipated throughout the study area for the 100-year design storm event. The roadways designed to provide safe passage for the 100-year design storm are typically major evacuation routes, such as Interstate 75 (I-75).

Table 3-11: Existing Conditions 100-Year, 3-Day ICPR4 Model Results at Key Locations

Existing Conditions 100-Year, 3-Day ICPR4 Model Results at Key Locations		
Node	**Location**	**ICPR4 100-Year, 3-Day Peak Stage (FT-NAVD)**
ER-N16	ER at Broadway Conveyance Connection	3.94
ER-N21	ER & US-41 Downstream	4.53
ER-N23	Rail Road - Downstream	5.3
ER-N24	Rail Road - Upstream	5.31
ER-N26	ER & Sandy Lane Bridge	6.7
ER-N27	West side of Bamboo Island	7.33
ER1-N18	Corkscrew to Sandy Lane	15.42
ER1-NC57	Estero Community Park	15.57
ER4N-N12	SGLR Ditch & Estero Pkwy US	14.86
ER4N-NC19	Cascades	14.6
ER4N-NC23	Belle Lago	15.14
ER4N-NC24	The Reserve	16.04
ER4N-N6	Cascades Outfall / SGLR Ditch	13.9
ER4S-N3	SGLR Ditch Upstream of Corkscrew Road	16.05
ER6-N1	Walmart Ultimate Outfall	15.01
ER6-NC3	Walmart/Osprey Cove	14.61
ER804-N1	Pineland Preserve Outfall	12.32
ER804-NC1	Pineland Preserve	16.44
ERNB-N1	East side of Bamboo Island	8.37
ERNB-N17	USGS Gage-South of Rookery Point	13.01
ERNB-N20	Rookery Point Cir. Bridge	15.04
ERNB-N30	D/S Three Oaks Pkwy Crossing	15.19
ERNB-N6	Villages of Country Creek - Halfhitch Rd Bridge	10.56
ERNB-NC05	The Villages at Country Creek Basin 3	10.92
ERNB-NC25	Rookery Basin 2	16.41
ERNB-NC46	Villagio	16.94
ERNB1-NC018	Waste Water Treatment Plant	20.33

Existing Conditions 100-Year, 3-Day ICPR4 Model Results at Key Locations		
Node	Location	ICPR4 100-Year, 3-Day Peak Stage (FT-NAVD)
ERNB1-NC022	Three Oaks Community Park (Park)	17.93
ERNB1-NC025	Three Oaks Community Park (Pond)	17.91
ERNB2-NC23	Country Oaks	17.68
ERNB2E-N13	Estero Pkwy & 3Oaks	15.63
ERNB2E-N24	End nodes Three Oaks near Coastal Villages	18.28
ERNB2N-NC20	Three Oaks Town Center	17.01
ERNB2N-NC59	Three Oaks Middle School	18.44
ERNB2W-NC22	Estero Oaks	16.55
ERNB2W-NC24	Rookery Basin 3	17.58
ERNB3-NC16	Somerset	17.53
ERNB4-N10	U/S Estero Parkway Culvert	16.33
ERNB4-NC14	Our Lady Of Light	17.25
ERNB4-NC4	Rookery Basin 1	16.83
ERNB5E-NC7	Pond 100 Estero Parkway	19.65
ERNB5E-NC8	The Reef	17.08
ERNBD2-N4	ERNB at 3Oaks Crossing N (US)	15.16
ERSB-N20	USGS Gage - ERSB at Corkscrew Rd	10.66
ERSB-N32	ERSB Downstream of Sanctuary Rd	14.06
ERSB-N34	ERSB at Sanctuary Road Crossing	14.13
ERSB-NC05	The Villages at Country Creek Basin 7	11.01
ERSB1-N2	See See St. - Downstream	10.81
ERSB1-NC534	Courtyard Apartments	16.76
ERSB2E-N14	Post Office on 3Oaks	15.5
ERSB2E-N7	3 Oaks at Quente Way	15.44
ERSB2E-NC37	Copper Oaks	17.17
ERSB5-N05	ERSB5-N05	14.31
ERSB6-NC03	The Villages at Country Creek Basin 10	12.95
ERSB6-NC06	The Villages at Country Creek Basin 5	11.89
ERSB9-N12	River Ranch at Block Lane	15.38
HC-N22	HC Downstream of FPL Crossing	10.17
HC-N34	Halfway Creek at U.S. 41 - U/S	13.79
HC-N35	Halfway Creek at U.S. 41 - U/S (+100 FT)	13.79
HC-N55	The Brooks North Outfall Gage	14.18

Existing Conditions 100-Year, 3-Day ICPR4 Model Results at Key Locations		
Node	Location	ICPR4 100-Year, 3-Day Peak Stage (FT-NAVD)
HCD1-NC10	Coconut Point Mall- North Outfall	15.77
HCD1-NC3	The Brooks South Outfall Gage	14.92
HC-NC17	Marsh Landing Basin 2 Outfall	12.89
HC-NC24	Fountain Lakes Basin 1 Outfall	14.05
HC4-NC1	Coconut Shores Basin Outfall	16.14
NS-052	Broadway Ave., North Side	13.79
N-010	North Side of Broadway Ave. Tributary/ Trailside Dr.	13.95
NC-100	Terra Vista	13.88
ER802-N5	Breckenridge	13.47
NS-473	Trailside Dr., North End	14.03
NS-476	Trailside Dr., South End	14.3
ER802-N3	North Side of Broadway Ave. at Sherrill Lane	11.56

3.5. Modeling Results – Build-out Conditions Scenario

3.5.1. 25-Year, 3-Day Design Storm

To conduct a review of the Build-out Conditions within the Local-Scale model study area, consideration was given to the remaining vacant parcels that could potentially be developed. The selection of vacant, to-be-developed parcels did not include government-owned or publicly parcels, conservation parcels, State-owned lands, or out-parcels that were already part of a master plan development in which the master stormwater system was in place. Map 3-6 provides the locations of all of the parcels considered for the Build-out Conditions model evaluation.

The goal of the evaluation of the Build-out scenario is to evaluate the potential impacts on the surface water management facilities within The Village with the development of the build-out parcels under the current design criteria, specifically related to allowable discharge rates for the 25-Year, 3-Day design storm. Based on the current State regulations, through the South Florida Water Management District (SFWMD), the established allowable discharge rates for the watersheds located within The Village are as follows:

Estero River Watershed = 42 CSM (cubic feet per square mile) = 0.06 cfs/acre

Halfway Creek Watershed = 60 CSM (cubic feet per square mile) = 0.09 cfs/acre

To evaluate the potential impacts within the study area, a flow hydrograph was created for each of the built-out parcels to represent the anticipated timing of and peak stormwater run-off allowed to leave the parcel in the build-out condition. For example, for a build-out parcel located within the Estero River watershed area, the hydrograph was established to produce a peak discharge equal to 0.06 cfs per the amount of acreage within the parcel. The respective hydrographs were set as boundary conditions for each of the build-out parcels/nodes and the 25-Year, 3-Day model was executed. Table 3-12 provides a comparison between the peak water surface stages achieved in the Existing Conditions 25-Year, 3-Day model to those resulting in the Build-out Conditions at locations adjacent to the build-out parcels and their points of discharge.

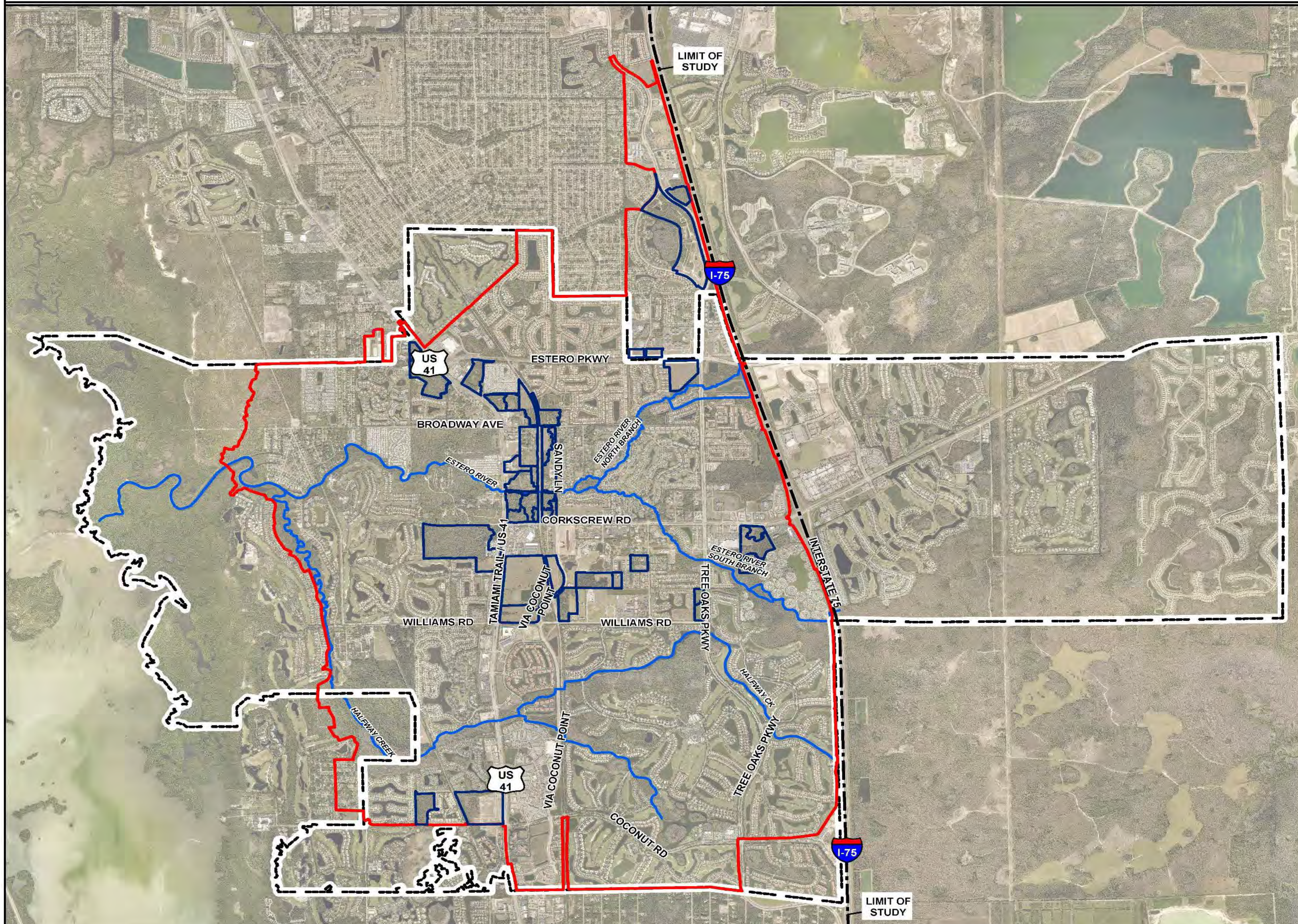
Table 3-12: Buildout Comparison 25-Year, 3-Day
ICPR4 Model Results at Key Locations

Buildout Comparison 25-Year, 3-Day ICPR4 Model Results at Key Locations					
Node	**Location**	**BO Model 25-Year Peak Stages**	**Existing 25-Year Peak Stages**	**Difference**	**BO Effect on Peak Stages**
ER-N16	ER at Broadway Conveyance Connection	3.22	3.34	-0.12	DECREASE
ER-N21	ER & US-41 Downstream	3.79	3.91	-0.12	DECREASE
ER-N23	Rail Road - Downstream	4.51	4.63	-0.12	DECREASE
ER-N24	Rail Road - Upstream	4.51	4.64	-0.13	DECREASE
ER-N26	ER & Sandy Lane Bridge	5.93	6.01	-0.08	DECREASE
ER-N27	West side of Bamboo Island	6.49	6.58	-0.09	DECREASE
ER1-N18	Corkscrew to Sandy Lane	14.76	15.14	-0.38	DECREASE
ER1-NC57	Estero Community Park	15.34	15.34	0	NO CHANGE
ER4N-N12	SGLR Ditch & Estero Pkwy US	14.4	14.4	0	NO CHANGE

Buildout Comparison 25-Year, 3-Day ICPR4 Model Results at Key Locations					
Node	**Location**	**BO Model 25-Year Peak Stages**	**Existing 25-Year Peak Stages**	**Difference**	**BO Effect on Peak Stages**
ER4N-NC19	Cascades	14.3	14.32	-0.02	DECREASE
ER4N-NC23	Belle Lago	14.6	14.61	-0.01	DECREASE
ER4N-NC24	The Reserve	15.7	15.71	-0.01	DECREASE
ER4N-N6	Cascades Outfall / SGLR Ditch	13.74	13.69	0.05	INCREASE
ER4S-N3	SGLR Ditch Upstream of Corkscrew Rd	15.09	15.71	-0.62	DECREASE
ER6-N1	Walmart Ultimate Outfall	14.44	14.7	-0.26	DECREASE
ER6-NC3	Walmart/Osprey Cove	14.32	14.37	-0.05	DECREASE
ER804-N1	Pineland Preserve Outfall	12.3	12.3	0	NO CHANGE
ER804-NC1	Pineland Preserve	15.99	15.99	0	NO CHANGE
ERNB-N1	East side of Bamboo Island	7.87	7.83	0.04	INCREASE
ERNB-N17	USGS Gage-South of Rookery Point	12.5	12.44	0.06	INCREASE
ERNB-N20	Rookery Point Cir. Bridge	14.66	14.66	0	NO CHANGE
ERNB-N30	D/S Three Oaks Pkwy Crossing	14.81	14.83	-0.02	DECREASE
ERNB-N6	Villages of Country Creek - Halfhitch Rd Bridge	10.05	9.98	0.07	INCREASE
ERNB-NC05	The Villages at Country Creek Basin 3	10.3	10.28	0.02	INCREASE
ERNB-NC25	Rookery Basin 2	16.21	16.16	0.05	INCREASE
ERNB-NC46	Villagio	16.69	16.66	0.03	INCREASE
ERNB1-NC018	Waste Water Treatment Plant	19.6	19.6	0	NO CHANGE
ERNB1-NC022	Three Oaks Community Park (Park)	17.6	17.6	0	NO CHANGE
ERNB1-NC025	Three Oaks Community Park (Pond)	17.57	17.58	-0.01	DECREASE
ERNB2-NC23	Country Oaks	17.34	17.34	0	NO CHANGE
ERNB2E-N13	Estero Pkwy & 3Oaks	15.36	15.35	0.01	INCREASE
ERNB2E-N24	End nodes Three Oaks near Coastal Villages	17.92	17.92	0	NO CHANGE
ERNB2N-NC20	Three Oaks Town Center	16.78	16.79	-0.01	DECREASE
ERNB2N-NC59	Three Oaks Middle School	18.15	18.15	0	NO CHANGE
ERNB2W-NC22	Estero Oaks	16.37	16.37	0	NO CHANGE
ERNB2W-NC24	Rookery Basin 3	17.43	17.43	0	NO CHANGE
ERNB3-NC16	Somerset	17.41	17.41	0	NO CHANGE
ERNB4-N10	U/S Estero Parkway Culvert	15.79	15.88	-0.09	DECREASE
ERNB4-NC14	Our Lady Of Light	17.11	17.11	0	NO CHANGE
ERNB4-NC4	Rookery Basin 1	16.6	16.6	0	NO CHANGE
ERNB5E-NC7	Pond 100 Estero Parkway	19.38	19.38	0	NO CHANGE
ERNB5E-NC8	The Reef	16.82	16.82	0	NO CHANGE

Buildout Comparison 25-Year, 3-Day ICPR4 Model Results at Key Locations					
Node	**Location**	**BO Model 25-Year Peak Stages**	**Existing 25-Year Peak Stages**	**Difference**	**BO Effect on Peak Stages**
ERNBD2-N4	ERNB at 3Oaks Crossing N (US)	14.8	14.77	0.03	INCREASE
ERSB-N20	USGS Gage - ERSB at Corkscrew Rd	9.59	9.92	-0.33	DECREASE
ERSB-N32	ERSB Downstream of Sanctuary Rd	13.83	13.89	-0.06	DECREASE
ERSB-N34	ERSB at Sanctuary Road Crossing	13.89	13.94	-0.05	DECREASE
ERSB-NC05	The Villages at Country Creek Basin 7	10.31	10.33	-0.02	DECREASE
ERSB1-N2	See See St. - Downstream	9.75	10.04	-0.29	DECREASE
ERSB1-NC534	Courtyard Apartments	16.62	16.62	0	NO CHANGE
ERSB2E-N14	Post Office on 3Oaks	15.32	15.32	0	NO CHANGE
ERSB2E-N7	3 Oaks at Quente Way	15.34	15.34	0	NO CHANGE
ERSB2E-NC37	Copper Oaks	16.95	16.95	0	NO CHANGE
ERSB5-N05	ERSB5-N05	13.74	13.74	0	NO CHANGE
ERSB6-NC03	The Villages at Country Creek Basin 10	12.66	12.66	0	NO CHANGE
ERSB6-NC06	The Villages at Country Creek Basin 5	11.42	11.42	0	NO CHANGE
ERSB9-N12	River Ranch at Block Lane	14.77	15.12	-0.35	DECREASE
HC-N22	HC Downstream of FPL Crossing	9.91	9.93	-0.02	DECREASE
HC-N34	Halfway Creek at U.S. 41 - U/S	13.53	13.53	0	NO CHANGE
HC-N35	Halfway Creek at U.S. 41 - U/S (+100 FT)	13.53	13.53	0	NO CHANGE
HC-N55	The Brooks North Outfall Gage	13.86	13.86	0	NO CHANGE
HCD1-NC10	Coconut Point Mall- North Outfall	15.54	15.54	0	NO CHANGE
HCD1-NC3	The Brooks South Outfall Gage	14.61	14.61	0	NO CHANGE
HC-NC17	Marsh Landing Basin 2 Outfall	12.72	12.72	0	NO CHANGE
HC-NC24	Fountain Lakes Basin 1 Outfall	13.78	13.78	0	NO CHANGE
HC4-NC1	Coconut Shores Basin Outfall	15.9	15.9	0	NO CHANGE
NS-052	Broadway Ave., North Side	13.49	13.48	0.01	INCREASE
N-010	North Side of Broadway Ave. Tributary/ Trailside Dr.	13.71	13.69	0.02	INCREASE
NC-100	Terra Vista	13.56	13.55	0.01	INCREASE
ER802-N5	Breckenridge	13.27	13.27	0	NO CHANGE
NS-473	Trailside Dr., North End	13.89	13.88	0.01	INCREASE
NS-476	Trailside Dr., South End	14.29	14.29	0	NO CHANGE
ER802-N3	North Side of Broadway Ave. at Sherrill Lane	11.25	11.24	0.01	INCREASE

Map 3-6: Build-out Parcels



N

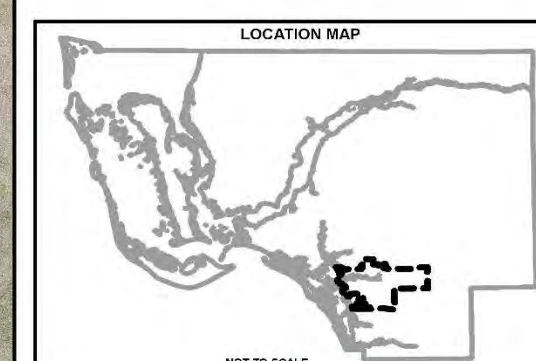
NOT TO SCALE

Legend

- BUILD-OUT PARCELS
- VILLAGE WATERSHED BOUNDARY
- LIMIT OF STUDY
- MAIN STREAM
- VILLAGE OF ESTERO BOUNDARY

NOTES:

1. 2017 AERIAL OBTAINED FROM LEE COUNTY AERIALS
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE FLORIDA WEST FIPS 0902 FEET
3. WATERSHED WITHIN THE STUDY AREA
4. REFER TO APPENDIX B FOR FULLSIZE, TO SCALE MAPS



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3.5.2. Discussion of Results

In reviewing the effects of the build-out conditions on the adjacent stormwater system, it is evident that the development of the vacant parcels does have impacts on the system. The decreases in peak stages on adjacent nodes is due to the effect of a vacant parcel having a controlled discharge in the developed condition where in the existing conditions scenario, it maintains an uncontrolled discharge and therefore produces a larger amount of stormwater runoff. Likewise, there are some vacant parcels that may have less stormwater runoff in the existing conditions scenario than the developed conditions due to the make-up of existing site characteristics, such as land cover (vegetation coverage), soil type, and storage areas. This evaluation of the build-out conditions supports the aspect that plans for development of vacant parcels within The Village should be reviewed thoroughly with respect to the impacts to the existing stormwater facilities. The developed ICPR4 Local-Scale model is a tool that can be utilized to conduct the evaluations of proposed development projects within The Village.

Identification of Problem Areas and Evaluations of Improvement Projects

4. Identification of Problem Areas and Evaluations of Improvement Projects

4.1. Description of Problem Areas

Historically, there are some known areas within The Village that have continuously experienced flooding conditions with the onset of significant rain events. These areas have included locations such as River Ranch Road near the intersection with Block Lane, Trailside Drive, Villages of Country Creek, Fountain Lakes and Marsh Landing communities. These locations contain older infrastructure and lower roadway elevations, which lend to greater vulnerability when facing significant rain events. The recent rainfall events of late August 2017 and early September 2017 further compounded the historic flooding areas and resulted in new peak stages which were higher than record for the Estero River, North Branch. The results of the 2017 events increased awareness of the importance of proper maintenance of the surface water management facilities within communities/developments and public lands. The fact that many of the watersheds' main streams traverse through residential communities containing HOA's, POA's or CDD's, makes the communication of proper monitoring and maintenance of these main waterways even more critical.

Specifically, for the Estero River South Branch watershed, the area of concern and of frequent flooding is located around the intersection of River Ranch Road and Block Lane. In past rainfall events, it has been documented that the existing roadside drainage swale/pipe network along River Ranch Road inefficiently handles the surface water flows and results in flooding of the intersection with Block Lane and other connecting internal roadways. These roadways lead to residential properties and are utilized to get to the major arterial roadways, such as Corkscrew Road and Three Oaks Parkway. The following pictures were taken after the August 2017 rainfall event and depicts the level of flooding in this area:

Figure 4-1: River Ranch Road and Block Lane, Looking South (August 28, 2017)

Figure 4-2: River Ranch Road and Block Lane, Looking South (August 28, 2017)

Within the Estero River Main and North Branch watersheds, one of the areas of concerns is the Villages of Country Creek community and surrounding parcels. The Villages of Country Creek is one of the oldest residential communities within The Village and the Estero River traverses through the community. During significant rainfall events, such as the storm of late August 2017, water levels reached high enough to completely flood many roadways within the community. Likewise, there were several other residential communities that experienced prolonged periods of roadway flooding after the August 2017 event and the passing of Hurricane Irma. The following pictures were taken after the August 2017 rainfall event and depicts the level of flooding in the Villages of Country Creek and level of water within the Estero River, North Branch:

Figure 4-3: Country Creek Drive, Looking North
(August 28, 2017)

Figure 4-4: Estero River, North Branch
(August 28, 2017)

Within the Estero River North Branch, another area of concern is the Three Oaks Parkway corridor, particularly the segment between Corkscrew Road and Estero Parkway. Significant changes have been made in recent years to the intersection with Estero Parkway leading to the overpass over I-75 and an increase in development along the east side of Three Oaks Parkway has also occurred. As a result of the August 2017 rainfall event, the location of Three Oaks Parkway at the crossing of the Estero River North Branch and Diversion (north) experienced flooding within Three Oaks Parkway and within adjacent communities, such as Rookery Point. Three Oaks Parkway is a major arterial roadway within The Village and provides access to other major arterial roadways and the Interstate. The following pictures were taken after the August 2017 rainfall event and depicts the level of flooding within Three Oaks Parkway and level of water within the Estero River, North Branch:

Figure 4-5: Three Oaks Parkway, Looking North (August 28, 2017)

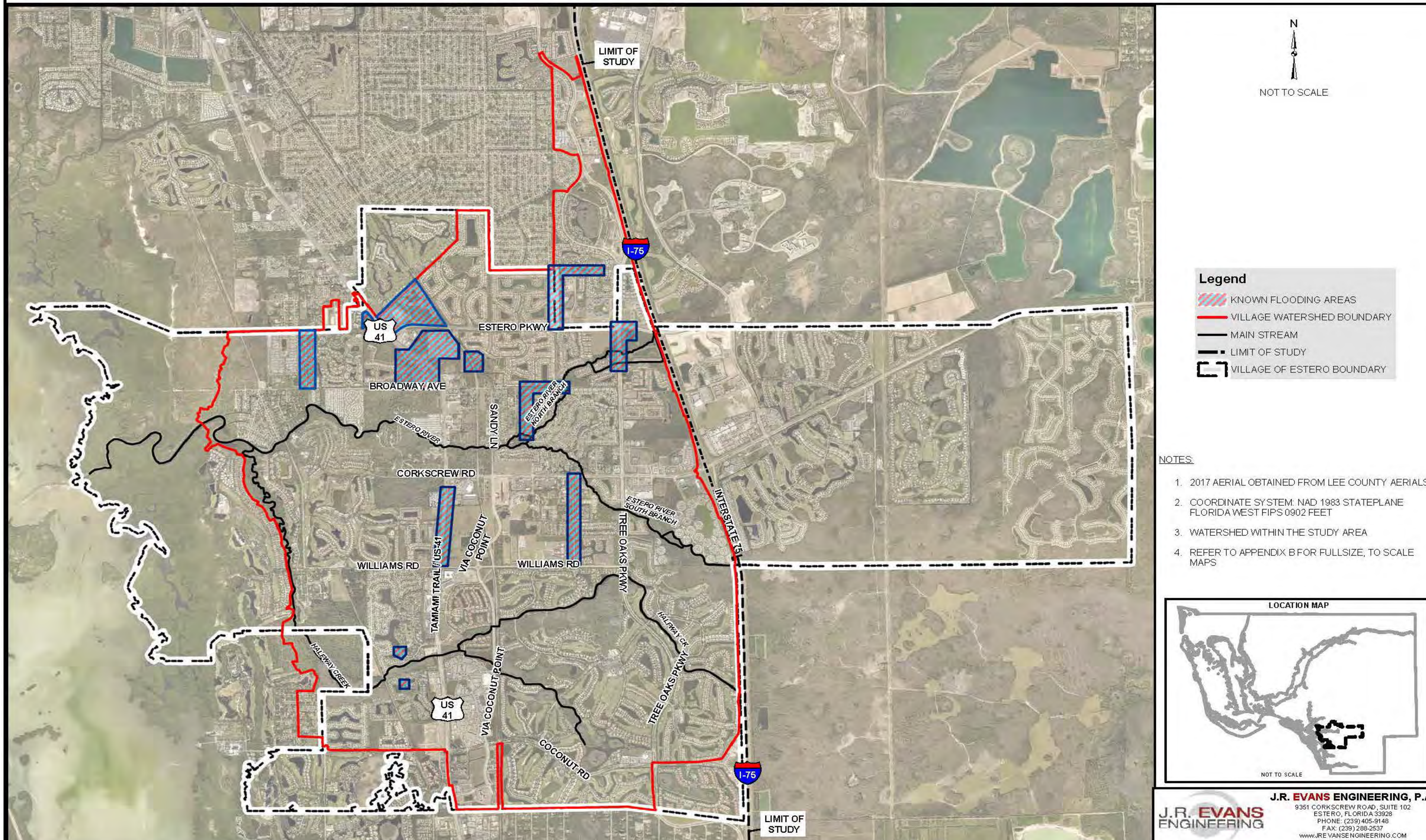
Figure 4-6: Three Oaks Parkway at Copper Oaks, Looking North (August 28, 2017)

Along US-41, north of Estero Parkway, two developments discharge stormwater from the east side US-41 through a set of box culverts to the westside of US-41. The stormwater is conveyed to an undeveloped parcel, Parcel Folio #10271295. The receiving parcel does not a defined path for which the incoming stormwater can connect to the Estero River or any other conveyance system. Essentially, stormwater discharge from the Walmart shopping center and its outparcels, along with the stormwater discharge from Osprey Cove, a residential community, are routed to the undeveloped parcel, with no means to effectively leave the parcel. Stormwater will remain within the parcel until it breaches the Breckenridge berm to the west, Cayo De Estero Shoppes berm to the southeast or the US-41 detention system berm to the northeast. The model shows that the undeveloped outparcel can currently store the incoming discharges from a 100-yr storm without major adverse impacts; however, development of the parcel would potentially cause catastrophic flooding of the areas discharging to the parcel and/or the surrounding roadways and developments.

A community of mobile and manufactured homes on the northside of Broadway West is another known area of concern. The community consists of the properties along Sherill Lane and Luettich Lane. The community lacks a proper stormwater management system, having no roadside swales for stormwater conveyance to the Broadway West drainage system, nor does it have storage ponds or retention areas.

In summary, there are many areas within The Village that have experienced flooding issues or issues with prolonged flooding within the roadways or drainage swales. It should be noted that it is not uncommon for roadways that are internal to residential communities to experience some level of rainwater/surface water runoff inundation for a period of time after a storm event. In many of the permitted developments, the roadways were designed to provide storage as part of the overall site storage available during major rainfall events. Major arterial roadway flooding and, of course structural flooding, are causes for major concern. The next sections of the report reviews select potential projects to address some of these areas of concern within The Village.

Map 4-1: Areas of Concern, Known Flooding Areas



4.2. Stormwater Projects

Understanding the historic problem areas and assessing the areas of concern with respect to the behavior of the stormwater management system within The Village greatly improves the evaluation of the system for potential improvement projects. Knowing where the problem areas are located aides in focusing the improvement projects to those locations. In addition to the observed conditions, a review of the model results during the 25-year design storm was conducted with evaluating hydraulic profiles of the main streams and major conveyances and noting significant "jumps" in water surface elevations.

Based on the evaluations, a selection of potential improvement projects was defined for each watershed area. Outlined below are the general description of each potential project grouped by watershed. The following report sections detail the ICPR4 modeling that was completed for the studied projects.

Project 1 - Villages at Country Creek Bypass:

Improve ditch cross-sections and install weir to better control flows. Redirect flow from the ditch between Cascades and Rookery Point to send large flows directly to the bypass. Reference Figure 4-7.

Project 2 - Three Oaks Parkway Drainage Improvements:

Improved pipe connections, weir controls and provide additional storage for better flow distribution. Reference Figure 4-8.

Project 3 - Villagio/Estero Parkway Drainage Improvements:

Improved flow-way through natural area located between Villagio and Estero Parkway. Reference Figure 4-9.

Project 4 - Estero Parkway Culvert:

Increase culvert size to reduce head loss. Reference Figure 4-10.

Project 5 - River Ranch Road Drainage Improvements:

Improve drainage along River Ranch Road. This could include additional cross-culvert connections and larger pipes and/or swales along the roadway. Reference Figure 4-11.

Project 6 - Dry Creek Bed Sediment Removal:

Removed sediment from a historical connection between the north and south branch of the Estero River, located between Bamboo Island and Villages at Country Creek. Reference Figure 4-13.

Project 7 – Estero River Side Banks Sediment Removal:

Remove sediment along the banks between the Sandy Lane bridge to the SGLR Railroad bridge to increase flow capacity. Reference Figure 4-16.

Project 8 - Broadway Ave. Main Tributary:

Engineered Design for Tributary Cross-sections

This project was partially completed with a prior hydrologic/hydraulic study specifically for the Broadway Ave. Tributary watershed. It is recommended that the improvements proposed in the Broadway Ave study are completed, particularly the proposed swale from Broadway Ave north to Trailside Drive. Reference Figure 4-17.

Project 9 - U.S. 41, North of Williams Rd. and South of Corkscrew Road:

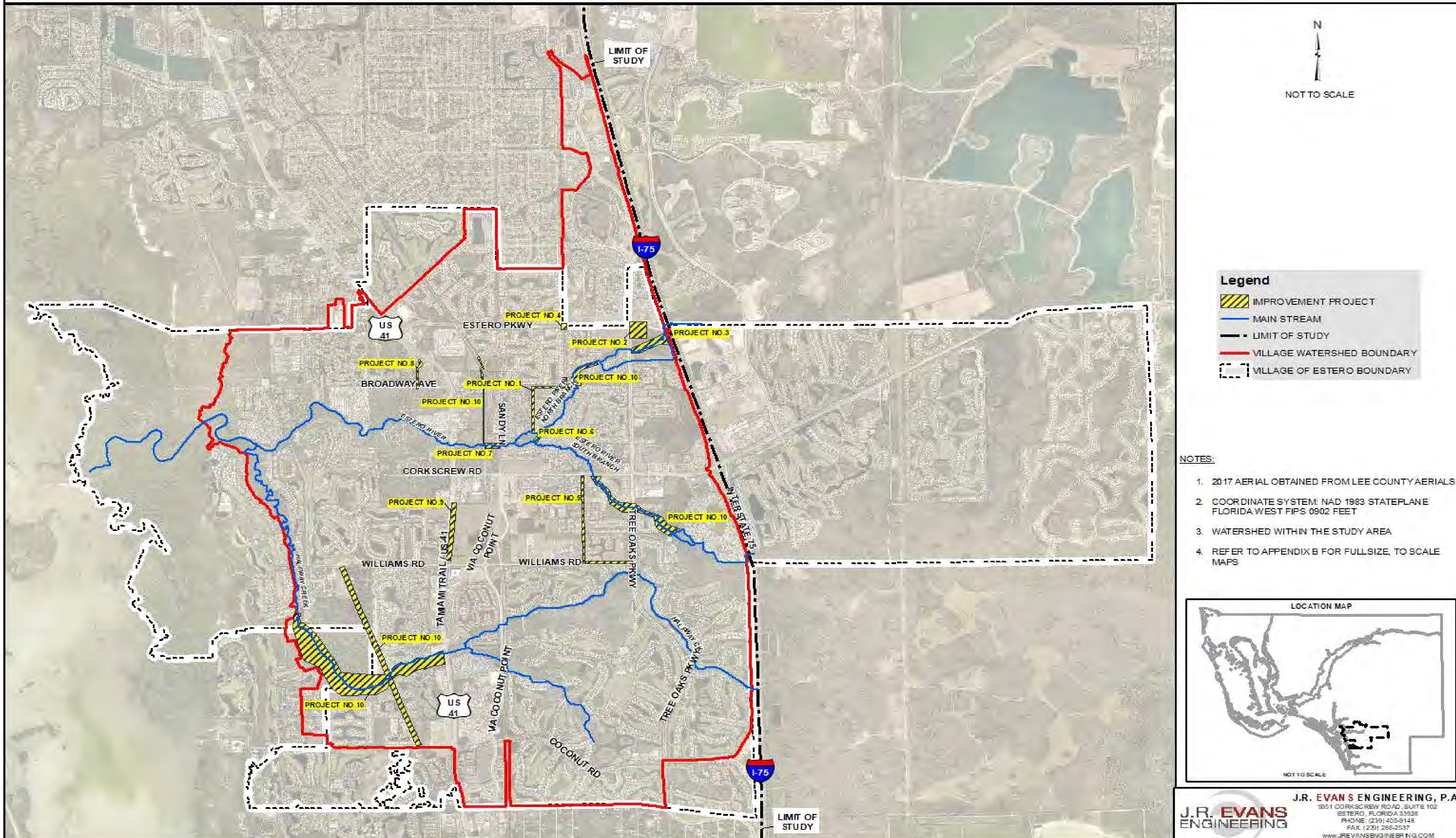
Recommend implementation of modifications to U.S. 41 structures to alleviate excessive flooding within the roadside system- which was permitted with SFWMD and never implemented. The previous design should be evaluated prior to implementation. (No modeling was completed for this project). Reference Figure 4-18.

Project 10 – Maintenance of the Natural Systems:

Removal of downed trees and excess debris, and the regular maintenance of high grass, weeds and other vegetation.

- Estero River North Branch, North of Villages at Country Creek. Figure 4-19.
- Estero River South Branch, South of Corkscrew Road to Sanctuary Road. Figure 4-20.
- Halfway Creek, West of U.S. 41. Figure 4-21.
- FPL Easement Ditches between Williams Road and Coconut Road. Reference Figure 4-22.
- Seminole Gulf Railroad Ditch, North of Estero River Main Branch. Reference Figure 4-23.

Map 4-2: Locations of Improvement Projects



4.3. Improvement Projects Evaluated with Model Scenarios

The following report sections detail the ICPR4 modeling that was completed for the studied projects.

4.3.1. Project One - Villages of Country Creek Bypass Swale Improvements

The intent for Project One is to re-establish the conveyance ability of the Villages at Country Creek Bypass Swale that runs along the north side of the Villages at Country Creek property, to the west and along the west boundary until it reaches the Estero River Main Branch. Based on the existing conditions hydraulic analysis, this bypass swale provides little relief to the North Branch prior to entering the Villages at Country Creek property. Re-establishing the bypass connection should provide a better distribution of flows within the North Branch as it enters the Villages at Country Creek property.

Project One: Phase One

Improvements considered for The Villages at Country Creek Bypass Swale, includes the addition of two inline structures and channel modifications to increase the flow capacity. The proposed improvements considered during this evaluation are described as follows:

- Improvements to the main channel sections considers modifications to the existing channel cross sections from the most downstream confluence of The Villages at Country Creek Bypass Swale with the Estero River North Branch Diversion 1 (ERNBD1) to the most upstream connection of the Bypass Swale with the Estero River North Branch (ERNB). The proposed trapezoidal cross sections at the Bypass Swale are considered to have side slopes of 3H:1V with variable top and bottom widths. Trapezoidal cross sections channel top width ranges from approximately 45 feet to 50 feet, while the bottom width varies from 4 feet to 20 feet. It should be noted, that bottom widths of 20 feet were used near the existing culvert structures to consider the full width of the culvert openings, since these two (2) structures are considered to stay. It should be noted, that a berm may be required at some locations to optimize the design through the entire Bypass Swale.
- The most downstream invert along the Bypass Swale is considered to be 1.3 feet-NAVD (same found at Estero River North Branch Diversion 1) and the most upstream invert is considered at 8.5 feet-NAVD (near the Bypass Swale connection with the Estero River). An adequate tie-in of all connections to the Bypass Swale should be warranted.
- Installation of an inline structure (weir) at the most upstream swale with an elevation equivalent or similar to the existing swale bottom (ranging from approximately 8.9 feet to 10.5 feet-NAVD).
- Installation of an inline structure (weir) some feet upstream of the confluence of The Villages of Country Creek Bypass and the Estero River North Branch Diversion 1 (Node Name: ERNBD1). Such structure should allow flows associated to less severe rainfall events.
- Proposed improvements consider a routine maintenance that will keep the Bypass Swale free of: obstructions, undesired vegetation, and sedimentation /scour.

Project One: Phase Two

Improvements considered for the Ditch Between Cascades and Rookery Point Alignment Improvement: Diversion to the Villages at Country Creek Bypass System, includes the addition of a supplemental channel to connect with the improved Villages at Country Creek Bypass Swale (as described in Phase 1) and immediately upstream channel cross section modification. Such ditch is named as ERNB4 in the ICPR4 Model. The proposed improvements are intended to divert some of the flows from the Ditch (ERNB4) while keeping the ultimate discharge point (Estero River, North Branch). The proposed improvements considered during this evaluation are described as follows:

- Creation of a diversion channel approximately 500 feet long, generally following a north to south alignment with a geometry similar to the one found at the existing downstream segment. A trapezoidal section with side slopes of 3H:1V, top width of 45 feet and bottom width of 23 feet was considered. The must downstream invert was established considering The Villages at Country Creek Bypass swale proposed sections (invert elevation of 8.25 feet-NAVD), while the upstream invert elevation was set to 11.7 feet -NAVD (consistent with the existing most downstream segment at the ditch).
- Improvements to the ditch cross section at the diversion point include: modifications to the channel section generally conforming the same geometry as the existing cross section, but warranting a well-defined, free of: obstructions, undesired vegetation at the channel, debris and sediment/erosion (as part of a continuous maintenance program). Approximate dimensions considered are: top width of 45 feet, bottom width of 19 feet, approximate side slopes of 3H:1V. It is proposed to keep the same invert as the existing conditions (11.61 feet-NAVD, based on the available LiDAR topographic information).
- Removal of undesired debris and vegetation from the most downstream ditch channel segment (to the confluence with the Estero River North Branch) as part of a continuous maintenance program.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate a significant decrease in peak water surface elevations along the Estero River North Branch channel from the confluence with the Main/South Branches up through the Three Oaks Parkway crossing. The maximum decrease in water surface elevation within the North Branch is 0.57 feet or 6.8 inches. Decreases in peak stages were also shown in the development areas adjacent to the North Branch, such as the Villages of Country Creek. Within the Bypass swale (ERNB6) itself, the decrease in peak water surface stages were also significant, with the maximum difference of 0.89 feet. This is attributed to the additional capacity of the Bypass swale system with the improved cross-section and maintained conditions. The results also indicate a slight increase (maximum of 0.15 feet) in the peak water stages of the North Branch Diversion 1 (ERNBD1) due to the increased flow from the improved Bypass swale. Provided below is a comparison table for the surrounding nodes for the Project One Peak Stage results. Also, reference Figure 4-7 for an exhibit of the project area.

Table 4-1: Project One Node Comparison Results

Project One Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_1 25-Year Stage**	**Run Difference**	**Notes**
ER-N1	0.48	0.49	**0.01**	
ER-N10	1.65	1.66	**0.01**	
ER-N11	1.83	1.84	**0.01**	
ER-N12	2.28	2.29	**0.01**	
ER-N13	2.61	2.62	**0.01**	
ER-N14	3.01	3.03	**0.02**	
ER-N15	3.10	3.12	**0.02**	
ER-N16	3.34	3.36	**0.02**	
ER-N17	3.38	3.40	**0.02**	
ER-N18	3.42	3.45	**0.03**	
ER-N19	3.56	3.58	**0.02**	
ER-N2	0.52	0.52	**0.00**	
ER-N20	3.74	3.76	**0.02**	
ER-N204	2.22	2.24	**0.02**	
ER-N21	3.91	3.94	**0.03**	
ER-N22	3.92	3.95	**0.03**	
ER-N23	4.63	4.66	**0.03**	
ER-N24	4.64	4.67	**0.03**	
ER-N24.5	5.41	5.44	**0.03**	
ER-N25	6.00	6.03	**0.03**	
ER-N26	6.01	6.04	**0.03**	
ER-N27	6.58	6.62	**0.04**	
ER-N28	6.69	6.72	**0.03**	
ER-N28.6	6.96	6.97	**0.01**	
ER-N29	7.08	7.09	**0.01**	
ER-N3	0.92	0.92	**0.00**	
ER-N4	1.24	1.24	**0.00**	
ER-N5	1.28	1.29	**0.01**	
ER-N6	1.43	1.43	**0.00**	
ER-N7	1.46	1.47	**0.01**	
ER-N8	1.48	1.49	**0.01**	
ER-N81	1.44	1.45	**0.01**	
ER-N9	1.50	1.51	**0.01**	

Project One Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_1 25-Year Stage**	**Run Difference**	**Notes**
ER-N901	6.80	6.80	**0.00**	
ERNB6-N1	9.11	8.40	**-0.71**	
ERNB6-N10	10.94	10.57	**-0.37**	
ERNB6-N11	11.05	10.84	**-0.21**	
ERNB6-N12	11.62	11.12	**-0.50**	
ERNB6-N13	11.78	11.20	**-0.58**	
ERNB6-N14	11.85	11.65	**-0.20**	
ERNB6-N15	12.33	12.33	**0.00**	
ERNB6-N2	9.34	8.66	**-0.68**	
ERNB6-N3	9.35	8.78	**-0.57**	
ERNB6-N4	10.19	9.30	**-0.89**	
ERNB6-N5	10.55	9.79	**-0.76**	
ERNB6-N6	10.59	9.95	**-0.64**	
ERNB6-N7	10.59	10.03	**-0.56**	
ERNB6-N8	10.78	10.17	**-0.61**	
ERNB6-N9	10.92	10.41	**-0.51**	
ERNBD1-N1	6.67	6.72	**0.05**	
ERNBD1-N2	6.67	6.73	**0.06**	
ERNBD1-N3	6.86	6.95	**0.09**	
ERNBD1-N4	7.28	7.43	**0.15**	
ERNB-N1	7.83	7.76	**-0.07**	
ERNB-N10	10.84	10.33	**-0.51**	
ERNB-N11	10.84	10.33	**-0.51**	
ERNB-N12	11.30	10.76	**-0.54**	
ERNB-N13	11.63	11.08	**-0.55**	
ERNB-N15	11.75	11.19	**-0.56**	
ERNB-N16	11.80	11.23	**-0.57**	
ERNB-N17	12.44	11.97	**-0.47**	
ERNB-N18	14.08	14.00	**-0.08**	
ERNB-N19	14.66	14.62	**-0.04**	
ERNB-N2	8.61	8.36	**-0.25**	
ERNB-N20	14.66	14.62	**-0.04**	
ERNB-N21	14.72	14.69	**-0.03**	
ERNB-N22	14.77	14.73	**-0.04**	

Project One Node Comparison Results				
Node	Existing 25-Year Stage	Project_1 25-Year Stage	Run Difference	Notes
ERNB-N23	14.78	14.75	**-0.03**	
ERNB-N24	14.79	14.76	**-0.03**	
ERNB-N26	14.80	14.77	**-0.03**	
ERNB-N27	14.83	14.79	**-0.04**	
ERNB-N3	9.41	9.04	**-0.37**	
ERNB-N30	14.83	14.80	**-0.03**	
ERNB-N31	14.88	14.85	**-0.03**	
ERNB-N31.5	14.89	14.86	**-0.03**	
ERNB-N34	15.28	15.27	**-0.01**	
ERNB-N35	15.32	15.31	**-0.01**	
ERNB-N35.5	15.34	15.33	**-0.01**	
ERNB-N36	15.34	15.33	**-0.01**	
ERNB-N37	15.43	15.42	**-0.01**	
ERNB-N39	15.81	15.81	**0.00**	
ERNB-N4	9.92	9.48	**-0.44**	
ERNB-N40	15.86	15.86	**0.00**	
ERNB-N41	15.86	15.86	**0.00**	
ERNB-N45	15.32	15.31	**-0.01**	
ERNB-N6	9.98	9.53	**-0.45**	
ERNB-N7	10.15	9.68	**-0.47**	
ERNB-N8	10.26	9.78	**-0.48**	
ERNB-NC014	12.96	12.89	**-0.07**	
ERNB-NC05	10.28	10.04	**-0.24**	Villages of Country Creek Basin 3
ERNB-NC09	11.19	11.01	**-0.18**	Villages of Country Creek Basin 1
ERNB-NC14	12.95	12.87	**-0.08**	Villages of Country Creek Basin 4
ERNB-NC25	16.16	16.16	**0.00**	Rookery Basin 2

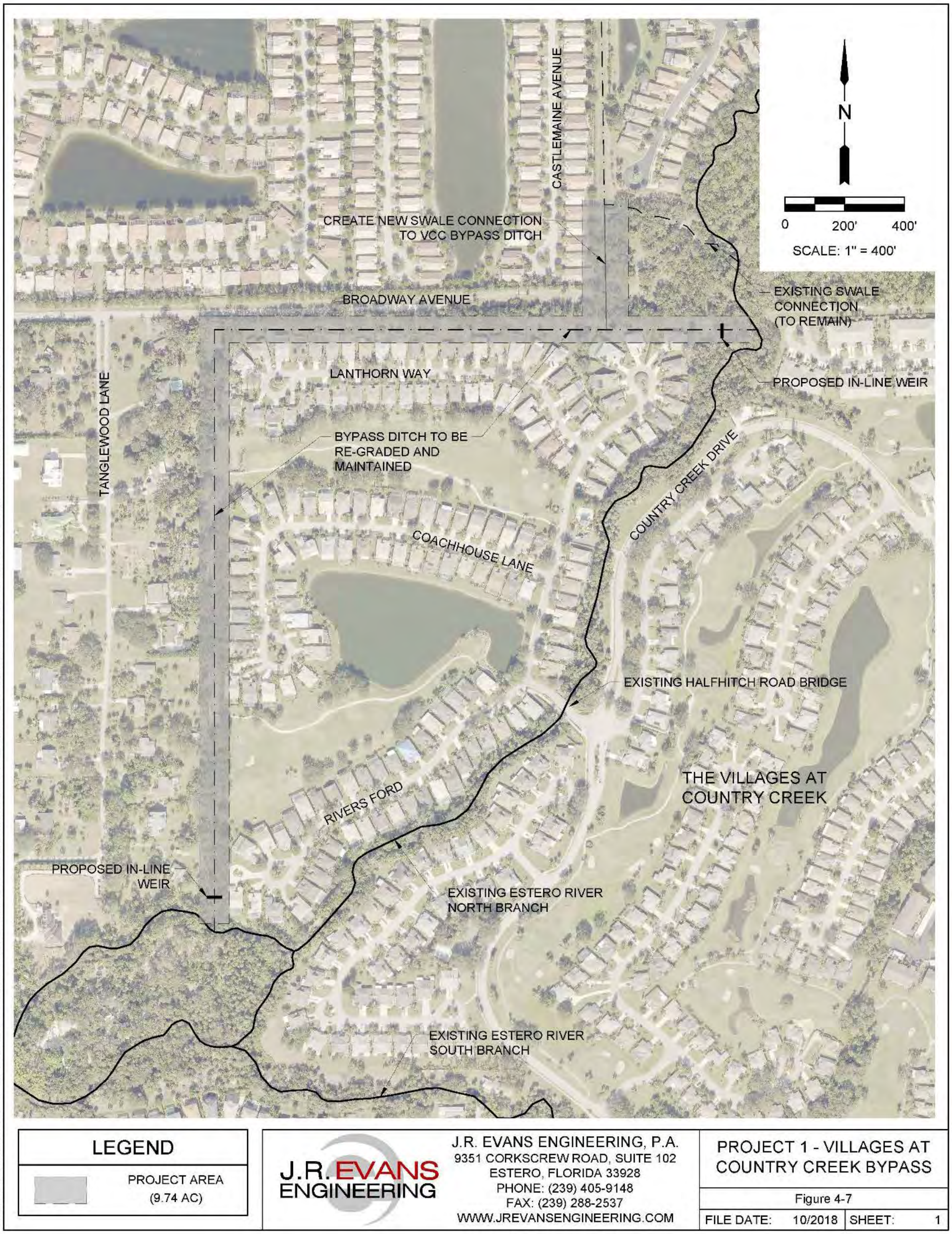


Figure 4-7: Project One - Villlages at Country Creek Bypass

4.3.2. Project Two – Three Oaks Parkway Drainage Improvements

Improvements considered for the Estero Parkway at Three Oaks (East Side), includes recommendations of increasing the storage capacity and modifications to the surface and underground storm drainage systems. The intention of the project is to reduce the potential for significant roadway flooding that was observed after the August 2017 storm and Hurricane Irma. The proposed improvements considered during this evaluation are described as follows:

- Increasing the storage capacity of the Three Oaks Parkway Pond warranting no impacts to the Estero Parkway drainage system.
- Removal of debris that is obstructing the Three Oaks Parkway pipe discharging to the Three Oaks Parkway Pond.
- Modification to the connecting pipes inverts to the Three Oaks Parkway.
- Modifications to the channel sections of the swale just west of The Reef development, warranting more capacity and efficient inverts.
- Increasing the storage capacity of the Estero Parkway Ditch.
- Modifications to the current structure just upstream of the Estero Parkway Ditch, to allow discharges at lower elevations.
- Modifications to the control structure just downstream of the Estero Parkway ditch to allow flows at lower elevations (orifice).
- Adding an orifice-like weir at the Estero Parkway Ditch berm to allow some flows to reach the natural area and subsequently the Estero River North Branch Diversion 2 controlled, but at a lower elevation.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate a significant decrease in peak water surface elevations, especially for the storm drainage network along the east side of Three Oaks Parkway (ERN2BE) leading upstream to the system located north of Estero Parkway. The maximum decrease in peak stage for this system was 0.24 feet or 2.88 inches. Additional decreases in peak stages occur within the eastern side of the intersection of Estero Parkway and Three Oaks Parkway, with the maximum decrease of 0.17 feet or 2.04 inches. There is an increase in peak stage shown for the Three Oaks Parkway pond (ERNBD2-NC9) due to the additional storage capacity provided. Therefore, Project Two provides benefit to this portion of the Estero River North Branch system by reducing peak stages near and upstream of the intersection of Three Oaks Parkway and Estero Parkway. Provided below is a comparison table for the surrounding nodes for the Project Two Peak Stage results. Also, reference Figure 4-8 for an exhibit of the project area.

Table 4-2: Project Two Node Comparison Results

Project Two Node Comparison Results				
Node	Existing 25-Year Stage	Project_2 25-Year Stage	Run Difference	Notes
ERNB2E-N1	15.2	15.2	0	
ERNB2E-N10	15.44	15.21	-0.23	East Side of Three Oaks Parkway
ERNB2E-N11	15.44	15.2	-0.24	East Side of Three Oaks Parkway
ERNB2E-N12	15.38	15.15	-0.23	Southeast Intersection of Three Oaks Pkwy and Estero Pkwy.
ERNB2E-N120	15.86	15.63	-0.23	
ERNB2E-N13	15.35	15.12	-0.23	Northeast side of Estero Pkwy. And Three Oaks Pkwy.
ERNB2E-N14	15.85	15.62	-0.23	Northeast side of Estero Pkwy. And Three Oaks Pkwy.
ERNB2E-N15	15.94	15.75	-0.19	Northeast side of Estero Pkwy. And Three Oaks Pkwy.
ERNB2E-N16	16.55	16.54	-0.01	Northeast side of Estero Pkwy. And Three Oaks Pkwy.
ERNB2E-N17	16.76	16.75	-0.01	
ERNB2E-N18	17	16.98	-0.02	
ERNB2E-N19	17.04	17.02	-0.02	
ERNB2E-N2	15.31	15.31	0	
ERNB2E-N20	17.07	17.05	-0.02	
ERNB2E-N21	17.09	17.07	-0.02	
ERNB2E-N22	17.61	17.59	-0.02	
ERNB2E-N23	17.66	17.65	-0.01	
ERNB2E-N24	17.92	17.9	-0.02	
ERNB2E-N25	17.96	17.94	-0.02	
ERNB2E-N3	15.31	15.31	0	
ERNB2E-N4	15.3	15.3	0	
ERNB2E-N5	14.82	14.82	0	
ERNB2E-N6	14.82	14.82	0	
ERNB2E-N7	14.81	14.82	0.01	
ERNB2E-N8	14.81	14.81	0	
ERNB2E-N9	15.71	15.71	0	
ERNB2N-N1	16.84	16.84	0	
ERNB5E-N1	14.83	14.83	0	
ERNB5E-N10	14.83	14.83	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N10a	15.77	15.77	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N11	14.83	14.83	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N12	14.93	14.83	-0.1	Estero Pkwy., East of Three Oaks Pkwy.

Project Two Node Comparison Results				
Node	Existing 25-Year Stage	Project_2 25-Year Stage	Run Difference	Notes
ERNB5E-N13	15.03	14.86	-0.17	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N2	14.83	14.83	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N3	14.83	14.83	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N4	14.84	14.84	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N5	17	16.97	-0.03	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N6	14.87	14.87	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N9	14.83	14.83	0	
ERNB5E-N9a	15.86	15.86	0	
ERNB5E-NC0	14.81	14.81	0	
ERNB5E-NC00	14.81	14.81	0	
ERNB5E-NC7	19.38	19.37	-0.01	
ERNB5E-NC8	16.82	16.82	0	The Reef
ERNB5-N1	15.55	15.55	0	
ERNB5-N10	15.69	15.69	0	
ERNB5-N11	15.69	15.69	0	
ERNB5-N13	15.57	15.57	0	
ERNB5-N14	15.56	15.56	0	
ERNB5-N14a	15.55	15.55	0	
ERNB5-N15	15.52	15.52	0	
ERNB5-N15a	15.53	15.53	0	
ERNB5-N16	15.49	15.49	0	
ERNB5-N17	15.42	15.42	0	
ERNB5-N18	15.34	15.34	0	
ERNB5-N19	15.34	15.34	0	
ERNB5-N2	15.55	15.55	0	
ERNB5-N20	15.34	15.34	0	
ERNB5-N21	15.33	15.33	0	
ERNB5-N22	15.33	15.33	0	
ERNB5-N23	15.33	15.33	0	
ERNB5-N24	15.32	15.32	0	
ERNB5-N25	15.32	15.32	0	
ERNB5-N26	15.31	15.31	0	
ERNB5-N27	15.26	15.26	0	
ERNB5-N28	15.26	15.26	0	

Project Two Node Comparison Results				
Node	Existing 25-Year Stage	Project_2 25-Year Stage	Run Difference	Notes
ERNB5-N29	15.16	15.16	0	
ERNB5-N3	15.55	15.55	0	
ERNB5-N30	15.15	15.15	0	
ERNB5-N30a	15.08	15.08	0	
ERNB5-N31	14.99	14.99	0	
ERNB5-N31a	15.02	15.02	0	
ERNB5-N32	14.99	14.99	0	
ERNB5-N33	14.96	14.96	0	
ERNB5-N34	15.7	15.7	0	
ERNB5-N35	15.57	15.57	0	
ERNB5-N4	15.62	15.62	0	
ERNB5-N5	15.62	15.62	0	
ERNB5-N6	15.62	15.62	0	
ERNB5-N7	15.63	15.63	0	
ERNB5-N8	15.63	15.63	0	
ERNB5-N9	15.69	15.69	0	
ERNBD1-N1	6.67	6.66	-0.01	
ERNBD1-N2	6.67	6.66	-0.01	
ERNBD1-N3	6.86	6.85	-0.01	
ERNBD1-N4	7.28	7.28	0	
ERNBD2-N1	14.74	14.74	0	
ERNBD2-N10	14.74	14.74	0	
ERNBD2-N2	14.76	14.76	0	
ERNBD2-N4	14.77	14.78	0.01	
ERNBD2-N5	14.78	14.78	0	
ERNBD2-N6	14.81	14.81	0	
ERNBD2-N7	14.81	14.82	0.01	
ERNBD2-N8	14.81	14.81	0	
ERNBD2-NC9	14.81	14.84	0.03	Storage capacity is proposed to be increased to contain flows.
ERNB-N1	7.83	7.83	0	
ERNB-N10	10.84	10.84	0	
ERNB-N11	10.84	10.85	0.01	
ERNB-N12	11.3	11.3	0	
ERNB-N13	11.63	11.64	0.01	

Project Two Node Comparison Results				
Node	Existing 25-Year Stage	Project_2 25-Year Stage	Run Difference	Notes
ERNB-N15	11.75	11.76	0.01	
ERNB-N16	11.8	11.8	0	
ERNB-N17	12.44	12.45	0.01	
ERNB-N18	14.08	14.08	0	
ERNB-N19	14.66	14.66	0	
ERNB-N2	8.61	8.61	0	
ERNB-N20	14.66	14.66	0	
ERNB-N21	14.72	14.72	0	
ERNB-N22	14.77	14.77	0	
ERNB-N23	14.78	14.78	0	
ERNB-N24	14.79	14.79	0	
ERNB-N26	14.8	14.8	0	
ERNB-N27	14.83	14.83	0	

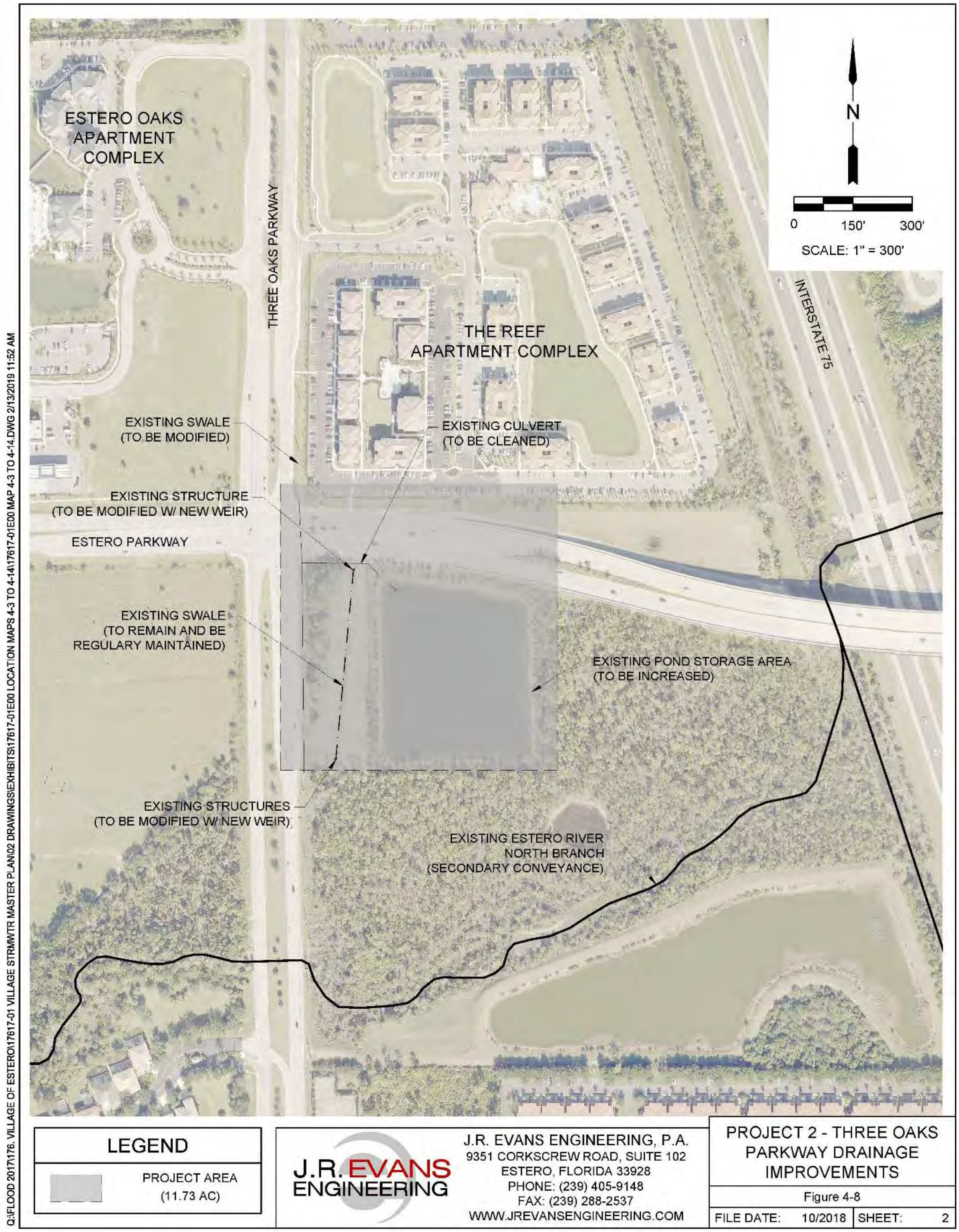


Figure 4-8: Project Two – Three Oaks Pkwy Drainage Improvements

4.3.3. Project Three – Villagio / Estero Parkway Drainage Improvements

Improvements considered for the Estero River North Branch Diversion (North of the Villagio development), includes modifications to the existing flow-way through the natural area. This diversion is named as ERNBD2 in the ICPR4 Model. Analysis of the ICPR4 model results indicates there is a significant increase in stage from the downstream to upstream section of the diversion. The proposed improvements considered during this evaluation are described as follows:

- Removal of debris and vegetation from the channel bottom; from the confluence of the diversion with the Estero River North Branch to the diversion point upstream. Minimal adjustments to the existing cross sections' channel bottom. It should be noted, that improvements should be done with the consideration of any potential environmentally sensitive areas.
- Removal of sediment and debris from the diversion culvert crossing at the Three Oaks Parkway.
- Removal of sediment and debris from the Estero River North Branch culvert crossing at the Three Oaks Parkway (just south of the Estero River North Branch Diversion culvert).
- It should be noted, that the berm that extends from the I-75 Pond to the west until reaches the Three Oaks Parkway (at the Estero River North Branch Diversion 2 left overbank) may be modified to prevent flowing waters to breach the berm and cross the Villagio property.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. In addition to comparing peak stages, the peak flows within the North Branch North Diversion were also compared. Since the intent of the project is to improve the conveyance ability of the North Diversion, the results should show an increase in peak flows through the section. The modeling results indicate minimal decrease in peak water surface elevations, especially for the storm drainage network along the east side of Three Oaks Parkway (ERN2BE) and through the North Branch Diversion itself (ERNBD2). The maximum decrease in peak stage within the Diversion was 0.03 feet. The results do indicate a slight increase (0.05 feet) in the Estero River North Branch downstream of the improvement area, most likely due to increased flow capacity of the Diversion 2 and Three Oaks Parkway crossing. In addition, the modeling results do show a significant improvement in peak flows through the Diversion section, increasing flows by up to 25%. Provided below is a comparison table for the surrounding nodes for the Project Three Peak Stage results. Also provided is a comparison table for the surrounding links for the Project Three Peak Flow results. Reference Figure 4-9 for an exhibit of the project area.

Table 4-3: Project Three Node Comparison Results

Project Three Node Comparison Results				
Node	Existing 25-Year Stage	Project_3 25-Year Stage	Run Difference	Notes
ERNB1-N01	16.01	16.01	0	
ERNB1-N010	16.72	16.72	0	
ERNB1-N011	16.73	16.73	0	
ERNB1-N013	16.73	16.73	0	
ERNB1-N014	16.74	16.74	0	
ERNB1-N015	16.81	16.81	0	
ERNB1-N02	16.47	16.47	0	

Project Three Node Comparison Results				
Node	Existing 25-Year Stage	Project_3 25-Year Stage	Run Difference	Notes
ERNB1-N05	16.7	16.7	0	
ERNB1-N07	16.7	16.7	0	
ERNB1-N09	16.71	16.71	0	
ERNB1-NC012	16.86	16.86	0	
ERNB1-NC018	19.6	19.6	0	
ERNB1-NC022	17.6	17.6	0	
ERNB1-NC022a	18.36	18.36	0	
ERNB1-NC025	17.58	17.58	0	
ERNB1-NC03	17.98	17.98	0	
ERNB1-NC08	16.84	16.84	0	
ERNB2E-N1	15.2	15.2	0	
ERNB2E-N10	15.44	15.44	0	East Side of Three Oaks Parkway
ERNB2E-N11	15.44	15.44	0	East Side of Three Oaks Parkway
ERNB2E-N12	15.38	15.38	0	Southeast Intersection of Three Oaks Pkwy and Estero Pkwy.
ERNB2E-N120	15.86	15.86	0	
ERNB2E-N13	15.35	15.35	0	Northeast side of Estero Pkwy. and Three Oaks Pkwy.
ERNB2E-N14	15.85	15.85	0	Northeast side of Estero Pkwy. and Three Oaks Pkwy.
ERNB2E-N15	15.94	15.94	0	Northeast side of Estero Pkwy. and Three Oaks Pkwy.
ERNB2E-N16	16.55	16.55	0	Northeast side of Estero Pkwy. and Three Oaks Pkwy.
ERNB2E-N17	16.76	16.76	0	
ERNB2E-N18	17	17	0	
ERNB2E-N19	17.04	17.04	0	
ERNB2E-N2	15.31	15.31	0	
ERNB2E-N20	17.07	17.07	0	
ERNB2E-N21	17.09	17.09	0	
ERNB2E-N22	17.61	17.61	0	
ERNB2E-N23	17.66	17.66	0	
ERNB2E-N24	17.92	17.92	0	
ERNB2E-N25	17.96	17.96	0	
ERNB2E-N3	15.31	15.31	0	
ERNB2E-N4	15.3	15.3	0	
ERNB2E-N5	14.82	14.82	0	
ERNB2E-N6	14.82	14.82	0	

Project Three Node Comparison Results				
Node	Existing 25-Year Stage	Project_3 25-Year Stage	Run Difference	Notes
ERNB2E-N7	14.81	14.82	**0.01**	
ERNB2E-N8	14.81	14.81	0	
ERNB2E-N9	15.71	15.71	0	
ERNB2-NC23	17.34	17.34	0	
ERNB2N-N1	16.84	16.84	0	
ERNB2N-N10	18.69	18.69	0	
ERNB2N-N100	17.66	17.66	0	
ERNB2N-N101	17.67	17.67	0	
ERNB2N-N102	17.82	17.82	0	
ERNB2N-N103	17.85	17.85	0	
ERNB2N-N104	18.3	18.3	0	
ERNB2N-N105	18.32	18.32	0	
ERNB2N-N106	18.3	18.3	0	
ERNB2N-N11	16.86	16.86	0	
ERNB2N-N110	18.37	18.37	0	
ERNB2N-N111	18.47	18.47	0	
ERNB2N-N12	16.92	16.92	0	
ERNB2N-N13	16.91	16.91	0	
ERNB2N-N14	17.14	17.14	0	
ERNB2N-N15	17.62	17.62	0	
ERNB2N-N16	17.71	17.71	0	
ERNB2N-N17	17.44	17.44	0	
ERNB2N-N18	17.44	17.44	0	
ERNB2N-N19	17.44	17.44	0	
ERNB2N-N2	16.88	16.88	0	
ERNB2N-N21	16.8	16.8	0	
ERNB2N-N22	16.8	16.8	0	
ERNB2N-N23	16.8	16.8	0	
ERNB2N-N24	16.82	16.82	0	
ERNB2N-N25	16.96	16.96	0	
ERNB2N-N26	16.98	16.98	0	
ERNB2N-N27	17.08	17.08	0	
ERNB2N-N28	17.23	17.23	0	
ERNB2N-N29	17.34	17.34	0	

Project Three Node Comparison Results				
Node	Existing 25-Year Stage	Project_3 25-Year Stage	Run Difference	Notes
ERNB2N-N3	16.84	16.84	0	
ERNB2N-N30	17.5	17.5	0	
ERNB2N-N31	17.62	17.62	0	
ERNB2N-N32	17.68	17.68	0	
ERNB2N-N33	17.72	17.72	0	
ERNB2N-N34	18.45	18.45	0	
ERNB2N-N35	18.65	18.65	0	
ERNB2N-N36	18.52	18.52	0	
ERNB2N-N37	18.28	18.28	0	
ERNB2N-N38	18.15	18.15	0	
ERNB2N-N39	18.52	18.52	0	
ERNB2N-N4	17.02	17.02	0	
ERNB2N-N40	18.52	18.52	0	
ERNB2N-N41	18.52	18.52	0	
ERNB2N-N42	18.52	18.52	0	
ERNB2N-N43	18.48	18.48	0	
ERNB2N-N44	18.45	18.45	0	
ERNB2N-N45	18.49	18.49	0	
ERNB2N-N46	18.51	18.51	0	
ERNB2N-N47	18.52	18.52	0	
ERNB2N-N48	17.86	17.86	0	
ERNB2N-N49	17.27	17.27	0	
ERNB2N-N5	16.85	16.85	0	
ERNB2N-N50	17.11	17.11	0	
ERNB2N-N51	18.54	18.54	0	
ERNB2N-N54	18.39	18.39	0	
ERNB2N-N55	18.39	18.39	0	
ERNB2N-N56	18.39	18.39	0	
ERNB2N-N6	17.08	17.08	0	
ERNB2N-N60	18.4	18.4	0	
ERNB2N-N61	18.47	18.47	0	
ERNB2N-N61.1	18.44	18.44	0	
ERNB2N-N61.2	18.43	18.43	0	
ERNB2N-N62	18.43	18.43	0	

Project Three Node Comparison Results				
Node	Existing 25-Year Stage	Project_3 25-Year Stage	Run Difference	Notes
ERNB2N-N63	18.4	18.4	0	
ERNB2N-N64	18.35	18.35	0	
ERNB2N-N65	18.35	18.35	0	
ERNB2N-N66	18.33	18.33	0	
ERNB2N-N67	18.31	18.31	0	
ERNB2N-N68	18.27	18.27	0	
ERNB2N-N69	18.18	18.18	0	
ERNB2N-N7	16.92	16.92	0	
ERNB2N-N70	18.29	18.29	0	
ERNB2N-N71	18.24	18.24	0	
ERNB2N-N72	18.09	18.09	0	
ERNB2N-N75	17.94	17.94	0	
ERNB2N-N8	17.95	17.95	0	
ERNB2N-N80	17.67	17.67	0	
ERNB2N-N83a	17.97	17.97	0	
ERNB2N-N84	17.97	17.97	0	
ERNB2N-N85	18.58	18.58	0	
ERNB2N-N8a	18.24	18.24	0	
ERNB2N-N9	18.63	18.63	0	
ERNB2N-N90	18.76	18.76	0	
ERNB2N-N91	18.8	18.8	0	
ERNB2N-N92	18.81	18.81	0	
ERNB2N-N95	18.87	18.87	0	
ERNB2N-N96	18.78	18.78	0	
ERNB2N-N97	18.79	18.79	0	
ERNB2N-N98	18.79	18.79	0	
ERNB2N-N9a	18.67	18.67	0	
ERNB2N-NC20	16.79	16.79	0	
ERNB2N-NC59	18.15	18.15	0	
ERNB2N-W112	17.66	17.66	0	
ERNB2W-N1	14.82	14.85	**0.03**	
ERNB2W-N10	15.63	15.63	0	
ERNB2W-N11	15.78	15.78	0	
ERNB2W-N12	15.82	15.82	0	

Project Three Node Comparison Results				
Node	Existing 25-Year Stage	Project_3 25-Year Stage	Run Difference	Notes
ERNB2W-N13	15.82	15.82	0	
ERNB2W-N14	15.87	15.87	0	
ERNB2W-N2	14.78	14.8	**0.02**	
ERNB2W-N3	14.78	14.79	**0.01**	
ERNB2W-N4	14.77	14.78	**0.01**	
ERNB2W-N5	15.19	15.19	0	
ERNB2W-N6	15.25	15.25	0	
ERNB2W-N7	15.33	15.33	0	
ERNB2W-N8	15.51	15.51	0	
ERNB2W-N9	15.61	15.61	0	
ERNB3-N10	16.49	16.49	0	
ERNB3-N2	16.6	16.6	0	
ERNB3-N3	16.19	16.19	0	
ERNB3-N4	16.23	16.23	0	
ERNB3-N5	16.25	16.25	0	
ERNB3-N7	16.27	16.27	0	
ERNB3-N8	16.48	16.48	0	
ERNB3-NC1	16.6	16.6	0	
ERNB3-NC6	16.33	16.33	0	
ERNB3-NC9	17.26	17.26	0	
ERNB4-N1	13.93	13.93	0	
ERNB4-N10	15.88	15.88	0	
ERNB4-N11	15.88	15.88	0	
ERNB4-N13	15.89	15.89	0	
ERNB4-N15	15.91	15.91	0	
ERNB4-N16	15.94	15.94	0	
ERNB4-N18	16.07	16.07	0	
ERNB4-N19	16.18	16.18	0	
ERNB4-N2	14	14	0	
ERNB4-N20	16.6	16.6	0	
ERNB4-N22	16.93	16.93	0	
ERNB4-N23	16.99	16.99	0	
ERNB4-N24	17	17	0	
ERNB4-N25	17.19	17.19	0	

Project Three Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_3 25-Year Stage**	**Run Difference**	**Notes**
ERNB4-N26	17.31	17.31	0	
ERNB4-N3	14.16	14.16	0	
ERNB4-N30	17.6	17.6	0	
ERNB4-N32	17.62	17.62	0	
ERNB4-N33	16.95	16.95	0	
ERNB4-N34	16.91	16.91	0	
ERNB4-N35	16.8	16.8	0	
ERNB4-N37	16.75	16.75	0	
ERNB4-N5	14.53	14.53	0	
ERNB4-N6	14.89	14.89	0	
ERNB4-N7	14.92	14.92	0	
ERNB4-N8	15.05	15.05	0	
ERNB4-N9	15.54	15.54	0	
ERNB4-NC12	16.39	16.39	0	
ERNB4-NC14	17.11	17.11	0	
ERNB4-NC17	17.1	17.1	0	
ERNB4-NC21	16.92	16.92	0	
ERNB4-NC27	17.63	17.63	0	
ERNB4-NC31	17.62	17.62	0	
ERNB4-NC4	16.6	16.6	0	
ERNB5E-N1	14.83	14.83	0	
ERNB5E-N10	14.83	14.83	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N10a	15.77	15.77	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N11	14.83	14.83	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N12	14.93	14.93	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N13	15.03	15.03	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N2	14.83	14.83	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N3	14.83	14.83	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N4	14.84	14.84	0	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N5	17	16.97	**-0.03**	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N6	14.87	14.86	**-0.01**	Estero Pkwy., East of Three Oaks Pkwy.
ERNB5E-N9	14.83	14.83	0	
ERNB5E-N9a	15.86	15.86	0	
ERNB5E-NC0	14.81	14.81	**0**	Three Oaks Pkwy., East Side

Project Three Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_3 25-Year Stage**	**Run Difference**	**Notes**
ERNB5E-NC00	14.81	14.81	**0**	Three Oaks Pkwy., East Side
ERNB5E-NC7	19.38	19.38	**0**	
ERNB5E-NC8	16.82	16.82	**0**	The Reef
ERNB5-N1	15.55	15.55	**0**	
ERNB5-N10	15.69	15.69	**0**	
ERNB5-N11	15.69	15.69	**0**	
ERNB5-N13	15.57	15.57	**0**	
ERNB5-N14	15.56	15.56	**0**	
ERNB5-N14a	15.55	15.55	**0**	
ERNB5-N15	15.52	15.52	**0**	
ERNB5-N15a	15.53	15.53	**0**	
ERNB5-N16	15.49	15.49	**0**	
ERNB5-N17	15.42	15.42	**0**	
ERNB5-N18	15.34	15.34	**0**	
ERNB5-N19	15.34	15.34	**0**	
ERNB5-N2	15.55	15.55	**0**	
ERNB5-N20	15.34	15.34	**0**	
ERNB5-N21	15.33	15.33	**0**	
ERNB5-N24	15.32	15.32	**0**	
ERNB5-N25	15.32	15.32	**0**	
ERNB5-N26	15.31	15.31	**0**	
ERNB5-N27	15.26	15.26	**0**	
ERNB5-N28	15.26	15.26	**0**	
ERNB5-N29	15.16	15.16	**0**	
ERNB5-N3	15.55	15.55	**0**	
ERNB5-N30	15.15	15.15	**0**	
ERNB5-N30a	15.08	15.08	**0**	
ERNB5-N31	14.99	14.99	**0**	
ERNB5-N31a	15.02	15.02	**0**	
ERNB5-N35	15.57	15.57	**0**	
ERNB5-N4	15.62	15.62	**0**	
ERNB5-N5	15.62	15.62	**0**	
ERNB5-N6	15.62	15.62	**0**	
ERNB5-N7	15.63	15.63	0	

Project Three Node Comparison Results				
Node	Existing 25-Year Stage	Project_3 25-Year Stage	Run Difference	Notes
ERNB5-N8	15.63	15.63	0	
ERNB5-N9	15.69	15.69	0	
ERNB6-N1	9.11	9.12	**0.01**	
ERNB6-N10	10.94	10.94	0	
ERNB6-N11	11.05	11.08	**0.03**	
ERNB6-N12	11.62	11.65	**0.03**	
ERNB6-N13	11.78	11.81	**0.03**	
ERNB6-N14	11.85	11.88	**0.03**	
ERNB6-N15	12.33	12.33	0	
ERNB6-N2	9.34	9.35	**0.01**	
ERNB6-N3	9.35	9.35	0	
ERNB6-N4	10.19	10.2	**0.01**	
ERNB6-N5	10.55	10.56	**0.01**	
ERNB6-N6	10.59	10.59	0	
ERNB6-N7	10.59	10.6	**0.01**	
ERNB6-N8	10.78	10.78	0	
ERNB6-N9	10.92	10.92	0	
ERNBD1-N1	6.67	6.68	**0.01**	
ERNBD1-N2	6.67	6.68	**0.01**	
ERNBD1-N3	6.86	6.88	**0.02**	
ERNBD1-N4	7.28	7.3	**0.02**	
ERNBD2-N1	14.74	14.76	**0.02**	
ERNBD2-N10	14.74	14.77	**0.03**	
ERNBD2-N2	14.76	14.78	**0.02**	North Branch Diversion 2- Improved Flow-way
ERNBD2-N4	14.77	14.79	**0.02**	North Branch Diversion 2- Improved Flow-way
ERNBD2-N5	14.78	14.79	**0.01**	North Branch Diversion 2- Improved Flow-way
ERNBD2-N6	14.81	14.81	0	North Branch Diversion 2- Improved Flow-way
ERNBD2-N7	14.81	14.82	**0.01**	North Branch Diversion 2- Improved Flow-way
ERNBD2-N8	14.81	14.81	0	North Branch Diversion 2- Improved Flow-way
ERNBD2-NC9	14.81	14.81	0	
ERNB-N1	7.83	**7.85**	**0.02**	
ERNB-N10	10.84	10.87	**0.03**	
ERNB-N11	10.84	10.87	**0.03**	

Project Three Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_3 25-Year Stage**	**Run Difference**	**Notes**
ERNB-N12	11.3	11.33	**0.03**	
ERNB-N13	11.63	11.66	**0.03**	
ERNB-N15	11.75	11.78	**0.03**	
ERNB-N16	11.8	11.83	**0.03**	
ERNB-N17	12.44	12.48	**0.04**	
ERNB-N18	14.08	14.11	**0.03**	
ERNB-N19	14.66	14.69	**0.03**	
ERNB-N2	8.61	8.63	**0.02**	
ERNB-N20	14.66	14.69	**0.03**	
ERNB-N21	14.72	14.75	**0.03**	
ERNB-N22	14.77	14.8	**0.03**	
ERNB-N23	14.78	14.81	**0.03**	
ERNB-N24	14.79	14.82	**0.03**	
ERNB-N26	14.8	14.83	**0.03**	
ERNB-N27	14.83	14.85	**0.02**	
ERNB-N3	9.41	9.43	**0.02**	
ERNB-N30	14.83	14.86	**0.03**	
ERNB-N31	14.88	14.9	**0.02**	
ERNB-N31.5	14.89	14.9	**0.01**	
ERNB-N32	15.1	15.11	**0.01**	
ERNB-N33	15.21	15.22	**0.01**	
ERNB-N34	15.28	15.28	0	
ERNB-N35	15.32	15.33	**0.01**	
ERNB-N35.5	15.34	15.35	**0.01**	
ERNB-N36	15.34	15.35	**0.01**	
ERNB-N37	15.43	15.44	**0.01**	
ERNB-N39	15.81	15.81	0	
ERNB-N4	9.92	9.95	**0.03**	
ERNB-N40	15.86	15.86	0	
ERNB-N41	15.86	15.86	0	
ERNB-N45	15.32	15.33	**0.01**	
ERNB-N6	9.98	10.01	**0.03**	
ERNB-N7	10.15	10.18	**0.03**	
ERNB-N8	10.26	10.29	**0.03**	

Project Three Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_3 25-Year Stage**	**Run Difference**	**Notes**
ERNB-NC014	12.96	12.96	0	
ERNB-NC05	10.28	10.29	**0.01**	Villages of Country Creek Basin 3
ERNB-NC09	11.19	11.2	**0.01**	Villages of Country Creek Basin 1
ERNB-NC14	12.95	12.95	0	Villages of Country Creek Basin 4
ERNB-NC25	16.16	16.16	0	Rookery Basin 2
ERNB-NC43	16.63	16.63	0	
ERNB-NC46	16.66	16.66	0	
ERNB-NC5	10.27	10.29	**0.02**	
ERNB-NC9	11.16	11.17	**0.01**	
ERNB-NT1	99.79	99.79	0	
ERNB-NT2	15.86	15.86	0	
ERSB-N1	7.34	7.35	**0.01**	
ERSB-N13	8.97	8.97	0	
ERSB-N14	8.98	8.99	**0.01**	
ERSB-N15	9.16	9.16	0	
ERSB-N18	9.44	9.45	**0.01**	
ERSB-N19	9.5	9.5	0	
ERSB-N2	7.54	7.55	**0.01**	
ERSB-N3	7.54	7.55	**0.01**	
ERSB-N4	8.13	8.13	0	
ERSB-N6	8.13	8.13	0	
ERSB-N8	8.57	8.57	0	

Table 4-4: Project Three Peak Flows Comparison Results

Project Three Peak Flows Comparison Results				
Link	**Existing 25-Year Peak Flows (Cfs)**	**Project_3 25-Year Peak Flows (Cfs)**	**Run Difference (Cfs)**	**Notes**
ERNBD2-C1	65.78	72.36	**6.58**	Increased Flows within North Branch North Diversion
ERNBD2-C2	76.59	87.22	**10.63**	Increased Flows within North Branch North Diversion
ERNBD2-P1	54.71	66.3	**11.59**	Increased Flows within North Branch North Diversion
ERNBD2-C4	45.86	57.77	**11.91**	Increased Flows within North Branch North Diversion
ERNBD2-C5	53.3	64.52	**11.22**	Increased Flows within North Branch North Diversion
ERNBD2-C6	18.67	27.06	**8.39**	Increased Flows within North Branch North Diversion
ERNB-C22	299.32	297.23	**-2.09**	Decreased Flows within North Branch
ERNB-C23	299.35	297.24	**-2.11**	Decreased Flows within North Branch
ERNB-C24	299.75	297.45	**-2.3**	Decreased Flows within North Branch
ERNB-C25	300.58	299.57	**-1.01**	Decreased Flows within North Branch
ERNB-C27	291.95	291.45	**-0.5**	Decreased Flows within North Branch
ERNB-C28	292.07	291.56	**-0.51**	Decreased Flows within North Branch

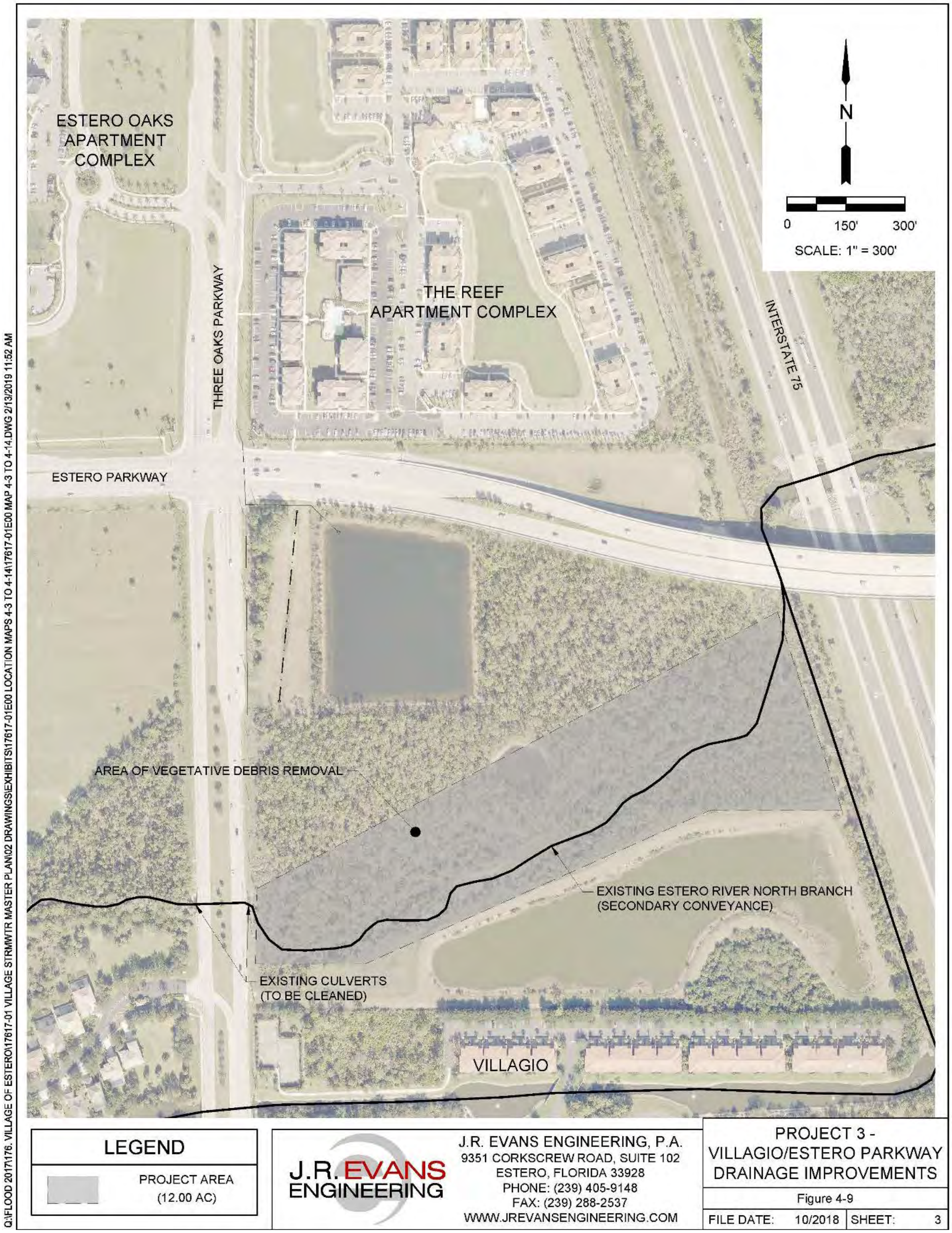


Figure 4-9: Project Three – Villagio / Estero Parkway Drainage Improvements

4.3.4. Project Four - Estero Parkway Culvert

During the evaluation of the design storms simulations, it was noted that the change in hydraulic grade through the cross-culvert at Estero Parkway connecting the north-south ditch between Cascades and Rookery Point was approximately 1.0 feet during the 25-Year, 3-Day simulation. This cross-culvert receives flow from many properties located north of Estero Parkway, including Country Oaks, Pine Glen, and the Our Lady of Light Church. Improvements considered for the Estero Parkway Cross Culvert (North of Rookery Pointe), includes modifications to the culvert and channel cross sections. This culvert is along the ditch named as ERNB4 in the ICPR4 Model. The proposed improvements considered during this evaluation are described as follows:

- Replacement of the one (1) 34” x 53” pipe for two (2) 29” x 45” (reinforced concrete), lengths of the three segments are considered to have the same inverts as the ones shown in the Estero Parkway Plans (approximately 11.45 feet-NAVD upstream and 11.35 feet-NAVD downstream).
- Modifications to the cross sections upstream and downstream of the Estero Parkway Culvert crossing. Trapezoidal cross sections are considered from a point 56 feet downstream of the Estero Parkway culvert to the upstream side (adequate transition upstream of this point is considered as well). The proposed cross sections are considered to have side slopes of 3H:1V with a top width of 40 feet and a bottom width of 19.7 feet. Invert elevations were considered to match the culvert inverts at the respective locations (11.35 feet-NAVD downstream and 11.45 feet-NAVD upstream). Such cross sections were considered to be well maintained, free of debris and undesired vegetation.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The results for Project Four indicate a reduction in head-loss across the culvert of 0.31 feet. Therefore, the peak stage on the upstream side of the crossing was reduced by 0.31 feet or 3.72 inches. There were also decreases in peak stage along the north side of Estero Parkway, west and east of the culvert crossing. Provided below is a comparison table for the surrounding nodes for the Project Four Peak Stage results. Also, reference Figure 4-10 for an exhibit of the project area.

Table 4-5: Project Four Node Comparison Results

Project Four Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_4 25-Year Stage**	**Run Difference**	**Notes**
ER-N1	0.48	0.48	**0**	
ER-N10	1.65	1.65	**0**	
ER-N11	1.83	1.83	**0**	
ER-N12	2.28	2.28	**0**	
ER-N13	2.61	2.61	**0**	
ER-N14	3.01	3.02	**0.01**	
ER-N15	3.1	3.11	**0.01**	
ER-N16	3.34	3.34	**0**	
ER-N17	3.38	3.39	**0.01**	
ER-N18	3.42	3.43	**0.01**	
ER-N19	3.56	3.57	**0.01**	

Project Four Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_4 25-Year Stage**	**Run Difference**	**Notes**
ER-N2	0.52	0.52	**0**	
ER-N20	3.74	3.74	**0**	
ER-N204	2.22	2.23	**0.01**	
ER-N21	3.91	3.92	**0.01**	
ER-N22	3.92	3.93	**0.01**	
ER-N23	4.63	4.65	**0.02**	
ER-N24	4.64	4.65	**0.01**	
ER-N24.5	5.41	5.43	**0.02**	
ER-N25	6	6.02	**0.02**	
ER-N26	6.01	6.03	**0.02**	
ER-N27	6.58	6.6	**0.02**	
ER-N28	6.69	6.72	**0.03**	
ER-N28.6	6.96	6.98	**0.02**	
ER-N29	7.08	7.1	**0.02**	
ER-N3	0.92	0.92	**0**	
ER-N4	1.24	1.24	**0**	
ER-N5	1.28	1.29	**0.01**	
ER-N6	1.43	1.43	**0**	
ER-N7	1.46	1.47	**0.01**	
ER-N8	1.48	1.49	**0.01**	
ER-N81	1.44	1.44	**0**	
ER-N9	1.5	1.51	**0.01**	
ER-N901	6.8	6.8	**0**	
ERNB4-N1	13.93	14.1	**0.17**	
ERNB4-N10	15.88	15.47	**-0.41**	Estero Parkway Culvert Crossing Upstream Side
ERNB4-N11	15.88	15.47	**-0.41**	
ERNB4-N13	15.89	15.49	**-0.4**	
ERNB4-N15	15.91	15.53	**-0.38**	
ERNB4-N16	15.94	15.61	**-0.33**	
ERNB4-N18	16.07	15.76	**-0.31**	
ERNB4-N19	16.18	15.9	**-0.28**	
ERNB4-N2	14	14.18	**0.18**	
ERNB4-N20	16.6	16.46	**-0.14**	
ERNB4-N22	16.93	16.89	**-0.04**	

Project Four Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_4 25-Year Stage**	**Run Difference**	**Notes**
ERNB4-N23	16.99	16.98	**-0.01**	
ERNB4-N24	17	16.98	**-0.02**	
ERNB4-N25	17.19	17.18	**-0.01**	
ERNB4-N26	17.31	17.31	0	
ERNB4-N28	17.46	17.45	**-0.01**	
ERNB4-N29	17.51	17.51	0	
ERNB4-N3	14.16	14.37	**0.21**	
ERNB4-N30	17.6	17.6	0	
ERNB4-N32	17.62	17.62	0	
ERNB4-N33	16.95	16.94	**-0.01**	
ERNB4-N34	16.91	16.89	**-0.02**	
ERNB4-N35	16.8	16.79	**-0.01**	
ERNB4-N37	16.75	16.74	**-0.01**	
ERNB4-N5	14.53	14.76	**0.23**	
ERNB4-N6	14.89	14.82	**-0.07**	
ERNB4-N7	14.92	14.82	**-0.1**	Estero Parkway Culvert Crossing Downstream Side
ERNB4-N8	15.05	14.91	**-0.14**	
ERNB4-N9	15.54	15.27	**-0.27**	
ERNB4-NC12	16.39	16.38	**-0.01**	
ERNB4-NC14	17.11	17.1	**-0.01**	
ERNB4-NC17	17.1	17.07	**-0.03**	
ERNB4-NC21	16.92	16.88	**-0.04**	
ERNB4-NC27	17.63	17.63	0	
ERNB4-NC31	17.62	17.62	0	
ERNB4-NC4	16.6	16.6	0	
ERNB5-N1	15.55	15.52	**-0.03**	
ERNB5-N10	15.69	15.63	**-0.06**	
ERNB5-N11	15.69	15.63	**-0.06**	
ERNB5-N13	15.57	15.36	**-0.21**	
ERNB5-N14	15.56	15.35	**-0.21**	
ERNB5-N14a	15.55	15.31	**-0.24**	
ERNB5-N15	15.52	15.26	**-0.26**	
ERNB5-N15a	15.53	15.27	**-0.26**	
ERNB5-N16	15.49	15.25	**-0.24**	

Project Four Node Comparison Results				
Node	Existing 25-Year Stage	Project_4 25-Year Stage	Run Difference	Notes
ERNB5-N17	15.42	15.17	**-0.25**	
ERNB5-N18	15.34	15.33	**-0.01**	
ERNB5-N19	15.34	15.33	**-0.01**	
ERNB5-N2	15.55	15.52	**-0.03**	
ERNB5-N20	15.34	15.32	**-0.02**	
ERNB5-N21	15.33	15.32	**-0.01**	
ERNB5-N22	15.33	15.32	**-0.01**	
ERNB5-N23	15.33	15.31	**-0.02**	
ERNB5-N24	15.32	15.31	**-0.01**	
ERNB5-N25	15.32	15.3	**-0.02**	
ERNB5-N26	15.31	15.3	**-0.01**	
ERNB5-N27	15.26	15.25	**-0.01**	
ERNB5-N28	15.26	15.25	**-0.01**	
ERNB5-N29	15.16	15.11	**-0.05**	
ERNB5-N3	15.55	15.52	**-0.03**	
ERNB5-N30	15.15	15.1	**-0.05**	
ERNB5-N30a	15.08	14.98	**-0.1**	
ERNB5-N31	14.99	14.8	**-0.19**	
ERNB5-N31a	15.02	14.86	**-0.16**	
ERNB5-N32	14.99	14.79	**-0.2**	
ERNB5-N33	14.96	14.76	**-0.2**	
ERNB5-N34	15.7	15.63	**-0.07**	
ERNB5-N35	15.57	15.36	**-0.21**	
ERNB5-N4	15.62	15.57	**-0.05**	
ERNB5-N5	15.62	15.58	**-0.04**	
ERNB5-N6	15.62	15.58	**-0.04**	
ERNB5-N7	15.63	15.58	**-0.05**	
ERNB5-N8	15.63	15.58	**-0.05**	
ERNB5-N9	15.69	15.63	**-0.06**	
ERNBD1-N1	6.67	6.69	**0.02**	
ERNBD1-N2	6.67	6.7	**0.03**	
ERNBD1-N3	6.86	6.89	**0.03**	
ERNBD1-N4	7.28	7.32	**0.04**	
ERNBD2-N1	14.74	14.74	0	
ERNBD2-N10	14.74	14.74	0	

Project Four Node Comparison Results				
Node	Existing 25-Year Stage	Project_4 25-Year Stage	Run Difference	Notes
ERNBD2-N2	14.76	14.76	0	
ERNBD2-N4	14.77	14.77	0	
ERNBD2-N5	14.78	14.78	0	
ERNBD2-N6	14.81	14.81	0	
ERNBD2-N7	14.81	14.81	0	
ERNBD2-N8	14.81	14.81	0	
ERNBD2-NC9	14.81	14.81	0	
ERNB-N1	7.83	7.86	**0.03**	
ERNB-N10	10.84	10.88	**0.04**	
ERNB-N11	10.84	10.89	**0.05**	
ERNB-N12	11.3	11.34	**0.04**	
ERNB-N13	11.63	11.67	**0.04**	
ERNB-N15	11.75	11.79	**0.04**	
ERNB-N16	11.8	11.84	**0.04**	
ERNB-N17	12.44	12.49	**0.05**	
ERNB-N18	14.08	14.08	0	
ERNB-N19	14.66	14.65	**-0.01**	
ERNB-N2	8.61	8.64	**0.03**	
ERNB-N20	14.66	14.66	0	
ERNB-N21	14.72	14.72	0	
ERNB-N22	14.77	14.77	0	
ERNB-N23	14.78	14.78	0	
ERNB-N24	14.79	14.79	0	
ERNB-N26	14.8	14.8	0	
ERNB-N27	14.83	14.82	**-0.01**	
ERNB-N3	9.41	9.45	**0.04**	
ERNB-N30	14.83	14.83	0	
ERNB-N31	14.88	14.88	0	
ERNB-N31.5	14.89	14.89	0	
ERNB-N32	15.1	15.1	0	
ERNB-N33	15.21	15.21	0	
ERNB-N34	15.28	15.28	0	
ERNB-N35	15.32	15.32	0	
ERNB-N35.5	15.34	15.34	0	
ERNB-N36	15.34	15.34	0	

Project Four Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_4 25-Year Stage**	**Run Difference**	**Notes**
ERNB-N37	15.43	15.43	0	
ERNB-N39	15.81	15.81	0	
ERNB-N4	9.92	9.96	**0.04**	
ERNB-N40	15.86	15.86	0	
ERNB-N41	15.86	15.86	0	
ERNB-N45	15.32	15.32	0	
ERNB-N6	9.98	10.02	**0.04**	
ERNB-N7	10.15	10.19	**0.04**	
ERNB-N8	10.26	10.3	**0.04**	
ERNB-NC014	12.96	12.97	**0.01**	
ERNB-NC05	10.28	10.3	**0.02**	
ERNB-NC09	11.19	11.2	**0.01**	
ERNB-NC14	12.95	12.95	0	
ERNB-NC25	16.16	16.16	0	
ERNB-NC43	16.63	16.63	0	
ERNB-NC46	16.66	16.66	0	
ERNB-NC5	10.27	10.3	**0.03**	
ERNB-NC9	11.16	11.18	**0.02**	
ERNB-NT1	99.79	99.79	0	
ERNB-NT2	15.86	15.86	0	
ER-NC203	15.55	15.55	0	
ER-NC205	15.9	15.9	0	
ER-NC206	9.09	9.09	0	
ER-NC207	15.47	15.47	0	
ER-NC30	11.66	11.66	0	
ER-NC802	4.92	4.92	0	
ER-NC820	1.43	1.44	**0.01**	
ER-NC821	14.79	14.79	0	
ER-NC900	5.35	5.35	0	
ER-NCPS1	14.79	14.79	0	
ER-NCPS2	10.44	10.44	0	
ER-NCPS3	14.79	14.79	0	
ER-NCPS3B	14.76	14.76	0	
ER-NCPS5	8.72	8.72	0	
ER-NCPS6	7.46	7.46	0	

Project Four Node Comparison Results				
Node	**Existing 25-Year Stage**	**Project_4 25-Year Stage**	**Run Difference**	**Notes**
ER-NCPS7	7.41	7.41	0	
ER-NCPS8	11.4	11.4	0	
ER-NPS8	8.81	8.81	0	
ER-NT1	0.39	0.39	0	
ERSB-N1	7.34	7.36	**0.02**	
ERSB-N13	8.97	8.98	**0.01**	
ERSB-N14	8.98	8.99	**0.01**	
ERSB-N15	9.16	9.16	0	
ERSB-N18	9.44	9.45	**0.01**	
ERSB-N19	9.5	9.5	0	
ERSB-N2	7.54	7.56	**0.02**	
ERSB-N20	9.92	9.92	0	
ERSB-N21	9.95	9.96	**0.01**	
ERSB-N22	10.05	10.06	**0.01**	
ERSB-N23	10.07	10.07	0	
ERSB-N24	10.27	10.28	**0.01**	
ERSB-N25	10.56	10.57	**0.01**	
ERSB-N26	10.58	10.58	0	
ERSB-N28	10.62	10.62	0	
ERSB-N29	10.81	10.81	0	
ERSB-N3	7.54	7.56	**0.02**	
ERSB-N30	11.44	11.44	0	
ERSB-N31	13.41	13.41	0	
ERSB-N32	13.89	13.89	0	
ERSB-N33	13.93	13.93	0	
ERSB-N34	13.94	13.94	0	
ERSB-N35	13.94	13.94	0	
ERSB-N36	14.11	14.11	0	
ERSB-N37	14.16	14.16	0	
ERSB-N38	14.21	14.21	0	
ERSB-N39	14.21	14.21	0	
ERSB-N4	8.13	8.14	**0.01**	
ERSB-N40	14.06	14.06	0	
ERSB-N41	14.17	14.17	0	
ERSB-N42	14.38	14.38	0	

Project Four Node Comparison Results				
Node	Existing 25-Year Stage	Project_4 25-Year Stage	Run Difference	Notes
ERSB-N43	14.68	14.68	0	
ERSB-N44	14.86	14.86	0	
ERSB-N45	14.84	14.84	0	
ERSB-N47	10.06	10.06	0	
ERSB-N53	14.15	14.15	0	
ERSB-N6	8.13	8.14	**0.01**	
ERSB-N8	8.57	8.58	**0.01**	

Figure 4-10: Project Four - Estero Pkwy Culvert Replacement

4.3.5. Project Five - River Ranch Road Drainage Improvements

Improvements considered for the River Ranch Road drainage system includes the addition of culverts connecting the east and west roadside swales, additional culverts at several existing culvert crossings and the upsizing of existing driveway culverts. The intention of the proposed improvements is to increase the hydraulic connectivity of the east and west roadside swale systems and to increase the flow capacity to the North Lakes of Estero conveyance swale and to the South Corkscrew Road conveyance system.

Additionally, improvements to the maintenance of the North Williams Road swale, east of the River Ranch Road intersection, and the removal and replacement of the temporary construction access culvert would improve the River Ranch Road drainage system. The River Ranch Road and Williams Road drainage improvements were considered together since the two systems are hydraulically connected during major storm events.

The proposed improvements considered during this evaluation are described as follows:

- Adding a 19”x30” ERCP culvert to connect the east and west roadside swale, approximately 690’ south of the Corkscrew Road intersection.
- The removal and replacement of the driveway culverts along the east and west roadside swales to 2’ RCP culverts, and the adjustment of the pipe inverts.
- The removal and replacement of the culvert crossing approximately 140’ south of Ridge Runner Court, from one (1) 24” RCP culvert to two (2) 24” ERP culverts.
- The removal and replacement of the 12” HDPE culvert at the temporary construction access across the North Williams Road swale with a 30” RCP culvert, approximately 1,200’ west of the River Ranch Road intersection.
- The vegetation removal and maintenance of the North Williams Road swale from the River Ranch Road intersection east to the Three Oaks Parkway intersection. Manning’s values were adjusted to account for routine maintenance that will keep the channel free of obstructions, undesired vegetation, and sedimentation.
- Increase due to greater flow reaching north lakes of estero swale

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate that the highest roadside swale elevation, which occurred at the northwest corner of the Block Lane intersection, decreased 0.25 feet or 3 inches. Several nodes did show an increase in peak stage, however, the increases occurred at the nodes with the lowest peak stages in the pre-project conditions. Provided below is a comparison table for the surrounding nodes for the Project Five Peak Stage results. Also, reference Figure 4-11 for an exhibit of the project area.

Table 4-6: Project Five Node Comparison Results

Node	Existing 25-Year Stage	Projects_5 25-Year Stage	Run Difference	Notes
ERSB-N24	10.27	10.32	0.05	Increase Due to Greater Flow Reaching ERSB
ERSB-N25	10.56	10.61	0.05	Increase Due to Greater Flow Reaching ERSB
ERSB-N26	10.58	10.62	0.04	Increase Due to Greater Flow Reaching ERSB
ERSB4-N2	12.56	12.8	0.24	Increase Due to Greater Flow Reaching North Lakes of Estero Swale
ERSB4-N3	13.76	13.93	0.17	Increase Due to Greater Flow Reaching North Lakes of Estero Swale
ERSB4-NC4	14.86	14.86	0	Communities
ERSB4-NC5	14.14	14.14	0	
ERSB9-N1	14.11	14.06	-0.05	
ERSB9-N12	15.12	14.87	-0.25	Highest Roadside Stage Under Existing Conditions
ERSB9-N29	14.53	14.5	-0.03	
ERSB9-N32	14.73	14.75	0.02	Increase Due to Greater Flow Reaching East Roadside Swale
ERSB9-N44	14.15	14.62	0.47	Increase Due to Improved Connectivity Between West and East Side Swales.
ERSB9-NC50	15.29	15.29	0	Communities
ERSB9-NC51	15.27	15.15	-0.12	
ERSB9-NC53	16.16	16.15	-0.01	
ERSB9-NC54	15.42	15.4	-0.02	

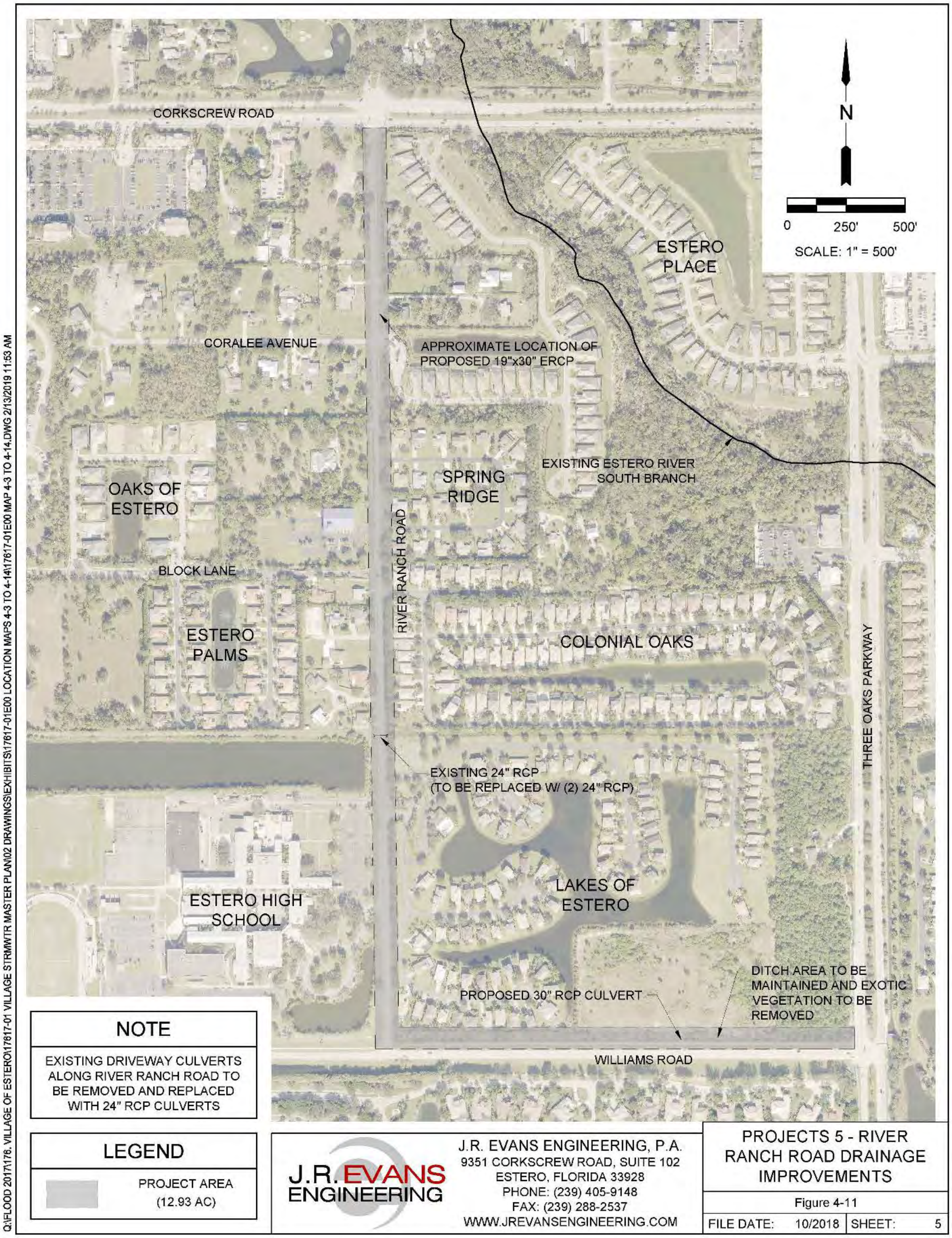
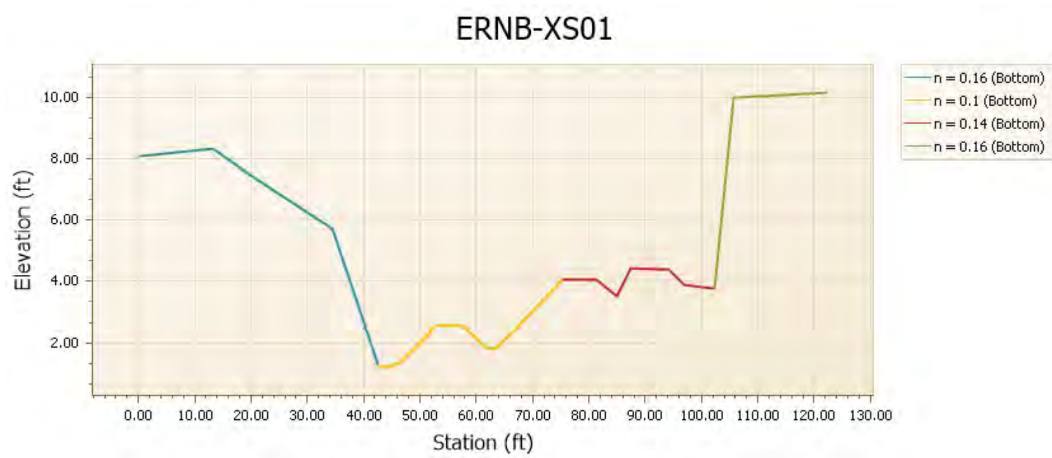


Figure 4-11: Project Five– River Ranch Road Drainage Improvements

4.3.6. Project Six - Dry Creek Bed Sediment Removal

Improvements considered for the Bamboo Island bypass between the North Branch and South Branch of the Estero River include the dredging, reshaping and removal of vegetation within the bypass channel to increase the flow capacity and better distribute the flow between the north diversion and the subject bypass channel. The proposed improvements to the bypass channel are shown in the below cross-sections:

EXISTING CHANNEL CROSS-SECTION ERNB-XS01



PROPOSED CHANNEL CROSS-SECTION ERNB-XS01

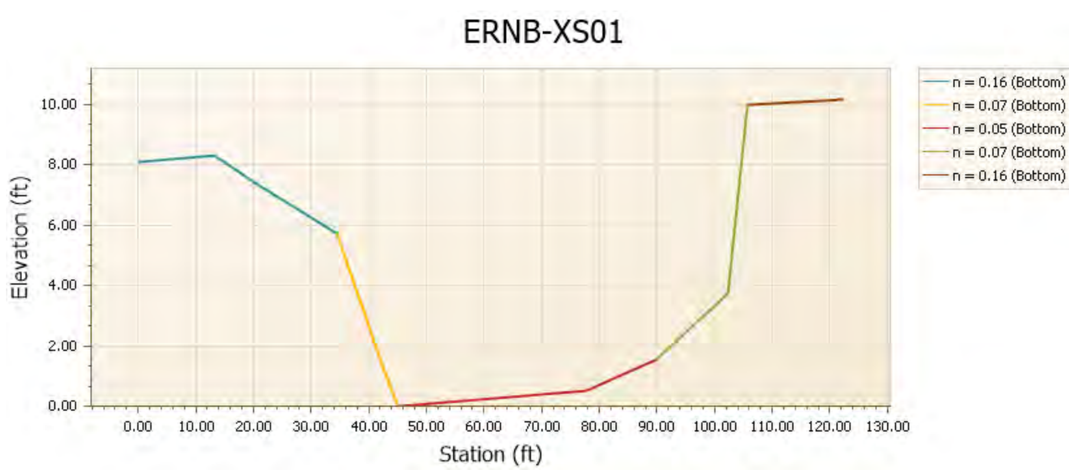
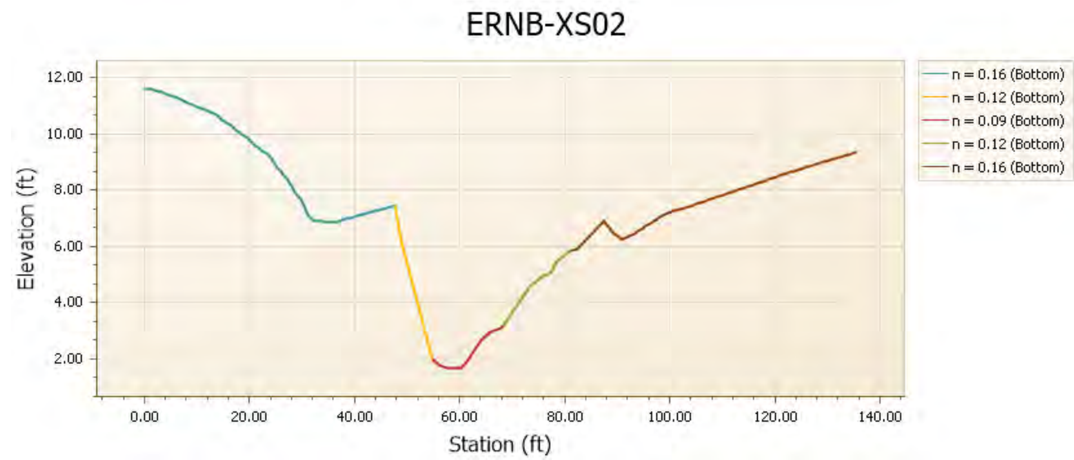


Figure 4-12: Channel Cross-section ERNB-XS01 Comparison

EXISTING CHANNEL CROSS-SECTION ERNB-XS02



PROPOSED CHANNEL CROSS-SECTION ERNB-XS02

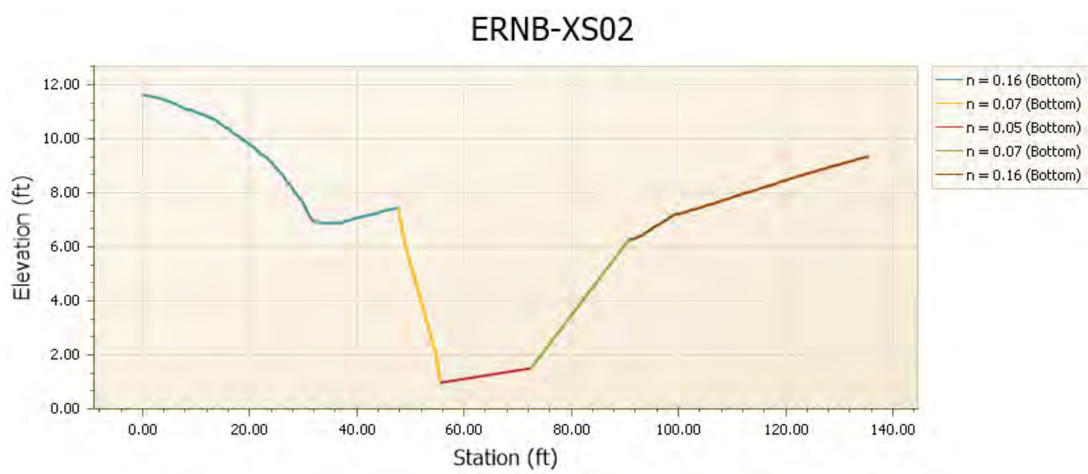


Figure 4-13: Channel Cross-section ERNB-XS02 Comparison

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate that the modification proposed to the bypass channel would decrease peak stages upstream and within several of the Country Creek basins. Provided below is a comparison table for the surrounding nodes for the Project Six Peak Stage results. Also, reference Figure 4-14 for an exhibit of the project area.

Table 4-7: Project Six Node Comparison Results

Node	Existing 25-Year Stage	Project_6 25-Year Stage	Run Difference	Location
ER-N22	3.92	3.92	0	Downstream of Modified Cross Section
ER-N24	4.64	4.64	0	Downstream of Modified Cross Section
ER-N26	6.01	6.01	0	Downstream of Modified Cross Section
ER-N27	6.58	6.58	0	Downstream of Modified Cross Section
ER-N29	7.08	7.09	**0.01**	Downstream of Modified Cross Section
ERNB-N1	7.83	7.73	**-0.1**	Upstream of Modified Cross Sections
ERNB-N10	10.84	10.81	**-0.03**	Upstream of Modified Cross Sections
ERNB-N13	11.63	11.62	**-0.01**	Upstream of Modified Cross Sections
ERNB-N15	11.75	11.74	**-0.01**	Upstream of Modified Cross Sections
ERNB-N17	12.44	12.44	0	Upstream of Modified Cross Sections
ERNB-N3	9.41	9.36	**-0.05**	Upstream of Modified Cross Sections
ERNB-N4	9.92	9.88	**-0.04**	Upstream of Modified Cross Sections
ERNB-N8	10.26	10.23	**-0.03**	Upstream of Modified Cross Sections
ERNB-NC14	12.95	12.95	0	Downstream of Modified Cross Section
ERNB-NC5	10.27	10.26	**-0.01**	Downstream of Modified Cross Section

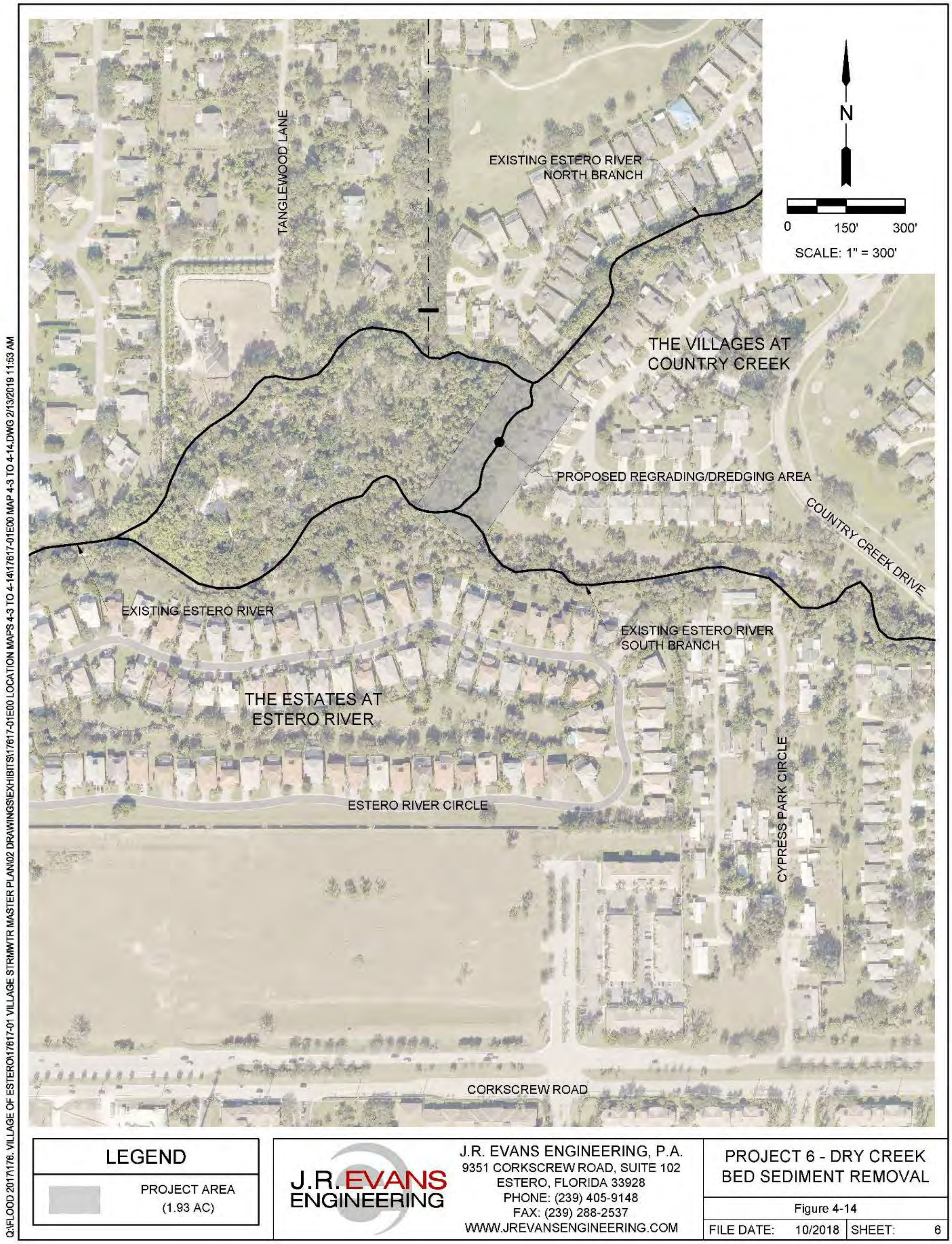
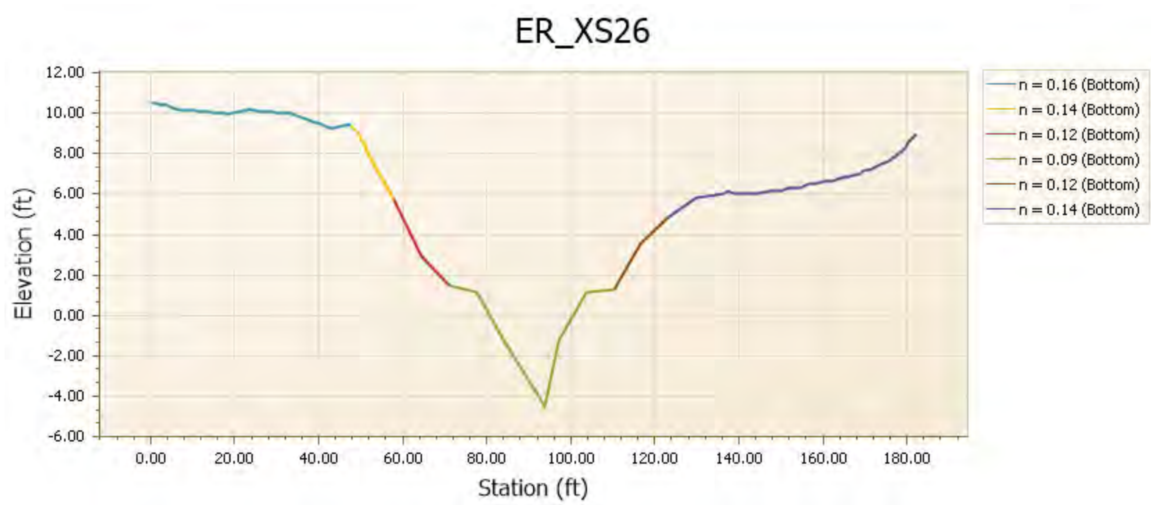


Figure 4-14: Project Six – Dry Creek Bed Sediment Removal

4.3.7. Project Seven - Estero River Side Banks Sediment Removal

Improvements considered for the Estero River Main Branch between the Seminole Gulf Railroad and the Sandy Lane bridge include the dredging, reshaping and removal of vegetation within the channel to increase the flow capacity. Based on the existing conditions analysis, the model indicates significant increases in water surface elevation through this section of the river. The proposed improvements to the channel are shown in the below cross-sections.

EXISTING CHANNEL CROSS-SECTION ER-XS26



PROPOSED CHANNEL CROSS-SECTION ER-XS26

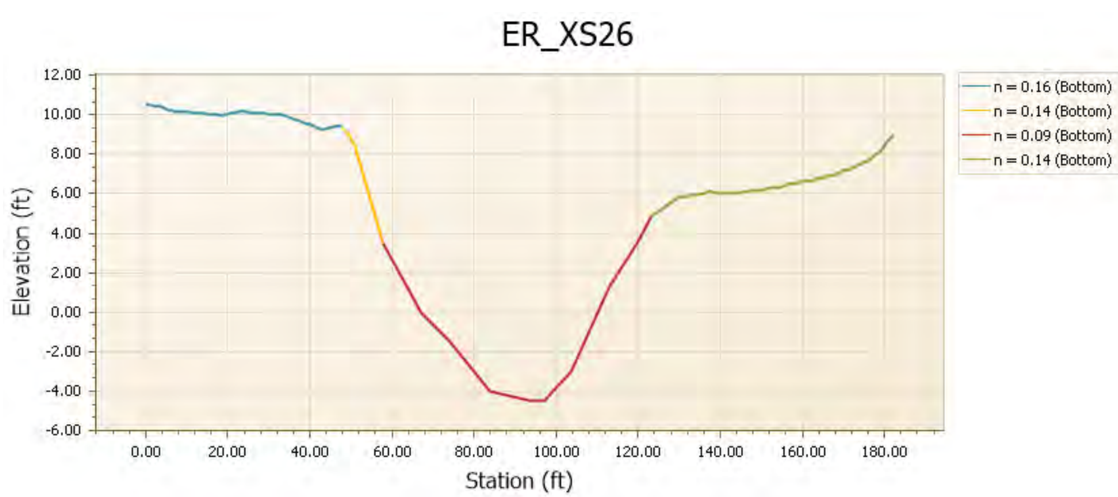


Figure 4-15: Channel Cross-section ER-XS26 Comparison

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate that the modification proposed to the channel would significantly decrease peak stages upstream, while only slightly increasing downstream peak stages. Provided below is a comparison table for the surrounding nodes for the Project Seven Peak Stage results. Also, reference Figure 4-16 for an exhibit of the project area.

Table 4-8: Project Seven Node Comparison Results

Node	Existing 25-Year Stage	Project_7 25-Year Stage	Run Difference	Notes
ER-N20	3.74	3.76	0.02	
ER-N22	3.92	3.95	0.03	
ER-N24	4.64	4.67	0.03	
ER-N24.5	5.41	5.02	-0.39	
ER-N25	6.00	5.41	-0.59	
ER-N26	6.01	5.42	-0.59	
ER-N27	6.58	6.13	-0.45	
ER-N28	6.69	6.26	-0.43	
ER-N28.6	6.96	6.58	-0.38	
ER-N29	7.08	6.74	-0.34	
ERNB-N1	7.83	7.71	-0.12	
ERNB-N12	11.3	11.29	-0.01	
ERNB-N15	11.75	11.74	-0.01	
ERNB-N2	8.61	8.54	-0.07	
ERNB-N3	9.41	9.37	-0.04	
ERNB-N8	10.26	10.24	-0.02	
ERSB-N18	9.44	9.36	-0.08	
ERSB-N20	9.92	9.85	-0.07	
ERSB-N8	8.57	8.42	-0.15	

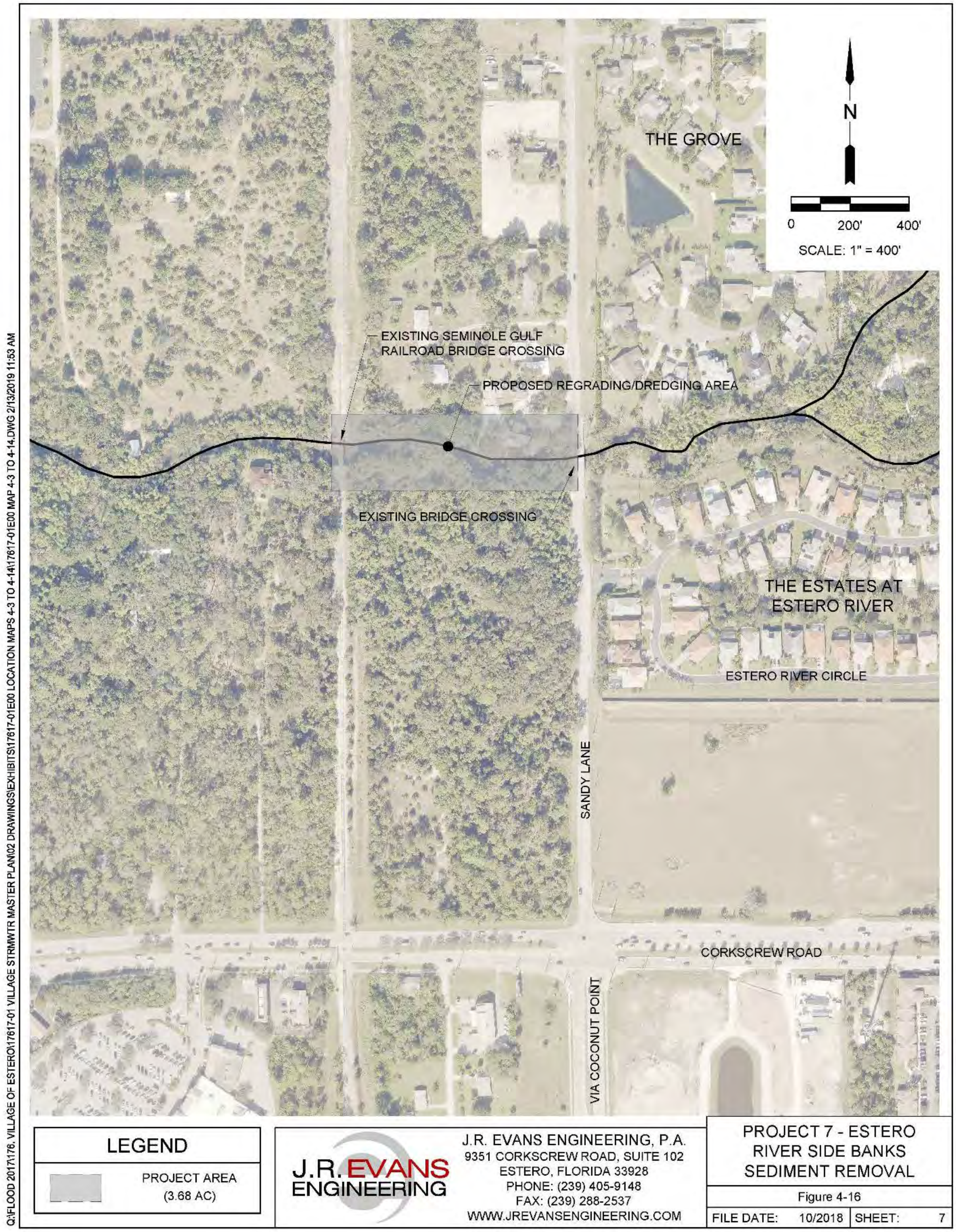


Figure 4-16: Project Seven – Sediment Removal along Side Banks

4.3.8. Project Eight – Broadway Ave. Main Tributary: Engineered Design for Tributary Cross-Sections.

Improvements considered for the Tributary of the Estero River (where Broadway Ave. West/U.S. 41 discharge) include replacement of some culverts and channel modifications to increase the flow capacity. A summary of the proposed improvements is included below. For more details related to these improvements, please refer to the Broadway Ave./U.S. 41 Drainage Improvement Plan (September 2017).

- Broadway Ave. pipe's replacement considers changing the 29"x45" CMP's for 42" RCP's. Adjustments to the proposed pipe inverts were also considered to account for constructability. Note: This portion of the project is under construction as of July 2018.
- Broadway Ave. east receiving swale connection and weir changes considers the installation of 15 feet of a 24" RCP with a mitered entrance, and the removal of the existing east weir (notch). Note: This portion of the project is under construction as of July 2018.
- The replacement of the pipe parallel to the Trailside Drive considers changing the 30" CMP for a 30" RCP with mitered end sections. Adjustment to the pipe inverts are also proposed.
- The Greenway Landscape pipe replacement considers changing the 24" CMP for a 24" RCP with mitered end sections. Adjustment to the pipe inverts are also proposed.
- Improvements to the main channel sections considers an overall increase on the Tributary of Estero River channel width from a point approximately 30 feet downstream of the Broadway Ave. proposed culvert exit to the northeastern Greenway Landscape Property Boundary. Proposed trapezoidal cross sections at the Tributary starts from approximately 30 feet downstream of the Broadway Ave. proposed culvert exit to the southwestern Greenway Landscape Property Boundary. The trapezoidal cross sections are considered to have side slopes of 3H:1V, a channel bottom width of 3.5 feet and a channel top width ranging from approximately 23 feet to 35 feet. The most downstream invert is considered to be 7.5 feet-NAVD (matching with the proposed pipe invert) and the most upstream invert is considered to be 10 feet-NAVD (upstream of the Trailside Drive culvert). Within the Greenway Landscape property, V-Shape cross section were considered with side slope of 3H:1V and general invert elevation of 10 feet (NAVD). An adequate tie-in with the area near the Greenway Landscape property boundary and the exit of the US-41 culverts is proposed.
- Manning's "N" values were adjusted to account for a routine maintenance that will keep the channel free of: obstructions, undesired vegetation, and sedimentation/scour. The Tributary channel is considered to be covered with short grass, and to contain no rifts or deep pools.
- Confluences of secondary swales with the Tributary of Estero River are considered to be modified to warrant adequate tie-in with the proposed Tributary invert elevations. Approximately 30 feet of the swales directly connected to the Tributary of Estero River should be modified.

- Based on the previous ICPR4 modeling completed for this project, results obtained show that the proposed improvements decreased the water surface elevations up to 0.8 feet, 9.6 inches, along the Tributary of Estero River (net change varies for each rainfall event). It should be noted that positive impacts to the water surface elevations were also obtained at the contributing swales and other areas within the area of interest. Also, reference Figure 4-17 for an exhibit of the project area.
- Improvements to the Tributary of Estero River are required to resolve some of the deficiencies the drainage system currently has, and which are affecting the existing residential and commercial developments. The implementation of the proposed improvements will result in benefits to the existing developments.

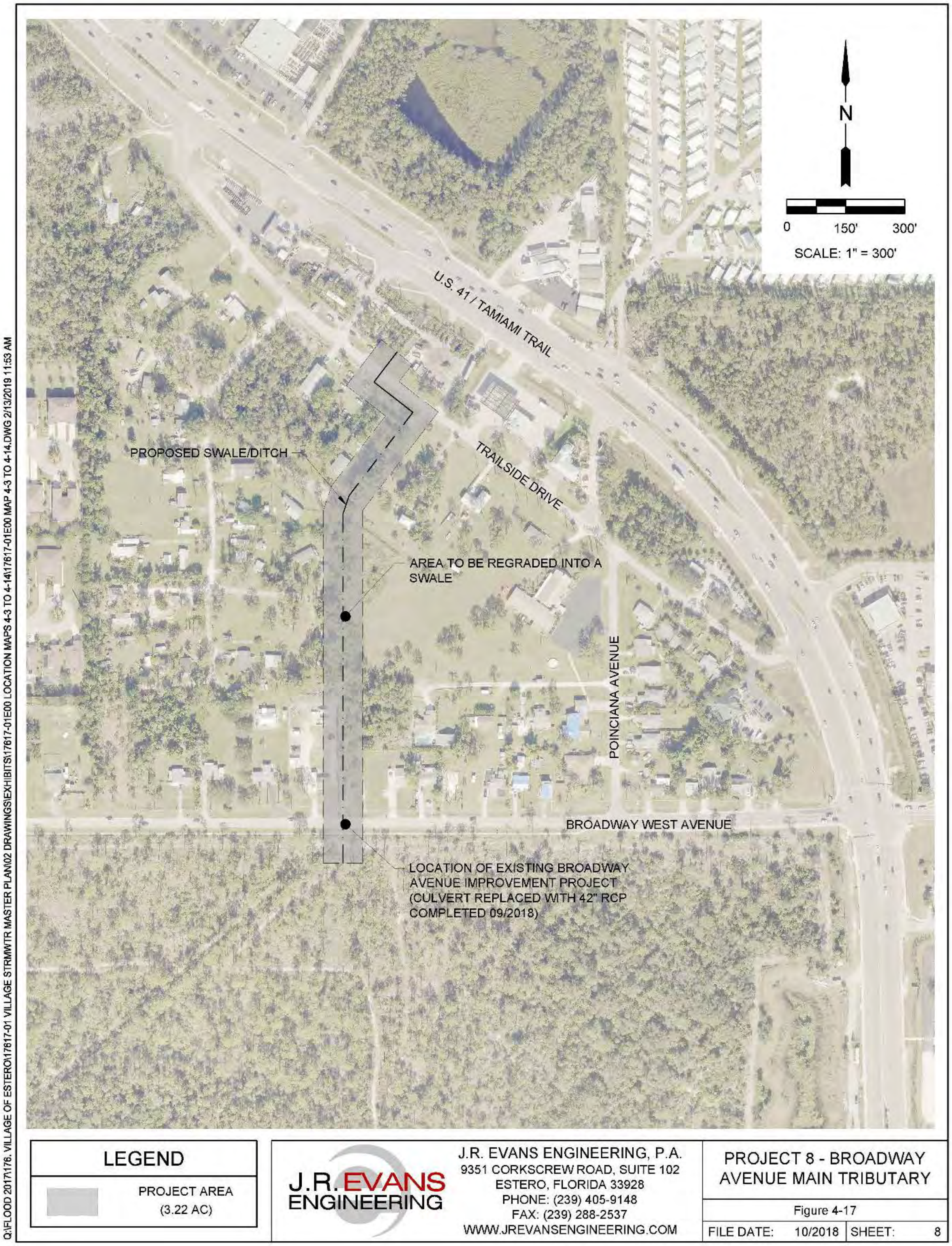


Figure 4-17: Project Eight– Broadway Avenue Tributary Improvement

4.3.9. Project Nine – U.S. 41, North of Williams Rd. and South of Corkscrew Rd.

This is a recommended project to relieve the flooding issues experienced along the east side of U.S. 41, north of Williams Road and south of Corkscrew Road. At this time the U.S. 41 storm drainage system within this area does not have a positive outfall to the west and therefore water fills the roadside detention ponds and remains there for prolonged periods after rain events. The sidewalk along this stretch of U.S. 41 is consistently flooded during the wet season. In 2006, FDOT obtained a permit from SFWMD (App. 060613-6) to modify some of the FDOT control structures along the east side of U.S. 41 and re-direct the stormwater flow. However, based upon the permit records and site observations, the improvements were never conducted. It is recommended that these improvements be implemented to relieve the flooding conditions in this vicinity. This could also have an impact on the adjacent lands to the east of U.S. 41 being able to achieve a positive outfall. Reference Figure 4-18 for an exhibit of the project area.

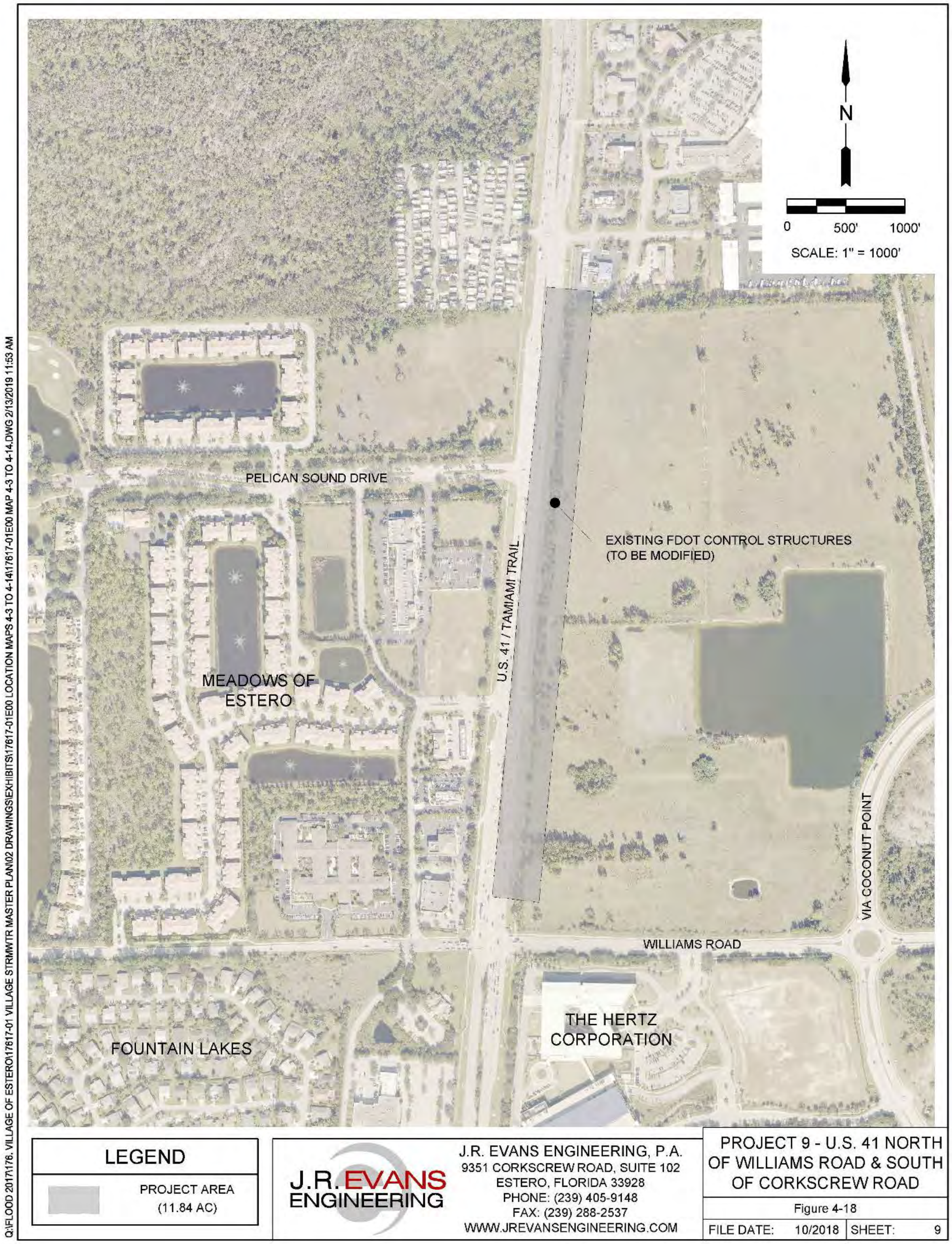


Figure 4-18: Project Nine– U.S. 41, N. Williams Rd. & S. Corkscrew Rd. Drainage Modification

4.3.10. Project Ten -Maintenance of the Natural System

The maintenance of the main channels is pertinent for the functionality of the Village's natural drainage conveyance systems. Debris, vegetative and nonorganic, collects within the natural conveyances overtime. The collection of debris is often intensified and accelerated by storm events. Debris collected within the waterways can cause blockages in structures, such as culverts and bridges, which results in increase stages upstream. Excess debris, even when it does not cause blockages, can have negative affects by slowing down the flow, which can also lead to higher stages. The same is true for unmaintained vegetation within the channel and the channel banks. Tall grasses, shrubs, an overgrowth of weeds and downed trees can have a large impact on the flood stage due to the increased roughness of the flow path.

Areas recommended to be regularly evaluated and maintained are as follows:

- Estero River South Branch, South of Corkscrew Road to Sanctuary Road
- Estero River North Branch, North of Villages at Country Creek
- Halfway Creek, West of U.S. 41
- FPL Easement Ditches between Williams Road and Coconut Road
- Seminole Gulf Railroad Ditch, North of Estero River Main Branch

Estero River North Branch, North of Villages at Country Creek - Figure 4-19:

The intent of the maintenance in this area is to improve the conveyance ability for the portion of the North Branch located between the north property boundary of Villages at Country Creek and Rookery Drive within the Rookery Pointe community. Based on the existing conditions analysis, the model indicates significant increases in water surface elevation through this section of the North Branch, which is attributed to the channel cross-section and heavily vegetative conditions.

Improvements considered for the Estero River North Branch between the north property line of Country Creek upstream to the Rookery Drive bridge includes the reshaping and removal of vegetation within the channel to increase the flow capacity. Analysis of the various storm events shows a significant increase in the hydraulic grade line through this section of the North Branch.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate that the modification proposed to the channel would substantially decrease peak stages upstream of the project area; however, downstream increases in peak stages did result from the changes. Reference Figure 4-19 for an exhibit of the project area.

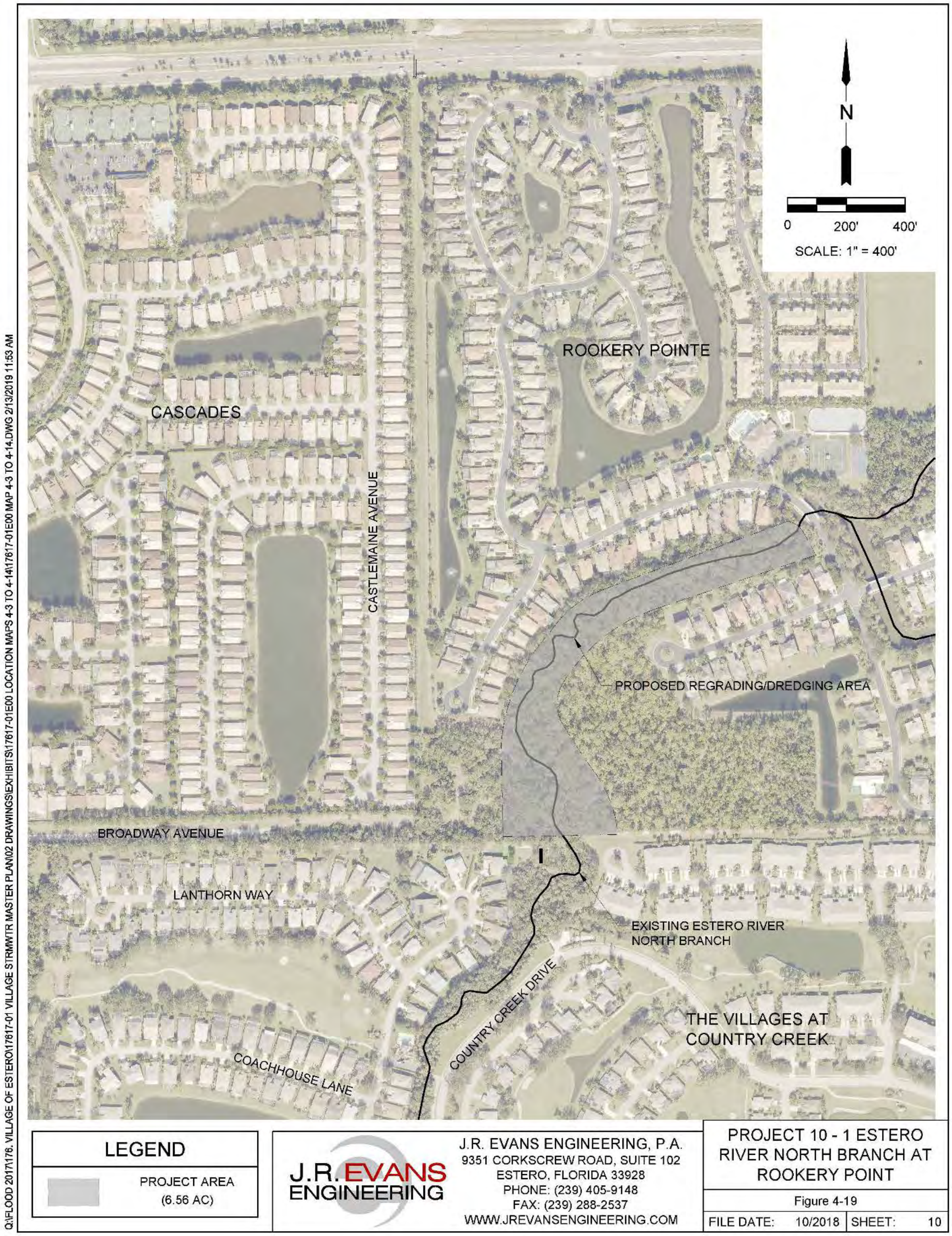


Figure 4-19: Project 10-1 – Estero River North Branch at Rookery Point

Estero River South Branch - Figure 4-20:

Improvements considered for the Estero River South Branch from Sanctuary Road to Corkscrew Road includes maintenance and vegetation removal from the channel. Based on the existing conditions analysis, the model indicates that flow through this section of the South Branch decreases from upstream to downstream, indicating poor conveyance. The proposed improvements considered during this evaluation are described as follows:

Removal of debris and vegetation from the channel bottom; from the downstream side of the Sanctuary Road crossing to the upstream side of Corkscrew Road. It should be noted, that improvements should be done considering any potential environmentally sensitive areas.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate that the modifications proposed will decrease peak stages upstream of the proposed modifications by up to 0.39’ or 4.7”. The improvements may also increase the peak stages downstream due to the greater flow capacity of the improved channel segment. Reference Figure 4-20 for an exhibit of the project area.

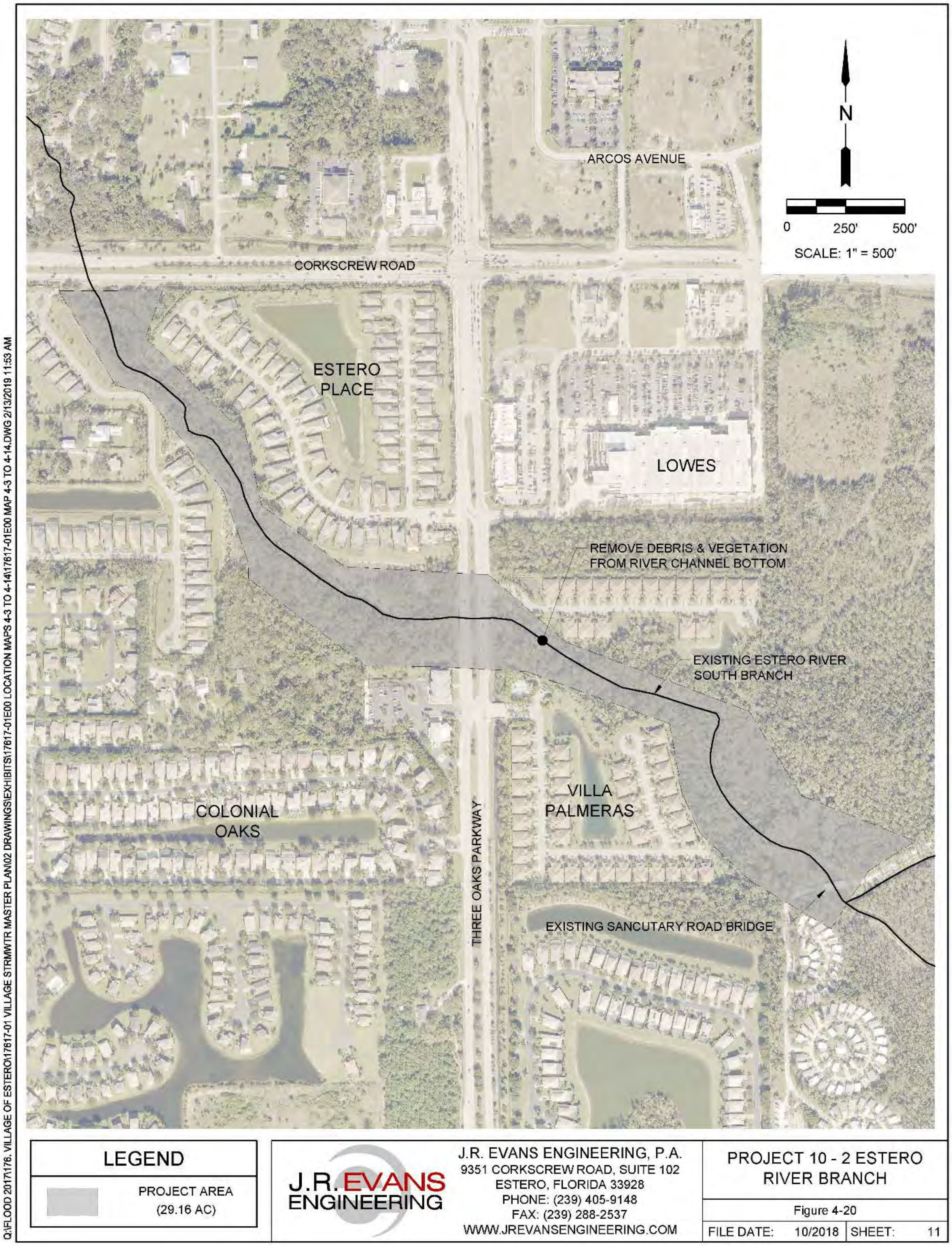


Figure 4-20: Project 10-2 – Estero River South Branch Maintenance

Halfway Creek, West of U.S. 41 - Figure 4-21:

Improvements considered for Halfway Creek, West of the FPL easement up to the West Bay Club, includes the maintenance and removal of brush and trees from the channel portion of the creek. Based on the existing conditions analysis, the model indicates significant increases in water surface elevation through this section of Halfway Creek. The typical proposed improvements to the subject portion of Halfway Creek is shown in the below cross-sections.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate that the modifications proposed will decrease peak stages upstream and downstream of the proposed modifications. Reference Figure 4-21 for an exhibit of the project area.

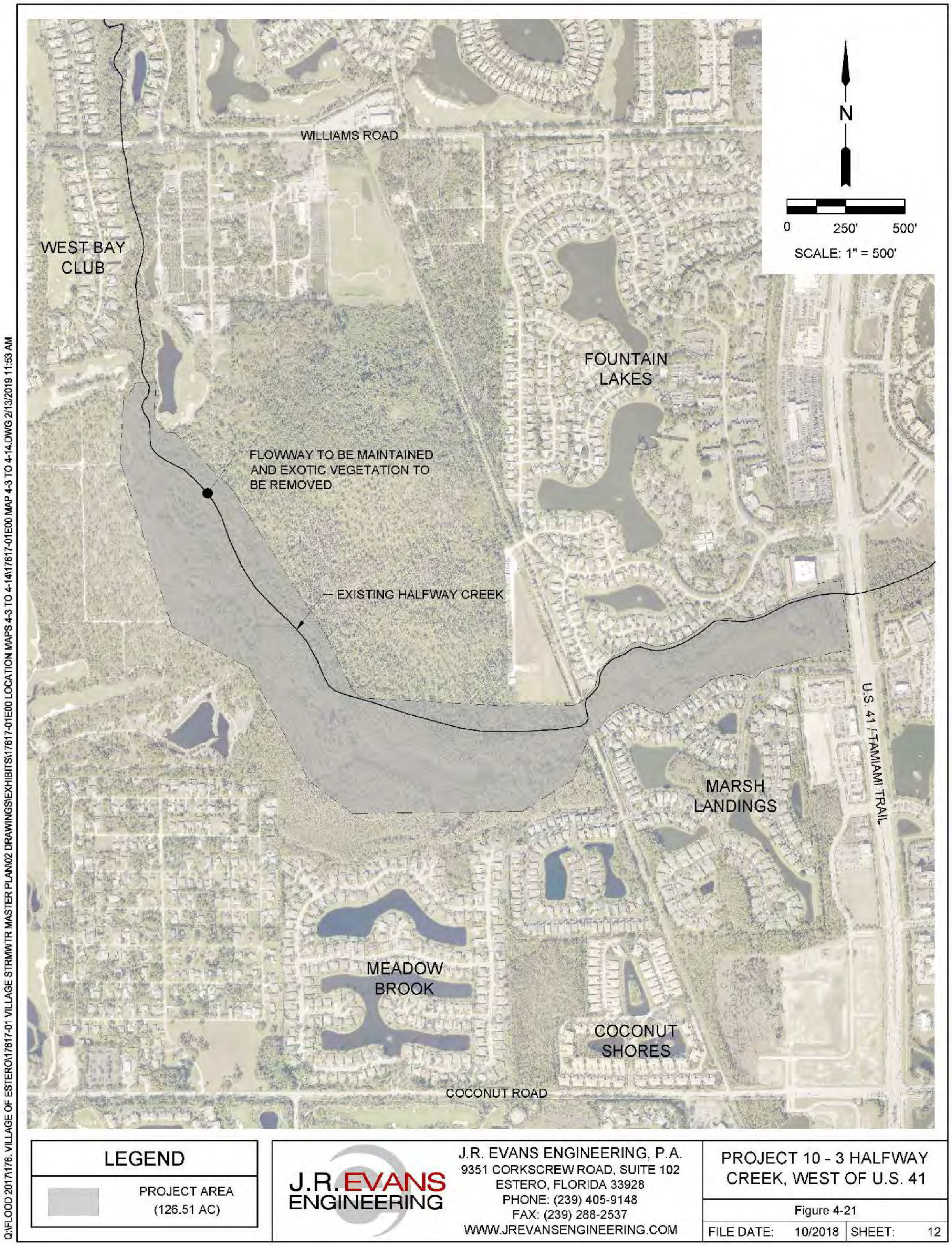


Figure 4-21: Project 10-3 – Halfway Creek Maintenance

FPL Easement Ditches between Williams Road and Coconut Road - Figure 4-22:

Improvements considered for the FPL easement ditches, between Williams Road and Coconut Road, includes the maintenance and removal of brush and trees from the east and west ditches along the easement, to decrease the hydraulic difference between the upstream and downstream stages. The typical proposed improvements to the FPL easement ditches are shown in the below cross-sections.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate that the modifications proposed will decrease peak stages upstream and downstream of the proposed modifications. Reference Figure 4-22 for an exhibit of the project area.

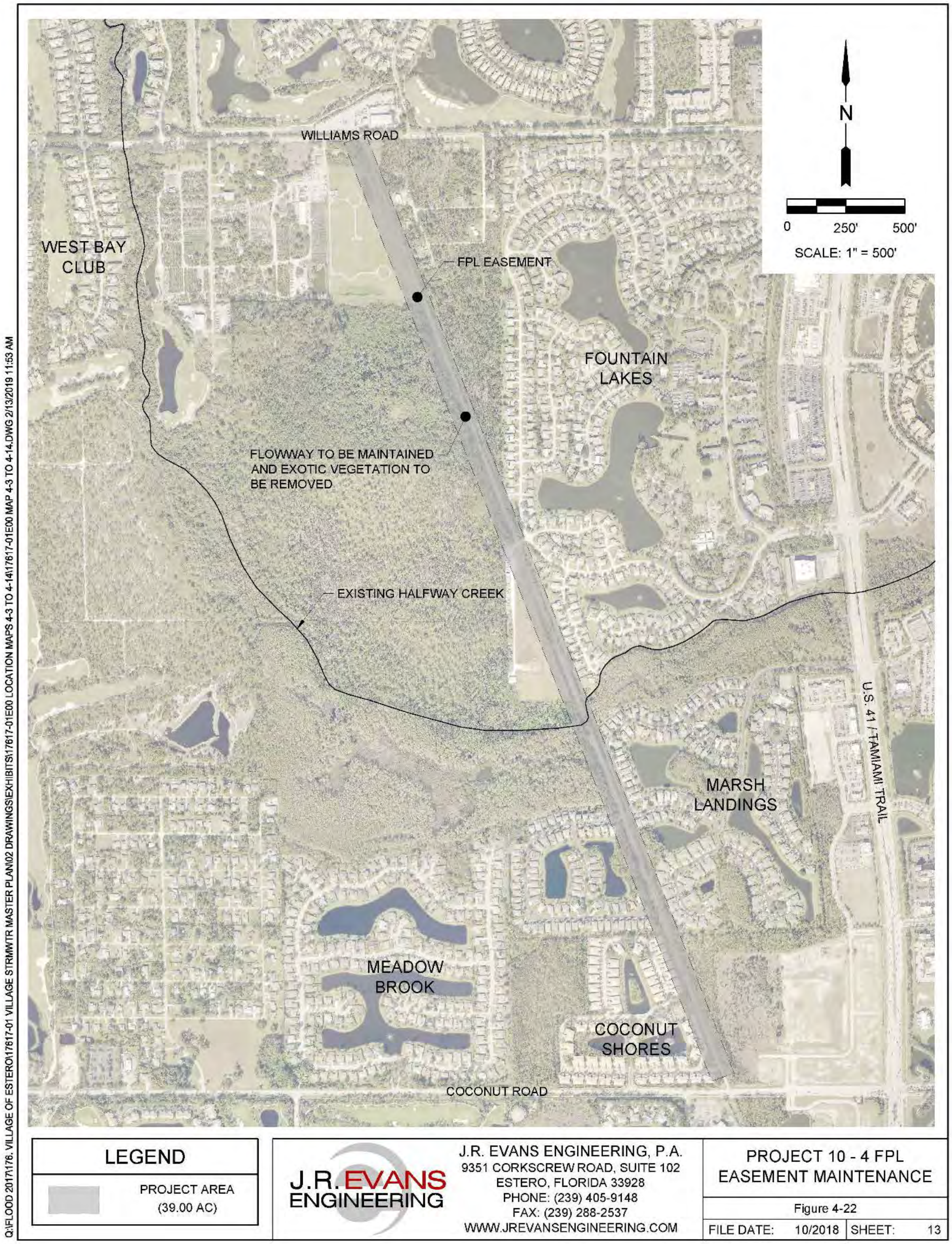


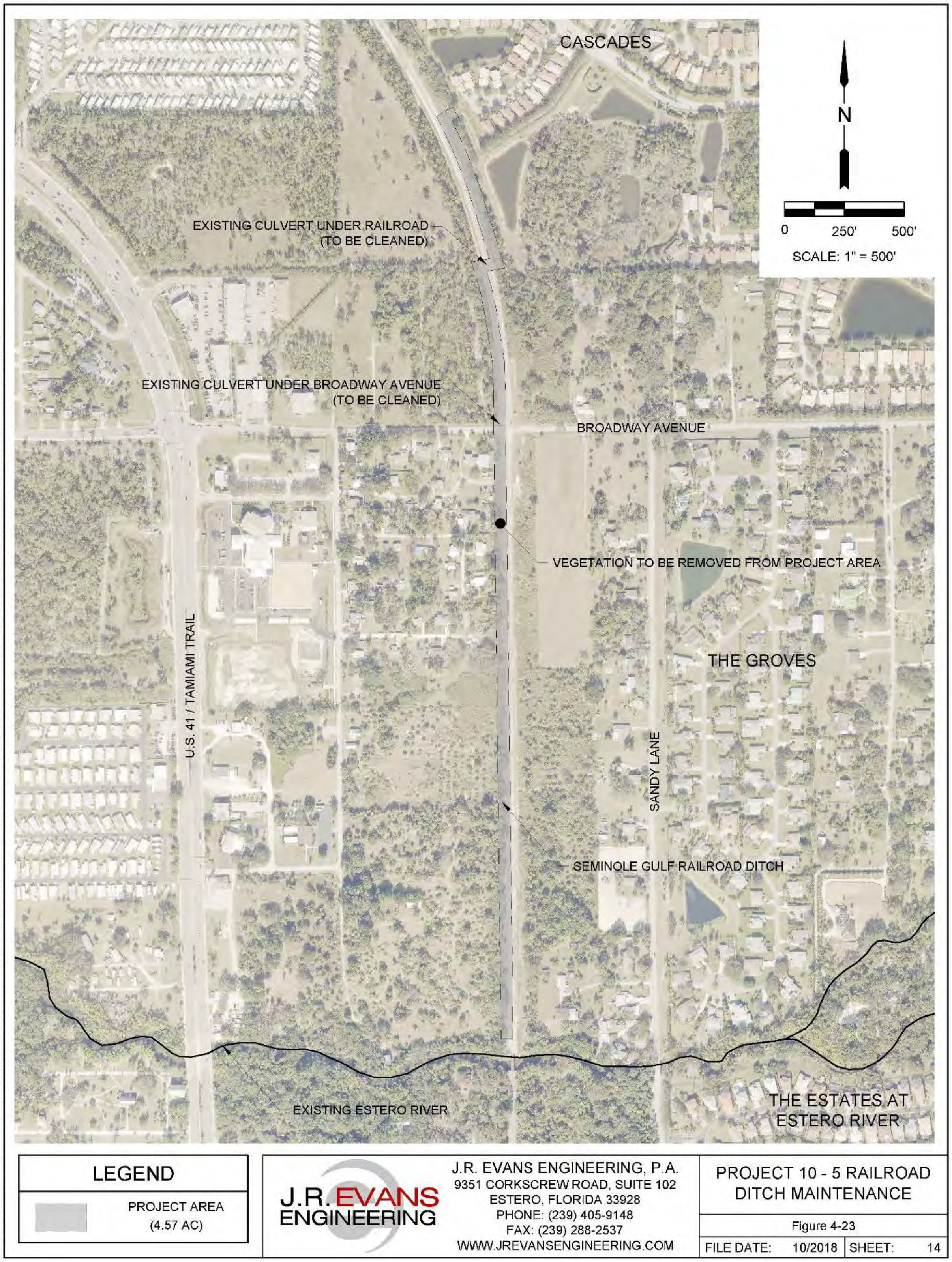
Figure 4-22: Project 10-4 – FPL Easement Maintenance

Seminole Gulf Railroad Ditch, North of Estero River Main Branch - Figure 4-23:

Improvements considered for the Seminole Gulf Railroad ditch include the removal of trees, obstructions and weeds to increase the flow capacity of the ditch. Reshaping of the ditch is not proposed. Currently, the ditch conveys stormwater from Estero Parkway and three residential communities, The Reserve, Belle Lago and Cascades. After the August 2017 storm and again after Hurricane Irma, the areas that drain to the conveyance swale experienced roadway flooding lasting upwards of five days. Improving the conveyance ditch will provide the communities and roadways a greater chance of adequately handling a large storm event.

The proposed improvements to the conveyance ditch are shown in Cross-Section ER4N-XS2; similar improvements are proposed to cross-sections ER4N-XS1, ER4N-XS3, ER4N-XS4, ER4N-XS5, ER4N-XS6, and ER4N-XS7. Reference Figure 4-23 for an exhibit of the project area.

Once the modifications were conducted in the ICPR4 model, the 25-Year, 3-Day design storm simulation was executed, and peak stage results were compared with the pre-project stages. The modeling results indicate that the proposed modifications to the channel would decrease peak stages.



Q:\FLOOD 2017\178. VILLAGE OF ESTERO\17617-01 VILLAGE STRMWTR MASTER PLAN\02 DRAWINGS\EXHIBITS\17617-01E00 LOCATION MAPS 4-3 TO 4-14\17617-01E00 MAP 4-3 TO 4-14.DWG 2/13/2019 11:53 AM

Figure 4-23: Project 10-5 – Seminole Railroad Ditch Maintenance

4.4. Recommended Improvement Projects

When evaluating the potential improvement projects for a final recommendation, consideration was given to the following factors:

- Magnitude of Potential Benefits to the Overall System
- Estimated Construction Cost for the Improvements or Activities
- Ease of Difficulty of Implementing the Improvements or Activities- Permit Requirements, Coordination with Other Entities, etc.

In the following report sections, the above items are reviewed in greater detail for each project.

4.4.1. Estimated Costs and Required Permitting

Provided below are the estimated construction costs associated with the evaluated projects along with a discussion related to any required permitting and coordination with outside agencies or entities. The estimated construction costs do not include final design or permitting costs.

Project One Estimated Construction Costs

Summary				
1.00	Earthwork		=	$147,973.21
2.00	Drainage		=	$12,000.00
3.00	Permitting		=	$7,500.00
4.00	Engineering (Design, Surveying, Observation)		=	$50,000.00
		Total	**=**	**$217,473.21**
		Add 10%	**=**	***$239,220.53***

Project One Permitting Requirements:
Project One will most likely require a permit approval through the South Florida Water Management District (SFWMD). In addition, the Village will need to coordinate with the Villages of Country Creek Homeowner's Association to achieve an easement along the northern and western property lines for the instalment of the improvement project.

Project Two Estimated Construction Costs:

Summary				
1.00	Earthwork		=	$16,380.50
2.00	Drainage		=	$8,220.00
3.00	Permitting		=	$4,260.00
4.00	Engineering (Design, Surveying, Observation)		=	$75,000.00
		Total	**=**	**$103,860.50**
		Add 10%	**=**	***$114,246.55***

Project Two Permitting Requirements:
Project Two will require a permit approval through the South Florida Water Management District (SFWMD). The property is owned by Lee County and the Village will need coordinate with Lee County on the proposed improvements and modifications to the respective storm drainage facilities.

Project Three Estimated Construction Costs:

Summary				
1.00	Earthwork		=	$151,750.00
2.00	Drainage		=	$2,325.00
3.00	Permitting		=	$13,125.00
4.00	Engineering (Design, Surveying, Observation)		=	$25,000.00
		Total	**=**	**$192,200.00**
		Add 10%	***=***	***$211,420.00***

Project Three Permitting Requirements:
Project Three will require a permit approval through the South Florida Water Management District (SFWMD). In addition, the property is owned by Lee County and the Village will need coordinate with Lee County on the proposed improvements and clean-up to the diversion channel sections.

Project Four Estimated Construction Costs:

Summary				
1.00	Earthwork		=	$1,842.50
2.00	Paving / Roadway		=	$24,414.00
3.00	Drainage		=	$79,805.00
4.00	Permitting		=	$1,200.00
5.00	Engineering (Design, Surveying, Observation)		=	$30,000.00
		Total	**=**	**$137,261.50**
		Add 10%	***=***	***$150,987.65***

Project Four Permitting Requirements:
Project Four will require a permit approval through the South Florida Water Management District (SFWMD). In addition, the Village will need coordinate with the respective property owners located at the downstream and upstream sides of the culvert crossing with respect to the modifications of the channel cross-sections leading from the culvert ends. The removal of the existing culvert and installation of the new culverts will require a restoration of the Estero Parkway pavement sections. Since overall improvements are proposed by The Village for Estero Parkway within the next 1-3 years, it is recommended that Project Four be incorporated with the overall Estero Parkway project.

Project Five Estimated Construction Costs

Summary				
1.00	Earthwork		=	$137,125.07
2.00	Paving / Roadway		=	$1,468.56
3.00	Drainage		=	$143,802.62
4.00	Permitting		=	$5,500.00
5.00	Engineering (Design, Surveying, Observation)		=	$82,500.00
		Total	**=**	**$370,396.25**
		Add 10%	***=***	***$407,435.87***

Project Five Permitting Requirements:
Project Five require a permit approval through the South Florida Water Management District (SFWMD). In addition, the Village will need coordinate with the respective property owners located along the project area with respect to the driveway culvert restoration. In addition, the cross-culvert installations may involve adjustments to the existing utility mains (potable water and wastewater) which will need to be coordinated and permitted with Lee County Utilities.

Project Six Estimated Construction Costs:

Summary				
1.00	Earthwork		=	$31,412.93
2.00	Permitting		=	$5,500.00
3.00	Engineering (Design, Surveying, Observation)		=	$30,000.00
		Total	**=**	**$66,912.93**
		Add 10%	***=***	***$73,604.22***

Project Six Permitting Requirements:
Project Six requires a permit approval through the South Florida Water Management District (SFWMD), as well as permit approval through the Army Corps of Engineers (ACOE) for the proposed activities within the open waters of the River. An environmental specialist is recommended to be involved with the project to ensure limited negative environmental impacts to the area.

Project Seven Estimated Construction Costs:

Summary				
1.00	Earthwork		=	$19,701.30
2.00	Permitting		=	$3,300.00
3.00	Engineering (Design, Surveying, Observation)		=	$25,000.00
		Total	**=**	**$48,001.30**
		Add 10%	***=***	***$52,801.43***

Project Seven Permitting Requirements:
Project Seven requires a permit approval through the South Florida Water Management District (SFWMD). In addition, the Village will need coordinate with the respective property owners and potentially Property Owner’s Associations located along the project area with respect to work performed along the river bank.

Project Eight Estimated Construction Costs:

Summary				
1.00	Earthwork		=	$77,756.86
2.00	Permitting		=	$5,500.00
3.00	Engineering (Design, Surveying, Observation)		=	$50,000.00
		Total	**=**	**$133,256.86**
		Add 10%	**=**	***$146,582.54***

Project Eight Permitting Requirements:
Project Eight requires permit approval through the Village of Estero and the South Florida Water Management District (SFWMD).

Project Nine Estimated Construction Costs:

Summary				
1.00	Earthwork		=	$9,300.00
2.00	Drainage		=	$25,000.00
3.00	Permitting		=	$500.00
4.00	Engineering (Design, Surveying, Observation)			$35,000.00
		Total	**=**	**$69,800.00**
		Add 10%	**=**	***$76,780.00***

Project Nine Permitting Requirements:
Project Nine requires the coordination with SFWMD, FDOT, and Lee County to perform maintenance and vegetation removal along the ditch north of Williams Road and south of Corkscrew Road.

Project Ten Construction Costs:

Summary				
1.00	Earthwork		=	$2,164,257.30
2.00	Permitting		=	$40,250.00
3.00	Engineering (Design, Surveying, Observation)		=	$80,000.00
		Total	**=**	**$2,284,507.30**
		Add 10%	**=**	***$2,512,958.30***

Project Ten Permitting Requirements:
Project Ten will require permit approvals through the South Florida Water Management District (SFWMD). Coordination with private landowners and community associations will be required to access the areas to be maintained that are not owned by the Village or Lee County. Coordination with FPL and the Seminole Gulf Railway will also be required for maintaining ditches and swales on land they own. An environmental specialist is recommended to be involved with the project to ensure limited negative environmental impacts to the areas.

4.4.2. Prioritizing of Recommended Projects

Of the ten potential improvement projects, four of the projects are considered high priority, three are considered medium priority and two are considered low priority. Priority was assigned to the projects based on the positive benefit they are expected to provide, the expected cost to implement the improvement and the feasibility of permitting and implementation of the project.

High priority projects recommended to be implemented within 1-5 years are as follows:

- Project One: Villages at Country Creek Bypass Swale
- Project Four: Estero Parkway Culvert
- Project Five: River Ranch Road Drainage Improvement
- Project Eight: Broadway Ave. Main Tributary

Medium priority projects recommended to be implemented within 5-10 years are as follows:

- Project Three: Villagio / Estero Parkway Drainage Improvements
- Project Six: Dry Creek Bed Sediment Removal
- Project Seven: Estero River Side Banks Sediment Removal

Low priority projects recommended to be implemented at a time greater than 10 years present time are as follows:

- Project Two: Three Oaks Parkway Drainage Improvements
- Project Nine: U.S. 41, North of Williams Rd. and South of Corkscrew Rd

Of the ten potential improvement projects, one project, Project Ten, is categorized as maintenance and is recommended to be reviewed on an annual basis.

The maintenance project involves the main conveyances and should be routinely evaluated to determine the flow areas that need to be maintained with debris removal and exotic vegetation removal. A routine review of these areas will reduce potential issues of flow obstructions for future significant rainfall events.

4.4.3. Recommended Rule Changes

In addition to the identified potential improvement projects, there are other activities The Village can implement to mitigate issues with negative impacts on the stormwater management system and damages related to flooding. These activities include placing language within the Land Development Code and Comprehensive Plan documents to establish policies and guidelines with respect to stormwater management. Outlined below are the recommended policies for the stormwater management criteria of such documents:

Minimum Finished Floor Elevation Criteria

Issue to be Addressed: Protection of new residential and commercial structures from potential structural flooding by requiring the finished floors to be located higher than the anticipated base flood elevation (BFE) for the location.

Recommended Rule:

New residential and commercial structures shall be designed so that the elevation of the first floor (habitable for residential structures) is at the applicable Base Flood Elevation (BFE), as defined on the effective FEMA Flood Insurance Rate Map, plus 1 foot OR the 100-year, 3-day design stage elevation, whichever is greater.

Potential Issues Created by Rule:

There could be greater construction costs associated with having to construct the structure at a higher elevation than the base flood elevation.

<u>Allowable Discharge Analysis</u>

Issue to be Addressed: Assurance that new development projects do not discharge more surface water into the existing Village stormwater infrastructure than allowed during the pre-development conditions or per the regionally-accepted value, whichever is less. This recommended rule will limit future development discharge rates and reduce the potential for adverse impacts on the Villages' strormwater system.

Recommended Rule:

For new private and public developments within The Village, the allowable discharge shall be based upon the comparison of a pre-development hydrology calculations and the previously regionally accepted value of 0.06 or 0.09 cfs/acre, depending on the watershed. At time of development order submittal, new development projects must provide pre- and post- development hydrology calculations and the post-development discharge must be limited to the pre-development levels or the 0.6 cfs/ac, whichever is less.

Potential Issues Created by Rule:

Due to the limit on the discharge rate, the developer may need to provide more surface water storage than originally anticipated. This could affect the overall usable development footprint.

<u>Minimum Roadway Elevations</u>

Issue to be Addressed: Protection of internal roadways for new private and public developments to reduce the potential for flooding within the roadway section. In prior years, many of the internal roadways within residential communities were designed to the 10-year, 1-day design water surface elevation, which can contribute to the storage of stormwater water during the larger storm events, such as a 25-year or 100-year event. The negative of this design aspect is an increase in long-term roadway flooding during the more intense or longer-duration storms, leading to health and safety issues for the residences of those communities.

Recommended Rule:

New private and public developments must design the internal roadways with a minimum centerline of pavement elevation equal to or above the determined water surface design stage during a 25-year, 3-day storm event.

Potential Issues Created by Rule:

Due to the higher roadway elevations, the developer may need to provide more surface water storage than originally anticipated because the roadways will not be considered as part of the site storage until higher stages are reached. There will also be additional construction costs with additional fill for the higher roadway elevations.

Confirmation of Positive Outfall for Surface Water Management System

Issue to be Addressed: There are some developments within the Village that discharge to secondary conveyances, which lead to an ultimate main waterway such as the Estero River or Halfway Creek. However, the secondary conveyance receiving the discharge is typically not under the public ownership and the maintenance conditions are unknown. This recommended rule will require an in-depth review of the discharge route for the project's surface water discharge to identify and address potential issues in the beginning, which will aid in avoiding further problems after construction.

Recommended Rule:

At time of development order submittal, new private and public development projects must demonstrate and provide sufficient information on the proposed route of the projects' surface water discharge to the ultimate receiving water body, i.e. Estero River. This will ensure that there is a clear understanding of the outfall route and potential impedance issues that can be addressed with Village staff during the development order review process.

Potential Issues Created by Rule:

This rule may require maintenance agreements and responsibilities to be established either with the developer, secondary conveyance land owner or both.

Additional Recommended Activities

Another activity that the Village can pursue to address flood mitigation is install additional water data (stage and flow) loggers within the main waterways. The additional water data loggers can be set-up to record continuous data which can be downloaded and evaluated. There are also loggers with telemetry which provide real-time data , which is beneficial during the wet season where the potential for large rainfall events is greater. The recommended locations for the water data loggers are as follows:

- Estero River/North Branch : U.S. 41 Bridge, Rookery Circle Crossing, Three Oaks Parkway Culverts, and the I-75 Bridge
- Estero River South Branch: I-75 Bridge
- Halfway Creek: FPL Easement Crossing, U.S. 41 Crossing, and I-75 Culverts

Having more stations will do the following:

- Provide real-time data during major storm events which can be used by the Village to effectively monitor potential flooding issues and act efficiently; and
- Provide more data which can be used to continuously calibrate the Local-Scale ICPR model.

100-Year
Floodplain Analysis

5. 100-Year Floodplain Analysis

5.1. Description of Floodplain Analysis

Since 1970, the Village of Estero jurisdiction has been included within the Federal Emergency Management Agency (FEMA) Special Flood Hazard Area mapping of the Lee County region. As part of the Lee County Flood Insurance Study (FIS), effective August 18, 2008, FEMA conducted a hydrologic and hydraulic analysis for the Estero River (all branches) and Halfway Creek. FEMA's study modeled the Estero River Main Branch and North Branch as one main stream. The Estero River South Branch and Halfway Creek were considered separate streams in the FEMA floodplain analysis. In March 2017, the Village of Estero officially became part of the National Flood Insurance Program (NFIP) as a participating community. In May 2017, the Village was approved as participating in the NFIP Community Rating System (CRS) program, which relates to discounts on NFIP flood insurance policies held by property owners within the Village jurisdiction. As an inductee into the CRS program, the Village received a Class 6 rating with equates to a 20% discount for insurance policies within the NFIP. Since the Village is a new community within the NFIP, the Village is responsible for maintaining their floodplain management policies and practices and their flood mapping products. As a tool to better understand the effects of potential riverine flooding associated with the Estero River and Halfway Creek, the local-scale ICPR model can be used to support a specific riverine floodplain analysis for each of the waterways. The riverine floodplain analysis includes a hydraulic, open-channel flow analysis of the waterways. The local-scale ICPR model provides the hydrologic analysis required to support and provide input for the hydraulic floodplain analysis.

Both the Estero River and Halfway Creek are impacted by coastal storm surge flooding as well as riverine flooding. Therefore, the FEMA flood maps depict the special flood hazard areas associated with coastal storm surge up to where the riverine flooding controls. For the Estero River, the effects of coastal storm surge flooding extend upstream from the Estero Bay to approximately 0.82 miles downstream of the U.S. 41 crossing. For the Halfway Creek, the effects of coastal storm surge flooding extend from the confluence with Estero River to approximately 0.90 miles downstream of the U.S 41 crossing. For this analysis, the focus was on updates to the riverine floodplain and does not include an evaluation of the coastal storm surge flooding. For the hydraulic analysis, the modeling programs HEC-RAS (Hydrologic Engineering Center's River Analysis System) and GeoHECRAS were used. The HEC-RAS program is designed to perform one and two-dimensional hydraulic calculations for a full network of natural and constructed channels. The GeoHECRAS software allows the user to property geo-reference the HEC-RAS model so the stream alignment, cross-section locations, in-line structures and bridges can be located with respect to their actual location.

The first steps in preparing the new riverine 100-year floodplain analysis involved compiling the following data for each main stream:

- Cross-sections contained within the ICPR model;
- Main stream alignment for each stream;
- Bridge Crossings from the original HEC-RAS models and updates per the ICPR model;
- Culvert Crossings form the original HEC-RAS models and updates per the ICPR model;
- Flow value results from the ICPR model for the 100-year, 3-day design storm; and
- Digital Elevation Model (DEM) utilized in the ICPR model.

The data was compiled within the GeoHECRAS hydraulic modeling program. For this analysis, Halfway Creek was considered and modeled as one (1) steam. Estero River was modeled was one (1) stream with two (2) branches, North and South Branch, connecting at a common junction along the river. Foe each stream, the cross-sections were evaluated and further refined to include ineffective flow areas and extended to ensure that high ground was attained at the ends. For each stream, the model was geo-referenced so that it follows the actual alignment of the waterway and can be easily referenced in other map programs such as Google Earth and ArcGIS Explorer.

Once the geometry and elevation data were complied, an evaluation of the flow input data was conducted. Using the ICPR model and the maximum flow results from the 100-year, 3-day design storm, flow values were selected at specific locations along the main waterway and provided as input for the HEC-RAS model. In the modeling program, the flow change locations are noted to occur at specific cross-section or river stations along the waterway.

The rationale for selecting the locations at which the flow amount changed was based upon the following criteria:

- Most upstream locations- at upstream boundary nodes;
- Locations of changes in waterway conditions (width, major crossings, etc.); and
- Locations where a major secondary conveyance connected to main stream.

Provided below in Table 5-1 is the flow input data for the Estero River, Main Branch.

Table 5-1: Estero River Main Flow Input Data

River Cross-Section/ River Station	100 Year, 3-Day Flow (cfs)
XS 41	1035.22
XS 27	1239.19
XS 16	1452.38
XS 13	1570.38
XS 10	1719.9
XS 6.6	2315.22
XS 1	2376.88

Provided below in Table 5-2 is the flow input data for the Estero River, North Branch.

Table 5-2: Estero River North Branch Flow Input Data

River Cross-section/ River Station	100 Year, 3-Day Flow (cfs)
XS 262	246.26
XS 248	428
XS 231	389.04
XS 227	444.95
XS 202	237.12

Provided below in Table 5-3 is the flow input data for the Estero River South Branch.

Table 5-3: Estero River- South Branch
Flow Input Data

River Cross-section/ River Station	100 Year, 3-Day Flow (cfs)
XS 169	252.12
XS 166	321.91
XS 151	406.75
XS 143.2	408.24
XS 130.1	455.14
XS 120	546.57
XS 102	784.31

Provided below in Table 5-4 is the flow input data for the Halfway Creek.

Table 5-4: Halfway Creek
Flow Input Data

River Cross-Section/ River Station	100 Year, 3-Day Flow (cfs)
XS 37.4	527.23
XS 28.4	516.45
XS 21.4	358.81
XS 19	552.99
XS 15.6	659.04
XS 9.05	828.21

Once the flow values were entered, the hydraulic models were executed, and results evaluated. The water surface elevation results in the HEC-RAS model were compared to the peak stages at the nearest node in the ICPR model for each waterway. For any comparison differences that were 1.0 feet or greater, the HEC-RAS model was reviewed further for additional adjustments in those areas of the greater difference. Adjustments made to the HEC-RAS model included updates to ineffective flow areas and Manning's "n" values along the cross-sections. After completion of any adjustments, the majority of the peak stage comparisons were considered acceptable, with the majority averaging with less than 0.5 feet +/- difference. Provided below in Table 5-5 and Table 5-6 are the 100-year stage comparisons for the modeled streams.

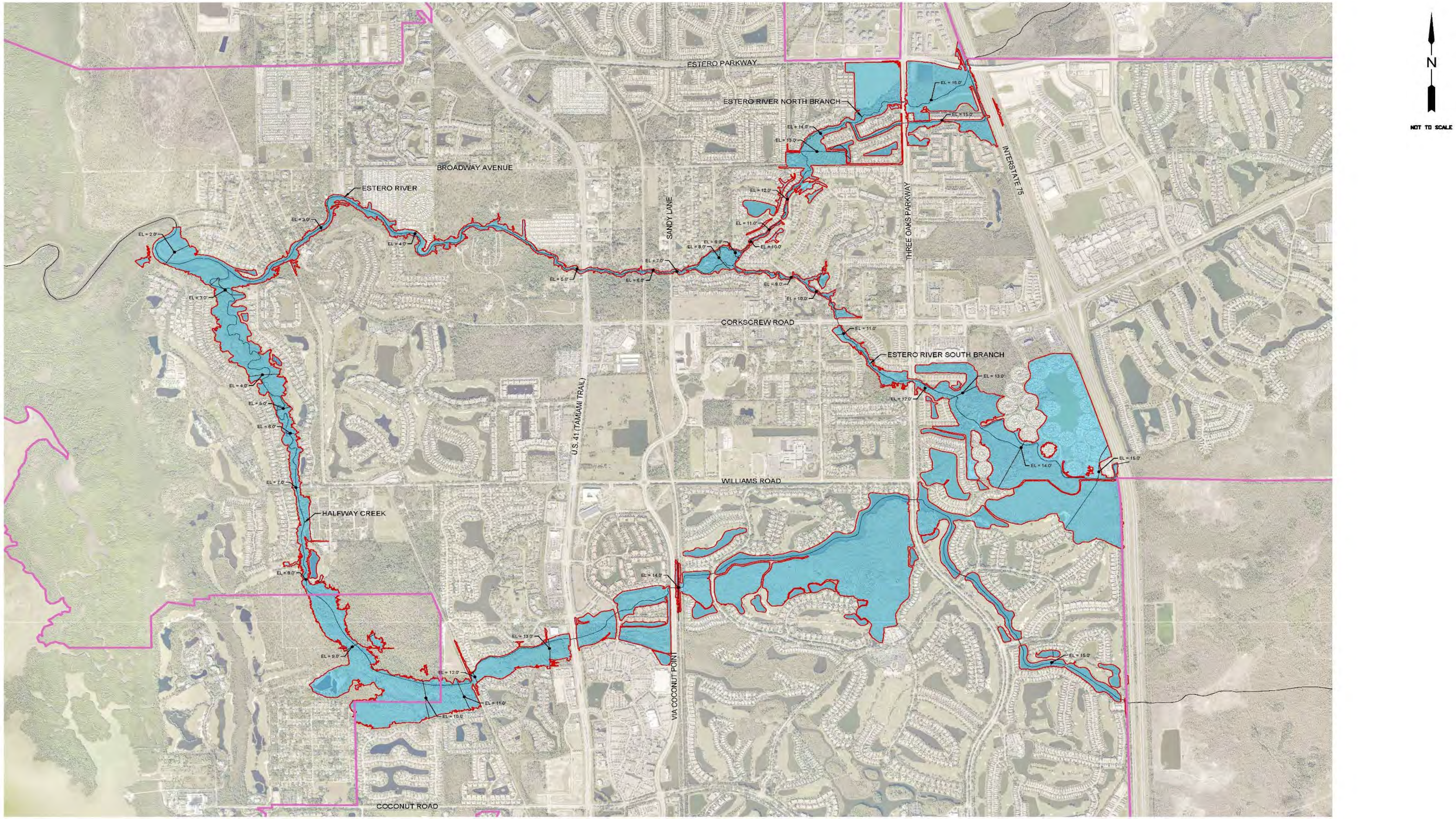
Table 5-5: Estero River - 100-Year Stage Comparison

Node/X-Section Station		Peak Stage (FT-NAVD)		Difference (ICPR-HECRAS)
ICPR4	HEC-RAS	ICPR4	HEC-RAS	
Upstream Nodes				
ERSB-N45	169	15.10	15.44	-0.34
ERNB-N41	262	15.91	15.53	0.38
ERNB-N36	256	15.65	15.04	0.61
South Branch Nodes				
ERSB-N39	166	14.42	14.04	0.38
ERSB-N30	151	11.82	12.46	-0.64
ERSB-NC27	143.2	11.30	11.67	-0.37
ERSB-N21	130.1	10.71	10.91	-0.20
ERSB-N15	120	9.94	10.46	-0.52
ER-N28.6	102	7.72	7.93	-0.21
Connection of N & S Branches				
ER-N27	41	7.33	6.86	0.47
North Branch Nodes				
ERNB-N32	248	15.42	14.97	0.45
ERNBD2-N5		15.17	14.97	0.20
ERNB-N21	231	15.10	14.54	0.56
ERNB-N17	227	13.01	12.99	0.02
ERNBD1-N3	202	7.57	7.70	-0.13
Main Branch Nodes				
ER-N22	27	4.54	5.08	-0.54
ER-N16	16	3.94	4.39	-0.45
ER-N13	13	3.14	3.73	-0.59
ER-N10	10	2.27	2.74	-0.47
ER-N6	6.6	2.12	2.47	-0.35
ER-N1	2	1.03	1.03	0.00

Table 5-6: Halfway Creek -
100-Year Stage Comparison

Node/X-Section Station		Peak Stage (FT-NAVD)		Difference (ICPR-HECRAS)
ICPR4	HEC-RAS	ICPR4	HECRAS	
HC-NT1	27	14.44	15.24	-0.80
HC-N69	16	14.25	14.41	-0.16
HC-N55	13	14.17	14.20	-0.03
HC-N34	10	13.81	13.55	0.26
HC-N24	6.6	11.55	11.62	-0.07
HC-N12	2	7.16	7.14	0.02

Based upon the 100-year floodplain analysis results, utilizing GeoHECRAS, the floodplain was delineated using the available Digital Elevation Model (DEM) prepared for the ICPR local-scale model along with additional as-built data for newly developed properties. The riverine floodplain delineation is based upon the peak 100-year water surface elevations determined in the HEC-RAS analysis. Included with Map 5-1 and Map 5-2 are the 100-year riverine floodplain boundaries for the Estero River and Halfway Creek. The floodplain elevations (FT-NAVD) are also shown on the enclosed maps. This analysis and associated mapping does not include the effects of coastal storm surge flooding.



NOTES:

1. 2018 AERIAL OBTAINED FROM LEE COUNTY, FLORIDA AERIALS.
2. REFER TO APPENDIX B FOR FULLSIZE, TO SCALE MAPS.

LEGEND

100-YEAR RIVERINE FLOODPLAIN (ZONE AE)
EL. -.-- = BASE FLOOD ELEVATION (FT-NAVD)

EXISTING VILLAGE OF ESTERO BOUNDARY

#	DATE	REVISIONS

J.R. EVANS ENGINEERING

J.R. EVANS ENGINEERING, P.A.
9351 CORKSCREW ROAD, SUITE 102
ESTERO, FLORIDA 33928
PHONE: (239) 405-9148
FAX: (239) 288-2537
WWW.JREVANSENGINEERING.COM

STORMWATER MASTER PLAN

MAP 5-1
100-YR RIVERINE FLOODPLAIN EXHIBIT

ELIZABETH A. FOUNTAIN, P.E.
FL. LICENSE NO. 60077
FL. COA # 29226

PROJECT #:	---
FILE DATE:	10/2017
DESIGN BY:	JMK
SCALE:	AS SHOWN
SHEET :	1 of 1

APPENDIX A

Integrated Surface/ Ground Water Modeling Report

Appendix A

Integrated Surface / Ground Water Modeling Report

Prepared by

Water Science Associates

Integrated Surface/Ground Water Modeling for the Village of Estero Watershed Lee County, Florida

PREPARED FOR:

J.R. EVANS ENGINEERING, P.A.
9351 CORKSCREW ROAD, STE. 102
ESTERO, FLORIDA 33928

JULY 2018

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Integrated Surface/Ground Water Modeling for the Village of Estero Watershed Lee County, Florida

Water Science Associates

JULY 2018

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Water Science Associates, Inc was contracted by J.R. Evans Engineering, P.A. to provide a regional modeling assessment for the Estero River and Halfway Creek watersheds. The purpose of the modeling assessment was to evaluate regional hydrology and provide ground and surface water boundary conditions to JR Evans that will be used in a Village-scale, detailed local-scale modeling assessment. The regional model used the integrated surface/ground water model MIKE SHE/MIKE 11, and the input files are based on files used in the Lee County Density Reduction/Groundwater Recharge project and the South Lee County Watershed Plan Update (SLCWM).

The scope of work includes incorporation of a number of model improvements with more recently acquired data sources, recalibration of the model to known hydrologic data, and development of boundary conditions for the Village ICPR model based on the updated SLCWM.

The model:

- Provides boundary conditions from the regional model calibrated to over 200 calibration stations for the local-scale modeling effort
- Provides base information for the development of a local-scale ICPR model to be utilized as an appropriate tool for evaluating development proposals located west of I-75.
- Utilized recent information from two large rainfall events in 2017, including Hurricane Irma, to support the calibration effort.
- Was used to identify areas with regional drainage problems
- Can be used to evaluate the impact of drainage changes on wet season water levels in the vicinity of the proposed improvements.

The model domain is over 400 square miles and includes the drainage basins of the Estero River, Halfway Creek, Spring Creek, and the Imperial River. The model domain extends north of SR 82 into Lehigh Acres, east of SR 29 in Hendry County, and south of Bonita Beach Road in Bonita Springs, Florida. This integrated surface/ground water model includes the Water Table, Lower Tamiami, and Sandstone aquifers as well as the Bonita Springs Marl and Upper Peace River confining units. The model includes groundwater pumpage from public water supply wellfields, and irrigation routines were used to represent irrigation from both agricultural and residential areas. The model has overland flow routines that simulate overland flow in large wetlands east of I-75 and has hydrologic routines established for mining areas. Major road culverts and/or bridges are represented in the model for the North and South Branches of the Estero River and Halfway Creek, including the Brooks by-pass gate and the outflow weirs west of the Brooks.

The model was calibrated to the 2013 – 2014 time period with the wet season of 2013 as the primary focus of the calibration. Measured data was obtained for more than 200 surface and groundwater monitoring stations, and calibration plots and statistical results were used during the calibration process. The calibration was considered to be successful for the 2013 wet season for 39 of 47 calibration stations that were within the focus area of the modeling domain.

The calibrated model is deemed appropriate for use in providing wet season boundary conditions for the Estero River and Halfway Creek at I-75. These boundary condition files can be used for more detailed ICPR modeling within the Village. The model provides acceptable results for the North and South Branch of the Estero River as well as for Halfway Creek. Simulated wet season groundwater levels within the Village of Estero are also considered to be representative of wet season conditions. Calibration during the wet season is particularly good at most stations with simulated values extremely close to measured values. The model calibration included a detailed analysis of peak water levels from major floods in August and September 2017 (Hurricane Irma delivered heavy rainfall to the watershed that had experienced heavy rainfall in late August). Because the field investigations in August and September of 2017 provided high water marks at more locations than were available in the wet season of 2013, the model input files were modified to better represent floodplain headloss during flood conditions.

Design storm simulations were conducted for the 5-, 10-, 25-, and 100-year rainfall events, and results from those simulations were extracted from model result files and provided to J.R. Evans Engineering, Inc. to provide boundary conditions for the local-scale hydrologic and hydraulic modeling. The results were extracted for locations along I-75 for the North Branch Estero River, South Branch Estero River, and Halfway Creek. Result files for the downstream boundary of the Estero River were also extracted and provided to J.R. Evans Engineering, Inc. A grid file of surficial aquifer levels for August 1, 2013 was provided to assist in local-scale model development.

The model is sufficient for analysis of regional hydrology and hydraulics during wet season conditions. Additional effort will be needed to evaluate wetland hydroperiods during both wet and dry season conditions. The recommended improvements include a more detailed representation of area of willow invasion in Corkscrew Swamp Sanctuary, more detailed calibration of groundwater levels in the Lower Tamiami aquifer, and more detailed calibration of irrigation demands of urban and agricultural areas.

1.0 BACKGROUND AND PURPOSE

Water Science Associates, Inc was contracted by J.R. Evans Engineering, P.A. to provide a regional modeling assessment for the Estero River and Halfway Creek watersheds. The purpose of the modeling assessment was to evaluate regional hydrology and provide ground and surface water boundary conditions to JR Evans that will be used in a Village-scale, detailed local-scale modeling assessment. The regional model used the integrated surface/ground water model MIKE SHE/MIKE 11, and the input files are based on files used in the Lee County Density Reduction/Groundwater Recharge project and the South Lee County Watershed Plan Update (SLCWM). The area of study is shown on Figure 1.

The scope of work includes incorporation of a number of model improvements with more recently acquired data sources, calibration of the model to known hydrologic data at over 200 surface and ground water monitoring stations, assessment of regional hydrology, and development of boundary conditions for the Village ICPR model based on the updated SLCWM.

The model:

- Provides boundary conditions from the regional model calibrated to over 200 calibration stations for the local-scale modeling effort
- Provides base information for the development of a local-scale ICPR model to be utilized as an appropriate tool for evaluating development proposals located west of I-75.
- Utilized recent information from two large rainfall events in 2017, including Hurricane Irma, to support the calibration effort.
- Was used to identify areas with regional drainage problems
- Can be used to evaluate the impact of drainage changes on wet season water levels in the vicinity of the proposed improvements.

2.0 MODEL UPDATE

Water Science Associates used and updated the MIKE SHE/MIKE 11 models for the Lee County Density Reduction/Groundwater Recharge project and the SLCWM as the basis of the regional model. The model domain is over 400 square miles and includes the drainage basins of the Estero River, Halfway Creek, Spring Creek, and the Imperial River. The model domain extends north of SR 82 into Lehigh Acres, east of SR 29 in Hendry County, and south of Bonita Beach Road in Bonita Springs, Florida, as shown in Figure 1. This integrated surface/ground water model includes the Water Table, Lower Tamiami, and Sandstone aquifers as well as the Bonita Springs Marl and Upper Peace River confining units. The model includes groundwater pumpage from the Green Meadows, Corkscrew, Pinewoods, and Bonita Spring Utilities wellfields. Irrigation from both agricultural and residential areas is withdrawn from the appropriate sources and is applied to land areas according to information obtained from permit files. The model has overland flow routines that simulate overland flowin large wetlands east of I-75 and has hydrologic routines established for mining areas. Major road culverts and/or bridges are represented in the model for the North and South Branches of the Estero River and Halfway Creek, including the Brooks by-pass gate and the outflow weirs west of the Brooks.

The updated model includes more recent topography, climate data, land use, hydrogeology, surface water information (surveyed river cross sections, new weirs, culverts, and gates), water use records for public water supply wellfields, and calibration data.

After updating input files and calibration of the model, surface and ground water result files have been provided to JR Evans that represent wet season conditions. The groundwater grid files will be used as an initial starting point in the Village ICPR model to be developed by JR Evans. In addition, 5-, 10-, 25- and 100-year design storm time series files of water levels and flows on the west side of I-75 were provided for the North Branch Estero River, South Branch Estero River, and Halfway Creek.

2.1 Initial Conditions and Simulation Period

The simulation period of 2013 through 2014 was selected for calibration. Information from large rainfall events in 2017 were used to check the reasonableness of design storm simulation results as discussed below in Section 3.2. The 2013 - 2014 period is within the simulation period used in the recent developments of the Lehigh Acres, Big Cypress Basin (BCB), and Collier County models, which will allow results from those models to be used as boundary conditions for the regional model. The 2013 to 2014 period includes the very wet conditions experienced in 2013 as well as relatively dry conditions during 2014. The initial water levels in the MIKE11, the Overland and the Saturated Zone components are adopted from the results from previous model runs at the end of the simulation period, i.e., January 1, 2015.

2.2 Topography

The South Florida Water Management District (SFWMD) maintains a topographic data base in GIS that includes the latest LiDAR data for Lee, Collier, and Hendry counties. Water Science downloaded the LiDAR files from the SFWMD and incorporated the new data using a 750-foot sampling resolution, as shown below in Figure 1. This digital elevation model (DEM) was modified for mining pits to represent best available information regarding the mine pit bottom elevations. Elevations within the study area range from +50-ft NAVD in the east portion of the model to -1 ft-NAVD along the coast on the west side of the model domain.

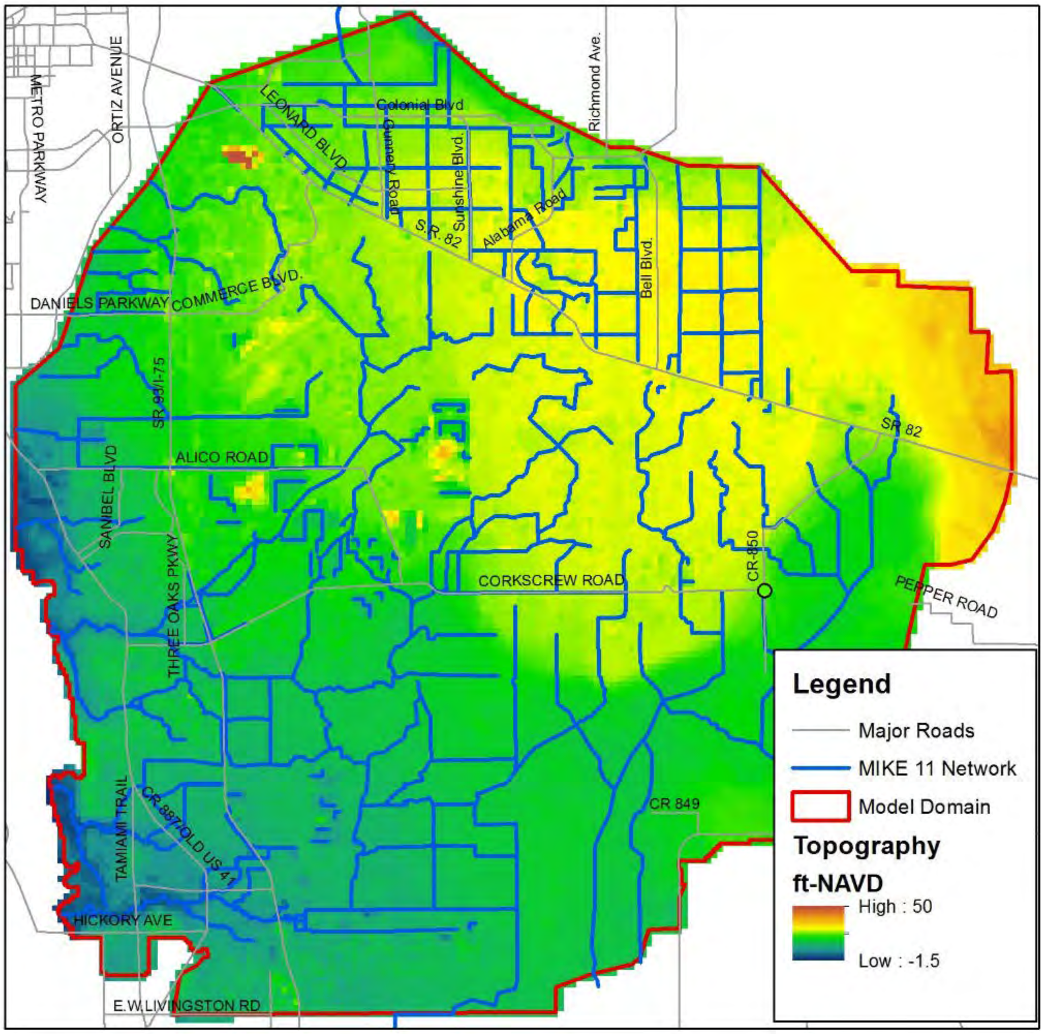


Figure 1 - Topography for the MIKE SHE Model

2.3 Climate

Rainfall. Hourly NEXRAD rainfall data was obtained from the SFWMD for the period from January 1996 through November 2016, and it was processed in into the appropriate format to be used in the MIKE SHE model. Figure 2 presents the plot of the hourly rainfall time series for a NEXRAD pixel near the center of the model domain. The annual average rainfall distribution is also presented in Figure 3.

Reference Evapotranspiration. Daily reference ET (RET) data was downloaded from the USGS website from the years 1995 through 2015 and processed into the appropriate format to be used in the MIKE SHE model.

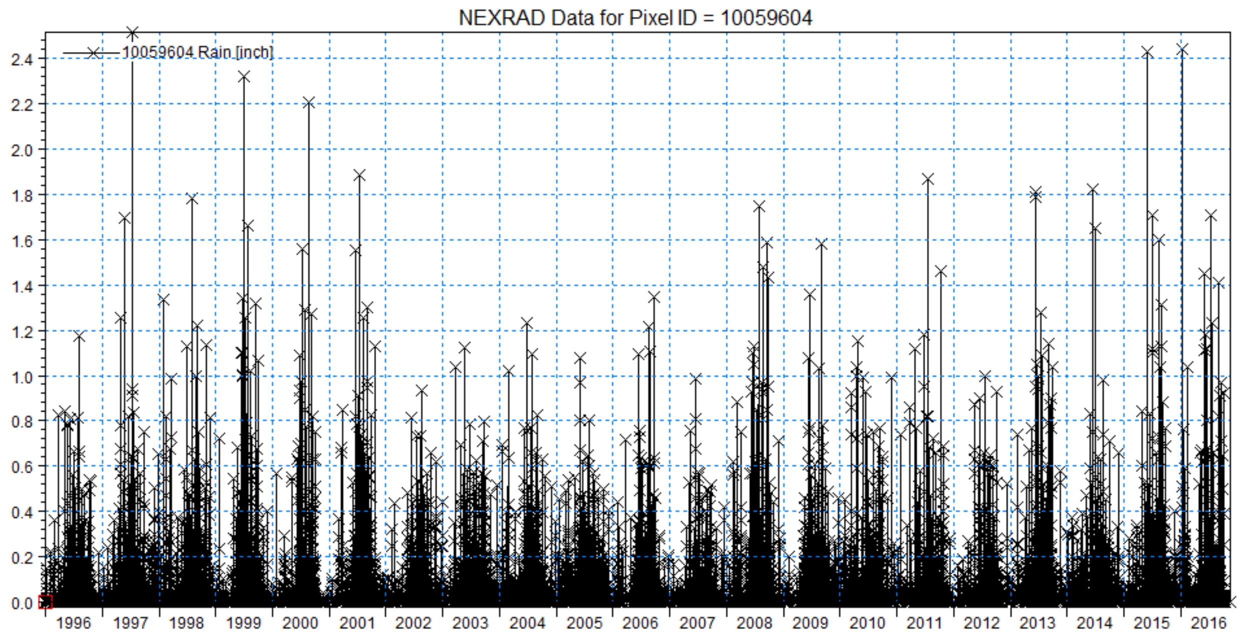


Figure 2 - Time Series of Rainfall for 1996 – 2016

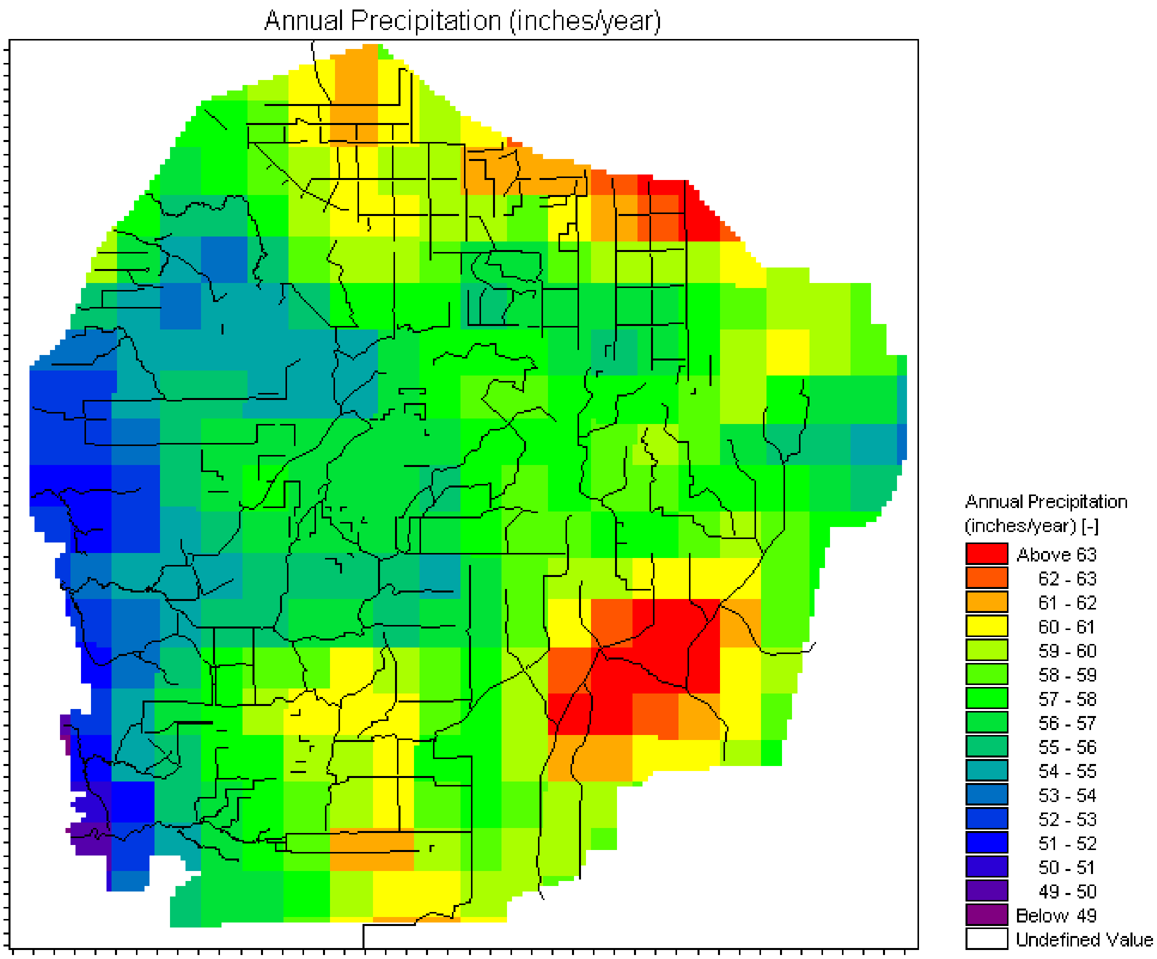


Figure 3 - Distribution of Average Annual Rainfall for 1996 - 2016

2.4 Land Use

Land use information in MIKE SHE influences the rainfall runoff process. Land use information is used to create other files such as detention storage, paved areas, overland roughness, and irrigation, which are then processed by MIKE SHE to govern infiltration and runoff. The source of the land use data was SFWMD land use files that were used in the 2009 South Lee County Watershed Plan Update (Boyle Engineering and ADA Engineering, 2009). The land use file was updated within the MIKE SHE graphical user interface to represent a number of developments that were constructed between 2009 and 2013, including eastern portions of Miromar, the Preserve, southern portions of Bella Terra, and Corkscrew Shores. In addition, changes were made in a number of agricultural areas that were abandoned between 2009 and 2013. Associated parameters such as drainage, detention, and irrigation were modified to be consistent with the land use changes

MIKE SHE uses land use codes that have land use-dependent information that is contained within a vegetation property database. This database includes information such as leaf area index and rooted depth of vegetation that vary through a typical year. It is impractical to provide all information for the hundreds of land use/land cover categories provided in the SFWMD land use file so 23 land use codes were selected for this modeling assessment, and the SFWMD land use categories were assigned to the most reasonable MIKE SHE land use code. For example, the MIKE SHE land use code for pasture includes SFWMD land use/land cover codes such as rangeland, improved pasture, unimproved pasture, and fallow crop land. Table 1 provides a listing of the SFWMD land use/land cover codes assigned to the MIKE SHE land use codes, and Figure 4 presents a map of the MIKE SHE land use distribution.

The crop development was extended up to year 2016 in order to cover the long-term simulation period. The vegetation database from the most recent model developed for the Collier County was used. The Crop Coefficient (which governs the percentage of Potential Evapotranspiration that is evaporated) was increased from 0.78 to 0.82 during calibration for Mesic Flatwood, Mesic Hammock, Xeric Flatwood, and Hydric Flatwood. In addition, the Crop Coefficient for Water was increased from 1.08 to 1.12.

Irrigation. Irrigation was specified for land use types based on SFWMD water use irrigation permit records. MIKE SHE uses an irrigation command area file to define which areas are irrigated, how irrigation is applied (sprinkler, drip, or sheet), and the irrigation source (river, single well, shallow well, or external). Irrigation from a single well is specified with State Plane coordinates, while shallow well irrigation is drawn from all grid cells that are included in a particular irrigation command area (ICA). Irrigation control parameters vary depending on the source. For wells, the screened interval is specified along with a maximum rate. For river irrigation, the input file includes information such as river name, section of the river (upstream and downstream cross section chainages1), maximum irrigation rate, and threshold start/stop values for either river flow or water level. A Licensed Limited Irrigation file was utilized for a number of ICAs which limits the rate of irrigation to a monthly maximum amount that can vary according to season.

In addition, irrigation command areas file was carefully checked within the Estero River watershed to assure that irrigated lands were represented in the model. Also, the type of irrigation and the water sources were checked and modified as appropriate. Figure 5 presents a map of the irrigation command area codes used in the model.

1 River chainage is a modeling term used to define the location of a cross section along a stream reach. It is equivalent to the HEC-RAS term "River Mile".

Table 1 - Cross Reference Table for MIKE SHE and SFWMD Land Use Codes

Code	MIKE SHE Label	Land Use FLUCCS Code
1	Citrus	2210, 2230
2	Pasture	1650, 1920, 2110, 2120, 2130, 2610, 8320
3	Sugar Cane & Sod	2420
5	Truck Crops	2140, 2150, 2156, 2160
6	Golf Course	1820
7	Bare Ground	1610, 1620, 1630, 1670, 1810, 7400, 8350
8	Mesic Flatwood	1900, 2240, 3100, 3200, 3210, 3300, 4110, 4410, 4430, 7470
9	Mesic Hammock	4200, 4220, 4270, 4271, 4340, 4370
10	Xeric Flatwood	4130
11	Xeric Hammock	3220
12	Hydric Flatwood	6240, 6250, 6260
13	Hydric Hammock	4240, 4280, 6110, 6111, 6180, 7430
14	Wet Prairie	6430
15	Dwarf Cypress	---
16	Marsh	6410, 6411, 6440
17	Cypress	6200, 6210, 6215, 6216
18	Swamp Forest	6170, 6172, 6191, 6300
19	Mangrove	6120, 6420
20	Water	1660, 1840, 2540, 5110, 5120, 5200, 5300, 5410, 5420, 5430, 5720, 6510
41	Urban Low Density	1110, 1120, 1130, 1180, 1190, 1480, 1640, 1800, 1850, 2320, 2410, 2430, 2500, 2510
42	Urban Medium Density	1210, 1220, 1230, 1290, 1760, 8120, 8330, 8340
43	Urban High Density	1310, 1320, 1330, 1340, 1350, 1390, 1400, 1411, 1423, 1460, 1490, 1540, 1550, 1560, 1700, 1710, 1830, 1870, 2520, 8110, 8113, 8115, 8140, 8200, 8300, 8310

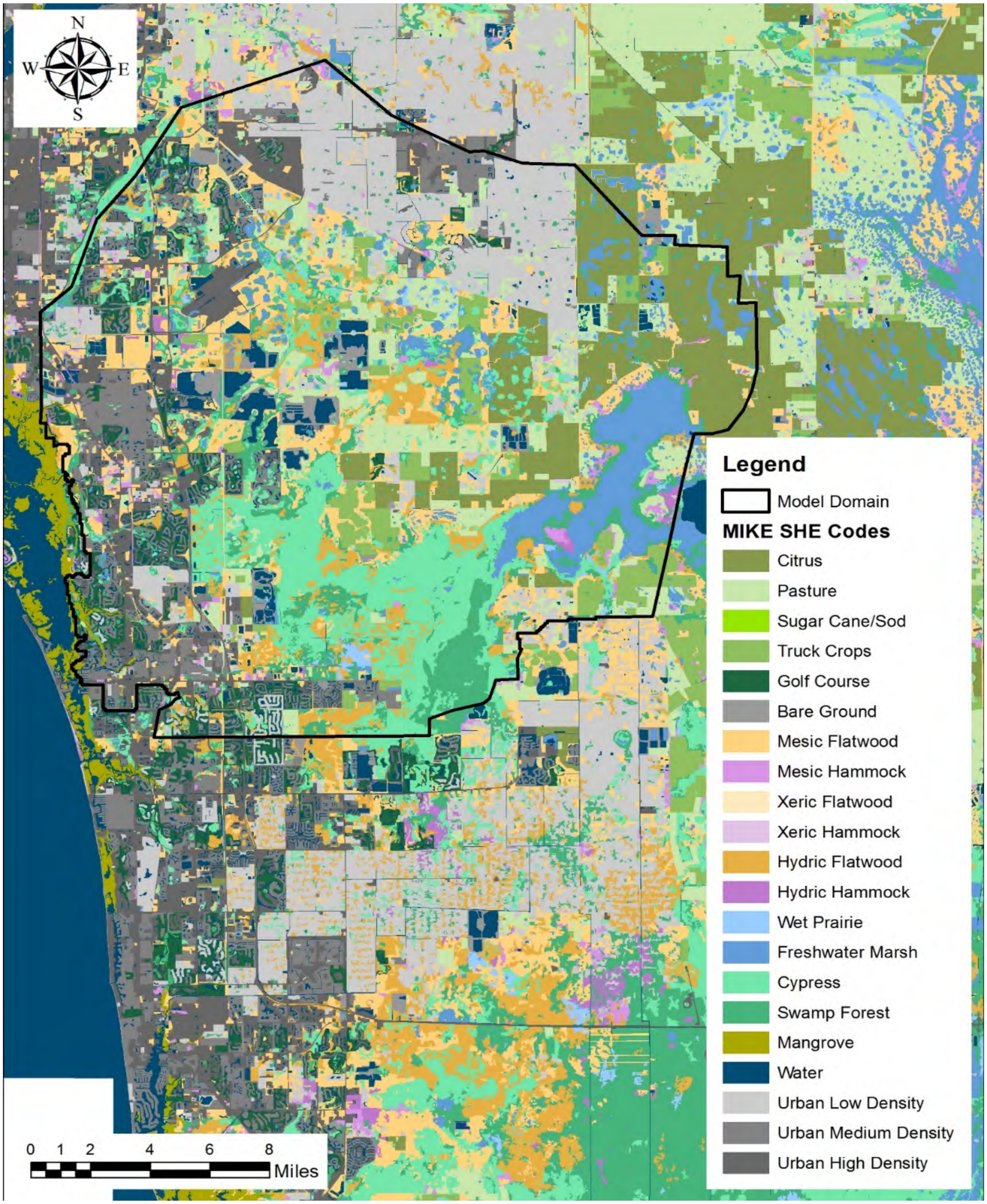


Figure 4 - Map of Grouped Land Use for MIKE SHE Model

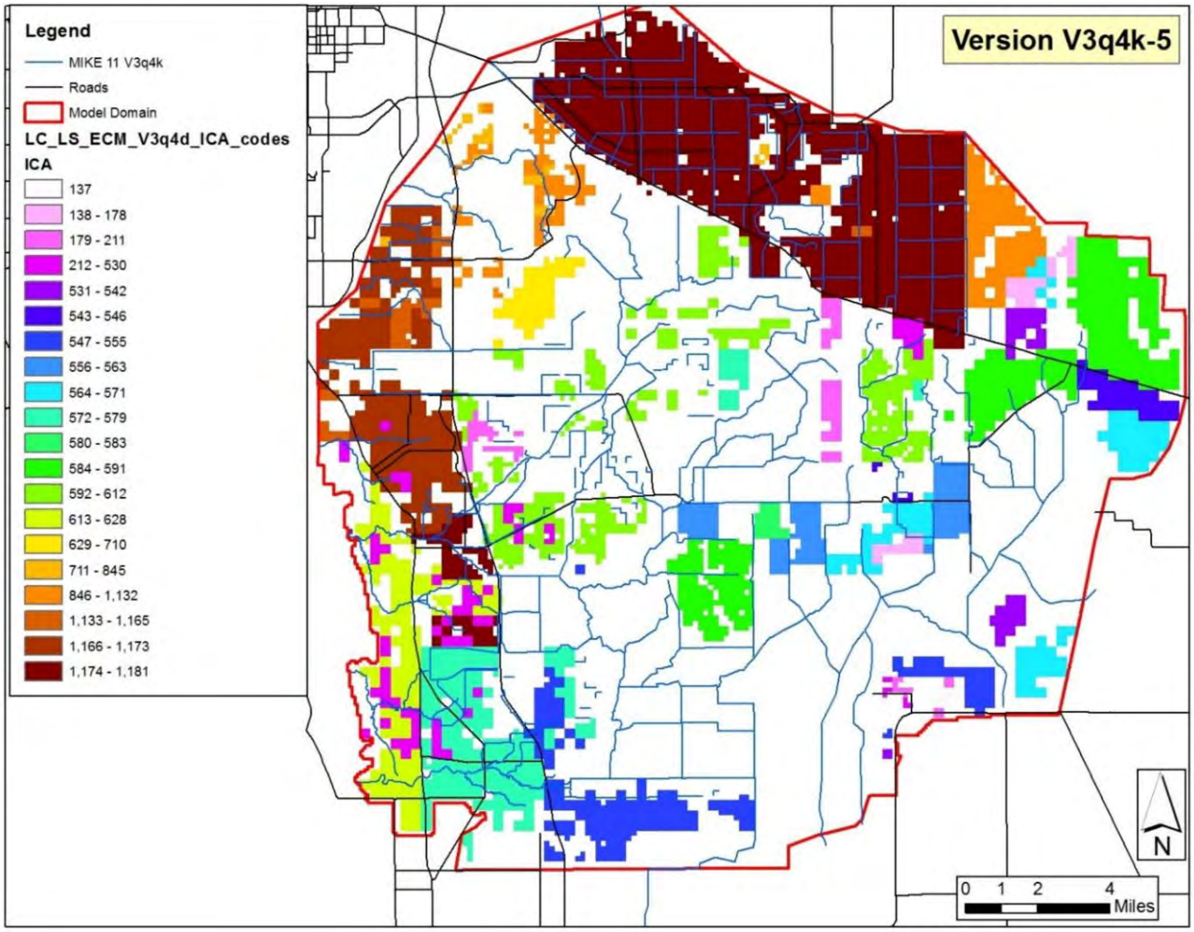


Figure 5 - Irrigation Command Area Codes

2.5 MIKE 11 Surface Water

Network. The MIKE11 network, presented in Figure 6 was modified in the Corkscrew Swamp area in accordance with the new flow paths from the most recent Collier County Model. North from SR-80 the branches and structures were replaced from the ones in the most recent model that is being used for watershed evaluations of the Lehigh Acres Municipal Services Improvement District (A.D.A. Engineering, Inc., 2016). In addition, the path of some branches in the western part of the model were redrawn, and other small branch segments added to represent stormwater detention facilities that attenuate wet season runoff. The cross sections were set to be consistent with the combined area within a development, and an outflow weir was added based on a review of permit files for the particular development.

Cross Sections. As for the MIKE11 branches, the cross sections in the Corkscrew Swamp area and north from SR-80 were adopted from the most recent models for Collier County and Lehigh Acres Models. At the end of the AlicoRdCan branch, the cross sections were adopted from the SFWMD Application # 991208-9. Some recent surveyed cross sections of the North and South Branches of the Estero River were also included (see Section 1.9 of the main report for additional information).

Flood Codes. Flood codes govern areas where water from MIKE 11 channels can enter the overland flow plane. This is important for rivers or channels that have abrupt constrictions where the water elevation in the river or channel is higher than the ground elevation for grid cells adjacent to the river. The flood codes map was modified in the Corkscrew Swamp area in accordance to the new flow paths from the most recent Collier County Model.

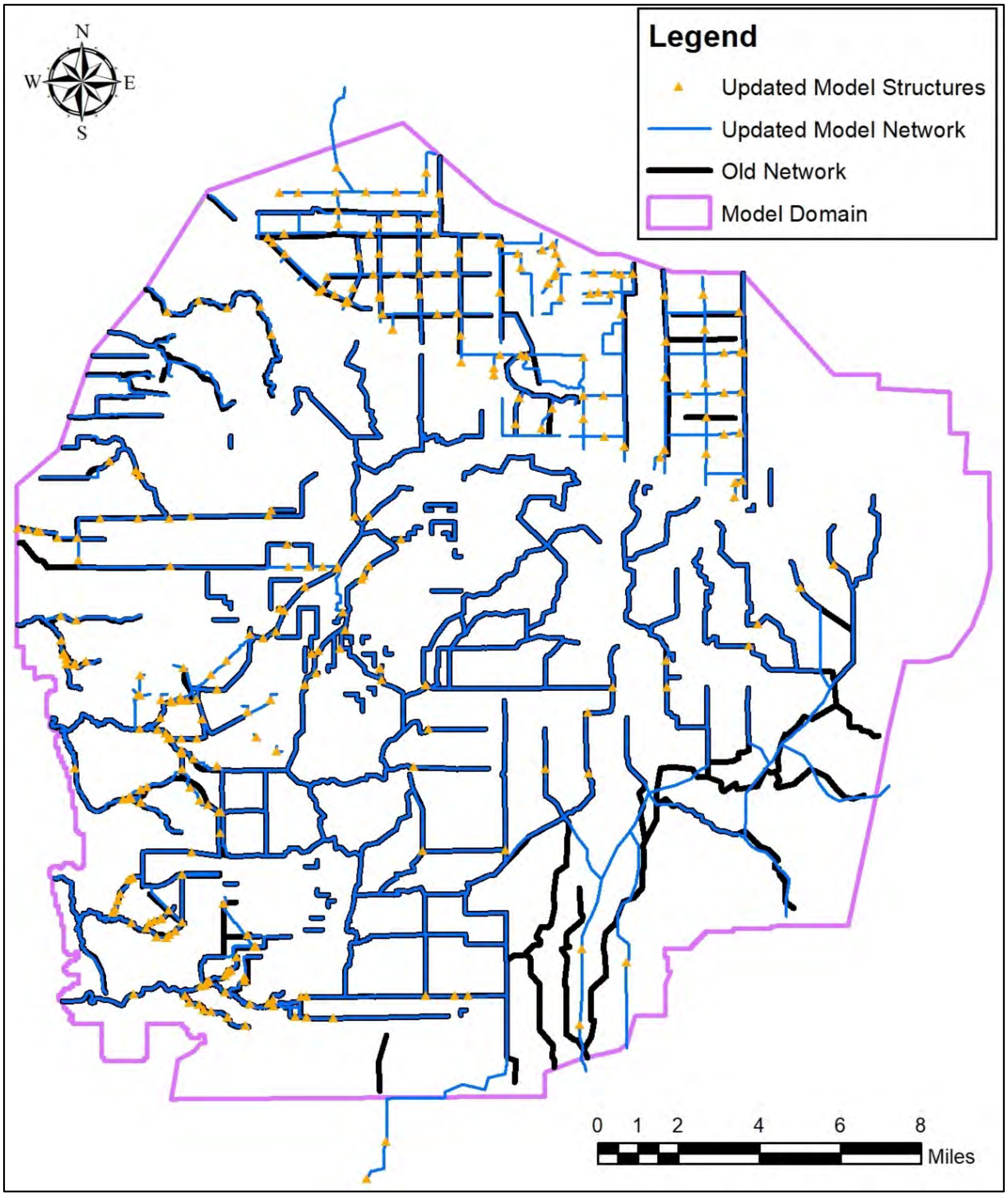


Figure 6 - MIKE 11 Network Illustrating Improvements Made for this Study

2.6 Overland Flow

Detention Storage is an empirical parameter within MIKE SHE that is used to represent stormwater detention when the MIKE 11 network does not adequately simulate on-site ponds and water control structures. This feature is used to govern runoff from both urban and agricultural land uses. Detention was increased in developed areas within the Estero River watershed to decrease wet season runoff in order to represent storage in lakes within developments such as Wildcat Run or Stonybrook where the MIKE 11 network does not represent the detention storage within large developments. The detention storage map is shown in Figure 7

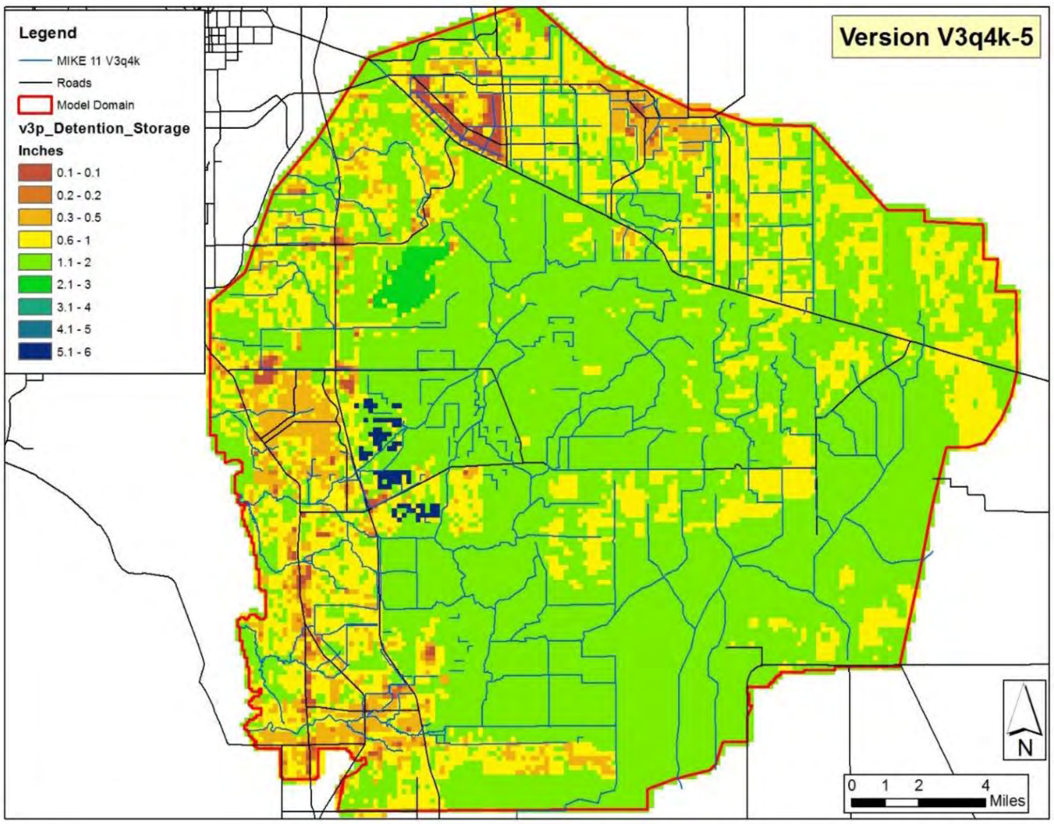


Figure 7 - Detention Storage Used in the MIKE SHE Model

The overland flow module of MIKE SHE also includes the option of specifying limits to overland flow, such as a major road that limits movement of water outside of river channels or for planned unit developments that have berms around the perimeter of the development. For these situations, a separated flow map is used. The separated overland flow area (SOLFA) map was subdivided north from SR-82 in accordance with the most recent Lehigh Acres model. The separated flow area map was also modified to represent a number of developments that regulate surface water runoff pathways, such as the Brooks and Miromar. The SOLFA map is presented in Figure 8.

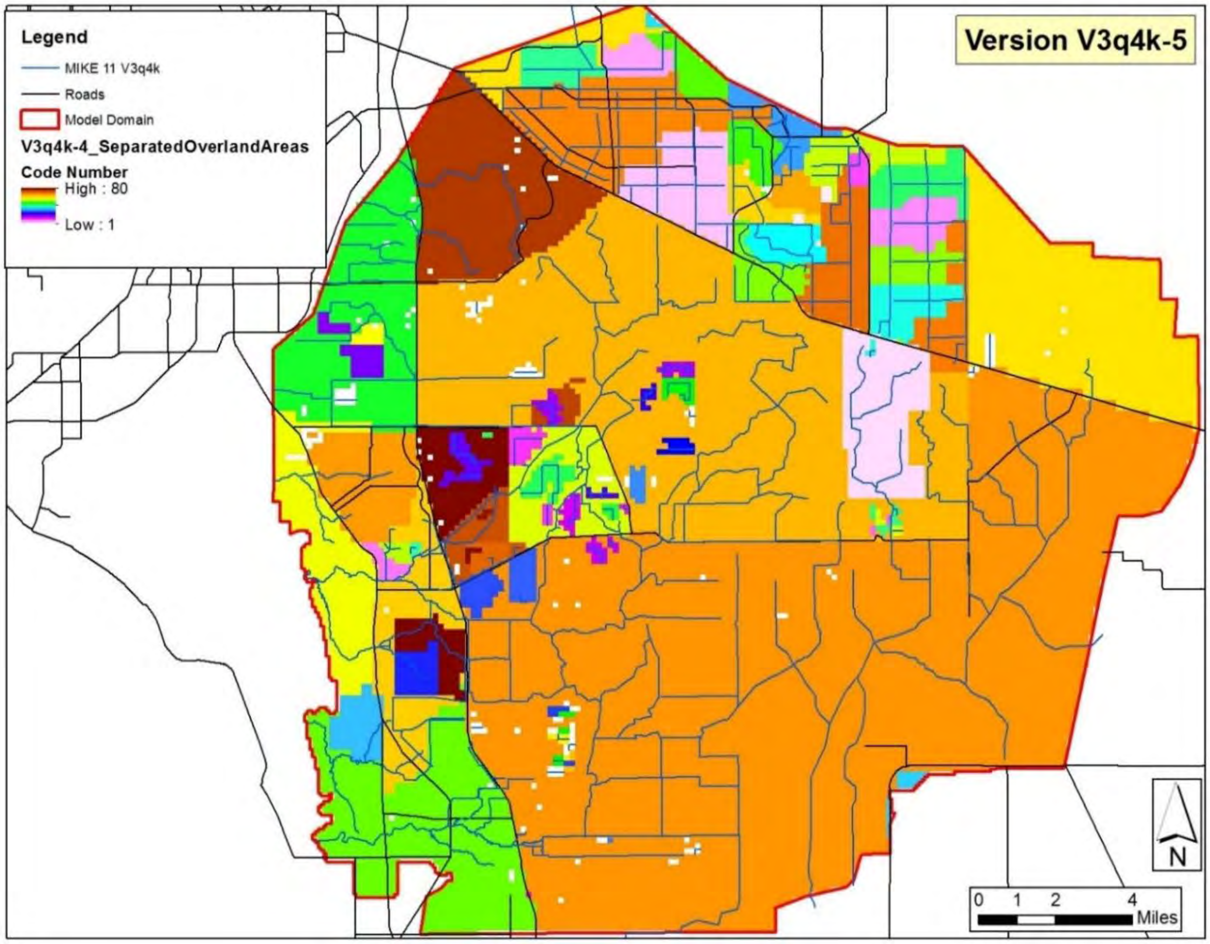


Figure 8 - Separated Flow Areas Used in the MIKE SHE Model

2.7 Unsaturated and Saturated Zone

The input parameters for the Unsaturated Flow component remain unchanged from files used in prior MIKE SHE models of the study area.

The following improvements were implemented for the Saturated Zone. Geological Layers and Lenses were modified as follows:

- Confining units are now represented as layers as shown in Figure 9. This representation is equivalent and simpler since the top elevation and horizontal extent of each confining unit does not have to be specified.
- The Mid-Hawthorn aquifer has been added. This aquifer is shallower in the model area than areas south of Bonita Springs, and the Mid-Hawthorn Aquifer is used in portions of the Estero River watershed as an irrigation supply.
- Top and bottom elevations for all geological layers were obtained from the most recent Lower West Coast Water Supply Update (SFWMD, 2015). These files produced significant improvements in the BCB model development conducted recently (add reference).
- Specific yield and specific storage parameters were set uniformly as in the recent Collier County model.

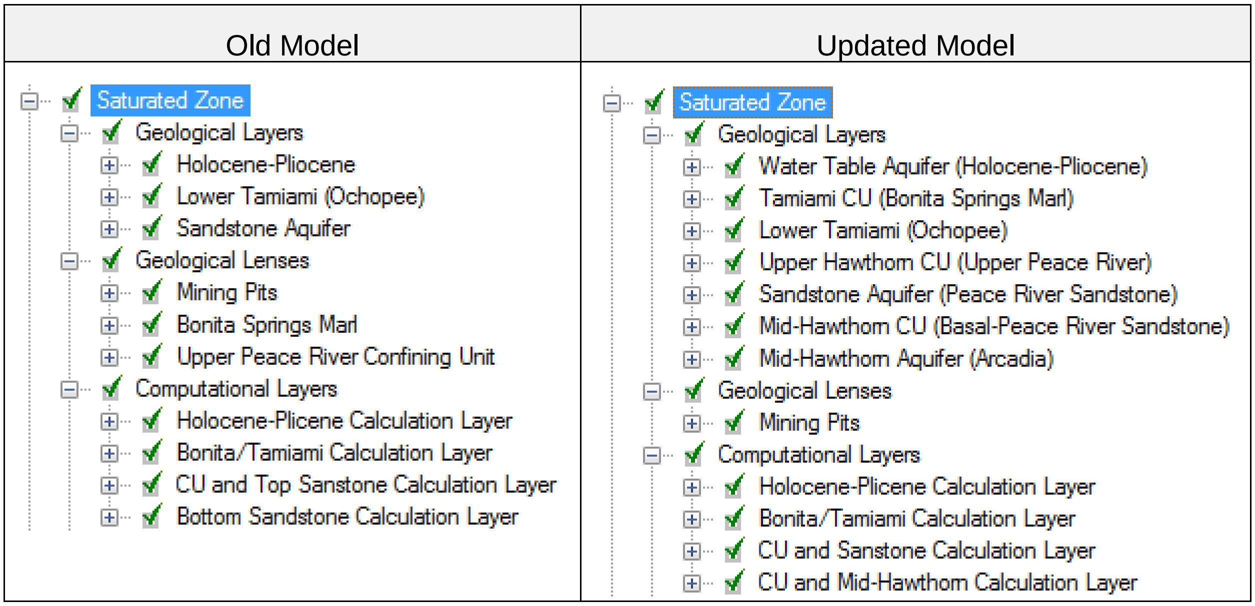
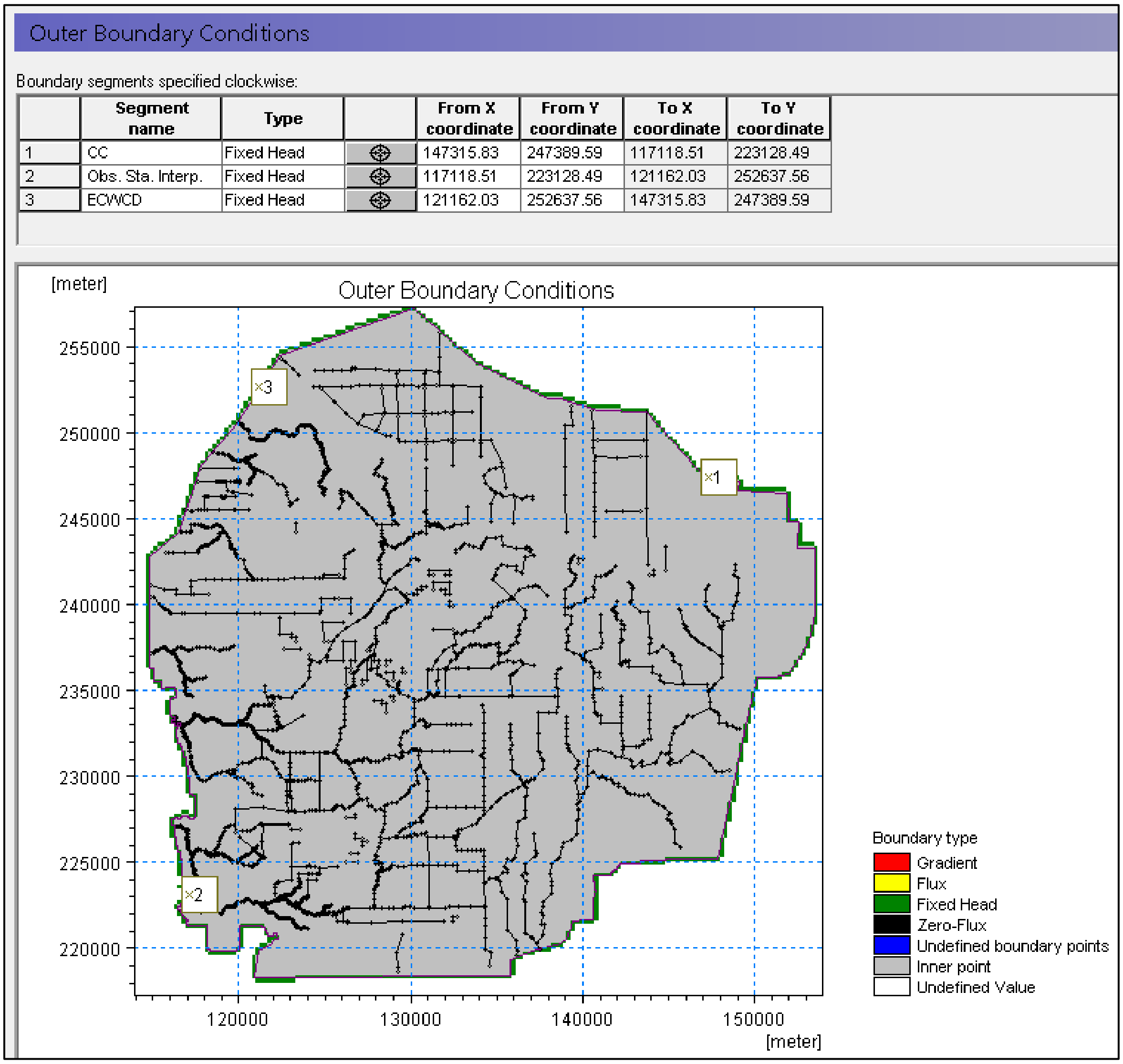


Figure 9 - Comparison of Groundwater Representation of Current Model to Prior Model

Computational layers are grouped aquifers and confining units that are used to improve model execution time. For example, the water table (Holocene-Pliocene) aquifer and the Bonita Springs Marl are merged into the Holocene-Pliocene Calculation Layer (see Figure 9). This approach was tested during the BCB model development and it was proven to reduce the simulation time without affecting significantly the calibration statistics.

Vertical and horizontal hydraulic conductivity values were set to uniform values at the beginning of calibration and were then modified during calibration according to calibration performance metrics. The end result was varying conductivity rates across the model domain. More information on this is presented below in Section 3.

Boundary Conditions. Model boundary conditions are assumed to represent water exchanges at the MIKE SHE model boundaries (exterior limits of the model). If simulated water levels for a given aquifer are higher within the model than the assumed level at the boundary, water will leave the model domain. Conversely, if simulated water levels within the model are lower than assumed levels at the boundary, water is imported into the model. Since it is difficult to determine the appropriate water levels at the boundaries, the model domain is larger than needed so that any water exchanges at the boundary are minor compared to the water movement within the primary area of interest. When other MIKE SHE modeling efforts have been conducted that have the same simulation period and encompass the limits of a new model, results from those modeling efforts can be used for model boundaries, which greatly reduces model error. In this modeling study, results were used from two other modeling studies to generate boundary conditions, as shown below in Figure 10. On the northern domain of this study, boundary conditions were generated from a MIKE SHE/MIKE 11 model that is being used by the Lehigh Acres Municipal Improvement District (the boundary between points 3 and 1 in Figure 10). The western and southern boundary conditions were obtained from the BCB model recently developed for Collier County (the boundary between points 1 and 2). The western portion of the model is the Gulf of Mexico, which simplified this boundary. The northwest portion of the model runs along the centerline of Six Mile Cypress and Ten Mile Canal, and measured water levels at a number of stations along those two surface water bodies were used. In addition, groundwater data for wells in the vicinity of Six Mile Cypress and Ten Mile Canal were used for groundwater boundary conditions.



	Segment name	Type		From X coordinate	From Y coordinate	To X coordinate	To Y coordinate
1	CC	Fixed Head		147315.83	247389.59	117118.51	223128.49
2	Obs. Sta. Interp.	Fixed Head		117118.51	223128.49	121162.03	252637.56
3	ECWCD	Fixed Head		121162.03	252637.56	147315.83	247389.59

Figure 10 - Boundary Conditions Used in MIKE SHE Model

Drainage. Drainage is an empirical model parameter that is used to represent the impact of field-scale ditches on drainage from the Water Table Aquifer to the MIKE 11 network. The components of drainage are drainage depth (a value less than zero relative to the ground surface), drainage time constant (1/day), drainage codes, and drainage option distribution. Natural lands typically are not drained, while developed lands often have higher drainage depths due to roadside or agricultural ditches. Citrus agricultural operations have higher drainage depths which are required to maintain adequate root health. The drainage time constant is the inverse of the number of days that it takes for the drainage water to reach the MIKE 11 branch. A drainage depth of 3 feet with a drainage time constant of 0.25 indicates that the model will deliver drainage flow in the upper 3 feet of the soil profile over a four-day period (1/4 = 0.25). Drainage depths are shown in Figure 11 and drainage time constants are shown in Figure 12. Drainage codes are used in certain areas of the model to specify where drainage flows will be routed. Negative drain codes are used where drainage is routed to nearby depressions or wetlands (referred to as local depressions in MIKE SHE terminology), and positive drainage codes are used where drainage is routed to the nearest river segment as shown in Figure 13. The option distribution grid file (see Figure 14) is used to specify the destination of drainage for any value greater than zero. Most of the model has negative drainage codes, while eleven areas have positive drainage codes as shown in Table 2.

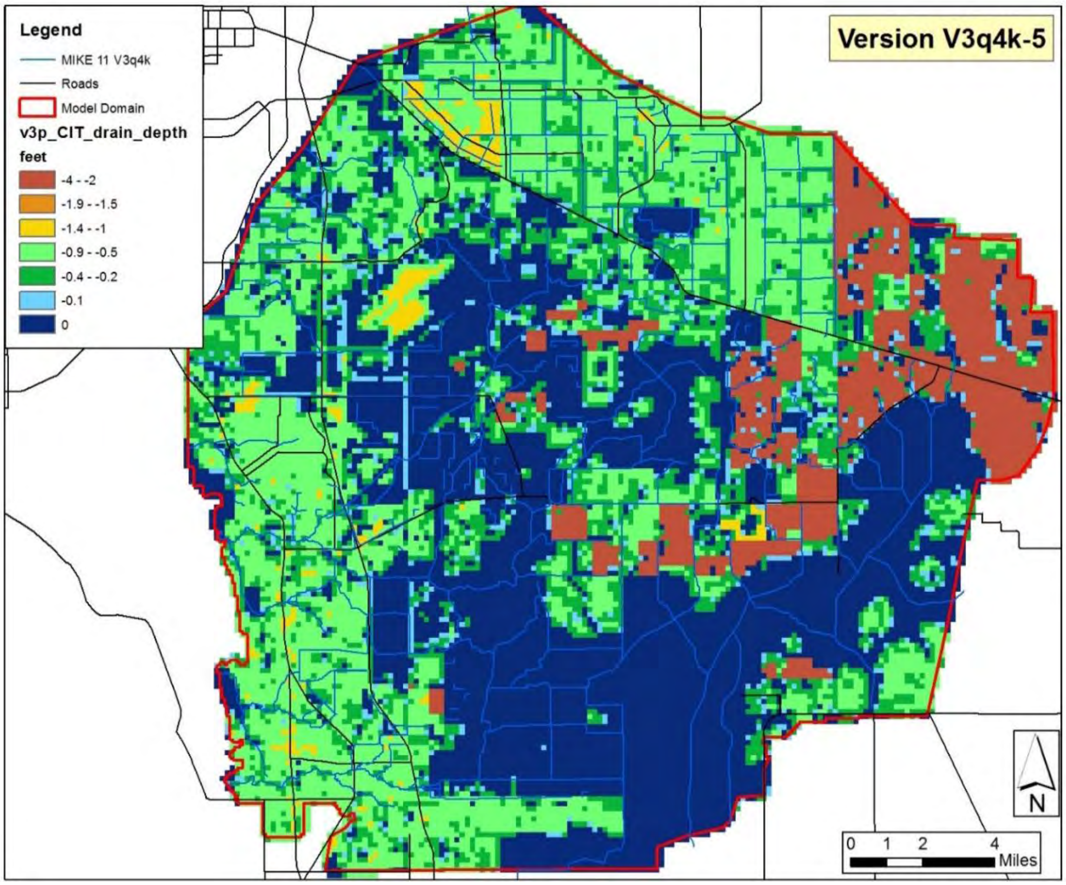


Figure 11 - Distribution of Drainage Depth Used in MIKE SHE Model

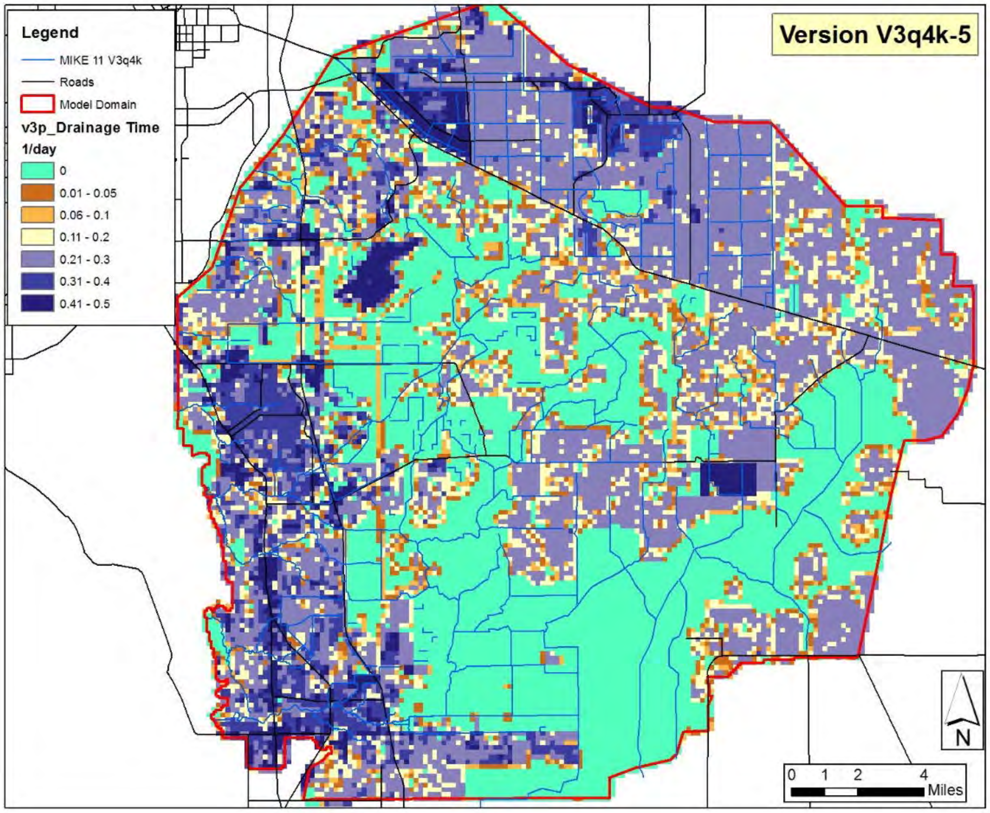


Figure 12 - Distribution of Drainage Time Constant Used in the MIKE SHE Model

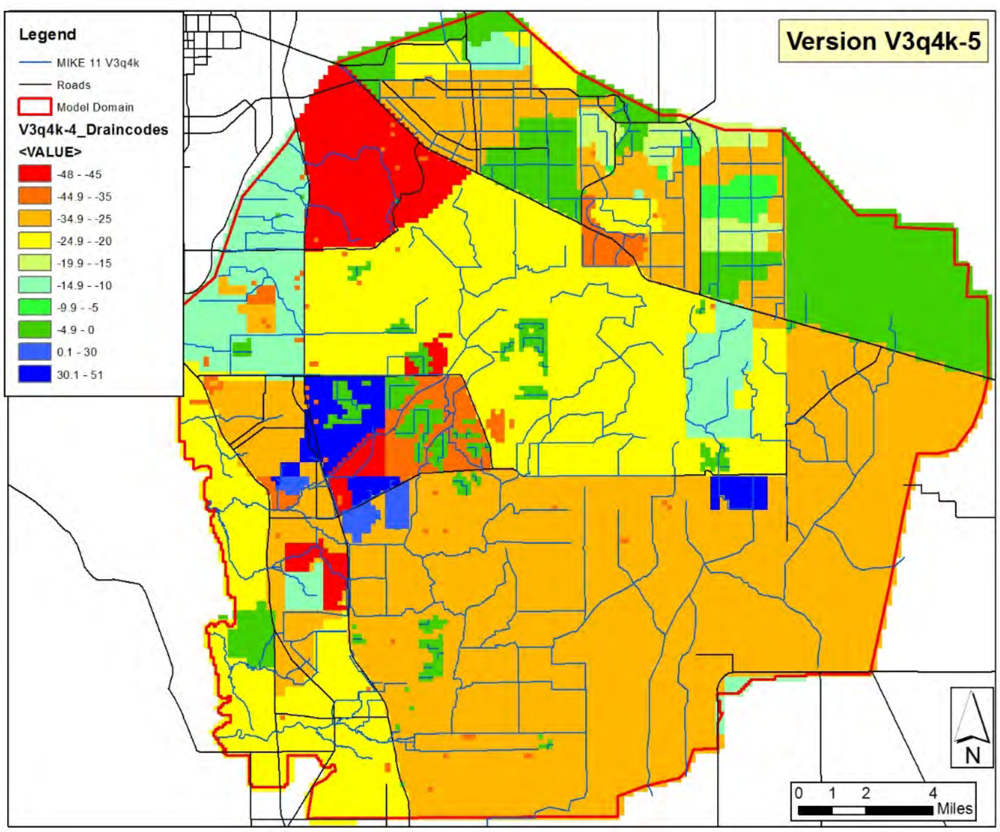


Figure 13 - Drainage Codes Used in the MIKE SHE Model

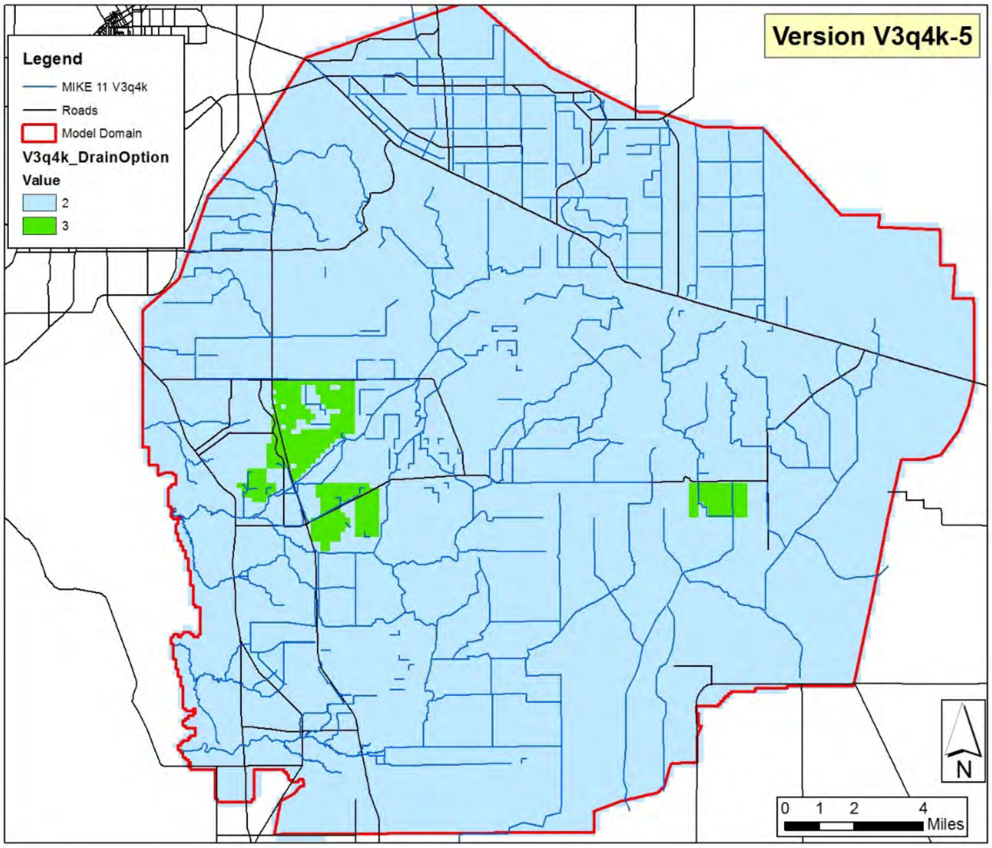


Figure 14 - Drain Option Code used in the MIKE SHE Model

Table 2 - Drain Codes Used in MIKE SHE Model

Drain Code	MIKE 11 Branch	Upstream chainage (meters)	Downstream chainage (meters)
17	Cascade Outfall 1	0	50
21	StoneyBrook Outfall	0	50
25	Rookery Point	0	50
29	Wildcat Run 4	0	50
40	Grandezza Outfall	0	50
41	Grandezza Outfall 2	0	50
42	Cascade Outfall 2	0	50
43	Reserve West Ditch	0	50
44	Village San Carlo	0	50
50	CorkIrrCanW	3367	4535
51	MiningP10S	0	914

Municipal Potable Water Withdrawals. The well component of MIKE SHE comprises only municipal potable water supply wells. The irrigation routine is used to simulate pumpage associated with irrigation associated with agriculture and large residential developments. The well locations and screen interval were taken from the Water Supply Permitted Facility Site shape file (imerrwuf.shp) as on October 21, 2015. The monthly pumping extraction data reports for all the wells was obtained from the SFWMD for years 2006 throughout 2015. This raw data was processed to convert it to more useful tables, and then, to time series files. Table 3 shows the number of wells in the updated model database for the different well fields. The well locations are presented in Figure 15.

Table 3 - Well Fields Represented in MIKE SHE Model

Permit	Well field	Aquifer	No Wells
36-00003-W	Lee County Utility - Green Meadows	LTA/SSA	27
36-00003-W	Lee County Utility - Corkscrew	LTA/SSA	53
36-00008-W	Bonita Springs	LTA	21
36-00122-W	Gulf Environmental Services	WTA/SSA	12
36-00166-W	Lehigh Acres Utilities	SSA	20
36-00208-W	Citrus Park	WTA/LTA	3
		Total	332

Note: LTA is Lower Tamiami Aquifer
WTA is Water Table Aquifer
SSA is Sandstone Aquifer

2.8 Observation Stations

Observation station data were adopted from recent models or compiled otherwise for years 2013 and 2014. Data through 2015 for all stations were added to existing databases that include data from 2006, thereby providing data for the continuous period of 2006 to 2015. The location was not limited only to the model domain but also to the surrounding area in order to generate time-varying head maps that are used to impose boundary conditions, as detailed in a previous section.

Table 4, below, summarizes the number of observation stations with data inside the model domain that are available to conduct the calibration of the model. In comparison to previous models, some stations were eliminated since the data collection ended before the year 2013. There are also other stations incorporated mainly from other sources, such as data reported to Lee County by private land managers. Maps of the calibration stations are presented below in Section 3.

Table 4 - Types of Calibration Stations Used in Calibration Effort

Component	Type	DBHYDRO + USGS	Lee County	LA-MSID	Other	Total
Surface Water	Stage	6	0	29	1	36
	Flow	4	0	3	0	7
Ground Water Aquifers	Water Table	13	67	0	22	102
	Lower Tamiami	19	11	0	2	32
	Sandstone	14	1	0	0	15
	Mid-Hawthorn	9	0	0	0	9
Total		65	79	32	25	201

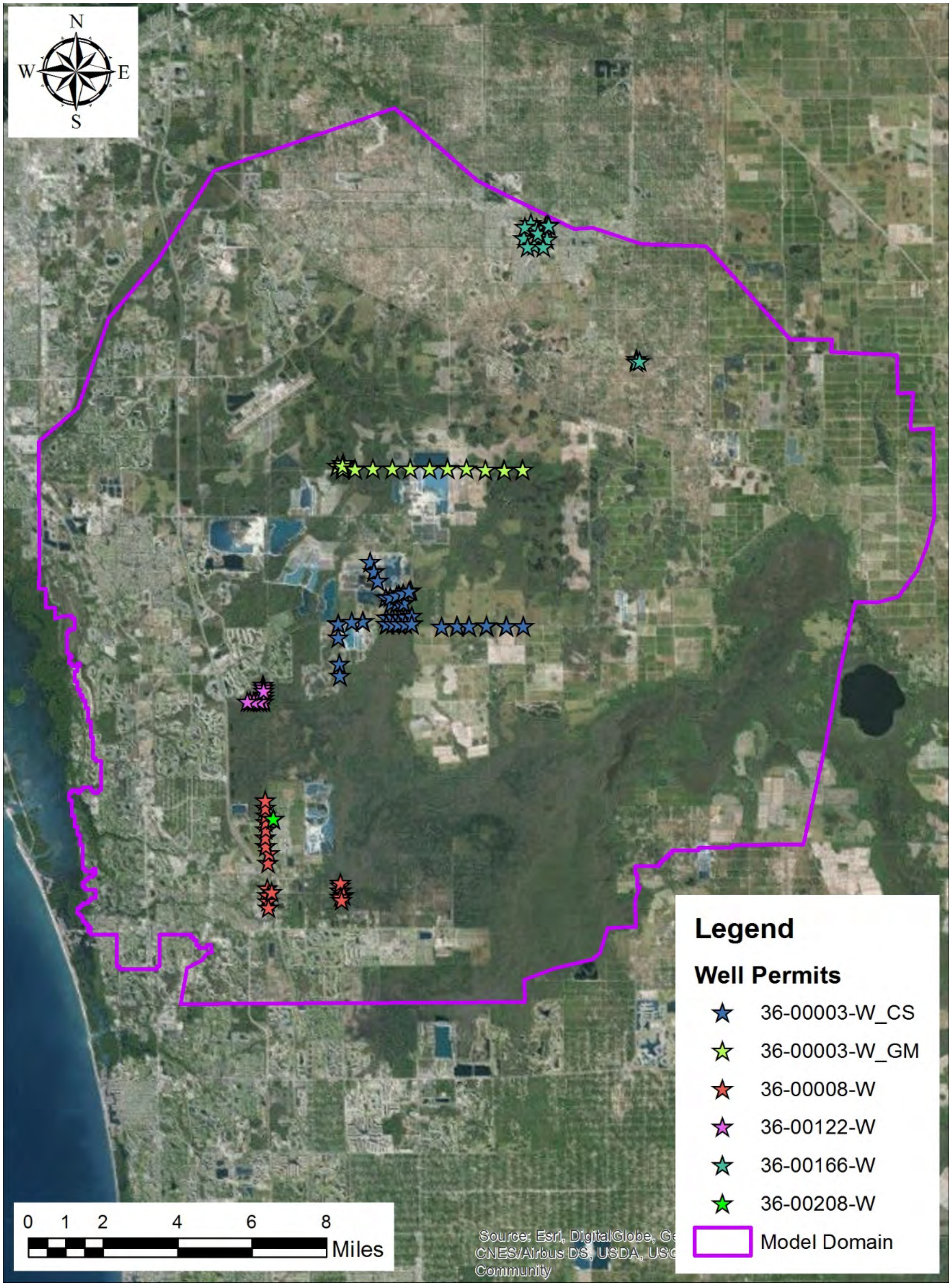


Figure 15 - Location of Wellfields in the MIKE SHE Model

3.0 CALIBRATION

3.1 Calibration Approach

Model calibration is a process of developing an input data set that allows the model code to simulate changes in water levels and river flows over a specified period of time that is a close approximation of reality, or observed conditions. The calibrated model is a simplification of actual conditions because it is not possible to fully represent the myriad of factors that govern both surface and ground water flow in a 418-square mile area. However, applying changes to model inputs is a key calibration process and allows reasonable estimation of some unknown conditions. Model simulation results at the 203 calibration stations described above were compared to measured water levels and flows, and adjustments were gradually applied to input data to improve calibration. Calibration is measured through visual inspection of calibration plots as well as a review of the statistical performance of the model. The simulation period for calibration was initially set to January 1, 2013 through December 30, 2014. The calibration period was then reduced to the 2013 wet season since the primary focus of this project was to provide boundary conditions for a local-scale detailed ICPR flood simulation model for the Village of Estero west of I-75.

During the later phases of calibration, heavy rainfall during August and September of 2017 provided an unique opportunity to compare peak stages of design storm simulations using the model that resulted from this calibration effort to these observed 2017 peak stages. Two rainfall events of August 23 through 27 and September 9 through 14 (associated with Hurricane Irma) resulted in rainfall amounts averaging 11.6 and 9.4 inches, respectively. Two events of this magnitude within a three-week period is extremely rare, which resulted in new period-of-record maximum peak stages and flow at the North and South Branch Estero River USGS gages. Therefore, it was decided to further adjust model input data so that 100-year design storm peak stages were reasonably similar to 2017 peak water elevations and flows. The sections below discuss the adjustments made to input data during the calibration process, calibration statistics used in calibration, the results of the calibration process, and recommendations for future modeling studies of the Estero River, Halfway Creek, Spring Creek, and Imperial River.

3.2 Calibration

The three primary statistical measures for calibration are mean error, mean absolute error and correlation coefficient. Mean error is the arithmetic average of the difference between the simulated and measured water levels or flows during the calibration period. Mean error can be 0.0 (perfect calibration) if half of the differences are -1.0 foot and the other half of the differences are +1.0 foot, therefore this calibration parameter needs to be complimented with other calibration metrics. The mean error statistic is an effective statistic to quantify the overall model performance relative to measured data. For example, if most stations have a mean error of 1.0 foot, then model's ability to simulate reality is biased. Mean absolute error is the arithmetic average of the absolute difference between the simulated and measured water levels or flows during the calibration period. The correlation coefficient is used to measure the strength and direction of the linear relationship between the measured data and the results at that location in the model. A value of 0 indicates no correlation, a value of 1 indicates an exact correlation. For the purposes of this study, the guidelines presented in Table 5 were used during calibration.

Table 5 - Calibration Performance Metrics

Performance	Mean Error (ME)	Mean Absolute Error (MAE)	Correlation Coefficient (r)
Good	-0.5 to 0.5 ft	<0.75 ft	>0.80
OK	-1.0 to -0.5 or 0.5 to 1.0	>0.75 and < 1.0 ft	>0.65 and < 0.80
Poor	<-1.0 or >1.0	>1.0 ft	<0.65

Groundwater calibration performance is presented in Table 6, Table 7, Figure 16, and Figure 17. Calibration plots are presented in Appendix 1. Calibration, as measured strictly by the calibration statistics, was considered good in 37 of 74 stations for MAE and 52 of 74 stations for correlation coefficient. Model performance considered both good and OK for 48 of 74 stations for MAE and 63 of 74 stations for correlation coefficient. In all of the stations where calibration was considered to be OK, the calibration was very good in the wet season, which is the primary focus of this modeling project. The mean error for the surficial aquifer groundwater stations is 0.1 feet, which is another indication of acceptable model performance. As stated above, the main objective of this modeling assignment was to provide boundary conditions for an ICPR model of the Estero River watershed west of I-75. Calibration is important primarily at those stations that would impact the ability of the model to provide accurate boundary conditions to the Village-scale ICPR model, and of those 47 stations (indicated by bold station names in Tables 6 and 7), 39 stations perform well in the wet season, and two stations do not perform well in the wet season primarily due to the station location next to ditches that regulate water levels. For example, calibration at well 47A-GW06 (see appendix for plot) is affected by a stormwater pond located next to a car dealership. The pond is not in the model, and the simulated stages are lower than measured stages. It is suspected that groundwater recharge from the pond results in measured water levels that are higher than simulated water levels. Calibration could be improved if the MIKE 11 network was modified to include that pond, however the regional nature of this modeling project precluded inclusion of all local stormwater ponds. Of the 47 primary stations, model performance is ranked as “sort of good” at six stations where the model performance is good for a portion of the wet season or the model is slightly higher or lower than measured values.

The following adjustments were made during the calibration process:

1. Improved cross sections were obtained for the North Branch Estero River, and the location of the USGS gaging station was found to be incorrectly mapped in GIS files available from SFWMD. The location of the North Branch Estero River gaging station was corrected in the MIKE SHE model, which improved calibration.

2. In spite of the corrected location of the USGS gaging station, simulated flows during the early phases of the calibration process were too high during the wet season. As a result, many calibration simulations were run that changed a wide variety of parameters, which significantly improved the calibration. All changes were reasonable and within normal ranges. The changes that proved to be effective are listed below:

    a. The Crop Coefficient for water (which governs evaporation from mining pits) was changed from 1.08 to 1.12. A water budget comparison was conducted, which found that this change increased evaporation from 88 to 92% of rainfall. The higher evaporation rate is considered reasonable.
    b. A number of separated overland flow areas (SOLFAs) were implemented to reduce the rate of runoff to the North Branch Estero River. SOLFAs were added for Grandezza, Florida Gulf Coast University, Miromar, the Reserve at Estero, and a number of developments north of Estero Parkway west of I-75. MIKE 11 branches were added for those SOFAs with cross section storage added to represent on-site stormwater detention ponds. Weirs were added based on information obtained from permit files.

c. Additional detention storage was added for some of the developed areas in the vicinity of the North Branch Estero River west of I-75 (see Figure 7).
d. Drainage was routed to the upstream sections of branches added to represent on-site detention storage.

3. Vertical and horizontal hydraulic conductivity of the surficial aquifer was modified in a systematic manner to improve calibration. The initial calibration runs used the same conductivity values for the entire model domain and subsequent calibration runs were conducted with +50% and -50% conductivity values. Where the change in conductivity resulted in improved calibration, the modified conductivity was retained in the vicinity of that calibration station. This process was repeated multiple times, and surficial aquifer conductivity maps became less uniform according to the results of the calibration checks. In general, horizontal conductivity values were maintained as 10x vertical conductivity. Vertical and horizontal conductivity maps used in the model are presented in Appendix 2. The specific yield of the Water Table Aquifer was set at 0.15.

4. Cross section roughness was assumed to have a Manning's "n" of 0.05 for river channels, while overbank (e.g. floodplain) roughness was assumed to have a Manning's "n" of 0.2. MIKE 11 utilizes markers to indicate the boundary between channel flow and overbank flow. The markers can be used to define the width of channel flow. Field visits were conducted to determine the typical width of channel flow, and marker positioning was set in accordance with the information obtained from field visits. In some channel reaches east of I-75 that were predominantly broad wetlands with very narrow sections of channelized flow, the entire cross section Manning "n" roughness was set to 0.2. This approach was modified after reviewing observed peak stages during August and September 2017, as discussed below.

5. After the completion of calibration, water levels during the August and September events were compared to peak elevations predicted for the 100-year design storm (discussed below in Section 4); therefore, additional calibration runs were conducted with the objective of increasing peak stages for 100-year design storm simulations without compromising calibration performance for the 2013 wet season. Observed peak water levels were compared to simulated 100-year design storm peak elevations at a number of locations where surveyed high-water marks were available. During this effort, Manning's n values for the overbank were increased from 0.2 to 0.5 for the reach of the North Branch Estero River from upstream of the Halfhitch Road Bridge in Country Creek Estates to Ben Hill Griffin Parkway. The same change was made for the South Branch Estero River from Corkscrew Road upstream until I-75. In addition, peak flows at the two Estero River USGS gaging stations were compared to simulated peak flows for the 100-year design storm. This comparison is presented in Table 8.

The comparison indicates that simulated peak stages and flows are in the range of observed peak stages and flows. A direct comparison of observed and simulated values is not reasonable because the design storm simulation assumes a uniform rainfall amount and intensity for the entire watershed, while the actual watershed response to the two 2017 events is dependent upon rainfall intensities and amounts that varied across the watershed. Rainfall data for the August rainfall event was available from four Lee County rain gages with rainfall totals that varied from 9.3 to 13.5 inches over a 5-day period. The September event (Hurricane Irma) rainfall totals from three Lee County rain gages varied from 6.3 to 12.3 inches over a 6-day period (the Three Oaks rainfall gage did not have a total rainfall amount for the September event due to either equipment failure, clogging of the rain gage, or some other problem). Overall, this comparison provides confidence that the calibrated model is a valuable tool for the purposes of providing representative boundary conditions for a local-scale ICPR model for the Village of Estero west of I-75.

Table 6 - Calibration Statistics (units in feet and cfs)

Name	Data_type	Layer	ME	MAE	R_Correlat	Comment	WS Good?
46A-GW04	Head Elev, sat zone	206	-0.47	0.77	0.81	10-Mile Canal	Yes
46A-GW05	Head Elev, sat zone	12	-0.17	0.42	0.97		Yes
46A-GW28	Head Elev, sat zone	202	0.65	0.68	0.95		Yes
46B-GW02	Head Elev, sat zone	12	-0.29	1.42	0.54	Mullock Ck	OK
47A-GW01	Head Elev, sat zone	212	-0.68	0.68	0.95		OK
47A-GW02	Head Elev, sat zone	12	-0.62	0.74	0.84		Yes
47A-GW03	Head Elev, sat zone	11	-0.15	0.64	0.75		Yes
47A-GW04	Head Elev, sat zone	12	-0.78	0.84	0.77	Mullock Ck	Yes
47A-GW05	Head Elev, sat zone	12	0.44	0.44	0.98		Yes
47A-GW6	Head Elev, sat zone	212	1.39	1.41	0.94	Next to pond	OK
47A-GW7	Head Elev, sat zone	12	-0.23	0.99	0.47	Great in WS	Yes
47A-GW10	Head Elev, sat zone	11	-0.27	0.94	0.79	Great in WS	Yes
47A-GW13	Head Elev, sat zone	12	-1.66	1.66	0.75	Gage in I-75 Ditch	OK
49-GW02	Head Elev, sat zone	212	-0.83	1.10	0.56	Next to canal not in model	OK
49-GW03	Head Elev, sat zone	12	-2.45	2.45	0.87	Next to mine	No
49-GW04	Head Elev, sat zone	12	-0.64	0.68	0.99		Yes
49-GW05	Head Elev, sat zone	12	0.02	0.69	0.86	Great in WS	Yes
49-GW06	Head Elev, sat zone	12	0.73	0.74	0.85	Next to ag operation	Yes
49-GW07	Head Elev, sat zone	11	0.01	0.64	0.61	Great in WS	Yes
49-GW08	Head Elev, sat zone	212	0.76	0.94	0.91	So. CREW	Yes
49-GW09	Head Elev, sat zone	212	1.28	1.28	0.89	Need more info	OK
49-GW10	Head Elev, sat zone	11	0.67	0.77	1.00	Kehl Canal headwaters	OK
49-GW11	Head Elev, sat zone	11	0.87	1.03	0.94	Great in WS	Yes
49-GW21	Head Elev, sat zone	12	0.32	0.32	0.94		Yes
49-GW22	Head Elev, sat zone	12	-1.40	1.40	0.71	Need more info	No
49-GW23	Head Elev, sat zone	12	-0.24	0.96	0.69	Great in WS	Yes
49-GW24	Head Elev, sat zone	12	0.94	0.98	0.68	Great in WS	Yes
49-GW25	Head Elev, sat zone	12	-0.16	1.20	0.58	Great in WS	Yes
49L-GW03	Head Elev, sat zone	212	0.98	0.98	0.90	Imperial R area, good in WS	Yes
C-492	Head Elev, sat zone	3	-1.14	1.14	1.00	Good in WS	Yes
FP2_GW1	Head Elev, sat zone	212	0.12	0.21	0.98		Yes
FP11	Head Elev, sat zone	3	-1.61	1.61	0.98	Need more info	No
HF1_G	Head Elev, sat zone	212	-0.74	1.11	0.78	Great in WS	Yes
L-1138	Head Elev, sat zone	4	-0.07	0.15	0.95		Yes
L-1985	Head Elev, sat zone	4	-1.11	1.25	0.97	Great in WS	Yes
L-1999	Head Elev, sat zone	2	-1.20	1.20	1.00	Good in WS	Yes
L-2550	Head Elev, sat zone	4	-1.09	1.20	0.97	Great in WS	Yes
L-5667	Head Elev, sat zone	4	1.17	1.17	0.87	Good in WS	Yes

Table 7 - Calibration Statistics, continued (Units in feet and cfs)

Name	Data_type	Layer	ME	MAE	R_Correlat	Comment	WS Good?
ST1_G	Head Elev, sat zone	212	0.53	0.56	0.81	Great in WS	Yes
ST2_G	Head Elev, sat zone	212	0.45	0.64	0.92		Yes
WF3_G	Head Elev, sat zone	212	0.29	0.59	0.77	Great in WS	Yes
Pa_MW1	Head Elev, sat zone	212	1.03	1.03	0.87		OK
Pa_MW2	Head Elev, sat zone	212	0.22	0.53	0.87		Yes
Pa_MW3	Head Elev, sat zone	212	-0.30	0.34	0.97		Yes
Pa_MW4	Head Elev, sat zone	212	-0.12	0.36	0.93		Yes
Pa_MW5	Head Elev, sat zone	212	0.38	0.43	0.94		Yes
Pa_MW6	Head Elev, sat zone	212	-0.12	0.29	0.97		Yes
Pa_MW7	Head Elev, sat zone	212	0.00	0.27	0.97		Yes
Pa_MW8	Head Elev, sat zone	208	-0.43	0.47	0.89		Yes
Pa_MW9	Head Elev, sat zone	208	-0.11	0.41	0.91		Yes
Pa_MW10	Head Elev, sat zone	207	-0.12	0.28	0.95		Yes
Pa_MW11	Head Elev, sat zone	207	0.24	0.38	0.95		Yes
Pa_MW12	Head Elev, sat zone	205	-0.09	0.28	0.92		Yes
Pa_MW13	Head Elev, sat zone	205	-0.35	0.36	0.97		Yes
Pa_MW14	Head Elev, sat zone	205	-0.15	0.25	0.92		Yes
Pa_MW15	Head Elev, sat zone	205	-0.49	0.49	0.96		Yes
PWS-MW2	Head Elev, sat zone	182	-1.54	1.54	0.60	Next to canal not in model	No
PWS-MW3	Head Elev, sat zone	213	-1.74	1.84	0.14	Next to canal not in model	No
DEW-MW4	Head Elev, sat zone	213	-0.24	0.47	0.86		Yes
Estero_NB	Water Level	212	0.52	0.55	0.95	Good in WS	Yes
Estero_SB	Water Level	212	-0.68	0.75	0.89	Good in WS	Yes
HalfwayCrDS HW	Water Level	212	0.14	0.41	0.74		Yes
IMPERIA1	Water Level	212	1.78	1.80	0.98	More work needed in Imp R	No
KEHL_H	Water Level	212	0.39	1.26	0.68	Guessed on gate operation	Yes
KEHL_T	Water Level	212	1.26	1.26	0.96		No
S-H-4_HW	Water Level	4872	0.79	1.03	0.04		Yes
S-ML-4_HW	Water Level	4876	0.48	0.65	0.63		Yes
S-SF-2_HW	Water Level	4753	1.04	1.05	0.11		No
Spring_Ck	Water Level	211	-0.30	0.38	0.82		Yes
Estero_NB_Q	Discharge	212	-14.8	16.8	0.93	Sim flows slightly high	OK
Estero_SB_Q	Discharge	212	4.7	6.5	0.91		Yes
IMPERIA1_Q	Discharge	212	108.7	108.8	0.94	More work needed in Imp R	No
Spring_Ck_Q	Discharge	211	3.2	3.4	0.86		OK

Note: Results taken from LC_LS_ECM_V3q4k-6 _six-mo_CS_test3.SHE

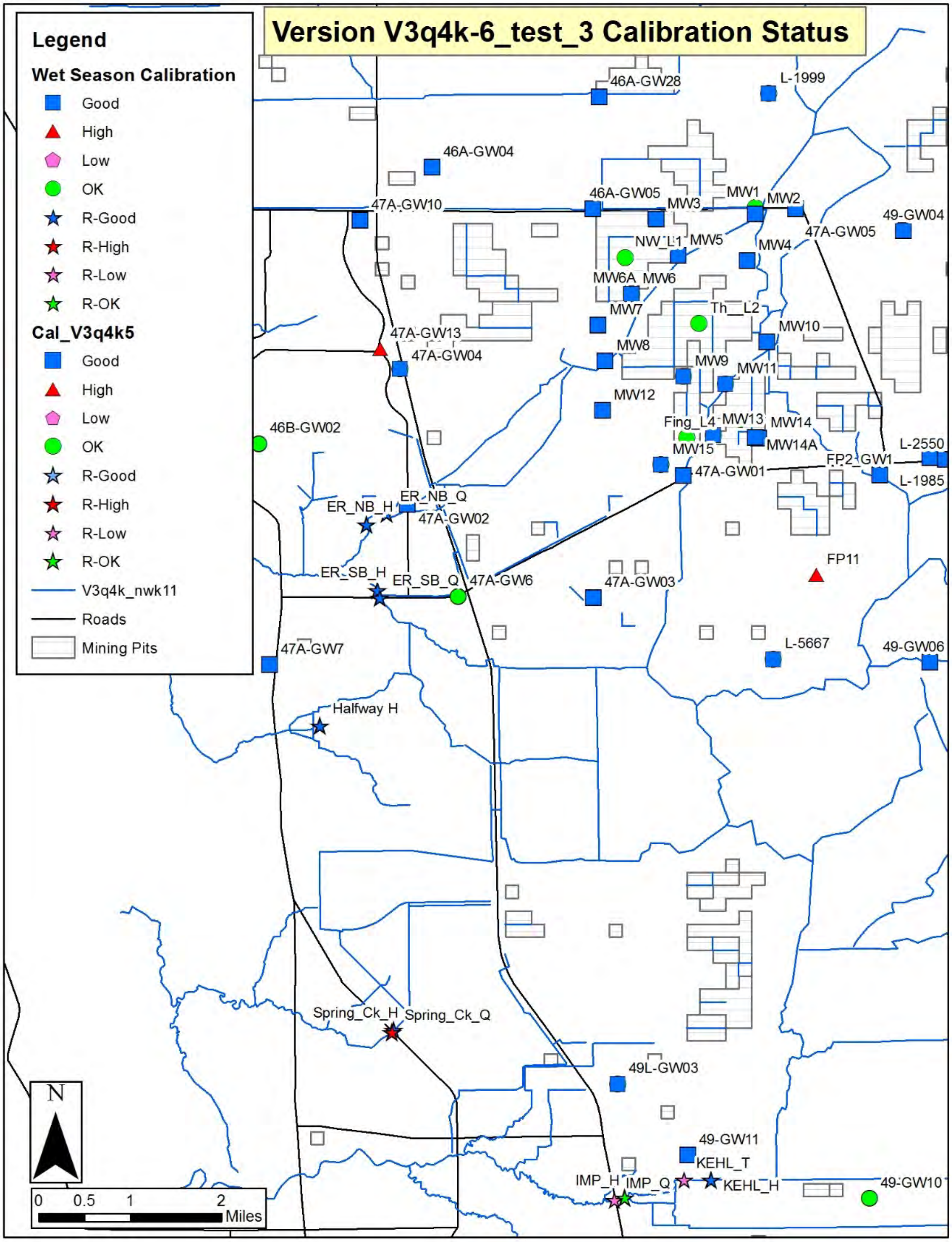


Figure 16 - Map of Calibration Performance

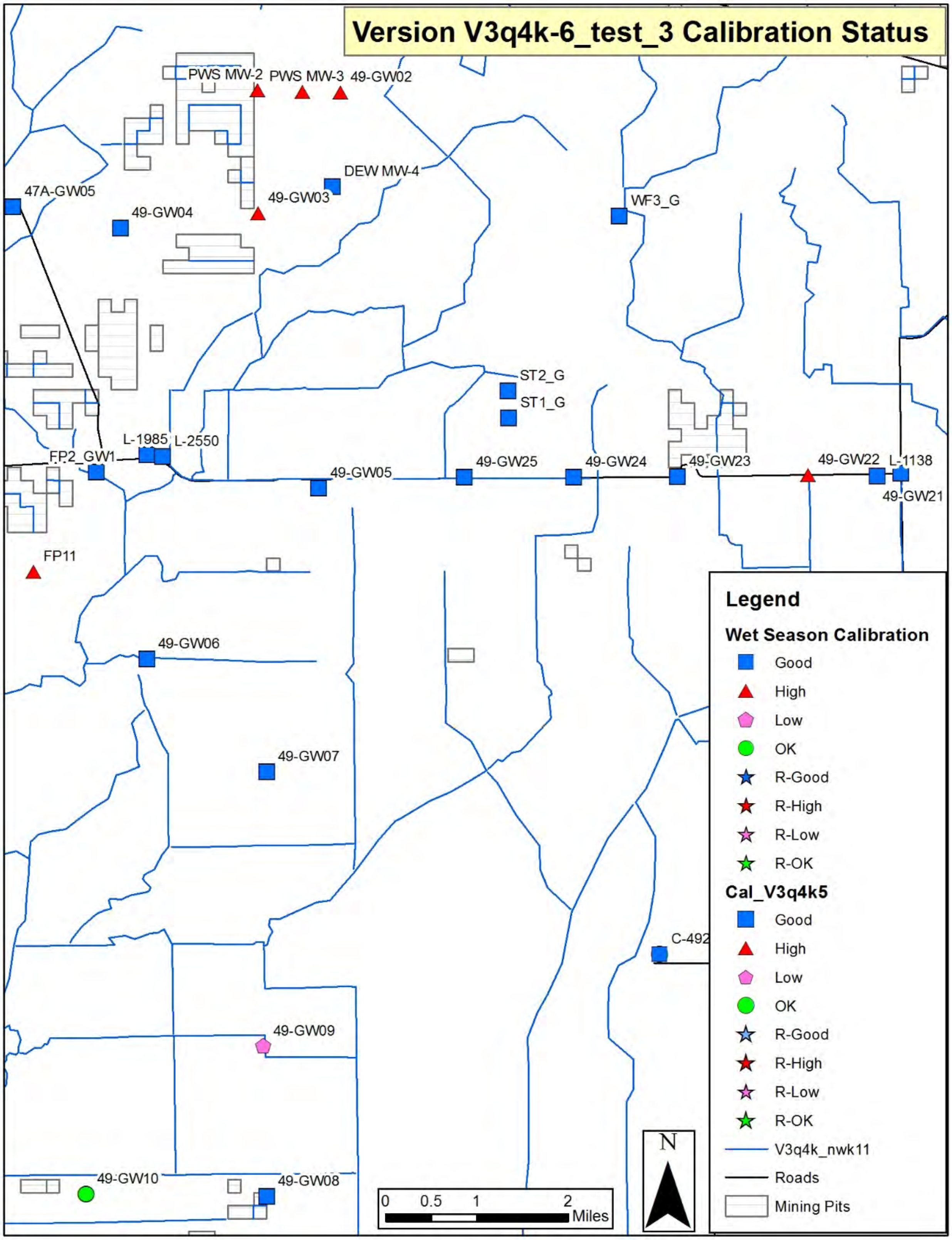


Figure 17 - Map of Calibration Performance, East

Table 8 - Comparison of Simulated 100-Year Design Storm Peak Stages to Observed 2017 Peak Stages

River	Location	Deck Elev ft-NAVD	Low chord ft-NAVD	100-yr_v3_test ft-NAVD	h point Chainage, m	Harvey ft-NAVD	Irma ft-NAVD	Description
	MW-6A			21.3	7011	21.9	22.1	Measured WL data, WildBlue
N Branch	Ben Hill Griffin			17.4	2286	17.7	18.1	Based on field visit by R. Copp, 8/28 and 9/20
N Branch	Three Oaks	16.7	14.5	15	525	16.7		reported by JR Evans
N Branch	Rookery Dr	15.7	18	14.6	1000			
	USGS gage			12.6	1400	13.2	14.0	13.5 ft-NGVD is top of staff gage
N Branch	Halfhitch Rd		8.9	11.4	1956			Br 4 in MIKE 11
S Branch	Sanctuary	14.6		14	1600.2	14.5	15	approx, based on field visit by R. Copp on 8/28
S Branch	Three Oaks		12.8	11.6	2230			
S Branch	Corkscrew Rd		8.35	11.4	3045	10.6	12.1	USGS gage data
S Branch	Br 1		9.4	11.4	3045			Br 1 in MIKE 11
	Br 2		8.7	10.5	3429			Br 1 in MIKE 11
USGS Gaging Stations				Flow, cfs		USGS Peak Flows, cfs		
				100-yr_v3_test		Harvey	Irma	
N Branch				514		414	515	
S Branch				445		367	516	

Note: Results taken from LC_LS_ECM_V3q4k-6_100-yr_v2_test3.SHE

The observed peak stage during Hurricane Irma for the North Branch Estero River at the USGS gage is lower than the actual peak stage due to a malfunction of the USGS water level recorder

3.3 Summary of Model Calibration

The calibrated model is deemed appropriate for use in providing wet season boundary conditions for the Estero River and Halfway Creek at I-75. These boundary condition files can be used for more detailed ICPR modeling within the Village. The model provides acceptable results for the North and South Branch of the Estero River as well as for Halfway Creek. Simulated wet season groundwater levels within the Village of Estero are also considered to be representative of wet season conditions. Calibration during the wet season is particularly good at most stations with simulated values extremely close to measured values. The plots of simulated vs. measured water levels and flows presented below in Figure 18 are evidence that the model does an excellent job of predicting water levels during the wet season.

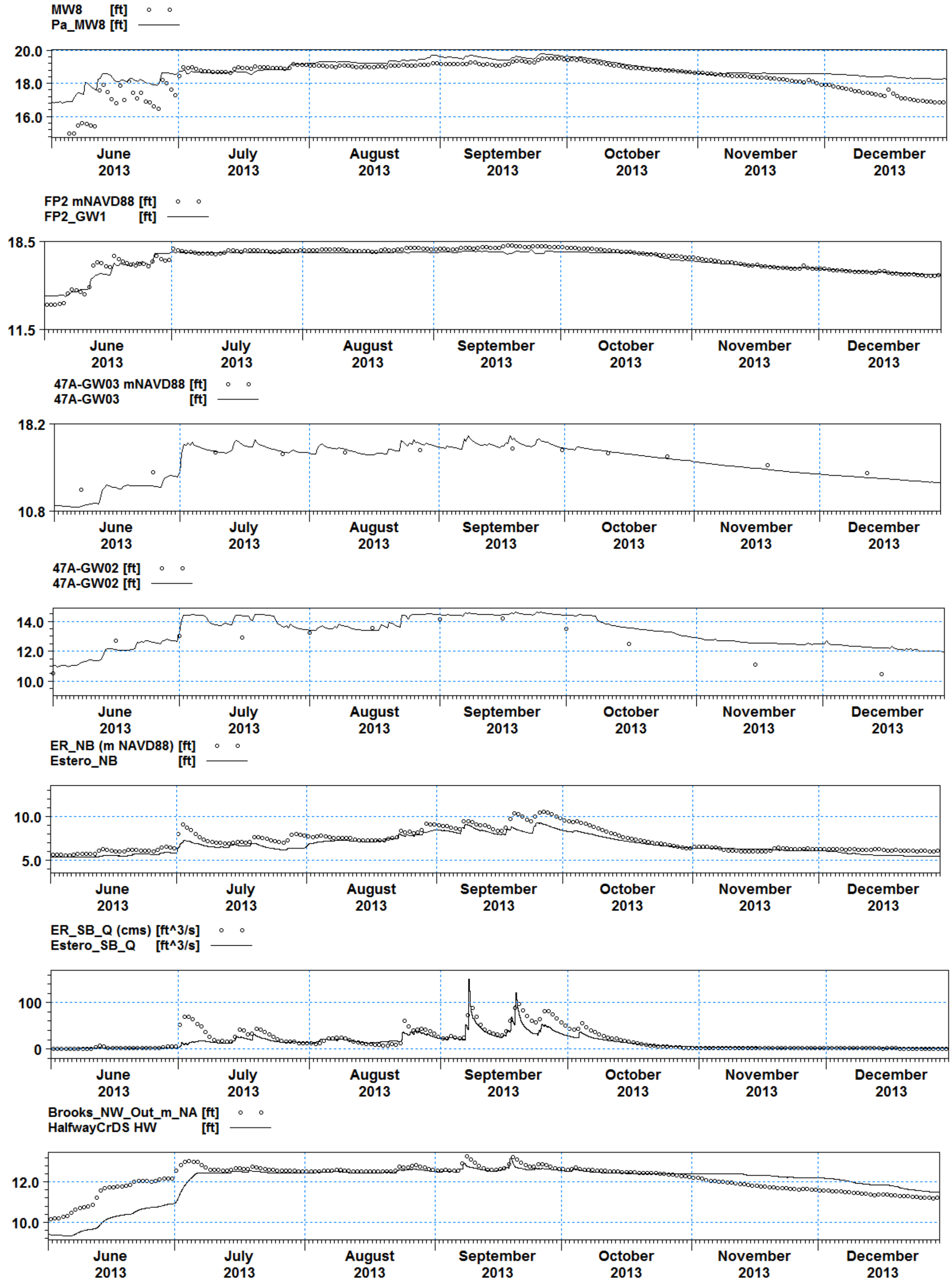


Figure 18 - Sample Calibration Plots for the MIKE SHE/MIKE 11 Model

3.4 Model Limitations

Because of the large model domain required to develop a representative model of hydrology and hydraulics for the Estero River and Halfway Creek, plus calibrating to over 200 ground and surface water calibration locations, the model calibration was oriented on model performance during a wet season with above-average precipitation. Attention was given to dry season groundwater conditions, however the level of effort expended to refine dry season calibration was less than the level of effort for the wet season. Therefore, additional calibration will be necessary should the model be used for dry season simulations. While the 2013 hydroperiod simulation results shown in Figure 19 are considered reasonable, multi-year hydroperiod assessments of the extensive wetlands east of I-75 should not be conducted with this model. During the calibration process, the model performance during the dry season continued to improve, therefore it is believed that additional calibration effort would be fruitful.

Calibration effort should focus on the following areas:

- The model calibration is reasonable for Spring Creek, however additional effort is recommended to reduce peak flows.
- If possible, reducing the model grid size should be considered. The 750-ft grid size limits accuracy of surface topography in urban areas. Improved representation of ground elevations in urban planned unit developments will lead to more accurate representation of irrigation.
- Additional effort is warranted to improve calibration next to farms in the vicinity of the Green Meadows wellfield. Simulated water levels at some wells are higher than measured water levels, and an improved representation of farm ditches surrounding the agricultural fields may improve calibration.
- Addition effort of a similar nature is needed in the vicinity of citrus farms on the eastern portion of Corkscrew Road, particularly well 49-GW22. It is suspected that a more detailed representation of farm ditches and above-ground impoundments may improve calibration.
- It is suspected that a more detailed representation of surficial aquifer groundwater flow may improve calibration in the headwaters of Kehl Canal, Kehl Canal gate headwater and tailwater monitoring stations, and the USGS Imperial River gaging station. Some modification of MIKE 11 branches in the vicinity of 49-GW09 may be appropriate.
- The land use file should be reviewed to determine if it is appropriate to include land cover categories for willow and melaleuca.
- Calibration for station 47A-GW06 (located south of Corkscrew Road west of I-75) could be improved with a finer grid and representation of stormwater detention facilities next to the well.
- Calibration in Mullock Creek (generally west of I-75 and north of Estero Parkway) could be improved with a more detailed MIKE 11 representation of canals that drain into Mullock Creek.

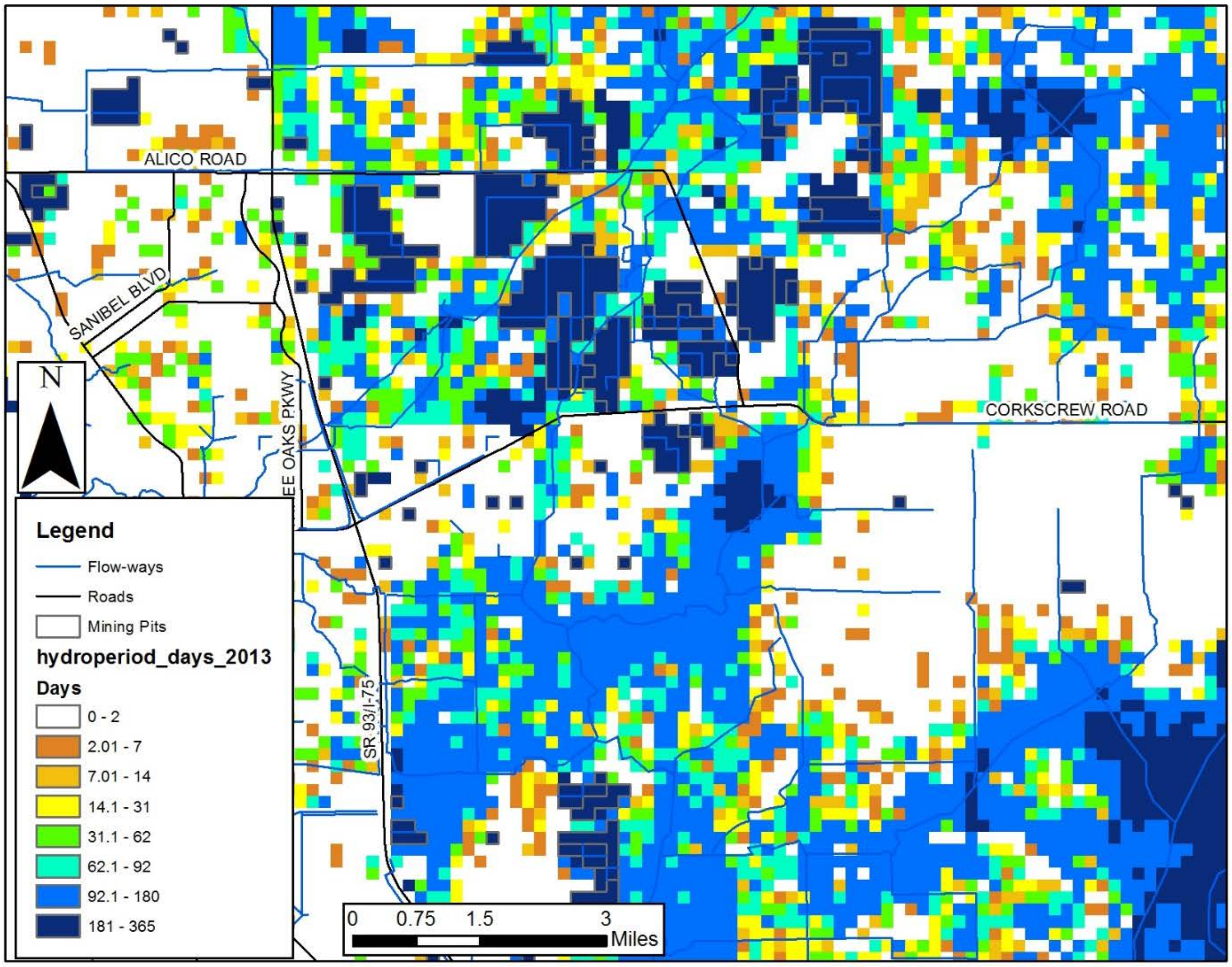


Figure 19 - Simulated Hydroperiod for 2013 (Number of days water depth > 0.2 feet)

4.0 BOUNDARY CONDITIONS FOR LOCAL-SCALE MODELING

4.1 Modeling Approach

Results from this modeling effort were utilized to provide boundary conditions for a Village-scale ICPR model. Simulations were conducted using design storm rainfall for the once-in-5-, 10, 25-year and once-in-100-year rainfall events. The simulations were conducted using simulated ground and surface water levels from the wet season calibration simulations as hot-start files (which are used to set initial water levels throughout the model domain). The 5-, 10-, 25-year and 100-year simulations were launched using initial condition ground water levels from July 15, 2013 and surface water levels from August 20, 2013. Ground water levels on July 31 were representative of high wet season conditions. Surface water levels from early July were initially selected for design storm simulations, but were revised to August 20 after a review of observed water levels from large rainfall events that were experienced in late August and early September 2017. Figure 20 illustrates the differences in water levels between July and August of 2013. The design storm rainfall amounts were 5.5, 6,5, 11, and 13 inches, respectively for the 5-, 10-, 25- and 100-year events. The rainfall distribution presented in Figure 21 was as defined in the SFWMD Applicants Handbook, and the rainfall was applied to the entire model domain. Figure 22 presents initial groundwater elevations used for design storm simulations.

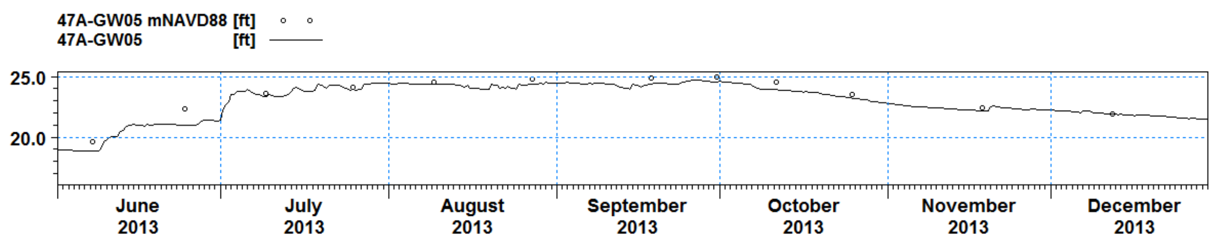


Figure 20 - Measured and Simulated Water Levels East of I-75 in the North Branch Estero River Watershed

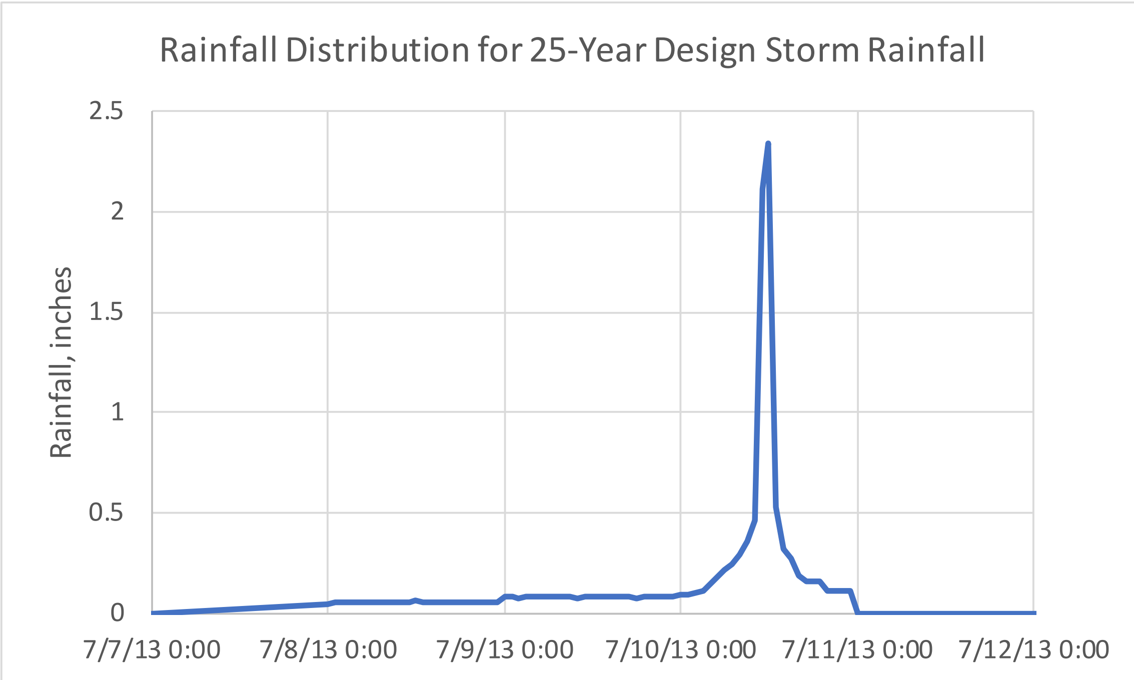


Figure 21 - Rainfall Distribution for 25-Year Design Storm

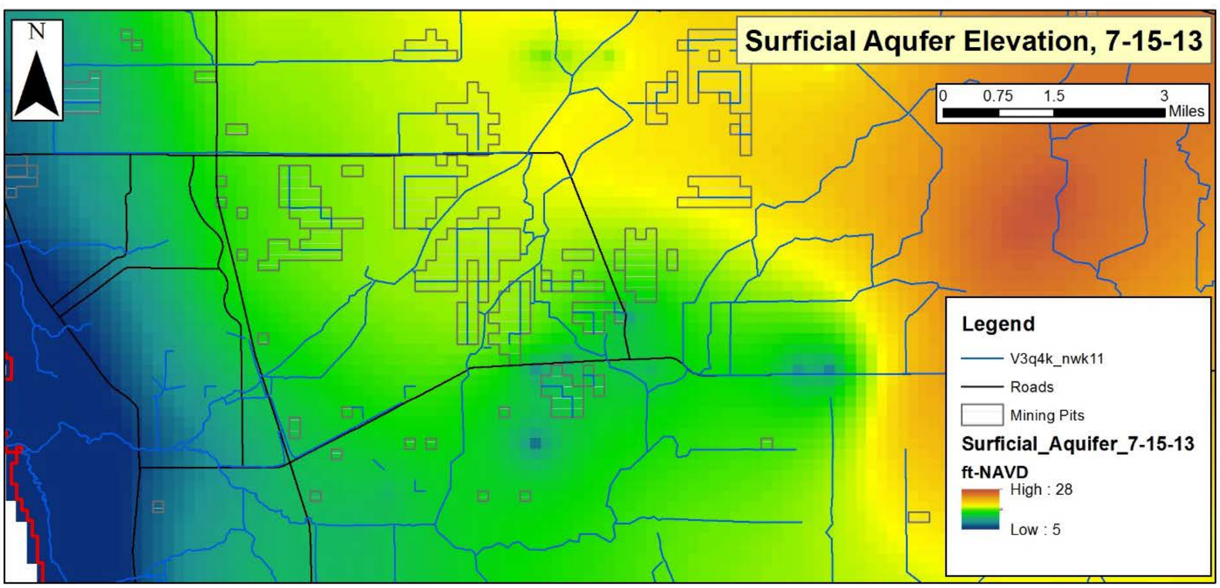


Figure 22 - Initial Groundwater Elevations Used for Design Storms

4.2 Design Storm Modeling

The network file for the design storm simulations was modified so that gates operate according to defined gate operation criteria. Gates in Lehigh Acres are fully open during the wet season: therefore, their operation was changed from being controlled by reported gate openings to fully open. The Brooks Diversion structure, which allows flows from Halfway Creek to be diverted to the South Branch Estero River, was modified to reflect the structural changes implemented in 2014 (SFWMD ERP Permit #36-04007-P). The Kehl Canal and the Brooks Diversion gates were changed to be consistent with gate operation protocols defined the permits for those structures. Simulated stages and flows were extracted from the MIKE 11 result files at locations along I-75 where culverts or bridges allow for conveyance west of I-75 (Figure 23 illustrates these boundary condition locations). Location 4 includes a bridge (dimensions obtained from FDOT files) and four 8' x 8' box culverts that are physically located south of the I-75 bridge and are included as part of the South Branch Estero River MIKE 11 branch. Simulated stages and flows for the 25-year design storm are presented in Figure 24, Figure 25, Figure 26, and Figure 27. Peak stages and flows for the 5-, 10-, 25- and 100-year design storms are shown in Table 9.

The boundary condition files included the downstream boundary condition for the Estero River. Tidal water level data from the NOAA Naples tidal station 8725110 were used as the downstream boundary condition.

Figure 23 - Map of Locations for Design Storm Results

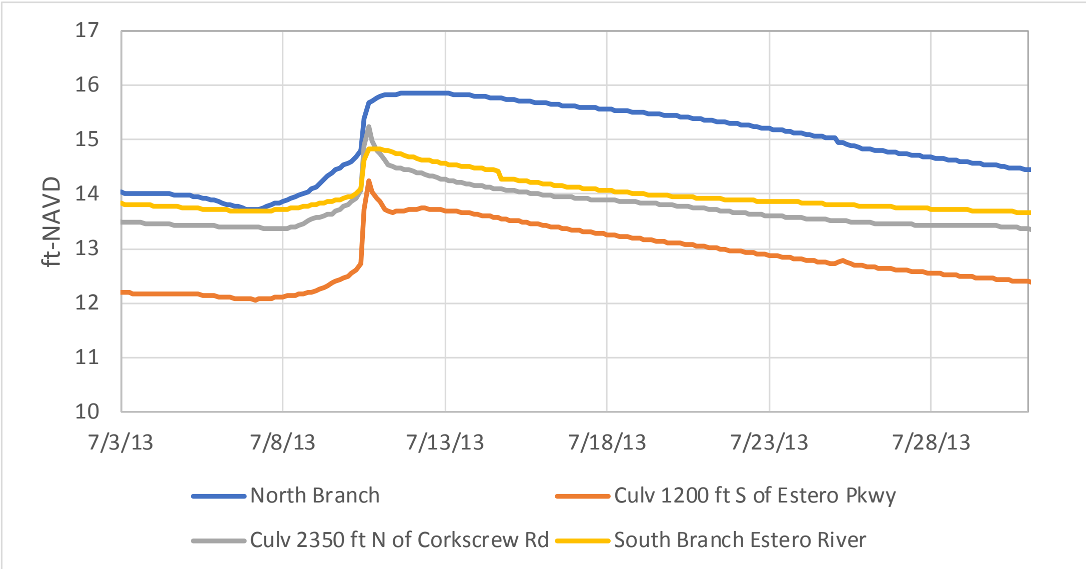


Figure 24 - 25-Year Boundary Condition Stages for North and South Branch Estero River

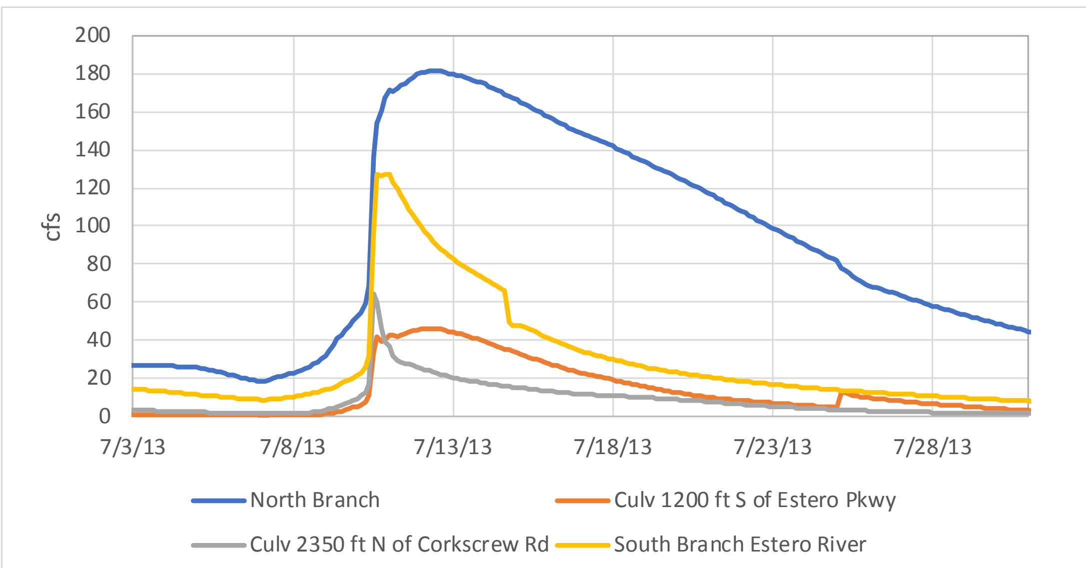


Figure 25 - 25-Year Boundary Condition Flows for North and South Branch Estero River

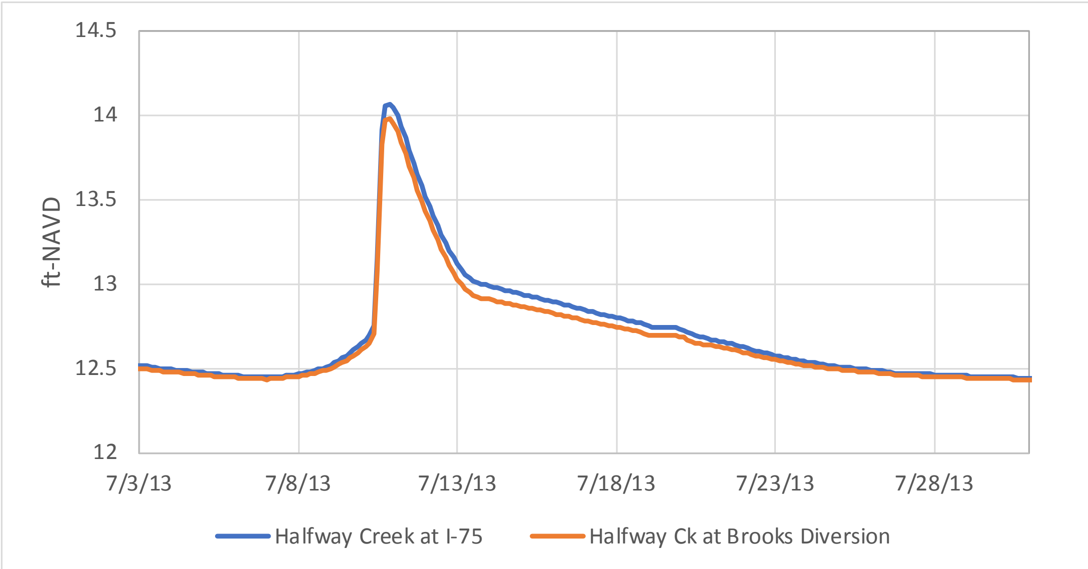


Figure 26 - 25-Year Stages for Halfway Creek at I-75 and Headwater of the Brooks Diversion

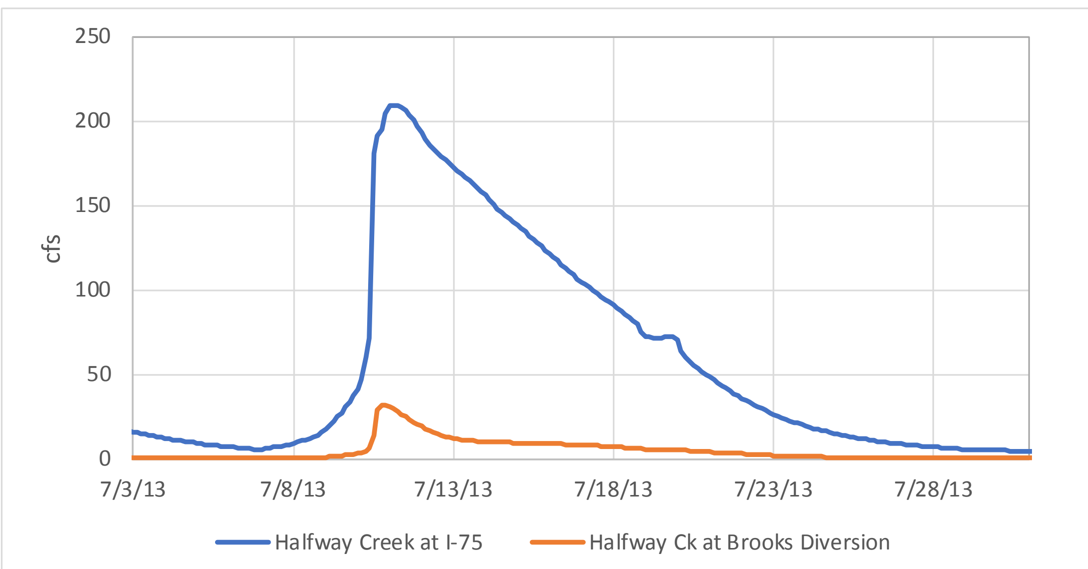


Figure 27 - 25-Year Flows for Halfway Creek at I-75 and Headwater of the Brooks Diversion

Table 9 - Simulated Peak Boundary Stages and Flows

	5-Year Design Storm		10-Year Design Storm	
Location	**ft-NAVD**	**cfs**	**ft-NAVD**	**cfs**
North Branch at I-75	15.4	121.6	15.6	141.8
Culv 1200 ft S of Estero Pkwy	13.2	18.4	13.4	23.7
Culv 2350 ft N of Corkscrew Rd	14.6	33.3	14.8	41.1
South Branch Estero River	14.4	62.1	14.6	94.7
Halfway Creek at I-75	13.1	133.3	13.4	155.1
Halfway Ck at Brooks Diversion	13.1	13.5	13.4	18.0

	25-Year Design Storm		100-Year Design Storm	
Location	**ft-NAVD**	**cfs**	**ft-NAVD**	**cfs**
North Branch at I-75	15.9	181.5	15.9	187.3
Culv 1200 ft S of Estero Pkwy	14.2	46.4	15.2	135.0
Culv 2350 ft N of Corkscrew Rd	15.2	64.3	15.7	104.0
South Branch Estero River	14.8	127.5	15.0	167.5
Halfway Creek at I-75	14.1	209.3	14.4	251.2
Halfway Ck at Brooks Diversion	14.0	31.8	14.3	41.9

5.0 REGIONAL ISSUES

The modeling results were reviewed to determine if there were actions that could be taken to reduce flooding conditions. In addition, observations made during major flooding events were also considered. Based on a review of modeling results and flooding problems observed in late 2018, the following actions should be considered:

- Increased storage is needed in the North Branch Estero River for large events. High water levels were observed in September 2017 both east and west of I-75, therefore storage of floodwaters during large rainfall events would benefit multiple developments along the North Branch.
  - Lee County already owns an inactive mining pit south of Alico Road that could be converted to an off-line reservoir for temporary storage during major floods. Numerous other mining pits could also be used for storage if a private-public arrangement could be established (the SFWMD Water Farming Program is an example of how this can be implemented).
- If additional storage is provided, consideration should be given to decreasing or eliminating flows along the north side of Alico Road east of I-75 that are conveyed west to Ten Mile Canal. Surveying of channel dimensions and roadway culverts would be required along with flow measurements during flooding events to better understand the potential impacts of capturing flows that currently flow west
- Between I-75 and Alico Road, direct more flow south of Corkscrew Road. Flow pathways for the area south of Corkscrew Road and east of I-75 are shown below in Figure 28.
- Encourage private-public partnerships to re-establish historic flow-ways across Corkscrew Road east of the intersection with Alico Road.
- Promote more groundwater recharge in the headwaters of the Estero River, Halfway Creek, and Imperial River watersheds.

Water depths relative to land surface south of Corkscrew Road east of I-75 are presented in Figure 28. In the areas south of Corkscrew Road, flow is to the south and west towards the South Branch Estero River (point 4) and Halfway Creek (point 5), as indicated by the arrows on Figure 28. Flows in cubic feet per second for September 8, 2013 are shown in yellow. Figure 29 presents a map of wet season water depths relative to land surface for areas east of I-75 in the area of Corkscrew Road and Alico Road.

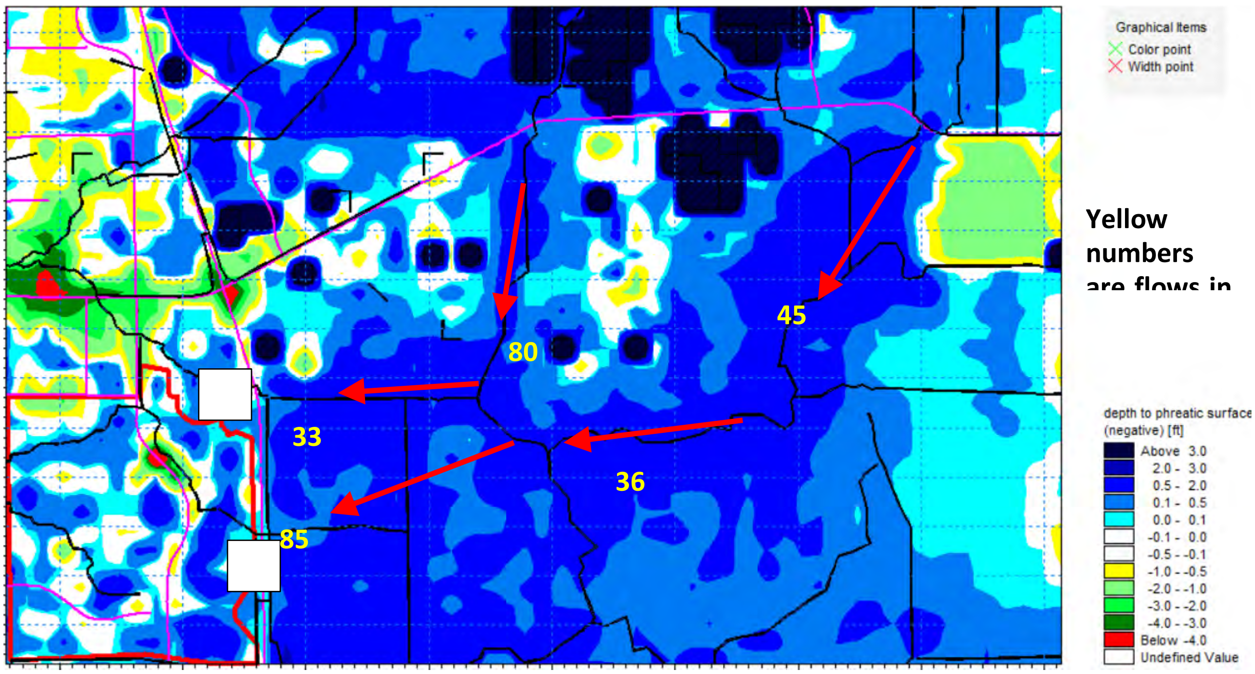


Figure 28 - Map of Wet Season Flow Depths (9-8-13) Relative to Land Surface for Areas South of Corkscrew Road and East of I-75 (red arrows indicate flow direction, Point 4 is the South Branch Estero River, Point 5 is Halfway Creek)

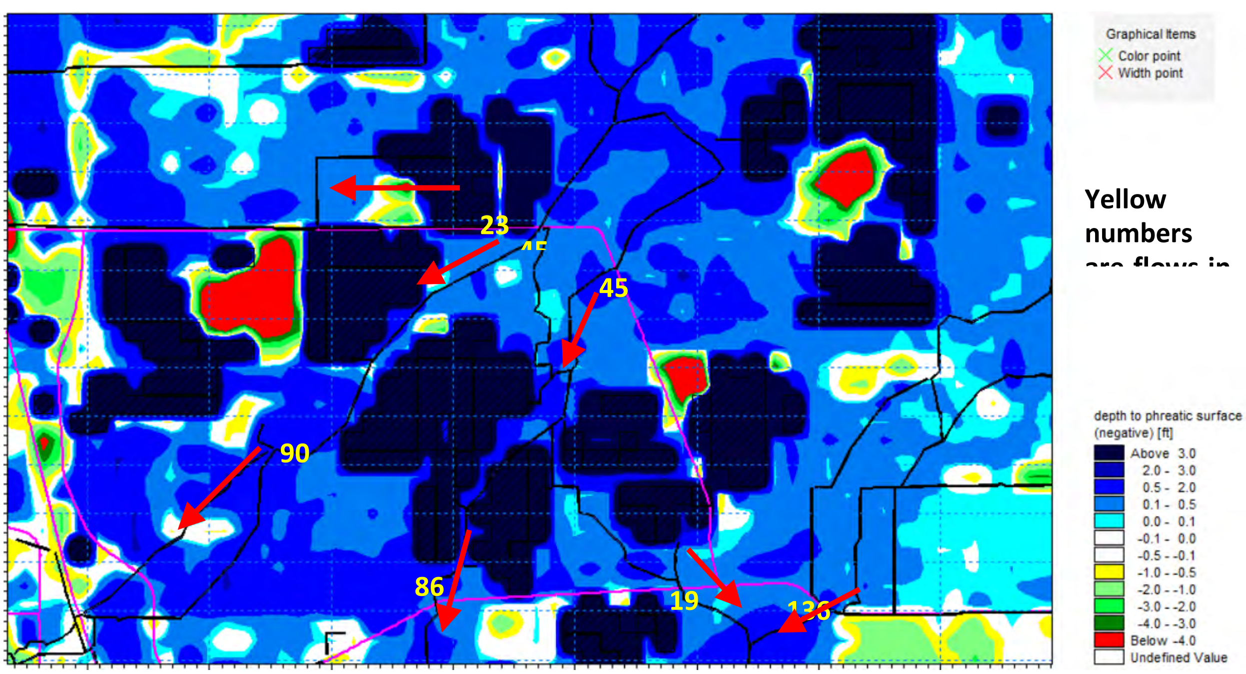


Figure 29 - Map of Wet Season Flow Depths (9-8-13) Relative to Land Surface for Areas North of Corkscrew Road and East of I-75 (red arrows indicate flow direction)

6.0 CONCLUSIONS

- An integrated surface-ground water model was successfully developed and calibrated at more than 200 calibration stations for the 2013 wet season. Wet season calibration was good at more than 90% of the 47 key calibration stations within the areas that contribute to the Estero River and Halfway Creek.
- Calibration for the period of January 1, 2013 to December 31, 2014 indicate that model performance is generally good, however simulated water levels during the dry season at some stations are less than measured water levels.
- The calibrated model was used to simulate the 100-year design storm and was then compared to observed peak stages during flood events of August and September, 2017. The calibration was revised to better represent peak flood conditions.
- The model was used to provide regional boundary conditions at I-75 that will be used in a Village-scale ICPR modeling assessment of Village hydrology and hydraulics.
- Utilizing the calibrated model that considered peak stages and flows during August and September, 2017 results from this modeling effort were utilized to conduct regional-scale 5-, 10-, 25- and 100-year design storm modeling and provide boundary conditions for a Village-scale ICPR model.
- The model files that control the duration of the simulation were updated as part of this modeling effort so that the model can be run continuously from 2006 through 2016. This will enable the model to be further calibrated with a focus on the dry season, which will enable the model to be used for long-term assessments of wetland hydroperiods.

7.0 MODEL LIMITATIONS

The modeling files are completed adequate for use in simulating wet season conditions during normal wet seasons as well as for major flooding events. The model can be used to simulate water levels for rainfall events up to and exceeding the once-in-a-100-year rainfall.

If the model will be used for more than wet season boundary conditions for the Estero River and Halfway Creek, calibration effort should focus on the following areas:

- The model calibration is reasonable for Spring Creek, however additional effort is recommended to reduce simulated peak flows
- If possible, reducing the model grid size should be considered. The 750-ft grid size limits accuracy of surface topography in urban areas. Improved representation of ground elevations in urban planned unit developments will lead to more accurate representation of irrigation.
- Additional effort is warranted to improve calibration next to farms in the vicinity of the Green Meadows wellfield. Simulated water levels at some wells are higher than measured water levels, and an improved representation of farm ditches surrounding the agricultural fields may improve calibration.
- Calibration is considered to be good for most agricultural areas within the study area, however calibration in the vicinity of citrus farms on the eastern portion of Corkscrew Road in the vicinity of well 49-GW22 could be improved if the farm best management practices were represented in greater detail. It is suspected that a more detailed representation of farm ditches and above-ground impoundments will improve calibration.
- It is suspected that a more detailed representation of surficial aquifer groundwater flow may improve calibration in the headwaters of Kehl Canal, Kehl Canal gate headwater and tailwater monitoring stations.

8.0 REFERENCES

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