CITY OF BONITA SPRINGS
STORMWATER MASTER PLAN UPDATE

Prepared for

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1 Executive Summary

INTERA, Inc. (INTERA) along with its sub-contractor Engineering and Applied Science (EAS) was engaged in March of 2010 to prepare an update of the existing City of Bonita Springs stormwater management plan. The project was overseen by the City of Bonita Springs (City) and the South Florida Water Management District (District or SFWMD). The previous stormwater management plan was developed in 2002, an updated plan was necessary as numerous land development projects have been implemented within and adjacent to the City limits. The objectives of this stormwater management plan update were to: 1) assess the ability of the City's existing stormwater management system to mitigate flooding concerns under typical design storm conditions, and 2) develop prioritized recommendations for Capital Improvement Plan (CIP) projects to reduce the frequency and extent of flooding within the City.

To accomplish these project objectives, an ArcGIS geodatabase was created of stormwater infrastructure (data collected by the City and City contractors), basins contributing runoff to select portions of the City stormwater system were delineated, and an Interconnected Pond and Routing (ICPR) hydrologic and hydraulic model of the stormwater system was developed. The ICPR model was then used to assess flooding resulting from design storms selected by the City. Potential stormwater infrastructure improvement projects were incorporated into the model, and where then evaluated based on the extent that each project reduced the model-calculated flooding extents. Modeling efforts were focused on 16 flood-prone areas as identified by the City based on historical flooding complaints. Potential CIP projects for mitigating flooding in these 16 areas were evaluated and prioritized according to established Level of Service (LOS) standards within the City.

This report documents all work performed to meet the objectives of the stormwater management plan update. Detailed descriptions of the processes used in development of the stormwater infrastructure geodatabase, basin delineation, ICPR model development, and assessment of potential CIP projects are given. An assessment of potential funding sources was provided to be considered by the City when implementing recommended CIP projects. All work was performed under consultation with both the City and SFWMD, and all pertinent GIS data, ICPR model files and results, and relevant supporting documents are provided in electronic format on a DVD accompanying this report.

1.1 Recommendations

Of the 16 flood-prone areas identified within the City, 8 CIP projects were recommended as part of the City's CIP program. The 8 flood prone areas are , listed in priority order below:

1. **Windsor Road Area** **(Flood Area #3)**
2. **Imperial Harbor Subdivision Area** **(Flood Area #11)**
3. **Michigan Street Area** **(Flood Area #7)**
4. Imperial Gates Subdivision (Flood Area #5)
5. Dellwood Lane Area (Flood Area # 9)
6. Enterprise Avenue Area (Flood Area # 8)
7. Industrial Street Area (Flood Area #14)
8. Bonita Elementary School Area (Flood Area #10)

The three CIP projects listed in bold above were simulated in the ICPR model. For each flood prone area three alternatives were analyzed and compared with respect to effectiveness in alleviating the flooding problems, implementation cost, maintenance requirements.

Continued maintenance of existing stormwater infrastructure in other flood prone areas, including mowing and periodic removal of accumulated sediments, is expected to be sufficient to mitigate flooding under modeled design storm conditions. Modeling results also indicated that CIP projects currently or recently undertaken by the City have contributed to reducing local flooding hazards.

Regular updates of the stormwater infrastructure geodatabase and stormwater master plan are recommended. Changes to the system are inevitable including continued development within the City or as the City implements CIP projects. This stormwater master plan will be an invaluable tool as the City evaluates both current and future infrastructure projects. The infrastructure database could also be updated based on survey data, to include specific invert elevations, pipe dimensions, and span lengths. In addition, data derived from Environmental Resource Permits (ERPs) should be verified to ensure that existing stormwater infrastructures meet the specifications stipulated in their respective permit documents. Finally, the installation of a rain gauge in the urban center of the City, as well as multiple stage & flow gauges within Spring Creek, Leitner Creek, Oak Creek and Rosemary Canal are recommended as they can aid in future calibration efforts. Additional calibration will only help gain confidence in the model's predictive capability. The additional data will also aid in addressing water quality concerns.

2 Introduction

2.1 Authorization

In February of 2010, the City of Bonita Springs, Florida, (the City) contracted with INTERA, Inc. (INTERA) to update their Stormwater Management Plan (SMP) by performing the following tasks:

- Review and update the existing SMP,
- Perform stormwater modeling,
- Provide recommendations for capital improvements to mitigate flooding concerns, and
- Verify and update a GIS database of drainage features within the City limits

INTERA performed these tasks at the direction of the City and the South Florida Water Management District (SFWMD). This report outlines the activities performed to complete tasks listed above, and includes documentation of the engineering procedures and information used in accomplishing each task.

2.2 Purpose and Objective

The purpose of this project was to update the Stormwater Master Plan for the City of Bonita Springs, and to study the contributing basins that affect stormwater conveyance inside the City limits. The stormwater management plan currently in place for the City of Bonita Springs was conducted and completed in 2002. Since that time, field investigations have revealed additional drainage structures not previously included in the SMP, and supplementary data for existing drainage structures has been gathered. Furthermore, capital improvements have been made in an effort to protect flood prone areas, and land development has altered drainage pathways within the City limits. Because of the additional drainage information, improvements, and alterations, it became necessary to update the existing SMP. The new SMP will make it possible to more accurately assess the impact of projected growth, analyze alternatives for flood protection, and support the use of Best Management Practices (BMPs).

The newly developed SMP will effectively address and identify the following:

- Existing stormwater problems,
- The condition of the stormwater drainage system,
- Adequacy of the drainage system, and
- Necessary capital improvements to mitigate flooding hazards.

Two project phases were undertaken to achieve this objective: 1) digitization and mapping of known drainage system features in ArcGIS, and 2) numerical modeling of the performance of the drainage system. During Phase 1, over 400 pages of field notes provided by the City were utilized to create a geodatabase of known drainage system features. This database was used in determining the land areas (basins) contributing runoff to each drainage feature during storm events. The drainage feature geodatabase and delineated basins formed the first deliverable for this project. During Phase 2, the basins and drainage features were used in the development of a hydraulic model to simulate storm events in the City and its contributing drainage areas. The model selected for use was the Interconnected Channel and Pond Routing (ICPR) stormwater model, Version 3.10. The model domain includes the drainage areas of the Imperial River and Spring Creek systems, including the Imperial River tributaries (Oak Creek, Rosemary Canal, and Leitner Creek). After calibration, the model was used to test and prioritize several stormwater management strategies designed to mitigate flooding concerns within the City of Bonita Springs.

Along with fully documenting all work performed in updating the Stormwater Management Plan, this report is designed to serve as a resource for the City of Bonita Springs for all matters related to stormwater management. Section 3 of this report contains a list of previous studies, reports, documents, and figures relevant to local stormwater management. These resources will be beneficial to the City on issues related to stormwater management.

3 Existing Reports and Studies

The following reports, studies, and documents were collected as part of background study conducted prior to commencing the SMP update. Copies of these documents are included in portable document format (.pdf) on the enclosed DVD. This compilation of files is included as a source of information only and is included on an "as is" basis with no expressed warranty implied.

3.1 Surface Water Management Studies

"*Stormwater Master Plan Bonita Springs, Florida*"
Hartman & Associates, August 2002

"*Surface Water Management Study for the Bonita Springs Area*"
Johnson Engineering Inc., November 1983

"*South Lee County Watershed Plan*"
South Florida Water Management District, July 1999

"*Bonita Springs-Summer 1995, Imperial River Area; Flood Reconnaissance, Evaluation and Recommendations*"
Johnson Engineering Inc. and Agnoli, Barber, Brundage, Inc., November 1995

"Michigan Street Drainage Study"
Pitman-Hartenstein & Associates, Inc., January 2005

"Quail Drive – Windsor Road Area Drainage Evaluation"
Lake Hickory Ventures, Inc., June 2010

"Foley Road – Beaumont Road Area Evaluation"
Lake Hickory Ventures, Inc., August 2010

3.2 Miscellaneous Documents

"*Bathymetric Survey*" November 2006 (City of Bonita Springs)

3.3 State and Federal Agencies

"*Best Management Practices for South Florida Urban Stormwater Management Systems*"
South Florida Water Management District, April 2002

3.4 FEMA - Flood Insurance Study

"*Flood Insurance Study: Lee County, Florida and Incorporated Areas*"
Federal Emergency Management Agency, Revised January 2008

4 Inventory of Existing Facilities

4.1 Environmental Resource Permits

The list below contains Environmental Resource Permits (ERPs) that were issued by the South Florida Water Management District (SFWMD). Each of these permits was listed as contributing stormwater flow to a water source or receiving body that is contained within the City system. This compilation is included as a source of information only and is included on an "as is" basis with no expressed warranty implied.

SFWMD ERPs

(Note: Some permits have multiple projects associated with them.)

PROJECT NAME	PERMIT NO
Mediterra	11-01761-P
Mediterra Phase 2	11-01761-P
Tony Rosbough	36-00077-S
Disaster Farms	36-00078-S
Peninsular Groves Inc.	36-00095-S
Wildcat Farms Lease	36-00167-S
M & W Farms Grove	36-00218-S
Mwg Farms	36-00221-S
Corkscrew Groves	36-00321-S
Schoenbrun Farms Grove 2	36-00326-S
M & W Groves	36-00327-S
Harper Brothers Inc	36-00612-S
Southern Pines North Farming Area	36-00625-S
Billy Don Grant Borrow Pit	36-00821-S
Worthington Country Club	36-01472-S
East Terry Street Wellfield Fence	36-02449-S-02
Cedar Creek / Hames Walkway	36-02556-S
Louisi Property Boardwalk	36-02556-S
Boardwalk At Cedar Creek Dr Residence	36-02556-S
Highland Woods Clubhouse Expansion	36-02912-S
Sr 45 (Us 41) At Imperial River	36-02988-P
Sr 45 (Us 41) North Of Bonita Beach Road To Us 41	36-02988-P
Bay Landing	36-03034-P
Publix At Corkscrew Village	36-03117-P
Pueblo Bonito Phase 3	36-03295-P
Monterra At Bonita Springs	36-03437-P
Parklands West	36-03632-P
Parklands West-Pods 8a 8b 3b And 3c	36-03632-P

Paradise Village-Single Family Dock-Dolsey	36-03644-P
Corkscrew Mining Ipd	36-03663-P
Corkscrew Road Mine	36-03663-P
Riverview Center Conservation Easement	36-03739-P
Bonita Beach Road Extension	36-03743-P
Livingston Oaks	36-03744-P
Vasari Country Club	36-03744-P
Livingston Oaks	36-03744-P
Vasari (Livingston Oaks)	36-03744-P
Livingston Oaks	36-03744-P
Livingston Oaks	36-03744-P
Plumosa Farms	36-03780-P
I 75 And Bonita Beach Road	36-03802-P
I-75 From Luckett Road To S R 80	36-03802-P
I-75 Corkscrew Road To Daniels Parkway/Segment C	36-03802-P
I-75 Pond C-12 (Segment C - Application No 070817-14)	36-03802-P
S R 93 (I - 75) At Daniels Parkway	36-03802-P
I-75 Collier/Lee Co. Line North to Corkscrew Road/Segment B	36-03802-P
I-75 Widening South Of Bonita Bch Rd to Lee/Collier Co. Line	36-03802-P
Sr 93 (I-75) At Alico Road	36-03802-P
I 75 Widening From South Of Colonial To South Of S R 82	36-03802-P
I-75 Daniels Parkway To Colonial Boulevard/Segments D & E	36-03802-P
Decorative Village Development Company	36-03803-P
Circle M Ranch	36-03847-P
Estero Interstate Commerce Park	36-03865-P
Spring Creek Square	36-03929-P
Albertsons Imperial Bonita Plaza	36-03946-P
Windsor Drainage Improvements	36-03971-P
Three Oaks Parkway (Williams Rd To Corkscrew Rd)	36-04007-P
Three Oaks Parkway (Brooks To East Terry Street)	36-04007-P
Grekos Medical Park	36-04069-P
Village Walk - Bonita Springs	36-04096-P
Corkscrew Growers Property	36-04096-P
Village Walk At Bonita Springs	36-04096-P
Plaza Del Sol	36-04135-P
Old Us 41 To Strike Lane	36-04196-P
Reserve Of Silverstone (Aka Bonita Bch Rd Est) Early Work	36-04234-P
Bonita Beach Rd Golf Club Rpd Aka Beach Road Golf Estates	36-04234-P
Reserve Of Silverstone Aka Bonita Beach Road Estates	36-04234-P
Reserves Of Silverstone	36-04234-P
Bonita Beach Road Rpd	36-04234-P
Bonita Beach Rd Rpd And Labelle Ranch	36-04234-P
East Bonita Active Adult Rpd	36-04234-P

S H R Bonita Springs	36-04234-P
East Bonita Active Adult Rpd	36-04234-P
Lee Parklands Golf & Country Club	36-04235-P
Cockleshell Village	36-04271-P
Riverwood At Bonita	36-04292-P
Serrano (A/K/A Riverwood At Bonita)	36-04292-P
Riverwood At Bonita	36-04292-P
Pennsylvania Avenue Realignment	36-04295-P
Wildwoods	36-04371-P
Section 21 Farm	36-04049-P
Tesone Basins 10 And 11	36-04499-P
Tesone	36-04499-P
The Villages At Old Cypress	36-04499-P-02
Walgreens-Bonita Beach Rd & Bonita Grand Dr	36-04506-P
North Bay Village	36-04585-P
North Bay Village	36-04585-P-02
Constitution Center	36-04608-P
Laser Grading Inc	36-04630-P
Corkscrew Links	36-04639-P
Fairwinds	36-04659-P
Corkscrew Commerce Center	36-04798-P
Lot 12 Corkscrew Estates	36-04944-P
Ultimate Ski Lake	36-05139-P
Windsor Road - Gbm Fka Bermuda Preserve	36-05370-P
Frp Llc	36-05619-P
Griffith/Greenway Landscaping	36-05670-P
Trieste Preserve	36-05941-P
Miarni Fields Soccer Complex	36-06564-P
Bonita Grande	36-06567-P
Roberts Group C.P.D.	36-06567-P
Anglers Paradise	36-07247-P
Bonita Springs Lock Up	36-07315-P
H L H Real Estate Properties Docking Facility	36-07357-P
Riverbend	36-07357-P
Oak Creek Restoration Dredge Phases 1 Through 5	36-07384-P

5 GIS Mapping and Database Development

As discussed in Section 2, the primary objectives of the SMP update include: 1) data compilation and inventory of existing drainage features, and 2) modeling rainfall events to predict and mitigate flooding within the City of Bonita Springs. Data generated in completing Task 1 was utilized to complete Task 2. This section describes the development of City of Bonita Springs stormwater infrastructure data in GIS format, including the digitization of drainage features, watershed delineation, and field work. All data described in this section are provided on the DVD accompanying this report.

5.1 Structures Data Collection

Three primary data sources were utilized to gather information on drainage structures within the City of Bonita Springs: (1) Stormwater Infrastructure Inventory Field Notes and the original City of Bonita Springs stormwater infrastructure inventory geographic database, (2) SFWMD Environmental Resource Permits (ERPs), which included the location, size and type of permitted drainage pipes and weirs, and (3) field survey data collected by INTERA and EAS on June 29 and 30, 2010 which included visual identification of drainage features not previously included in the drainage geodatabase, and estimated measurements of bridge spans and structure openings (culvert dimensions, swale widths, etc.).

Figures 5-1 through 5-6 identify the locations of the INTERA field survey measurements, and the locations at which photographs were taken. All photographs and field notes are provided on the DVD accompanying this report. The Figures 5-7 through 5-11 show examples of the Stormwater Infrastructure Inventory Field Notes and the digitizing process. Due to the level of detail required for this stormwater master plan, only major structures were used in the development of the model (see section 6). Figures 5-12 through 5-31 present the selected structures and final basins used in the model. Please note the City's Stormwater Infrastructure Field Notes only include areas where the City maintains jurisdiction. Privately maintained stormwater systems were not collected and therefore are excluded from the Stormwater Infrastructure Database (see Figures 5-32 through 5-37), however, when necessary key structures within HOA jurisdiction where used and defined using the data within the ERP documents.

5.2 Stormwater Infrastructure Digitization

Available stormwater infrastructure data was digitized to augment a geodatabase obtained from the City of Bonita Springs GIS Department. The purpose of the updated database is to: 1) provide City of Bonita Springs with an updated stormwater infrastructure inventory in support of its ongoing stormwater program and 2) serve as the basis for development of the City of Bonita Springs ICPR stormwater management model. Eight stormwater structure types were identified for digitization and attribution: ponds, open conveyances, inverted driveways, drain pipes, junction boxes, control structures, end structures, and inlets. This section describes the process of updating the features and attributes of the stormwater infrastructure inventory geodatabase including the quality assurance review performed prior to post-processing the datasets for consistent data attribution.

5.2.1 Required Input Datasets

Four main data sources were provided as inputs or references for the digitizing and quality assurance processes: City of Bonita Springs Stormwater Infrastructure Inventory Field Notes, Aerial Photographs, Google Earth/Maps, and the original City of Bonita Springs stormwater infrastructure inventory geographic database. These datasets are described in more detail in Table 5.1. An example of the field notes format is provided in Figure 5-7. The extent of the field notes reviewed and updated is shown in Figure 5-8.

Table 5-1. Datasets

Dataset	Format	Purpose
Google Maps	Website	Utilized to located streets and the area depicted on the field notes within the GIS framework. Google Street View was used when a more detailed image of a structure was required for identification or attribution.
Field Notes	Portable Document File(.pdf)	Field notes are the source data which were digitized, modified and/or attributed in the stormwater infrastructure inventory geodatabase.
Aerial Photographs	MrSid Image File (.sid)	Digital georeferenced aerial photographs were used as basemaps for orientation in GIS.
Stormwater Infrastructure Inventory Geodatabase	ArcGIS 9.3 personal geodatabase file (.mdb)	The stormwater infrastructure inventory geodatabase was the target for update, quality assurance and final delivery. A total of eight unique features types were identified for update in the field notes. For each type, several attributes were also updated or added.

5.2.2 Digitization and Attribution Procedures

Stormwater infrastructure were added to, modified in, and deleted from a geodatabase based on field notes hand-written on printed aerial photograph base maps supplied in digital file format (an example of the notes is shown in Figure 5-7). The result of this process was an updated stormwater infrastructure inventory for the City of Bonita Springs in the areas identified in Figure 5-8. Eight stormwater structure types were identified for digitization and attribution: ponds, open conveyances, inverted driveways, drain pipes, junction boxes, control structures, end structures, and inlets. Google Earth and Google Maps were used to locate areas depicted in the field notes within the GIS framework. Google Street View was used when a more detailed image of a structure was required for identification or attribution. Georeferenced aerial photography was used in ArcGIS 9.3 for the purposes of identifying and locating features. The stormwater infrastructure inventory geodatabase contained some data in the areas surveyed and updated from the field notes. In many cases, existing features in the inventory required modification, either spatially or in attribution. The field notes were divided into four sections and a team of four GIS analysts digitized the field notes associated with each section. The following general guidelines and rules were followed by the analysts during the digitization and attribution process:

- During the digitization and attribution phase of the project, existing features in the geodatabase were not deleted. If a feature was identified for a deletion on the field notes, the feature was flagged for deletion. All feature deletions were handled during post processing.
- Rather than adding or deleting features from the geodatabase, if a feature was already in the geodatabase, its attributes or locations were modified as prescribed by the field notes.
- In all cases (with the exception of units) the data were updated to reflect the information exactly as written in the field notes. If items were missing from a drop down menu in the geodatabase, the value was placed in the "Notes" attribute field and flagged for question.
- All dimensional data were entered in inches. If the units reported on the field notes were not inches, they were converted prior to feature attribution and entered consistently in inches. Dimensions were entered in a single attribute as a string with the format: 12x18
- When possible during feature attribution, the field calculator tool in ArcGIS was used to update sets of features in batches. Every feature edited, added, or flagged for deletion was attributed with the initials of the analyst and the "GISDataProvider" attribute was updated to "INTERA."
- Snap tolerances were set to ensure features were precisely located. For example, mitered ends were snapped to a drain pipe end to ensure there was no gap in the stormwater infrastructure network unless a real gap existed on the ground.
- Maintenance notes (typically denoted by '**') were not digitized.
- If a feature was not modified, the attributes were left as they previously existed in the database.
- Dangling features that appear incomplete were marked with a flag "INC" for further inspection during the data quality assurance phase.
- A flag, "ck", was placed in the "Notes" attribute of a feature class to draw attention to unresolved questions that arose during the digitizing process. A note indicating the unresolved question was also included in the attribute field.

- Where multiple pipes are denoted on the field sheets, the pipes were digitized adjacent to each other with kinks in the line segment to ensure the connectivity to end structures without stacking pipes in the same location.
- Daily backups of the database were made and spot checked by quality assurance personnel.

More detailed rules for the digitization and attribution of each feature type are included below:

Ponds: Pond features were the only polygon feature class to be digitized. No Pond features were identified in the field notes. Potential edit operations for this feature class included: add, move, edit attributes and flag for deletion.

Open Conveyances: Open conveyances were occasionally depicted in the field notes. Most often, open conveyances existed as digitized line segments in the geodatabase and needed to be moved to their proper location based on aerial photographs or snapped to adjacent features such as inverted swales and drain pipe end features. Potential edit operations for this feature class included: add, move, edit attributes and flag for deletion.

Inverted Driveways: (also called Inverted Swales, IS) An inverted swale is represented by a line and can be found in a driveway connecting conveyances across the driveway where the apron meets the neck. On the field notes, these features are usually denoted by the letters "IS". The code "No IS" indicates the absence of an inverted swale for a particular driveway. In some cases the code "No Culv. No ET" was used to indicate the need to construct an inverted swale feature at a particular driveway. Generally there were no lines drawn on the field notes, and only the code indicators were provided. Potential edit operations for this feature class included: add, move, edit attributes and flag for deletion.

Drain Pipes: Drain pipes are represented by lines drawn on the field notes, with the field notes typically containing shorthand notations describing their attributes. Drain pipe notations most often included codes denoting their material type and dimensions. These were added to the "Materials" and "Dimensions" fields in the drain pipes geodatabase feature class. Potential edit operations for this feature class include: add, move, edit attributes and flag for deletion. Table 5-2 contains a list of codes that were used to attribute drain pipes. Additionally, the following general rules were followed when digitizing and attributing drain pipes:

- When a pipe changes material in the middle of a driveway, the pipes were snapped together at the driveway midpoint (approximately) according to the aerial photograph basemap.
- Generally end structures must be snapped to the end nodes of drain pipe lines.
- Drain pipes attributed with "MES" or "Mitered End" or "ME" have associated end structures. Further information about these codes is provided in the discussion of end structures.

Table 5-2. Field Notes to Geodatabase Conversion Codes Applied to Drain Pipe Attributes

Attribute	**Field Notes Code**	**Geodatabase Code: Code Description**
Material	CSP	CGM: Corregated Steel Pipe = Corregated Galvanized Metal
Material	CMP	CGM: Corregated Metal Pipe = Corregated Galvanized Metal
Material	RCP	RCP: Reinforced Concrete Pipe
Dimensions	e.g. 12x18	Dimensions must be converted to standard units (inches)

Junction Boxes: A junction box is a point feature generally used when two or more drain pipes connect. A junction box feature was used when two or more pipes come together. In the field notes, these are noted by red squares with open circles and sometimes have an indicator of "JB". Occasionally a manhole is also noted "JB - MH". Potential edit operations for this feature class include: add, move, edit attributes and flag for deletion.

Control Structures: A control structure is a point feature generally used to direct or slow the flow of water. Most often these are ditch blocks on a conveyance. Potential edit operations for this feature class include: add, move, edit attributes and flag for deletion.

End Structures: An end structure is a point feature generally used at the end of a pipe and depicts the condition at the end of the pipe. Types of end structures include: headwalls, end walls, mitered ends, outfalls, or riprap. These features are not always depicted in the field notes as points. Most often they are coded on drain pipes in the field notes with codes like: "ME", "MES", "Mitered End", or "EW". Potential edit operations for this feature class include: add, move, edit attributes and flag for deletion. Table 5-3 contains a list of codes that were used to attribute end structures.

Table 5-3. Standard Codes Applied to End Structure Attributes

Attribute	Field Notes Code	Geodatabase Code: Code Description
	No ET*	No End Treatment: Pipe exists without an end structure
Type	EW	End Wall
Type	Concrete Block	End Wall
Structure Material	Concrete Block	Other
Notes	Concrete Block	"Material is a concrete block"
Type	Conc Block	End Wall
Structure Material	Conc Block	Other
Notes	Conc Block	"Material is a concrete block"
Material	CMP	CGM: Corregated Metal Pipe = Corregated Galvanized Metal
StructureType	Mitered End*	Mitered End
ColleredEnd	Mitered End*	No
Dimension	Mitered End*	Unknown
StructureType	MES*	Mitered End
ColleredEnd	MES*	Yes
Dimension	MES*	Unknown
StructureType	ME*	Mitered End
ColleredEnd	ME*	No

Grate	ME*	<Null>
StructureType	MES w/Bars	Mitered End
Dimension	MES w/Bars	<Null>
Grate	MES w/Bars	Yes
GrateMaterial	MES w/Bars	Enter value if on map; else enter "UNKNOWN"
GrateDimensions	MES w/Bars	Enter value in inches
Collared	MES w/Bars	Yes (if ME w/Bars then Collared = No)

*As coded next to a drain pipe feature

Inlets: Inlets are denoted as open square point feature and sometimes occur at the end of pipes. The features can occur anywhere. Inlets are usually coded by: "CB," "PTop," "P," or "Valley" and noted near pipe descriptors. Features are not always drawn on the map as points, however for inlets they most often are. Potential edit operations for this feature class include: add, move, edit attributes and flag for deletion. Table 5-4 contains a list of codes that were used to attribute inlets.

Table 5-4. Standard Codes Applied to Inlet Attributes

Attribute	Field Notes Code	Geodatabase Code: Code Description
InletType	Type-C	DBI: Drain Bottom Inlet
TypeDescriptor	Type-C	Type C
Dimensions	Type-C	<null>
NumberofGrates	Type-C	1
GrateDimensions	Type-C	24x36
InletType	C-Box	DBI: Drain Bottom Inlet
TypeDescriptor	C-Box	Type C
Dimensions	C-Box	<null>
NumberofGrates	C-Box	1
GrateDimensions	C-Box	24x36
InletType	Conc Box	DBI: Drain Bottom Inlet
TypeDescriptor	Conc Box	Type C
Dimensions	Conc Box	<null>
NumberofGrates	Conc Box	1
GrateDimensions	Conc Box	24x36
InletType	2'x3' Catch Basin	DBI: Drain Bottom Inlet
TypeDescriptor	2'x3' Catch Basin	Type C
Dimensions	2'x3' Catch Basin	<null>
NumberofGrates	2'x3' Catch Basin	1
GrateDimensions	2'x3' Catch Basin	24x36
InletType	Type-E	DBI: Drain Bottom Inlet or 42"x52" catch basin
TypeDescriptor	Type-E	Type E
Dimensions	Type-E	<null>
NumberofGrates	Type-E	1
GrateDimensions	Type-E	40x52
InletType	PTop	Curb Inlet
TypeDescriptor	PTop	Type P (P-top), P5, or P6

Slots, Bleeders, and Weirs: Any point feature type (junction box, control structure, end structure, or inlet) could have one or more slots, bleeders, or weirs as indicated in the field notes. Slots, bleeders, and weirs are devices added to structures to help control flow. Data were added to the "**slotbleederweir"** field of the associated feature to indicate the feature type, feature dimensions (in inches) and any additional noted details from the field notes (e.g. slot; 12x6; W). Table 5-5 contains a list of codes that were used to attribute features with slots, bleeders, or weirs.

Table 5-5. Codes applied to associate slots, bleeders, and weirs with point features

Feature Type	Attribute	Field Notes Code	Geodatabase Code: Code Description
Inlet	Structure Type	Type C Inlet w/ Slot	Modified Inlet
Inlet	Grate	Type C Inlet w/ Slot	Yes
Inlet	NumberofGrates	Type C Inlet w/ Slot	1
Inlet	GrateDimensions	Type C Inlet w/ Slot	24x36
Inlet	Slot	Type C Inlet w/ Slot	Yes
Inlet	SlotDimensions	Type C Inlet w/ Slot	Enter value as provided in field notes (inches)
Inlet	SlotElevation	Type C Inlet w/ Slot	Enter value as provided in field notes (feet)
Inlet	Structure Type	Type E Inlet w/ Slot	Modified Inlet
Inlet	Grate	Type E Inlet w/ Slot	Yes
Inlet	NumberofGrates	Type E Inlet w/ Slot	1
Inlet	GrateDimensions	Type E Inlet w/ Slot	40x52
Inlet	Slot	Type E Inlet w/ Slot	Yes
Inlet	SlotDimensions	Type E Inlet w/ Slot	e.g. 12x36 (for a 1'x3' slot)
Inlet	SlotElevation	Type E Inlet w/ Slot	Enter value as provided in field notes (feet)

5.2.3 Quality Assurance Procedures

Data were initially entered from the field notes into four separate geographic databases as each GIS analyst developed a database independent of the others. Upon completion, each of the four databases was reviewed for data quality assurance. This was done prior to integrating and post processing the databases into a single composite deliverable database. The data quality assurance process followed a basic procedure. Data layers were color-coded and displayed in the GIS by attribute type to provide a streamlined review of the feature locations and attribute data (Figure 5-9). Additionally, features were labeled with attribute information to enable efficient quality assurance. Database features were reviewed against the field notes for every page of field notes provided. As data entry errors were identified, they were corrected. If questions arose during the quality assurance process, the features were flagged and additional clarification was requested from the City of Bonita Springs. City of Bonita Springs officials reviewed the geodatabase on multiple occasions. All comments and corrections provided by the City of Bonita Springs were included in the final geodatabase submitted with this report.

5.2.4 Post-Processing Procedures

ArcGIS 9.3 ModelBuilder was used for batch post processing of attribute information. Table 5-6 is a list of models which were developed and the attribute values updated by each model. The models were run for each of the four geodatabases. Each geodatabase was spot checked to ensure the models ran properly. Next, the databases were merged together. Edges of field notes files were identified. Overlapping and duplicate data were also identified. Upon manual inspection, all duplicates and data gaps were reconciled. Slot, bleeder and weir data were manually added to the associated feature class and related within the geodatabase after the four separate geodatabases were compiled into one composite geodatabase.

Table 5-6. Post Processing ArcGIS ModelBuilder Models and Outputs

Model	Output	Description
JustifyGISProvider	Justify GIS Providers	• Updates the Justify and GIS Providers for all feature type layers
InServiceAll	Asset Status	• Updates the Asset Status for all feature type layers
Conveyances	ConveyanceType	• Updates the Conveyance Type to Swale for all conveyances added or edited by INTERA
DrainPipes	Dimensions Material PipeShape	• Updates the pipe dimensions to 0 where not known • Updates the pipe material to “Unknown” where it is not reported • Update the pipe shape based on pipe dimensions
EndStructures	StructureType Inlet_OutfallType ColleredEnd	• Updates the structure type to “Unknown” if the GIS Data Provider is INTERA and the structure type is null • Updates the inlet outfall type to “Unknown” if the GIS Data Provider is INTERA and the inlet outfall type is null • Update collared end to “No” when the structure type is head wall or end wall • Update collared end to “Yes” when the structure type is mitered end and the collared end is null or “Yes” • Update collared end to “Yes” when the structure type is mitered end and the collared end is null or “No” • Update collared end to “Yes” when the structure type is mitered end and the collared end is null or “Yes” and the notes field contains an “NC” flag
Inlets	TypeDescriptor InletMaterial InletType NumberofGrates	• Update the type descriptors based on the dimensions of the pipe • Update inlet material to unknown where it is not reported • Update inlet type to ditch bottom inlet where it is not reported • Update number of grates to “1” if not reported

5.3 Watershed & Basin Delineation

Watersheds were defined for the City of Bonita Springs to determine land areas that contribute flow directly to portions of the stormwater drainage system as digitized from City-provided field notes. Watersheds were delineated using automated GIS techniques and through manual interpretation of the digitized drainage features and aerial photographs. This section describes the procedures used in generating watersheds within the city limits. All watersheds delineated for this project are included in the geodatabase deliverable DVD accompanying this report. The two watershed datasets included with this report are: 1) medium-resolution basins used in developing the City of Bonita Springs ICPR model (see Section 6), and 2) low-resolution basins draining directly to the Imperial River, Estero Bay, Oak Creek, Rosemary Canal, Leitner Creek, and Spring Creek. For this discussion, the term watershed refers to small drainage areas about portions of the City of Bonita Springs stormwater drainage system; the term basin refers to larger drainage areas, made up of agglomerations of watersheds.

5.3.1 Automatic Watershed Delineation using ArcGIS

Preliminary high-resolution watersheds were developed using standard raster-based delineation techniques and the ArcGIS Spatial Analyst extension. Within ArcGIS, the land surface is represented with a digital elevation model (DEM), where each DEM grid cell contains the elevation of the land surface at that location. By assessing the relative elevations between adjacent grid cells, downhill directions may be determined, thus allowing for the determination of flowpaths and watershed boundaries. Watershed outlets may be defined manually or based on flow accumulation thresholds. More information about automatic watershed delineation with ArcGIS is available from the ArcHydro User's Manual and from ESRI, Inc. (ESRI, 2010).

Watershed delineation for the City of Bonita Springs was performed on a 5 ft x 5 ft DEM as provided by the South Florida Water Management District. With the exception of merging individual files into a single large DEM (Figure 5-10), these files were utilized as provided by the District. DEM files were provided by SFWMD on April 9, 2010. The merged DEM, named "COBS_DEM" contained 30592 x 23192 cells and covered an area of 636 square miles, including 7.2 , 15.2 and 9.7 miles to the north, east, and south of the City limits of the City of Bonita Springs, respectively.

Watersheds were defined around features of the stormwater drainage network identified upon review of the digitized drainage features (Section 5.1), drainage data provided by Lee County, the National Hydrography Dataset (NHD), the Arc Hydro Enhanced Database AHED dataset provided by SFWMD, and the hydrographic features dataset used by SFWMD for creating the available DEM files from LiDAR data. Drainage features were also identified upon review of available aerial photography provided by the South Florida Water Management District. Both the NHD and AHED datasets were found to be outdated, as many of the drainage features no longer match the current landuse (as discerned from aerial photographs from 2008). In locations where the NHD and AHED data do not match the current aerial photographs, drainage data were ignored. All datasets were used in the creation of a drainage flow network which describes how water would move through the City of Bonita Springs stormwater infrastructure. Watersheds were defined about segments of the flow network, with outlets located at confluences within the network or at significant features/structures within the flow network. Watersheds were also defined about drainage ponds and within the Corkscrew Swamp region upstream of the Kehl Canal weir. Watersheds in the Corkscrew Swamp area were initially defined using the cell threshold technique (Olivera, 2002), with the cell threshold of 10,000 used. Watersheds delineated using this threshold were then manually merged into larger units based on interpretations of land use as viewed from aerial photography.

5.3.2 Manual Correction of Watershed Boundaries

The basins developed with LiDAR data were useful in areas with low urbanization, such as Corkscrew Swamp. The natural drainage divides in these areas were well represented with the LiDAR data due to the lack of roadways features. Hydraulic divides due to roadway centerlines (crowns) were not represented during the automated delineation process. For this reason, manual modifications to the basins delineated in the urbanized areas were necessary in order to ensure proper representation of the actual drainage present.

Slight manual modifications to the automatically delineated watershed were made in order to more closely match the observed field conditions. These changes were necessary due to the lack of representation of roadway crowns and the flat topography of the region, which can cause errant calculations with even minute deviations in the DEM. For example, the DEM may not be sufficiently resolved in some areas to properly represent existing small drainage ditches along roadways, or may not reflect that roadway centerlines are often drainage divides. The automatic delineation process also does not incorporate the effects of culverts and drainpipes on watershed boundaries, unless these features are included in the drainage flow network or DEM. In the Corkscrew Swamp area, the manual correction was minimal due to lack of an urban stormwater network. The majority of the manual corrections occurred within the City limits in highly urbanized areas.

Watershed boundaries could be further refined upon field identification of drainage features within the City limits. Currently the drainage flow network, upon which the delineation is based, is concentrated in more urban portions of the City, and less detail is provided in the more rural areas. As a more detailed drainage flow network is developed, watershed boundaries should be continuously refined.

5.3.3 Watershed Attributes and Basin Creation

A total of 458 individual watersheds were delineated within the vicinity of the City of Bonita Springs, including all land areas contributing flow to the Imperial River and Spring Creek systems. Each watershed was attributed with its area (in acres), and was assigned two numerical IDs for identification purposes. Watersheds were given a BasinID identifying to which larger system basin the watershed contributes flow. The BasinID values are provided in Table 5-7, along with the basin "Group" identifier used in the City of Bonita Springs ICPR model (See Section 6). In developing the City of Bonita Springs ICPR model, watersheds were assigned an additional ID value reflecting their position within the modeled drainage network (See Section 6). All watersheds and basins along with the selected structures used in the model are shown in Figures 5-12 to 5-31.

Table 5-7 City of Bonita Springs basin ID, model groups, and descriptions

Basin ID	ICPR Model Group	Description
100	Oak Creek	Oak Creek Watershed
200	Leitner Creek	Leitner Creek Watershed
300	Imperial Low	Lower Imperial River watershed to the Leitner Creek confluence
400	Imperial Middle	Imperial River watershed from the Leitner Creek confluence to the Kehl Canal weir
500	Imperial Kehl	Imperial River watershed upstream of the Kehl Canal weir, including Corkscrew Swamp.
600	Rosemary	Rosemary Canal watershed
900	Spring Creek	Spring Creek watershed

5.4 Figures & Descriptions

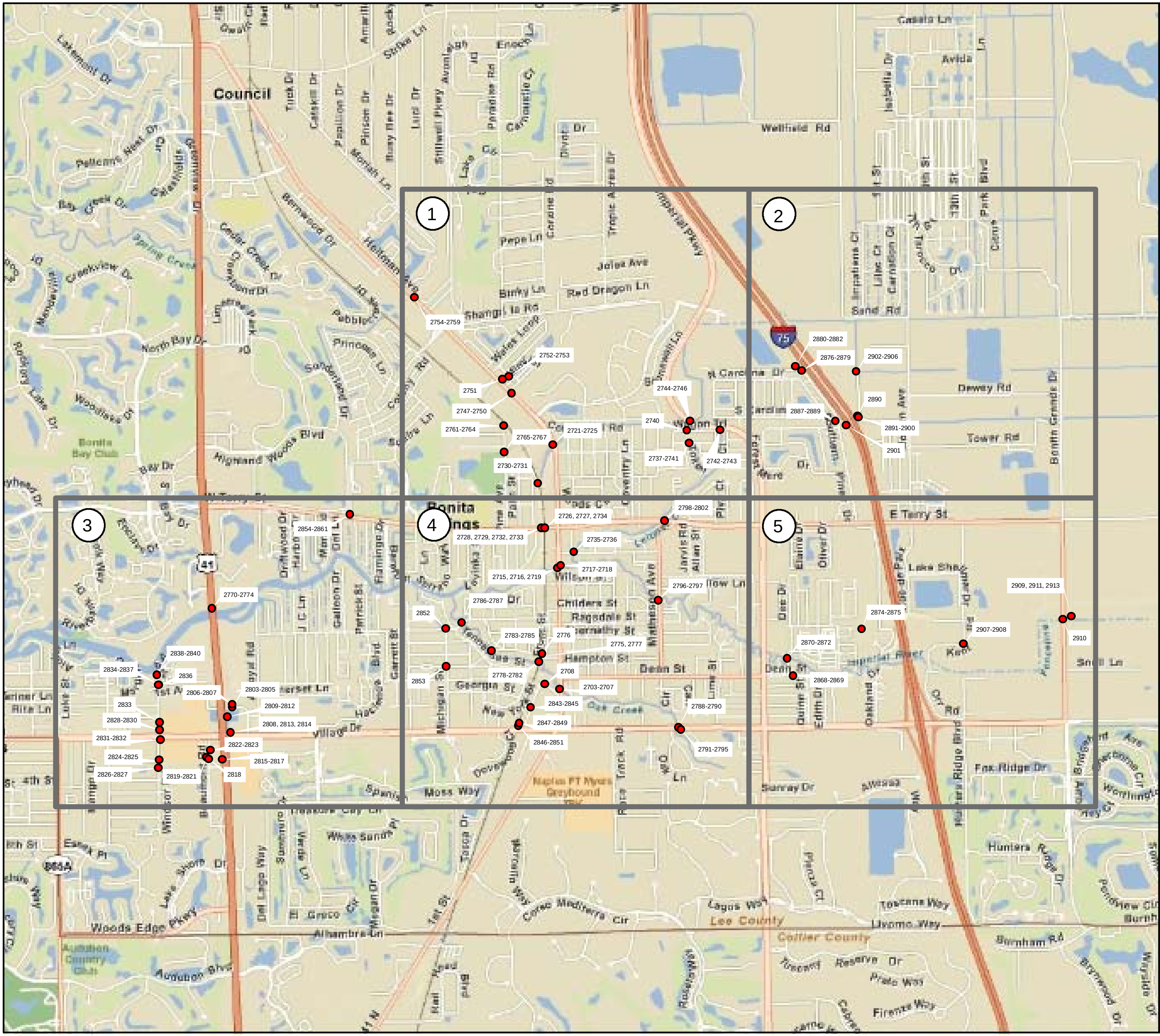
The following descriptions pertain to figures provided on the following pages and referenced in Sections 5.1-5.3.

Figure #	Description
5-1 through 5-6	Field Survey & Photograph Locations
5-7	Hand Written Field Notes
5-8	Stormwater Infrastructure Digitization Boundaries
5-9	GIS Digitization of Stormwater Items
5-10	Digital Elevation Model (DEM) Extent
5-11	ICPR Basin Groups
5-12 through 5-31	Basins and Selected Structures; ICPR Nodes, Links
5-32 through 5-37	HOA maintained areas

5.5 Section References

ESRI (2010) – ArcGIS Resource Centers Website – Accessible as of 9/8/2010
http://resources.esri.com/gateway/index.cfm

Olivera, Francisco (2002) – PrePro2002 Documentation – Accessible as of 9/8/2010
https://ceprofs.civil.tamu.edu/folivera/GISTools/PrePro2002/PrePro2002.htm



City of Bonita Springs Stormwater Master Plan

Field Survey Photo Locations

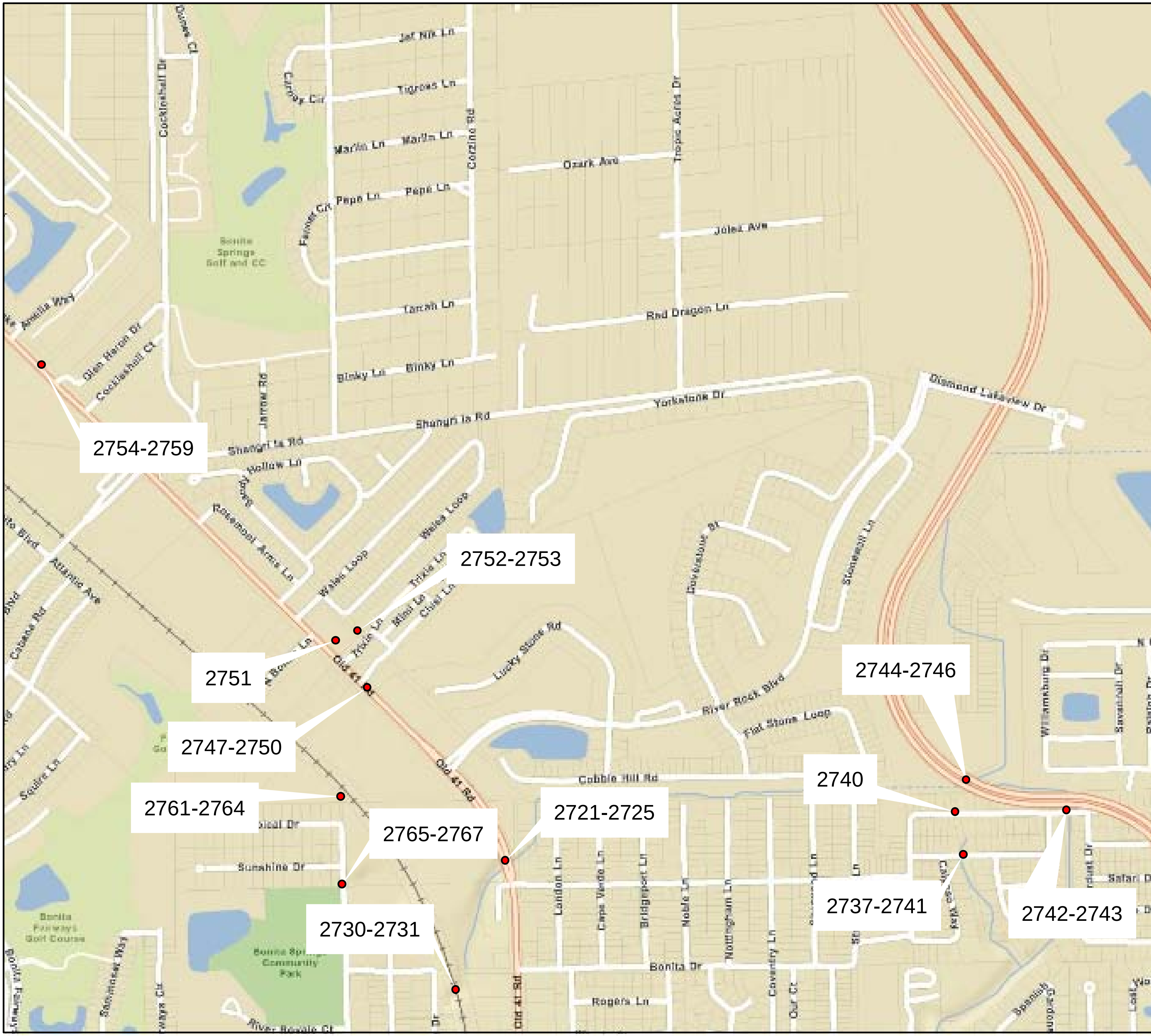
Project: 4600000955W003

Date: 9/13/2010

File: COBS_SMP_Fig5-1

Firm PE Registration Number: 4722

Figure 5-1



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N

Miles

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Photo Number

Photo Location

City of Bonita Springs Stormwater Master Plan

Field Survey Photo Locations Panel 1

Project: 4600000955W003

Date: 9/13/2010

File: COBS_SMP_Fig5-2

Firm PE Registration Number: 4722

Figure 5-2

Legend

N

Miles

0 0.05 0.1 0.2

Photo Number

Photo Location

City of Bonita Springs
Stormwater
Master Plan

Field Survey
Photo Locations
Panel 2

Project: 4600000955W003

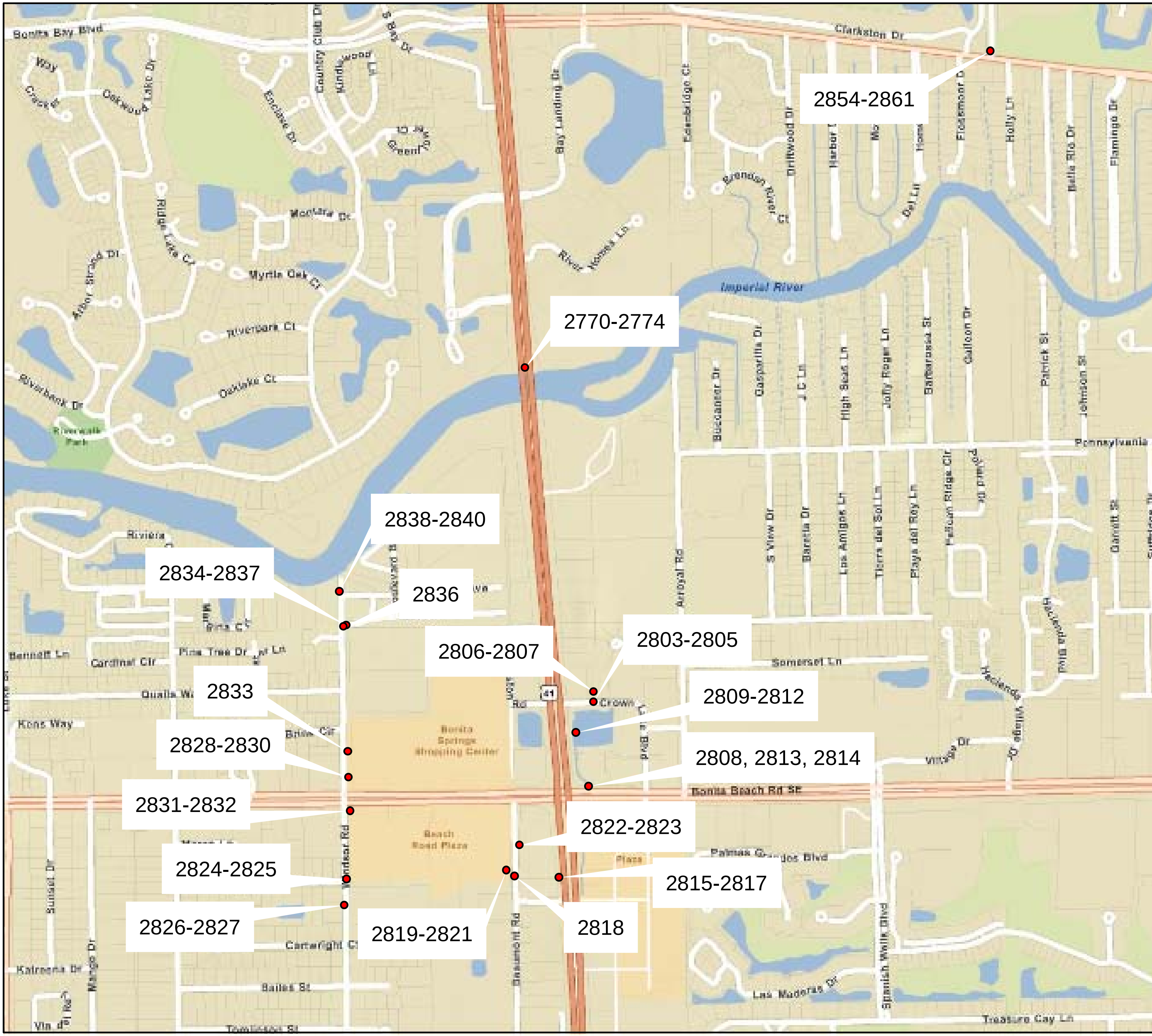
Date: 9/13/2010

File:
COBS_SMP_Fig5-3

INTERA

Firm PE Registration Number: 4722

Figure 5-3



Legend

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Miles

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Photo Number

Photo Location

City of Bonita Springs Stormwater Master Plan

Field Survey Photo Locations Panel 3

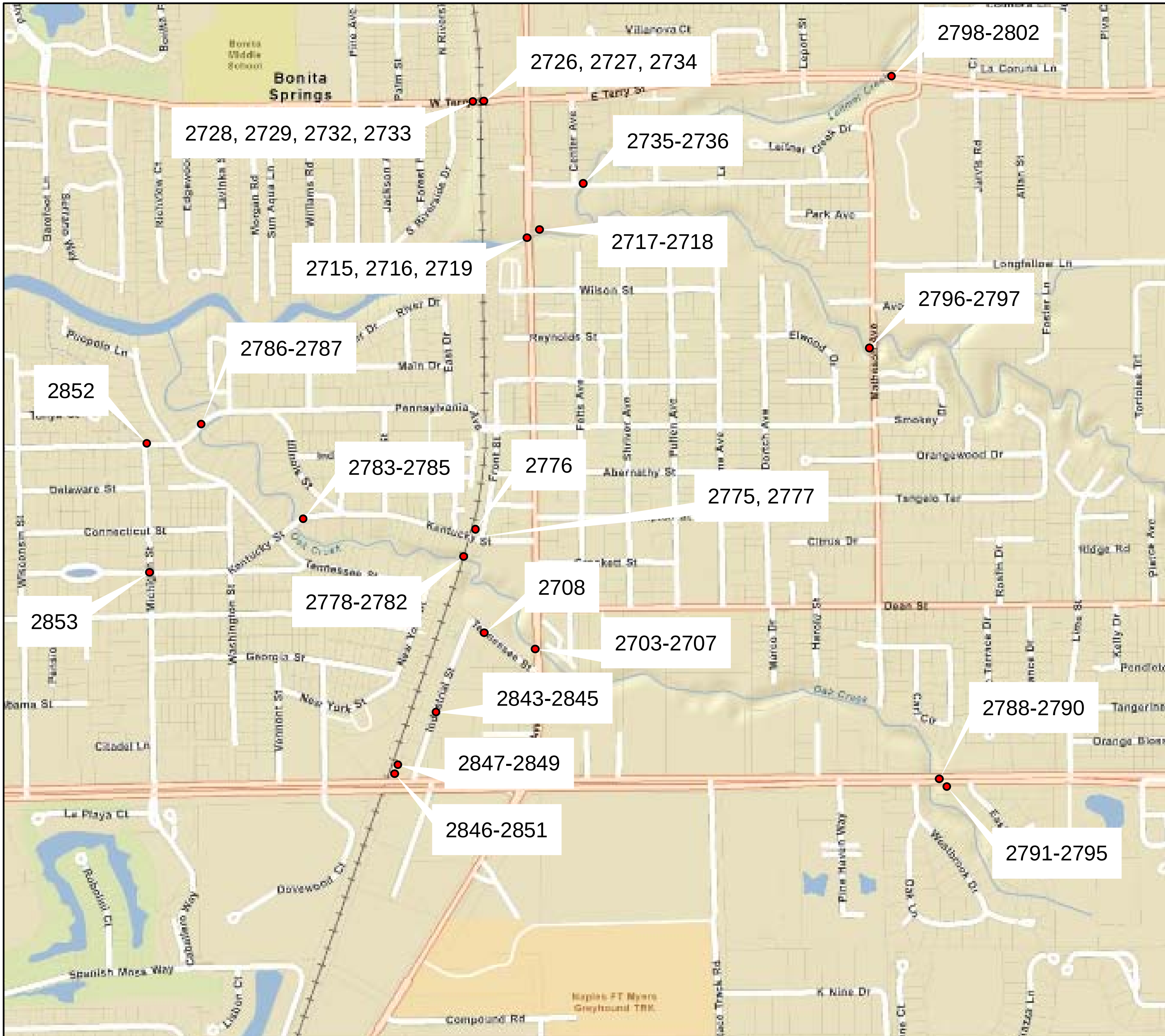
Project: 4600000955W003

Date: 9/13/2010

File: COBS_SMP_Fig5-4

Firm PE Registration Number: 4722

Figure 5-4



Legend

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Miles

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Photo Number

Photo Location

City of Bonita Springs Stormwater Master Plan

Field Survey Photo Locations Panel 4

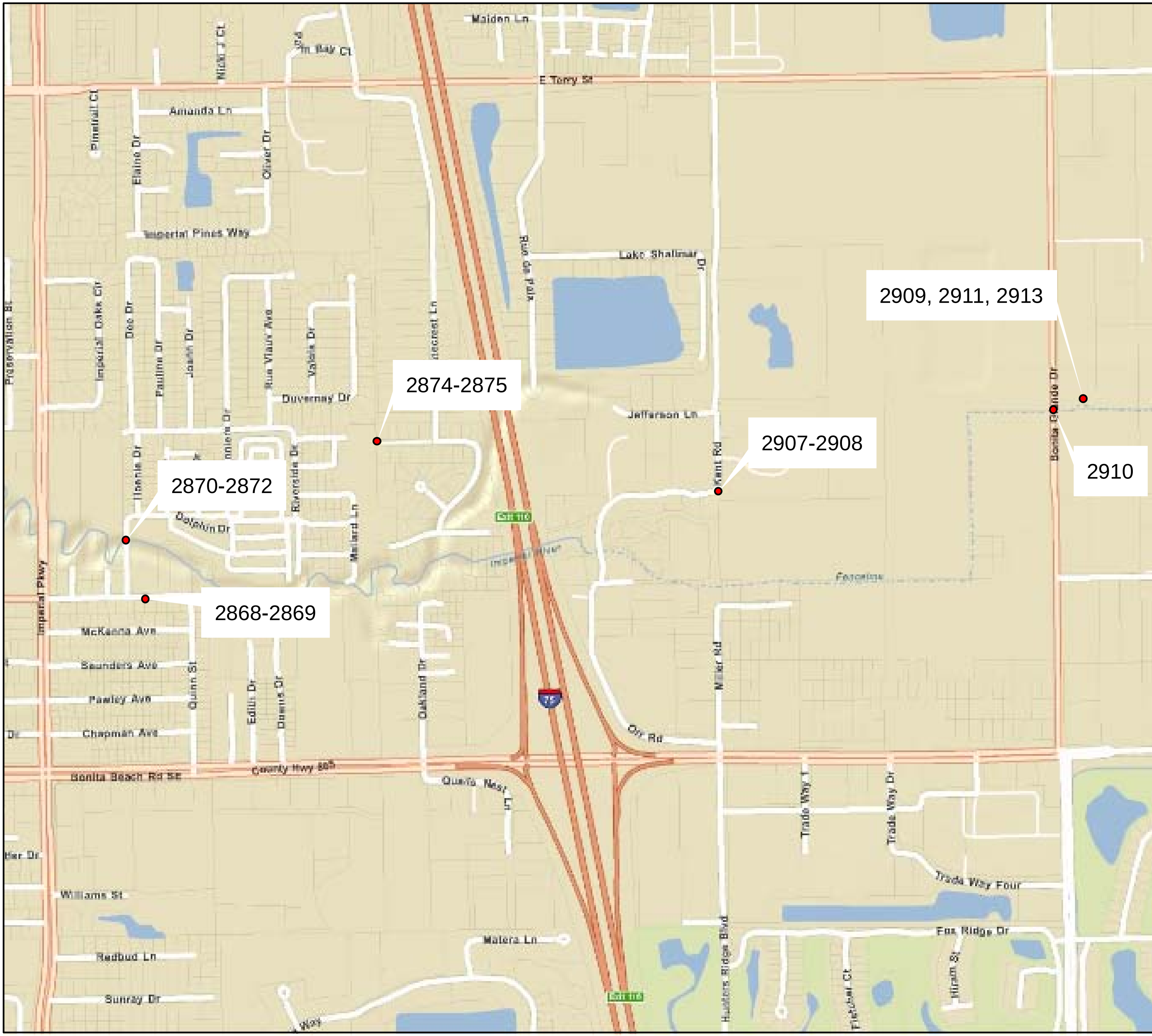
Project: 4600000955W003

Date: 9/13/2010

File: COBS_SMP_Fig5-5

Firm PE Registration Number: 4722

Figure 5-5



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Miles

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Photo Number

Photo Location

City of Bonita Springs Stormwater Master Plan

Field Survey Photo Locations Panel 5

Project: 4600000955W003

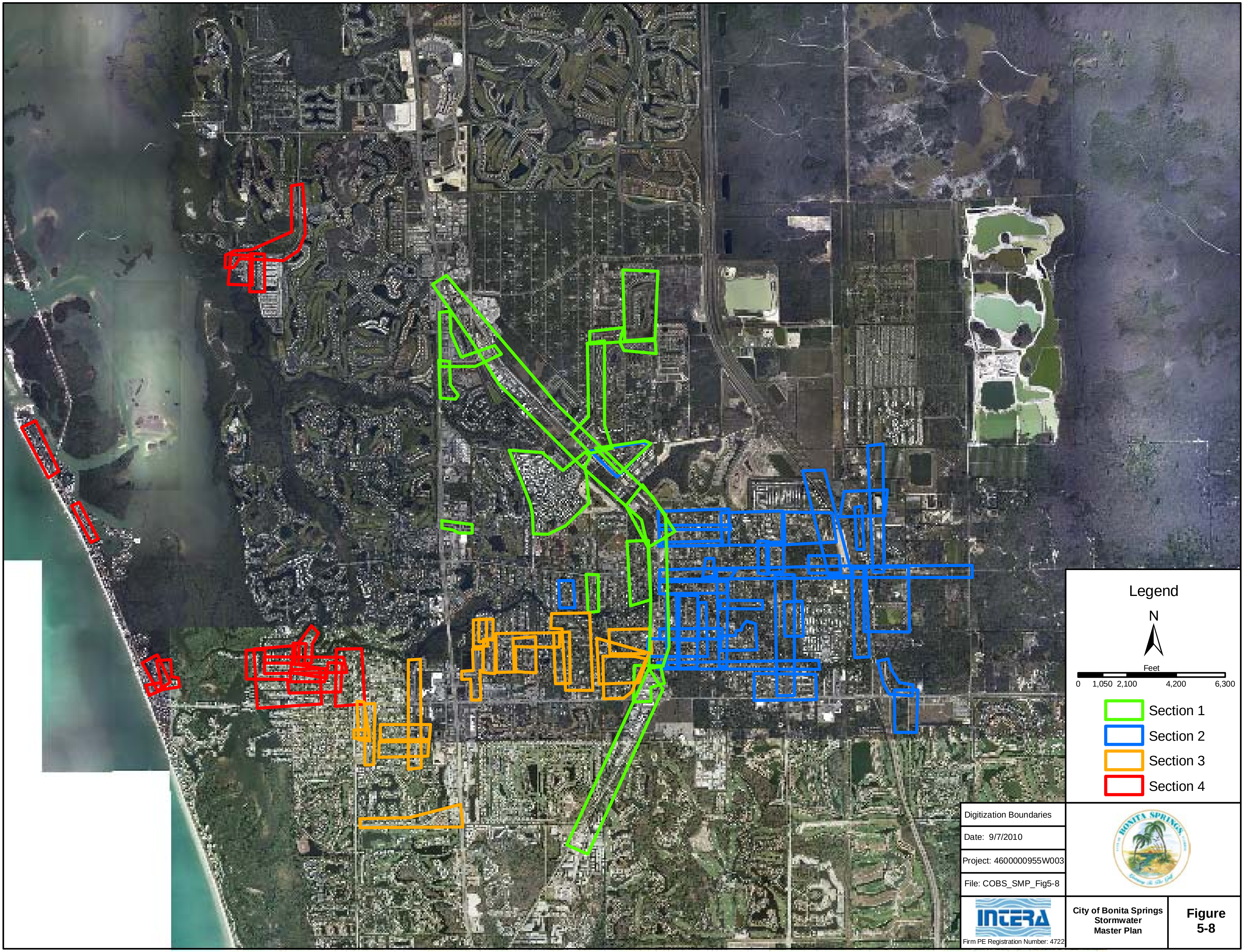
Date: 9/13/2010

File: COBS_SMP_Fig5-6

Firm PE Registration Number: 4722

Figure 5-6

Hand Written Field Notes		
Date: 9/7/2010		
Project: 4600000955W003		
File: COBS_SMP_Fig5-7		
INTERA Firm PE Registration Number: 4722	**City of Bonita Springs Stormwater Master Plan**	**Figure 5-7**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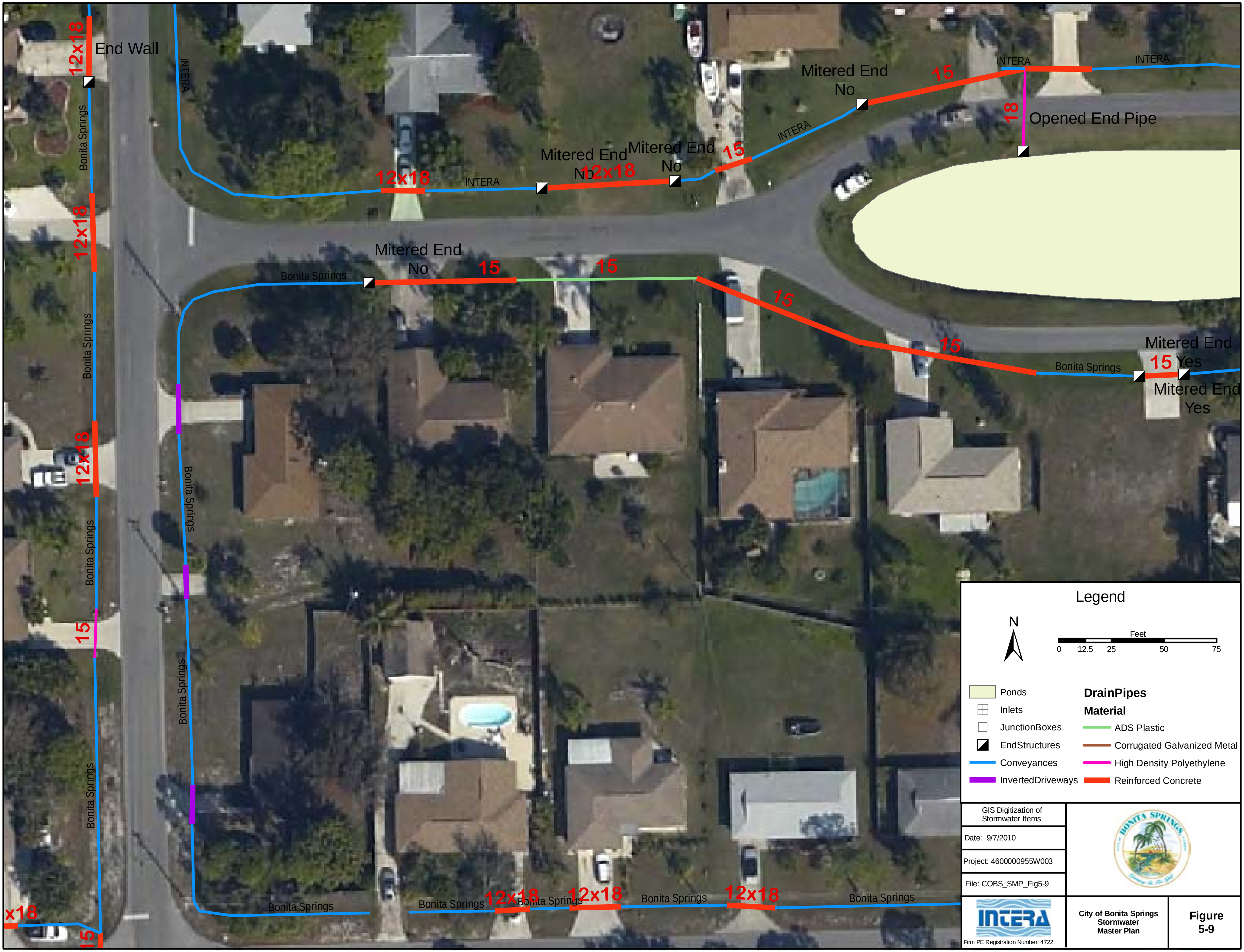
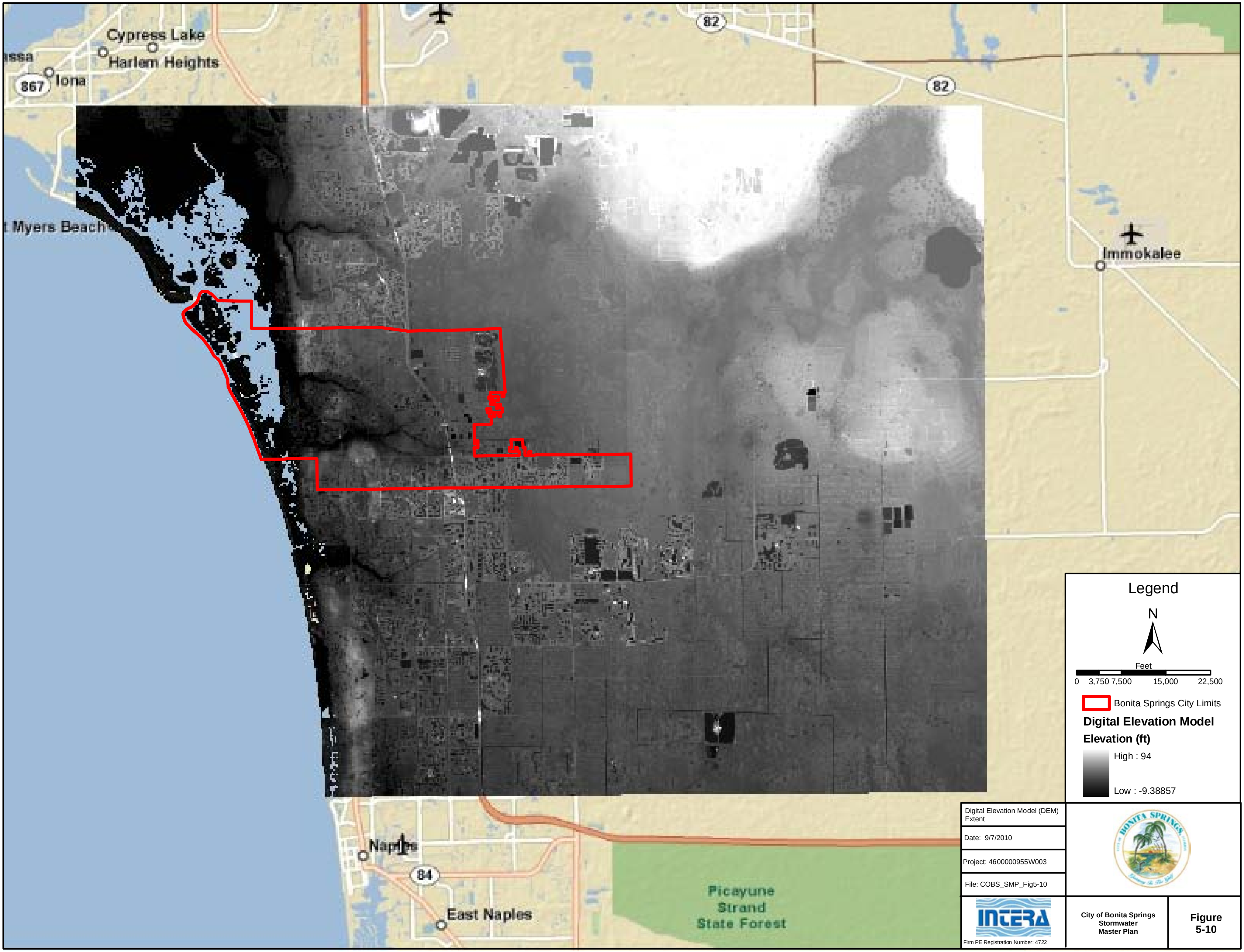
N
Feet
0 1,050 2,100 4,200 6,300
Section 1
Section 2
Section 3
Section 4
Digitization Boundaries
Date: 9/7/2010
Project: 4600000955W003
File: COBS_SMP_Fig5-8
INTERA
Firm PE Registration Number: 4722
City of Bonita Springs
Stormwater
Master Plan

Figure 5-8



End Wall
12x18
INTERA
Bonita Springs
Mitered End
No
12x18
INTERA
Mitered End
No
12x18
Mitered End
No
15
INTERA
Mitered End
No
15
INTERA
INTERA
18
Opened End Pipe
Mitered End
No
15
15
15
15
Bonita Springs
Mitered End
15 Yes
Mitered End
Yes
Bonita Springs
12x18
12x18
15
x18
15
12x18
12x18
12x18
Legend
N
Feet
0 12.5 25 50 75
Ponds
Inlets
JunctionBoxes
EndStructures
Conveyances
InvertedDriveways
DrainPipes
Material
ADS Plastic
Corrugated Galvanized Metal
High Density Polyethylene
Reinforced Concrete
GIS Digitization of Stormwater Items
Date: 9/7/2010
Project: 4600000955W003
File: COBS_SMP_Fig5-9
INTERA
Firm PE Registration Number: 4722
City of Bonita Springs Stormwater Master Plan
Figure 5-9



Digital Elevation Model (DEM) Extent

Date: 9/7/2010

Project: 4600000955W003

File: COBS_SMP_Fig5-10

INTERA

Firm PE Registration Number: 4722

City of Bonita Springs Stormwater Master Plan

Figure 5-10

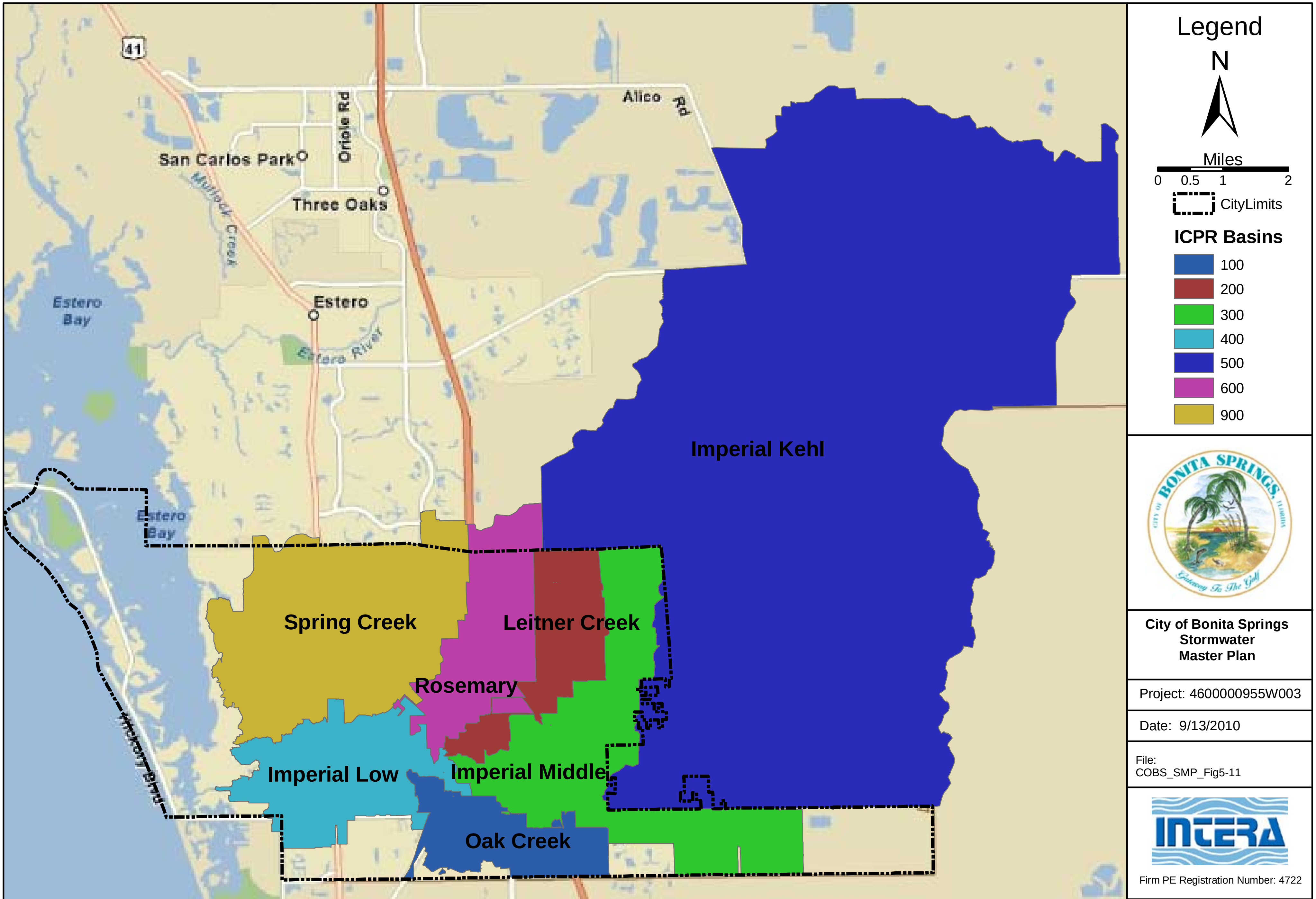
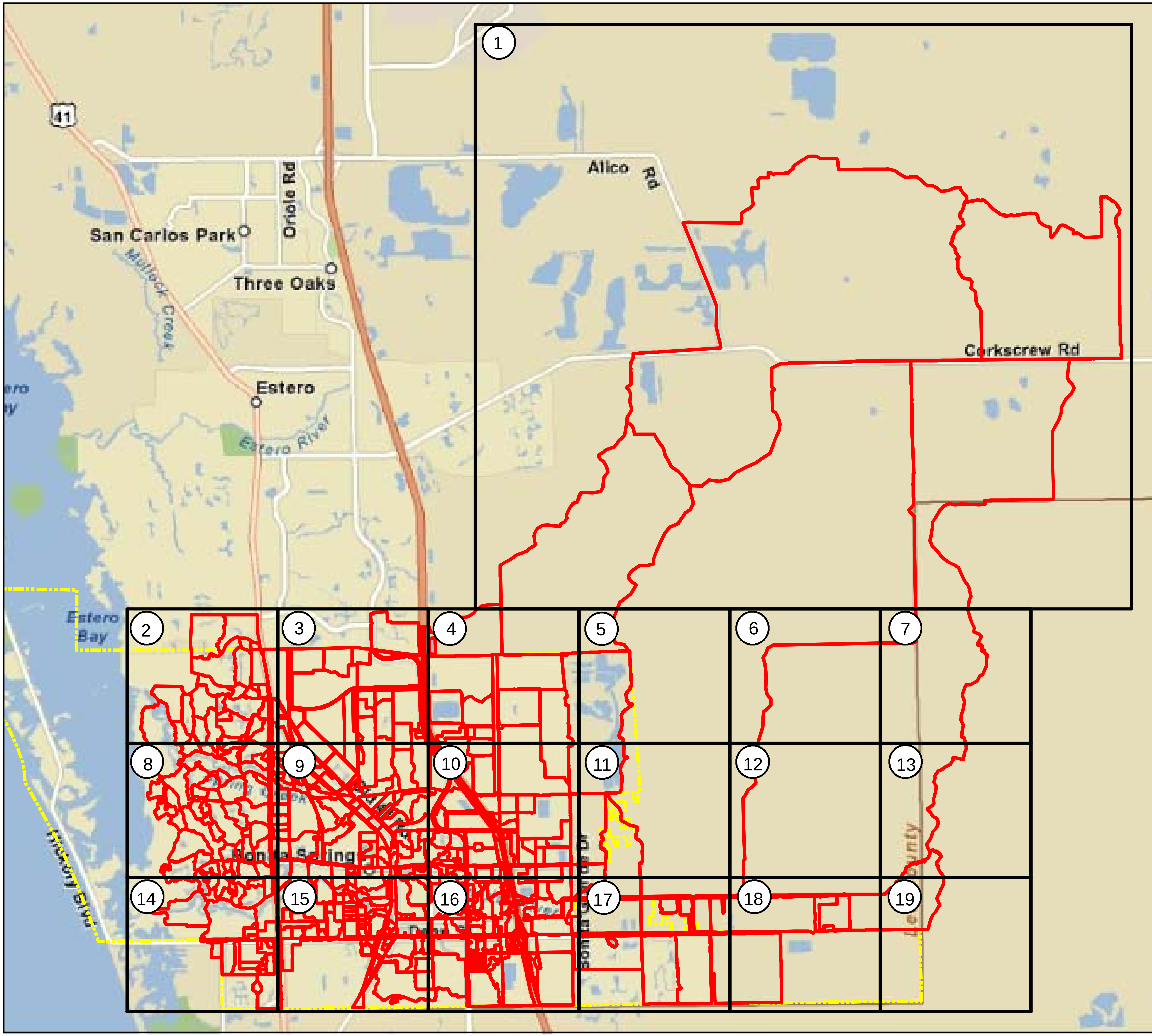

Legend
N
Miles
0 0.5 1 2
CityLimits
ICPR Basins
100
200
300
400
500
600
900
City of Bonita Springs
Stormwater
Master Plan
Project: 4600000955W003
Date: 9/13/2010
File:
COBS_SMP_Fig5-11
Firm PE Registration Number: 4722
Imperial Kehl
Spring Creek
Leitner Creek
Rosemary
Imperial Low
Imperial Middle
Oak Creek
San Carlos Park
Three Oaks
Estero
Estero Bay
Estero River
Alico Rd
Oriole Rd
Mullock Creek
Hickory Blvd
Old 41 N
41

Figure
5-11



Legend

N

Miles

0 0.5 1 2

ICPR Basins

CityLimits

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

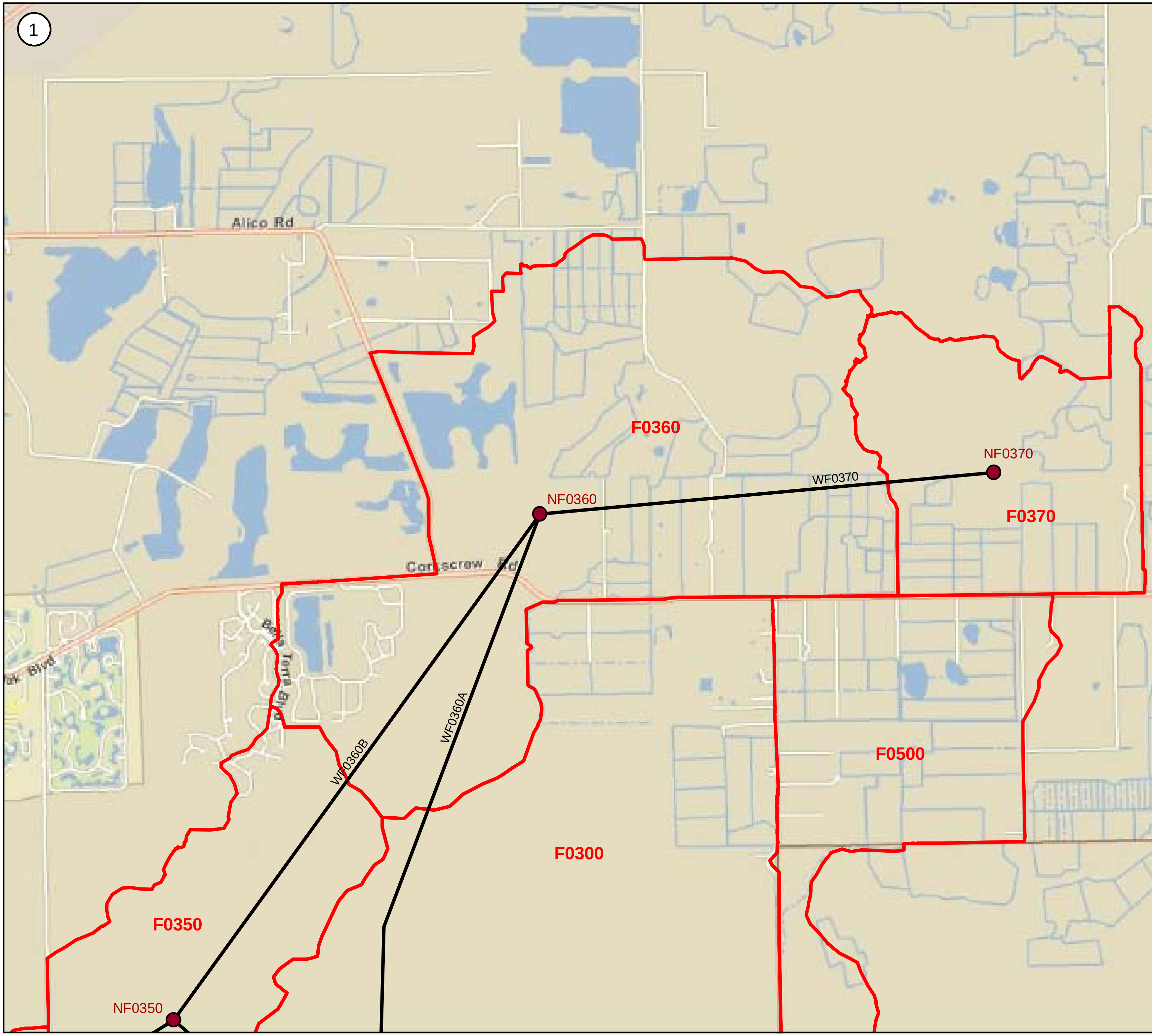
Date: 10/18/2010

File: COBS_SMP_Fig5-12

INTERA

Firm PE Registration Number: 4722

Figure 5-12



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N

Miles

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ICPR Nodes

ICPR Links

ICPR Basins

CityLimits

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

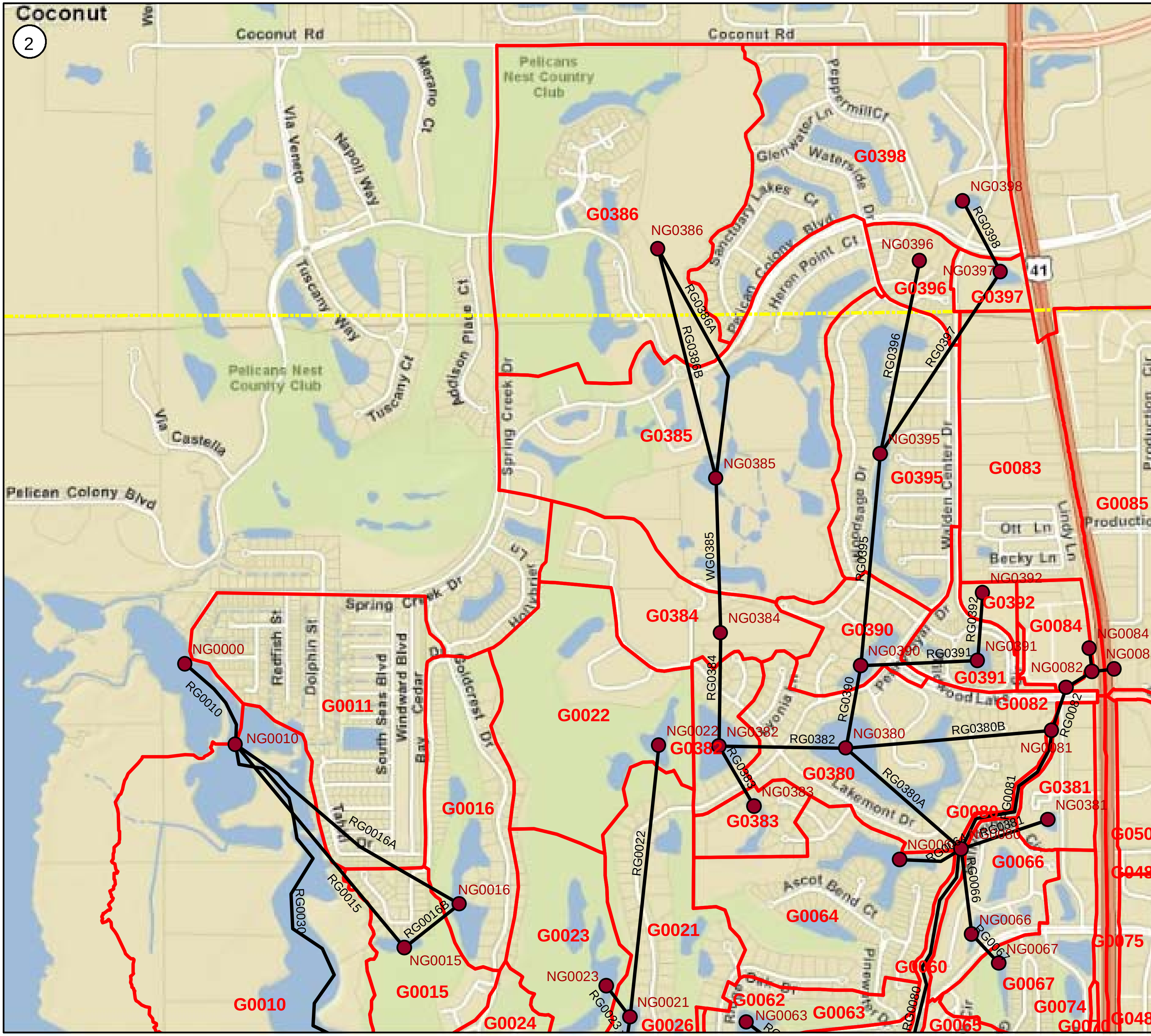
Date: 10/18/2010

File: COBS_SMP_Fig5-13

INTERA

Firm PE Registration Number: 4722

Figure 5-13



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N

Miles

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ICPR Nodes

ICPR Links

ICPR Basins

CityLimits

\# I.D. Number

City of Bonita Springs, Florida — Gateway To The Gulf

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

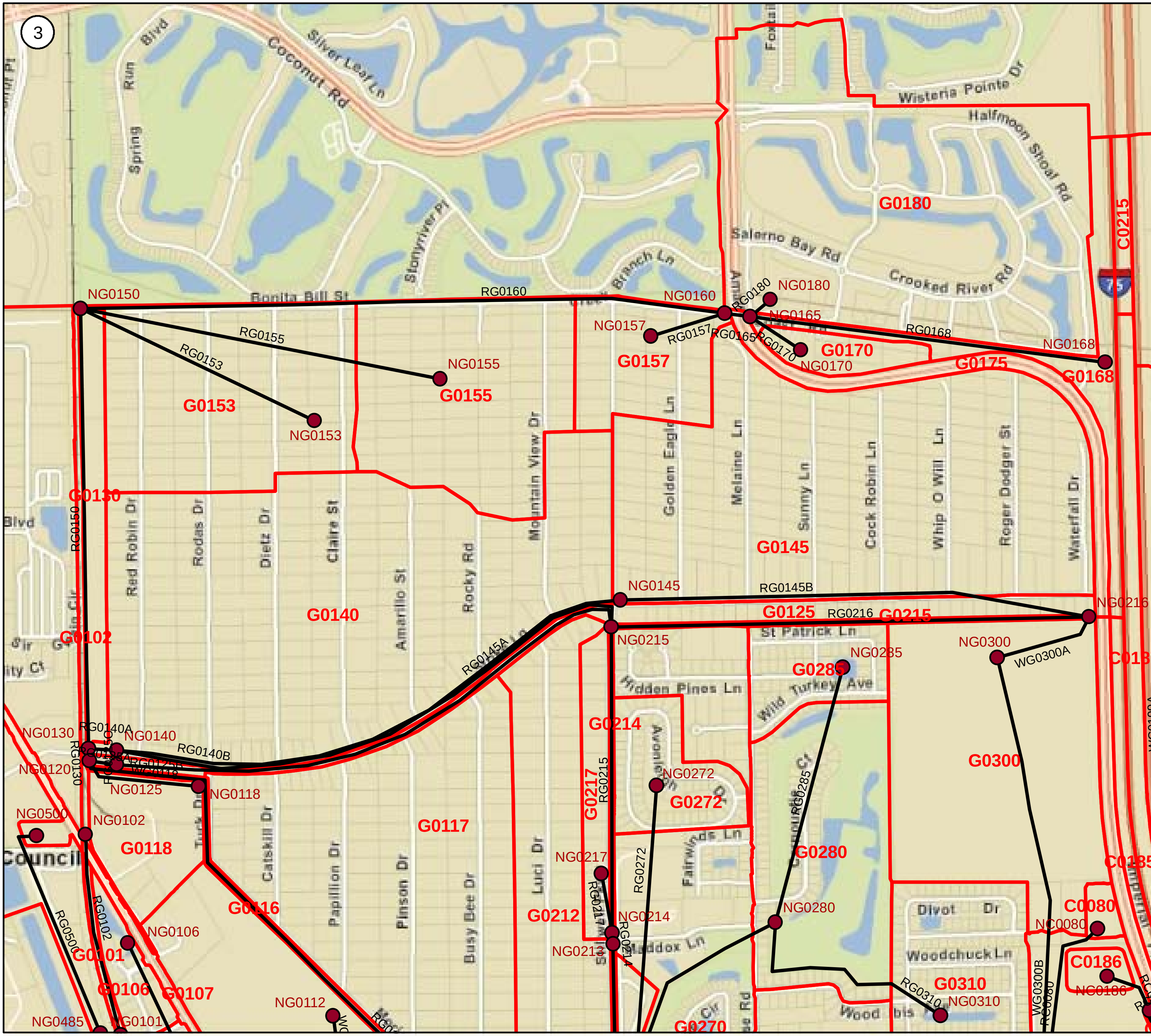
Date: 10/18/2010

File: COBS_SMP_Fig5-14

INTERA

Firm PE Registration Number: 4722

Figure 5-14



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Miles

0 0.05 0.1 0.2 0.3

- ICPR Nodes
- ICPR Links
- ICPR Basins
- # I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

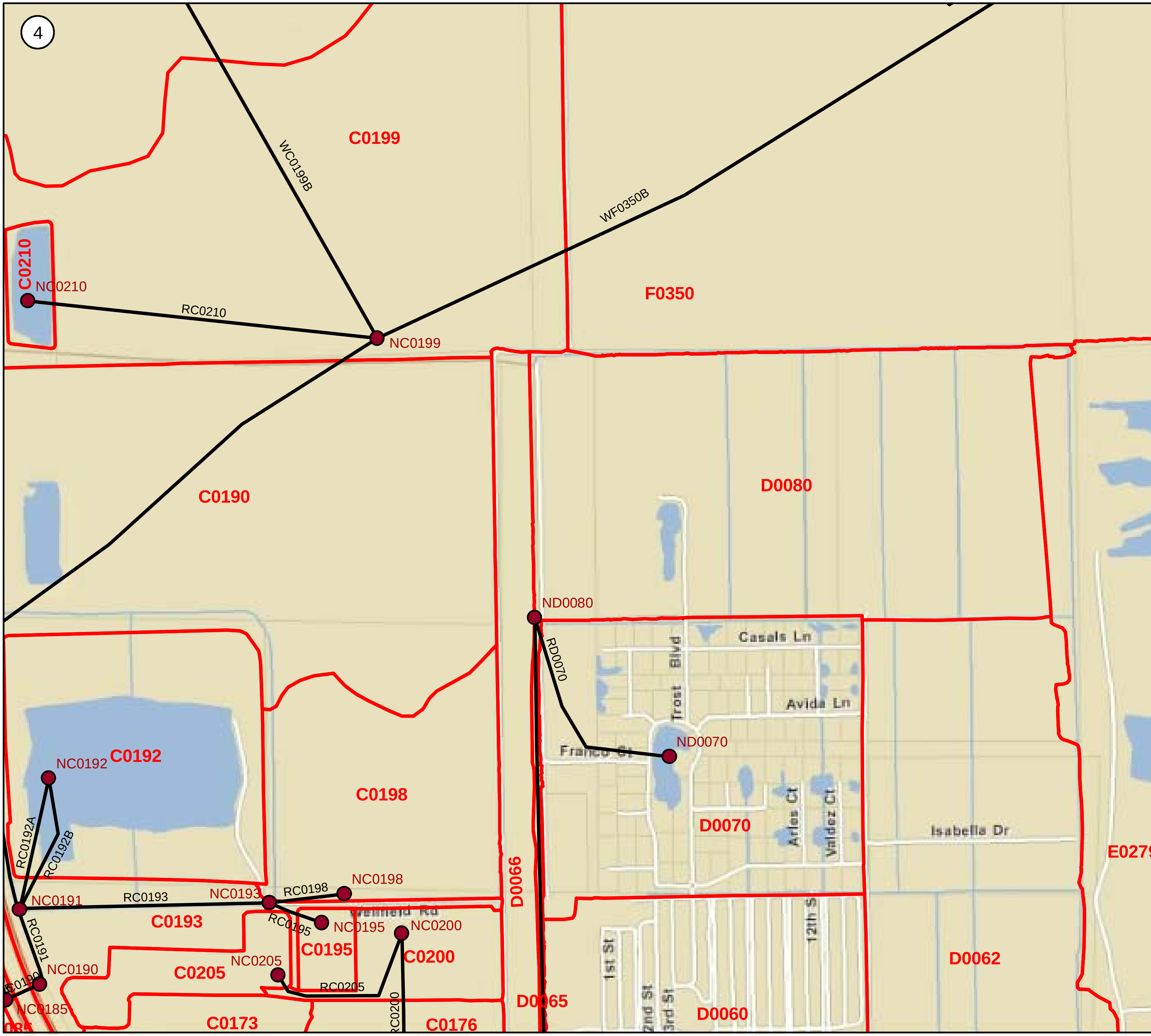
Date: 10/18/2010

File: COBS_SMP_Fig5-15

INTERA

Firm PE Registration Number: 4722

Figure 5-15



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N

Miles

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ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

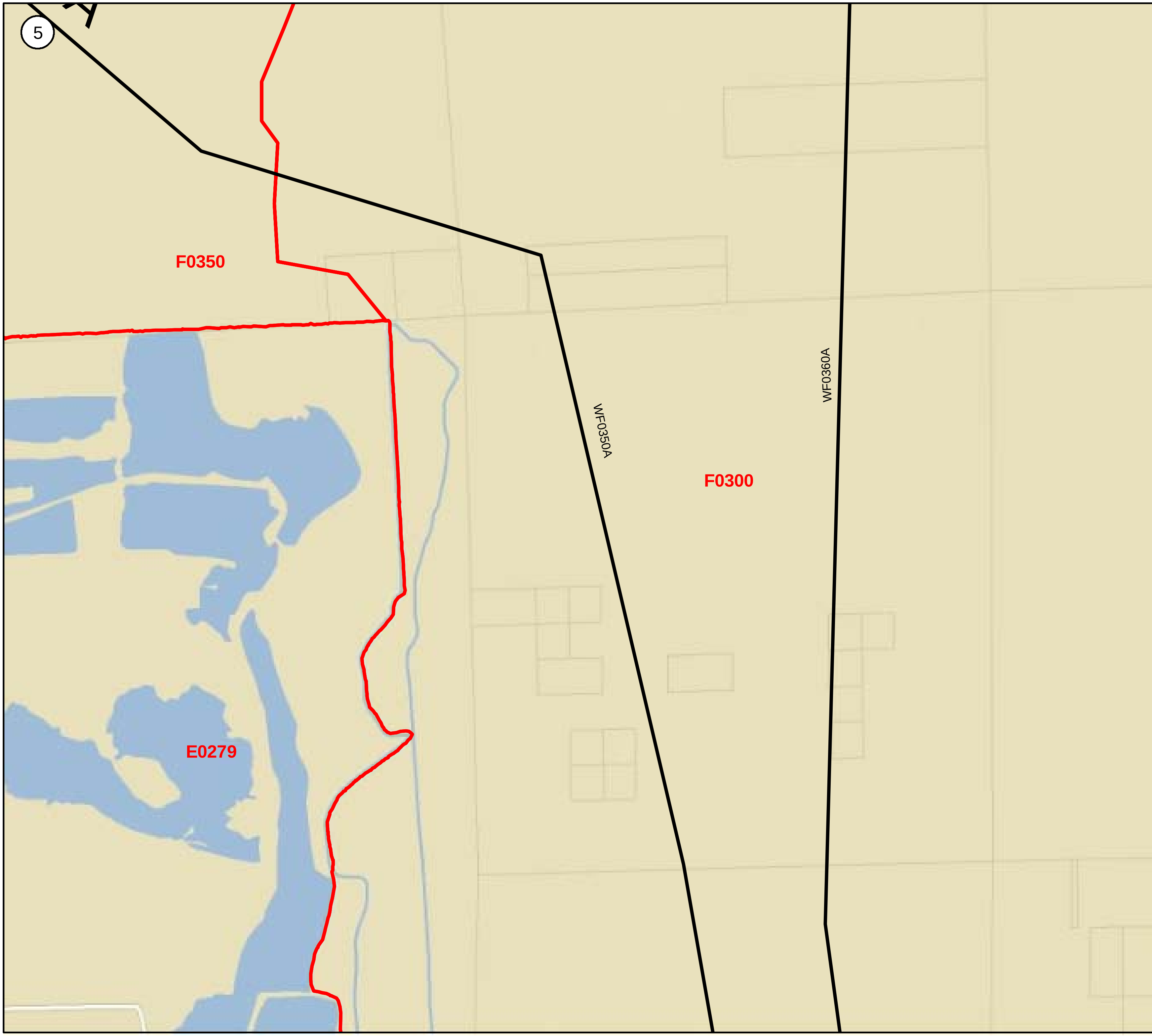
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-16

Firm PE Registration Number: 4722

Figure 5-16



Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-17

Firm PE Registration Number: 4722

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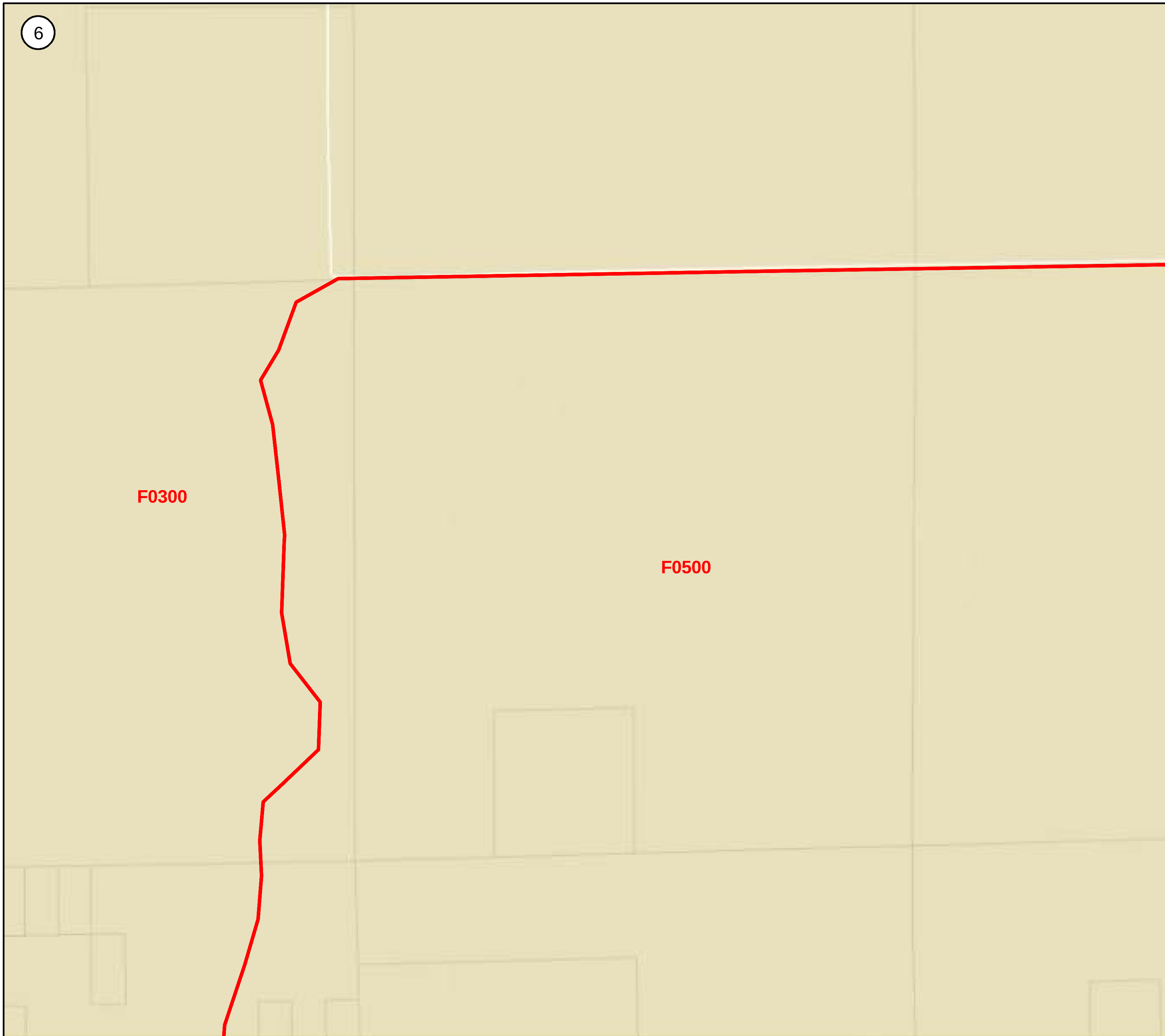

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N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

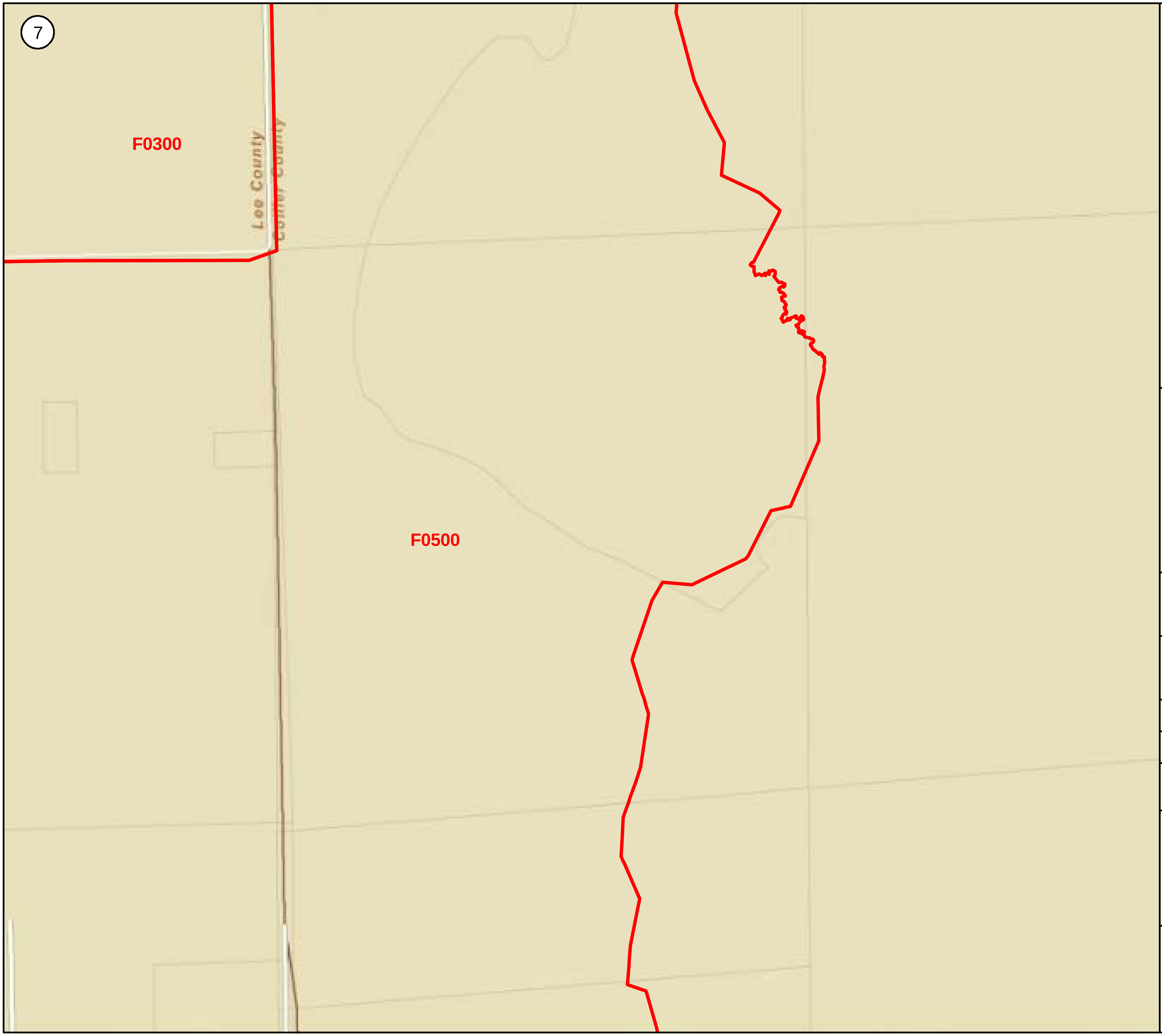
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-18

Firm PE Registration Number: 4722

Figure 5-18



Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

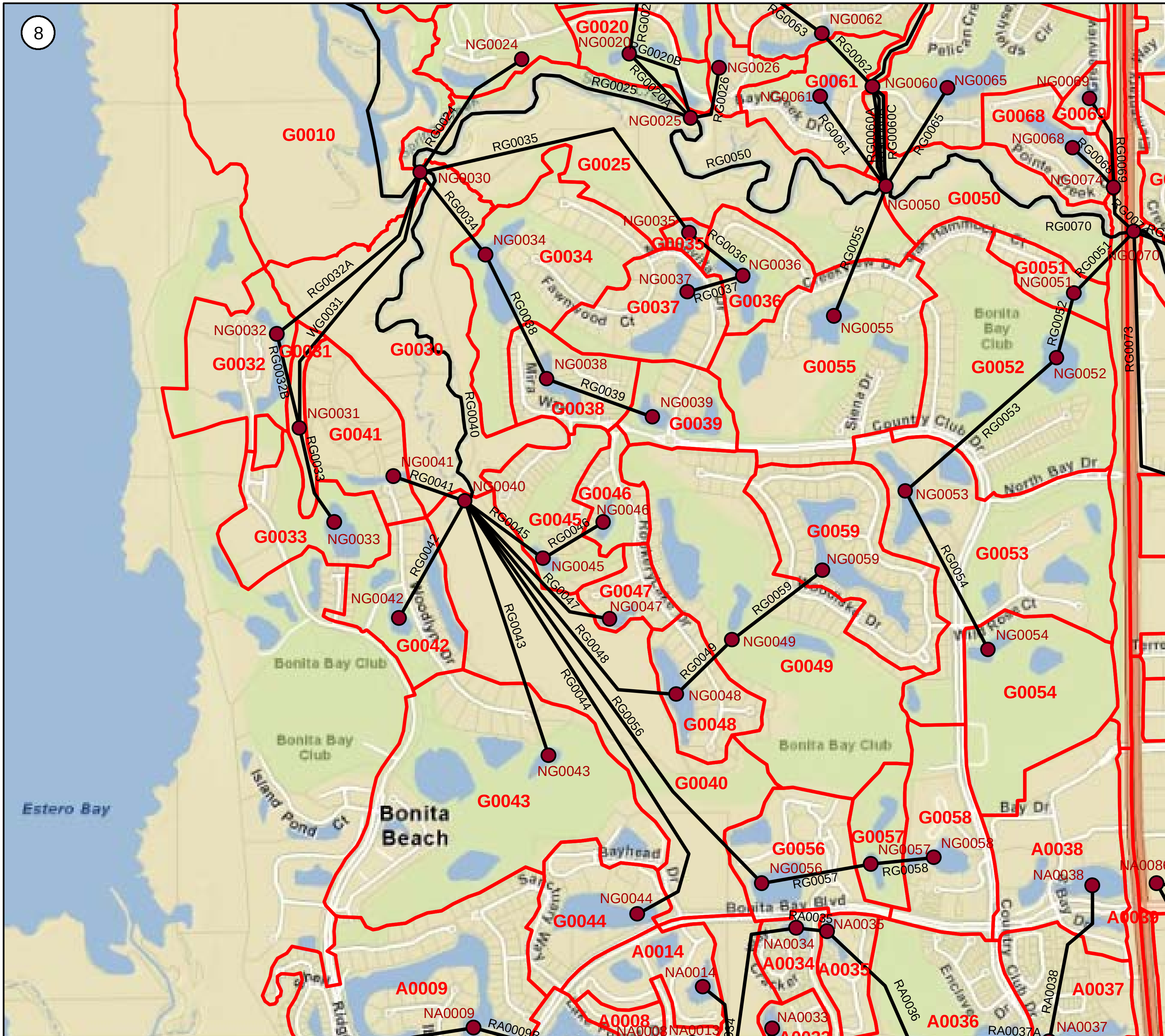
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-19

Firm PE Registration Number: 4722

Figure 5-19



Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

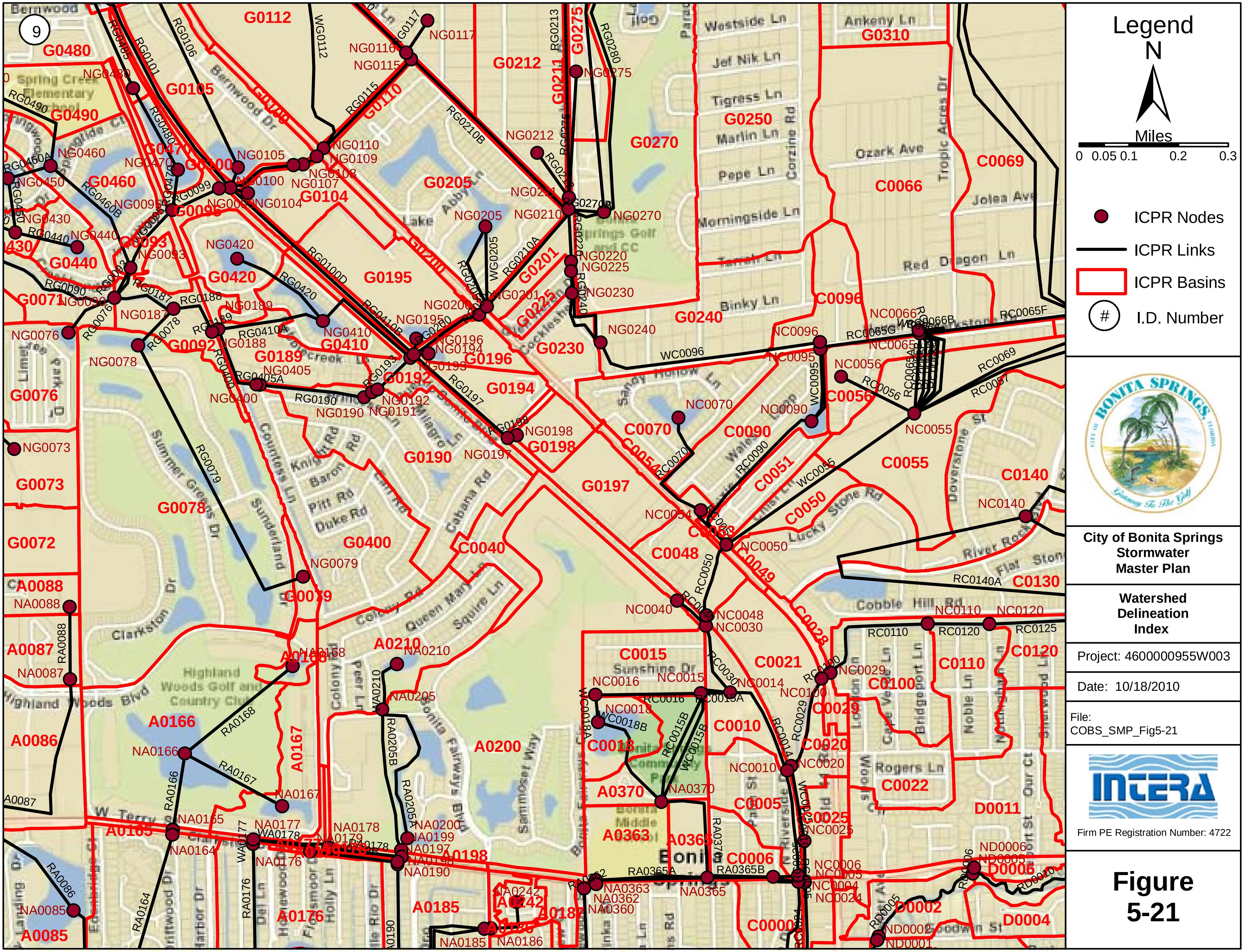
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-20

Firm PE Registration Number: 4722

Figure 5-20



City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

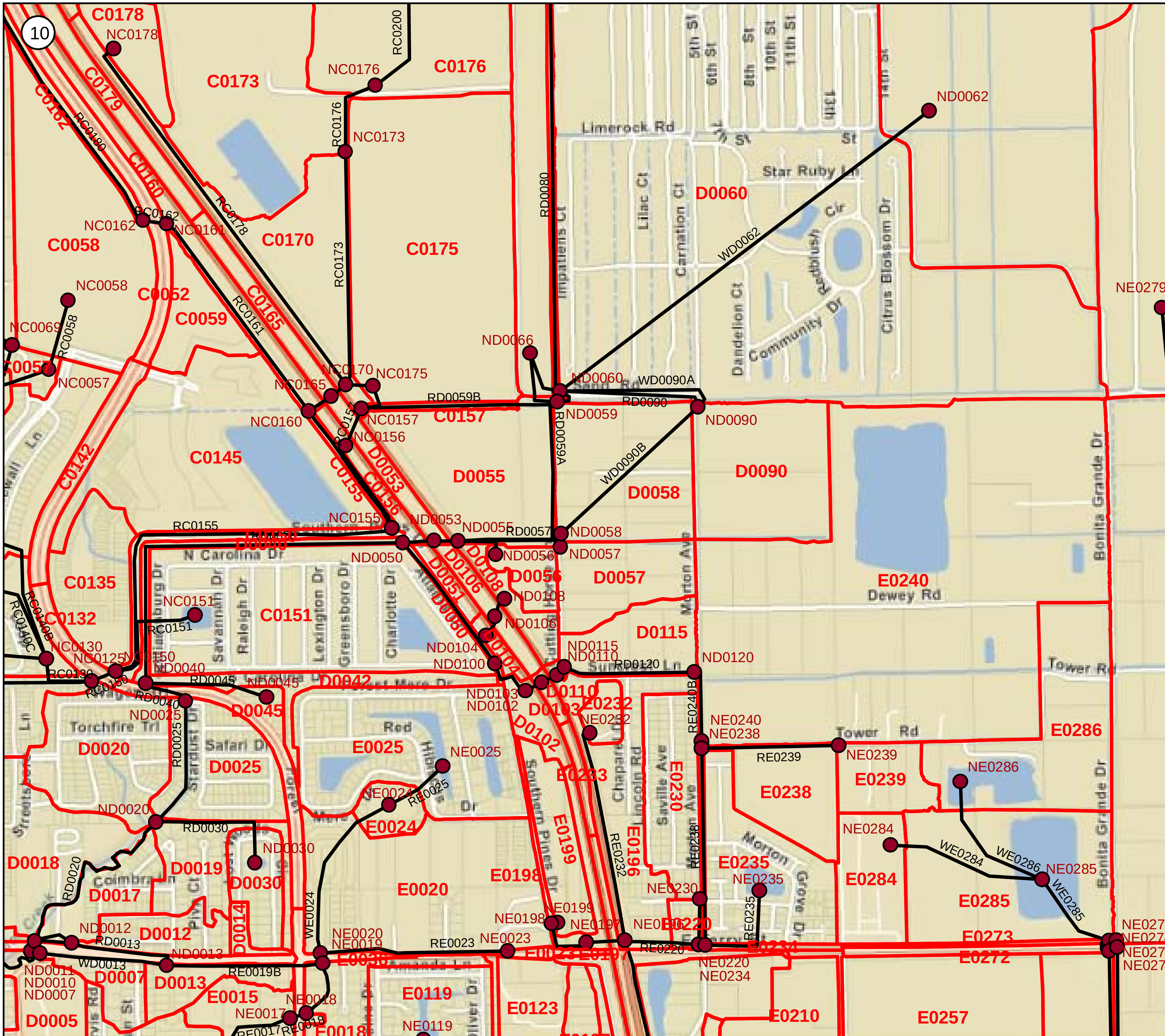
Date: 10/18/2010

File: COBS_SMP_Fig5-21

INTERA

Firm PE Registration Number: 4722

Figure 5-21



Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

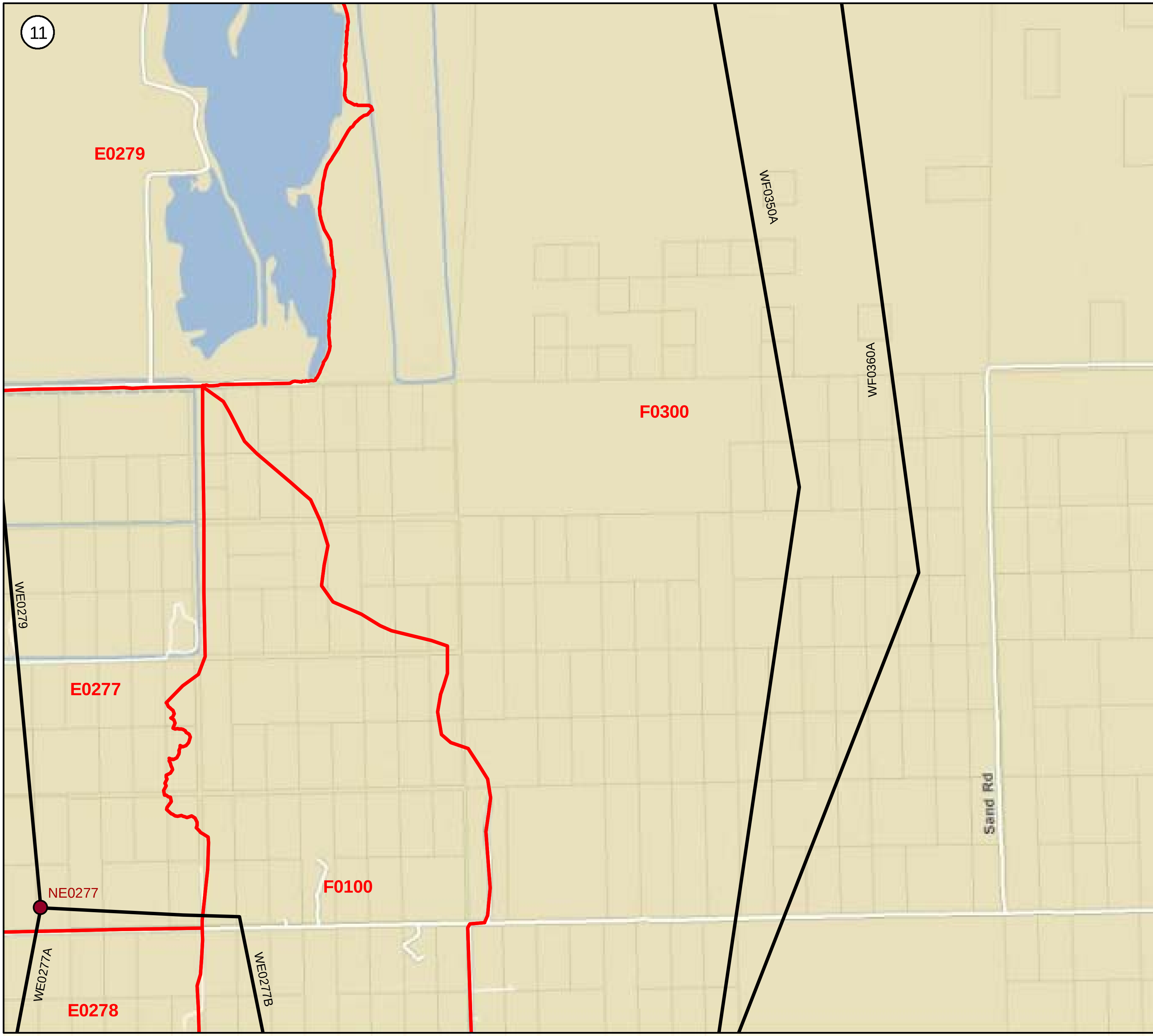
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-22

Firm PE Registration Number: 4722

Figure 5-22



Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

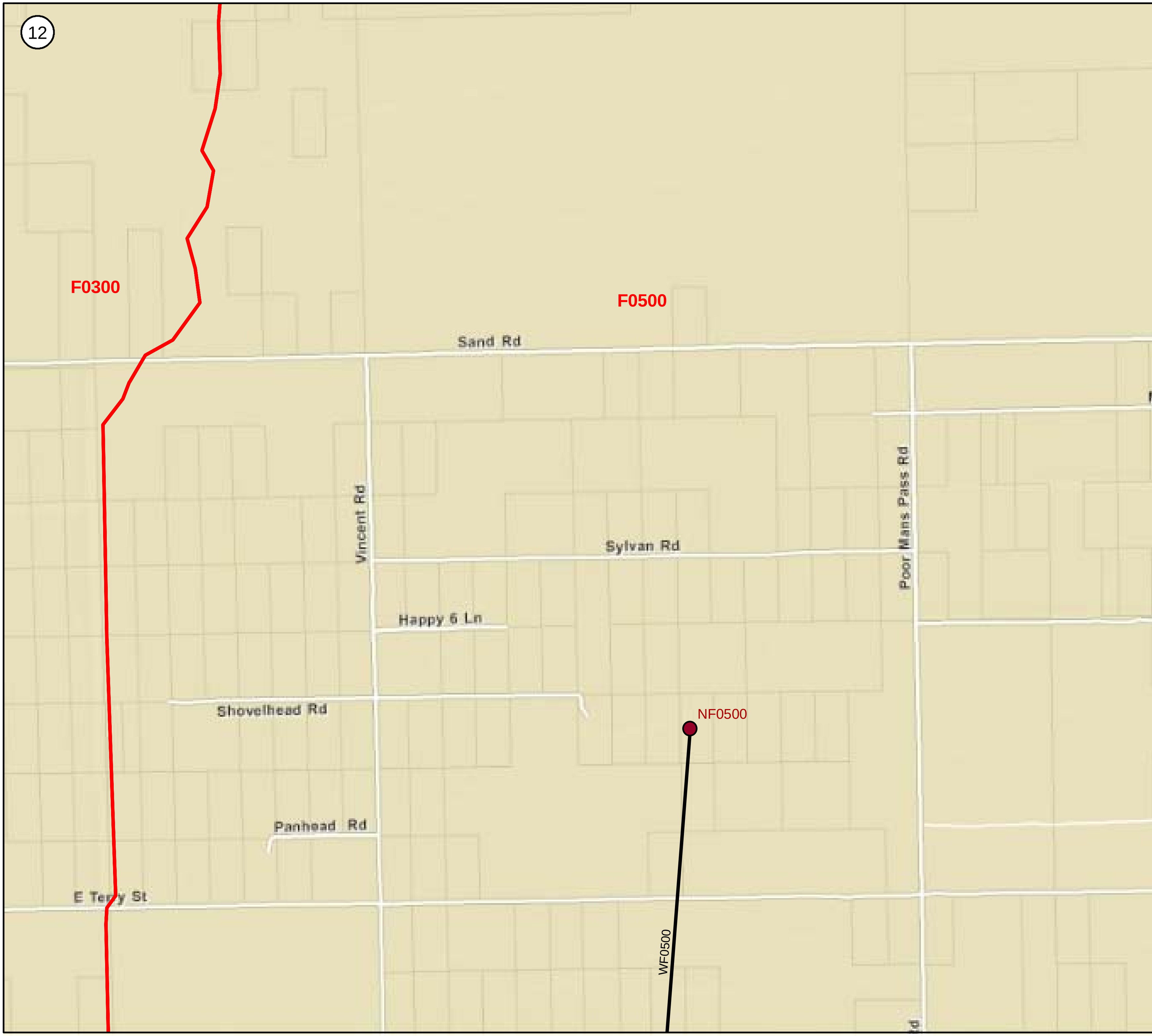
Date: 10/18/2010

File: COBS_SMP_Fig5-23

INTERA

Firm PE Registration Number: 4722

Figure 5-23



Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

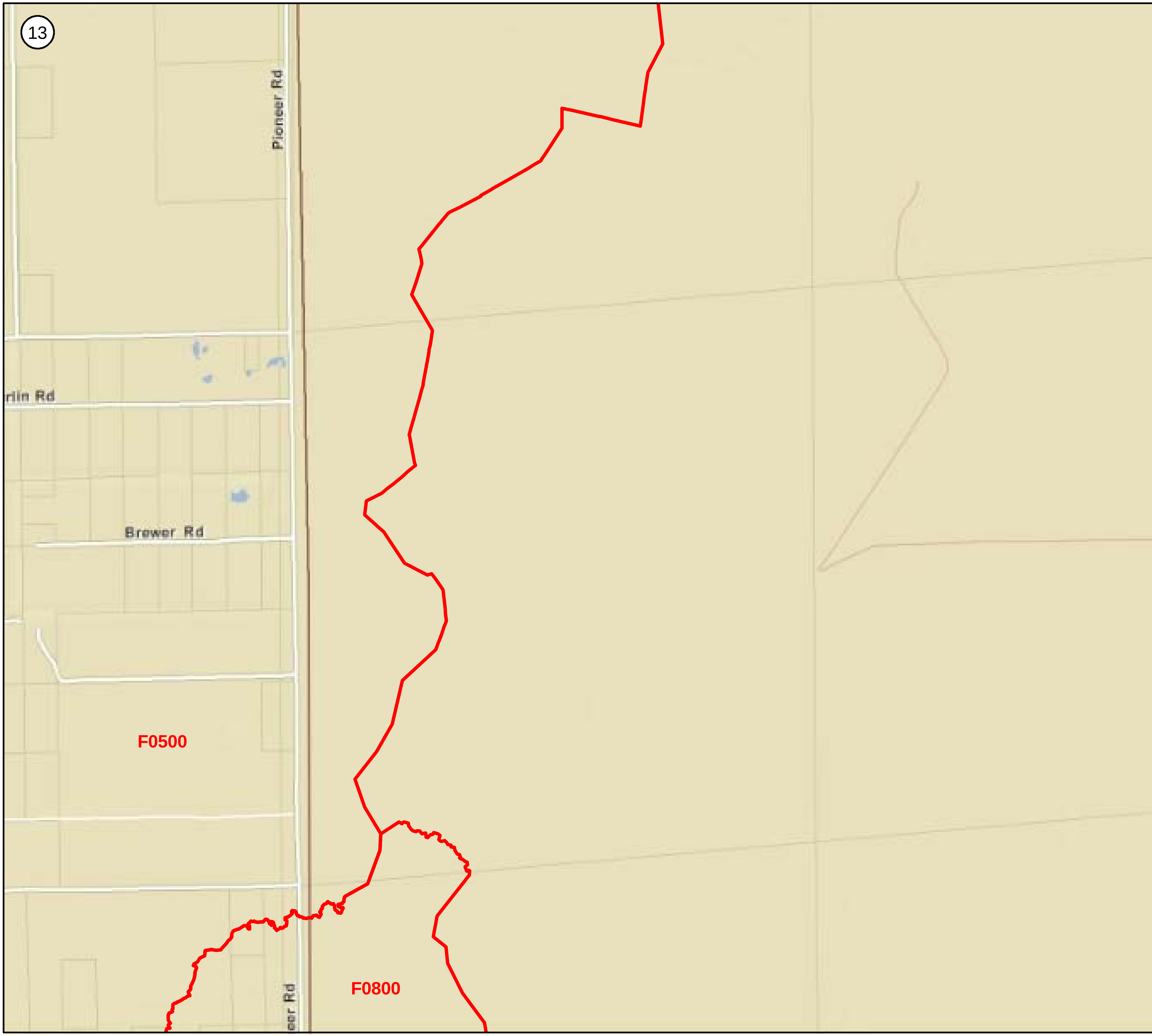
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-24

Firm PE Registration Number: 4722

Figure 5-24



Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

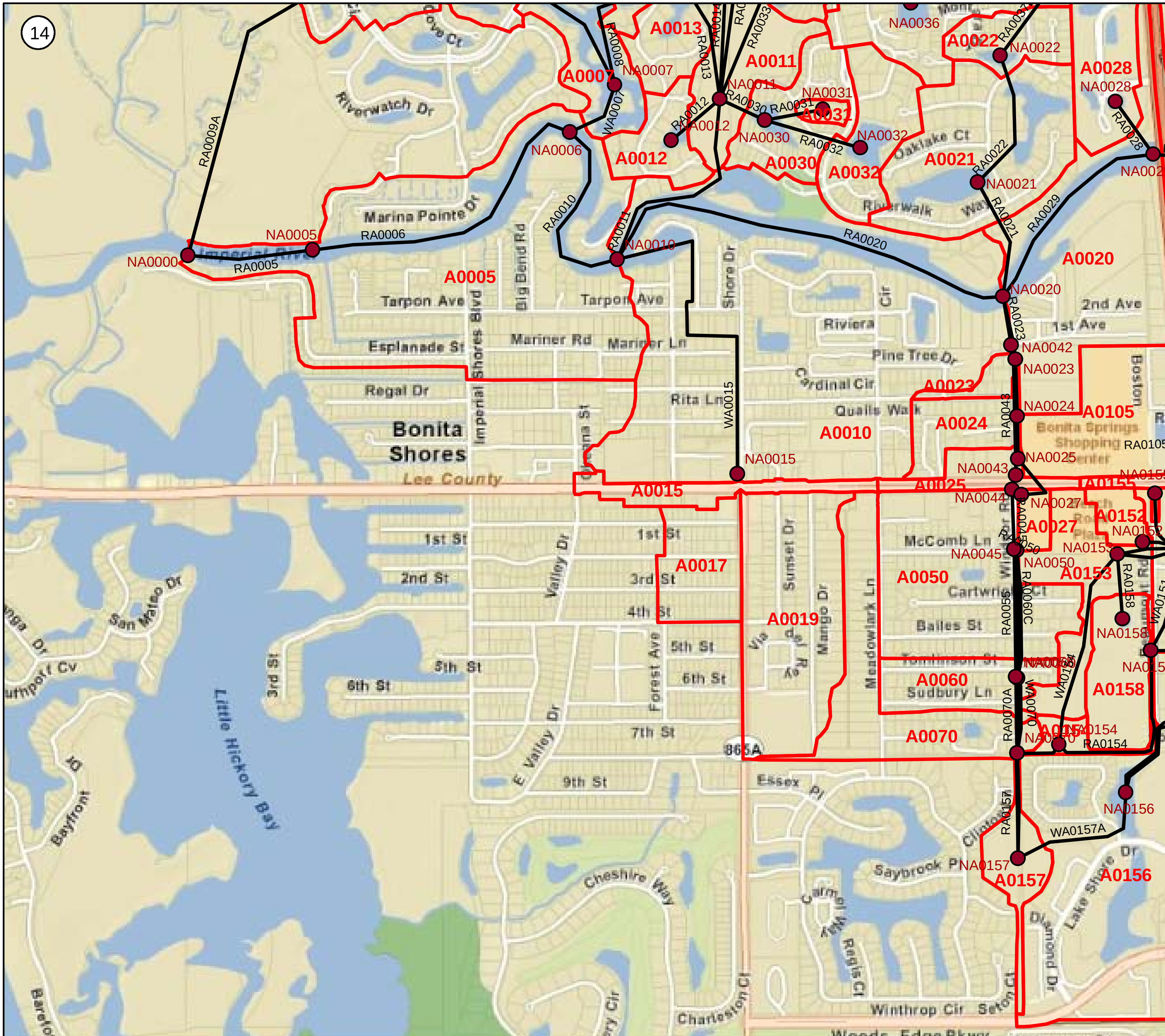
Date: 10/18/2010

File: COBS_SMP_Fig5-25

INTERA

Firm PE Registration Number: 4722

Figure 5-25



Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

\# I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

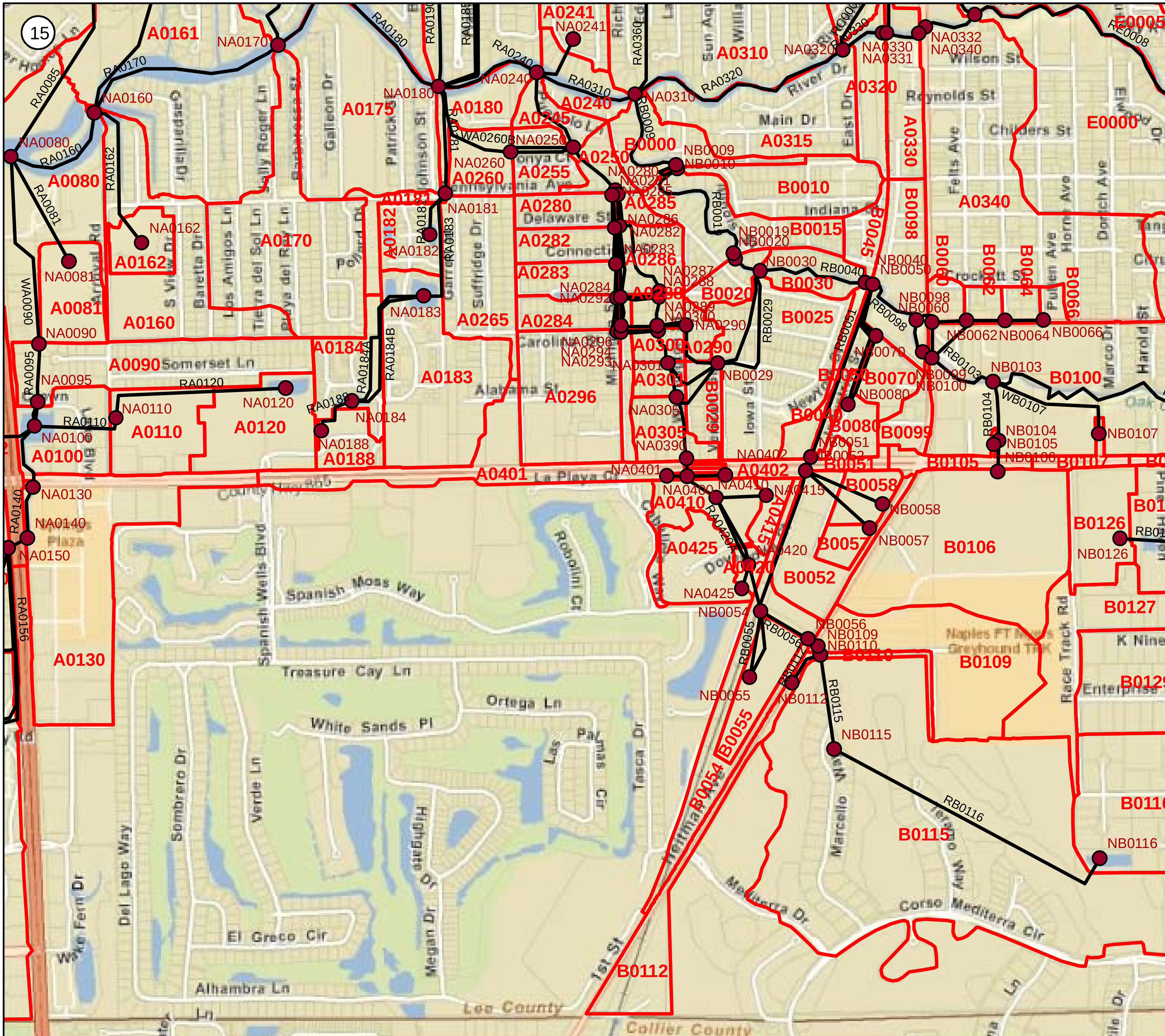
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-26

Firm PE Registration Number: 4722

Figure 5-26



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N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

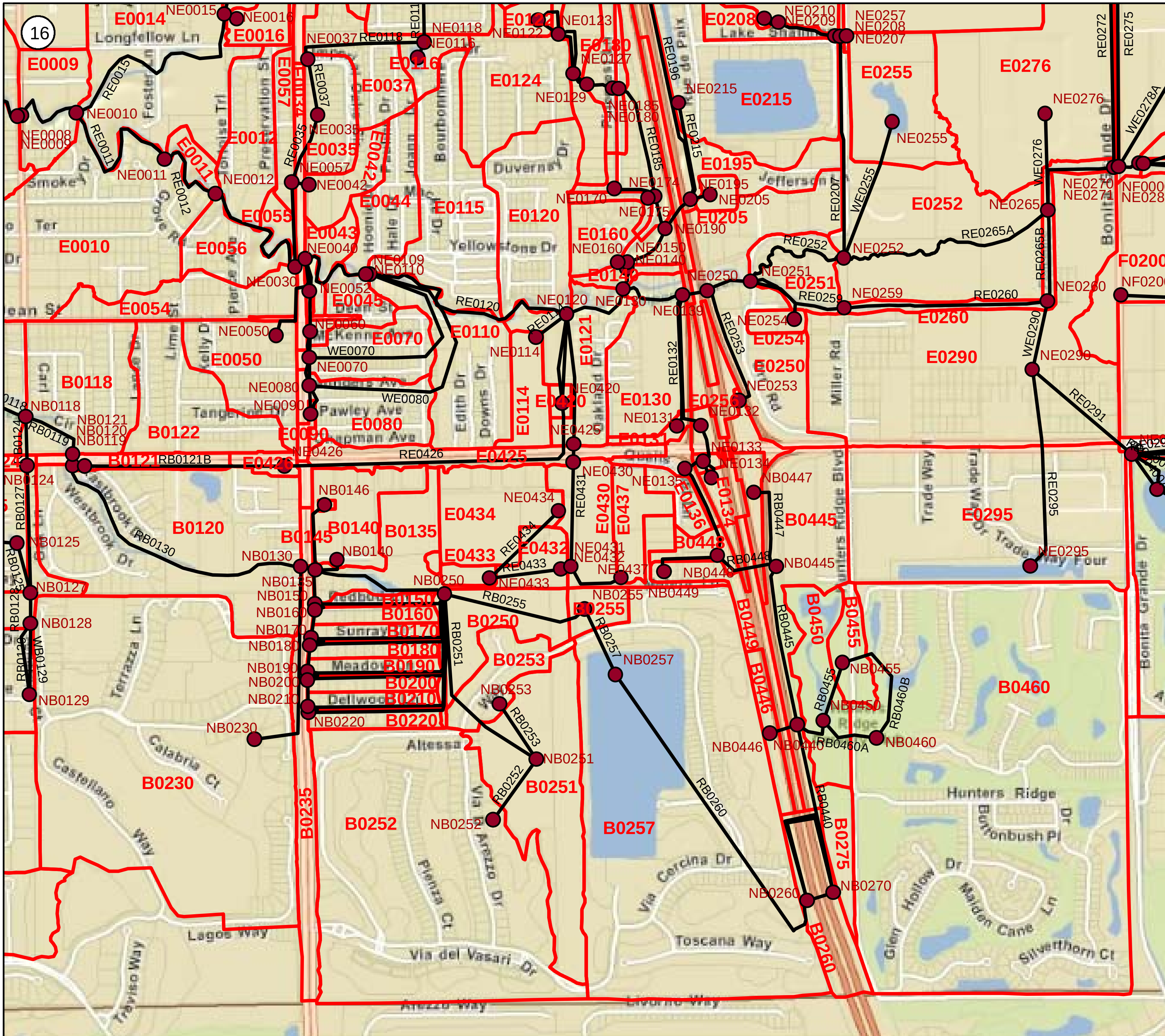
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-27

Firm PE Registration Number: 4722

Figure 5-27



Legend

- ICPR Nodes
- ICPR Links
- ICPR Basins
- # I.D. Number

N

Miles

0 0.05 0.1 0.2 0.3

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

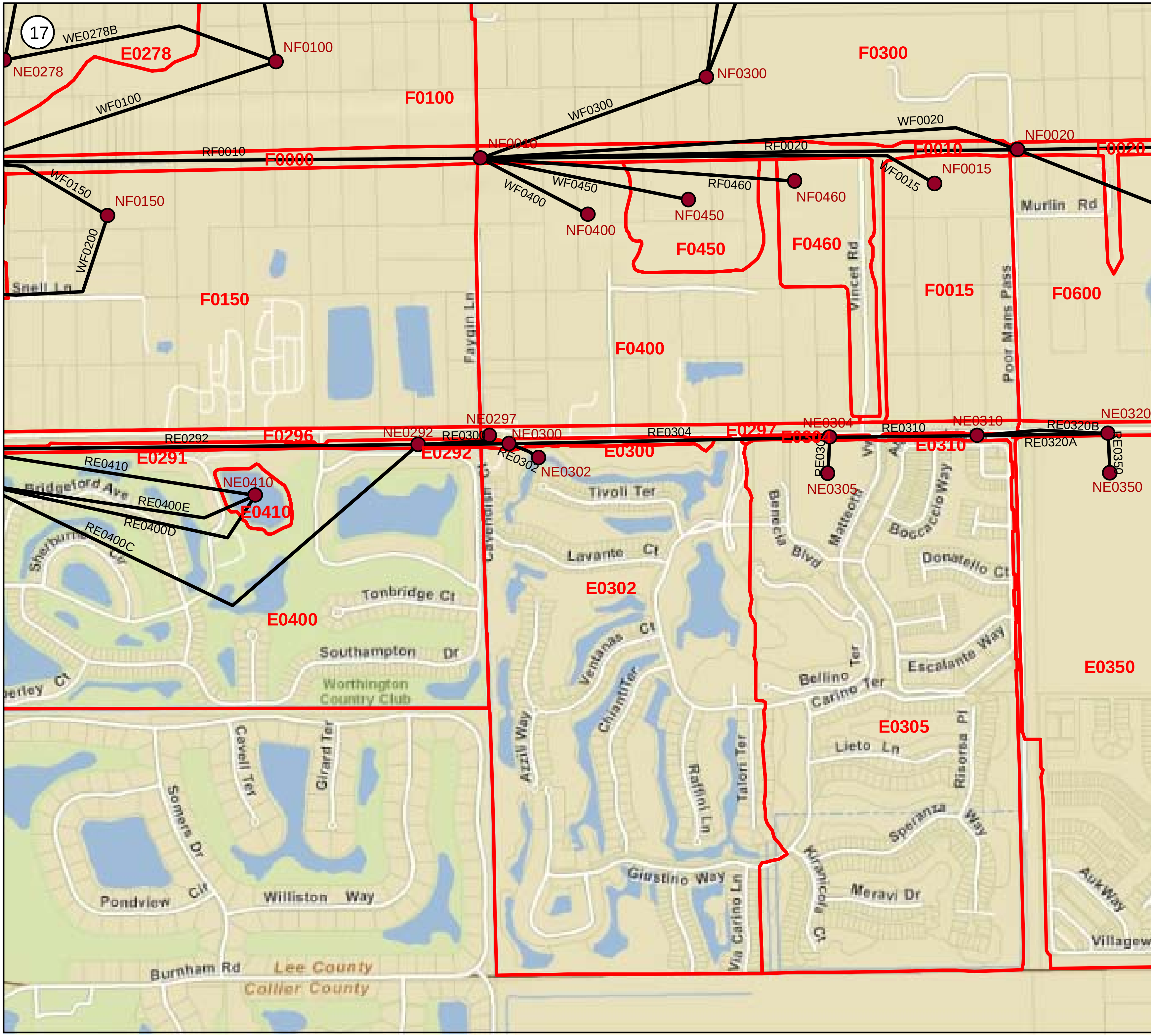
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-28

Firm PE Registration Number: 4722

Figure 5-28



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N

Miles

0 0.05 0.1 0.2 0.3

- ICPR Nodes
- ICPR Links
- ICPR Basins
- \# I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

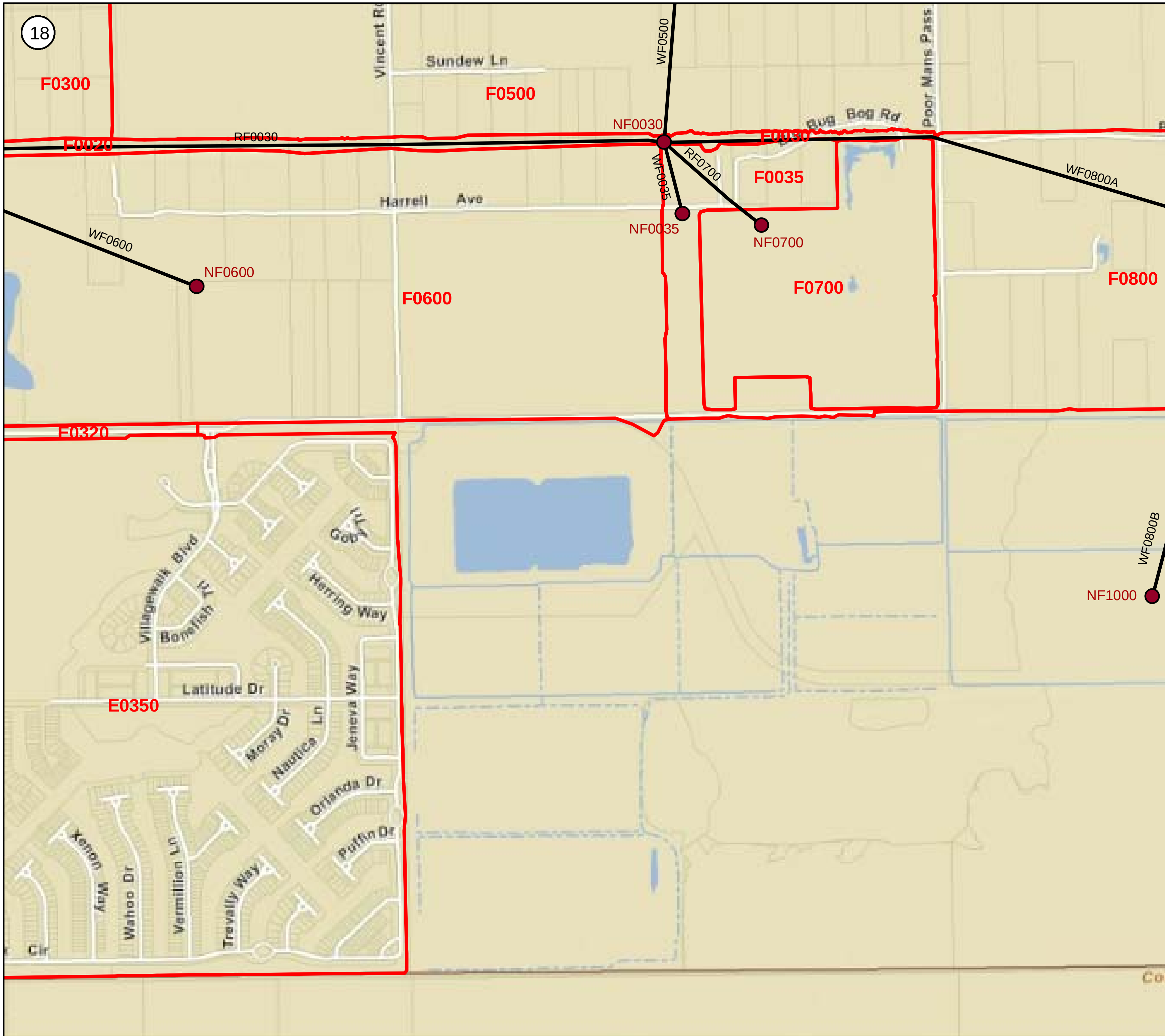
Date: 10/18/2010

File: COBS_SMP_Fig5-29

INTERA

Firm PE Registration Number: 4722

Figure 5-29



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N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-30

INTERA

Firm PE Registration Number: 4722

Figure 5-30

Legend

N

Miles

0 0.05 0.1 0.2 0.3

ICPR Nodes

ICPR Links

ICPR Basins

I.D. Number

City of Bonita Springs Stormwater Master Plan

Watershed Delineation Index

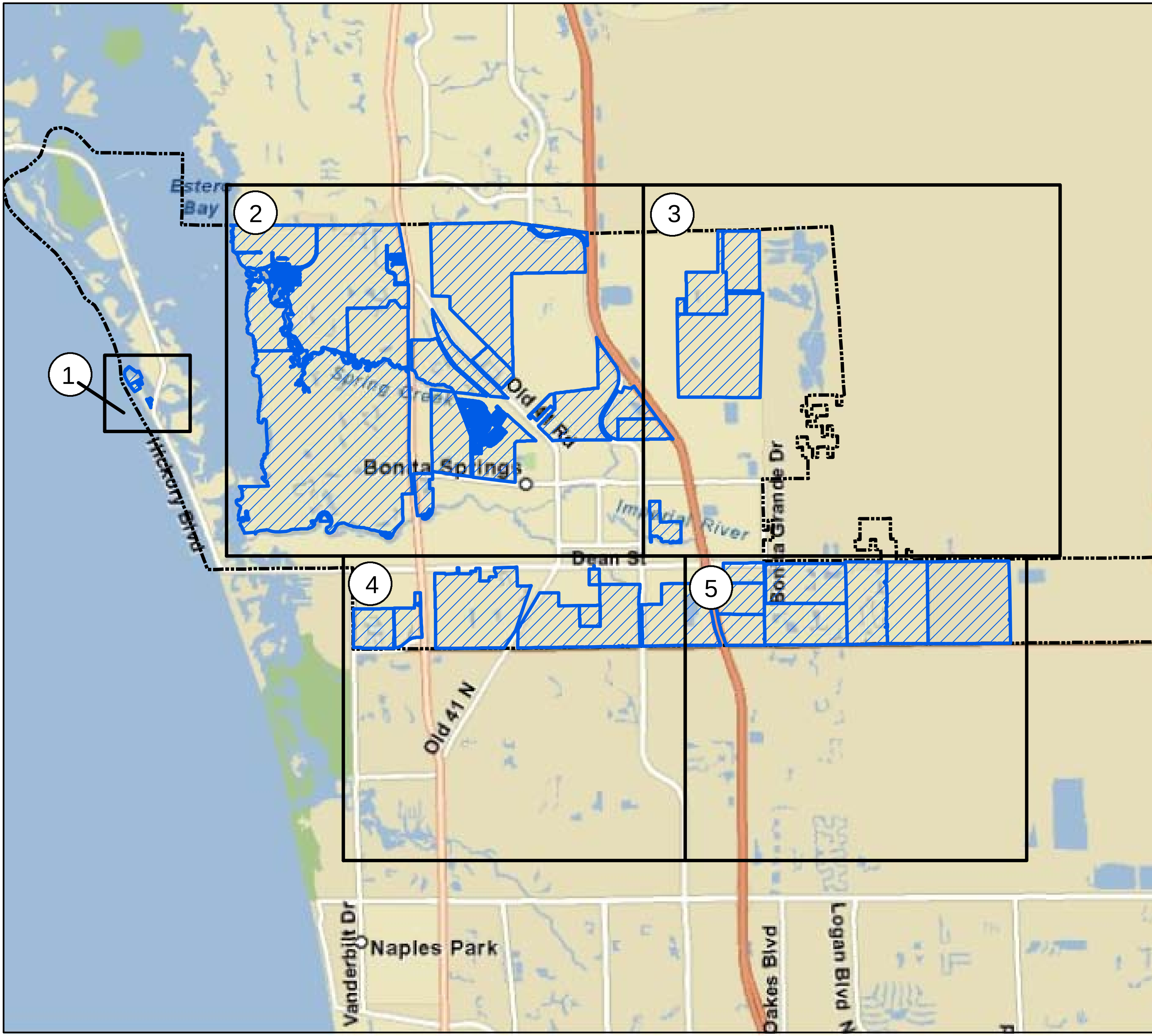
Project: 4600000955W003

Date: 10/18/2010

File: COBS_SMP_Fig5-31

Firm PE Registration Number: 4722

Figure 5-31



Legend

N

Miles
0 0.5 1 2

Private Ownership Entities
CityLimits
I.D. Number

City of Bonita Springs
Stormwater
Master Plan

Private Ownership Entities

Project: 4600000955W003

Date: 11/8/2010

File: COBS_SMP_Fig5-32

Firm PE Registration Number: 4722

Figure 5-32

Legend

N

Yards

0 75 150 300

Private Ownership Entities

CityLimits

I.D. Number

City of Bonita Springs Stormwater Master Plan

Private Ownership Entities

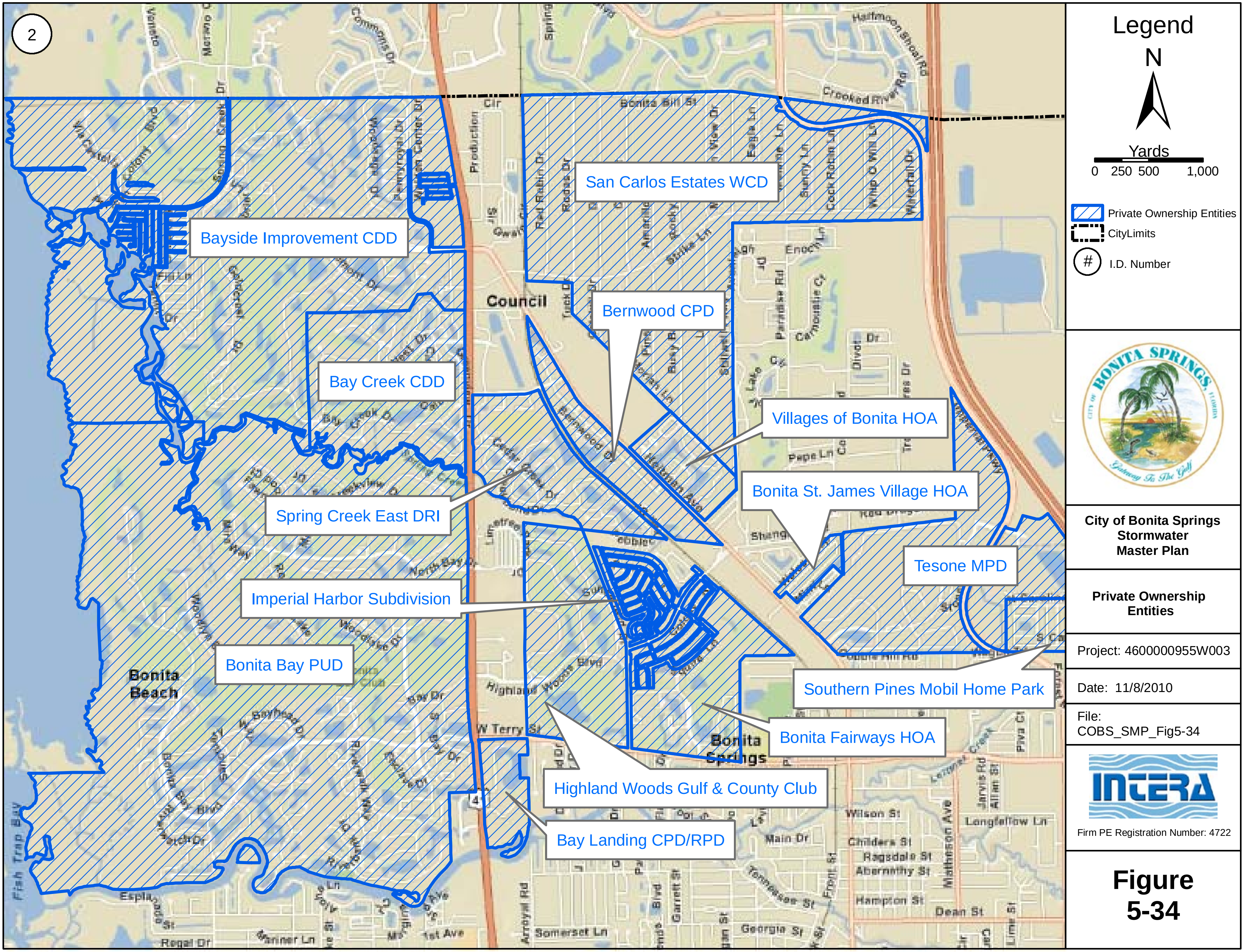
Project: 4600000955W003

Date: 11/8/2010

File: COBS_SMP_Fig5-33

Firm PE Registration Number: 4722

Figure 5-33



City of Bonita Springs Stormwater Master Plan

Private Ownership Entities

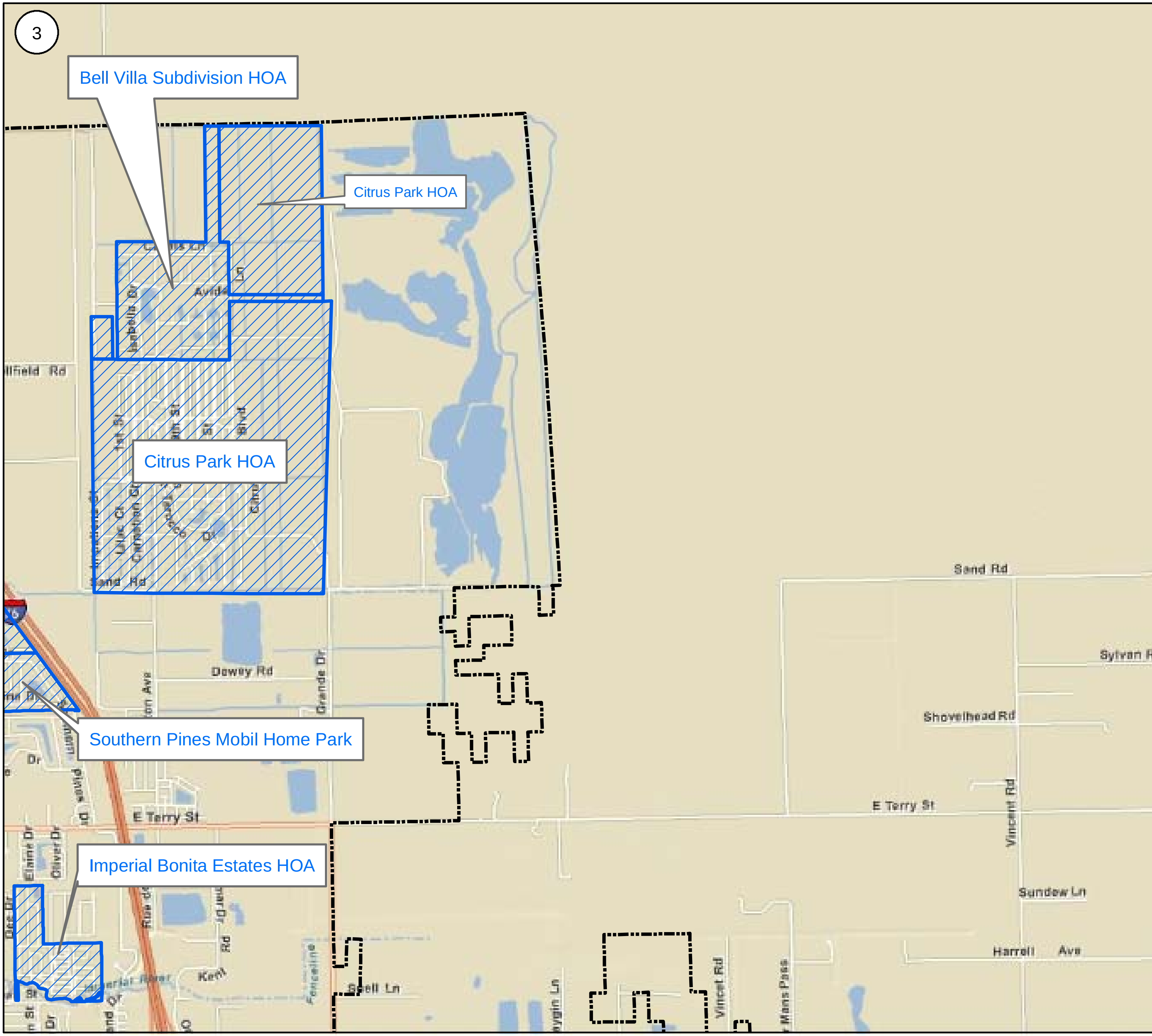
Project: 4600000955W003

Date: 11/8/2010

File: COBS_SMP_Fig5-34

Firm PE Registration Number: 4722

Figure 5-34



Legend

N

Yards

0 250 500 1,000

Private Ownership Entities

CityLimits

I.D. Number

City of Bonita Springs Stormwater Master Plan

Private Ownership Entities

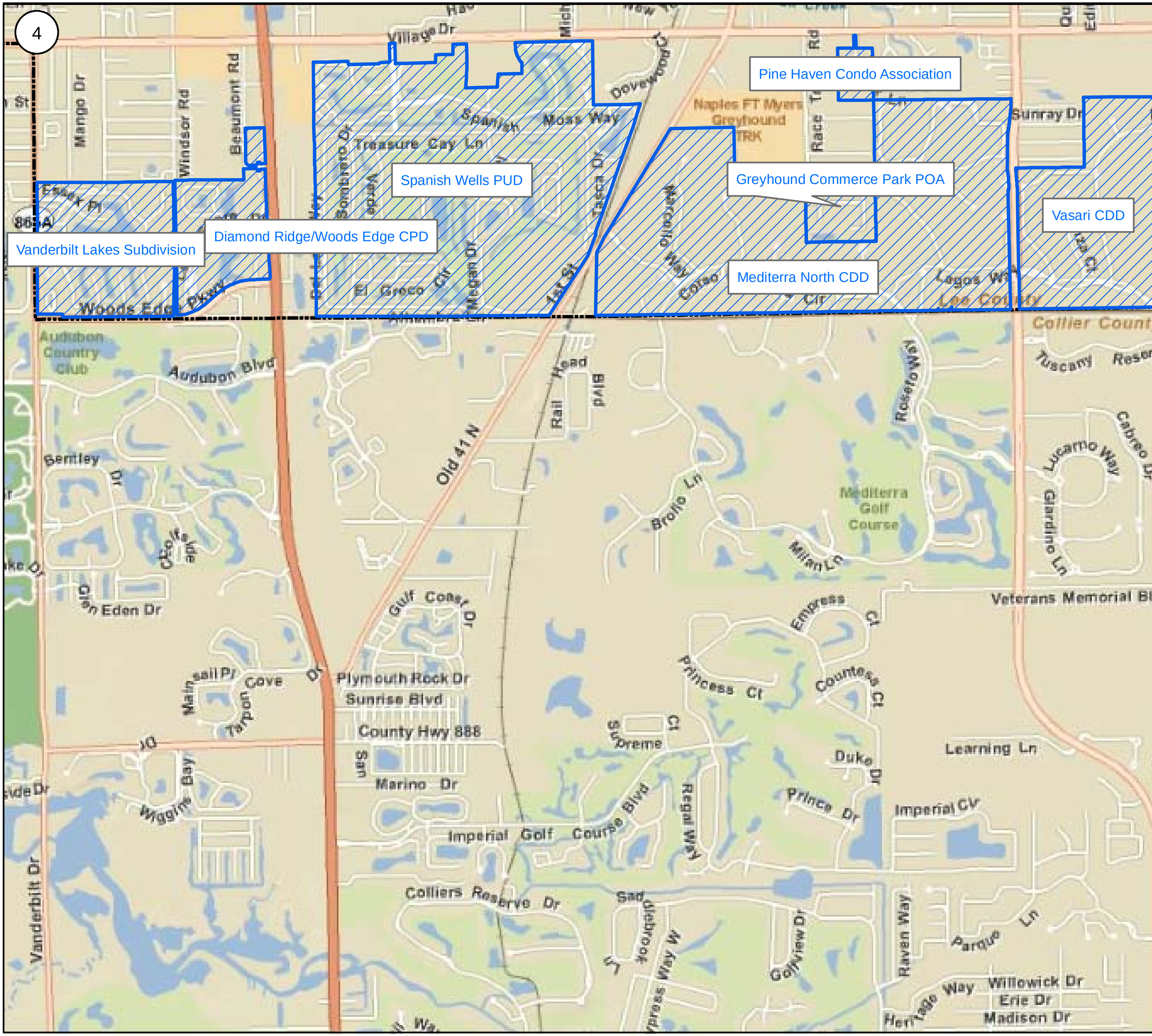
Project: 4600000955W003

Date: 11/8/2010

File: COBS_SMP_Fig5-35

Firm PE Registration Number: 4722

Figure 5-35



Legend

N

Yards

0 250 500 1,000

Private Ownership Entities

CityLimits

I.D. Number

City of Bonita Springs Stormwater Master Plan

Private Ownership Entities

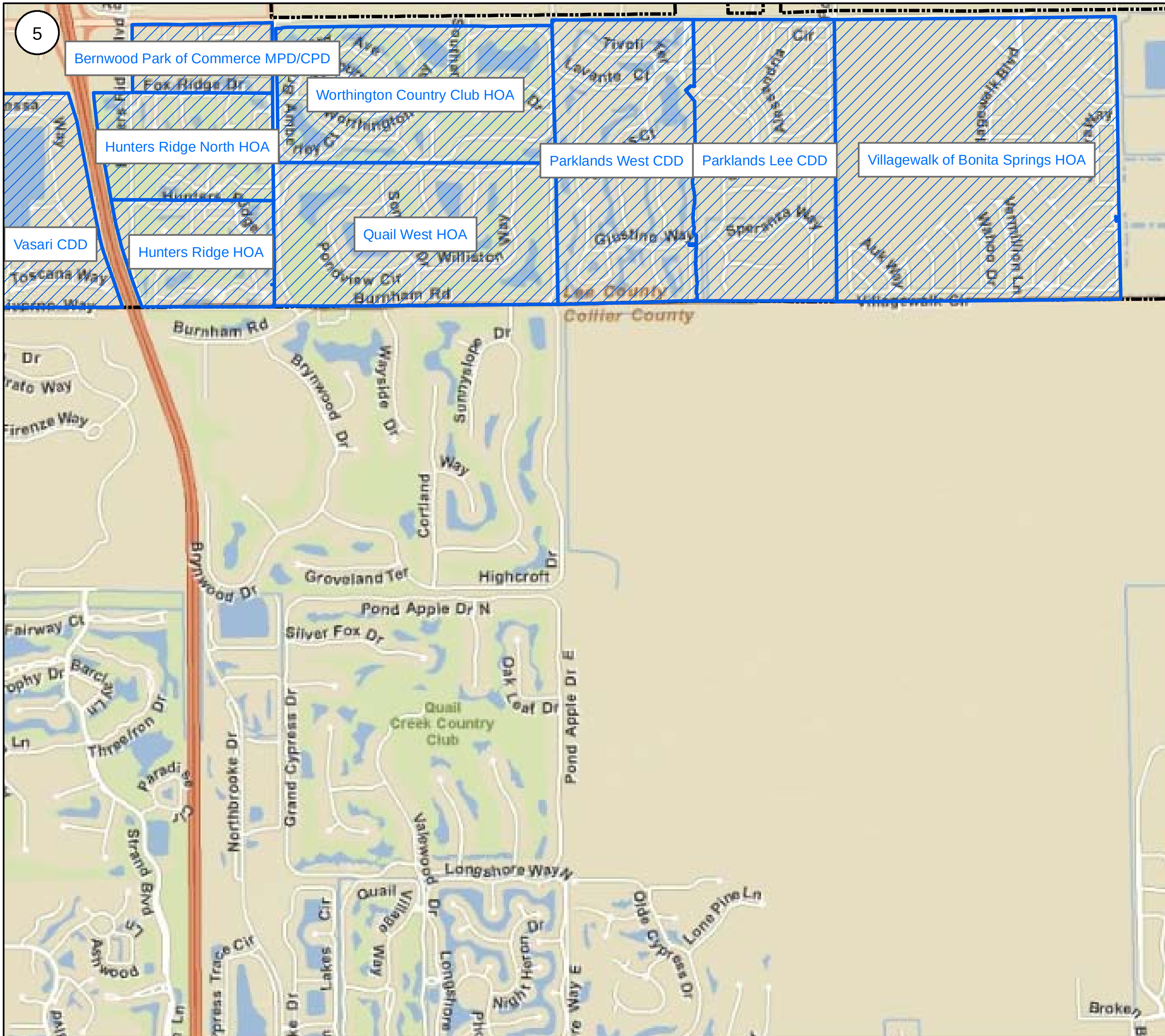
Project: 4600000955W003

Date: 11/8/2010

File: COBS_SMP_Fig5-36

Firm PE Registration Number: 4722

Figure 5-36



Legend

N

Yards

0 250 500 1,000

- Private Ownership Entities
- CityLimits
- # I.D. Number

City of Bonita Springs Stormwater Master Plan

Private Ownership Entities

Project: 4600000955W003

Date: 11/8/2010

File: COBS_SMP_Fig5-37

Firm PE Registration Number: 4722

Figure 5-37

6 Model Selection, Construction, and Calibration

6.1 ICPR Model Overview

To simulate the response of City of Bonita Springs stormwater infrastructure to rainfall from design storm events, the Interconnected Channel and Pond Routing model (ICPR) was used. ICPR was developed by Streamline Technologies (Winter Springs, FL), and is listed as an approved hydraulic model by the US Federal Emergency Management Agency (FEMA). The model simulates runoff quantities using standard curve-number methods, and routes the runoff through the modeled drainage network, storage, and treatment areas. ICPR has the capability of performing detailed hydraulic flow routings for the purpose of evaluating improvements and/or alterations to stormwater infrastructure. The model can simulate individual physical rainfall events (from which results can be compared to measured data) or flooding occurrences due to user-specified design storms.

The City of Bonita Springs ICPR model was developed to determine flooding extents expected from the following design storms: 2 year- 1hour, 2year- 24 hour, 5 year- 1 hour, 5 year- 24 hour, 10 year- 1 hour, 10 year- 24 hour, 25 year- 72 hour and 100 year- 72 hour storm events. Any flooding resulting from these design storms is to be mitigated by modeling alterations to the existing stormwater infrastructure. Prior to modeling design storms, adequate calibration of the model to reproduce observed river flows and stages is necessary. The City of Bonita Springs ICPR model was calibrated to a storm event which occurred on April 18, 2010. Details concerning the model calibration are provided in Section 6.3. Section 6.4 includes recommendations for increasing confidence in the model.

6.2 ICPR Model Development

Within ICPR, the physical land surface/drainage system is represented as a combination of basins, links, and nodes. Linear features that transport water (such as rivers, channels, drainpipes, and conveyances) are modeled as links, which are connected to other links via nodes. Model nodes are point features of the drainage network, and can represent physical confluences of the drainage system, discharge points, weir locations, drop structures, or other similar objects. Nodes are also points in the ICPR model at which water enters the drainage system as runoff from basins. Within ICPR, basins are represented as nodes and are modeled land areas which receive the rainfall, for which ICPR computes runoff hydrographs. Nodes provide the storage found within the basin. The modeled storage is an aggregate of all the ponds, wetlands, and other storage found within each basin and is represented as a stage area relationship for each basin in the model.

In developing the City of Bonita Springs ICPR model, only those drainage features deemed most significant were included in the model. Examples of such features include larger drainage ditches/culverts, rivers, and canals. Features that were not included in the model include individual driveway culverts, small local detention ponds, and small weirs within modeled conveyances. Although small local detention ponds and other small storages were not explicitly included in the model, storage was addressed in an aggregate manner for each basin through the use of a stage-area discharge relationship at each node. Model results are not likely to be improved upon inclusion of minor drainage features, as many of these features are neither known with certainty nor impact the overall response of the basin. However, as future data is collected on each structure within the drainage system, the ICPR model can be easily updated to incorporate the new data.

Within the City of Bonita Springs ICPR model, all links, nodes, basins, and other structures (weirs, cross-sections, etc.) were named using a systematic naming convention. The overall study area was divided into 7 sub-regions with each sub-region contributing flow directly to the larger drainage features of the study area. Each sub-region was assigned a letter A to G as dictated in Table 6.1. Figure 6-1 shows the location of each sub-region, basin, link, and node that is included in the ICPR model. Nodes were named with the convention "NSxxxx" where "N" is an object identifier specifying the object was a node, "S" corresponds to the letter designation of the sub-region watershed in which the node is located, and "xxxx" is a four-digit number assigned to the node. A list of identifiers is listed below in Table 6.2. Node numbers were assigned with lower numbers located downstream in the drainage network. For example, node "NG0212" is located within the Spring Creek watershed, and is upstream of node "NG0201" and downstream of node "NG0220". Node numbers were not assigned consecutively, thus allowing for the inclusion of future additional nodes in between nodes that are currently adjacent to one another within the modeled drainage network. Modeled links were assigned names based on the node on the upstream end of the link, and were assigned the object identifier "R". For example, the link connecting nodes "NG0211" and "NG0212" is named "RG0212". Basins were assigned names similar to the name of the node to which they drain. Unlike links and nodes, however, basins were not assigned an object identifier. Where appropriate, modeled weirs and cross-sections were assigned names similar to the link names, but with the object identifiers "W" and "X," respectively. For cross sections that were used on multiple reaches, general names were assigned (such as "swale," "Kehl Canal", and "Imperial Low").

Table 6-1. Regional Watersheds as included in the City of Bonita Springs ICPR Model

Subregion Watershed	ICPR Group	Letter Designation
Imperial River downstream from Leitner Creek	Imperial Low	A
Oak Creek	Oak Creek	B
Rosemary Canal	Rosemary	C
Leitner Creek	Leitner Creek	D
Imperial River from Leitner Creek to Kehl Canal Weir	Imperial Middle	E
Imperial River – Upstream of Kehl Canal Weir	Imperial Kehl	F
Spring Creek	Spring Creek	G

Table 6-2. ICPR Model Identifiers

Identifier (I)	Type
N	Basin Node
R	Pipe, Channel, Drop Structure
W	Weir
X	Cross-Section

The 582 basins defined in the GIS database (Section 5.3) were incorporated into the model. Modeled basins in ICPR were created by manually merging individual watersheds delineated around drainage systems features. Figures 5-12 to 5-31 show the boundaries of the modeled basins as well as the delineated watershed locations within the modeled basins. Along with the aforementioned basins, the ICPR model of both the Imperial River and Spring Creek watersheds contained 602 nodes and 771 links.

6.2.1 ICPR Model Basin Attributes

Within ICPR, runoff is generated for each basin, and is discharged from the basin through the node associated with the basin. All basins are attributed with the following properties:

- Basin Name
- Node Name
- Basin area (in acres)
- Unit Hydrograph & Peak Factor
- Curve Number
- Time of Concentration

In the City of Bonita Springs ICPR model, basins are usually named after the node to which they contribute flow, with names formatted as described in Section 6.2. The basin area is calculated with ArcGIS. All basins were modeled using a U484 unit hydrograph (Peak Factor 484). Procedures for determining basin curve numbers and times of concentration are discussed individually in sections 6.2.1.1 and 6.2.1.2.

6.2.1.1 ICPR Model Basin Curve Numbers

Runoff is determined according to a method developed by the United States Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS), which uses Curve Numbers (CN) to estimate the amount rainfall that will produce runoff. The equation listed below is presented in Technical Release 55 (TR-55), produced by the USDA (USDA, 1986). In this equation, the runoff (Q) is calculated as:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad S = \frac{1000}{CN} - 10$$

Where P is the amount of rainfall (in inches), S is the potential maximum retention after runoff begins (in inches), and CN is the curve number for the basin. Curve numbers are dimensionless and correlate the rainfall to the basin runoff; they reduce the many physical processes within a watershed into a single lumped parameter. Curve number values range from 0 to 100, with 100 corresponding to complete runoff (zero loss) and 0 corresponding to zero runoff (complete loss). Curve numbers are related to the land use and soil characteristics, and also vary depending on antecedent moisture conditions. For development of the City of Bonita Springs ICPR model, curve numbers were initially assigned assuming average antecedent moisture conditions (AMCII).

To determine appropriate curve numbers for all basins, ArcGIS was used to overlay basin boundaries with polygons of land use and soil classification data. Land use data provided by SFWMD (representing 2004 conditions). Where appropriate, the land use data was updated using the 2010 aerial photos in order to match current conditions. Soils data was obtained from the SSURGO data available from the South Florida Water Management District. Within ArcGIS, the basins, land use, and soil classification polygons were overlaid, creating a single curve number polygon dataset where each polygon is attributed with its area (in acres), soil classification, land use classification, and basin name as used in ICPR. Through the use of an accepted lookup table, curve numbers were assigned to each CN polygon based on the Florida land use code and soil classification values. The lookup table used in developing the City of Bonita Springs ICPR model is provided in Appendix A. The curve number for each ICPR modeled basin was computed as the area-weighted average of the curve numbers for all CN polygons making up the ICPR modeled polygon.

6.2.1.2 ICPR Model Basin Time of Concentration

The Time of Concentration (ToC) for a basin in ICPR is the time at which water falling on the portion of the basin most distant from the basin outlet may be expected to arrive at the basin outlet. ICPR incorporates this travel time in computations of the basin hydrographs generated for each rainfall event. Although numerous methods exist for calculating ToC values (Chow et al, 1988), ToC values are most often calculated according to procedures outlined in TR-55. To determine ToC values for use in the City of Bonita Springs ICPR model, a modified version of the TR-55 calculation method was implemented.

Within TR-55, ToC values are computed as the sum of individual travel times for various consecutive flow segments within a basin:

$$ToC = T_1 + T_2 + ...T_n$$

The number of flow segments within a basin depends on the basin size and land use/infrastructure along the flow paths through the basin. Typically there are three types of flow for which travel times are calculated: 1) sheet flow (overland flow over the ground surface), 2) shallow concentrated flow (sheet flow directed into channels) and 3) open channel flow.

TR-55 recommends using equations for sheet flow for distances of up to 300 ft, after which flow is typically concentrated into channels. Travel times for sheet flow are calculated using Manning's kinematic solution (USDA, 1986):

$$T = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

Where n is a Manning's roughness coefficient, L is the flow length, P_2 is the 2-year, 24 hour rainfall depth (in inches), and s is the general land surface slope along the flow path. For the City of Bonita Springs, P_2 was determined to be 4.8 inches. Flow lengths were estimated in ArcGIS based on the basin area and shape. For basins with flow lengths greater than 300 ft, the flow length used in computing sheet flow travel time was limited to 300 ft. The land surface slope along the flow path was approximated based upon the flow path length and the maximum and minimum elevations within the basin as extracted from the 5 ft x 5 ft DEM model provided by the South Florida Water Management District. Manning's n values of 0.05 were used in all sheet flow calculations.
For computing travel times for shallow concentrated flows, TR-55 uses empirical equations relating flow velocities to watercourse slope:

$$\text{Unpaved:} \quad V = 16.1345(s)^{0.5}$$

$$\text{Paved:} \quad V = 20.3282(s)^{0.5}$$

$$T = \frac{L}{V}$$

Travel times for shallow concentrated flow in the City of Bonita Springs ICPR model were computed using the land surface slope approximated in the sheet flow calculation and flow lengths equal to 50% of the remaining flow path distance after accounting for sheet flow.

For computing travel times in open channels, TR-55 recommends using Manning's equation:

$$V = \frac{1.49 r^{2/3} s^{1/2}}{n}$$

$$T = \frac{L}{V}$$

Where r is the hydraulic radius (defined as the cross-sectional area divided by the flow perimeter) and all other terms are as previously defined. Within the City of Bonita Springs ICPR model, open channel travel times were computed assuming n = 0.05 and r = 0.96, with the slope determined as for the sheet flow and shallow concentrated flow calculations. The flow length for open channel flow was approximated as 50% of the remaining flow path distance after accounting for sheet flow.

Time of concentration values for basins within the City of Bonita Springs ICPR model were computed as the sum of the times for sheet flow, shallow concentrated flow, and open channel flow. Calculated ToC values ranged from 15 minutes to 1,750 minutes.

6.2.2 ICPR Model Node & Link Attributes

Within ICPR, nodes may be attributed as stage/area nodes or as flow boundary nodes. Boundary nodes are used to specify boundary conditions within the model, and can be locations in which stage time-series are used in driving model simulations. Stage/Area nodes are used to determine the amount of water storage available within the model at the node location. Specifically, stage-area nodes have attributes that describe the relationship between water stage and inundated land surface area at the node location. The stage area nodes define the aggregated storage within the basin including the ponds, lakes, and wetlands.

Stage-area relationships for all model nodes receiving flow directly from basins were calculated using the 5 ft x 5 ft DEM provided by the South Florida Water Management District. ArcGIS Spatial Analyst tools were used to export the DEM data into ASCII format, and customized MATLAB scripts were employed to perform the stage-area calculations on a basin-by-basin basis using the exported DEM data. Output from MATLAB was then imported directly into ICPR.

Initial stage elevations for all nodes were determined from the DEM. Upstream and downstream invert elevations across all model links were also approximated from the DEM, with adjustments made to ensure that downstream elevations were always lower than upstream elevations (which may not be discernible due to errors in the DEM). Invert elevations for links within the channels of the Imperial River, Spring Creek, Oak Creek, and Leitner Creek for locations where bathymetric data were unavailable were computed based on known bathymetry downstream and using an approximate riverbed slope of 0.0003 ft/ft. This slope was determined based on the elevation change between the most-upstream point of measured bathymetry in the Imperial River channel and the Kehl Canal gate structure (whose invert elevation of 3.0 ft NGVD29 is known based on the structure permit). The river distance between the two available channel bed elevation points was measured with ArcGIS.

For the City of Bonita Springs ICPR model, two boundary nodes were included at locations within the Gulf of Mexico, downstream from where the Imperial River and Spring Creek discharge into Estero Bay. The water stage at these nodes was set to a constant value of 1.61 ft NGVD29, which is the mean high water elevation for station No. 8725110 in Naples, FL (NOAA, 2010).

6.2.3 ICPR Model Structures and Cross Sections

All drainage structures included within the City of Bonita Springs ICPR model were based on data from field notes provided by the City of Bonita Springs, field data collected by INTERA on June 29-30, 2010, or from Environmental Resource Permits (ERPs) as listed in Section 3. Each modeled structure is also included in the structure geodatabase described in Section 5 and provided on the DVD accompanying this report. In instances where drainage culverts underneath roadways or bridges where included in the model, the roadways themselves were modeled as weirs, thereby allowing for modeling of extreme flooding events in which the roadways would be overtopped by the stormwater flow. Bridges over the Imperial River, Oak Creek, and Spring Creek, and Leitner Creek were modeled as trapezoidal shaped channels with a top clip or as box culverts, with the widths corresponding to the distances between bridge supports (as measured during field visits, approximated from ERP plans, or estimated from aerial photographs).

Cross sections for all modeled links were derived from the 5 ft x 5 ft DEM provided by the South Florida Water Management District, from the bathymetric survey of the Estero Bay area performed by Coastal Engineering Consultants, Inc. in 2006, and from data from ERP plans. Cross-sections generated in ArcGIS from the DEM were limited in extent to the width of the channels and conveyance structures to which they pertained, and were computed using the "Interpolate Line" and "Create Profile Graph" functions in the ArcGIS 3D Analyst extension. Cross-sections were then exported directly from ArcGIS into individual text files, which were processed into a single file suitable for importation into ICPR. In areas for which bathymetric data were unavailable (such as the Imperial River upstream from the confluence with Oak Creek, within Leitner Creek, and within Oak Creek), cross-sections were approximated based on field notes and data available within nearby portions of each respective water body.

6.3 ICPR Model Calibration

In order to calibrate the ICPR model, an actual storm event was used to compare measured data to the simulated output. The storm that was selected for calibration occurred on April 18, 2010, and had a total precipitation of 4.83 inches, which occurred over a period of 24.5 hours. A hyetograph showing the rainfall distribution is shown in Figure 6-2. This data was selected because there was a sufficient period before and after the storm when there was no other rainfall, it was a recent storm, and because of the large precipitation depth. With the measured rainfall from this storm, the model was calibrated with respect to measured stage and flow data obtained from gauging locations within the watershed. Figure 6-3 shows the location of the gauging sites that were used in this analysis. Two of the gauging stations used in the calibration are operated by the United States Geological Survey (USGS). The first USGS gauging site, USGS gauge number 02291524, is located on Spring Creek. The second gauging site, USGS gauge number 02291500, is located on the Imperial River. Both of these gauges measure stage and flow every 15 minutes. Two additional gauges that were used in the analysis are operated by Lee County. These gauges measure stage elevation upstream (headwater elevation) and downstream (tailwater elevation) of the Kehl Canal Weir Structure. These gauges also measure stage elevation at 15 minute intervals. In addition to these gauges, one further gauge was evaluated but not used in the calibration. This gauge is operated by Lee County and is located on the Imperial River. Information from this gauge was not used because of the strong tidal influence that occurs at the location.

Data recorded from these gauges was utilized to calibrate the model. Figures 6-3 through 6-7 show the calibrated model results versus the recorded gauge data. The modeled simulation was for 120 hours after the start of the calibration storm. It can be seen from these graphs that the volume of runoff is conserved (i.e. the area under the observed and simulated curves are similar), and that the shape of the hydrographs and location of peak runoffs match fairly well. However, a difference can be seen when comparing the modeled and measured peak flow on the Spring Creek. This is most likely due to the presence of pumping stations on Spring Creek, which are responsible for pumping stormwater to prevent flooding and a lack of data on the pumping rates during the calibration storm.

During the calibration process several model parameters were adjusted, including using the dry antecedent moisture condition (AMCI) instead of the average antecedent moisture condition (AMCII), lowering initial stage elevations of water bodies to match drier conditions, adjusting Manning's n based on rating curves obtained from the USGS, adding information for a pumping station at node NG0270 on the Spring Creek, and gate operation rules for the Kehl Canal. After calibration to measured data, design storms could be simulated.

6.4 Recommendations

The calibrated ICPR model adequately represents the hydrology of the basin. The model is adequate to make predictions as it pertains to improvements to stormwater infrastructure within the City jurisdiction. However, additional data can aid in the increased confidence in the model. If additional resources are available for future modeling efforts it is recommended that the following additional data be collected:

- Survey of all major structures
- Additional calibration data, particularly within urbanized areas
- Additional pump station data

Currently, some data obtained on major structures (e.g. bridges, culverts, and pipes) within the modeled area was gathered from ERPs and field estimates. Inverts for some of these structures were estimated from DEM data. If a survey of these structures was completed, including invert elevations, span lengths, and height measurements, it would further increase the accuracy of the model. The data obtained from ERPs contained plans that were permitted, but may not reflect the as-built conditions. Furthermore, data obtained from field estimates could be greatly enhanced from surveying.

Additional calibration data would enhance the confidence in the model results. The current calibration is limited by the availability of gauges within the watershed. If additional gauges were installed in Leitner Creek, Oak Creek, or Rosemary Canal, it would be possible to enhance the confidence in the model especially in the urbanized portion of the watershed. The USGS gauge on the Imperial River reflects the inflow to the City, but land use upstream of the gauge is not representative of urbanized conditions within the City boundaries.

Lastly, the Spring Creek gauge is impacted by a pump station. The modified system does not respond like a natural system and therefore cannot be calibrated as such. It is understood that the system as operated may not be reflected in the current ERP documents. Additional information would assist in the calibration of this watershed. Other pump stations were also found within the Imperial Middle, Leitner Creek and Rosemary watersheds, during the site visit on June 29-30, 2010. Some pumps were found disabled and no longer in service.

6.5 Figures & Descriptions

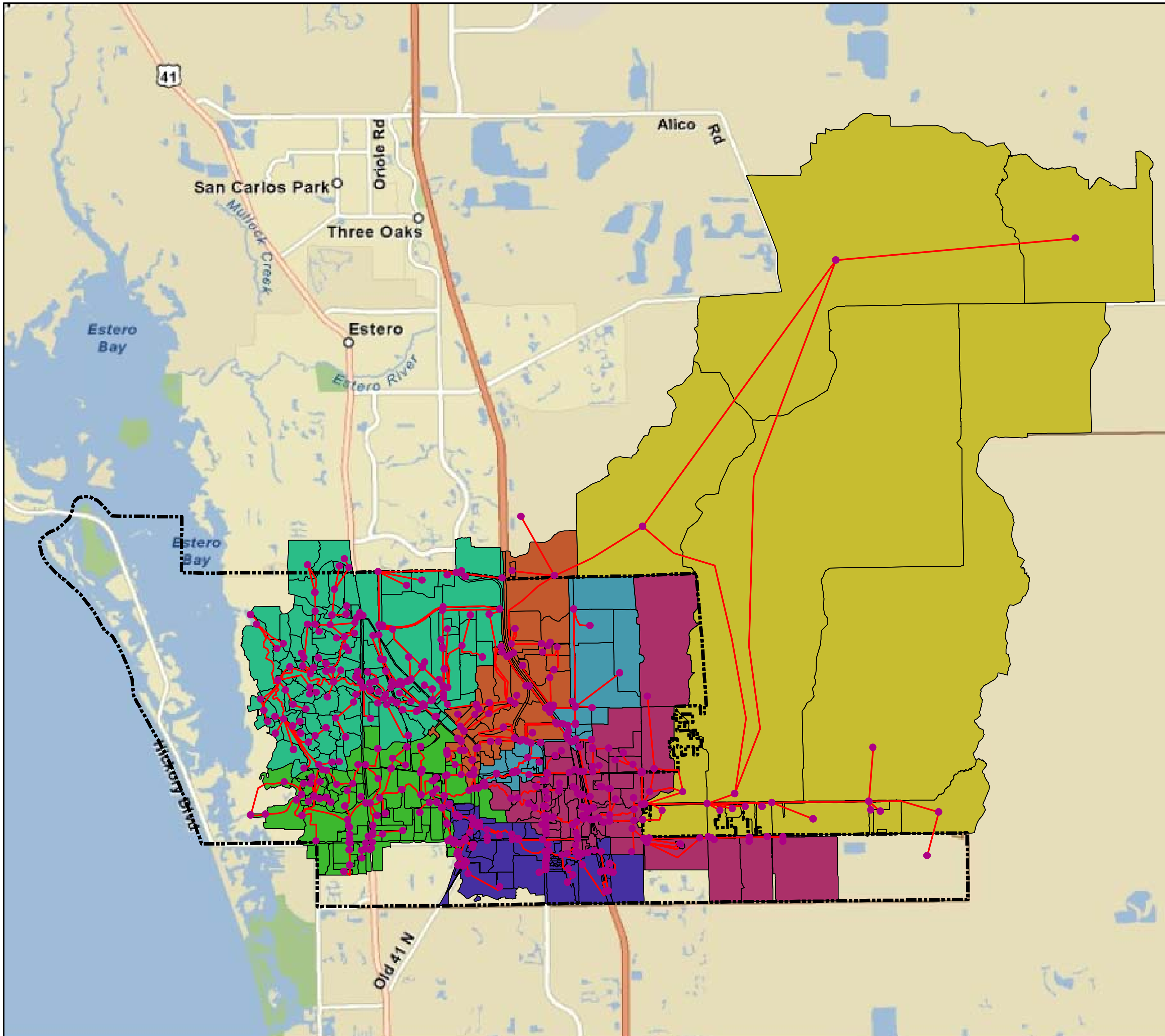
The following descriptions pertain to figures provided on the following pages and referenced in Sections 6.1-6.4.

Figure #	Description
6-1	ICPR Nodes, Links, and Basins
6-2	April 18, 2010 Hyetograph
6-3	Gauge Locations
6-4	Imperial River Flow Calibration
6-5	Imperial River Stage Calibration
6-6	Spring Creek Flow Calibration
6-7	Spring Creek Stage Calibration
6-8	Kehl Canal Stage Calibration

6.6 Section References

Chow, V. T., Maidment, D., and Mays, L. (1988). *Applied Hydrology*. McGraw-Hill.

United States Department of Agriculture. (1986). *Urban Hydrology for Small Watersheds (TR-55).* Washington D.C.: USDA.



Legend

N

Miles

0 0.5 1 2

CityLimits

Node

Link

Basin

ICPR Basin Subregions

Letter Designation

A E

B F

C G

D

City of Bonita Springs Stormwater Master Plan

ICPR Nodes, Links, and Basins

Project: 4600000955W003

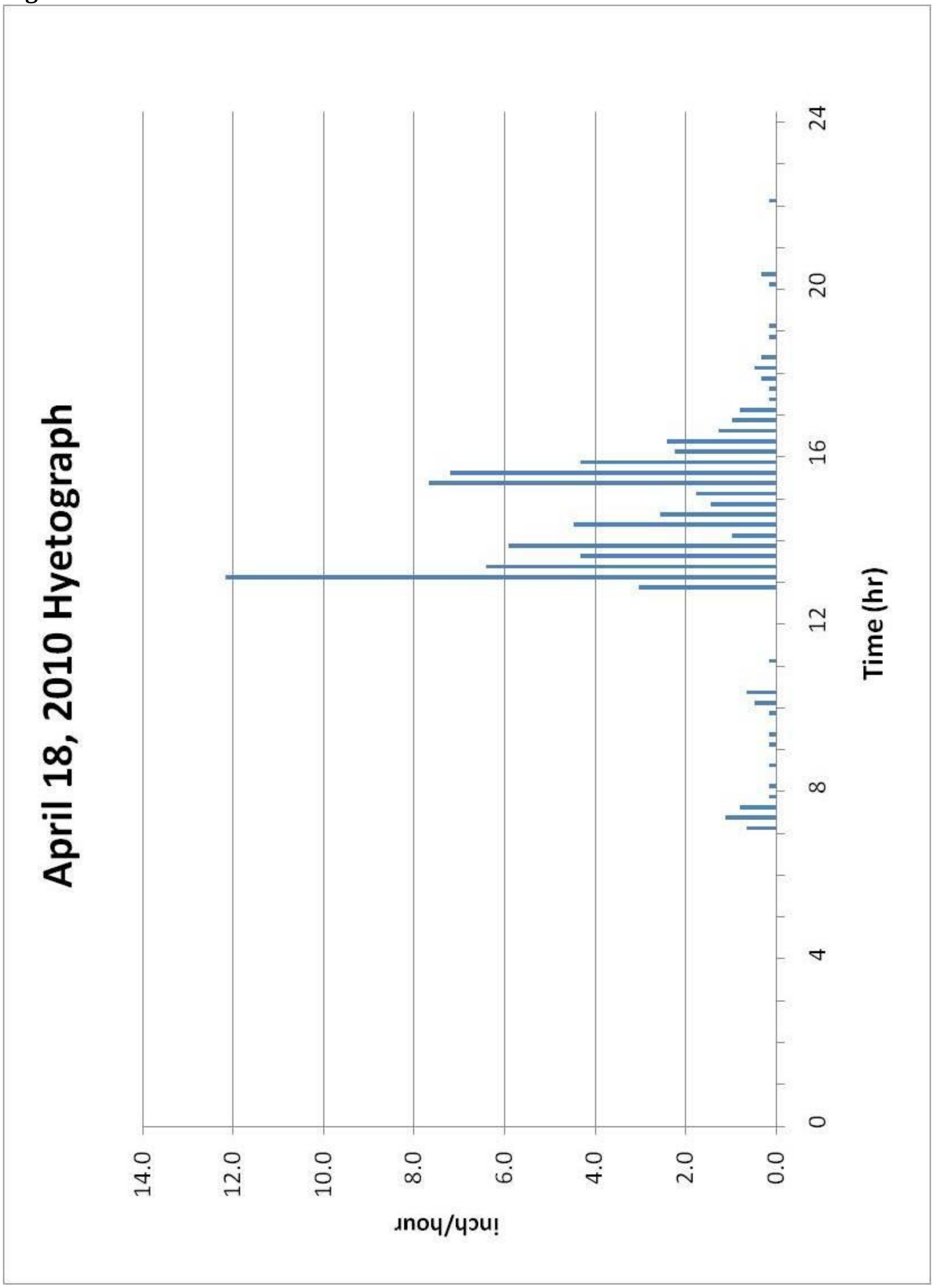
Date: 9/24/2010

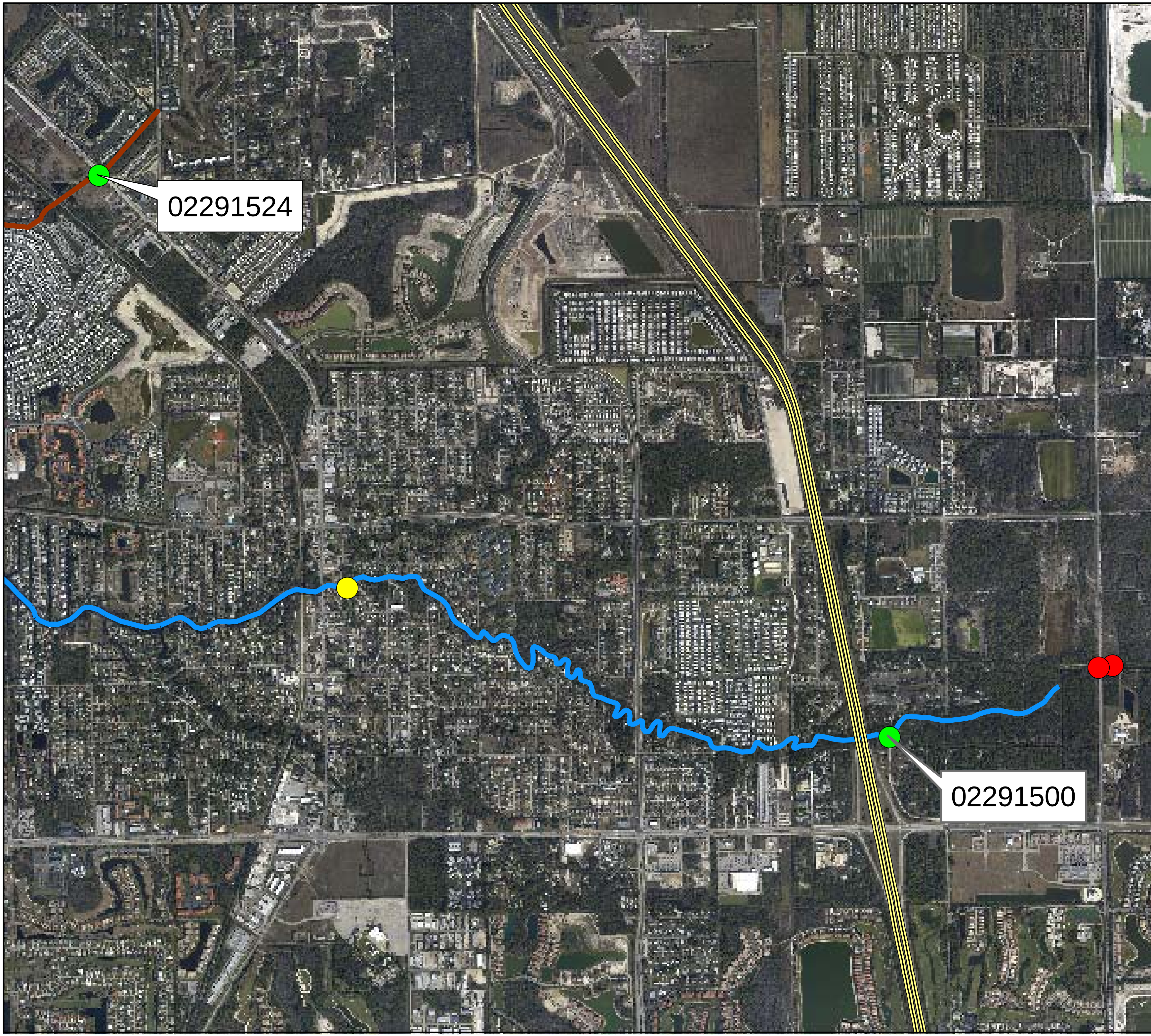
File: COBS_SMP_Fig6_1

Firm PE Registration Number: 4722

Figure 6-1

Figure 6-2


April 18, 2010 Hyetograph
inch/hour
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
4
8
12
16
20
24
Time (hr)



Legend

N

Miles
0 0.125 0.25 0.5

- Kehl Canal Gauges
- Imperial River Gauge
- USGS Gauges
- I-75
- Spring Creek
- Imperial River

City of Bonita Springs Stormwater Master Plan

Gauge Locations

Project: 4600000955W003

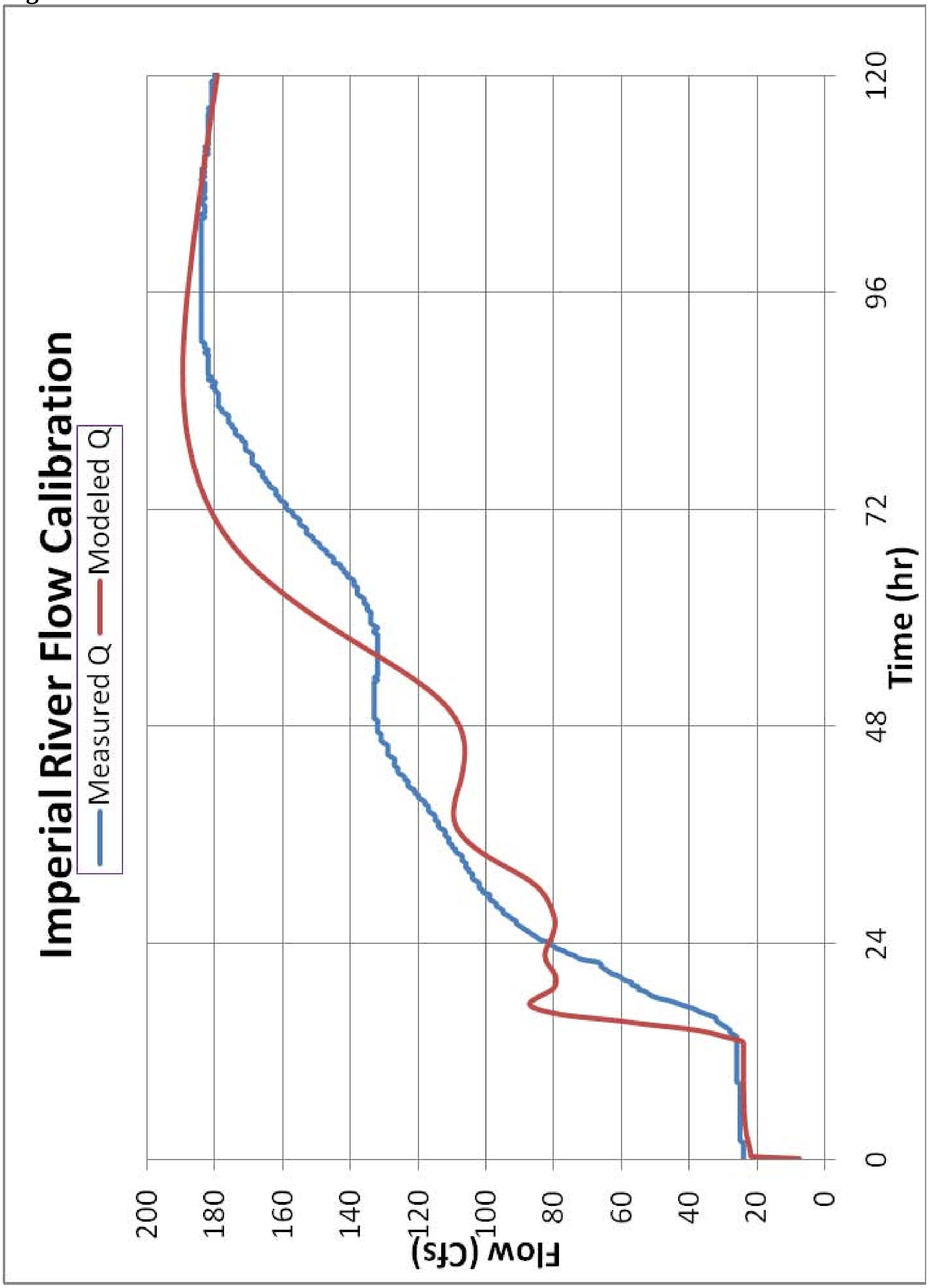
Date: 9/28/2010

File: COBS_SMP_Fig6_3

Firm PE Registration Number: 4722

Figure 6-3

Figure 6-4



Imperial River Flow Calibration
Measured Q
Modeled Q
Flow (Cfs)
200
180
160
140
120
100
80
60
40
20
0
0
24
48
72
96
120
Time (hr)

Figure 6-5

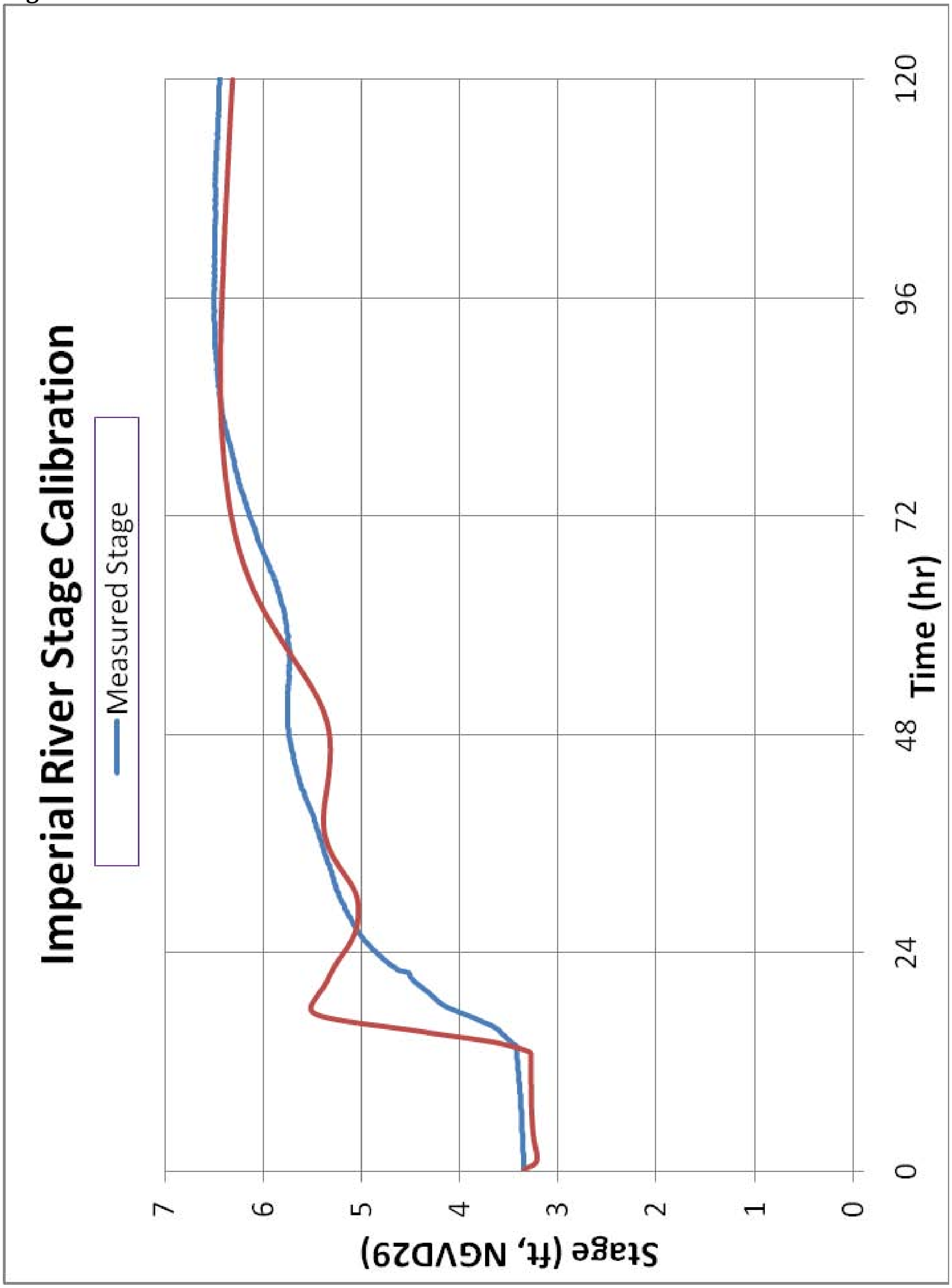

Imperial River Stage Calibration
Measured Stage
Stage (ft, NGVD29)
Time (hr)
0
1
2
3
4
5
6
7
0
24
48
72
96
120

Figure 6-6

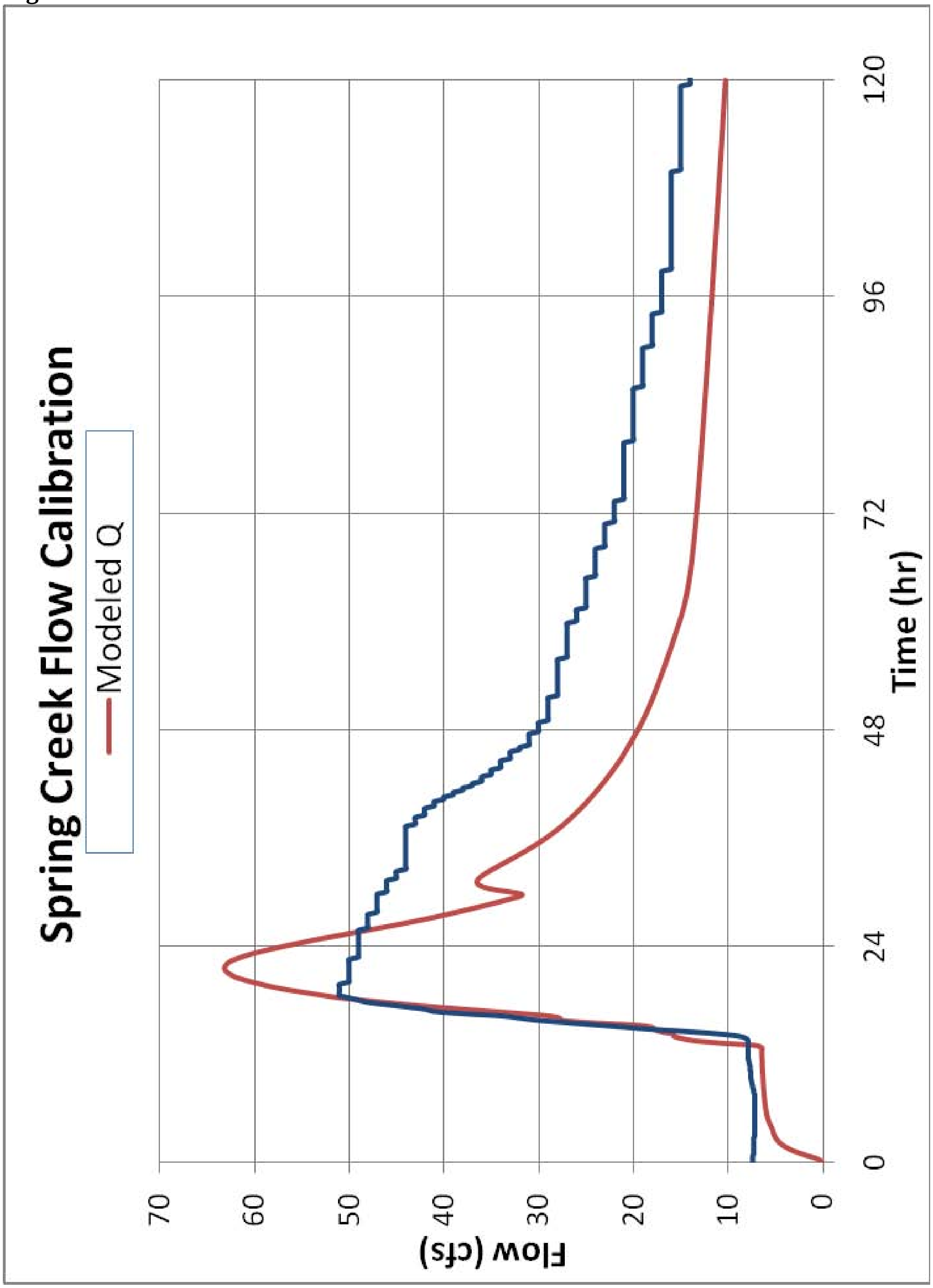

Spring Creek Flow Calibration
Modeled Q
Flow (cfs)
70
60
50
40
30
20
10
0
Time (hr)
0
24
48
72
96
120

Figure 6-7

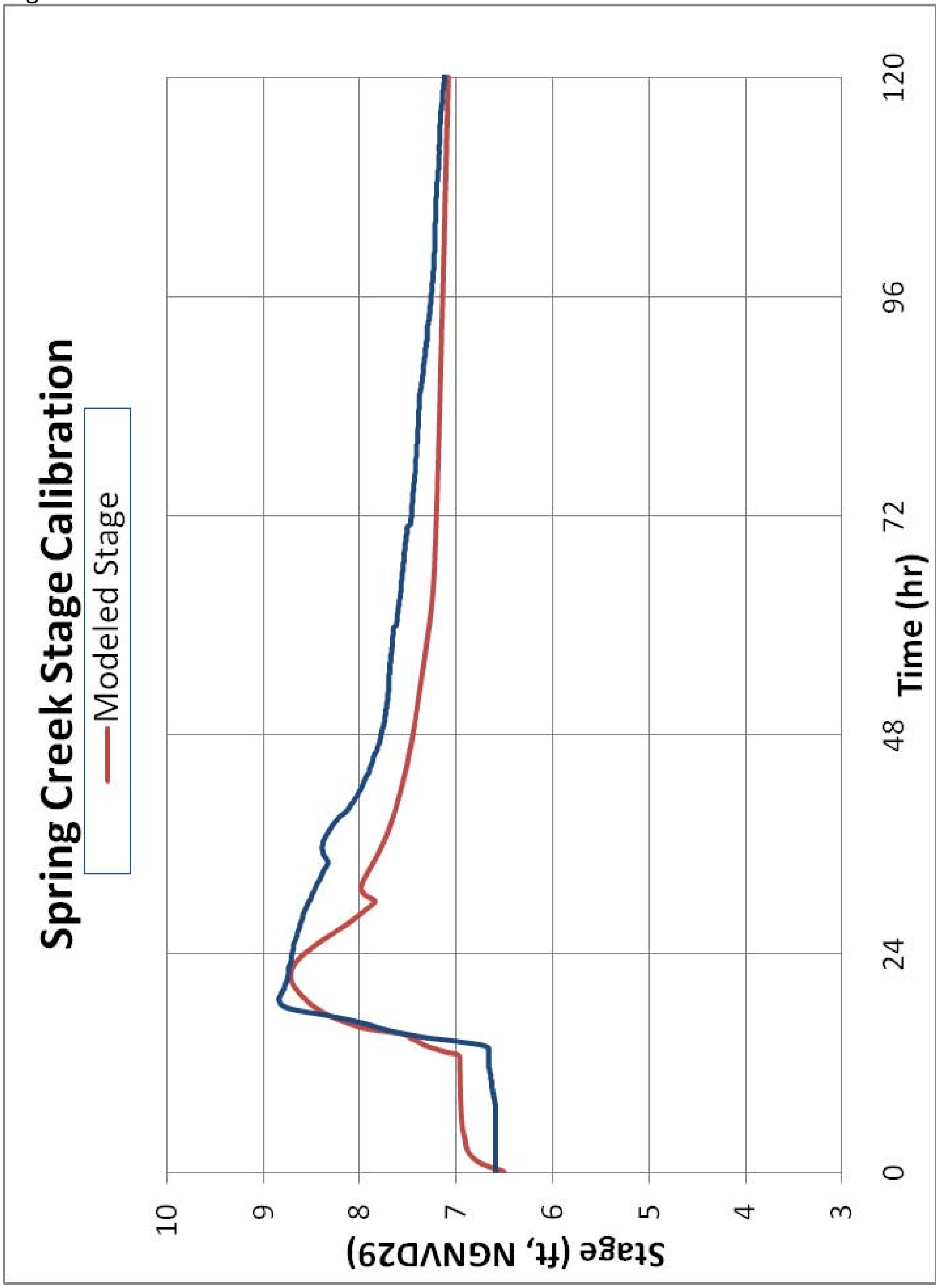
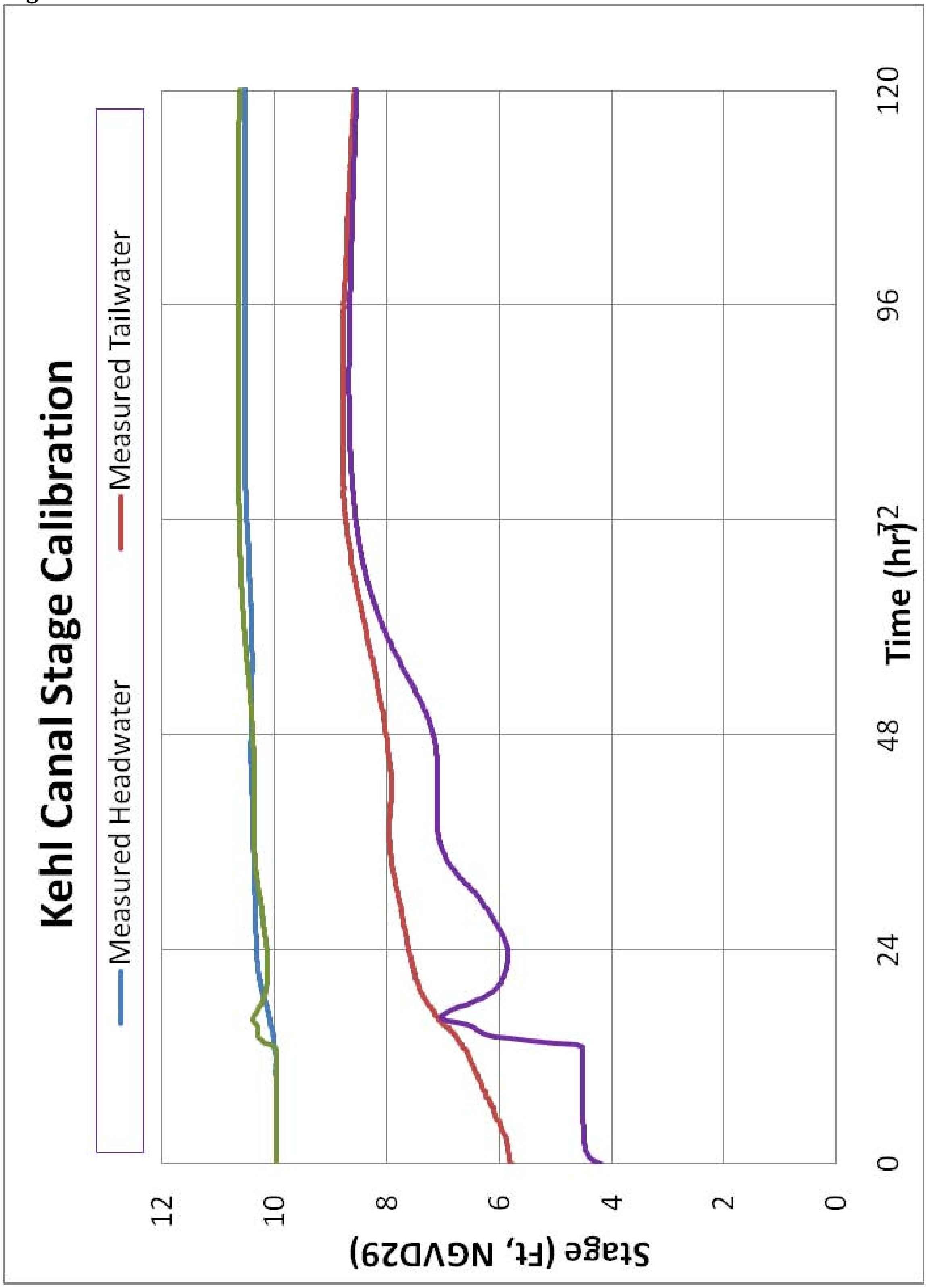

Spring Creek Stage Calibration
Modeled Stage
Stage (ft, NGNVD29)
10
9
8
7
6
5
4
3
Time (hr)
0
24
48
72
96
120

Figure 6-8



Kehl Canal Stage Calibration
Measured Headwater
Measured Tailwater
Stage (Ft, NGVD29)
Time (hr)
0
2
4
6
8
10
12
0
24
48
72
96
120

Table 6-3. Curve Number Look-up Table

FLORIDA LAND USE CODE ID	DESCRIPTION	Curve Numbers for Hydrologic Soil Group A	Group B	Group C	Group D	Group B-D
1100	Residential, low density	50	68	79	84	82
1110	Low Density: Fixed Single Family Units	50	68	79	84	82
1130	Low Density: Mixed Units, Fixed and Mobile Home	50	68	79	84	82
1180	Rural Residential	50	68	79	84	82
1200	Residential, medium density	57	72	81	86	84
1300	Residential, high density	77	85	90	92	91
1400	Commercial and services	89	92	94	95	95
1500	Industrial	81	88	91	93	92
1600	Extractive	77	86	91	94	93
1700	Institutional	69	81	87	90	89
1800	Recreational	49	69	79	84	82
1900	Open land (Urban)	39	61	74	80	77
2100	Cropland and pastureland	49	69	79	84	82
2110	Improved pastures	49	69	79	84	82
2120	Unimproved pastures	49	69	79	84	82
2130	Woodland pastures	49	69	79	84	82
2140	Cropland and pastureland	49	69	79	84	82
2200	Tree crops	44	65	77	82	80
2210	Citrus groves	44	65	77	82	80
2300	Feeding operations	73	83	89	92	91
2400	Nurseries and vineyards	57	73	82	86	84
2500	Specialty farms	59	74	82	86	84
2550	Aquaculture	59	74	82	86	84
2600	Other open land (Rural)	30	58	71	78	75
2610	Flallow Cropland	30	58	71	78	75
3100	Rangeland	63	71	81	89	85
3200	Shrub and brushland	35	56	70	77	74
3210	Palmetto Prairies	35	56	70	77	74
3300	Mixed rangeland	49	69	79	84	82
4100	Upland coniferous forests	45	66	77	83	80
4110	Upland coniferous forests	57	73	82	86	84
4120	Upland coniferous forests	43	65	76	82	79
4200	Upland hardwood forests	36	60	73	79	76
4220	Brazilian Pepper	36	60	73	79	76
4340	Mixed coniferous/hardwood	36	60	73	79	76
4400	Tree plantations	36	60	73	79	76
5100	Streams and waterways	100	100	100	100	100
5200	Lakes	100	100	100	100	100
5300	Reservoirs	100	100	100	100	100
5400	Bays and estuaries	100	100	100	100	100

Table 6-3 (cont.). Curve Number Look-up Table

FLORIDA LAND USE CODE ID	DESCRIPTION	Curve Numbers for Hydrologic Soil Group A	Group B	Group C	Group D	Group B-D
6100	Wetland hardwood forests	98	98	98	98	98
6110	Bay swamps	98	98	98	98	98
6120	Mangrove swamps	98	98	98	98	98
6150	Stream and lake swamps	98	98	98	98	98
6170	Mixed wetland hardwoods	98	98	98	98	98
6172	Mixed Shrubs	98	98	98	98	98
6200	Wetland coniferous forests	98	98	98	98	98
6210	Cypress	98	98	98	98	98
6215	Cypress - Domes/Heads	98	98	98	98	98
6250	Wet Pinelands Hydric Pine	98	98	98	98	98
6300	Wetland forestedmixed	98	98	98	98	98
6400	Vegetated non-forested wetlands	98	98	98	98	98
6410	Freshwater marshes	98	98	98	98	98
6411	Freshwater Marshes - Sawgrass	98	98	98	98	98
6420	Saltwater marshes	98	98	98	98	98
6430	Saltwater marshes	98	98	98	98	98
6440	Emergent aquatic vegetation	98	98	98	98	98
6500	Non-vegetated	98	98	98	98	98
6510	Tidal flats	98	98	98	98	98
6520	Tidal flats	98	98	98	98	98
6530	Intermittent ponds	98	98	98	98	98
7100	Beaches	77	86	91	94	93
7400	Disturbed land	77	86	91	94	93
8100	Transportation	81	88	91	93	92
8200	Communications	81	88	91	93	92
8300	Utilities	81	88	91	93	92

7 Existing Conditions Modeling - Design Storm Events

7.1 Selection of Design Storm Events

After calibration of the City of Bonita Springs ICPR model (Section 6) the model was used to simulate selected design storm events listed in Table 7-1. These design storms were selected based on the project scope of work as required by the City of Bonita Springs, Lee County, and SFWMD.

Table 7-1 Summary of Selected Design Storm Events

Design Storm Events	Rainfall Depth (Inches)	Rainfall Distribution Curve	Comments
2-Year/1-hour	2.5	FDOT 1-Hour	Mean-Annual Storm - LOS Standards (City and County)
2-Year/24-hour	4.5	FDOT 24-Hour	
5-Year/1-hour	3.0	FDOT 1-Hour	SFWMD Standards
5-Year/24-hour	5.7	FDOT 24-Hour	
10-Year/1-hour	3.3	FDOT 1-Hour	LOS Standards (City and County)
10-Year/24-hour	6.7	FDOT 24-Hour	
25-Year/72-hour	11.7	SFWMD 72-Hour	SFWMD Standards
100-Year/72-hour	13.7	SFWMD 72-Hour	

7.2 Simulation Results for Design Storm Events

The design storm events listed in Table 7-1 were simulated using ICPR. The simulation results of peak stages and flow rates are summarized in Tables 7-2 and 7-3 at the end of this section.

As listed in Table 7-1, two rainfall durations (1-hour and 24-hour) were simulated at the 2, 5, and 10-year frequencies to predict the peak flow and stage values at all model links and nodes respectively. The maximum water stage values between the 1-hour and 24-hour storm simulations were used in the floodplain delineation. Floodplains for the 2, 5, 10, 25 and 100-year design storm events are presented in Figures 7-1 through 7-5, respectively and are based on LiDAR DEM data provided by SFWMD.

7.3 Model Verification

To further verify the validity of the existing conditions modeling, stage information derived from various data sources was compared with the simulation results, including the node peak stages as well as the floodplain delineation for each design storm event.

The model was reviewed or adjusted when considerable differences between modeled and documented stages were identified.

Major data sources used in the model verification process are listed below:

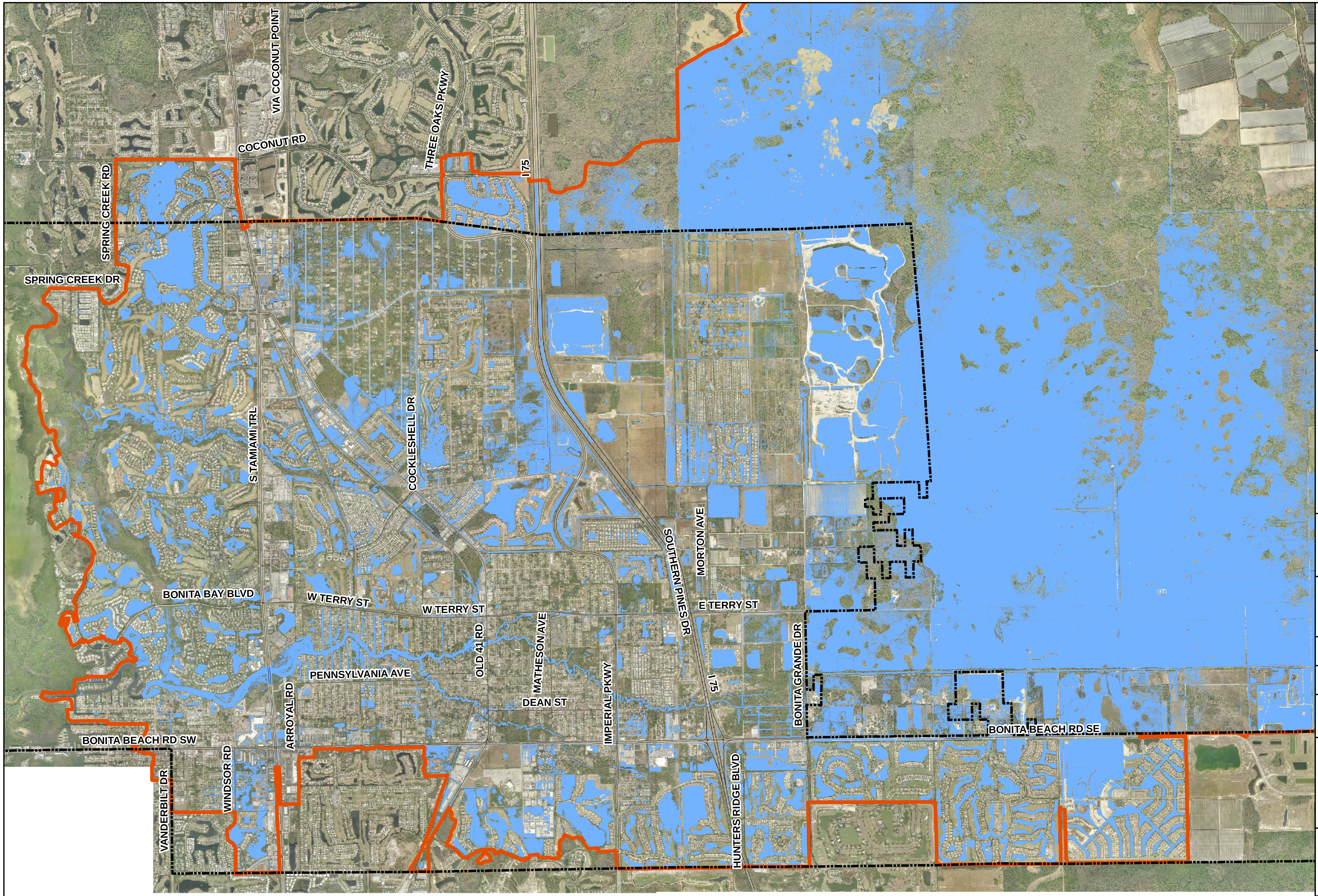
- ERP Documents
  - Road Crown Elevations vs. 5-year peak stages for the local/private roads within the land development areas
  - Road Crown Elevations vs. 10-year peak stages for the collector/public roads, e.g. Terry Road
  - Building Finished Floor Elevations (FFEs) vs. 100-year peak stages for the developed areas, particularly the recently developed subdivisions
- Roadway Plans
  - Road Crown Elevations vs. 25 and 100-year peak stages for the arterial roads or excavation routes, e.g. I-75, US 41, and Bonita Beach Road
- Flood Problem Areas Identified by the City as detailed in Section 8
  - Road Crown Elevations and FFEs vs. 2, 5, and 10-year peak stages to verify the roadway and structure flooding
  - Study, report, field photos and comments from the City associated with the flood problem areas vs. 2, 5, and 10-year floodplain maps

7.4 Figures & Tables Descriptions

The figures and tables discussed in this section are summarized below:

Figure #	Description
7-1	Floodplain Map of 2-Year Design Storm Events
7-2	Floodplain Map of 5-Year Design Storm Events
7-3	Floodplain Map of 10-Year Design Storm Events
7-4	Floodplain Map of 25-Year/72-Hour Design Storm Event
7-5	Floodplain Map of 100-Year/72-Hour Design Storm Event

Table #	Description
7-2	Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
7-3	Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events



Legend

Miles

0 0.25 0.5 1

- Major Road
- CityLimits
- Watershed
- Floodplain

City of Bonita Springs Stormwater Master Plan

Floodplain Map of 2-Year Design Storm Events

Project: 4600000955W003

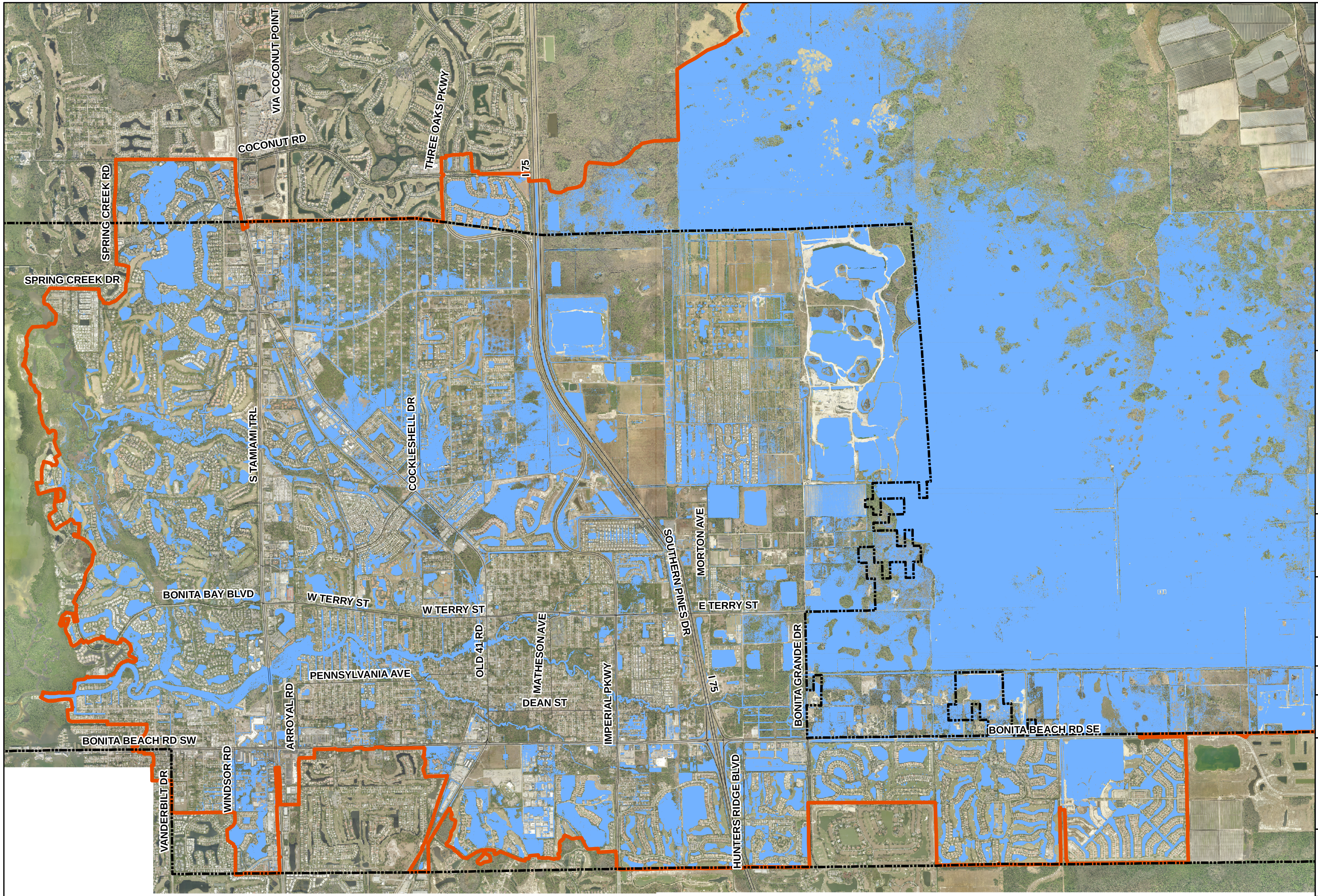
Date: 12/10/2010

File: COBS_SMP_Fig7_1

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 7-1



Legend

Miles

0 0.25 0.5 1

Major Road

CityLimits

Watershed

Floodplain

City of Bonita Springs Stormwater Master Plan

Floodplain Map of 5-Year Design Storm Events

Project: 4600000955W003

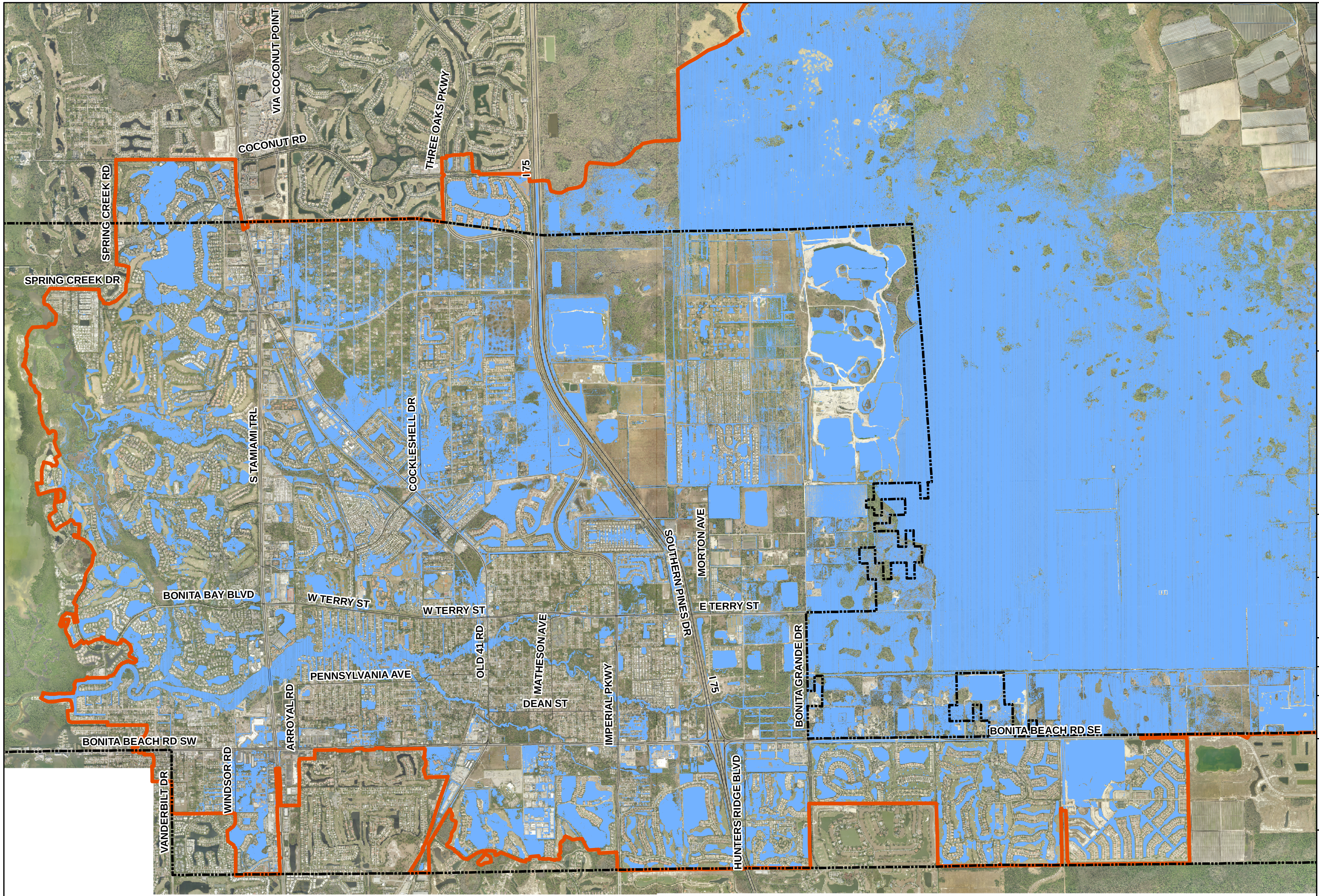
Date: 12/10/2010

File: COBS_SMP_Fig7_2

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 7-2



Legend

Miles

0 0.25 0.5 1

Major Road

CityLimits

Watershed

Floodplain

City of Bonita Springs Stormwater Master Plan

Floodplain Map of 10-Year Design Storm Events

Project: 4600000955W003

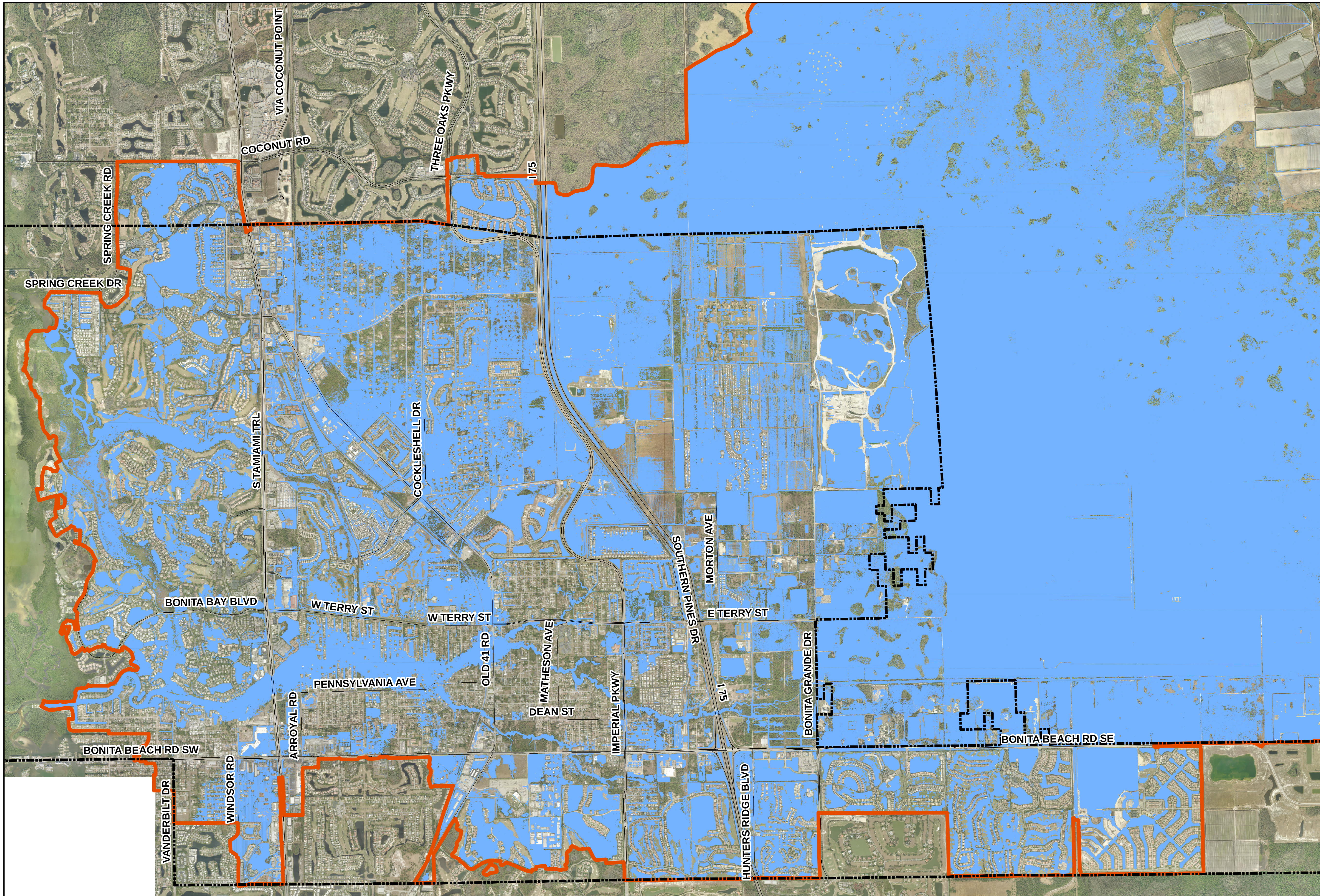
Date: 12/10/2010

File: COBS_SMP_Fig7_3

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 7-3



Legend

Miles

0 0.25 0.5 1

Major Road

CityLimits

Watershed

Floodplain

City of Bonita Springs Stormwater Master Plan

Floodplain Map of 25-Year/72-Hour Design Storm Even

Project: 4600000955W003

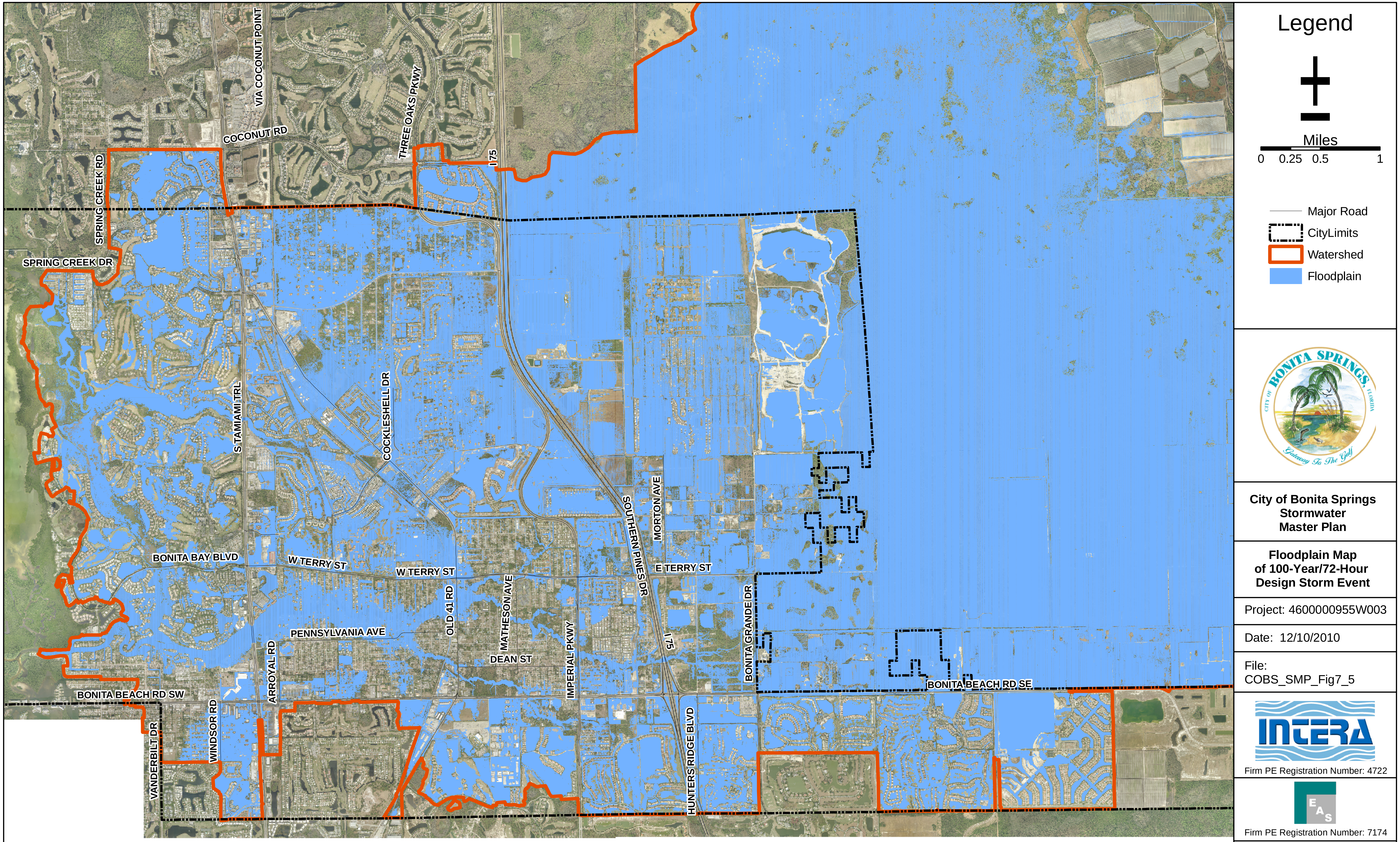
Date: 12/10/2010

File: COBS_SMP_Fig7_4

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 7-4



City of Bonita Springs Stormwater Master Plan

Floodplain Map of 100-Year/72-Hour Design Storm Event

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig7_5

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 7-5

Table 7-2
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NA0000	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
NA0005	1.77	1.81	1.84	1.94	1.88	2.07	2.55	2.70
NA0006	1.97	2.18	2.10	2.50	2.18	2.78	3.73	3.95
NA0007	2.74	3.10	2.83	3.34	2.89	3.54	4.49	4.93
NA0008	3.21	3.69	3.44	3.96	3.58	4.16	5.13	5.35
NA0009	2.83	3.45	3.00	3.80	3.10	4.07	5.11	5.43
NA0010	2.07	2.36	2.24	2.76	2.34	3.09	4.20	4.45
NA0011	3.16	3.37	3.35	3.87	3.46	4.27	5.65	6.03
NA0012	3.30	3.90	3.68	4.28	3.90	4.54	5.66	6.03
NA0013	2.89	3.62	3.15	4.03	3.30	4.35	5.65	6.03
NA0014	2.79	3.46	2.99	3.91	3.11	4.27	5.66	6.03
NA0015	3.45	2.71	3.70	2.81	3.83	3.11	4.54	4.88
NA0020	2.14	2.54	2.33	3.03	2.45	3.42	4.70	4.99
NA0021	4.22	5.06	4.45	5.47	4.59	5.77	6.83	7.15
NA0022	6.12	6.51	6.39	6.75	6.53	6.93	7.99	8.21
NA0023	8.53	7.99	8.67	8.06	8.74	8.11	8.99	9.06
NA0024	9.30	8.04	9.89	8.14	10.24	8.23	11.57	11.98
NA0025	9.37	8.06	9.95	8.17	10.32	8.26	11.68	12.10
NA0027	12.42	12.73	12.66	13.16	12.79	13.45	13.91	14.05
NA0028	5.17	4.98	5.41	5.13	5.55	5.25	6.59	6.88
NA0029	2.25	2.77	2.49	3.32	2.64	3.76	5.12	5.41
NA0030	3.84	4.65	4.20	5.13	4.42	5.46	6.74	7.03
NA0031	5.17	4.69	5.31	5.14	5.39	5.47	6.74	7.01
NA0032	5.22	5.82	5.45	6.13	5.60	6.37	7.75	8.09
NA0033	3.59	3.92	3.78	4.12	3.89	4.32	5.66	6.03
NA0034	4.37	4.56	4.66	4.76	4.82	4.95	6.06	6.41
NA0035	5.24	5.43	5.43	5.61	5.53	5.79	6.98	7.28
NA0036	5.87	6.51	6.10	6.80	6.23	7.01	7.95	8.24
NA0037	6.64	6.98	7.03	7.32	7.24	7.55	8.71	8.97
NA0038	7.88	7.92	8.07	8.06	8.17	8.16	9.25	9.51
NA0042	3.85	3.89	3.95	4.14	4.00	4.68	6.36	6.63
NA0043	4.72	4.93	4.97	5.41	5.11	6.89	8.72	8.97
NA0044	4.77	4.99	5.03	5.54	5.19	7.25	9.26	9.51
NA0045	5.06	5.28	5.33	5.86	5.49	8.17	10.63	10.86
NA0050	11.32	11.43	11.49	11.63	11.57	11.74	12.39	12.58
NA0055	5.91	6.05	6.08	6.42	6.19	9.09	11.90	12.11
NA0060	11.25	11.40	11.42	11.60	11.51	11.71	12.38	12.57
NA0070	11.14	11.28	11.33	11.52	11.43	11.65	12.35	12.55
NA0080	2.29	2.84	2.54	3.41	2.70	3.85	5.25	5.53
NA0081	5.26	5.59	5.36	5.78	5.42	5.89	6.41	6.60

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NA0085	4.70	5.82	5.00	6.44	5.19	6.82	7.34	7.64
NA0086	8.48	8.05	8.80	8.23	8.97	8.42	10.08	10.40
NA0087	8.34	9.53	8.74	10.32	8.97	10.73	11.27	11.48
NA0088	9.58	10.62	10.10	10.85	10.39	10.92	12.03	12.27
NA0090	9.21	8.95	9.46	9.12	9.60	9.24	10.38	10.56
NA0095	10.26	10.18	10.59	10.51	10.80	10.75	11.79	11.99
NA0100	10.31	10.23	10.66	10.59	10.85	10.80	11.84	12.03
NA0105	10.71	11.31	11.06	11.51	11.20	11.66	12.27	12.44
NA0110	13.49	12.58	13.81	12.93	13.97	13.19	14.73	14.97
NA0120	13.80	14.04	14.25	14.51	14.46	14.84	15.74	15.94
NA0130	10.32	10.24	10.67	10.59	10.86	10.81	11.86	12.07
NA0140	10.32	10.24	10.67	10.59	10.86	10.82	11.86	12.08
NA0150	10.32	10.24	10.67	10.60	10.86	10.82	11.84	12.18
NA0151	10.32	10.25	10.67	10.61	10.85	10.84	11.85	12.19
NA0152	12.12	12.63	12.38	13.02	12.52	13.26	13.51	13.66
NA0153	10.31	10.61	10.48	10.93	10.58	11.18	11.86	12.19
NA0154	10.30	10.62	10.48	10.94	10.58	11.18	11.87	12.20
NA0155	10.32	10.25	10.67	10.60	10.86	10.82	11.84	12.19
NA0156	10.33	10.91	10.51	11.23	10.62	11.44	12.13	12.29
NA0157	10.33	10.91	10.52	11.23	10.62	11.44	12.13	12.29
NA0158	10.58	11.08	10.76	11.32	10.85	11.48	11.92	12.19
NA0160	2.40	3.04	2.70	3.65	2.88	4.12	5.56	5.84
NA0162	8.56	9.13	8.74	9.50	8.84	9.79	10.74	11.02
NA0164	4.78	4.55	4.88	4.74	4.94	4.82	5.67	6.06
NA0165	5.63	5.52	5.70	5.60	5.74	5.66	6.00	6.24
NA0166	6.48	7.36	6.75	7.82	6.91	8.15	9.12	9.35
NA0167	6.95	7.36	7.22	7.83	7.38	8.16	9.15	9.44
NA0168	7.14	7.36	7.23	7.82	7.29	8.15	9.12	9.36
NA0170	2.59	3.33	2.95	4.01	3.16	4.51	6.01	6.28
NA0176	3.00	3.35	3.06	4.02	3.21	4.52	6.02	6.44
NA0177	6.63	6.62	6.81	6.89	6.91	7.04	7.42	7.52
NA0178	6.63	6.62	6.81	6.89	6.91	7.04	7.42	7.52
NA0179	6.82	6.59	6.96	6.66	7.03	6.71	7.38	7.48
NA0180	2.81	3.63	3.23	4.37	3.48	4.90	6.46	6.71
NA0181	5.44	5.00	5.64	5.19	5.75	5.40	6.52	6.77
NA0182	11.03	11.61	11.27	11.95	11.40	12.22	13.12	13.31
NA0183	14.17	14.82	14.44	15.27	14.59	15.52	16.11	16.27
NA0184	12.67	11.50	13.09	11.50	13.27	11.66	13.98	14.24
NA0185	2.81	3.61	3.23	4.34	3.51	4.95	6.20	6.27
NA0186	2.81	3.65	3.23	4.39	3.48	4.92	6.20	6.27

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NA0188	15.28	15.68	15.49	15.98	15.59	16.18	16.65	16.74
NA0190	2.81	3.64	3.23	4.37	3.48	4.90	6.46	6.71
NA0197	3.69	3.86	3.91	4.50	4.04	5.02	6.79	7.06
NA0198	4.46	4.66	4.62	4.84	4.73	5.13	7.10	7.37
NA0199	5.19	5.43	5.26	5.71	5.29	5.94	8.78	9.16
NA0200	8.50	9.29	8.76	9.68	8.91	9.95	10.68	10.93
NA0205	8.63	9.07	8.88	9.40	9.01	9.60	10.19	10.42
NA0210	8.68	9.08	8.92	9.41	9.05	9.62	10.20	10.42
NA0240	2.94	3.80	3.40	4.57	3.66	5.11	6.76	7.08
NA0241	3.71	4.45	3.91	4.97	4.04	5.40	6.77	7.10
NA0242	6.16	6.99	6.51	7.67	6.71	8.21	9.33	9.48
NA0250	2.95	3.81	3.40	4.57	3.66	5.11	6.76	7.08
NA0260	4.47	3.95	4.73	4.63	4.86	5.11	6.76	7.07
NA0280	2.96	3.81	3.41	4.57	3.67	5.11	6.76	7.08
NA0281	3.84	3.81	4.35	4.61	4.62	5.18	6.77	7.08
NA0282	5.93	4.89	6.25	5.23	6.37	5.46	6.78	7.09
NA0283	7.67	6.63	7.83	7.01	7.89	7.24	8.05	8.11
NA0284	8.56	7.05	8.62	7.55	8.65	7.91	8.78	8.83
NA0285	3.54	3.84	4.23	4.60	4.60	5.15	6.77	7.08
NA0286	5.93	4.75	6.26	5.08	6.37	5.33	6.83	7.10
NA0287	7.04	6.27	7.40	6.42	7.54	6.55	8.01	8.13
NA0288	7.14	6.31	7.58	6.47	7.76	6.61	8.44	8.63
NA0289	7.51	6.67	7.92	6.84	8.08	6.98	8.70	8.88
NA0290	8.59	7.98	8.74	8.10	8.82	8.19	9.18	9.35
NA0292	7.60	6.22	8.04	6.33	8.33	6.46	8.76	8.81
NA0293	8.75	7.60	9.09	7.74	9.22	7.92	9.43	9.49
NA0294	9.29	7.65	9.43	7.82	9.48	8.06	9.59	9.64
NA0296	9.60	7.71	9.66	7.90	9.70	8.21	9.79	9.83
NA0300	7.58	6.68	8.05	6.86	8.24	7.01	9.02	9.26
NA0301	7.83	7.25	8.20	7.40	8.37	7.50	9.15	9.38
NA0305	9.34	9.22	9.45	9.30	9.52	9.41	9.74	9.81
NA0310	3.07	3.99	3.57	4.78	3.84	5.33	7.09	7.46
NA0320	3.25	4.29	3.79	5.11	4.08	5.67	7.54	7.95
NA0330	3.27	4.32	3.81	5.14	4.11	5.70	7.60	8.01
NA0331	3.29	4.37	3.84	5.21	4.15	5.79	7.78	8.23
NA0332	3.30	4.39	3.86	5.23	4.16	5.81	7.82	8.27
NA0340	3.31	4.41	3.87	5.25	4.18	5.84	7.87	8.33
NA0350	3.33	4.43	3.89	5.28	4.20	5.87	7.93	8.40
NA0360	3.07	3.99	3.57	4.78	3.84	5.33	7.09	7.46
NA0362	6.22	4.87	6.48	5.03	6.59	5.34	7.14	7.51

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NA0363	6.86	5.38	7.18	5.57	7.34	5.70	7.82	8.13
NA0365	8.28	7.71	8.41	8.06	8.48	8.22	9.04	9.06
NA0370	7.94	7.50	8.21	8.23	8.35	8.63	10.02	10.37
NA0390	10.54	10.40	10.69	10.69	10.78	10.87	11.54	11.74
NA0400	10.54	10.41	10.70	10.70	10.79	10.89	11.58	11.79
NA0401	10.72	10.42	10.90	10.71	10.99	10.90	11.59	11.81
NA0402	10.54	10.41	10.70	10.70	10.79	10.89	11.58	11.80
NA0410	10.55	10.42	10.71	10.70	10.80	10.89	11.59	11.80
NA0415	12.27	12.47	12.41	12.69	12.48	12.84	13.23	13.35
NA0420	10.72	10.53	10.92	10.81	11.01	10.98	11.76	11.97
NA0425	11.59	12.18	11.79	12.44	11.90	12.61	13.17	13.38
NB0009	3.18	4.03	3.68	4.82	3.96	5.38	7.16	7.54
NB0010	3.19	4.03	3.69	4.83	3.97	5.38	7.18	7.57
NB0019	3.82	4.14	4.29	4.92	4.53	5.47	7.28	7.69
NB0020	3.85	4.14	4.33	4.93	4.57	5.49	7.36	7.82
NB0029	9.27	8.48	9.44	9.08	9.51	9.39	9.69	9.74
NB0030	3.97	4.17	4.45	4.95	4.69	5.51	7.39	7.85
NB0040	4.25	4.25	4.74	5.02	4.97	5.58	7.47	7.95
NB0050	4.27	4.26	4.76	5.03	5.00	5.59	7.50	7.98
NB0051	9.64	8.53	9.87	8.78	9.99	8.96	10.53	10.64
NB0052	10.50	9.19	10.75	9.37	10.87	9.50	11.43	11.61
NB0054	10.78	10.66	10.94	10.84	11.03	11.00	11.77	11.98
NB0055	13.29	13.91	13.50	14.22	13.62	14.41	14.98	15.04
NB0056	10.91	10.71	11.08	10.90	11.17	11.06	11.85	12.05
NB0057	12.41	11.44	12.63	11.54	12.75	11.63	13.06	13.28
NB0058	12.44	12.81	12.61	13.08	12.71	13.27	13.77	13.98
NB0060	9.44	8.65	9.65	8.79	9.75	8.91	10.11	10.16
NB0062	10.04	10.02	10.06	10.02	10.07	10.04	10.26	10.29
NB0064	11.18	11.64	11.32	11.82	11.40	11.83	12.00	12.02
NB0066	12.01	12.02	12.05	12.03	12.07	12.03	12.14	12.15
NB0070	10.18	7.95	10.31	8.24	10.37	8.46	10.50	10.59
NB0080	11.03	10.71	11.11	10.74	11.15	10.77	11.24	11.30
NB0098	4.34	4.30	4.85	5.07	5.09	5.62	7.55	8.04
NB0099	4.38	4.32	4.89	5.09	5.13	5.64	7.58	8.07
NB0100	4.39	4.32	4.90	5.10	5.15	5.66	7.70	8.23
NB0103	4.67	4.62	5.31	5.45	5.65	6.04	8.28	8.71
NB0104	8.87	8.07	9.17	8.36	9.33	8.58	10.11	10.29
NB0105	9.08	8.46	9.43	8.49	9.64	8.60	10.29	10.72
NB0106	9.29	8.73	9.65	8.82	9.87	8.93	10.80	11.00
NB0107	8.15	7.94	8.20	7.95	8.22	7.96	8.28	8.71

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NB0109	11.11	10.77	11.32	10.98	11.44	11.16	12.21	12.42
NB0110	11.12	10.79	11.33	11.01	11.45	11.20	12.42	12.70
NB0112	12.36	12.66	12.60	12.96	12.74	13.18	14.30	14.58
NB0115	11.51	11.93	11.63	12.15	11.70	12.32	13.03	13.31
NB0116	12.57	13.04	12.73	13.28	12.82	13.45	14.03	14.20
NB0118	5.45	5.72	6.20	6.63	6.61	7.29	9.47	9.86
NB0119	5.60	5.92	6.34	6.82	6.75	7.48	9.64	10.04
NB0120	5.60	5.92	6.35	6.82	6.76	7.48	9.68	10.08
NB0121	7.06	6.92	7.15	6.99	7.21	7.51	9.65	10.07
NB0124	7.48	6.97	7.75	7.30	7.90	7.63	9.96	10.50
NB0125	10.56	11.05	10.90	11.33	11.07	11.53	12.20	12.36
NB0126	10.04	11.43	10.45	11.90	10.72	12.22	13.23	13.41
NB0127	11.34	10.92	11.52	11.19	11.62	11.37	12.25	12.40
NB0128	11.93	11.34	12.06	11.53	12.13	11.63	12.43	12.56
NB0129	11.97	11.62	12.10	11.65	12.16	11.69	12.45	12.57
NB0130	7.26	7.07	7.50	7.47	7.63	7.88	9.79	10.17
NB0135	7.50	7.11	7.73	7.50	7.86	7.90	9.83	10.21
NB0140	9.72	10.45	9.95	10.90	10.09	11.24	12.37	12.66
NB0146	9.78	9.90	9.98	10.23	10.10	10.53	11.33	11.49
NB0150	10.20	9.18	10.40	9.34	10.49	9.45	10.90	11.05
NB0160	10.34	9.45	10.43	9.67	10.50	9.83	10.90	11.05
NB0170	11.15	9.73	11.31	9.94	11.40	10.09	11.74	11.88
NB0180	11.27	9.83	11.43	10.03	11.52	10.18	11.76	11.88
NB0190	11.32	9.97	11.46	10.18	11.54	10.34	11.79	11.90
NB0200	11.31	9.99	11.45	10.20	11.52	10.35	11.79	11.90
NB0210	11.21	9.99	11.33	10.19	11.40	10.35	11.67	11.77
NB0220	11.20	9.99	11.33	10.19	11.40	10.35	11.67	11.77
NB0230	11.89	12.23	11.99	12.42	12.04	12.57	13.19	13.41
NB0250	7.92	7.14	8.20	7.54	8.34	7.93	9.86	10.24
NB0251	11.98	12.40	12.10	12.65	12.16	12.85	13.60	13.85
NB0252	12.10	12.42	12.26	12.69	12.35	12.90	13.71	13.97
NB0253	12.95	12.82	13.26	13.07	13.41	13.25	14.35	14.53
NB0255	12.31	12.81	12.43	13.12	12.50	13.35	14.21	14.51
NB0257	12.34	12.83	12.46	13.14	12.54	13.38	14.26	14.57
NB0260	12.32	12.83	12.44	13.14	12.53	13.38	14.27	14.58
NB0270	12.32	12.83	12.44	13.14	12.53	13.39	14.27	14.58
NB0440	12.32	12.83	12.44	13.14	12.53	13.39	14.27	14.58
NB0445	12.32	12.83	12.44	13.14	12.53	13.39	14.27	14.58
NB0446	12.32	12.83	12.54	13.14	12.65	13.39	14.27	14.58
NB0447	12.41	13.14	12.65	13.38	12.77	13.52	14.33	14.58

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NB0448	12.32	12.83	12.44	13.14	12.52	13.39	14.20	14.40
NB0449	12.31	12.84	12.44	13.14	12.52	13.39	14.22	14.46
NB0450	13.13	13.57	13.24	13.80	13.31	13.99	14.87	15.23
NB0455	13.13	13.57	13.24	13.81	13.31	14.00	14.94	15.34
NB0460	13.69	14.18	13.82	14.44	13.90	14.63	15.34	15.54
NC0004	4.82	5.83	5.33	6.51	5.60	6.98	8.32	8.70
NC0005	5.04	6.41	5.71	7.33	6.11	7.97	9.45	9.83
NC0006	8.27	7.66	8.39	8.01	8.45	8.18	8.78	8.90
NC0010	6.16	7.38	6.78	8.16	7.12	8.72	10.04	10.37
NC0014	7.13	7.44	7.54	8.21	7.78	8.76	10.08	10.42
NC0015	7.47	7.46	7.94	8.22	8.17	8.75	10.07	10.41
NC0016	7.47	7.46	7.94	8.22	8.17	8.75	10.07	10.41
NC0018	7.40	7.85	7.51	8.11	7.57	8.39	10.04	10.38
NC0020	6.18	7.48	6.80	8.30	7.15	8.87	10.25	10.61
NC0024	4.17	5.58	4.99	6.18	5.31	6.58	8.05	8.43
NC0025	5.69	6.98	6.22	7.86	6.60	8.48	9.96	10.33
NC0029	6.93	7.98	7.27	8.72	7.46	9.22	10.48	10.83
NC0030	8.98	7.94	9.21	8.56	9.32	9.04	10.37	10.64
NC0040	9.02	7.94	9.27	8.56	9.40	9.04	10.38	10.64
NC0048	9.26	7.98	9.67	8.62	9.89	9.14	11.22	11.61
NC0050	10.17	9.21	10.41	9.60	10.55	9.95	11.55	11.86
NC0054	11.17	11.47	11.31	11.63	11.39	11.71	12.17	12.36
NC0055	12.45	12.74	12.54	12.80	12.60	12.83	13.06	13.14
NC0056	12.87	12.79	13.08	12.97	13.20	13.18	14.22	14.42
NC0057	12.40	12.72	12.50	12.85	12.55	12.97	13.49	13.68
NC0058	12.40	12.72	12.50	12.86	12.55	12.97	13.51	13.71
NC0065	12.69	12.94	12.78	13.06	12.83	13.15	13.47	13.71
NC0066	12.85	13.19	13.00	13.38	13.08	13.52	13.97	14.09
NC0069	13.36	13.65	13.48	13.82	13.54	13.96	14.38	14.55
NC0070	11.05	11.69	11.36	12.05	11.52	12.28	12.94	13.15
NC0080	14.64	14.51	14.89	14.66	15.03	14.76	16.10	16.41
NC0090	12.24	12.46	12.36	12.61	12.42	12.71	13.10	13.24
NC0095	12.33	12.48	12.48	12.62	12.55	12.72	13.16	13.30
NC0096	12.50	12.51	12.60	12.64	12.65	12.73	13.19	13.32
NC0100	7.13	8.18	7.48	8.92	7.69	9.48	10.87	11.26
NC0110	7.92	8.80	8.27	9.43	8.46	9.88	11.17	11.54
NC0120	8.15	9.01	8.51	9.61	8.70	10.04	11.32	11.64
NC0125	8.62	9.43	8.99	9.99	9.18	10.38	11.61	11.87
NC0130	11.23	11.73	11.38	12.01	11.46	12.22	12.97	13.24
NC0140	11.53	11.74	11.66	12.02	11.74	12.24	12.99	13.26

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NC0150	8.68	9.55	9.06	10.19	9.28	10.61	11.91	12.20
NC0151	11.99	12.09	12.25	12.43	12.36	12.65	13.19	13.38
NC0155	9.70	10.41	10.08	10.97	10.28	11.31	12.38	12.63
NC0156	9.70	10.41	10.09	10.97	10.28	11.31	12.38	12.63
NC0157	10.20	10.46	10.60	11.00	10.79	11.36	12.57	12.82
NC0160	10.12	10.74	10.49	11.29	10.69	11.59	12.56	12.80
NC0161	10.77	11.20	11.13	11.72	11.32	11.96	12.78	12.98
NC0162	11.00	11.41	11.39	11.98	11.60	12.28	13.21	13.43
NC0165	10.12	10.76	10.49	11.31	10.69	11.63	12.61	12.86
NC0170	10.38	10.77	10.80	11.33	11.03	11.65	12.69	12.96
NC0173	10.36	11.59	10.87	12.18	11.16	12.56	13.58	13.77
NC0175	10.96	10.50	11.48	11.04	11.76	11.43	12.93	13.15
NC0176	12.33	11.60	12.74	12.20	12.94	12.59	13.70	13.89
NC0178	14.21	14.40	14.26	14.49	14.29	14.56	14.85	14.97
NC0180	11.70	11.99	12.07	12.50	12.25	12.75	13.62	13.90
NC0185	11.91	12.19	12.31	12.76	12.51	13.08	14.38	14.75
NC0186	14.73	15.03	14.81	15.17	14.86	15.27	15.68	15.84
NC0190	12.13	12.40	12.57	13.13	12.81	13.55	15.26	15.75
NC0191	12.13	12.47	12.57	13.20	12.81	13.63	15.39	15.86
NC0192	14.19	14.38	14.24	14.50	14.27	14.60	15.17	15.45
NC0193	12.13	12.49	12.57	13.21	12.81	13.63	15.39	15.86
NC0195	14.38	14.75	14.49	14.97	14.56	15.14	15.96	16.28
NC0198	13.30	12.89	13.45	13.21	13.53	13.63	15.39	15.86
NC0199	14.28	14.30	14.34	14.38	14.37	14.50	15.58	15.99
NC0200	12.68	11.94	12.99	12.22	13.14	12.61	13.86	14.04
NC0205	11.65	12.32	11.83	12.77	11.94	13.14	14.60	15.08
NC0210	15.75	15.92	15.80	16.00	15.83	16.05	16.32	16.43
NC1000	13.20	13.20	13.20	13.20	13.20	13.20	13.20	13.20
ND0001	3.36	4.45	3.92	5.30	4.23	5.89	7.96	8.43
ND0002	3.38	4.46	3.94	5.32	4.26	5.92	8.12	8.56
ND0005	3.54	4.53	4.14	5.40	4.47	5.99	8.26	8.70
ND0006	6.83	6.75	6.92	6.79	6.98	6.83	8.27	8.71
ND0007	9.70	9.41	9.82	9.46	9.93	9.49	10.91	11.17
ND0010	5.05	5.04	5.79	5.87	6.18	6.45	9.20	9.60
ND0011	5.06	5.05	5.80	5.88	6.19	6.46	9.22	9.62
ND0012	9.86	8.43	10.17	8.71	10.31	8.92	10.73	10.86
ND0013	10.38	9.75	10.66	9.99	10.79	10.18	11.24	11.35
ND0020	6.84	6.60	7.41	7.22	7.72	7.68	10.23	10.58
ND0025	6.99	6.91	7.55	7.52	7.86	7.96	10.41	10.75
ND0030	9.94	9.45	10.33	9.80	10.51	10.06	11.49	11.72

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
ND0040	7.01	6.95	7.58	7.56	7.89	8.01	10.54	10.91
ND0045	10.95	10.80	11.17	10.97	11.30	11.11	12.31	12.63
ND0050	8.03	8.22	8.45	8.70	8.70	9.04	11.19	11.50
ND0053	8.13	8.47	8.59	8.99	8.85	9.35	11.61	11.94
ND0055	8.21	8.63	8.69	9.18	8.97	9.55	11.91	12.27
ND0056	13.69	12.63	13.85	12.86	13.94	13.04	14.22	14.46
ND0057	9.77	9.25	10.02	9.41	10.15	9.69	12.21	12.52
ND0058	11.20	12.22	11.90	12.35	12.14	12.43	13.11	13.22
ND0059	10.29	10.51	10.42	10.88	10.47	11.03	12.27	12.58
ND0060	13.16	14.02	13.48	14.36	13.65	14.57	15.18	15.36
ND0062	13.40	14.04	13.71	14.38	13.87	14.59	15.19	15.38
ND0066	14.13	14.02	14.25	14.22	14.32	14.37	14.81	14.99
ND0070	12.16	13.02	12.37	13.52	12.50	13.93	15.35	15.63
ND0080	13.32	14.18	13.70	14.51	13.90	14.72	15.33	15.56
ND0090	13.16	13.99	13.45	14.32	13.60	14.52	14.77	14.86
ND0100	11.66	10.95	11.74	11.14	11.78	11.26	11.98	12.08
ND0102	11.97	10.98	12.17	11.28	12.26	11.62	12.68	12.85
ND0103	11.91	11.25	12.09	11.58	12.17	11.87	12.75	12.96
ND0104	12.52	11.08	12.66	11.35	12.73	11.56	12.94	13.08
ND0106	12.60	11.14	12.73	11.42	12.80	11.63	13.01	13.14
ND0108	12.63	11.16	12.76	11.44	12.83	11.65	13.03	13.16
ND0110	11.76	11.35	12.07	11.74	12.19	12.03	12.87	13.09
ND0115	11.77	11.36	12.09	11.77	12.21	12.08	12.96	13.18
ND0120	11.68	11.38	11.98	11.80	12.09	12.13	13.10	13.33
NE0008	3.41	4.78	4.01	5.72	4.34	6.38	8.72	9.23
NE0009	3.41	4.78	4.01	5.73	4.34	6.39	8.75	9.27
NE0010	3.47	4.90	4.07	5.88	4.41	6.55	8.98	9.51
NE0011	3.50	4.98	4.12	5.95	4.46	6.62	9.07	9.60
NE0012	3.53	5.03	4.15	5.99	4.50	6.67	9.12	9.65
NE0015	7.86	8.12	8.14	8.55	8.28	8.86	10.13	10.51
NE0016	9.75	10.45	10.05	10.95	10.21	11.27	11.96	12.05
NE0017	11.04	10.89	11.24	11.17	11.34	11.35	12.06	12.23
NE0018	11.05	10.90	11.25	11.18	11.35	11.36	12.13	12.30
NE0019	11.36	11.06	11.54	11.34	11.64	11.52	12.29	12.44
NE0020	11.40	11.07	11.59	11.36	11.69	11.54	12.37	12.54
NE0023	13.59	13.31	13.80	13.75	13.87	13.79	14.09	14.14
NE0024	11.40	11.08	11.59	11.36	11.69	11.54	12.38	12.54
NE0025	12.57	13.13	12.73	13.41	12.83	13.60	14.28	14.51
NE0030	3.55	5.06	4.17	6.03	4.52	6.71	9.18	9.71
NE0035	8.77	10.17	9.29	10.49	9.58	10.67	11.72	12.01

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NE0037	10.22	10.34	10.31	10.79	10.41	11.08	12.12	12.38
NE0040	3.55	5.08	4.18	6.05	4.53	6.73	9.21	9.75
NE0042	8.15	8.07	8.23	8.11	8.28	8.14	10.43	10.69
NE0050	8.21	8.12	8.34	8.18	8.46	8.23	10.20	10.46
NE0052	7.43	6.76	8.01	7.40	8.35	8.01	10.05	10.09
NE0057	4.86	5.24	5.26	6.24	5.50	7.05	9.60	10.17
NE0060	9.14	9.73	9.35	9.99	9.45	10.13	10.51	10.64
NE0070	9.14	9.73	9.35	9.99	9.45	10.13	10.53	10.68
NE0080	9.15	9.73	9.35	9.99	9.45	10.13	10.54	10.71
NE0090	9.15	9.73	9.35	9.99	9.45	10.13	10.54	10.71
NE0109	3.57	5.11	4.19	6.09	4.55	6.77	9.27	9.81
NE0110	3.57	5.12	4.20	6.10	4.56	6.79	9.31	9.85
NE0114	10.04	10.13	10.18	10.18	10.23	10.22	10.64	10.74
NE0116	10.02	10.61	10.17	11.00	10.41	11.25	12.16	12.41
NE0118	10.50	10.60	10.68	10.99	10.73	11.23	12.16	12.40
NE0119	11.26	11.32	11.47	11.51	11.61	11.76	12.97	13.19
NE0120	3.63	5.22	4.27	6.22	4.63	6.92	9.49	10.04
NE0122	11.56	11.73	11.61	11.84	11.65	11.94	12.41	12.60
NE0123	11.95	10.03	12.22	10.41	12.33	10.68	12.65	12.79
NE0127	10.96	9.94	11.15	10.27	11.23	10.49	11.70	11.84
NE0129	10.14	9.69	10.26	9.88	10.34	9.98	11.06	11.32
NE0130	3.67	5.25	4.29	6.26	4.65	6.96	9.55	10.10
NE0131	11.60	12.47	11.84	12.57	11.98	12.62	13.36	13.44
NE0132	10.81	10.89	11.11	11.15	11.27	11.34	12.41	12.62
NE0133	11.45	11.06	11.69	11.27	11.82	11.46	12.69	12.93
NE0134	13.17	13.05	13.30	13.12	13.38	13.16	13.72	13.81
NE0135	11.68	11.19	11.86	11.39	11.97	11.56	12.79	13.46
NE0139	4.37	5.73	4.75	6.46	4.95	7.13	9.71	10.26
NE0140	4.31	5.27	4.71	6.27	4.91	6.97	9.55	10.10
NE0150	4.37	5.27	4.80	6.27	5.01	6.97	9.57	10.13
NE0160	9.42	9.30	9.75	9.48	9.94	9.65	11.11	11.29
NE0170	10.45	10.49	10.56	10.55	10.64	10.60	11.39	11.51
NE0174	9.98	9.93	10.16	10.01	10.25	10.08	11.16	11.31
NE0175	6.47	6.00	6.74	6.41	6.90	7.03	9.60	10.15
NE0180	10.01	9.57	10.15	9.76	10.24	9.87	10.97	11.24
NE0185	9.67	9.36	9.73	9.49	9.77	9.54	10.40	10.70
NE0190	5.43	5.36	5.78	6.32	5.96	7.00	9.59	10.14
NE0195	7.01	6.15	7.25	6.41	7.38	7.05	9.63	10.18
NE0196	10.97	9.13	11.38	9.56	11.57	9.87	12.43	12.63
NE0197	10.97	9.14	11.38	9.57	11.57	9.89	12.44	12.64

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NE0198	11.05	10.82	11.40	10.93	11.61	11.00	12.57	12.76
NE0199	12.53	12.70	12.68	12.81	12.76	12.88	13.25	13.34
NE0205	7.85	8.28	7.98	8.47	8.05	8.60	9.66	10.20
NE0207	10.18	10.22	10.35	10.39	10.44	10.56	11.82	12.16
NE0208	12.41	10.54	12.64	10.83	12.76	11.06	13.27	13.43
NE0209	12.39	12.36	12.64	12.42	12.76	12.47	13.27	13.44
NE0210	13.17	13.75	13.35	14.07	13.46	14.31	15.07	15.31
NE0215	9.30	9.67	9.40	9.91	9.46	10.09	10.78	11.15
NE0220	11.51	10.68	11.74	10.85	11.87	10.97	12.54	12.71
NE0230	12.50	11.81	12.66	12.05	12.74	12.18	13.27	13.44
NE0232	13.28	13.52	13.37	13.64	13.42	13.72	14.16	14.31
NE0234	11.84	10.84	12.09	11.09	12.22	11.30	12.86	13.06
NE0235	12.13	12.91	12.38	13.37	12.53	13.68	14.52	14.66
NE0238	12.61	11.16	12.93	11.52	13.08	11.78	13.46	13.62
NE0239	12.99	11.17	13.23	11.53	13.33	11.82	13.74	13.88
NE0240	10.44	11.43	10.72	11.97	10.89	12.40	13.81	14.10
NE0250	4.81	6.18	5.20	6.89	5.40	7.44	9.84	10.39
NE0251	5.20	6.62	5.61	7.35	5.82	7.92	10.33	10.97
NE0252	9.78	9.73	10.07	9.99	10.20	10.27	11.79	12.14
NE0253	12.06	11.54	12.30	11.63	12.43	11.70	13.01	13.17
NE0254	9.55	10.00	9.71	10.22	9.82	10.38	11.39	11.59
NE0255	9.70	10.22	9.83	10.51	9.91	10.75	11.87	12.15
NE0257	12.97	13.02	13.07	13.17	13.12	13.28	13.56	13.68
NE0259	5.73	7.22	6.16	8.01	6.38	8.62	11.20	11.90
NE0260	6.51	8.11	6.97	8.98	7.21	9.64	12.45	13.18
NE0265	6.76	8.39	7.23	9.28	7.47	9.96	12.86	13.61
NE0270	7.15	8.79	7.62	9.69	7.86	10.39	13.38	14.14
NE0271	7.18	8.82	7.65	9.73	7.89	10.43	13.44	14.25
NE0272	12.16	11.59	12.34	12.11	12.41	12.44	13.38	14.14
NE0273	12.34	12.18	12.39	12.45	12.42	12.66	13.42	14.14
NE0274	12.27	12.18	12.36	12.45	12.42	12.66	13.42	14.14
NE0275	12.27	12.18	12.36	12.45	12.42	12.66	13.42	14.15
NE0276	8.94	9.86	9.17	10.32	9.31	10.59	12.86	13.61
NE0277	13.87	14.25	13.99	14.40	14.05	14.50	14.86	14.99
NE0278	13.86	14.25	13.98	14.39	14.05	14.49	14.84	14.96
NE0279	13.30	13.60	13.37	13.78	13.42	13.93	14.64	14.91
NE0280	7.26	8.90	7.74	9.81	7.97	10.52	13.54	14.35
NE0284	13.34	13.34	13.45	13.41	13.51	13.46	13.85	14.14
NE0285	11.67	12.43	11.86	12.71	12.00	12.88	13.56	14.14
NE0286	11.70	12.43	11.91	12.72	12.04	12.89	13.57	14.14

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NE0290	9.95	10.66	10.14	10.83	10.24	10.90	12.46	13.19
NE0291	9.95	10.68	10.15	10.86	10.25	10.92	12.46	13.19
NE0292	9.96	10.70	10.16	10.88	10.27	10.95	12.47	13.19
NE0295	13.04	13.51	13.18	13.74	13.25	13.92	14.65	14.93
NE0296	13.47	13.88	13.58	14.12	13.65	14.31	15.12	15.34
NE0297	14.55	15.02	14.70	15.29	14.79	15.48	15.99	16.24
NE0300	9.96	10.70	10.17	10.88	10.27	10.96	12.47	13.19
NE0302	14.01	14.54	14.16	14.89	14.25	15.16	16.09	16.38
NE0304	9.97	10.72	10.17	10.90	10.28	10.97	12.47	13.20
NE0305	13.96	14.39	14.09	14.68	14.17	14.93	15.91	16.26
NE0310	11.59	10.73	11.78	10.92	11.89	11.00	12.47	13.20
NE0320	14.92	14.36	15.18	14.63	15.34	14.84	16.06	16.38
NE0350	13.92	14.37	14.03	14.64	14.10	14.85	15.83	16.19
NE0400	12.56	13.06	12.73	13.39	12.83	13.64	14.45	14.74
NE0410	12.55	13.06	12.72	13.39	12.81	13.64	14.45	14.74
NE0420	6.76	7.04	7.13	7.23	7.33	7.55	9.52	10.05
NE0425	4.32	5.22	4.62	6.23	4.81	6.92	9.50	10.04
NE0426	6.79	7.04	7.12	7.21	7.30	7.54	9.60	10.06
NE0430	4.46	5.22	4.80	6.23	4.99	6.92	9.50	10.04
NE0431	7.94	7.02	8.30	7.21	8.48	7.36	9.51	10.06
NE0432	8.62	7.56	8.85	7.65	8.98	7.71	9.53	10.10
NE0433	11.40	11.54	11.44	11.86	11.46	12.60	14.09	14.35
NE0434	12.91	13.65	13.18	13.94	13.31	14.03	14.50	14.71
NE0437	11.95	12.48	12.15	12.74	12.26	12.93	13.54	13.72
NF0000	8.72	10.36	9.41	10.65	9.82	10.98	13.77	14.59
NF0010	9.23	10.90	9.85	11.41	10.23	11.89	15.08	16.19
NF0015	13.70	13.90	13.78	14.01	13.83	14.10	15.08	16.19
NF0020	10.60	11.60	10.81	12.42	10.88	13.26	16.16	16.48
NF0030	12.08	13.20	12.36	13.95	12.52	14.69	17.32	17.72
NF0035	15.62	15.83	15.75	15.99	15.82	16.10	17.32	17.72
NF0100	13.88	14.24	13.98	14.37	14.04	14.46	14.80	14.91
NF0150	12.71	13.23	12.89	13.45	12.98	13.61	14.14	14.59
NF0200	12.79	13.23	12.90	13.45	12.98	13.61	14.15	14.59
NF0300	15.06	15.73	15.25	16.08	15.36	16.35	17.24	17.45
NF0350	16.06	16.45	16.20	16.57	16.27	16.66	17.22	17.43
NF0360	17.52	18.24	17.73	18.58	17.84	18.82	19.59	19.82
NF0370	28.39	28.77	28.51	28.93	28.58	29.05	29.52	29.69
NF0400	13.67	13.98	13.79	14.13	13.85	14.24	15.07	16.19
NF0450	13.02	13.20	13.06	13.30	13.09	13.39	15.08	16.19
NF0460	14.23	14.45	14.29	14.58	14.33	14.69	15.14	16.03

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NF0500	16.45	17.02	16.63	17.26	16.72	17.42	18.05	18.27
NF0600	14.34	14.75	14.48	14.94	14.56	15.07	15.97	16.22
NF0700	16.21	16.41	16.26	16.53	16.29	16.63	17.14	17.37
NF0800	16.64	16.91	16.72	17.03	16.77	17.13	17.50	17.64
NF1000	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50
NG0000	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
NG0010	1.72	1.63	1.76	1.65	1.79	1.67	1.94	2.02
NG0015	5.68	5.81	6.22	6.22	6.49	6.53	8.27	8.64
NG0016	11.64	12.30	11.86	12.64	11.99	12.89	14.23	14.60
NG0020	4.72	5.49	4.90	5.78	5.01	5.98	6.62	6.79
NG0021	12.18	12.68	12.42	13.02	12.56	13.31	14.61	14.95
NG0022	13.39	13.88	13.66	14.40	13.82	14.78	15.64	16.03
NG0023	12.59	13.29	12.78	13.68	12.90	13.99	15.00	15.44
NG0024	4.60	5.27	5.04	5.70	5.30	6.02	8.03	8.34
NG0025	2.03	2.13	2.16	2.41	2.25	2.63	3.63	3.92
NG0026	5.93	6.30	6.10	6.59	6.21	6.82	7.39	7.56
NG0030	1.87	1.87	1.95	2.04	2.00	2.17	2.88	3.11
NG0031	3.12	3.47	3.27	3.79	3.36	4.03	4.98	5.45
NG0032	3.15	3.59	3.36	3.89	3.48	4.13	5.30	5.62
NG0033	3.10	3.75	3.34	4.26	3.49	4.64	5.83	6.01
NG0034	4.27	4.99	4.54	5.39	4.71	5.66	6.74	7.03
NG0035	5.62	6.24	5.82	6.49	5.93	6.69	7.44	7.66
NG0036	5.74	6.53	5.99	6.86	6.14	7.12	8.14	8.43
NG0037	6.29	6.59	6.45	6.90	6.54	7.15	8.23	8.52
NG0038	7.38	7.93	7.64	8.32	7.80	8.61	9.57	9.79
NG0039	7.23	7.94	7.44	8.33	7.57	8.62	9.59	9.77
NG0040	2.23	1.99	2.41	2.24	2.51	2.45	3.52	3.76
NG0041	3.37	3.69	3.57	3.98	3.68	4.20	4.86	5.07
NG0042	2.99	3.47	3.15	3.76	3.24	4.02	5.10	5.46
NG0043	3.09	3.52	3.24	3.77	3.32	3.97	4.77	5.05
NG0044	3.13	3.22	3.23	3.30	3.29	3.35	4.06	4.27
NG0045	4.97	4.95	5.29	5.30	5.45	5.54	6.60	6.88
NG0046	5.39	5.96	5.69	6.24	5.87	6.45	7.59	7.86
NG0047	3.41	3.99	3.70	4.36	3.89	4.64	5.79	6.09
NG0048	3.25	3.65	3.36	3.86	3.43	4.03	5.14	5.74
NG0049	5.72	6.41	5.98	6.76	6.12	7.02	7.92	8.19
NG0050	2.17	2.30	2.35	2.65	2.45	2.90	4.07	4.40
NG0051	6.81	6.84	6.98	7.11	7.09	7.39	8.23	8.50
NG0052	7.56	7.55	7.79	7.88	7.92	8.20	9.55	9.97
NG0053	8.89	9.47	9.12	9.76	9.25	9.96	10.87	11.12

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NG0054	9.25	9.77	9.51	10.07	9.65	10.29	11.35	11.63
NG0055	6.79	7.62	7.06	8.06	7.21	8.37	8.98	9.20
NG0056	3.78	4.58	3.98	4.99	4.11	5.30	6.40	6.84
NG0057	6.96	7.81	7.20	8.24	7.35	8.53	9.70	9.88
NG0058	7.32	8.06	7.74	8.53	7.99	8.85	10.37	10.62
NG0059	8.17	8.62	8.36	8.80	8.47	8.92	9.86	10.07
NG0060	2.27	2.33	2.45	2.68	2.56	2.95	4.28	4.66
NG0061	4.78	5.50	5.07	5.87	5.24	6.14	6.99	7.17
NG0062	8.83	9.03	9.09	9.28	9.24	9.42	10.96	11.29
NG0063	11.84	12.78	12.17	13.31	12.37	13.65	14.45	14.76
NG0064	11.93	12.68	12.20	13.13	12.36	13.42	14.17	14.42
NG0065	6.94	7.69	7.25	8.16	7.43	8.48	9.51	9.85
NG0066	9.79	10.34	10.00	10.66	10.12	10.92	11.90	12.20
NG0067	10.66	11.25	10.85	11.65	10.97	11.97	12.87	13.11
NG0068	5.87	6.69	6.15	7.21	6.31	7.58	8.67	9.03
NG0069	6.54	6.69	6.76	7.20	6.88	7.56	8.57	8.88
NG0070	2.19	2.36	2.38	2.72	2.49	2.99	4.17	4.51
NG0073	10.95	12.21	11.35	12.65	11.57	12.92	13.82	14.11
NG0074	6.38	6.69	6.60	7.20	6.73	7.56	8.56	8.82
NG0076	8.42	7.82	8.81	8.05	9.04	8.23	10.15	10.38
NG0078	7.74	8.43	8.02	8.83	8.18	9.12	10.00	10.28
NG0079	8.86	8.79	8.90	8.84	8.93	9.12	9.99	10.27
NG0080	6.76	6.43	6.89	6.71	6.97	6.94	7.98	8.17
NG0081	9.83	9.20	9.88	9.36	9.90	9.47	9.94	10.06
NG0082	12.25	10.92	12.42	11.31	12.50	11.59	12.84	12.93
NG0083	13.18	11.45	13.43	11.89	13.56	12.23	14.06	14.25
NG0084	14.77	15.24	15.09	15.71	15.26	16.04	16.61	16.79
NG0085	13.33	11.61	13.57	12.06	13.69	12.40	14.23	14.42
NG0090	2.20	2.39	2.39	2.76	2.51	3.03	4.21	4.56
NG0093	5.42	6.92	5.91	7.54	6.16	7.99	9.10	9.22
NG0095	7.01	7.65	7.18	8.02	7.30	8.48	10.01	10.33
NG0099	7.01	7.78	7.24	8.15	7.39	8.58	10.06	10.38
NG0100	8.52	10.00	9.08	10.35	9.39	10.58	11.02	11.27
NG0101	10.51	10.01	10.68	10.35	10.78	10.58	11.09	11.28
NG0102	11.55	10.90	11.77	11.04	11.89	11.14	12.40	12.56
NG0104	10.48	10.88	10.67	11.21	10.78	11.46	12.20	12.52
NG0105	11.29	12.11	11.68	12.73	11.91	13.00	13.89	14.18
NG0106	11.55	12.58	11.91	13.25	12.11	13.45	14.37	14.67
NG0107	8.55	10.10	9.14	10.46	9.46	10.69	11.16	11.42
NG0108	8.56	10.18	9.16	10.58	9.48	10.84	11.44	11.75

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NG0109	8.57	10.21	9.17	10.61	9.51	10.87	11.47	11.78
NG0110	8.60	10.33	9.23	10.80	9.58	11.07	11.83	12.23
NG0112	11.33	11.56	11.45	11.71	11.51	11.84	12.31	12.44
NG0115	9.38	11.40	10.32	11.83	10.75	12.06	12.69	12.90
NG0116	10.63	11.75	11.04	12.19	11.36	12.43	13.05	13.23
NG0117	11.66	11.85	11.81	12.27	11.90	12.54	13.32	13.53
NG0118	13.58	13.49	13.68	13.53	13.74	13.55	13.96	14.03
NG0120	10.74	12.23	11.26	12.75	11.62	12.99	13.56	13.75
NG0125	12.45	13.14	12.99	13.27	13.04	13.40	13.97	14.14
NG0130	10.80	12.75	11.42	13.48	11.88	13.75	14.43	14.62
NG0140	13.25	13.40	13.40	13.68	13.48	13.90	14.50	14.68
NG0145	13.14	13.47	13.33	13.78	13.44	14.01	14.66	14.82
NG0150	10.94	13.01	11.59	13.72	12.09	13.97	14.64	14.83
NG0153	13.79	13.97	13.94	14.01	14.00	14.05	14.71	14.87
NG0155	13.33	13.57	13.51	13.78	13.56	14.03	14.69	14.88
NG0157	13.85	13.86	13.96	13.91	14.02	14.08	14.77	14.99
NG0160	11.44	13.07	11.94	13.80	12.23	14.06	14.75	14.97
NG0165	11.45	13.07	11.94	13.80	12.24	14.06	14.76	14.98
NG0168	12.13	13.07	12.51	13.81	12.72	14.07	14.76	15.00
NG0170	14.57	14.81	14.70	15.02	14.78	15.18	15.97	16.26
NG0180	14.55	14.98	14.67	15.22	14.75	15.41	16.23	16.50
NG0187	2.22	2.43	2.42	2.80	2.54	3.06	4.24	4.59
NG0188	5.24	5.76	5.58	6.16	5.76	6.37	7.38	7.63
NG0189	5.31	5.84	5.66	6.25	5.84	6.47	7.50	7.75
NG0190	6.97	7.80	7.42	8.43	7.66	8.81	9.62	9.83
NG0191	6.99	7.85	7.44	8.47	7.68	8.84	9.65	9.86
NG0192	7.01	7.90	7.45	8.53	7.70	8.92	9.84	10.09
NG0193	7.31	8.49	7.71	9.00	7.93	9.31	10.18	10.45
NG0194	7.37	8.59	7.75	9.08	7.97	9.39	10.26	10.52
NG0195	10.38	10.69	10.52	10.90	10.59	11.07	11.61	11.83
NG0196	10.10	10.35	10.26	10.56	10.34	10.72	11.19	11.40
NG0197	10.57	9.41	10.71	9.67	10.79	9.88	11.04	11.21
NG0198	10.90	11.23	11.03	11.45	11.11	11.62	12.14	12.36
NG0200	7.82	9.48	8.45	9.89	8.80	10.13	10.93	11.20
NG0201	8.00	9.79	8.70	10.22	9.07	10.50	11.45	11.84
NG0205	10.37	11.04	10.63	11.51	10.79	11.83	12.39	12.55
NG0210	9.30	11.37	10.20	11.79	10.63	12.02	12.67	12.86
NG0211	10.48	11.62	10.83	12.01	11.08	12.23	12.92	13.10
NG0212	12.30	12.42	12.43	12.53	12.50	12.62	13.25	13.42
NG0213	10.82	12.41	11.64	12.69	11.99	12.85	13.37	13.52

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NG0214	10.84	12.62	11.74	12.93	12.14	13.11	13.68	13.84
NG0215	11.07	12.99	12.15	13.26	12.57	13.42	13.91	14.10
NG0216	11.40	13.29	12.68	13.57	12.98	13.74	14.32	14.52
NG0217	13.62	13.31	13.72	13.39	13.78	13.44	14.25	14.38
NG0220	9.31	11.37	10.20	11.79	10.63	12.02	12.67	12.86
NG0225	9.61	11.38	10.20	11.80	10.63	12.03	12.69	12.88
NG0230	10.32	11.06	10.52	11.47	10.63	11.83	12.78	13.00
NG0240	10.62	11.40	11.18	11.84	11.37	12.08	12.78	13.00
NG0270	11.39	12.27	11.76	12.64	11.96	12.90	13.77	14.01
NG0272	13.77	14.45	14.01	14.81	14.15	15.06	15.78	16.00
NG0275	12.68	12.70	12.78	12.75	12.84	12.80	13.36	13.50
NG0280	11.39	12.51	11.76	13.06	11.96	13.37	14.25	14.48
NG0285	12.60	12.53	13.04	13.11	13.30	13.48	14.82	15.02
NG0300	13.57	13.66	13.65	13.83	13.70	13.96	14.38	14.55
NG0310	11.96	12.66	12.46	13.29	12.71	13.64	14.58	14.86
NG0380	11.77	12.11	11.87	12.26	11.93	12.37	13.15	13.36
NG0381	12.93	12.72	13.21	12.95	13.37	13.13	14.36	14.59
NG0382	12.49	12.76	12.62	12.99	12.70	13.19	14.29	14.62
NG0383	13.52	13.88	13.63	14.06	13.69	14.21	14.71	14.86
NG0384	14.63	14.66	14.71	14.75	14.75	14.81	15.24	15.68
NG0385	15.16	15.48	15.24	15.68	15.29	15.84	16.51	16.71
NG0386	15.29	15.63	15.39	15.84	15.45	16.00	16.69	16.96
NG0390	12.22	12.72	12.47	13.07	12.62	13.36	14.61	14.90
NG0391	12.31	12.78	12.58	13.15	12.72	13.47	15.08	15.38
NG0392	15.03	15.42	15.23	15.58	15.35	15.62	16.21	16.44
NG0395	13.22	13.91	13.40	14.38	13.52	14.75	15.75	16.05
NG0396	14.29	14.74	14.44	15.02	14.53	15.24	16.11	16.30
NG0397	13.45	14.06	13.69	14.55	13.83	14.94	16.00	16.32
NG0398	13.52	14.13	13.76	14.63	13.90	15.03	16.14	16.46
NG0400	6.36	6.99	6.79	7.44	7.01	7.69	8.92	9.21
NG0405	6.58	7.49	7.10	8.19	7.38	8.59	9.36	9.55
NG0410	6.70	6.79	6.87	6.94	6.97	7.08	8.40	8.75
NG0420	6.97	6.81	7.12	6.98	7.23	7.13	8.45	8.81
NG0430	6.28	6.73	6.48	7.06	6.60	7.38	8.38	8.59
NG0440	6.40	6.74	6.66	7.07	6.80	7.38	8.39	8.61
NG0450	6.88	6.84	7.16	7.19	7.32	7.53	8.59	8.90
NG0460	7.13	6.96	7.32	7.37	7.44	7.75	9.03	9.20
NG0470	9.29	10.86	9.86	11.49	10.21	11.93	12.81	12.93
NG0480	10.59	10.94	10.73	11.58	10.84	12.02	13.04	13.27
NG0485	12.15	11.33	12.40	11.61	12.54	12.06	13.43	13.67

Table 7-2 (Continued)
Simulated Node Peak Stages (ft NGVD29) of Selected Design Storm Events
Note: Node locations are provided in Figures 5-12 to 5-31

NODE	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
NG0490	9.12	9.51	9.38	9.93	9.52	10.25	11.08	11.24
NG0500	13.21	12.62	13.38	12.72	13.46	12.80	13.89	14.06

Table 7-3
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RA0005	786.42	889.85	945.22	1161.47	1036.18	1379.25	2102.71	2296.37
RA0006	628.29	873.33	751.16	1142.22	821.69	1357.32	2078.91	2245.76
RA0008	0.32	0.92	0.58	1.42	0.78	1.86	13.24	17.30
RA0009A	0.09	0.64	0.18	1.23	0.26	1.87	5.92	7.73
RA0009B	0.15	1.22	0.32	2.38	0.47	3.63	17.20	32.49
RA0010	622.69	872.00	740.92	1140.35	810.33	1354.91	2071.80	2234.48
RA0011	21.89	24.81	25.58	32.10	27.43	36.12	48.51	51.87
RA0012	0.65	1.81	1.35	2.65	1.88	3.40	17.54	18.33
RA0013	0.48	0.95	0.61	1.28	0.67	1.66	5.59	10.71
RA0014	0.53	0.82	0.74	1.41	0.88	1.97	5.33	8.67
RA0020	550.50	822.07	683.86	1078.96	761.25	1286.43	1990.29	2141.54
RA0021	1.73	8.77	3.02	14.80	4.00	20.30	45.23	56.00
RA0022	4.84	10.07	8.18	14.73	10.53	18.59	46.32	52.81
RA0023	46.70	10.03	58.65	13.62	65.24	16.62	89.93	97.89
RA0024	41.47	8.66	52.08	11.73	57.90	14.29	76.38	81.39
RA0025	24.15	4.12	30.66	5.41	34.49	6.48	41.06	44.81
RA0027	0.35	0.37	0.36	0.40	0.37	0.42	1.64	4.30
RA0028	8.46	5.57	11.61	7.92	12.83	9.58	15.70	15.30
RA0029	535.17	797.92	668.56	1045.21	745.74	1241.68	1922.84	2055.80
RA0030	1.33	4.41	2.42	6.90	3.25	9.03	36.45	50.15
RA0031	2.86	0.78	3.85	1.08	4.42	1.25	10.54	13.36
RA0032	0.46	2.09	0.93	3.42	1.33	4.55	14.62	18.34
RA0033	0.40	1.14	0.77	1.64	1.07	2.15	8.86	10.24
RA0034	8.45	14.74	18.42	22.35	24.98	28.35	71.33	78.48
RA0035	7.20	13.38	13.17	20.17	16.92	25.82	54.39	56.77
RA0036	3.07	12.01	5.49	18.12	7.26	23.20	50.05	51.50
RA0037A	6.30	8.80	10.56	12.61	13.50	15.50	49.92	54.31
RA0037B	5.50	7.96	9.26	11.67	11.85	14.60	43.30	46.39
RA0038	9.41	10.77	15.76	15.32	19.87	18.59	41.48	44.52
RA0042	5.21	6.43	6.71	9.24	7.57	15.42	19.41	19.21
RA0043	5.24	6.43	6.72	9.25	7.58	15.43	19.91	19.79
RA0044	5.23	6.43	6.72	9.25	7.58	15.43	19.98	19.87
RA0045	5.24	6.43	6.73	9.25	7.58	15.43	20.01	19.91
RA0050	1.23	1.45	1.58	2.45	1.81	4.48	7.00	6.46
RA0055	4.07	4.98	5.21	6.81	5.87	10.96	13.61	13.56
RA0060A	1.51	1.84	1.88	2.57	2.09	4.32	6.49	5.96
RA0060B	8.36	3.97	8.91	3.75	9.42	4.02	5.23	4.88
RA0060C	3.67	1.42	3.81	1.34	3.87	1.44	1.87	1.75
RA0070A	2.58	3.14	3.36	4.25	3.82	6.66	10.34	10.12
RA0070B	4.34	3.60	5.38	3.26	5.83	3.34	3.99	3.68

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RA0070C	5.36	2.49	5.84	2.38	6.08	2.37	2.68	2.47
RA0080	529.17	794.84	662.36	1041.46	739.26	1237.43	1915.02	2046.43
RA0081	0.21	0.81	0.34	1.47	0.44	2.86	13.21	18.56
RA0085	2.61	7.00	3.63	9.97	4.34	17.75	51.14	70.75
RA0086	25.61	17.87	26.80	23.54	27.42	24.57	23.24	24.42
RA0087	1.40	1.86	1.55	2.14	1.63	2.37	15.02	18.23
RA0088	0.83	0.76	0.87	2.72	0.89	4.64	18.64	17.85
RA0095	40.87	38.88	50.87	48.45	58.01	56.37	104.09	116.96
RA0100	40.82	38.87	48.64	48.45	48.56	48.97	49.11	49.04
RA0105	0.55	3.87	1.94	5.38	2.77	6.24	8.13	8.71
RA0110	14.04	7.74	18.04	10.07	20.78	11.86	27.24	27.69
RA0120	2.72	3.86	3.60	4.94	4.09	5.69	11.03	11.42
RA0130	86.29	27.10	96.12	31.34	101.10	35.94	85.40	96.43
RA0140	34.17	18.14	42.43	29.60	47.40	29.33	65.06	76.68
RA0150	49.40	17.85	60.21	23.40	66.66	27.12	63.90	75.02
RA0151	3.59	1.80	5.13	3.06	5.95	4.26	6.69	6.87
RA0152	0.34	0.38	0.36	0.40	0.37	0.41	4.19	7.04
RA0153	3.75	5.46	4.59	7.17	5.62	8.28	9.05	9.07
RA0154	0.63	1.70	1.24	2.95	1.98	4.11	5.33	5.36
RA0155	13.02	1.11	16.07	1.41	17.89	1.78	14.93	17.36
RA0156	4.40	8.90	5.97	11.05	6.84	12.32	14.49	14.11
RA0157	1.61	5.11	2.25	7.51	2.66	9.21	18.41	18.66
RA0158	0.44	0.76	0.59	0.89	0.64	0.99	3.17	5.36
RA0160	487.17	743.53	614.99	976.67	688.90	1155.99	1766.48	1860.57
RA0162	0.16	0.24	0.19	0.28	0.20	0.31	0.38	0.47
RA0164	5.52	3.62	7.01	5.00	7.91	6.12	14.78	21.50
RA0165A	1.70	1.02	2.24	1.50	2.57	1.90	5.08	7.80
RA0165B	3.10	2.19	3.78	2.85	4.18	3.36	7.09	10.10
RA0165C	0.75	0.41	1.04	0.65	1.21	0.86	2.64	4.27
RA0166	1.40	3.54	1.99	4.90	2.36	5.98	13.33	19.76
RA0167	8.58	4.06	10.79	4.37	12.01	4.59	12.12	11.98
RA0168	9.47	1.89	12.46	2.57	13.89	3.11	18.23	20.88
RA0170	475.91	727.42	609.03	957.83	685.25	1134.86	1773.78	1840.95
RA0176	0.84	0.81	0.92	0.93	0.97	1.23	9.92	12.71
RA0177	0.82	0.82	0.90	0.93	0.94	1.24	9.97	12.76
RA0178	0.00	0.00	0.00	0.00	0.00	0.07	1.59	2.23
RA0179A	0.00	0.00	0.00	0.00	0.04	0.05	0.72	0.75
RA0179B	0.90	0.36	1.34	0.50	1.61	0.62	3.03	3.50
RA0180	471.72	715.87	613.52	945.56	695.40	1123.10	1848.21	1910.90
RA0181	12.65	7.99	16.77	9.57	19.31	10.47	35.09	39.89

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RA0182	0.23	0.73	0.38	0.93	0.53	1.06	1.82	3.20
RA0183	4.37	6.62	5.50	7.75	5.97	8.30	9.85	11.11
RA0184A	0.00	0.00	0.01	0.00	0.31	0.00	0.00	0.00
RA0184B	6.24	6.24	6.24	6.24	6.24	6.24	6.24	6.24
RA0185	21.46	14.76	28.45	14.73	32.75	17.61	97.73	102.06
RA0186	21.74	13.70	28.81	15.19	33.15	13.25	78.79	78.90
RA0188	0.38	0.41	0.40	0.43	0.41	0.45	0.67	1.67
RA0190	13.99	10.82	18.72	13.15	21.99	15.61	29.68	32.71
RA0197	7.10	8.95	9.36	11.45	10.80	13.68	25.42	27.75
RA0198	6.63	8.99	8.03	11.31	9.22	13.57	22.96	24.78
RA0199	6.63	8.74	7.21	11.20	7.51	14.86	22.68	23.78
RA0200	3.44	5.44	3.93	7.87	4.18	9.95	20.54	21.65
RA0205A	6.35	2.68	7.05	2.64	7.36	2.67	0.00	0.35
RA0205B	3.33	3.32	3.37	3.36	3.40	3.41	3.46	3.53
RA0240	471.25	696.46	616.21	922.48	700.80	1095.02	1959.05	2276.45
RA0241	0.18	0.27	0.21	0.31	0.23	0.34	3.55	5.84
RA0242	0.24	0.32	0.28	0.38	0.30	0.42	1.86	5.23
RA0250	99.63	49.56	121.43	62.03	132.29	69.27	200.95	200.01
RA0260	21.10	9.88	20.97	12.88	20.86	12.96	7.69	6.92
RA0280	74.92	40.51	102.04	50.91	120.20	59.13	234.60	290.93
RA0281	36.38	11.39	44.11	16.00	47.95	19.25	32.47	28.29
RA0282A	21.21	8.97	24.80	12.82	26.13	15.59	26.22	25.43
RA0282B	13.31	5.44	14.25	5.58	14.67	5.68	9.69	7.93
RA0283	20.31	11.78	22.36	14.99	22.29	16.86	22.19	22.07
RA0284	16.31	9.62	16.25	12.32	16.25	13.71	15.46	15.40
RA0285	56.60	30.91	81.57	37.30	96.36	43.18	89.13	77.51
RA0286	52.60	30.24	60.69	36.55	66.57	42.68	52.48	47.83
RA0287	43.39	19.83	58.24	24.37	65.01	28.05	91.05	98.40
RA0288	44.28	19.85	58.83	24.42	65.33	28.14	91.00	98.41
RA0289	43.40	18.64	58.63	22.77	63.58	26.19	82.82	90.43
RA0290	3.20	1.20	3.72	1.58	4.16	1.87	5.26	5.70
RA0292A	13.94	2.60	18.19	3.32	20.70	4.18	24.02	24.66
RA0292B	1.61	0.00	3.51	0.00	4.74	0.00	5.33	5.34
RA0293A	7.40	2.30	7.41	2.92	7.33	3.72	6.55	6.34
RA0293B	6.75	1.73	7.88	2.28	7.98	3.05	7.44	7.38
RA0294A	13.90	4.03	13.77	5.20	13.62	6.77	12.82	12.57
RA0294B	5.90	1.25	6.55	1.75	6.60	2.48	6.20	6.09
RA0296A	18.74	7.03	18.88	9.37	18.97	10.36	18.59	18.46
RA0296B	16.11	4.10	16.46	5.37	16.58	7.37	15.99	15.81
RA0300	34.13	15.76	48.23	18.94	53.04	21.32	73.08	80.07

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RA0301	19.63	13.38	22.68	15.50	24.26	16.82	37.42	41.29
RA0305	15.91	12.43	17.58	13.81	18.78	15.63	21.37	21.92
RA0310	420.77	670.07	557.54	892.39	639.19	1063.70	1962.16	2274.17
RA0320	312.77	557.08	410.58	740.38	470.53	877.60	1599.83	1822.21
RA0330	195.62	384.19	272.24	536.17	320.63	651.84	1369.27	1565.32
RA0331	195.13	384.25	272.04	536.34	320.96	652.09	1371.49	1567.09
RA0332	171.93	308.58	226.11	442.74	263.48	551.10	1290.12	1492.37
RA0340	171.19	308.72	225.68	442.99	263.97	551.42	1293.61	1497.01
RA0350	166.75	299.88	219.01	430.90	254.26	536.81	1241.08	1426.62
RA0360	28.79	4.39	33.79	5.86	35.94	7.54	42.07	39.57
RA0362	37.59	7.15	45.02	9.81	48.53	12.15	59.01	59.66
RA0363	37.59	7.15	45.02	9.81	48.52	12.15	59.02	59.72
RA0365A	1.17	0.08	1.57	0.61	1.78	1.00	3.52	3.58
RA0365B	5.97	2.17	6.16	3.06	6.25	4.97	5.85	5.74
RA0370	0.50	0.02	1.49	0.45	2.30	4.55	16.61	19.28
RA0390	12.55	10.89	14.72	15.01	16.06	18.07	33.25	39.07
RA0400	14.35	10.89	15.71	15.01	16.34	18.07	33.25	39.06
RA0415	0.31	0.33	0.32	0.35	0.32	0.36	0.38	0.76
RA0420A	3.25	1.82	4.89	3.72	5.73	4.83	10.80	12.04
RA0420B	3.24	1.81	4.88	3.71	5.70	4.80	10.76	11.98
RA0425	0.25	0.31	0.27	0.33	0.28	0.34	0.38	0.39
RB0009	226.06	122.19	264.23	159.10	284.24	189.42	500.57	584.37
RB0010	235.19	123.94	276.31	161.15	297.66	191.96	503.24	547.38
RB0019	201.80	118.01	245.02	155.45	271.15	184.96	503.65	587.31
RB0020	208.79	120.39	258.07	160.41	287.81	212.34	536.62	619.35
RB0029	5.65	2.13	6.50	4.73	6.89	6.27	7.81	8.04
RB0030	209.95	119.64	261.00	159.85	291.80	190.94	539.60	626.31
RB0040	160.00	108.97	204.33	145.74	230.48	173.82	434.70	497.40
RB0050	166.21	107.76	215.84	145.42	245.46	173.98	461.37	522.22
RB0051	57.80	22.44	64.48	28.04	67.99	31.94	73.88	74.02
RB0052A	31.23	10.92	34.62	13.76	36.43	15.72	40.64	41.12
RB0052B	32.56	11.93	35.83	14.80	37.64	16.78	41.05	41.29
RB0054	16.73	14.99	19.33	17.21	20.79	19.33	32.07	36.36
RB0055	0.24	0.30	0.26	0.42	0.27	0.53	0.96	1.29
RB0056	26.62	12.85	32.12	18.08	34.86	21.51	49.29	50.47
RB0057	5.47	1.55	6.34	1.96	6.80	2.30	7.91	8.59
RB0058	0.32	0.35	0.33	0.37	0.34	0.38	0.42	0.43
RB0060	6.12	1.58	6.92	2.27	7.39	2.87	8.92	9.13
RB0070	13.41	4.04	13.81	5.27	14.01	6.29	14.41	14.67
RB0098	109.10	83.87	146.05	117.26	171.03	142.09	389.48	445.28

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RB0099	93.67	79.42	124.18	111.95	147.11	136.47	370.27	422.67
RB0100	92.04	78.53	128.03	111.08	152.22	135.70	379.02	430.99
RB0103	79.87	65.53	104.94	92.65	121.08	112.33	258.59	285.32
RB0104	48.78	18.80	61.80	26.29	69.13	32.03	85.48	87.71
RB0105	19.05	2.17	23.53	2.80	26.50	3.29	25.61	28.94
RB0106	49.12	17.28	62.23	24.33	69.65	29.83	82.63	84.73
RB0109A	11.64	5.43	14.31	7.85	15.68	9.51	24.12	25.28
RB0109B	15.16	7.41	17.96	10.32	19.33	12.12	25.34	25.38
RB0110	6.44	5.08	7.69	6.89	8.43	9.40	21.96	25.92
RB0112	1.39	2.21	2.04	3.07	2.44	3.76	6.44	6.92
RB0115	1.23	2.59	1.64	3.75	1.84	5.59	16.45	20.57
RB0116	0.73	1.55	0.97	2.10	1.12	2.50	5.22	7.20
RB0118	50.65	54.24	68.53	76.86	78.40	92.88	176.42	201.06
RB0119	28.63	35.48	40.16	49.94	46.93	60.62	108.57	128.96
RB0120A	13.98	17.65	19.71	24.86	23.04	30.18	54.15	64.18
RB0120B	14.09	17.77	19.84	25.00	23.17	30.33	54.15	64.18
RB0121A	15.22	6.17	22.66	10.64	27.69	15.42	96.63	94.58
RB0121B	2.24	2.03	3.51	3.97	4.90	5.54	35.52	37.94
RB0124	25.70	16.63	30.95	22.91	34.03	27.51	57.43	66.42
RB0125	7.71	3.77	8.98	5.34	9.45	6.60	10.47	12.12
RB0126	0.19	0.69	0.17	0.95	0.30	1.09	1.49	2.24
RB0127	25.92	16.17	31.20	22.30	34.29	26.97	58.84	66.93
RB0128	30.43	12.25	34.91	15.53	37.28	16.80	37.44	39.68
RB0129	2.26	2.16	2.27	2.17	2.28	2.16	2.15	2.14
RB0130	36.19	18.81	44.72	26.16	48.99	32.65	82.63	93.87
RB0135	57.92	18.84	71.71	27.21	79.86	34.02	132.32	143.32
RB0140	0.35	0.54	0.42	0.62	0.45	0.68	1.39	1.81
RB0146	0.19	0.20	0.22	0.25	0.23	0.28	2.13	3.92
RB0150A	6.86	4.55	7.31	4.91	7.50	5.18	8.59	8.37
RB0150B	4.67	0.97	5.51	1.44	5.85	1.83	7.39	8.05
RB0160	8.35	4.78	8.55	5.27	8.64	5.64	6.30	6.34
RB0170A	5.41	3.28	5.64	3.31	5.73	3.32	5.53	5.58
RB0170B	6.50	1.13	7.09	1.77	7.38	2.30	8.50	8.89
RB0180A	4.56	2.66	5.01	2.68	5.07	2.68	3.98	3.44
RB0180B	6.93	1.41	7.51	2.09	7.80	2.63	8.54	8.90
RB0190A	4.23	2.33	4.84	2.38	5.03	2.41	4.57	4.42
RB0190B	5.18	0.48	5.76	0.98	6.06	1.44	7.01	7.40
RB0200A	4.73	1.25	5.53	1.28	5.73	1.35	4.88	4.79
RB0200B	5.15	0.52	5.70	1.02	5.98	1.48	7.00	7.39
RB0210A	4.10	0.56	4.22	0.55	4.30	0.63	3.95	3.88

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RB0210B	6.70	1.95	7.17	2.68	7.40	3.24	8.27	8.59
RB0220A	2.55	0.36	2.68	0.40	2.72	0.44	2.72	2.73
RB0220B	6.69	1.95	7.16	2.68	7.40	3.24	8.27	8.59
RB0230	0.96	3.84	1.44	6.14	1.83	8.47	17.83	21.66
RB0250	59.43	14.84	74.99	22.22	83.93	28.50	128.56	140.82
RB0251	2.28	5.35	3.35	6.57	3.94	7.62	11.86	13.34
RB0252	17.60	11.54	21.57	14.87	23.64	17.37	31.58	32.29
RB0253	3.40	2.63	4.97	3.73	5.77	4.59	10.29	11.02
RB0255	0.34	1.46	0.56	2.35	0.72	3.14	6.59	7.97
RB0257	2.38	3.34	3.76	4.92	4.78	6.17	20.84	23.91
RB0260	14.55	10.51	10.35	13.04	7.93	17.64	40.70	38.45
RB0270A	37.50	14.53	48.79	14.60	54.90	14.33	19.72	29.18
RB0270B	0.02	0.04	0.04	0.09	0.07	0.12	0.95	1.64
RB0270C	0.03	0.05	0.06	0.10	0.10	0.13	0.86	1.50
RB0440	37.23	13.61	50.33	13.73	57.13	13.30	29.17	37.52
RB0445	11.65	9.87	21.41	10.10	24.26	9.75	27.88	36.89
RB0446	19.90	2.04	22.64	2.39	23.74	2.82	12.01	12.24
RB0447	0.14	0.14	0.15	0.59	0.16	0.89	6.18	10.85
RB0448	23.41	8.75	25.80	8.60	26.52	8.60	10.93	12.62
RB0449	0.18	0.23	0.19	0.37	0.19	0.53	3.27	4.51
RB0450	0.28	1.65	0.51	2.88	0.69	4.03	13.80	19.16
RB0455	3.10	0.83	4.04	1.45	4.59	2.02	6.78	8.70
RB0460A	0.17	0.94	0.31	1.60	0.42	2.21	7.78	11.92
RB0460B	0.17	0.94	0.31	1.60	0.42	2.21	7.44	11.35
RC0004	126.24	171.10	150.71	203.73	164.29	230.07	284.18	314.17
RC0005	122.13	169.57	146.61	202.00	160.24	224.19	256.07	260.31
RC0006	5.61	4.41	5.84	5.78	5.95	6.70	7.79	7.21
RC0010	122.04	167.91	146.98	200.12	162.39	222.11	300.00	305.83
RC0014	97.44	30.88	121.50	41.76	132.44	51.19	132.25	130.32
RC0015A	21.83	7.94	23.97	10.75	24.96	11.18	12.00	13.94
RC0015B	7.33	4.55	8.15	5.85	8.75	6.14	8.71	9.31
RC0016	8.16	0.98	12.11	1.50	14.25	1.72	9.71	11.79
RC0020	116.72	138.23	129.06	162.43	135.98	178.23	225.09	235.98
RC0024	31.30	74.57	53.05	93.10	64.14	101.43	115.74	115.28
RC0025	31.29	74.55	54.03	92.96	64.94	101.14	113.93	115.05
RC0029	147.87	206.81	174.96	249.16	189.71	272.87	368.03	385.35
RC0030	99.92	26.91	125.47	39.43	137.67	50.66	160.20	168.38
RC0040	24.43	5.27	29.25	6.51	31.56	7.21	13.86	16.01
RC0048	89.41	26.64	104.88	38.90	116.39	49.63	151.37	160.18
RC0050	78.83	26.54	93.53	38.66	101.53	48.66	146.49	154.45

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RC0054	1.93	2.90	2.03	4.25	2.31	4.98	7.62	7.80
RC0056	4.97	4.07	6.05	5.45	6.54	5.94	7.77	8.26
RC0057	1.37	2.09	1.75	2.41	1.98	2.74	5.22	5.91
RC0058	14.43	2.05	17.19	2.37	18.76	2.69	20.35	21.99
RC0065A	2.32	3.84	2.95	4.67	3.29	5.39	7.57	9.15
RC0065B	2.29	3.81	2.91	4.62	3.24	5.32	7.44	8.99
RC0065C	2.08	3.61	2.60	4.34	2.93	4.91	6.91	8.38
RC0065D	2.21	3.74	2.84	4.59	3.17	5.31	7.76	9.15
RC0065E	1.49	2.93	1.94	3.71	2.24	4.36	6.65	7.84
RC0065F	8.82	13.10	10.55	16.47	11.56	19.43	30.12	34.59
RC0065G	0.48	1.05	0.67	1.42	0.77	1.73	3.26	4.88
RC0066A	2.26	4.06	2.90	4.64	3.25	5.00	6.15	6.19
RC0066B	3.06	4.09	3.61	4.71	3.92	5.05	6.15	6.19
RC0069	5.42	6.82	6.13	7.79	6.44	8.54	10.93	11.93
RC0070	1.55	2.55	2.22	3.63	2.45	4.19	5.52	5.64
RC0080	10.32	7.53	16.61	10.77	20.97	13.38	43.51	45.27
RC0090	3.88	5.76	4.80	7.11	5.33	8.11	12.34	13.59
RC0096	4.74	2.98	5.53	3.58	5.68	3.69	3.96	3.95
RC0100	147.99	206.42	175.13	248.81	189.90	272.39	366.97	382.87
RC0110	148.23	204.16	175.43	246.07	190.24	268.29	348.57	348.35
RC0120	148.47	202.44	175.74	243.97	190.58	265.23	346.78	343.12
RC0125	148.92	200.62	176.24	241.90	191.11	262.37	329.59	325.74
RC0130	5.83	9.67	6.91	12.08	7.55	13.53	19.24	20.58
RC0140A	19.91	12.88	23.67	13.36	25.06	13.38	9.58	8.96
RC0140B	19.91	12.89	23.73	13.38	25.14	13.40	9.63	9.01
RC0140C	19.91	13.14	25.02	13.91	26.87	13.90	10.88	10.19
RC0150	143.52	191.02	169.87	229.88	187.06	249.29	280.16	294.67
RC0151	15.04	14.63	18.39	15.64	18.98	15.81	15.57	17.36
RC0155	140.27	177.54	165.12	215.94	178.45	235.57	268.35	283.12
RC0156	44.92	75.89	57.02	102.58	63.58	91.75	90.33	90.37
RC0157	45.31	26.89	57.33	31.60	64.10	34.70	49.12	46.15
RC0160	136.51	162.07	159.37	203.05	172.51	217.92	258.47	274.30
RC0161	136.62	145.67	157.97	180.00	169.32	191.96	257.47	273.45
RC0162	137.49	145.31	158.91	179.80	170.83	196.32	257.48	273.47
RC0165	67.44	28.22	83.69	37.17	93.09	45.05	117.85	111.80
RC0170	65.53	25.68	81.52	33.92	90.70	41.27	106.90	106.48
RC0173	8.07	13.67	12.31	20.45	15.10	25.94	43.17	45.57
RC0175A	35.52	11.10	47.12	14.24	53.81	16.53	42.25	38.84
RC0175B	46.96	20.50	58.91	27.46	66.15	33.74	50.26	46.71
RC0176	51.23	25.59	60.61	35.02	65.58	41.21	69.77	63.43

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RC0178	0.18	0.37	0.24	1.53	0.28	2.88	12.31	17.25
RC0180	138.97	144.90	160.46	179.62	173.68	191.29	257.50	273.51
RC0185	139.99	144.23	161.92	182.78	175.21	188.78	257.18	273.20
RC0186	0.26	0.45	0.30	1.73	0.31	3.08	11.31	15.45
RC0190	140.27	144.19	162.53	177.99	180.41	188.66	257.22	273.32
RC0191	74.62	86.66	87.75	108.98	95.37	129.18	371.10	447.87
RC0192A	0.07	0.20	0.10	0.28	0.12	0.31	0.68	1.65
RC0192B	0.04	0.07	0.05	0.09	0.06	0.10	5.20	9.23
RC0193	48.78	34.53	54.19	44.48	56.97	50.48	69.49	73.43
RC0195	0.15	0.33	0.18	0.55	0.20	0.71	1.13	1.25
RC0198	50.62	35.59	56.58	46.82	59.84	53.00	73.07	76.59
RC0200	20.66	8.49	24.79	11.85	26.73	15.15	34.10	37.45
RC0205	0.73	0.74	0.77	0.86	0.78	0.94	1.23	1.74
RC0210	0.22	0.57	0.29	2.00	0.32	3.25	14.10	17.45
RD0001	148.82	128.60	208.22	175.47	244.77	215.91	538.62	591.26
RD0002	150.37	129.23	210.39	189.11	247.31	231.34	495.79	505.35
RD0005	157.96	130.70	221.01	177.70	259.90	218.75	556.23	610.36
RD0006	3.49	1.44	6.42	2.46	8.51	3.39	23.20	20.08
RD0007	18.63	4.07	26.51	5.76	28.96	7.19	30.11	28.46
RD0010	165.40	126.08	229.56	170.39	268.43	209.24	561.38	608.65
RD0011	166.45	124.26	229.02	168.04	265.77	206.55	549.37	596.37
RD0012	34.39	12.83	39.19	16.53	41.50	19.57	49.64	54.07
RD0013	15.89	8.57	17.97	10.80	18.28	12.69	21.90	23.20
RD0020	123.56	96.12	163.38	130.31	188.08	159.72	400.85	446.42
RD0025	74.30	82.02	97.83	110.12	110.82	130.97	278.12	302.64
RD0030	4.31	2.80	5.67	3.87	6.39	4.74	14.06	13.72
RD0040	70.76	81.86	93.11	109.89	105.76	130.79	276.79	301.40
RD0045	3.94	3.05	5.39	4.09	6.31	4.97	14.02	16.71
RD0050	61.70	76.61	80.91	103.12	91.89	120.71	252.87	273.06
RD0053	49.29	68.78	61.68	90.42	69.90	105.31	214.94	234.26
RD0055	49.05	67.86	60.38	89.20	70.56	103.36	211.70	230.59
RD0056	15.22	2.72	20.56	3.43	23.76	4.00	26.36	26.36
RD0057	17.73	6.67	24.10	9.02	27.95	10.79	49.01	47.72
RD0059A	41.02	53.09	45.65	67.97	48.35	73.75	90.31	96.57
RD0059B	6.84	8.91	8.33	8.87	9.35	8.10	11.89	13.68
RD0060A	12.95	25.90	17.49	31.69	20.02	35.37	46.27	49.86
RD0060B	17.82	17.82	17.82	17.82	17.82	17.82	17.82	17.82
RD0066	17.74	16.37	19.29	18.94	20.28	20.85	25.87	27.96
RD0070	5.99	7.04	7.29	7.97	8.04	7.64	9.52	15.87
RD0080	19.88	21.03	24.64	25.13	28.11	27.38	42.73	45.90

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RD0090	20.15	15.91	24.79	22.18	27.30	24.83	28.45	29.72
RD0100	27.06	10.02	29.83	13.48	31.13	16.22	34.57	35.88
RD0102	11.21	5.28	13.04	9.15	13.66	12.01	19.34	20.62
RD0103	7.44	4.61	9.42	8.36	9.86	11.19	18.24	19.55
RD0104	18.52	6.86	18.83	8.85	18.99	10.49	19.13	19.61
RD0106	22.88	5.86	23.43	7.54	23.61	8.93	16.28	16.67
RD0108	12.48	3.23	12.40	4.13	12.36	4.88	9.78	9.93
RD0110	12.06	4.52	14.98	8.24	16.17	11.05	18.18	19.49
RD0115A	12.00	4.50	15.16	8.02	16.56	10.20	14.07	14.50
RD0115B	0.10	0.00	0.56	0.18	0.80	0.83	4.19	5.04
RD0120	10.67	5.43	13.03	7.43	13.93	9.86	15.09	15.96
RE0008	106.93	209.85	131.52	281.55	145.93	345.48	785.19	904.25
RE0009	135.83	209.85	131.50	281.67	145.91	345.09	783.44	902.32
RE0010	106.77	209.85	131.50	281.71	145.91	345.18	781.09	899.33
RE0011	106.25	208.99	131.03	280.86	145.36	344.53	719.29	829.96
RE0012	106.12	209.00	131.04	281.03	145.36	344.97	719.57	829.98
RE0015	15.52	17.65	18.61	21.89	20.47	25.04	36.77	40.65
RE0016	0.25	0.32	0.28	0.36	0.30	0.38	0.78	2.13
RE0017	16.20	15.60	19.23	19.72	20.93	22.77	36.50	39.18
RE0018	16.19	15.58	19.20	19.71	20.91	22.77	36.54	39.25
RE0019A	27.38	14.44	30.56	16.61	32.33	18.72	36.61	39.23
RE0019B	7.04	5.46	7.79	6.41	8.12	7.24	9.95	10.34
RE0020	35.06	19.96	38.67	22.99	40.43	25.92	45.54	47.85
RE0023	0.35	0.33	0.93	0.36	2.21	0.73	9.40	11.52
RE0025	0.52	0.89	0.65	1.02	0.72	1.10	1.35	1.42
RE0030	106.01	209.02	131.05	281.18	145.36	345.34	716.99	830.00
RE0035	0.19	5.78	0.26	10.53	0.35	13.17	14.67	14.58
RE0037	4.59	6.89	8.03	9.64	10.16	11.04	10.84	10.59
RE0040	105.76	208.77	130.82	281.00	145.10	345.33	705.27	829.83
RE0042	2.53	0.86	5.08	1.59	6.89	2.31	13.69	11.64
RE0050	4.28	1.93	8.29	3.46	10.25	5.06	13.81	12.49
RE0052	0.28	0.21	0.34	0.28	0.36	0.34	0.42	0.39
RE0057	4.12	6.41	8.50	12.00	11.62	15.24	41.90	39.44
RE0060	0.40	0.44	0.42	0.46	0.42	1.11	5.56	7.68
RE0070A	2.16	0.39	1.62	0.39	1.29	0.85	6.44	6.18
RE0070B	2.04	1.66	1.88	1.60	1.80	1.67	0.82	0.74
RE0080A	1.46	0.50	3.01	0.81	3.70	1.10	7.30	6.90
RE0080B	0.72	0.66	1.03	0.66	1.19	0.67	0.88	0.80
RE0090	2.26	0.29	2.49	0.35	2.24	0.31	4.43	3.14
RE0109	105.47	208.36	130.47	280.62	144.72	345.02	705.02	829.64

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RE0110	105.44	208.37	131.71	280.66	160.26	345.12	714.59	848.13
RE0114	0.66	1.81	2.73	2.81	4.02	3.71	12.49	12.32
RE0116	0.20	0.94	1.77	1.94	2.41	2.38	2.60	3.38
RE0118	4.51	5.48	6.55	7.93	7.09	8.47	9.77	10.23
RE0119	4.98	6.42	8.30	8.47	9.36	9.50	10.10	10.34
RE0120	105.39	208.41	137.63	280.74	158.97	345.33	705.14	829.74
RE0122	0.15	0.12	0.19	0.14	0.20	0.16	0.23	0.40
RE0123	20.67	5.72	21.62	7.52	21.99	8.95	20.08	20.29
RE0127	18.75	10.35	19.64	12.91	19.79	14.59	17.45	15.77
RE0129	18.79	10.31	20.90	12.91	22.42	14.60	34.55	38.65
RE0130	105.05	208.06	130.24	280.62	144.44	345.38	725.00	867.02
RE0131	0.00	0.10	0.00	0.38	0.00	0.56	8.96	11.19
RE0132	4.23	4.69	6.02	6.24	6.94	7.31	13.45	14.72
RE0133	8.15	4.40	10.89	6.18	12.80	7.15	14.20	15.13
RE0135	5.73	2.75	6.20	3.35	6.50	3.71	9.87	13.28
RE0139	103.14	203.38	127.63	274.65	141.42	338.57	719.68	862.11
RE0140	119.43	50.24	152.69	69.81	171.14	85.81	278.80	311.97
RE0150	119.74	49.97	151.42	69.31	169.22	84.97	280.50	315.16
RE0160	1.19	0.82	2.45	1.39	3.33	2.05	9.42	10.34
RE0170	0.07	0.12	0.23	0.21	0.37	0.29	2.58	2.94
RE0174	0.29	0.20	0.70	0.34	0.97	0.51	4.91	5.66
RE0175	32.65	15.76	45.73	21.64	54.20	26.02	113.65	131.12
RE0180	20.84	11.80	23.89	15.24	25.74	17.54	41.42	45.05
RE0185	19.96	11.97	23.59	15.63	25.77	18.14	43.69	47.69
RE0190	130.02	52.12	159.75	72.44	178.28	88.60	294.51	328.00
RE0195	107.19	37.17	130.64	52.63	143.66	65.35	224.77	246.14
RE0196	84.62	29.91	97.65	41.85	104.08	51.45	132.56	143.98
RE0197	26.69	4.04	32.07	6.26	35.12	7.88	32.98	32.58
RE0198	6.60	2.96	8.16	4.56	9.08	5.72	15.47	16.72
RE0199	0.91	2.65	2.34	4.07	3.34	5.10	10.71	12.06
RE0205	0.11	0.28	0.14	0.83	0.16	1.30	4.64	5.22
RE0207	9.44	11.18	10.67	13.07	11.35	14.50	19.51	21.75
RE0208	8.88	2.72	9.42	3.73	9.69	4.61	10.77	11.10
RE0209	0.96	0.85	1.97	1.21	2.53	1.49	2.70	3.40
RE0210	0.34	0.85	0.48	1.21	0.58	1.49	2.56	2.95
RE0215	0.53	1.77	0.81	2.77	1.01	4.48	18.58	19.09
RE0220	41.85	16.68	45.86	23.19	48.18	28.18	58.52	65.50
RE0230	15.11	7.36	17.73	9.99	19.45	11.51	26.21	27.86
RE0232	0.23	0.54	0.27	0.97	0.30	1.34	3.96	5.11
RE0234	26.70	13.29	27.99	18.08	28.47	21.67	35.06	40.54

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RE0235	0.78	1.14	0.91	1.31	0.98	1.41	3.65	7.56
RE0238	25.96	11.77	27.15	16.25	27.47	19.63	31.48	31.83
RE0239	14.68	4.72	17.32	6.42	18.85	7.82	13.45	12.98
RE0240A	22.12	10.39	24.36	13.98	25.32	16.44	23.01	23.85
RE0240B	10.66	5.42	13.03	7.43	13.92	9.86	15.09	15.96
RE0250	103.14	203.37	127.63	274.63	141.42	338.59	715.21	855.23
RE0251	103.15	203.39	127.64	274.65	141.43	338.64	715.23	855.24
RE0252	22.82	27.36	27.89	33.35	31.06	38.44	63.31	69.51
RE0253	3.04	1.39	3.52	1.81	3.75	2.13	4.69	7.05
RE0254	0.15	0.82	0.27	1.41	0.44	1.92	10.05	18.47
RE0257	9.01	9.50	9.90	10.88	10.36	11.86	14.56	15.70
RE0259	102.93	202.96	127.35	274.13	141.10	338.06	711.70	846.56
RE0260	102.95	203.01	127.38	274.19	141.13	338.16	711.79	846.64
RE0265A	0.00	0.00	0.00	0.00	0.03	0.06	6.12	9.01
RE0265B	94.43	183.18	115.89	248.24	128.10	307.71	679.63	816.76
RE0270	94.41	183.16	115.87	248.09	128.08	307.53	683.17	825.89
RE0271	94.40	182.82	115.86	247.54	128.07	306.92	686.89	911.86
RE0272	9.69	2.61	12.88	8.77	14.43	15.10	50.87	60.46
RE0273A	0.47	0.11	0.71	0.89	0.83	2.13	6.09	8.53
RE0273B	2.48	0.78	3.30	4.24	3.79	6.86	16.43	18.35
RE0273C	2.07	0.65	2.74	3.40	3.18	5.79	28.60	33.58
RE0274A	1.02	0.90	0.99	0.95	1.08	0.99	1.19	2.28
RE0274B	0.49	0.05	0.67	0.13	0.80	0.29	1.23	3.38
RE0275	0.00	0.00	0.00	0.00	0.00	0.00	0.34	1.36
RE0280	94.40	182.82	115.86	247.54	128.07	306.91	687.26	827.45
RE0291	19.77	35.41	27.87	45.70	32.99	53.17	112.80	120.96
RE0292	11.68	23.00	16.92	29.47	20.26	34.09	64.28	75.89
RE0295	0.35	0.53	0.41	0.63	0.44	0.82	2.13	2.77
RE0296	0.12	0.18	0.14	0.21	0.15	0.24	0.92	1.55
RE0297	0.20	0.26	0.22	0.28	0.23	0.60	4.66	5.89
RE0300	12.78	21.42	17.26	26.40	20.14	29.73	59.03	68.20
RE0302	4.85	8.01	5.92	9.51	6.49	10.56	13.50	14.29
RE0304	15.39	13.36	19.84	16.48	22.53	18.68	45.12	52.09
RE0305	6.31	12.17	8.85	14.73	9.89	16.57	22.39	24.12
RE0310	13.16	2.32	16.67	3.09	18.76	3.73	25.24	29.85
RE0320A	1.45	0.89	1.68	1.18	1.80	1.39	3.58	4.30
RE0320B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RE0350	18.95	3.43	21.58	4.43	22.96	5.22	21.07	22.61
RE0400A	0.16	0.34	0.18	0.63	0.20	0.89	4.58	5.00
RE0400B	0.02	0.60	0.12	1.60	0.22	2.78	15.61	17.87

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RE0400C	0.24	1.20	0.47	2.31	0.66	3.25	11.04	12.82
RE0400D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RE0400E	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
RE0410	7.74	10.76	8.82	12.33	9.40	13.41	16.40	17.33
RE0425	23.84	8.83	32.70	10.51	37.93	11.35	48.44	44.36
RE0426	1.78	1.62	3.93	3.28	6.78	4.67	34.37	38.53
RE0430	26.41	9.52	36.32	12.29	42.20	14.43	64.49	63.00
RE0431	28.82	9.83	39.39	12.99	45.67	15.62	70.82	70.87
RE0432	20.91	3.07	26.11	4.06	29.13	4.86	33.83	35.17
RE0433	0.23	0.32	0.26	0.45	0.28	0.74	6.29	6.63
RE0434	0.30	0.35	0.32	1.49	0.33	3.81	18.35	18.49
RE0437	0.17	0.53	0.27	0.78	0.35	0.98	1.74	1.98
RF0010	85.40	163.49	104.14	224.23	114.99	281.23	691.69	936.98
RF0020	51.67	96.93	62.48	137.44	68.27	177.21	223.82	213.69
RF0030	46.64	86.57	55.82	124.02	60.93	161.47	333.51	390.36
RF0460	0.12	0.38	0.19	0.53	0.23	0.62	2.61	9.82
RF0700	0.00	0.00	0.00	0.00	0.00	0.00	2.36	4.23
RG0010	1258.15	538.81	1495.03	731.60	1632.55	882.20	2240.05	2548.77
RG0015	7.15	8.26	12.27	12.28	15.21	15.75	72.24	77.94
RG0016A	0.18	1.08	0.38	1.94	0.55	2.75	8.66	10.19
RG0016B	0.40	2.35	0.83	4.23	1.20	6.02	16.98	19.47
RG0020A	2.63	6.63	3.39	8.76	3.91	10.40	18.52	24.89
RG0020B	2.63	6.63	3.39	8.76	3.91	10.40	18.54	24.98
RG0021	7.30	13.24	10.40	16.55	12.09	19.03	30.58	32.71
RG0022	5.60	5.71	5.68	6.28	5.75	6.93	13.11	13.45
RG0023	0.18	1.20	0.34	2.21	0.47	3.19	18.05	19.58
RG0024	1.67	3.99	3.07	6.15	4.14	8.14	39.65	58.40
RG0025	340.69	410.70	406.25	539.01	444.34	633.48	1091.88	1232.97
RG0026	0.47	0.79	0.62	1.07	0.71	1.31	12.67	18.90
RG0030	460.83	486.94	545.15	654.49	593.68	779.87	1382.12	1569.36
RG0032A	0.21	0.76	0.41	1.25	0.58	1.51	2.35	4.57
RG0032B	0.56	1.99	1.07	2.91	1.56	3.93	16.67	20.15
RG0033	0.52	1.74	0.93	2.25	1.23	2.58	4.57	11.52
RG0034	1.73	5.32	2.80	8.40	3.60	10.95	32.75	48.02
RG0035	0.77	3.89	1.56	5.61	2.10	7.11	13.79	15.95
RG0036	0.82	3.76	1.67	5.37	2.30	6.81	14.26	16.41
RG0037	1.57	3.17	3.17	4.16	4.37	5.19	9.23	11.07
RG0038	0.56	1.95	1.14	2.69	1.62	3.09	5.10	11.87
RG0039	3.45	2.19	5.58	2.95	6.82	3.23	9.02	8.97
RG0040	101.48	54.84	121.82	78.25	133.54	97.51	223.29	244.32

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RG0041	1.41	2.60	2.20	3.23	2.58	3.62	4.55	4.75
RG0042	0.26	1.43	0.51	2.12	0.72	2.52	3.72	3.97
RG0043	1.98	6.16	3.18	9.31	4.00	12.06	20.80	23.39
RG0044	2.50	5.36	5.72	8.17	7.99	10.51	17.48	17.45
RG0045	5.88	5.73	8.19	8.25	9.48	10.24	49.03	50.17
RG0046	0.31	1.39	0.61	2.25	1.00	2.90	15.01	15.05
RG0047	0.39	1.19	0.77	1.79	1.03	2.32	25.14	27.49
RG0048	2.67	13.02	5.00	20.17	6.76	25.95	52.99	58.24
RG0049	3.51	11.44	5.85	17.83	7.51	23.16	46.27	53.13
RG0050	338.81	387.60	405.12	504.57	443.75	592.35	1047.16	1183.00
RG0051	23.08	24.21	29.96	33.78	33.19	40.92	62.61	68.00
RG0052	24.21	23.00	30.94	32.23	34.35	39.26	60.68	64.98
RG0053	3.26	11.55	5.83	18.02	7.71	23.57	70.08	87.24
RG0054	2.01	4.58	3.49	6.83	4.54	8.73	20.18	25.16
RG0055	1.18	1.83	1.42	2.10	1.54	2.26	28.81	45.68
RG0056	0.79	4.57	1.41	8.20	1.88	11.78	30.57	38.94
RG0057	0.82	4.09	1.46	6.94	1.97	9.43	25.64	33.82
RG0058	3.09	3.42	4.19	5.61	5.27	7.60	31.31	34.30
RG0059	0.17	5.51	1.46	9.06	2.96	12.02	37.34	42.18
RG0060A	64.78	46.01	71.08	60.99	74.97	72.52	120.19	119.42
RG0060B	50.86	35.33	57.01	48.55	60.84	59.68	127.84	137.78
RG0060C	35.01	23.46	40.52	34.46	44.01	44.91	114.66	132.28
RG0061	0.48	1.80	0.93	2.72	1.24	3.47	7.43	12.95
RG0062	2.55	3.51	3.82	5.17	4.79	7.02	29.81	32.09
RG0063	0.41	1.26	0.68	1.87	0.85	2.86	22.08	22.61
RG0064	1.72	4.17	2.52	5.97	3.03	7.23	24.69	27.19
RG0065	1.76	3.93	2.59	5.53	3.11	7.69	18.58	19.54
RG0066	1.69	3.70	2.39	5.14	2.85	6.37	11.75	15.16
RG0067	0.93	1.67	1.20	2.04	1.37	2.35	5.62	8.30
RG0068	8.73	2.67	8.96	3.00	9.06	2.93	2.98	4.25
RG0069	5.24	2.13	4.87	2.22	4.69	2.15	2.50	2.42
RG0070	188.11	299.61	237.20	380.51	265.25	436.33	658.20	742.25
RG0073	0.00	0.68	0.27	0.96	0.43	1.37	2.26	2.46
RG0074	0.82	0.86	0.85	1.26	0.87	1.82	4.51	7.08
RG0076	11.82	6.24	15.24	8.44	17.32	10.12	35.69	37.86
RG0078	5.52	11.88	8.19	15.47	9.69	18.12	33.83	36.96
RG0079	3.04	1.22	4.43	1.74	5.32	2.18	6.19	6.70
RG0080	149.51	102.32	167.24	140.14	178.21	170.51	333.40	362.94
RG0081	138.26	81.42	145.74	101.60	149.51	115.67	171.43	182.97
RG0082	135.65	79.37	141.97	98.03	144.97	111.02	157.02	163.19

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RG0083	135.45	79.03	141.79	97.57	144.82	110.45	155.96	162.03
RG0084	1.13	1.43	1.29	1.62	1.37	1.74	3.39	4.60
RG0085	122.25	54.41	128.11	67.46	128.13	76.38	120.49	123.65
RG0090	128.82	255.30	166.59	316.97	191.41	358.20	532.29	597.10
RG0093	52.59	93.88	65.28	113.01	72.03	127.23	160.98	164.45
RG0099	22.66	84.37	41.18	103.64	53.90	117.67	155.67	169.78
RG0100A	15.27	42.93	24.52	50.48	30.22	56.06	70.40	73.19
RG0100B	7.23	29.91	14.27	36.79	18.97	41.75	56.13	61.36
RG0100C	0.18	11.54	2.47	16.40	4.79	20.12	29.65	35.92
RG0100D	2.79	10.82	5.20	13.38	6.83	15.40	19.71	22.88
RG0101	13.03	3.93	16.38	5.25	18.38	6.33	27.09	31.04
RG0102	8.22	2.65	10.64	3.60	12.09	4.37	18.88	21.38
RG0104	1.02	1.20	1.14	1.31	1.21	1.40	1.59	1.66
RG0105	3.27	3.75	3.66	4.81	3.87	9.33	10.76	11.04
RG0106	0.77	0.92	0.80	1.02	0.83	3.04	3.85	4.05
RG0107	21.95	89.50	42.50	109.38	56.63	120.55	162.50	180.16
RG0108	22.05	89.50	42.81	109.34	56.97	120.49	162.59	180.41
RG0109	22.08	89.50	42.90	109.34	57.07	120.48	162.61	180.48
RG0110	22.10	89.51	43.00	109.34	57.19	120.47	162.63	180.56
RG0115	21.01	77.63	43.35	94.12	57.60	102.96	139.25	149.49
RG0117	12.61	37.17	34.28	47.39	48.62	49.48	47.92	51.30
RG0120	19.56	68.15	33.18	87.99	46.07	95.44	145.24	155.08
RG0125A	0.00	7.32	1.51	13.78	3.36	19.21	33.01	34.41
RG0125B	0.00	5.55	1.18	7.17	2.63	8.27	17.20	18.04
RG0125C	6.25	8.17	8.59	10.46	9.69	11.78	13.85	14.32
RG0130	20.64	59.07	33.75	70.41	42.52	72.95	80.25	82.74
RG0140A	11.89	21.07	20.82	31.59	26.42	34.95	24.67	23.68
RG0140B	11.89	19.96	20.82	25.89	26.42	28.39	24.73	25.25
RG0145A	9.14	8.81	12.24	11.00	13.39	12.24	15.22	15.14
RG0145B	14.95	40.31	38.98	48.32	52.35	50.48	46.97	48.79
RG0150	10.91	38.29	18.94	48.12	26.25	51.06	61.99	65.57
RG0153	0.00	20.48	13.90	31.35	27.41	42.96	49.84	43.69
RG0155	0.00	18.05	5.98	27.00	17.22	27.46	37.01	39.52
RG0157	8.40	9.02	21.26	15.00	29.67	19.31	24.95	20.51
RG0160	17.56	18.64	25.02	22.82	28.60	24.03	55.89	63.19
RG0165	25.96	13.36	28.59	17.65	30.55	19.28	54.32	67.02
RG0168	36.44	9.68	44.90	10.88	49.63	12.09	40.49	46.93
RG0170	2.12	3.64	2.91	5.07	3.42	6.24	12.03	15.03
RG0180	2.01	4.78	2.74	6.68	3.20	8.24	15.05	19.65
RG0187	108.38	156.78	136.29	197.29	152.37	223.49	364.86	406.47

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RG0188	103.71	144.38	129.37	181.44	144.29	204.96	338.03	377.17
RG0189	103.74	144.38	129.39	181.44	144.32	204.96	338.04	377.18
RG0190	100.44	134.06	125.17	163.55	137.61	181.83	275.60	306.71
RG0191	54.50	129.89	76.19	156.36	93.42	177.03	240.15	263.13
RG0192	54.38	129.91	76.13	156.37	93.40	184.86	240.11	263.09
RG0193	52.75	129.26	75.47	155.22	93.03	170.27	234.83	256.32
RG0194	52.47	129.37	75.34	155.28	92.98	170.30	234.68	256.15
RG0195	1.72	2.01	1.86	2.20	1.93	2.33	2.64	2.76
RG0196	0.67	0.79	0.75	0.88	0.78	0.94	1.05	1.09
RG0197	18.31	8.85	19.46	10.87	20.07	12.42	17.87	16.23
RG0198	0.33	0.41	0.36	0.49	0.38	0.58	0.99	1.17
RG0200	34.93	112.10	62.18	132.89	78.52	144.18	195.37	215.20
RG0201	34.76	112.12	62.18	132.90	78.50	148.03	195.24	215.05
RG0205	3.09	4.48	3.68	5.04	4.01	5.42	5.41	5.20
RG0210A	31.75	106.79	58.76	127.05	74.72	137.82	168.48	179.86
RG0210B	9.95	16.43	18.38	22.24	22.97	26.56	31.17	34.80
RG0212	10.78	17.51	18.20	25.77	22.77	32.50	57.14	58.33
RG0213	16.19	53.18	36.28	57.22	45.24	59.28	67.88	71.51
RG0214	16.25	53.29	36.56	57.25	45.31	59.21	67.52	71.18
RG0215	16.63	50.86	38.14	54.95	46.45	57.26	66.43	69.63
RG0216	12.27	34.18	30.93	35.41	34.90	38.28	52.68	57.21
RG0217	15.77	5.65	20.03	7.77	22.45	9.54	14.62	14.22
RG0220	25.85	21.43	28.88	21.43	31.92	21.43	21.43	21.43
RG0225	27.99	13.62	31.53	16.29	33.48	17.55	17.59	18.87
RG0230	0.22	0.49	0.24	0.98	0.26	1.25	1.25	1.46
RG0240	27.88	11.84	31.79	13.98	34.64	16.14	15.18	16.22
RG0270A	0.00	20.00	0.00	20.00	0.00	20.00	20.00	20.00
RG0270B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RG0272	0.68	1.03	0.83	1.18	0.90	1.27	1.36	1.36
RG0275	3.56	4.13	7.22	6.14	9.55	7.85	15.54	15.06
RG0280	13.72	8.13	14.31	10.81	14.51	11.55	13.86	13.76
RG0285	13.95	8.09	15.61	10.66	16.12	10.73	10.76	10.69
RG0310	11.70	9.64	13.04	9.83	13.62	9.88	8.40	8.66
RG0380A	12.51	33.64	17.96	44.54	21.81	53.63	112.92	123.86
RG0380B	1.86	4.23	2.49	5.41	2.92	6.39	14.74	20.30
RG0381	5.88	4.51	7.82	6.00	8.97	7.23	15.51	16.87
RG0382	6.66	11.99	9.46	16.43	11.25	20.22	38.50	44.95
RG0383	0.10	0.38	0.16	0.60	0.21	0.82	3.37	6.05
RG0384	8.21	9.40	11.19	12.77	13.07	15.70	34.27	39.69
RG0386A	1.17	2.65	1.62	3.56	1.90	4.23	7.22	8.52

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
RG0386B	0.30	1.75	0.57	3.07	0.78	4.31	11.45	15.37
RG0390	15.28	15.66	16.41	18.25	17.11	20.27	27.16	28.58
RG0391	0.43	3.16	0.72	4.24	2.29	5.14	9.53	9.73
RG0392	0.32	0.35	0.34	1.14	0.35	1.73	6.73	6.81
RG0395	8.78	11.75	10.38	12.98	10.80	13.87	16.20	16.64
RG0396	0.29	0.65	0.41	0.80	0.49	0.89	1.40	3.00
RG0397	9.89	8.70	11.31	9.41	11.92	10.03	14.10	14.90
RG0398	10.19	7.09	11.69	7.56	12.64	8.24	14.51	15.90
RG0400	99.47	137.77	127.96	170.95	144.93	191.64	330.13	365.71
RG0405A	74.31	108.03	89.77	131.93	96.86	144.56	148.34	149.03
RG0405B	18.61	25.95	21.56	31.69	23.26	34.72	35.63	35.79
RG0410A	6.17	7.74	9.46	10.64	11.14	12.84	17.16	17.30
RG0410B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RG0420	22.43	6.32	27.17	6.85	29.37	8.41	30.15	32.20
RG0430	8.94	10.73	9.83	11.80	10.26	12.74	15.39	20.45
RG0440	28.12	3.67	30.95	3.50	32.23	3.73	19.27	20.30
RG0450	32.62	13.57	34.23	13.28	34.90	13.56	23.66	23.34
RG0460A	13.39	9.23	12.54	9.10	12.26	9.41	11.82	12.02
RG0460B	2.06	0.98	2.98	2.59	3.38	3.14	7.06	7.32
RG0470	3.21	8.78	6.10	10.10	7.15	10.88	19.24	23.91
RG0480	20.10	31.57	29.52	41.26	38.14	43.04	37.44	35.08
RG0485	26.84	17.95	30.05	21.69	32.01	24.36	30.10	29.79
RG0490	1.76	2.12	2.00	2.45	2.13	2.67	4.30	9.96
RG0500	8.51	2.52	10.64	3.38	12.02	4.08	12.20	11.73
WA0007	0.49	1.34	0.67	2.17	0.79	3.04	8.73	13.20
WA0015	131.65	31.32	172.78	41.99	198.05	50.85	307.14	362.18
WA0060	4.76	3.40	9.16	5.56	11.92	7.18	27.98	30.56
WA0070	0.23	2.18	2.33	5.36	3.71	6.90	13.91	16.92
WA0090	64.11	45.09	84.13	56.84	95.93	66.36	188.65	215.53
WA0100	0.00	0.00	4.07	0.00	19.42	16.04	67.68	79.16
WA0151	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65
WA0153	0.00	0.00	0.00	0.00	0.00	0.00	69.21	85.64
WA0154	5.04	3.77	8.78	5.05	11.14	5.46	18.91	18.86
WA0156	0.00	0.00	0.00	0.00	0.00	0.00	11.65	34.67
WA0157A	69.43	5.42	88.46	7.12	99.97	9.31	98.49	109.31
WA0157B	10.59	11.18	13.68	14.24	15.44	16.13	24.25	26.45
WA0177	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WA0178	2.27	0.57	3.28	0.69	3.69	0.68	2.64	3.21
WA0185	0.00	0.00	0.00	0.00	0.00	0.00	498.11	843.94
WA0186	0.00	0.00	0.00	0.00	0.00	0.00	246.16	301.74

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
WA0210	9.75	5.88	10.53	5.83	10.87	5.87	3.46	3.81
WA0260A	0.00	0.00	0.00	0.00	0.00	1.25	51.79	56.89
WA0260B	0.00	0.00	0.04	0.00	0.73	2.80	38.01	52.07
WA0281	0.00	0.00	0.00	0.00	0.00	0.00	73.17	111.25
WA0282A	0.00	0.00	0.00	0.00	2.53	0.00	90.08	132.68
WA0282B	0.00	0.00	1.17	0.00	5.59	0.00	72.89	103.31
WA0283A	0.00	0.00	0.00	0.00	0.00	0.00	1.75	6.21
WA0283B	0.00	0.00	8.46	0.00	16.20	0.00	49.99	68.21
WA0284A	2.03	0.00	6.71	0.00	9.61	0.00	32.53	45.06
WA0284B	11.16	0.00	20.03	0.00	24.88	0.00	40.79	44.56
WA0285A	0.00	0.00	0.00	0.00	0.00	0.00	70.48	106.18
WA0285B	0.00	0.00	0.00	0.00	0.00	0.00	27.94	38.47
WA0286	3.51	0.00	19.06	0.00	27.04	0.00	69.61	80.99
WA0288	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WA0290	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WA0292A	0.00	0.00	0.00	0.00	0.00	0.00	11.07	18.54
WA0292B	0.00	0.00	0.00	0.00	0.00	0.00	9.17	13.15
WA0293	0.00	0.00	0.87	0.00	4.55	0.00	19.68	27.12
WA0294A	0.00	0.00	5.20	0.00	9.71	0.00	24.61	32.17
WA0294B	10.20	0.00	23.24	0.00	29.05	0.00	45.33	53.71
WA0296A	4.62	0.00	10.84	0.00	14.73	0.00	28.67	37.07
WA0296B	18.68	0.00	32.31	0.00	39.26	0.00	61.08	73.61
WA0300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.96
WA0365A	0.00	0.00	0.00	0.00	0.00	0.00	5.46	6.01
WA0365B	0.00	0.00	0.00	0.00	0.00	0.00	3.69	6.98
WA0401	43.15	8.00	57.50	10.46	66.13	12.42	88.94	103.36
WA0402	14.17	1.22	16.66	1.49	17.84	1.61	12.87	15.32
WA0410	29.83	6.17	44.51	9.87	53.15	12.70	68.81	78.33
WB0010	0.00	0.00	0.00	0.00	0.00	0.00	43.87	96.99
WB0029A	6.25	0.34	9.36	3.47	10.47	4.75	32.93	46.06
WB0029B	0.00	0.00	0.00	0.00	0.31	0.00	25.48	35.98
WB0029C	0.00	0.00	0.00	0.00	0.16	0.00	14.43	20.85
WB0029D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
WB0054	7.24	3.02	11.46	6.96	16.91	9.22	29.61	31.05
WB0055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.62
WB0060	0.00	0.00	0.00	0.00	0.79	0.00	35.13	44.93
WB0062A	1.04	0.29	2.12	0.54	2.82	1.35	27.53	33.47
WB0062B	0.00	0.00	0.00	0.00	0.00	0.00	1.85	4.15
WB0064	0.00	0.00	0.00	0.25	0.00	0.86	18.45	23.66
WB0066	0.13	0.30	1.80	0.60	2.81	0.79	9.45	11.45

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
WB0070	4.05	0.00	8.93	0.00	11.74	0.00	18.58	23.69
WB0080A	6.14	0.88	8.43	1.19	9.77	1.45	12.93	15.28
WB0080B	7.70	1.51	10.27	1.90	11.76	2.23	15.23	17.81
WB0107	11.04	1.30	14.09	1.70	15.93	2.03	17.97	21.12
WB0129	29.89	10.65	34.45	14.48	36.86	16.06	37.41	39.74
WB0160	8.76	0.00	14.18	0.00	16.38	0.00	16.60	17.61
WB0180	0.00	0.00	0.00	0.00	0.00	0.00	6.92	9.30
WB0200	0.00	0.00	0.00	0.00	0.00	0.00	2.46	4.54
WB0220	0.00	0.00	0.18	0.00	0.26	0.00	0.65	0.79
WB0448	0.00	0.00	0.00	0.00	0.00	0.00	8.40	13.43
WC0006A	0.00	0.00	0.32	0.00	0.72	0.00	26.61	49.81
WC0006B	0.00	0.00	0.00	0.00	0.00	0.00	31.92	59.29
WC0015A	0.00	0.00	0.00	0.00	0.00	0.46	49.53	62.62
WC0015B	0.00	0.00	0.00	0.00	0.00	0.88	32.75	44.22
WC0018A	0.00	0.00	0.00	0.00	0.00	0.00	8.92	11.29
WC0018B	0.00	0.00	0.00	0.00	0.00	0.99	12.28	13.93
WC0025	31.30	73.62	54.66	92.30	66.40	100.89	164.74	172.31
WC0055	9.16	20.93	11.73	30.45	13.23	36.45	97.93	125.35
WC0066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.98
WC0095	4.73	2.97	5.48	3.26	5.68	3.48	3.96	3.94
WC0096	0.32	0.38	0.88	1.14	1.26	1.92	6.70	8.01
WC0199A	76.06	80.73	89.40	98.78	97.20	128.85	410.00	506.75
WC0199B	11.80	13.59	17.08	21.06	20.38	35.00	369.08	611.84
WD0002	0.00	0.00	0.00	0.00	0.00	0.00	94.10	218.08
WD0012	0.00	0.00	0.00	0.00	0.00	0.00	1.92	7.88
WD0013	0.00	0.00	1.16	0.00	3.74	0.00	28.24	36.40
WD0058	0.00	6.40	0.40	11.08	4.09	14.72	77.60	89.42
WD0062	128.93	51.12	171.80	68.87	199.20	81.32	253.71	288.11
WD0066	0.00	0.00	0.00	0.00	0.00	0.08	7.71	12.27
WD0090A	0.00	0.00	0.00	0.00	0.00	0.00	9.42	33.73
WD0090B	0.00	0.00	0.00	0.00	0.00	0.72	38.85	67.56
WE0024	21.31	3.26	25.82	4.39	29.45	5.31	39.70	41.21
WE0052	0.00	0.00	0.00	0.00	0.00	0.00	1.96	5.75
WE0070	0.00	0.00	0.00	0.00	0.00	0.58	7.11	11.65
WE0080	0.00	0.00	0.00	0.56	0.00	1.46	6.99	10.53
WE0090	0.00	0.00	0.00	0.00	0.00	0.01	1.43	2.66
WE0122	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WE0123	0.00	0.00	0.86	0.00	1.99	0.00	7.96	12.44
WE0127	0.00	0.00	1.24	0.00	2.63	0.00	17.98	23.75
WE0134A	0.29	0.29	0.29	0.29	0.28	0.29	0.29	0.29

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
WE0134B	3.20	1.26	6.33	2.34	8.38	3.04	21.51	25.96
WE0210	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
WE0255	0.00	0.00	0.00	0.00	0.00	0.00	0.76	8.95
WE0257	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WE0276	0.00	0.00	0.00	3.00	0.00	7.79	45.02	62.84
WE0277A	30.15	17.65	37.42	20.90	41.49	26.64	76.25	91.33
WE0277B	7.46	8.57	8.95	10.16	9.81	15.68	52.00	70.28
WE0278A	0.00	0.12	0.00	1.52	0.00	3.40	18.19	26.71
WE0278B	24.73	31.42	31.45	38.46	35.40	43.38	56.48	68.48
WE0279	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WE0284	4.69	4.66	8.44	6.86	10.89	8.71	33.42	37.62
WE0285	0.54	1.54	1.03	8.41	1.41	14.65	49.40	60.58
WE0286	0.00	3.70	0.00	6.58	0.38	8.90	84.20	105.53
WE0290	15.44	39.70	20.75	62.04	23.81	76.64	341.44	393.55
WE0420A	1.14	1.24	1.27	1.31	1.34	1.35	1.27	1.25
WE0420B	0.00	0.00	0.00	0.00	0.00	0.00	40.18	70.11
WE0432	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WF0000A	0.00	64.87	0.00	157.20	0.00	238.76	639.70	778.29
WF0000B	94.40	131.94	115.86	127.52	128.07	122.70	87.94	94.11
WF0015	3.54	7.82	5.13	10.90	6.13	13.56	49.71	73.58
WF0020	0.00	0.00	0.00	0.00	0.00	0.00	113.36	233.09
WF0035	4.19	6.37	5.49	8.27	6.23	9.86	66.23	86.44
WF0100	10.71	22.07	12.92	46.68	14.49	69.59	183.73	232.75
WF0150	5.49	18.44	9.18	25.83	11.49	31.73	56.29	74.44
WF0200	12.77	7.72	19.12	10.58	23.21	12.86	55.11	66.07
WF0300	35.39	68.49	43.69	90.48	48.71	110.26	463.17	680.55
WF0350A	35.30	54.89	40.05	70.94	42.81	87.32	192.97	350.81
WF0350B	0.00	34.32	0.00	94.93	1.95	165.38	794.92	1116.15
WF0360A	30.83	78.93	41.12	141.66	47.88	232.84	962.24	1301.26
WF0360B	38.71	99.12	53.23	165.36	62.12	259.16	996.13	1335.27
WF0370	22.21	32.14	25.15	37.14	26.78	41.01	67.94	92.53
WF0400	6.22	14.15	8.89	19.18	10.46	25.33	89.81	119.25
WF0450	0.00	0.00	0.00	0.00	0.00	0.00	36.43	57.86
WF0500	44.33	81.83	52.90	117.70	57.65	153.83	343.29	418.53
WF0600	9.59	16.52	11.76	20.29	13.00	23.25	35.39	40.40
WF0800A	3.41	7.30	4.41	9.85	5.02	12.11	23.32	28.28
WF0800B	5.73	12.03	7.41	15.87	8.42	19.16	40.53	55.66
WG0031	2.71	3.98	3.23	5.18	3.52	6.12	10.04	12.28
WG0093	0.00	0.00	0.00	0.00	0.00	0.00	8.34	26.83
WG0095	30.48	93.67	47.00	114.51	60.73	129.05	175.41	194.30

Table 7-3 (Continued)
Simulated Link Peak Flow Rates (cfs) of Selected Design Storm Events
Note: Link locations are provided in Figures 5-12 to 5-31

LINK	2yr_1hr	2yr_24hr	5yr_1hr	5yr_24hr	10yr_1hr	10yr_24hr	25yr_72hr	100yr_72hr
WG0112	7.94	12.87	10.40	16.90	11.86	19.94	39.38	57.39
WG0116	31.26	89.26	62.49	112.76	81.46	125.65	155.17	161.49
WG0118	21.24	10.54	38.02	14.55	48.66	17.48	108.17	122.57
WG0205	0.00	0.00	0.00	0.00	0.00	0.00	30.64	60.96
WG0211	21.63	72.40	45.86	85.61	57.33	95.07	130.90	134.34
WG0225	0.00	0.00	0.00	0.00	0.00	0.00	0.50	3.55
WG0240	0.00	0.00	0.00	0.00	0.00	2.40	49.92	50.03
WG0300A	7.92	9.95	9.74	13.35	10.88	15.41	26.88	32.20
WG0300B	18.17	17.51	23.36	23.71	26.52	29.60	68.51	78.63
WG0385	0.78	2.34	1.12	3.51	1.34	4.57	24.73	37.82
WG0405	0.00	0.00	0.00	0.00	0.00	2.91	149.59	196.34

8 Inventory of Flood Problem Areas

A total of sixteen potential flood-prone areas were marked by the City and digitized in ArcGIS. Figure 8-1 illustrates the approximate locations of these flood-prone areas.

As described in Section 7, the existing conditions modeling in ICPR was performed for the selected design storm events. Based on the LiDAR DEM data and the model simulation results, including the node peak stages, floodplains were delineated to represent the flood-prone areas for each design storm event. Due to the fact that most of the flooding problems reported by residents are related to annual storms, logic dictates there would be no added value to use the floodplains for 25 or 100-year storms in the evaluation of these local flooding problems. As shown in Figures 8-2 thru 8-8, the 2, 5 and 10-year floodplain maps were overlaid with the roadways, property boundaries and subbasin boundaries to better identify the simulated flood-prone areas.

To assist in the evaluation of the sixteen flood-prone areas, the drainage geodatabase (Section 5) was used along with information derived from numerous Environmental Resource Permit (ERP) documents. The Level of Service (LOS) of existing stormwater infrastructure was evaluated for each subbasin based on the LOS criteria defined in Section 9. Each uses a letter designation that ranges from "A" to "E", and the evaluation results are shown in Figures 8-2 thru 8-8.

The following sections discuss the sixteen flood-prone areas. Each section includes analysis of probable flooding history, potential flooding causes, actions taken by the City, and any preliminary engineering recommendations for flood mitigation.

Table 8-1 is also included at the end of this section to summarize the contents of these sections. Based upon this preliminary engineering analysis, CIP projects are recommended in eight of the sixteen flood-prone areas. The CIP projects are discussed in more detail in Section 9 using an established prioritization methodology.

8.1 Flood Area #1 – Near Suncrest Lane & Cutting Horse Lane

Flood Area #1 refers to the area in the vicinity of the intersection between of Suncrest Lane and Cutting Horse Lane, just east of I-75 (Figure 8-2). In 2009, with the support of funding from SFWMD, the city undertook a dozen of minor drainage improvement projects for the maintained ditches and canals. These improvements included: ditch cleaning, vegetation removal and other maintenance actions. Based on information from the city, flood area #1 was included in one of these improvement projects. As a result, no flooding problems have been reported after completion of the improvement projects.

During the field visit by INTERA and EAS staff in June 2010, the existing drainage system, including two culverts under Suncrest Lane, was found to be adequate to convey the surface water runoff from its contributing area. The culverts found during the field visit have been included in the existing conditions modeling and the existing LOS rating is "A" based on the simulated model results. As shown in Figure 8-2, there is no extensive floodplain predicted for this flood area. Therefore, CIP projects are not recommended for this area.

8.2 Flood Area #2 – E. Terry Road at I-75 Area

Flood Area #2 is located in the vicinity of E. Terry Road at I-75, as shown in Figure 8-2. Roadway and site flooding occurred in this area during a storm in the summer of 2008 with major flooding occurring at the Morton Grove Apartments. Initial investigations by the city concluded the flooding was likely caused by the overgrowth of vegetation in the downstream ditches within the I-75 Right-of-Way (ROW). The city coordinated with the Florida Department of Transportation (FDOT) regarding this issue and the FDOT responded by removing overgrown vegetation in the ditches.

As shown in Figure 8-2, the existing LOS for the Morton Grove Apartments is evaluated as "B" and no significant flooding is predicted during the 5-year storm, which is the standard design storm event for local roadways per SFWMD ERP requirements. As long as the FDOT regularly maintains drainage ditches within this area, no flooding is anticipated. No CIP project is recommended for this area.

8.3 Flood Area #3 – Windsor Road Area

Flood Area #3, the Windsor Road Area, is bounded by Meadowlark Ln. to the west, Beaumont Road to the east, Bonita Beach Road to the north, and the Vanderbilt Lake Subdivision and Woods Edge PUD to the south. This residential area has been continuously developed over the past four decades with little consideration to surface water drainage patterns. Based on the LiDAR DEM data and drainage inventory geodatabase, the stormwater runoff drains from Bonita Beach Road to the east-west drainage ditch near the south end of Windsor Road, which then drains to the Imperial River through various control structures and a 30" RCP pipes along Windsor Road. Frequent roadway flooding was observed by the City staff, especially at the south end of Windsor Road. Within the past 10 years, the City has undertaken some actions to resolve this flooding problem by adding control structures and a 30" RCP pipeline to the Imperial River. Despite these improvements, however, local flooding still occurred as reported in the summer of 2010.

Based on the recent drainage study completed by the City in 2010, the Vanderbilt Lake Subdivision was observed to be contributing stormwater runoff to Windsor Road. However, according to the ERP document, part of the flooded area (about 50 acres) was supposed to join the stormwater system of the Audubon Country Club to the west through a perimeter swale along the southern border of the Vanderbilt Lake Subdivision and through a 42" RCP pipe under Vanderbilt Drive. The ultimate outfall of the Audubon

Country Club stormwater system is within Little Hickory Bay. However, this permitted perimeter swale system has never been constructed; therefore the natural flow way to Little Hickory Bay was blocked and never restored.

As indicated in SFWMD ERP document No. 36-03971-P, the local control structures were configured based on the allowable peak discharge of 8.76 cfs for 25-year/72-hour design storm event. The top grate elevation of the primary control structure at south end of Windsor Road was set as 11.56 ft-NGVD, which is even higher than the road crown elevation; therefore, to create the necessary hydraulic gradient, the water level in this area has to be raised above the road crown elevation before draining into the 30" pipe.

During the site visit in June 2010, two cross-drains were found under Beaumont Road and one of these cross-drains did not function due to the overgrowth vegetation downstream of Beaumont Road. These two cross-drains serve as the discharge point of the wetland area between Windsor Road and Beaumont Road; therefore, the wetland area will not drain as expected until the elevated culvert invert elevations are reached.

As shown in Figure 8-3, the existing LOS for Windsor Road Area is evaluated as "E" and significant flooding is predicted along the local roads and some lots for the 10-year design storm event. Based upon this preliminary engineering analysis, the recommended CIP projects should be listed as one of the top priority projects to mitigate the severe and frequent flooding problems in this area.

8.4 Flood Area #4 – Pinecrest Subdivision – South Region

Flood Area #4, the southern region of the Pinecrest Subdivision, is located in the southern part of a residential subdivision bounded by I-75 to the east, a Florida Power and Light (FPL) easement to the west, the Imperial River to the south and E. Terry Road to the east (Figure 8-4). Some residents in this area were reported to have been evacuated from their houses as a result of flooding in 1995. Both this area and the nearby Imperial Gates Subdivision experienced flooding in 1995 due to inadequate flow capacity in the Imperial River. Flooding in this area has been mitigated by the stormwater improvements documented for Flood Area #5 (Section 8.5). According to the City record, no flooding complaints have been reported in Flood Area #4 within past 5 years.

Based on the field observations in June 2010, the local stormwater management system includes two 72" CMP pipes under Riverview Drive and seems to be adequate to drain the upstream stormwater runoff. As shown in Figure 8-4, the existing LOS for this area is evaluated as "A" and no flooding is predicted along the local roads. Therefore no CIP project is recommended for Flood Area #4.

8.5 Flood Area #5 – Imperial Gates Subdivision

Flood Area #5 consists of the Imperial Gates Subdivision and is generally bounded by Bonita Beach Road to the south, Dean Street to the north, Imperial Pkwy to the west and Quinn Street to the east. Residents in the Imperial Gates Subdivision and the adjacent areas experienced the worst flooding in the city in 1995 and numerous residents were reported to have been evacuated from their houses per American Red Cross records.

Since the 1995 flooding, the city has implemented several improvement projects designed to increase the flow capacity of the Imperial River. Structural improvements include the construction of new infrastructure such as pipes, bridges, and weirs. Specifically, these improvements include:

- A cleaning and snagging operation from Old US 41 to the FPL easement
- Reconstruction of the Imperial River (Kehl Canal) weir, just east of Bonita Grande Road
- Replacement of the Bourbonniere Bridge
- Construction of a by-pass system under Bonita Beach Road (just west of the FPL easement) that is capable of routing flow to Oak Creek
- Construction of additional catch basins and drainage pipes along local roads and modification of the previously permitted stormwater ponds/structures adjacent to the Imperial Parkway.

In addition to the structural improvements, the City of Bonita Springs, Lee County and SFWMD purchased various properties located east of I-75 for the purpose of storing stormwater runoff. Also, the city purchased the floodway along the Imperial River starting from the west side of the FPL easement with support funding from the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program.

The ICPR existing conditions model incorporates most of the structural improvements projects implemented since 1995. The 100-year peak stage of the Imperial River near the bridge of Imperial Pkwy is predicted as 9.57 ft-NGVD, which is not high enough to cause backflow and severe flooding of the subdivision. It is noted that the stormwater model did not consider surge impacts, but it is adequate in the evaluation of the local flooding problem that repeats every two or three years.

An interim drainage improvement project was constructed in the summer of 2010. This drainage project was designed to alleviate the local site and roadway flooding by draining the runoff to the stormwater ponds on east side of Imperial Pkwy and was incorporated in the ICPR existing conditions model in the SMP update project. As shown in Figure 8-4 the existing LOS for the local roads is evaluated as "E" with extensive flooding predicted along Quinn Street, Saunders Avenue, and Pawley Avenue during 10-year storm events. The model results also indicate that this interim drainage improvement project may not eliminate the roadway or site flooding completely, but will drain the site quickly through various intake structures and pipes.

To completely eliminate the local flooding, a proposed stormwater management system may include raising road crown elevations, redesigning of the local stormwater pipes and catch basins, and adding a second outfall to the Imperial River at the north end of Quinn Street. This CIP recommendation would be costly if the desired LOS is “A” or “B” for the roadway and structures in this neighborhood.

Given the fact that the interim project has been constructed and has provided some relief of the local flooding problem, the city may not be interested in planning another CIP improvement in this area. However, considering the long-standing flooding history and high maintenance cost of the poorly-drained roadway, a CIP project could be implemented after other projects of higher priority are constructed.

8.6 Flood Area #6 – Shangri-La Road Area

Flood Area #6, the area adjacent to Shangri-La Road, is located on the north side of Hawthorne PUD between Windley Key Terrace and the Imperial Parkway (Figure 8-5). This area has a long history of drainage and flooding problems particularly after the development of Hawthorne PUD. During the summer of 2008, local residents experienced severe roadway and site flooding.

There are approximately 360 acres north of Shangri-La Road that historically drained south toward the road and then into a wetland slough which is now part of the Hawthorne PUD. Flow within the wetland slough drains very slowly toward the Old 41 Road into existing triple 7'x10' box culverts. The flow then heads toward the Seminole Gulf Railroad where it is directed south into the Imperial River. Field observations revealed that very little flow found its way to the Old 41 Road box culverts during a storm in the summer of 2008. Field observations also indicated that the flow was roughly equivalent to that which would occur through a 24" to 30" diameter culvert. Meanwhile there was extensive flooding within the contributing drainage area north of Shangri-La Road. It is suggested that the Old 41 box culverts are tremendously under-utilized due to the fact that runoff from the historical contributing drainage area can’t make its way to the culverts because of the development of Hawthorne PUD.

To provide a better drainage system for the Shangri-La Road, the city is currently developing plans for two-lane improvements and an easterly extension of the road from Windley Key Terrace to the Imperial Parkway. Agnoli, Barber & Brundage, Inc. was contracted by the city for both Phase 1 and Phase 2 of this drainage improvements project.

Phase 1 of the Shangri-La regional drainage improvements project is also known as interim drainage improvements project and was permitted under Application No’s. 10-0211-10 and 10-0211-11. Both projects are expected to be constructed in the summer of

2010. The stormwater runoff is intended to be directed south along the area between Hawthorne PUD and Bonita St. James Subdivision, and then to drain into a dry detention basin along the boundary of the Bonita Lakes RV Park. The dry detention basin is not designed for the water quality treatment of the off-site stormwater from the Shangri-La Road area. The flow is then directed south along the Old 41 easterly ROW lane through a proposed box culvert in a proposed easement along the frontage of Bonita Lakes to the Old 41 box culverts. Ultimately there will be drainage improvements made along Shangri-La Road to capture and direct flow to the conveyance structures between Hawthorne and Bonita St. James (Phase 2), as well as improvements downstream of the Old 41 box culverts and along the Seminole Gulf Railroad. These improvements will result in a system that will more efficiently convey the stormwater flows downstream to an outfall in the Imperial River.

The Phase 1 of the Shangri-La regional drainage improvement is incorporated into the existing conditions modeling. As shown in Figure 8.5, however, extensive flooding is still predicted on the north side of Shangri-La Road. The existing LOS of the Shangri-La Road is evaluated as "C" with tolerable flooding for the public roadways. However, the private roads to the north, including Tropic Acres Drive are still within the floodplain for 10-year design storm event.

According to the city staff, Phase 2 of the Shangri-La regional drainage improvements project is still in the design phase. A series of RCP pipes ranging from 48" to 60" in diameter are designed to collect the stormwater from the north side of Shangri-La Road and drain to the existing swale system previously constructed as part of Phase 1. An ERP permit modification is scheduled to be submitted to SFWMD by the end of 2010.

Upon the completion of the Phase 2 construction, the stormwater management model and floodplain delineation will be updated to re-evaluate the existing conditions.

Since the city has already entered into an agreement to initiate the design of the Phase 1 & Phase 2 of the Shangri-La Road regional drainage improvements project, no recommendations for an additional CIP plan is necessary.

8.7 Flood Area #7 – Michigan Street Area

Flood Area #7, in the vicinity of Michigan Street, begins at Bonita Beach Road to the south and runs north to Pennsylvania Avenue, as shown in Figure 8-6. The area is an old established Bonita Springs neighborhood, in which construction started around the 1960's. The homes have been built over the span of four decades with little consideration to stormwater drainage patterns. Michigan Street drains from south to north and the road drainage system consists of open swales parallel to the road. These swales discharge to a man-made canal to the north side of Pennsylvania Avenue and the canal connects directly to the Imperial River. There are numerous culverts placed within the swales to serve as side drains for driveways and streets. However, these culverts have not been sized to accommodate their contributing areas.

Based on the LiDAR DEM data, the grade change along Michigan Street is quite large for a roadway in southwest Florida. The majority of this change occurs north of Kentucky Street with the area south of Kentucky Street being fairly flat. The existing flood-prone areas are located from Carolina Street to Kentucky Street, along both sides of Michigan Street. Wisconsin Street is located about 1,000 feet west of Michigan Street and acts as a drainage ridgeline. The area east of Wisconsin Street drains toward an unnamed natural system between Michigan Street and Washington Street. Prior to 2005, there was no cross-drain under Michigan Street. Instead the side-drains along the west side of Michigan Street were used to carry the stormwater runoff northward to the Imperial River. The existing Michigan Street side-drains appear to be undersized to handle the runoff.

In 2005, Pitman-Hartenstein & Associates, Inc. (PHA) was contracted by the City to conduct a drainage improvements study for the Michigan Street flood area. Various cross drains under Michigan Street and the associated structures were recommended in this study. However, due to budget constraints only a few side-drains along Michigan Street were replaced with bigger sized pipes. One 19"x30" ERCP cross-drain was installed by the city under Michigan Street just south of Carolina Street to partially relieve the local flooding along Michigan Street.

As shown in Figure 8-6, the existing LOS for Flood Area #7 is evaluated as "E" and significant flooding is predicted along these local roads. A CIP project is recommended to retrofit the existing drainage system per city standards to relieve the flooding problems for public safety and welfare in this region.

8.8 Flood Area #8 – Enterprise Avenue Area

Flood Area #8, the Enterprise Avenue Area, is located on the south side of Bonita Beach Road and bounded by Race Trace Road to the west, Mediterra North CDD to the east, and Greyhound Commerce Park to the south (Figure 8-7). The flooding problems were reported to be along two private local roads - Enterprise Avenue and K-Nine Dive. The drainage inventory geodatabase shows no existing stormwater infrastructure in the flood-prone area. Currently, the city is not able to perform any drainage improvement projects in this area due to the lack of roadway easements ditches downstream.

One drainage improvement project funded by a private owner was designed and has been under construction since the summer of 2010. This project involves the installation of a series of 16" PVC pipes and a small stormwater detention area to drain the stormwater northward to the drainage ditch between Bonita Beach Road and K-Nine Drive. Based on the preliminary engineering estimate, the 16" PVC pipes will not improve the LOS to "D" or above. However this piping system will significantly reduce the flooding duration by transferring the stormwater more quickly into the ditch to the north. This drainage improvement project has been incorporated into the existing conditions model.

As shown in Figure 8-7, the existing LOS of the Enterprise Avenue Area is evaluated as "E" and significant flooding is predicted along Enterprise Avenue and K-Nine Drive even with the on-going drainage project implemented in the existing conditions model. To completely eliminate the local flooding, the stormwater management system should be redesigned with a lager pipe size and improvements to downstream drainage ditch.

8.9 Flood Area #9 – Dellwood Lane Area

Flood Area #9, the area adjacent to Dellwood Lane, is generally bounded by the Imperial Pkwy to the west, Oak Creek to the north and Vasari CDD to the east and south (Figure 8-7). Reports indicate that this area is subjected to frequent roadway and site flooding. In 2006, the City undertook an interim drainage improvement project that included the construction of swales along the roads and drain pipes under driveways. The stormwater collected by the drain pipes and swales is conveyed to a series of 18" RCP drain pipes along the Imperial Pkwy that directly connect to Oak Creek. A drainage ditch along the eastern boundary of the area was also found to drain stormwater to Oak Creek. No significant flooding issues have been reported since the completion of the interim project. In addition, the City has planned a creek restoration project to clean and restore the main channels of Oak Creek downstream of Bonita Beach Road. This creek restoration project will be completed by the summer of 2011 and will help to relieve the flooding problems in this area.

As shown in Figure 8-7, the existing LOS is evaluated as "E" for Dellwood Lane and Redbud Lane, and "D" for Sunray Drive. Limited flooding is predicted in the low areas along local roadways, mostly within the public ROW. The interim drainage improvement project helps reduce expected peak stages and flooding extents in this area.

Based on this preliminary engineering analysis, a CIP project is recommended for Flood Area #9. To eliminate the roadway flooding completely, the stormwater management system could be redesigned with appropriately sized drain pipes and improvements to the drainage ditch located along the eastern boundary of the area.

8.10 Flood Area #10 – Bonita Elementary School

Flood Area #10, contains the Bonita Elementary School and is also known as the Dean Street Area. This area is located on the east side of Old US 41 and north side of Dean Street (Figure 8-6). This area is an old established Bonita Springs neighborhood which dates back to the 1970's. According to the city record, Bonita Elementary School experienced site flooding during storms in the summer of 2008. The drainage inventory geodatabase indicates the 18" RCP cross-drain under Old US 41 is the only outfall into the Oak Creek. No action has been taken by the city to address the flooding issue.

The lack of the sufficient stormwater infrastructure along Dean Street is the primary cause of the roadway and site flooding in this area. As shown in Figure 8-6, the existing

LOS for the Dean Street Area is evaluated as "D", which means the flooding of the roadway may not result in vehicle accidents or other risks to the public. Flooding is predicted along Dean Street and the low residential areas during 10-year storms.

A CIP project is recommended for Flood Area #10. To eliminate the roadway and site flooding in this neighborhood, a new stormwater drainage system is recommended, including a series of side-drains, cross-drains and the associated catch basins. This new drainage system should be located along the north side of Dean Street, and should drain stormwater into the Oak Creek crossing at Old US 41. The existing 18" cross-drain under Old US 41 should upgraded to convey the increased stormwater runoff from upstream areas.

8.11 Flood Area #11 – Imperial Harbor Subdivision

Flood Area #11 is within the southern region of the Imperial Harbor Subdivision, bounded by Seminole Gulf Railroad to the east, Highland Woods Gulf and County Club to the west, Bonita Fairways HOA to the south and the south ditch of the Spring Creek to the north (Figure 8-8). The subdivision is a mobile home park dating back to the 1980's. The flooded roads include Squire Lane, Peer Lane, Queen Mary Lane, Duchess Lane, and Colony Road, where the stormwater runoff drains to an offset lake (Offset Lake) within the Bonita Fairways Subdivision.

As part of the development of the Bonita Fairways Subdivision, a stormwater management system was constructed in the 1990's, and includes various drain pipes, inlets, and ponds/lakes. The Offset Lake drains through a series of 15" stormwater pipes that connect to the catch basin on the north side of W. Terry Road. Water from this catch basin ultimately drains to the Imperial River. The outfall pipes were not properly sized when compared to their contributing drainage areas, resulting in high lake stages as well as roadway and site flooding in the upstream residential areas.

In 2005, an ERP modification of the Bonita Fairways Subdivision was permitted to fix the flooding problem around the offset lake area. A series of 24" RCP pipes with a flap gate were used to divert part of the lake runoff to the stormwater system downstream, which is located in the Bonita Fairways Subdivision. However, due to the high water levels of the ponds downstream, the additional discharge from the offset lake is limited and could not significantly reduce the lake peak stages as expected.

In response to the numerous flooding complaints from local residents, the City started an investigation of possible solutions by coordinating with various local stakeholders. However, due to the difficulty of obtaining drainage easements or ROW for the outfall routes, feasible CIP alternatives have yet to be developed for this area.

The existing stormwater system in the Imperial Harbor and Bonita Fairways subdivisions is simulated in the existing conditions ICPR model. As shown in Figure 8-8, the existing LOS for this area is evaluated as "E" and significant flooding is predicted along the local roads and residential lots. Based on this preliminary engineering analysis, a CIP project is recommended in this location.

Possible improvement alternatives include:

1. Upgrading the existing 1,550 feet of 15” RCP pipes running through the Bonita Fairways Subdivision.
2. Diverting the stormwater outflow through a combination of open swales, drain pipes and drainage ditches leading around the subdivision and into the Imperial River.
3. Draining the lake runoff northward into the stormwater pond/ditch within the Spring Creek watershed thru a series of stormwater pipes about 850 feet long within the public road ROW.

8.12 Flood Area #12 – Arroyal Mall (Crown Lake Blvd)

Flood Area #12 contains the Arroyal Mall, the commercial area bounded by US 41 to the west, Bonita Beach Road to the south, a FDOT stormwater pond and wetland area to the north and Arroyal Road to the east. Crown Lake Boulevard was reported to be flooded during a recent storm. Based on the review of pertinent SFWMD ERP documents, the stormwater pond located on the west side of Hampton Inn was designed to receive stormwater runoff of offset areas from the northwest, southwest, and southeast corners of the intersection of US 41 and Bonita Beach Road. During the site visit in June 2010, the downstream drainage ditch located just on the north side of Crown Lake Boulevard was observed to be filled in with silt and extensive sediments with noticeable overgrown vegetation. According to the ERP permit application, the local land owner is responsible for the maintenance and operation of the permitted stormwater management system. No flooding complaints have been reported in past several years according to the city records.

As shown in Figure 8-3, the existing LOS for the Arroyal Mall is evaluated as “D” and flooding is only predicted along Crown Lake Boulevard. Based on this preliminary engineering analysis, CIP projects are not recommended.

8.13 Flood Area #13 – Tropic Acres Drive Area

Flood Area #13 is the vicinity of Tropic Acres Drive, located at the wetland area on the north side of Shangri-La Road (Figure 8-5). This flooding area should be considered as part of Flood Area #6 (the area around Shangri-La Road) and discussed in Section 8.6. After the construction of Phase 2 of the Shangri-La Drainage Improvements project, the flooding problem for Tropic Acres Drive area will be relieved. Therefore, CIP projects are not recommended for this area.

8.14 Flood Area #14 – Industrial Street Area

Flood Area #14 is the immediate vicinity of Industrial Street, located on the north side of Bonita Beach Road and along the west side of the Seminole Gulf Railroad (Figure 8-6). The property owners and employees of the Industrial Commercial Park have experienced site and roadway flooding during recent storms. Based on field observations, two existing catch basins were found to be filled with silt and sediments. The catch basin discharge pipe was completely blocked. The city staff also mentioned that the catch basin drainage pipe runs through the private property, and that A/C units and other equipment were found above this pipe. The blockage of the discharge pipe would cause flooding in yards and on the roadway until the ponded water evaporated. This flooding problem is primarily caused by the poor maintenance of the drainage system pipe; however, currently the city is not able to perform the maintenance of the discharge pipe due to lack of an existing easement.

As shown in Figure 8-6, the existing LOS for the Industrial Street Area is evaluated as "E" and flooding is predicted along Industrial Street and Tennessee Street. The flooding problem along the Tennessee Street is mainly due to the undersized cross-drain under Industrial Street. No flood complaints have been reported in this area and one possible reason is the roadway flooding should be of short duration and may not cause significant inconvenience to local residents.

Based on this preliminary engineering analysis, a CIP project is recommended for Flood Area #14. The possible improvement components include:

1. Maintenance of the existing discharge pipe, if a drainage easement is obtained from the property owner,
2. Installation of an 800-foot pipe line within the roadway ROW to drain the stormwater northward to the ditch at north end of the street,
3. Upgrading the existing cross-drain at the north end of Industrial Street to eliminate the roadway overtopping and mitigate flooding near Tennessee Street.

8.15 Flood Area #15 – FPL & Terry Road Area

Flood Area #15 consists of the FPL and area adjacent to Terry Road. This area is located at the FPL access road to W. Terry Road (Figure 8-8). The flooding only occurred at the access road to the FPL easement, according to the flood complains reported in 2010, and apparently no site or property flooding was reported. Based on the stormwater management model results the primary flooding causes are the low road grade elevations and the lack of cross-drains under the access road.

As shown in Figure 8-8, the existing LOS for this area is evaluated as "B" and flooding is only predicted on the access road while W. Terry Road is flood-free. Since the City does not own or use the access road and no resident flooding is involved, CIP projects are not recommended.

8.16 Flood Area #16 – Pinecrest Subdivision – North Region

Flood Area #16 is the northern region of the Pinecrest Subdivision, located in a residential subdivision bounded by I-75 to the east, the FPL easement to the west, the Imperial River to the south and E. Terry Road to the east (Figure 8-4). Similar to Flood Area #4, no major flood complaints have been reported during recent years, and only maintenance type work was conducted by the City.

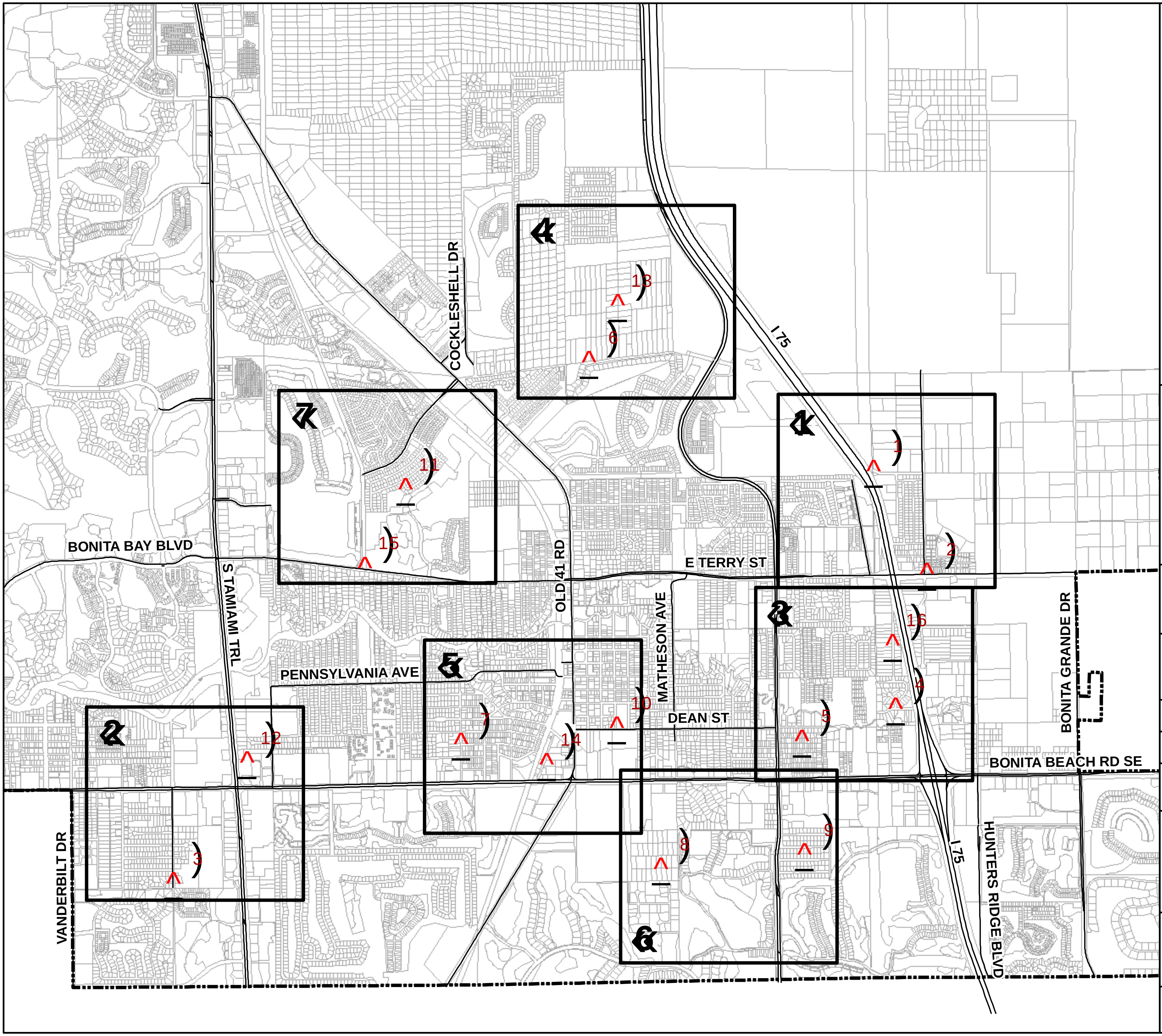
Documented in the field observation of June 2010, the existing stormwater management system includes a series of side-drains and cross-drains and appears to be adequate to convey the upstream stormwater runoff. As shown in Figure 8-4, the existing LOS for this area is evaluated as "A" and no structure is shown in the floodplain. CIP projects are not recommended at this location based on this preliminary engineering analysis.

8.17 Figures & Tables Descriptions

The figures and tables discussed in this section are summarized below:

Figure #	Description
8-1	Flood Area Locations
8-2	10-Year Floodplain Map at Flood Areas Nos. 1 and 2
8-3	10-Year Floodplain Map at Flood Areas Nos. 3 and 12
8-4	10-Year Floodplain Map at Flood Areas Nos. 4, 5 and 16
8-5	10-Year Floodplain Map at Flood Areas Nos. 6 and 13
8-6	10-Year Floodplain Map at Flood Areas Nos. 7, 10 and 14
8-7	10-Year Floodplain Map at Flood Areas Nos. 8 and 9
8-8	10-Year Floodplain Map at Flood Areas Nos. 11 and 15

Table #	Description
8-1	Summary of Flood-Prone Areas



Legend

Feet

0 1,000 2,000 4,000

Flood Area Location

Major Road

CityLimits

I.D. Number

City of Bonita Springs Stormwater Master Plan

Flood Area Locations

Project: 4600000955W003

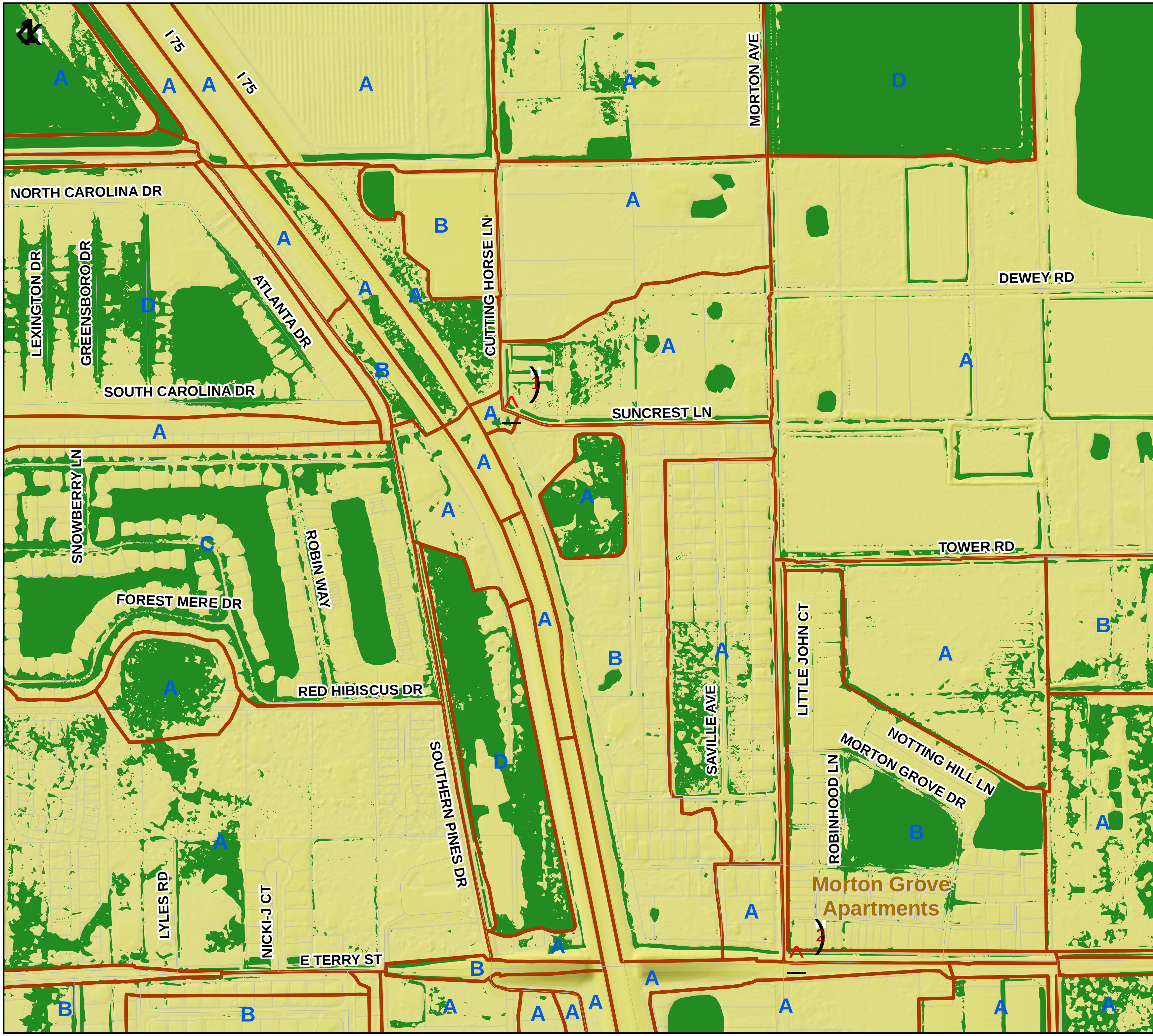
Date: 12/10/2010

File: COBS_SMP_Fig8_1

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 8-1



Legend

Feet
0 200 400 800

- A Existing LOS
- ^ Flood Area Location
- Road
- ICPR Basins
- Floodplain_10-Year

City of Bonita Springs Stormwater Master Plan

10-Year Floodplain Map at Flood Area Nos. 1 and 2

Project: 4600000955W003

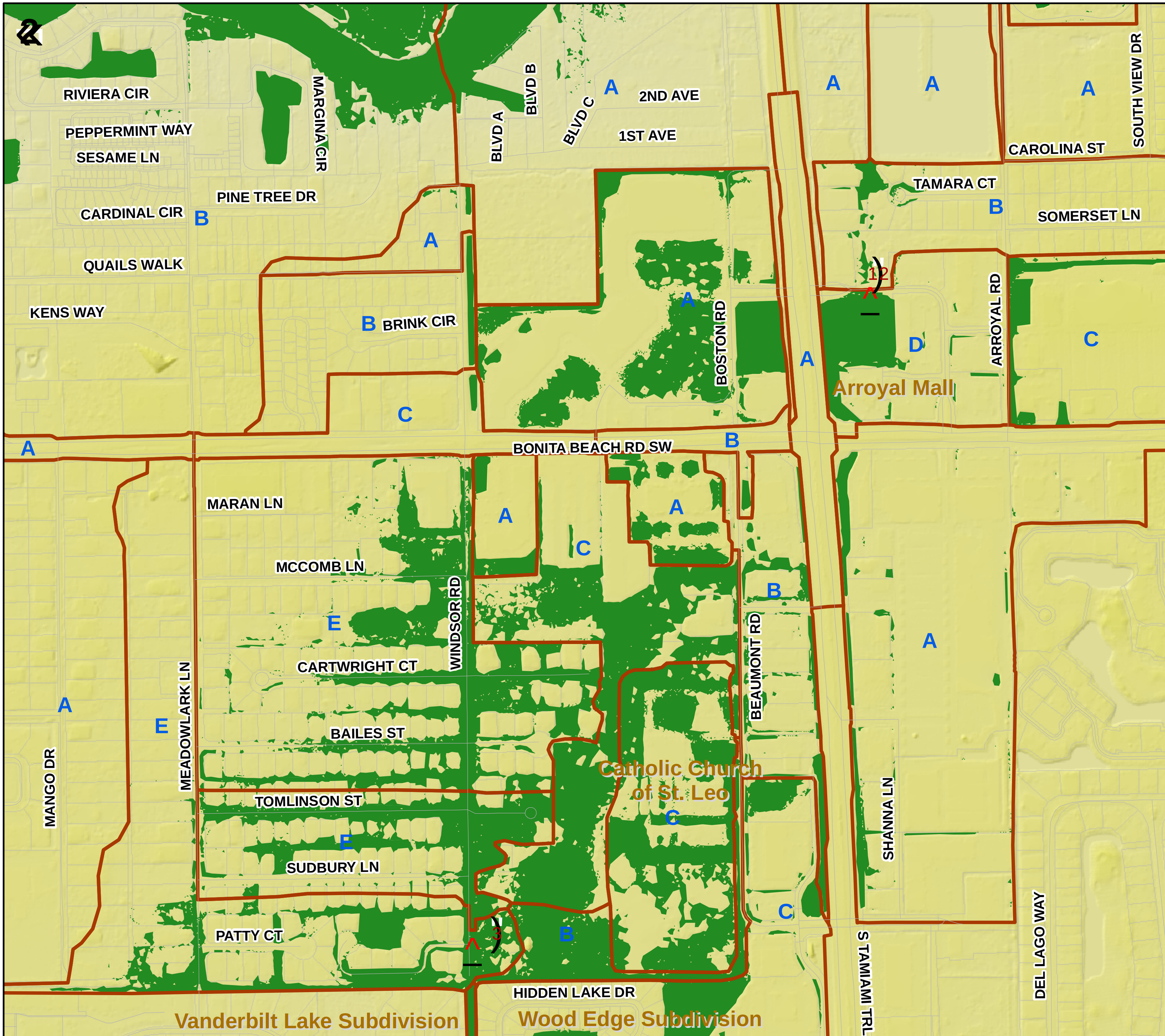
Date: 12/10/2010

File: COBS_SMP_Fig8_2

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 8-2



Legend

Feet

0 200 400 800

A Existing LOS

^ Flood Area Location

Road

ICPR Basins

Floodplain_10-Year

City of Bonita Springs Stormwater Master Plan

10-Year Floodplain Map at Flood Area Nos. 3 and 12

Project: 4600000955W003

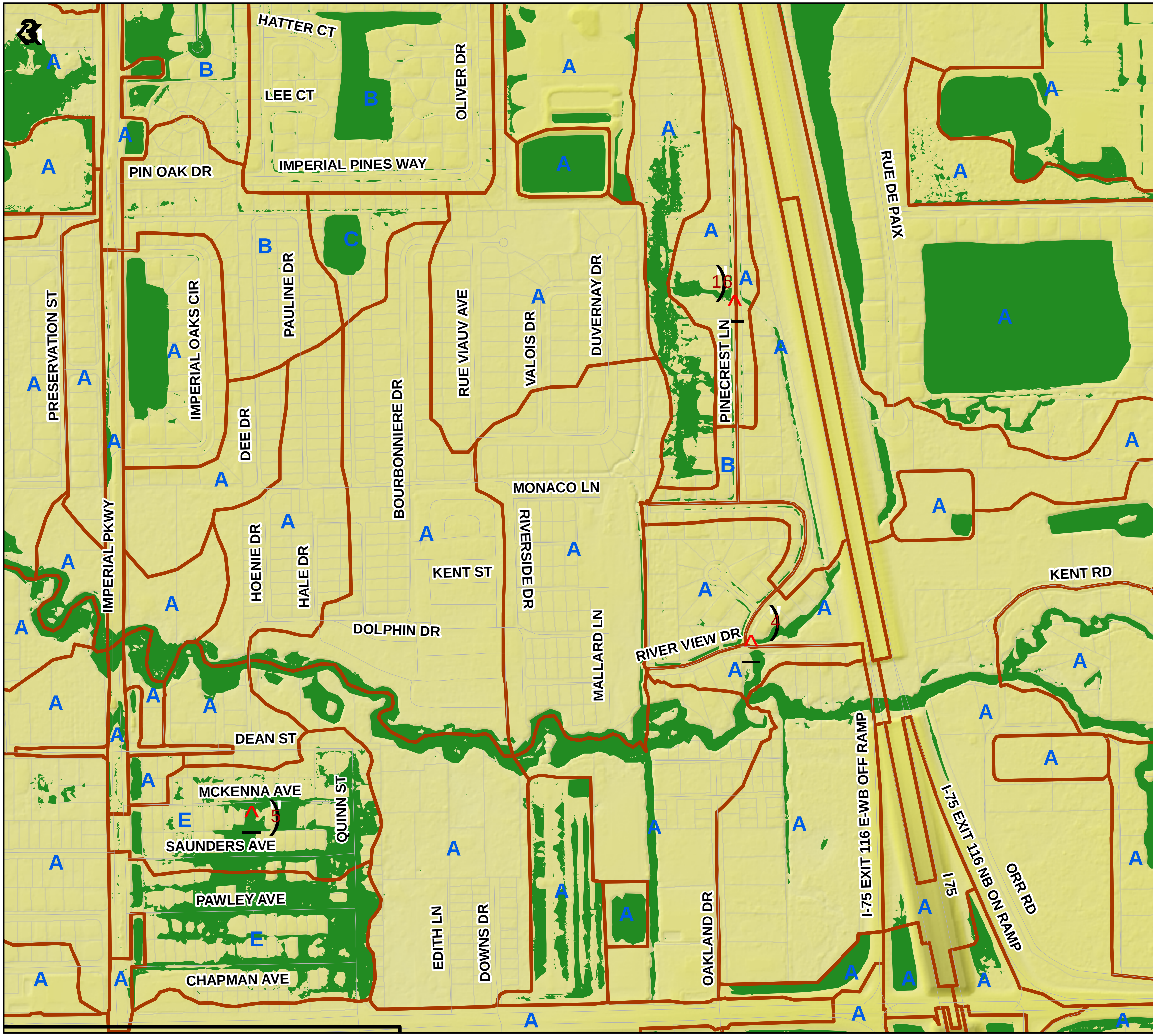
Date: 12/10/2010

File: COBS_SMP_Fig8_3

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 8-3



Legend

- A Existing LOS
- ^ Flood Area Location
- Road
- ICPR Basins
- Floodplain_10-Year

City of Bonita Springs Stormwater Master Plan

10-Year Floodplain Map at Flood Area Nos. 4, 5 and 16

Project: 4600000955W003

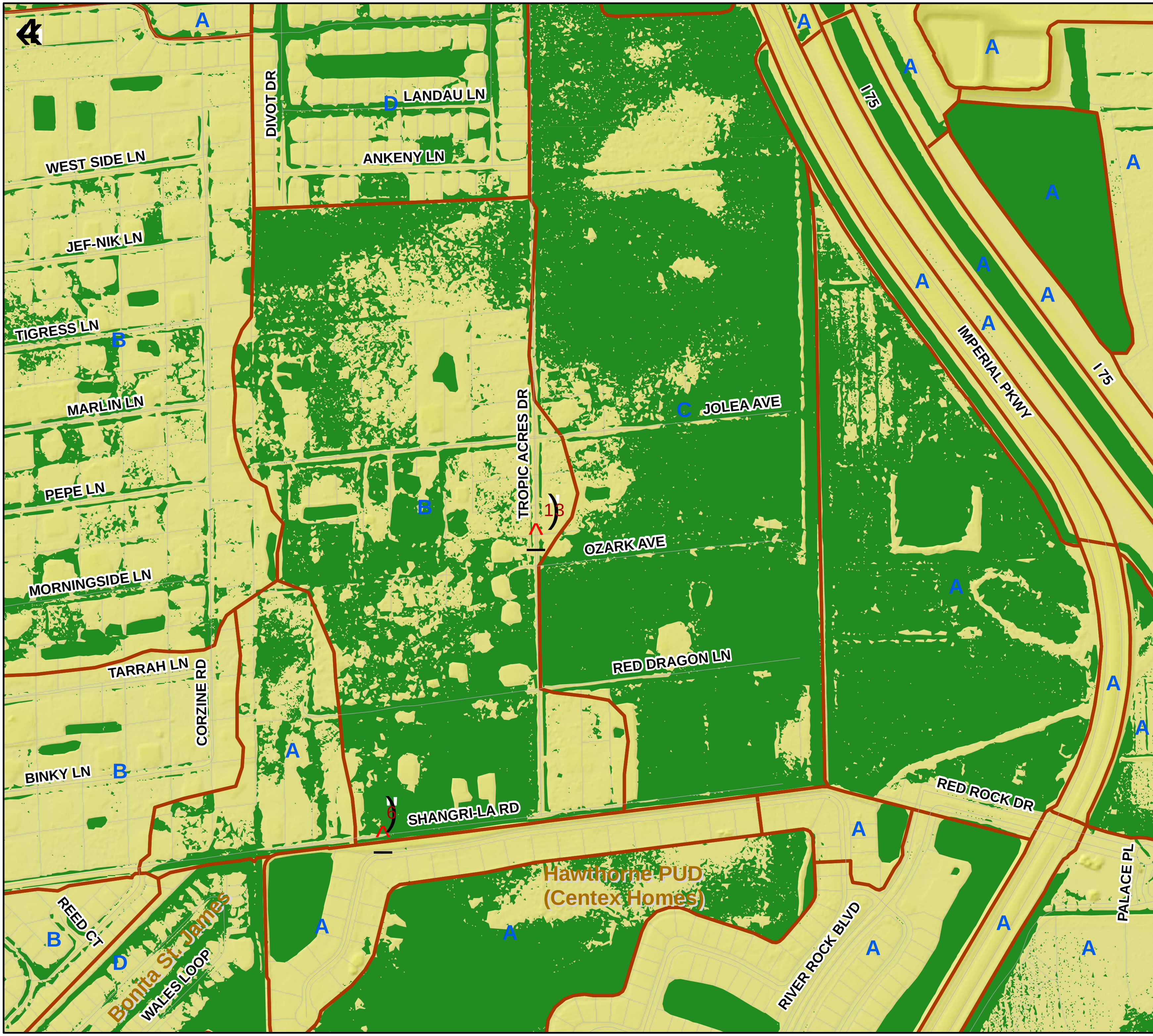
Date: 12/10/2010

File: COBS_SMP_Fig8_4

INTERA
Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 8-4



Legend

Feet

0 200 400 800

- A Existing LOS
- ^ Flood Area Location
- Road
- ICPR Basins
- Floodplain_10-Year

City of Bonita Springs Stormwater Master Plan

10-Year Floodplain Map at Flood Area Nos. 6 and 13

Project: 4600000955W003

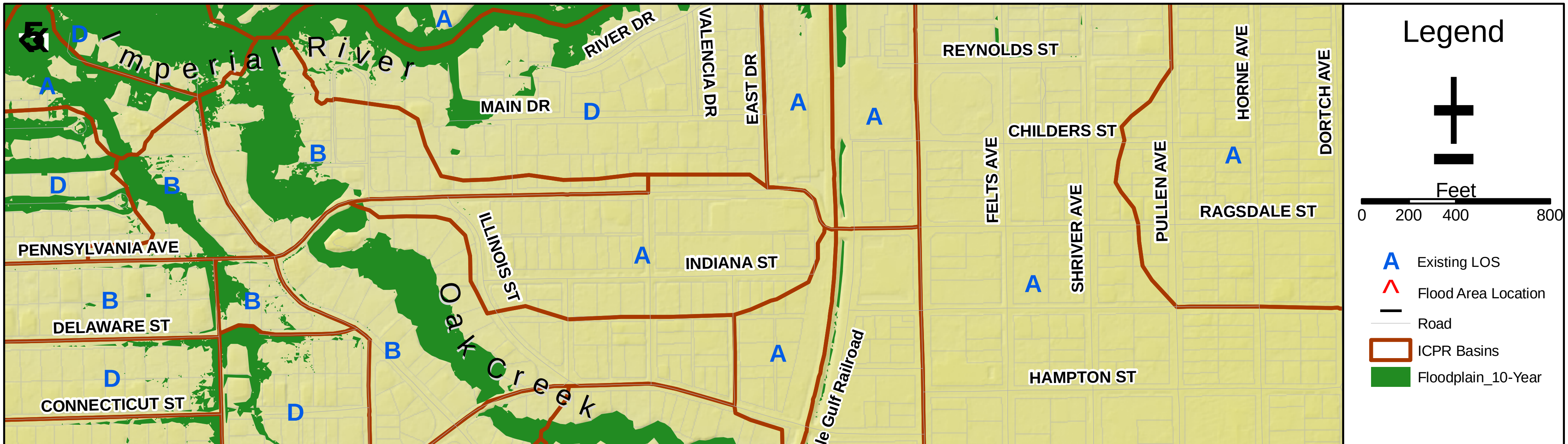
Date: 12/10/2010

File: COBS_SMP_Fig8_5

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 8-5



City of Bonita Springs Stormwater Master Plan

10-Year Floodplain Map at Flood Area Nos. 7, 10 and 14

Project: 4600000955W003

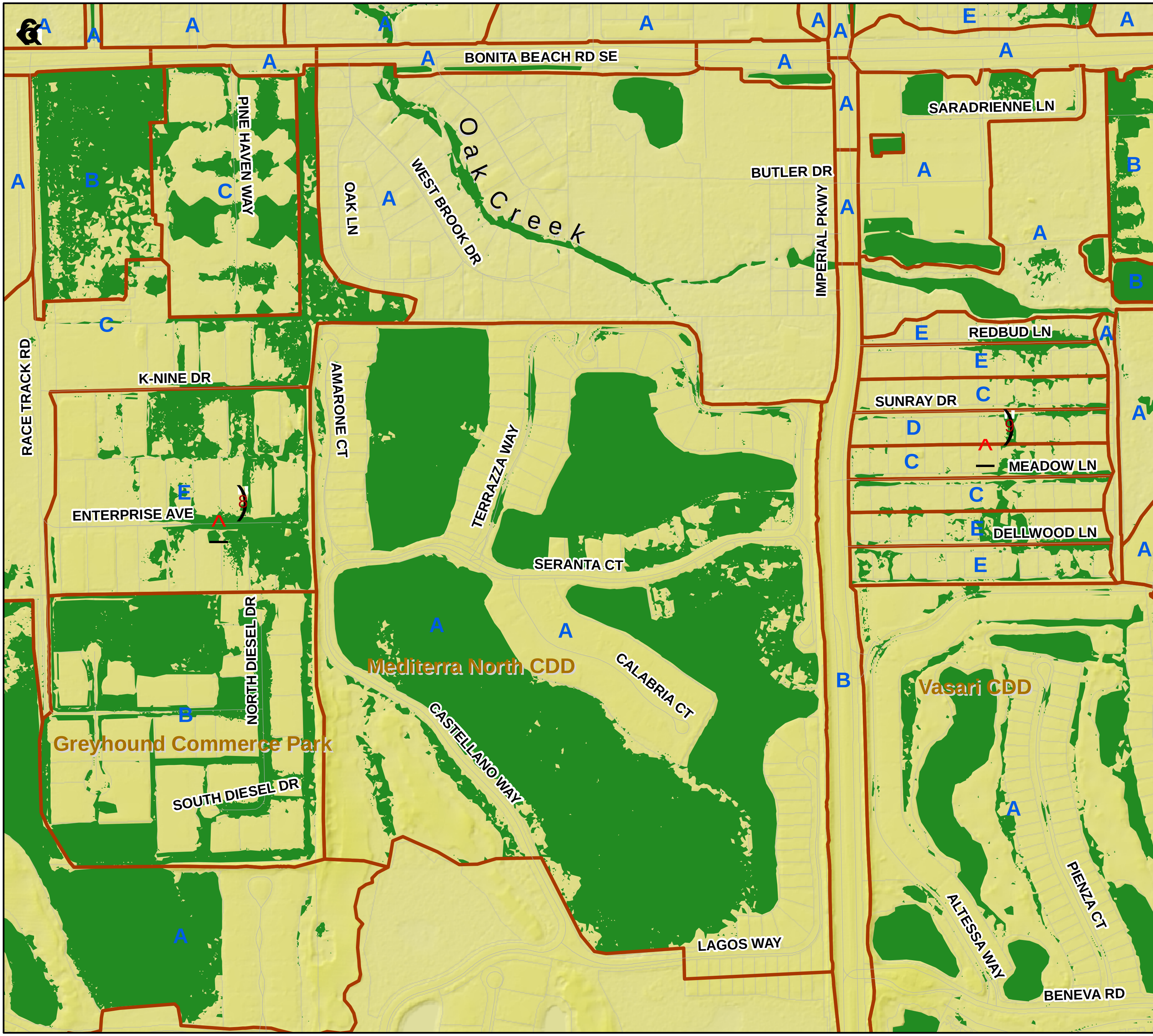
Date: 12/10/2010

File: COBS_SMP_Fig8_6

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 8-6



Legend

Feet

0 200 400 800

A Existing LOS

^ Flood Area Location

Road

ICPR Basins

Floodplain_10-Year

City of Bonita Springs Stormwater Master Plan

10-Year Floodplain Map at Flood Area Nos. 8 and 9

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig8_7

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 8-7

Legend

Feet

0 200 400 800

- A Existing LOS
- ^ Flood Area Location
- Road
- ICPR Basins
- Floodplain_10-Year

City of Bonita Springs Stormwater Master Plan

10-Year Floodplain Map at Flood Area Nos. 11 and 15

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig8_8

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 8-8

Table8-1
Summary of Flood-Prone Areas

#	Flood Area Location	Year of Complaints	Action By City?	City Actions and Comments	Engineer Suggestion
1	Suncrest Lane & Cutting Horse Lane Area	N/A	No	No flooding problem observed. Some maintenance work performed in 2010.	No CIP project suggested
2	E. Terry Road at I-75 Area	2008	Yes	Caused by the poor maintenance of the downstream ditch in I-75 ROW. FDOT has cleaned the ditches and will maintain regularly.	No CIP project suggested
3	Windsor Road Area	1985	Yes	The City has undertaken drainage improvements projects in 2001& 2009. Flooding problem is still observed.	CIP project is needed
4	Pinecrest Subdivision - South Region	1995	No	No flood complaint is reported within past five years.	No CIP project suggested
5	Imperial Gates Subdivision	1995	Yes	An interim drainage project constructed in 2010.	CIP project is needed
6	Shangri-La Road Area	2008	Yes	An interim drainage project constructed in 2010. City is working on a regional improvement project now.	No CIP project suggested
7	Michigan Street Area	1985	Yes	The flood is due to the poor drainage system along Michigan St. Property flooding observed. Minor drainage improvements work after 2005.	CIP project is needed
8	Enterprise Avenue Area	2005	No	The private owner is working on a drainage improvement project. City has no easement here.	CIP project is needed
9	Dellwood Lane Area	1995	Yes	Minor improvements constructed in 2006. Creek restoration in Oak Creek will be completed in 2011.	CIP project is needed
10	Bonita Elementary School	2008	No	Minor site flooding and no positive drainage system north side of Dean St.	CIP project is needed
11	Imperial Harbor Subdivision	1990	Yes	Long flooding history due to development to the south, complicated situation with local stakeholders.	CIP project is needed
12	Arroyal Mall	1995	No	Caused by the poor maintenance of the downstream ditch. No flood complaints recently.	No CIP project suggested
13	Tropic Acres Drive Area	2008	Yes	See Comment for No. 7 - Shangri-La Road Area.	No CIP project suggested
14	Industrial Street Area	2010	No	Caused by the poor maintenance of the discharge pipe. No easement or ROW for the discharge pipe.	CIP project is needed
15	FPL & Terry Road	2010	No	Minor flooding at the local access road. No property damage.	No CIP project suggested
16	Pinecrest Subdivision - North Region	1995	No	No flood complaint is reported within past five years.	No CIP project suggested

9 Level of Service and Prioritization

The existing Level of Service (LOS) and prioritization methodology for the City of Bonita Springs Stormwater Management Plan (SMP) was established in the 2002 City of Bonita Springs SMP. The LOS and prioritization methodology is restated in this section.

9.1 Level of Service Standard Review

LOS is defined by the Department of Community Affairs (DCA) as "an indicator of the extent or degree of service provided by or proposed to be provided by a facility based on and related to the operational characteristics of the facility." DCA defines facilities as "solid waste, sanitary sewer, stormwater, and potable water facilities." The existing LOS provided by City stormwater infrastructure is evaluated based on the severity or return frequency of a given flooding event.

The city Land Development Code (LDC) has established development standards for new stormwater manage systems (Ordinance No. 05-03). In general, the city LDC requires the new stormwater management system to be designed to meet or exceed SFWMD requirements. However, there are no LOS criteria for stormwater infrastructure that function below what would be considered an LOS of “A.”

LOS values typically range from A through F. A LOS of "A" equates to essentially negligible flooding. Systems in this category function at or above the acceptable requirements established by a municipality. A LOS of "C" represents tolerable flooding that allows public infrastructure to function below ideal operating conditions. A LOS of "F" represents an unacceptable level of flooding that presents a safety hazard to the public as well as natural resources. LOS values of "B", "D", and “E” represent gradations between the above-referenced LOS definitions.

Table 9-1 at the end of this section sets forth a detailed summary of the LOS standards, which is adopted from the existing City of Bonita Springs SMP report. The LOS was evaluated for each modeled subbasin according to the standards listed in Table 9-1 and the results are presented in Figure 9-1 and Table 9-2.

9.2 Evaluation of Prioritization Methodology

CIP projects to resolve stormwater management needs are generally ranked in an order that indicates their relative importance to one another. Based on the assessment of collected data and the existing conditions model results, it is possible to evaluate the priority ranking for the eight recommended CIP projects listed in Table 8-1. The drainage inventory geodatabase developed in Phase 1 of this project (Section 5) has also assisted in the evaluation.

The prioritization methodology from the 2002 report was adopted in this SMP update. The methodology of prioritization is divided into six (6) evaluation categories as follows:

1. Public Safety, Health and Welfare
2. Duration of Problems
3. Beneficiary Scope
4. Existing LOS Rating
5. Public Interest/Sensitivity (optional)
6. Deduction Potential (optional)

Category 1 - Public Safety, Health and Welfare. This category offers higher point values to projects that severely endanger public safety, health and welfare such as major flooding to multiple habitable structures or public property. The maximum point value in this category is 25.

Category 2 - Duration of Problem. This category offers a higher point value for projects that have the longest history of flooding problems. The maximum point value in this category is 5.

Category 3 - Beneficiary Scope. This category relates the number of residents (or beneficiaries) that will potentially benefit from a particular CIP project. The greater the number of dwelling units benefiting from an improvement project, results in higher point values under this category. The maximum point value in this category is 20.

Category 4 Existing LOS Rating. The definition of the existing LOS rating methodology has been addressed in Section 9.1. The maximum point value in this category is 25.

Categories 5 and 6 are optional. Category 5 accounts for public sentiment that may result from a long-standing or controversial flooding problem. Category 6 may be utilized to deduct points from flooding problems caused by the failure of private property owner's ability to maintain their stormwater infrastructure.

Upon evaluating the number of points awarded for Categories 1 through 6 in Table 9-3, the priority ranking is summarized in Table 9-4 for the eight CIP projects recommended in Section 8. The Top three (3) CIP projects are as follows:

1. Flood Area #3 - Windsor Road Area
2. Flood Area #11 - Imperial Harbor Subdivision
3. Flood Area #7 - Michigan Street Area

For the top three CIP projects - #3 Windsor Road Area, #11 Imperial Harbor Subdivision, and #7 Michigan Street Area, the roadway and site flooding in the neighborhood have been a long-endured problem in excess of 20 years. Local residents have experienced frequent roadway and site flooding as well as scattered property flooding. After the discussion with the City staff, 10 extra points were awarded to the top three CIP projects, as listed in Category 5 of Table 9-4.

For Flood Area #8 (the Enterprise Avenue Area – Section 8.8), the flooding problem is mainly caused by the lack of stormwater infrastructure for the local roads (Enterprise Avenue and K-Nine Drive). The city does not own the required easement or Right-Of-Way (ROW) to perform maintenance or operation activities in this area. The private owner is currently working on a drainage improvement project at his own cost. This project involves the installation of a series of 16" PVC pipes. Due to the involvement of a private owner, the city may not be interested in planning any drainage improvements in this area. Upon the consideration of factors mentioned above, 5 points were deducted for this CIP project, as listed in Category 6 of Table 9-4.

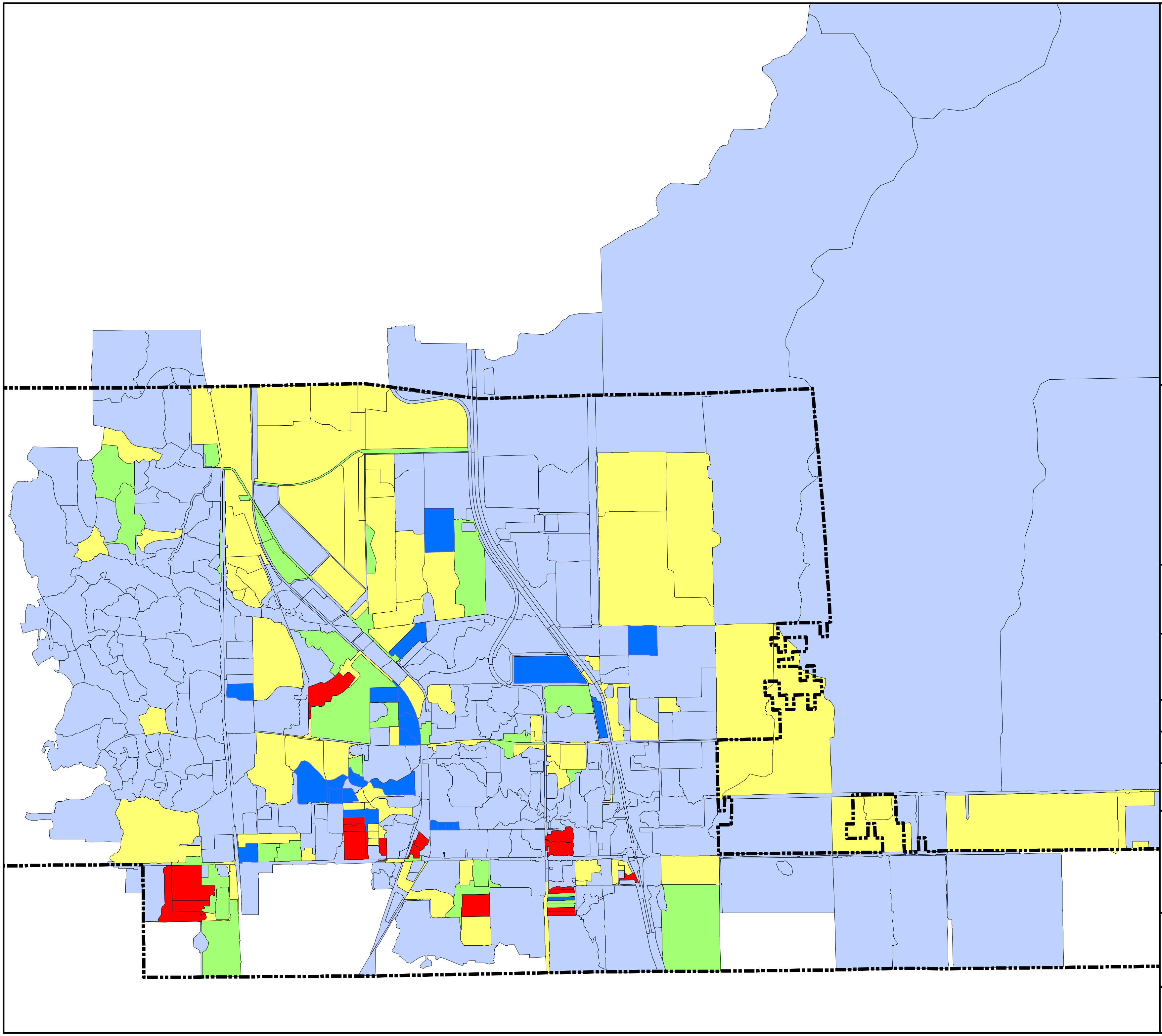
In Flood Area #14 (the Industrial Street Area – Section 8.14), property owners and employees of the Industrial Commercial Park experienced site and roadway flooding during recent storms. Based on the review of drainage inventory geodatabase and field observations, two catch basins were found to be silted with sediment and the discharge pipe of the catch basins was blocked completely. This flooding problem is primarily caused by poor maintenance of catch basins and the drainage system pipe. Therefore 6 points were deducted for this CIP project as listed in Category 6 of Table 9-4.

9.3 Figures & Tables Descriptions

The figures and tables discussed in this section are summarized below:

Figure #	Description
9-1	Existing Level of Service

Table #	Description
9-1	LOS Goals Evaluation Criteria for Stormwater
9-2	Summary of Estimated LOS for Existing Stormwater Infrastructures
9-3	Recommended Prioritization Methodology for Ranking CIP Projects
9-4	Summary of CIP Project Priority Ranking List



City of Bonita Springs Stormwater Master Plan

Existing Level of Service

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig9_1

Figure 9-1

[1]**Table 9-1**
LOS Goals Evaluation Criteria for Stormwater Infrastructures

DESCRIPTION	LOS RANKING					
	A	**B**	**C**	**D**	**E**	**F**
Retention/Detention Facilities						
Water Quality Treatment [2]	Achieves the City's design standards.	Does not achieve the City's design standards but provide some dry retention.	Does not achieve the City's design standards but some dry swale or pond retention with soil saturation limited to the bottom.	Does not achieve the City's design standards and standing water present or facility does not recover properly	Does not achieve the City's design standards, and wet swale, or only minor structural BMP's with no storage.	No water quality treatment provided.
Peak Rate Attenuation	Achieves the City's design standards and maintains 100-year/72-hour storm event within the facility	Achieves the City's design standards and maintains 25-year/72-hour storm event within the facility	Achieves the City's design standards	Does not achieve the City's design standards but maintains mean annual event within the facility	Does not achieve the City's design standards and does not maintain mean annual event within the facility	No peak rate attenuation provided.
Collection/Conveyance Facilities						
Primary Closed Conveyance System[3]	HGL occurs below 12"of the gutter or edge of pavement elevation for the 10-year design storm.	HGL occurs below 6" of the gutter or edge of pavement elevation for the 10-year design storm.	HGL occurs at gutter or edge of pavement elevation for the 10-year design storm	Half exterior travel lane not submerged or presence of significant inlet bypass during the 10-year design storm	Entire travel lane submerged to a depth not exceeding 1" at centerline during 10-year storm.	Entire travel lane submerged to a depth not exceeding 3" at centerline during 10-year storm.
Secondary Closed Conveyance System[4]	HGL occurs below gutter or edge of pavement elevation for the 10-year design storm	HGL occurs at or not exceeding 1" above the gutter or edge of pavement for the 10-year design storm.	Half exterior travel lane not submerged or presence of significant inlet bypass during the 10-year storm	Entire travel lane submerged to a depth not exceeding 1" at centerline during 10-year storm.	Entire travel lane submerged to a depth not exceeding 6" at centerline during 10-year storm.	Entire travel lane submerged to a depth exceeding 6" at centerline during 10-year storm.

Notes: HGL = Hydraulic Grade Line

Table 9-1 (Continued)
LOS Goals Evaluation Criteria for Stormwater Infrastructures

DESCRIPTION	LOS RANKING					
	A	**B**	**C**	**D**	**E**	**F**
Collection/Conveyance Facilities (continued)						
Open-channel conveyance facilities[5]	HGL occurs 12" below gutter or edge of pavement elevation for the 10-year design storm.	HGL occurs at the gutter or edge of pavement elevation for the 10-year design storm.	HGL occurs above the gutter or edge of pavement elevation but less than half exterior travel lane submerged for the 10-year design storm.	Half exterior travel lane submerged and flood condition maintained within public easements for the 10-year design storm.	Flooding condition extends beyond limits of public easement during 10-year storm.	Flooding condition results in damage to property beyond limits of public easement for the 10-year storm.
Miscellaneous drainage structures.	Structures constructed and performing in accordance with City, FDOT or BMP standards or guidelines.	Structure is currently under-sized by less than 10%, needs minor repair, or requires minor maintenance, but would otherwise qualify for a LOS A.	Structure is currently under-sized by less than 25%, needs intermediate levels of repair, or requires intermediate levels of maintenance, but would otherwise qualify for a LOS A.	Structure is currently under-sized by less than 50%, needs significant repair, or requires significant maintenance, but would otherwise qualify for a LOS A.	Structure exist but is not constructed in accordance with City, FDOT, or BMP standards or guidelines, is currently under-sized by more than 50%, level or needed repair or other condition that presents threat to public safety, health and welfare.	Structure absent where the function structure would serve is required (e.g. manhole junction, energy dissipator, etc.).

Notes:

1. At the time of construction, proposed drainage facilities shall achieve a LOS ranking of "A".
2. According to the scope of work for this SMP update, water quality treatment factor was not considered in the evaluating the LOS.
3. Examples of primary closed conveyance facilities are similar to drainage pipes serving arterial roadways or master drain systems.
4. Examples of secondary closed conveyance facilities are similar to drainage pipes serving local or collector roadways.
5. Examples of open channel facilities are canals, ditches and swales.

Table 9-2
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
A0005	A	14	
A0007	A	14	
A0008	A	8	
A0009	A	8	
A0010	B	14	
A0011	A	14	
A0012	A	14	
A0013	A	14	
A0014	A	8	
A0015	A	14	
A0017	A	14	
A0019	A	14	
A0020	A	14	
A0021	A	14	
A0022	A	14	
A0023	A	14	
A0024	B	14	
A0025	C	14	
A0027	A	14	
A0028	A	14	
A0030	A	14	
A0031	A	14	
A0032	A	14	
A0033	A	8	
A0034	A	8	
A0035	A	8	
A0036	A	8	
A0037	A	8	
A0038	A	8	
A0039	A	8	
A0050	E	14	Flood Area #3 - Windsor Road Area
A0060	E	14	Flood Area #3 - Windsor Road Area
A0070	E	14	Flood Area #3 - Windsor Road Area
A0080	A	15	
A0081	A	15	
A0082	A	15	
A0085	A	9	
A0086	A	9	

[1] Index Sheet Number was labeled in Figure 5-12.

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
A0087	D	9	Brighton Ln is flooded in 5-yr storm, but no site flooding
A0088	A	9	
A0090	B	15	
A0100	D	15	Flood Area #12, Arroyal Mall/Crown Lake Blvd
A0105	A	14	
A0110	C	15	
A0120	C	15	
A0130	A	15	
A0150	B	14	
A0152	A	14	
A0153	C	14	
A0154	B	14	
A0155	B	14	
A0156	C	14	
A0157	A	14	
A0158	C	14	
A0160	A	15	
A0161	B	15	
A0162	A	15	
A0165	A	9	
A0166	A	9	
A0167	A	9	
A0168	A	9	
A0170	A	15	
A0175	D	15	Patrick St. is flooded in 10-yr storm, but within public easement
A0176	B	9	
A0177	B	9	
A0178	B	9	
A0179	B	9	
A0180	D	15	Wisconsin St. is flooded in 5-yr storm, but no site flooding
A0181	A	15	
A0182	A	15	
A0183	A	15	
A0184	A	15	
A0185	B	9	
A0186	B	9	
A0187	A	9	
A0188	B	15	
A0198	A	9	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
A0200	C	9	
A0210	E	9	Flood Area #11 - Imperial Harbor Subdivision
A0240	D	15	Puo Polo Ln is flooded in 5-yr storm, but no site flooding
A0241	C	15	
A0242	A	9	
A0245	A	15	
A0250	B	15	
A0255	D	15	Flood Area #7 - Michigan Street Area
A0260	D	15	Flood Area #7 - Michigan Street Area
A0265	A	15	
A0280	B	15	
A0282	D	15	Flood Area #7 - Michigan Street Area
A0283	E	15	Flood Area #7 - Michigan Street Area
A0284	E	15	Flood Area #7 - Michigan Street Area
A0285	B	15	
A0286	D	15	Flood Area #7 - Michigan Street Area
A0288	B	15	
A0290	B	15	
A0292	D	15	Flood Area #7 - Michigan Street Area
A0294	E	15	Flood Area #7 - Michigan Street Area
A0296	E	15	Flood Area #7 - Michigan Street Area
A0300	B	15	
A0301	B	15	
A0305	A	15	
A0310	A	15	
A0315	D	15	Main Dr. is flooded in 10-yr storm, but within public easement
A0320	A	15	
A0330	A	15	
A0340	A	15	
A0363	A	9	
A0365	B	9	
A0370	C	9	
A0400	A	15	
A0401	A	15	
A0402	B	15	
A0410	A	15	Wetland area, no roadway or stormwater infrastructure
A0415	A	15	
A0420	A	15	Wetland area, no roadway or stormwater infrastructure
A0425	A	15	
B0000	B	15	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
B0010	A	15	
B0015	B	15	
B0020	A	15	
B0025	A	15	
B0029	E	15	Flood Area #7 - Michigan Street Area
B0030	A	15	
B0040	A	15	
B0045	A	15	
B0050	A	15	
B0051	C	15	
B0052	B	15	
B0054	A	15	
B0055	A	15	
B0057	A	15	
B0058	A	15	
B0060	D	15	Flood Area #10, Bonita Elementary School
B0062	D	15	Flood Area #10, Bonita Elementary School
B0064	D	15	Flood Area #10, Bonita Elementary School
B0066	D	15	Flood Area #10, Bonita Elementary School
B0070	E	15	Flood Area #14 - Industrial Street Area
B0080	E	15	Flood Area #14 - Industrial Street Area
B0098	A	15	
B0099	A	15	
B0100	A	15	
B0105	A	15	
B0106	A	15	
B0107	A	15	
B0109	B	15	
B0110	A	15	
B0112	A	15	
B0115	A	15	
B0116	B	15	
B0118	A	16	
B0120	A	16	
B0121	A	16	
B0122	A	16	
B0124	A	15	
B0125	C	15	
B0126	B	15	
B0127	C	15	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
B0129	E	15	Flood Area #8 - Enterprise Avenue Area
B0135	A	16	Wetland area, no roadway or stormwater infrastructure
B0140	A	16	
B0145	A	16	
B0146	A	16	
B0150	E	16	Flood Area #9 - Dellwood Lane Area
B0160	E	16	Flood Area #9 - Dellwood Lane Area
B0170	C	16	
B0180	D	16	Flood Area #9 - Dellwood Lane Area
B0190	C	16	
B0200	C	16	
B0210	E	16	Flood Area #9 - Dellwood Lane Area
B0220	E	16	Flood Area #9 - Dellwood Lane Area
B0230	A	16	
B0235	B	16	
B0250	A	16	
B0251	A	16	
B0252	A	16	
B0253	A	16	
B0255	A	16	
B0257	A	16	
B0259	A	16	
B0260	A	16	
B0275	A	16	
B0445	A	16	
B0446	A	16	
B0447	A	16	
B0448	E	16	Depressional area, no resident lives in the vicinity
B0449	A	16	
B0450	A	16	
B0455	A	16	
B0460	C	16	
C0000	A	9	
C0005	D	9	N. Riverside Dr. is flooded in 10-yr storm, but within public easement
C0006	D	9	W. Terry Rd. is flooded in 10-yr storm, but within public easement
C0010	D	9	Pine Ave. is flooded in 10-yr storm, but within public easement
C0015	D	9	Pine Ave. is flooded in 10-yr storm, but within public easement
C0018	A	9	
C0020	A	9	
C0021	B	9	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
C0022	A	9	
C0025	C	9	
C0028	A	9	
C0029	A	9	
C0040	B	9	
C0048	A	9	
C0049	A	9	
C0050	A	9	
C0051	A	9	
C0052	A	10	
C0053	A	9	
C0054	C	9	
C0055	A	9	
C0056	A	9	
C0057	A	10	
C0058	A	10	
C0059	A	10	
C0066	B	9	
C0069	C	9	
C0070	B	9	
C0080	A	3	
C0085	A	4	
C0090	D	9	Wales Lp is flooded in 5-yr storm, but no site flooding
C0096	A	9	
C0100	B	9	
C0110	A	9	
C0120	A	9	
C0130	A	9	
C0132	A	10	
C0135	A	10	
C0140	A	9	
C0142	A	10	
C0145	A	10	
C0150	A	10	
C0151	D	10	Montgomery Dr. is flooded in 5-yr storm, but no site flooding
C0155	A	10	
C0156	A	10	
C0157	A	10	
C0160	A	10	
C0162	A	10	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
C0165	A	10	
C0170	A	10	
C0173	A	10	Wetland area, no roadway or stormwater infrastructure
C0175	A	10	
C0176	A	10	
C0178	A	10	
C0179	A	10	
C0185	A	3	
C0186	A	3	
C0187	A	3	
C0190	A	4	
C0192	A	4	
C0193	A	4	
C0195	A	4	
C0198	A	4	
C0199	A	4	Wetland area, no roadway or stormwater infrastructure
C0200	A	4	
C0205	A	4	
C0210	A	4	
C0215	A	3	
D0002	A	9	
D0004	A	9	
D0005	A	10	
D0006	B	9	
D0007	C	10	
D0011	A	9	
D0012	C	10	
D0013	B	10	
D0014	B	10	
D0017	A	10	
D0018	A	10	
D0019	A	10	
D0020	A	10	
D0025	A	10	
D0030	B	10	
D0040	A	10	
D0042	A	10	
D0045	A	10	
D0050	A	10	
D0051	A	10	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
D0053	A	10	
D0055	A	10	
D0056	B	10	
D0057	A	10	
D0058	A	10	
D0060	B	10	
D0062	B	4	
D0065	A	4	
D0066	A	4	
D0070	B	4	
D0080	A	4	
D0090	D	10	Morton Ave. is flooded in 10-yr storm, but within public easement
D0102	A	10	
D0103	A	10	
D0104	B	10	
D0106	A	10	
D0108	A	10	
D0110	A	10	
D0115	A	10	
E0000	A	15	
E0005	A	15	
E0009	A	16	
E0010	A	16	
E0011	A	16	
E0012	A	16	
E0014	A	16	
E0015	A	10	Wetland area, no roadway or stormwater infrastructure
E0016	A	16	
E0018	B	10	
E0020	A	10	
E0023	B	10	
E0024	A	10	
E0025	C	10	
E0034	A	16	
E0035	A	16	
E0036	A	10	
E0037	B	16	
E0040	A	16	
E0042	A	16	
E0043	A	16	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
E0044	A	16	
E0045	A	16	
E0050	A	16	
E0051	A	16	
E0052	A	16	
E0054	A	16	
E0055	A	16	
E0056	A	16	
E0057	A	16	
E0060	A	16	
E0065	A	16	
E0070	E	16	Flood Area #5 - Imperial Gate Subdivision
E0080	E	16	Flood Area #5 - Imperial Gate Subdivision
E0090	A	16	
E0110	A	16	
E0114	A	16	
E0115	A	16	
E0116	C	16	
E0119	B	10	
E0120	A	16	
E0121	A	16	
E0122	A	16	
E0123	A	10	
E0124	A	16	
E0127	A	16	
E0130	A	16	
E0131	A	16	
E0132	A	16	
E0133	A	16	
E0134	A	16	
E0135	A	16	
E0136	B	16	
E0140	A	16	
E0150	A	16	
E0160	A	16	
E0170	B	16	
E0174	A	16	
E0175	A	16	
E0180	A	16	
E0185	A	16	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
E0195	A	16	
E0196	B	10	
E0197	A	10	
E0198	A	10	
E0199	D	10	Local road is flooded in 5-yr storm, but no site flooding
E0205	A	16	
E0206	A	16	
E0208	A	16	
E0210	A	10	
E0215	A	16	
E0220	A	10	
E0230	A	10	
E0232	A	10	
E0233	A	10	
E0234	A	10	
E0235	B	10	
E0238	A	10	
E0239	B	10	
E0240	A	10	
E0250	A	16	
E0251	A	16	
E0252	A	16	
E0253	A	16	
E0254	A	16	
E0255	A	16	Borrow pit, no roadway or stormwater infrastructure
E0256	A	16	
E0257	A	10	
E0260	A	16	
E0272	A	10	
E0273	A	10	
E0276	A	16	
E0277	B	11	
E0278	B	11	
E0279	A	5	
E0284	A	10	
E0285	A	10	
E0286	A	10	
E0290	A	16	
E0291	A	17	
E0292	A	17	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
E0295	B	16	
E0296	A	17	
E0297	A	17	
E0300	A	17	
E0302	A	17	
E0304	A	17	
E0305	A	17	
E0310	A	17	
E0320	A	18	
E0350	A	18	
E0400	A	17	
E0410	A	17	
E0420	A	16	
E0425	A	16	
E0426	A	16	
E0430	A	16	
E0432	A	16	
E0433	B	16	
E0434	B	16	
E0437	B	16	
F0000	A	17	
F0010	A	17	
F0015	A	17	
F0020	A	18	
F0030	B	18	
F0035	B	18	
F0100	B	11	
F0150	A	17	
F0200	A	16	
F0300	A	1	Outside of the City limit
F0350	A	1	Outside of the City limit
F0360	A	1	Outside of the City limit
F0370	A	1	Outside of the City limit
F0400	B	17	
F0450	B	17	
F0460	A	17	
F0500	A	7	Outside of the City limit
F0600	B	18	
F0700	A	18	
F0800	A	19	Outside of the City limit

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
G0010	A	2	
G0011	A	2	
G0015	A	2	
G0016	A	2	
G0020	A	8	
G0021	C	2	
G0022	C	2	
G0023	A	2	
G0024	B	8	
G0025	A	8	
G0026	A	8	
G0030	A	8	
G0031	A	8	
G0032	A	8	
G0033	A	8	
G0034	A	8	
G0035	A	8	
G0036	A	8	
G0037	A	8	
G0038	A	8	
G0039	A	8	
G0040	A	8	
G0041	A	8	
G0042	A	8	
G0043	A	8	
G0044	A	8	
G0045	A	8	
G0046	A	8	
G0047	A	8	
G0048	A	8	
G0049	A	8	
G0050	A	8	
G0051	A	8	
G0052	A	8	
G0053	A	8	
G0054	A	8	
G0055	A	8	
G0056	B	8	
G0057	A	8	
G0058	A	8	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
G0059	A	8	
G0060	A	2	
G0061	A	8	
G0062	A	8	
G0063	B	2	
G0064	A	2	
G0065	A	8	
G0066	A	2	
G0067	A	2	
G0068	A	8	
G0069	A	8	
G0070	A	8	
G0071	A	9	
G0072	A	8	
G0073	A	9	
G0074	C	8	
G0075	A	2	
G0076	A	9	
G0078	B	9	
G0079	A	9	
G0080	A	2	
G0082	A	2	
G0083	B	2	
G0084	C	2	
G0085	B	2	
G0092	A	9	
G0093	A	9	
G0095	A	9	
G0100	A	9	
G0101	A	3	
G0102	A	3	
G0104	A	9	
G0105	C	9	
G0106	C	3	
G0107	C	3	
G0109	C	9	
G0110	A	9	
G0112	A	3	
G0116	A	3	
G0117	B	3	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
G0118	A	3	
G0125	C	3	
G0130	A	3	
G0140	B	3	
G0145	B	3	
G0153	B	3	
G0155	B	3	
G0157	B	3	
G0168	A	3	
G0170	A	3	
G0175	A	3	
G0180	A	3	
G0189	A	9	
G0190	C	9	
G0192	A	9	
G0194	A	9	
G0195	A	9	
G0196	A	9	
G0197	A	9	
G0198	A	9	
G0200	A	9	
G0201	A	9	
G0205	B	9	
G0211	A	9	
G0212	B	3	
G0214	A	3	
G0215	A	3	
G0217	B	3	
G0225	B	9	
G0230	C	9	
G0240	B	9	
G0250	B	9	
G0270	B	3	
G0272	B	3	
G0275	C	9	
G0280	A	3	
G0285	A	3	
G0300	A	3	Wetland area, no roadway or stormwater infrastructure
G0310	D	3	Wood Ibis Ave. is flooded in 10-yr storm, but within public easement
G0380	A	2	

Table 9-2(Continued)
Summary of Estimated LOS for Existing Stormwater Infrastructures

SUBBASIN	LOS	INDEX SHEET[1]	COMMENTS
G0381	A	2	
G0382	A	2	
G0383	A	2	
G0384	B	2	
G0385	A	2	
G0386	A	2	
G0390	A	2	
G0391	A	2	
G0392	A	2	
G0395	A	2	
G0396	A	2	
G0397	A	2	
G0398	A	2	
G0400	A	9	
G0410	A	9	
G0420	A	9	
G0430	B	9	
G0440	B	9	
G0450	B	8	
G0460	B	9	
G0470	A	9	
G0480	B	3	
G0485	B	3	
G0490	B	9	
G0500	C	3	

Table 9-3
Recommended Prioritization Methodology for Ranking CIP Projects

1. GENERAL HARM TO HEALTH, SAFETY AND WELFARE OF PUBLIC	
Points Awarded	Description
0	No harm, to the general public.
5	Flooding that causes inconvenience to property owner or public road-way, but does not threaten property damage, health, safety or welfare of public. Erosion causing some inconvenience.
10	Flooding of roads that prevents normal vehicle passage but does not impede the passage of emergency vehicles. Erosion, causing inconvenience and causing minor degradation of downstream water quality. Existing structure has likelihood to cause damage or harm to public. Potential for hydroplaning and other safety problem in large storm events.
15	Property flooding that impounds water/area enough for mosquito breeding, attracts other biotic nuisances, interferes with septic tank systems or otherwise adversely affects safety, health and welfare of residents. Erosion causing minor property damage or downstream water quality degradation. Existing structure does not meet City or State standards for clear zone and has high likelihood for causing vehicular accidents or other public harm.
20	Major flooding of habitable structure. Property damage reported to insurance company or interior flooding. Erosion or stormwater causing major water quality degradation, property damage or public harm. Existing structure resulted in vehicular accidents. Flooding of roads causing significant hydroplaning during frequent rainfall events. Flooding that impede the safe passage of emergency vehicles and services.
25	Major flooding to multiple habitat structures or public property providing essential public services. Water quality may be degraded to levels of toxiCity to plants, wildlife, or people due to stormwater discharges. Existing structure has caused accidents resulting in death.
2. DURATION OF PROBLEMS	
Points Awarded	Description
0	0-1 Years since first noted
1	1-2 Years since first noted
2	2-4 Years since first noted
3	4-8 Years since first noted
4	8-10 Years since first noted
5	Greater than 10 years

Table 9-3 (Continued)
Recommended Prioritization Methodology for Ranking CIP Projects

3. BENEFICIARY SCOPE	
Points Awarded	Number of EDUs[1] Directly Benefiting
0	0
1-4	1-4
5-8	4-10
9-12	10-20
13-16	20-50
17-19	50-100
20	>100
4. EXISTING LOS RATING[2]	
Points Awarded	Existing LOS Rating
0	A
5	B
10	C
15	D
20	E
25	F
5. PUBLIC INTEREST/SENSITIVITY (OPTIONAL)	
Points Awarded	Description
0-10	Subjective, based upon intangible or other miscellaneous factors known by City staff, City Council, City Manager, or City Engineer. Such factors should be specified if any credit given.
6. DEDUCTION POTENTIAL (OPTIONAL)	
Points Deducted	Description
0-10	Subjective, based on portion of a flooding problem being caused by private property deficiencies such as not maintaining their privately owned exfiltration system or not repairing a failed control structure. Such factors should be specified if any deductions are given.

Notes:

1. Equivalent dwelling unit (EDU) is one residential structure or a commercial use or business equal to a specified contributing area, in square feet, as calculated for a “typical” residential unit. Assume 2,000 SF of residential or commercial building = 1 EDU.
2. The guidelines for evaluating the Level of Service (LOS) provided by stormwater infrastructures are outlined in Table 9-1 of this report. Where the guidelines do not adequately conform to a given situation, judgment shall be used to estimate the LOS in accordance with the relative service expectations indicated by Table 9-1.

Table 9-4
Summary of CIP Project Priority Ranking List

Priority Ranking	Project Description[3]	Prioritization Ranking Category[1]						Total Points Awarded[2]
		1 (25)	**2** (5)	**3** (20)	**4** (25)	**5** (10)	**6** (10)	
1	(3) Windsor Road Area	20	5	20	20	10	0	75
2	(11) Imperial Harbor Subdivision	20	5	19	20	10	0	74
3	(7) Michigan Street Area	20	5	17	20	10	0	72
4	(5) Imperial Gates Subdivision	20	5	19	20	0	0	64
5	(9) Dellwood Lane Area	20	5	14	20	0	0	59
6	(8) Enterprise Avenue Area	20	3	14	20	0	5	52
7	(14) Industrial Street Area	20	0	16	20	0	6	50
8	(10) Bonita Elementary School	10	1	13	15	0	0	39

Notes:

1. Table 9-3 sets forth the basis for the number of points awarded under Categories 1 through 6.
2. Total points awarded after summing point values in Categories 1 through 6.
3. Numbers in parenthesis preceding each project is the Flood Area No established in Section 8 of this report.

10 Operation & Maintenance & Repair and Replacement

10.1 Current Practices

When the City of Bonita Springs was incorporated in 1999, city officials committed to the residents that they would operate on a "government light" philosophy. As such, the city currently has implemented the existing 2002 Stormwater Management Plan (SMP) to carry out the day-to-day functions for effective stormwater management within the city limits. There were thirteen Capital Improvement Plan (CIP) projects identified in the 2002 SMP and most of these projects have been designed and constructed by the city over the past eight years. The city also prepares an annual report detailing the progress of the initiated CIP projects, the progress of the inventory and mapping of the drainage facilities, a list of stormwater infrastructures in need of maintenance or replacement, and various activities under NPDES permits.

Since 2000, the city has gradually taken charge of the maintenance and operation of stormwater infrastructure, previously maintained by Lee County. Currently, the Public Works Manager has a list of about 20 contractors that perform engineering, permitting, and construction services related to the practice of stormwater management. This contract agreement has been in place for over two years. Lee County still maintains several major roads within the city limits including Bonita Beach Road, Bonita Grande Drive and Hickory Boulevard, and the county's responsibilities on city-maintained roads are limited to traffic signal maintenance.

According to the city record, the city roadway and drainage maintenance budget for the past few years has averaged $700,000 per year. This budget does not include costs for independent engineering consultant and is limited to construction and maintenance contractor costs. As estimated by city staff, the drainage maintenance budget may be broken-down in to three categories:

- Swale and Ditch Maintenance: $ 85,000
- Canal Maintenance: $ 15,000
- Street Maintenance: $ 600,000

The "Street Maintenance" category covers the cost of street sweeping and of storm sewer pipes cleaning, in addition to other regular maintenance activities, such as street lighting, mowing, and curb and shoulder repair.

The development of the drainage inventory geodatabase in Phase 1 (Section 5) and the stormwater management model in Phase 2 of this SMP update (Section 6) provides the city with a more efficient means of prioritizing necessary maintenance to meet stormwater management needs. . The drainage inventory focused efforts on city jurisdictional areas. The, city defers all maintenance issues to the appropriate HOA organization and therefore does not maintain inventory in HOA areas.

10.2 Canals, Creeks, and Ditches

Data from the city indicates that over 26 miles of rivers, creeks and canals exist within the city limits. This total includes the main waterways of the Imperial River, Spring Creek, Leitner Creek and Oak Creek as well as other significant canals and ditches. Roadside drainage swales are not included in this total.

The city staff indicated that since 2000 the City of Bonita Springs has gradually taken charge of the maintenance and operation of canals, creeks and ditches that were previously maintained by Lee County. This was accomplished by contracting either with Lee County maintenance crews or independent contractors. As documented by the geodatabase developed during this SMP update, the total length of the city maintained canals, creeks and ditches is about 38,360 feet or 7.27 miles.

Table 10-1 at the end of this section lists the canals, creeks and ditches on the city's current maintenance list. This table contains the ID, name, length, and location description for each canal. The locations of these canals, creeks and ditches are presented in Figure 10-1 in this section.

The Florida Department of Environmental Protection (FDEP), SFWMD and the United States Army Corp of Engineers (USACE) all have jurisdiction over most of the city's canals and drainage ditches. FDEP has delegated much of its authority to the state's five (5) Water Management Districts (WMDs). Among this authority is statewide dredge and fill activities. The removal of material from canals (for sediment maintenance of excavation purposes) is considered a dredging activity, requiring permits if the canal systems are larger than WMD-derived size thresholds for surface water systems. The placement of material in canals is considered to be a filling activity which also requires permits if the volume of material to be deposited exceeds a certain threshold size.

The USACE also has jurisdiction over many of the canals in the city. Canal jurisdiction under USACE is regulated using two categories. These categories are Section 10 and Section 404 of USACE's canal regulations.

Section 404 of the USACE's canal regulations was instituted as part of the Federal Clean Water Act. Canal maintenance under this category has the least restrictive regulations of the two categories. Permits are not required for dredging operations in Section 404 canals. However a permit is required to place fill material within Section 404 Canals.

Section 10 of the USACE's canal regulations was instituted as part of the Rivers and Harbors Appropriation Act of 1899. This regulation governs jurisdictional canals that are navigable and/or tidally influenced. Canals or other surface waters under this category, such as the Imperial River have more onerous permitting requirements than Section 404 canals. Obtaining permits to allow dredging in Section 10 canals can be a very time consuming process depending on the magnitude of the project.

10.3 Estimated Operation &Maintenance and Repair & Replacement Costs

A stormwater master plan must include the following elements to maintain the City's infrastructure at an LOS that protects the health, safety and welfare of the public:

- Cost estimate for Operation & Maintenance (O&M) of stormwater infrastructure
- Cost estimate for Repair & Replacement (R&R) of stormwater infrastructure when it has exceeded its useful life
- Cost estimate for the recommended CIP alternatives as identified and prioritized in Sections 8 and 9

Table 10-2 summarizes estimated expenses that should be included in the city's annual operating budget for O&M and R&R of stormwater infrastructure. This cost also includes the estimated quantity of stormwater infrastructures including: 1) control structures/inlets/manholes; 2) drainage pipes; 3) roadside swales; and 4) canals, ditches & creeks. The stormwater infrastructure inventory geodatabase completed in Phase 1 of this project was used to estimate the quantities of the city maintained infrastructures under each category. The unit costs for new construction of stormwater infrastructure are based on representative values from the most recent FDOT pay item cost history for the region. The detailed assumptions used in establishing the quantities and percentages related to the O&M and R&R costs are listed in the foot notes at the bottom of Table 10-2.

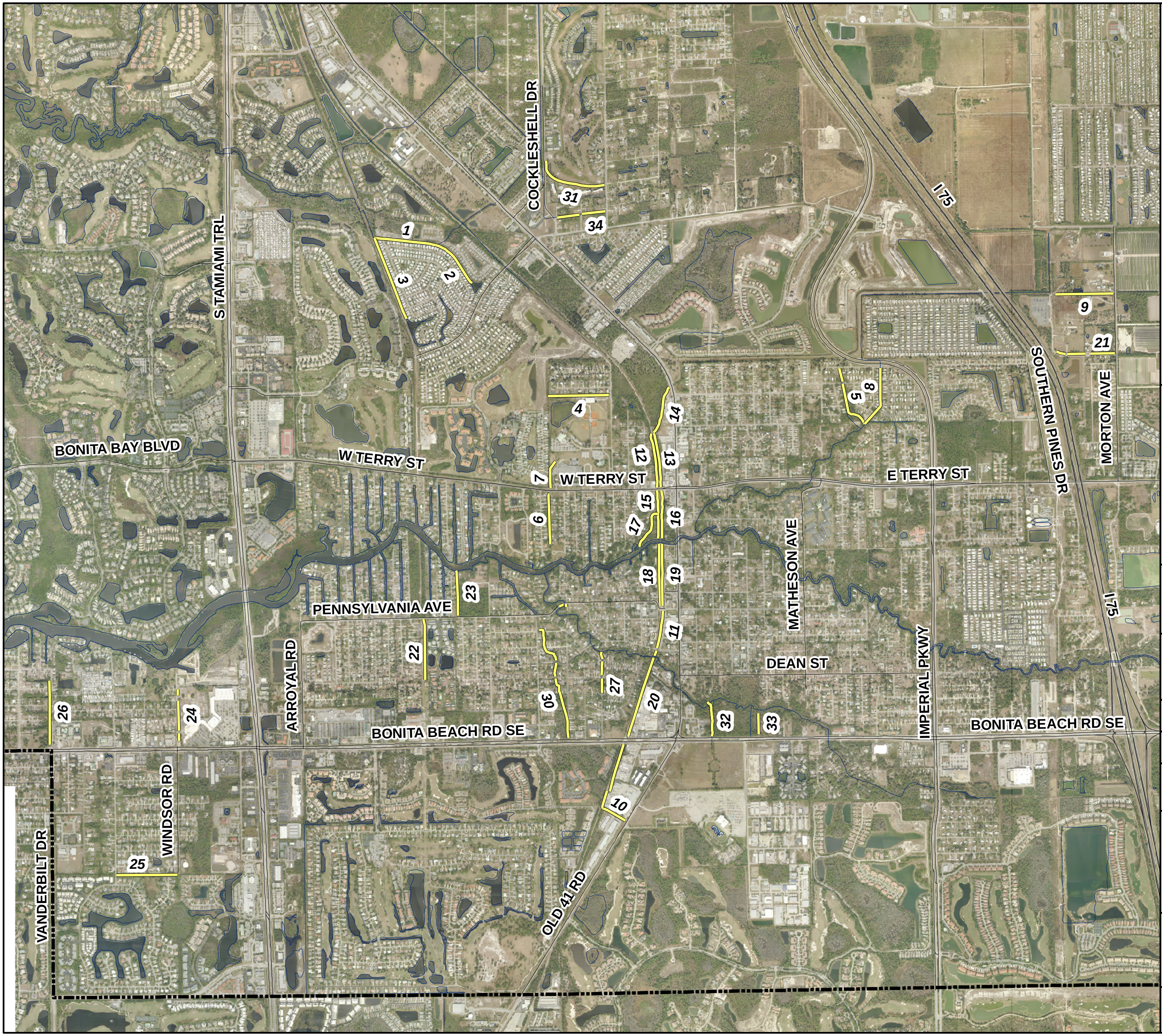
In summary, the total estimated cost is $867,828 per year, including $416,413 for O&M cost and $451,415 for R&R cost.

10.4 Figure & Tables Descriptions

The figures and tables discussed in this section are summarized below:

Figure #	Description
10-1	City Maintained Canals, Creeks, and Ditches

Table #	Description
10-1	Summary of City Maintained Canals, Creeks, and Ditches
10-2	Estimates of Average Annual Operation and Maintenance and Repair and Replacement Costs



Legend

Feet

0 750 1,500 3,000

- CityLimits
- City Maintained Canals
- Major Road

City of Bonita Springs Stormwater Master Plan

City Maintained Canals, Creeks, and Ditches

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig10_1

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 10-1

Table 10-1
Summary of City Maintained Canals, Creeks, and Ditches

ID	Name	Location Description	Length (feet)
1	Imperial Harbor E/W Ditch	North side Imperial Harbor - Access at the end of Countess Ln	1,300
2	Pueblo Bonito Lateral	Runs along east side of Imperial Harbor - Access along easement off Pueblo Bonito Dr	1,134
3	Imperial Harbor Powerline	Runs north from back side of Imperial Harbor Subdivision to marsh. - Access at the end of Imperial Harbor Dr	1,827
4	Pine Ave Ditch	North end of City Recreation Center Property - access at park	1,266
5	Leitner Creek North Trunk	Access off Torchfire Trail	1,347
6	Richview Lateral	West side of Richview Ct	1,059
7	Bonita Middle School	Runs South on West side of school and City Recreation Center properties.	586
8	Leitner Creek Bypass Canal	Access from Wagon Trail Rd.	1,295
9	Morton Ave Canal North	Access at 26300 Morton Ave	1,223
10	Cox Lumber E/W	South of Cox Lumber Property - E/W Ditch	548
11	CSX RR Ditch Pennsylvania/Oak Creek	East side of CSX RR tracks.	911
12	CSX RR-N of W Terry St/West Side of RR	West side of RR, North to where creek goes under tracks.	1,150
13	CSX RR-N of W Terry St/East Side of RR	East side of RR, North to where creek goes under tracks.	1,149
14	Rosemary Canal-Behind Buffalo Chips	Behind Buffalo Chips, south to survey marker	1,020
15	CSX RR-N of Imperial River/W side of RR	Access from W Terry St and CSX RR	1,013
16	CSX RR-N of Imperial River/E side of RR	Access from W Terry St and CSX RR	1,008
17	Island Park Canal	Access via S Riverside Dr	894
18	CSX RR-S of Imperial River/W side of RR	Access from Depot Park/ Pennsylvania Ave	1,307
19	CSX RR-S of Imperial River/E side of RR	Access: Riverside Park	1,294
20	CSX RR- Cox Lumber to Oak Creek/E of RR	Bonita Beach Rd and CSX RR-South to Cox Lumber, North to Oak Creek	3,135

Table 10-1 (Continued)
Summary of City Maintained Canals, Creeks, and Ditches

ID	Name	Location Description	Length (feet)
21	Suncrest Ln Ditch, north side	Suncrest Ln off Morton, north side	1,082
22	Pelican Ridge Outfall Ditch	East of Pollard Drive, south off Pennsylvania along FPL Easement to chain link fence.	1,283
23	Pennsylvania Ave/ E of Johnson St	Runs north from Pennsylvania Ave. to Imperial River	941
24	Winsor Rd Ditch	Windsor Rd North to Imperial River	926
25	Vanderbilt Lakes Lateral	Inside Vanderbilt Lakes along north boundary line.	1,280
26	Luke Street Lateral	Luke St - west side, from Bonita Beach Rd to Imperial River	1,335
27	Iowa St North	On north end of Iowa St, from Georgia St to Oak Creek	759
28	Pennsylvania @ Oak Creek	South side of Pennsylvania Ave, west of Oak Creek.	94
29	Pennsylvania @ Oak Creek East Side	Unknown	70
30	Michigan St Ditch	Between Michigan and Washington St, from Bonita Beach Rd to Delaware St.	2,446
31	Bonita Springs CC/Cockleshell Ditch	E/W Ditch on S Border of Bonita Springs Country Club, Between Cockleshell Dr and Paradise Rd	1,517
32	Oak Creek Ditch-BB RD, W of Glenbrook Ln	N/S Ditch on Bonita Beach Rd	757
33	Oak Creek Ditch-BB RD, E of Harold St	N/S Ditch on Bonita Beach Rd	443
34	Southern Pines	Between Shangri-La Road and Bonita Springs Country Club, from Paradise Rd to Noel Ln	958
		Total Length in feet:	**38,360**

Table 10-2
Estimates of Average Annual Operation and Maintenance and Repair and Replacement Costs

Description of Existing Stormwater Infrastructure	Unit	Average[1] Unit Cost	New Construction Value Quantity[2]	New Construction Value Replacement Cost[3]	Annual Operation & Maintenance %[4]	Annual Operation & Maintenance O&M Cost	Annual Repair & Replacement %[5]	Annual Repair & Replacement R&R Cost
1. Control Structures/Inlets/Manholes	EA	$1,500	4,595	$ 6,892,500	3	$ 206,775	2	$ 137,850
2. Drainage Pipes	LF	$ 30	216,776	$ 6,503,280	3	$ 195,098	2	$ 130,066
3. Roadside Swales	LF	$ 15	407,776	$ 6,116,640	N/A[6]	N/A	3	$ 183,499
4. Canals, Creeks & Ditches	Miles	$10,000	7.27[7]	$ 72,700	20[8]	$ 14,540	N/A	N/A
Sub Total						$ 416,413		$ 451,415
Total Estimated Average Annual Cost						**$ 867,828**		

1 The unit costs represented in this column are based on representative values estimated from the item average unit cost of the most recent FDOT Pay Item History.

2 The quantities for Item Nos. 1, 2, 3 & 4 are based on the stormwater infrastructure inventory geodatabase, as described in Section 5 in this report.

3 This program does not include the costs associated with administrative issues, payroll, equipment, nor O&M programs such as street sweeping which have already been accounted for in the annual budgeting of the General Fund. Additional equipment purchases are also excluded since these items have also been historically accounted for in annual budgets. This table addressed these O&M and R&R costs that are historically missing for municipal annual budget needs.

4 The percentage given is an estimate of the annual costs of O&M that should be allocated to structures based on a percentage of their approximate replacement value.

5 Assumed that life of a structure varies from 30 to 50 years depending upon the structure. 50 years for control structures/inlets/manholes, 50 years for drainage pipes, and 30 years for roadside swales.

6 Routine maintenance understood to already be in City budget as mowing. Repairing disfunctioning swales usually required complete renewal and replacement (re-excavating and sodding), thus no O&M costs is considered herein, only R&R.

7 The quantity for Item No. 4 (Canals/Creeks/Ditches) is estimated in Table 10-1. Based on engineer's past project experience, unit cost of $10,000 per mile was estimated for new construction of canals/ditches.

8 Assumed dredging costs at 20% of initial construction cost and maintenance occurs over 5 years.

11 Preliminary Stormwater Analysis and Alternatives

11.1 Preliminary Stormwater Analysis

As described in Section 8, sixteen areas were identified having flooding problems. Figure 8-1 illustrates the locations of these flood-prone areas. Upon the preliminary engineering analysis, eight CIP projects were recommended as part of the City's new CIP program. These eight CIP projects were further prioritized using the prioritization methodology presented in Section 9 of this report. For the top three ranked CIP projects in Table 9-4, a detailed alternative analysis was performed in the following sections. For the remaining five CIP projects, only one preliminary engineering cost was provided. We recommend that the city include a total of eight CIP projects in their 10-year CIP program. As additional flooding problem areas are identified, the CIP program can be expanded as needed by the city to accommodate additional projects if the funding is available.

The top three ranked projects have been analyzed for potential alternatives to alleviate flooding. These projects include:

1. Windsor Road Area (Flood Area #3)
2. Imperial Harbor Subdivision (Flood Area #11)
3. Michigan Street Area (Flood Area #7)

The flooding throughout the city is generally a result of one of four categories below or a combination thereof. They are as follows:

1. <u>Sufficient Stormwater Infrastructure in Place</u>
   The tail water or receiving water system backs up into the upstream areas, thereby causing flooding. In these areas, stormwater infrastructure may have adequate flow capacity; however the design and construction of the system may have assumed tailwater (receiving waters such as a river, creek or ditch) conditions significantly lower than actual flood condition levels. This happens when a designer assumes that the flood stage in a creek or ditch is significantly lower than the actual stage, due to the lack of field data.

2. <u>Undersized Infrastructure</u>
   In this category, reasonable tail water assumptions are made thereby preventing the backup of floodwaters into the stormwater management system. However, the existing stormwater infrastructure may be undersized because the designer may not have accounted for the total contribution area, including the offset area flowing into a stormwater management system.

3. Unmaintained Stormwater Infrastructure
   Sometimes the only remedy action required to address localized flooding is maintenance of stormwater infrastructure. The infrastructure may have adequate size; however, the buildup of sediment in a ditch, pipe or catch basin will reduce the flow capacity.

4. No Stormwater Infrastructure
   There are many areas in the city that have no stormwater infrastructure. The lack of stormwater structures will contribute to flooding.

The flooding in the Windsor Road Area (Flood Area #3) attributes to both Categories 2 and 3. The historic drainage pattern has been dramatically altered due to the development in the past four decades, including Woods Edge PUD to the southeast, Vanderbilt Lakes Subdivision to the south and Catholic Church of St. Leo to the east. Based on the recent drainage study by the City in 2010, the residential area in the Vanderbilt Lake Subdivision and other offset areas also contribute to the permitted stormwater system of the Windsor Road, which means the permitted stormwater infrastructure based on a smaller contribution area was apparently undersized. Regarding the Category 3 flooding problem, one of two cross-drains under the Beaumont Road was found to be blocked because of the heavy vegetation downstream of Beaumont Road. This means the wetland area east of Windsor Road will not drain to the east into the US 41 roadside swales until the elaborated invert elevations are reached. Additionally, according to ERP document for Vanderbilt Lake Subdivision (ERP No. 36-00254), part of the flood area (about 50 acres) was reported to join the stormwater system of Audubon Country Club to the west through a perimeter swale along the south border of the Vanderbilt Lake Subdivision and a 42” RCP pipe under Vanderbilt Drive. The ultimate outfall of the Audubon Country Club stormwater system is the Little Hickory Bay. However, this permitted perimeter swale system has never been constructed; therefore the natural flow way to the Little Hickory Bay was totally blocked and never restored.

The Imperial Harbor Subdivision (Flood Area #11) could be classified under Category 2. The flood area drains to an offset lake to the south which is located in another subdivision, Bonita Fairways Subdivision. This offset lake is drained through a series of 15” PVC pipes which are ultimately connected to the Imperial River. The outfall pipes were under-sized and are the primary cause of the roadway and site flooding in the residential area upstream. A second outfall point was added in 2005 to drain the lake to the stormwater system to the south thru a series of 24” RCP pipes with a flap gate. However, due to the high water levels of the ponds downstream, the additional discharge from the offset lake is limited and could not significantly reduce the lake peak stages as expected. The roadway grade elevations and building finished floor elevations were likely based on historic conditions prior to the development of the Bonita Fairways Subdivision.

The Michigan Street Area (Flood Area #7) flooding problem is a combination of both Categories 1 and 2. Historically, the surface water runoff from west side of Michigan Street drains to the unnamed natural flow way system, then to the Imperial River.

Currently, only one cross-drain was found under Michigan Street just south of Carolina Street beside a series of side-drains along both sides of Michigan Street. These undersized stormwater structures are the primary cause of the local roadway and periodic property flooding during a local storm event. For the bigger storm events like the 25 or 100-year storm events, the Imperial River exceeds its capacity and flood stages reach above the banks and flood the residential area close to the river. Many of the roadway grade elevations and building finished floor elevations were likely based on historic conditions prior to the regional changes in drainage pattern due to land development.

11.2 Methodology of Alternative Analysis

For the top three CIP projects, three alternatives were developed and evaluated to address the flooding problem. The 10-year design storm event was used to establish a proposed LOS for the stormwater infrastructure in the flood areas. As stated in Section 6, the existing conditions model in ICPR was developed and calibrated. The proposed conditions model for each recommended alternative was developed by implementing the proposed drainage improvement components.

The alternatives were then compared with respect to effectiveness in alleviating the flooding problems, implementing cost, maintenance requirements, permittability, feasibility, water quality benefits, and public acceptance.

The stormwater management modeling that was completed for this study is at the planning-level and is intended to assist the City in evaluating alternatives to alleviate flooding. Once the City decides to undertake the final engineering design for any of the alternatives below the modeling and design will be refined with accurate field survey and additional calibration.

There are numerous alternatives that could be implemented to manage stormwater in the watershed. In general these alternatives can be classified as structural or non-structural in nature. Structural alternatives refer to the construction of facilities which divert, contain, or transport channel flow, such as channels, control structures or reservoirs. Non-structural alternatives utilize techniques which do not physically modify the natural stream. Examples are floodplain management regulations, stormwater management ordinances for new developments, maintenance of systems, wetland protection ordinances, and zoning regulations.

Typical structural alternatives include the following and are mainly considered for this SMP update project:

1. <u>Channel Improvements:</u> Alternatives which increase channel capacity to carry flood flows resulting in lower flood elevations, for example:

    - Channel clearing and snagging
    - Regrading and stabilization

- Channelization (widening and/or deepening)
- Removal of constrictions and/or obstacles
- Flood levees

2. Diversion Channel: Flow channels which divert flooding out of the stream channel into another basin or downstream reach.

3. Structure Replacement or Rehabilitation: Replace or refurnish an undersized drainage structure at roadway or channel crossings.

4. Retention/Detention Pond: Reduce peak flows with off-line flood detention/retention storages.

5. Floodproofing: Protect individual structures or groups of structures within a floodplain.

Typical non-structural alternatives include:

1. Floodplain Management and Regulations Preservation of, or controlled land used within, the floodplain, and stormwater management regulations for new development to prevent future flooding problems.

2. Land Use Controls Zoning for future development to limit impervious cover concentrations and manage growth.

3. Land Acquisition Purchase of flood-prone properties for park land or conservation areas.

4. Flood Insurance Provide insurance for structures which can't be protected by other affordable alternatives.

11.3 Windsor Road Area

Windsor Road Area is a residential area that has been developed in the past four decades with little consideration of drainage. Based on the analysis of collected data, the existing outfall systems of the flood area are identified as: 1) Windsor Road System to the Imperial River; 2) Beaumont Road System to US 41 box culverts; and 3) Woods Edge PUD System to US 41 box culverts.

History of the first outfall system started in 2001 by the City. History shows a 30" RCP pipe and three control structures that connected the Imperial River to the north along the Windsor Road. The discharge capacity was limited by the allowable peak discharge to the Imperial River (8.76 cfs for 25-year/72-hour design storm) and could only partially relieve the flooding problem. The control elevation was 9.5 ft-NGVD at the control structures.

When the water level in the flood area rises higher the stormwater will overflow to the second outfall system including the wetland area between Windsor Road and Beaumont Road and the cross-drains under Beaumont Road. The stormwater then reaches the US 41 box culverts to the east. This outfall system is a secondary drainage system for the flood area and its discharge capacity is limited by the poor-defined flow way in the wetland area. Contributing to the limited flow capacity are the under-sized cross-drains under Beaumont Road as well as the high tailwater at the US 41 box culvert. The control elevation of this system is 9 ft-NGVD at the cross-drains under Beaumont Road.

For the third outfall system, the stormwater first drains to the wetland area between Vanderbilt Lake Subdivision and Woods Edge PUD through an overland flow weir. This wetland area is also a part of the stormwater management system of Woods Edge PUD. A concrete weir structure with an invert elevation of 9.5 ft-NGVD at northeast corner of Beaumont Road and US 41 acts as the control structure for this system. The receiving water body is the US 41 roadside ditch. The wetland area has another outfall route, according to the ERP document, including a perimeter swale along north property line of the PUD and a roadside ditch and a cross-drain under Beaumont Road. The roadside ditch along Beaumont Road is currently blocked by the temporary driveways used in the construction of Phase II project of Catholic Church of St. Leo. The invert elevation of the cross-drain is 9.0 ft-NGVD. Similar to the second outfall system, the discharge capacity for this system is limited by the narrow overland weir to the wetland area, poorly-maintained swale system as well as the high tailwater at the US 41 box culverts.

As stated above, this flood area has a very complicated drainage system including multiple outfall systems as a result of the continuous land development since 1980's. Prior to this SMP update project, this flood area has never been evaluated as part of a regional stormwater master plan where all the stormwater management systems of subdivisions in the vicinity were modeled and evaluated.

Note that only part of the outfall systems discussed above is currently under the City's O&M program. According to the ERP documents private owners and HOAs have been responsible for the operation and maintenance of the stormwater management system within their jurisdictional limits. Some flood problems could be omitted if the existing stormwater structures are maintained in fair condition; for example, one cross-drain under Beaumont Road was found to be silted by overgrowth vegetation during the site visit in June 2010. To make sure the recommended alternatives could function as proposed, the following maintenance items listed below have to be included into the City's O&M program. The recommendations should be implemented when the City schedules improvements to the proposed structures in this area. The recommended maintenance items are also presented in Figure 11-1.

- Request the Woods Edge PUD to maintain and clean the perimeter swale along its north property boundary annually prior to the wet season or acquire a drainage easement from the PUD

- Remove the temporary driveway to the Catholic Church of St. Leo and restore the roadside swale along Beaumont Road when the construction of the church is finished
- Make sure the control structures for the Catholic Church of St. Leo are constructed in accordance with the ERP document

Three alternatives were developed and evaluated to address the identified flooding problems in this area. It is assumed that the recommended maintenance activities have been undertaken by the City or private owners. The alternatives are discussed in the following sections.

11.3.1 Alternative No. 1 – Open Ditch to Vanderbilt Drive

According to the ERP document of Vanderbilt Lake Subdivision, part of the flood area was indicated to join the stormwater system of Audubon Country Club to the west through the perimeter swales along the borders of the Vanderbilt Lake Subdivision and a 42” RCP pipe under Vanderbilt Drive. The outfall point of the Audubon Country Club stormwater system is the Little Hickory Bay. Upon review of the USGS map and other documents, this historic flow way should be one of the primary outfall systems for this flood area. However, the perimeter swales along the subdivision borders have never been constructed as documented by the owner in ERP application. So the historic flow way to the Little Hickory Bay was blocked entirely.

The design concept of this alternative is to restore the historic flow way to the Little Hickory Bay. Referring to the 2010 aerial photos, part of the original perimeter swales have been converted into the roadside ditch for the Woods Edge Pkwy. Stormwater then drains south to the Cocohatchee River. The original swale route is no longer feasible. Along the north property boundary, a 30-foot drainage easement was found between Meadowlake Lane and Vanderbilt Drive. This 30-foot easement could be used to construct a swale to link the Windsor Road system to the Vanderbilt Drive roadside ditch.

The conceptual sketch of the drainage improvement components are presented in Figure 11-2 and are listed below:

- A 1,300 feet open ditch between Meadowlake Lane and Vanderbilt Drive, along the north border of the Vanderbilt Lake Subdivision
- Regrade the existing roadside ditch of Vanderbilt Drive from the west end of proposed ditch to the existing 42” RCP, about 1,000 feet in length

The analysis results are summarized in Table 11-1. For Subbasins A0050, A0060, and A0070, the proposed LOS is evaluated as “D”. The preliminary engineering cost estimate for Alternative No. 1 is $107,000 and a detailed cost breakdown is presented in Table 11-4. No land acquisition is required with this alternative. Coordination with

Collier County is necessary to regrade the roadside ditch within the Vanderbilt Drive ROW.

11.3.2 Alternative No. 2 – Upgrade Existing Control Structures Along Windsor Road

Alternative No. 2 proposes various structure improvements to upgrade the first outfall system of the flood area. Based on the model simulation results and field observation of the City staff, the existing 30" RCP pipe to the Imperial River is not used to its full flow capacity due to the limit of the three control structures. According to the ERP document, the allowable peak discharge to the Imperial River is calculated as 8.76 cfs for a 25-year/72-hour design storm given a basin area of 95 acres. However, based on the LiDAR DEM data and the stormwater infrastructure geodatabase, the actual contribution area drained by the 30" pipe systems is more than the permitted basin size if the wetland areas east and south of Windsor Road are also included. A detailed topographic survey should be performed to identify the accurate contribution area and then a new allowable peak discharge rate could be established between the City and SFWMD.

This alternative assumes full flow capacity of the 30" pipe could be allowed to alleviate the flooding problem. The three control structures are modified to allow more stormwater into the 30" pipe. The conceptual sketch of the drainage improvement components are presented in Figure 11-3 and listed below:

- Modify the existing control structure on the south side of Windsor Road by replacing the existing 12" wide weir to triple 21" wide weirs; the existing invert elevation of 10.7 ft-NGVD remains the same
- Modify the two existing control structures at the center section of Windsor Road by enlarging the existing double 3" slots to double 12" slots, and the existing invert elevation of 10.7 ft-NGVD remains the same

The alternative analysis results are summarized in Table 11-1. For Subbasins A0050 and A0060, the proposed LOS is evaluated as "D", while for Subbasin A0070 the proposed LOS is still evaluated as "E" due to the low road grade and flow capacity limit of the 30" pipe. The preliminary engineering cost estimate for Alternative No. 2 is $83,000 and a detailed cost breakdown is presented in Table 11-5. No land acquisition is required for this alternative. The main challenge of this alternative is to obtain the ERP permit for the modification of the previously permitted control structures.

The south part of Windsor Road is still submerged during a 10-year design storm. The roadway grade could be raised above 11.60 ft-NGVD, but the roadway embankment will occupy the existing floodplain volume and further increase the flooding risk to the residential lots sitting in the lower areas. In this particular subdivision the local residents have experienced frequent roadway flooding for a long time and will be more concerned about the site flooding near their houses. Therefore, no roadway regrading is being proposed in this alternative.

11.3.3 Alternative No. 3 – Pipe to the Wetland Area to the East and US 41 Box Culverts

Alternative No. 3 includes various structure improvements to increase the discharge rate through the second outfall system. The wetland area between Windsor Road and Beaumont Road receives the stormwater when the water level reaches the top of the wetland berm. However, the wetland area is drained primarily through an 18" cross-drain near Access Road. In this alternative, a new cross-drain will be proposed near the existing cross-drain to drain the wetland area to the US 41 box culverts. Additionally, a new pipe will be proposed to link the roadside ditch along Windsor Road to the wetland area.

The conceptual sketch of the drainage improvement components are presented in Figure 11-4 and described below:

- Install a new 14"x23" cross-drain (or the equivalent) under Beaumont Road just south of the existing 18" cross-drain near Access Road; the invert elevation is set at 9.5 ft-NGVD
- Install a new 24" RCP pipe (or the equivalent) to drain the roadside ditch of Windsor Road to the wetland area to the east; the invert elevation is set at 9.5 ft-NGVD

The alternative analysis results are summarized in Table 11-1. For Subbasins A0050 and A0060, the proposed LOS is evaluated as "D". For Subbasin A0070 the proposed LOS is still evaluated as "E" due to the low road grade and high tailwater at the US 41 box culverts. The preliminary engineering cost estimate for Alternative No. 3 is $95,000 and a detailed cost breakdown is presented in Table 11-6. No land acquisition is required for this alternative and the proposed pipes are located either in the roadway ROW or city owned property.

Similar to Alternative No. 2, the south part of Windsor Road will be still submerged during a 10-year design storm. As addressed in Section 11.3.2, the local residents who live in this subdivision may be more concerned about the site or property than the roadway flooding. In this alternative, no roadway regrading was proposed since the roadway embankment will occupy the existing floodplain volume and increase the flooding risk to the residential lots sitting in the lower areas.

11.4 Imperial Harbor Subdivision

Based on the preliminary stormwater analysis, the historic flow pattern of the natural drainage system has been dramatically altered due to the development of the Bonita Fairways Subdivision going back to the 1990's. Unfortunately the outfall structures of the lake were not adequately designed to eliminate the roadway and site flooding to the residential area upstream. Also based on the existing conditions model results, the existing LOS was evaluated as "E" and significant flooding is predicted along the local roads and residential lots.

The City staff started looking into possible drainage improvement solutions by coordinating with various local stakeholders. However, due to the lack of drainage easement or ROW among other issues, no feasible CIP project has been adopted yet.

Three alternatives were developed and evaluated to address the identified flooding problems in this area. The conceptual solutions by the City staff were also considered in the alternative analysis.

11.4.1 Alternative No. 1 – Replace Existing 15" PVC with 30" RCP Pipes

To relieve the flood problem in the Imperial Harbor Subdivision area, the outfall flow rate of the lake should be increased. One option is to replace the existing 15" PVC pipes with larger pipes. It is noted that the City does not own the easement or ROW along the existing 15" pipes in the Bonita Fairways Subdivision and the construction of this drainage improvement project may have to obtain a temporary construction easement. This alternative would also require the City to shut down part of the golf course during the construction period.

The conceptual sketch of the major drainage improvement components are presented in Figure 11-5 and described below:

- Replace the existing 15" PVC pipes with 30" RCP
- Replace eight (8) manholes
- Replace the headwall at the north end of the existing 15" PVC
- Replace the catch basin at the south end of the existing 15" PVC

The alternative analysis results are summarized in Table 11-2. For Subbasin A0210, the proposed LOS is evaluated as "D" and the peak stage for 10-year storm events is reduced to 8.96 ft-NGVD which is just below the existing road crown elevation. The preliminary engineering cost estimate for Alternative No. 1 is $235,000 and a detailed cost breakdown is presented in Table 11-7. This cost estimate doesn't include the temporary construction easement and the compensation for any incoming deductions or other losses associated with the golf course as a result of construction. It should be noted that damages related to this construction activity could be very costly.

11.4.2 Alternative No. 2 – Open Ditches along North and West Property Lines of Bonita Fairways Subdivision

This alternative involves adding a new outfall to the lake to drain the flood area to the receiving water body downstream. Upon review of 2010 aerial photos and LiDAR DEM data, the open spaces are available along the north and west property boundaries of the Bonita Fairways Subdivision and within the FPL easement. Open ditches and one cross-drain are proposed in the open spaces mentioned above, as presented in Figure 11-6. The major drainage improvement components are listed below:

- An open ditch along north property boundary of Bonita Fairways Subdivision
- A 24" cross-drain under the access road in the FPL easement
- An open ditch within the FPL easement, along west property boundary of Bonita Fairways Subdivision
- Regrading of the existing roadside ditch on north side of W. Terry Road, between FPL easement and the existing stormwater inlet

The alternative analysis results are summarized in Table 11-2. Similar to Alternative No. 1, the proposed LOS of Subbasin A0210 is evaluated as "D". The peak stage for 10-year storm events is reduced to 8.96 ft-NGVD just below the existing road crown elevation. The preliminary engineering cost estimate for Alternative No. 2 is $122,000 and a detailed cost breakdown is presented in Table 11-8. This cost estimate does not include the cost related to obtaining the drainage easement for the proposed ditches. Information provided by City staff indicates the property owner of the FPL easement area may not be as receptive as FPL for any proposed drainage improvement projects by the City. The cost for the ROW or easement acquisition could be significant compared with the construction and design cost of $122,000.

11.4.3 Alternative No. 3 – Pipe Northward to Spring Creek

Upon review of the existing conditions model results, about 2 feet of head difference is anticipated between the flooding area and the City maintained ditch in the north part of the subdivision. Instead of draining all of the stormwater to the Imperial River, part of the stormwater from the flood area could be diverted to the Spring Creek through a proposed stormwater pipe system.

The major drainage improvement components presented in Figure 11-7 are described below:

- A new control structure near the north bank of the lake
- A series of 24" pipes and manholes along the roadway ROW to connect the proposed control structure and the open ditch to the north.

As summarized in Table 11-2 for Alternative No. 3, the proposed LOS of Subbasin A0210 is evaluated as "D". The peak stage for 10-year storm events is reduced to 8.94 ft-NGVD, just below the existing road crown elevation. The preliminary engineering cost of Alternative No. 3 is estimated as $168,000 and a detailed cost breakdown is presented in Table 11-9. Since no land acquisition is involved in this alternative, the ultimate cost of this project is expected to be less than Alternative Nos. 1 & 2. The major challenge for this alternative is the potential utility conflict within the existing roadway.

11.5 Michigan Street Area

Michigan Street serves as a collector road for a single-family residential neighborhood dating back to the 1960's. The homes have been built with little consideration of drainage. The current road drainage system consists of open swales.

The existing flooding problem areas reported are located from Carolina Street to Kentucky Street along both sides of Michigan Street. Michigan Street acts as a dam and blocks the surface water runoff to the natural system between Michigan Street and Washington Street. For the time being there is only one cross-drain constructed under Michigan Street to convey the stormwater runoff to the natural flow way system. The side-drains along the west side of Michigan Street are used to carry the majority of runoff northward to the Imperial River. The existing side-drains are apparently inadequate to handle the runoff volume.

Another flood area was identified at the southeast corner of Washington Street and Georgia Street where a LOS of "E" was estimated. The flooding problem in this area is basically due to the overflow from the wetland area on west side of Washington Street. During big storm events the existing cross drain at the southwest corner of Vermont Street and Georgia Street is not sufficient to drain the stormwater without causing roadway and site flooding. There are no recorded flood complaints in this area yet. However, this flood area is recommended to be included in this CIP project.

Flood relief in the Michigan Street area will require means to increase the flow rate at which surface water runoff can be discharged out of the flooded area. Three alternatives were developed and evaluated to address the identified flooding problems in this area. The alternatives are discussed in the following sections.

11.5.1 Alternative No. 1 – Pipe to Natural Flow Way

This alternative includes the construction of multiple cross-drains under Michigan Street to allow the surface water runoff to the unnamed natural flow way system. As presented in the conceptual sketch in Figure 11-8, the following cross-drains are recommended to be added under Michigan Street:

- Two 24"x38" ERCPs cross-drains and one 19"x30" ERCP (or the equivalent) just to the south of Carolina Street and the existing 19"x30" ERCP under Michigan Street is to remain.
- One 19"x30" ERCP cross-drain (or the equivalent) just to the south of Kentucky Street

In addition to the cross-drains listed above, constructing an adequate open ditch system is necessary between Michigan Street and the natural flow way system. The following side-drains and ditches are suggested to be constructed as shown in Figure 11-8:

- Two 29"x45" ERCPs side-drains (or the equivalent) along south side of Carolina Street; remove the existing 15" and 18" side-drains
- One 19"x30" ERCP side-drain (or the equivalent) along south side of Kentucky Street; remove the existing 15" and 18" side-drains
- Dredge the existing roadside swales that connect the side-drains, with a minimum cross-sectional area of 12 square feet

For the flooding area east of Washington Street, an 18" RCP cross-drain under Washington St to the south of Georgia Street is proposed to divert the surface water to the slough area. This new cross-drain will relieve the flooding during mean-annual storm events but may not prevent the roadway overtopping at Washington Street for the 10-year design storm events. Note that the addition of the 18" RCP is not hydro-related to the drainage improvements proposed for the Michigan Street Area.

The alternative analysis results are summarized in Table 11-3. For Subbasins A0284 and A0296 the proposed LOS are evaluated as "C" and "D" respectively. The peak stage for 10-year storm is reduced 0.28 foot and 0.34 foot respectively. For Subbasin B0029 in the Washington Street area, the proposed LOS is evaluated "E" and the peak stage of the 10-year storm is reduced by about 0.1 foot. The preliminary engineering cost estimate of Alternative No. 1 is about $207,000 and a detailed cost breakdown is presented in Table 11-10.

11.5.2 Alternative No. 2 – Pipe to Natural Flow Way with Ditch Cleaning

This alternative is an enhancement of Alternative No. 1 with consideration of the channel improvement in the natural flow way system. According to the City record, this natural flow way system between Bonita Beach Road and Delaware Street is now part of the City maintenance program, which means the enhancement of the slough/creek area is possible without additional land acquisition.

As illustrated in Figure 11-9, Alternative No. 2 includes all the drainage improvement components listed in Alternative No.1 with the supplement of the ditch cleaning and other channel improvements proposed in the unnamed natural flow way system as listed below.

- All drainage improvement components of Alternative No.1
- Clean the natural creek, including sediment and vegetation removal, shoring, and widening to restore the historical channel cross-section
- Add one 30" RCP side-drain (or the equivalent) at the north end of the natural flow way system near Delaware Street and remain the existing 36"x48" ERCP
- Add a 400 feet flood levee or perimeter berm at 9.5 ft-NGVD between the slough area and Washington Street, south of Alabama Street

The new 30" RCP listed above is used to convey the increased flow rate as a result of the ditch cleaning and widening, in order to prevent any adverse impacts to the adjacent properties. The 400 feet wetland berm is to protect the residential area east of Washington Street from the high flood stage in the slough area.

As summarized in Table 11-3, for Alternative No. 2, the proposed LOS of Subbasins A0284 and A0296 are evaluated as "C" and "D" respectively, with a peak stage reduction of 0.28 foot and 0.30 foot, respectively. For Subbasin B0029 the proposed LOS is evaluated as "D" and the peak stage at this area is reduced to 9.16 ft-NGVD, just below the existing road crown elevation. The preliminary engineering cost of Alternative No. 2 is estimated as $262,000 and a detailed cost breakdown is presented in Table 11-11.

11.5.3 Alternative No. 3 – Pipe along Michigan Street

In Alternative Nos. 1 and 2, more stormwater runoff is conveyed to the natural flow way systems to relieve the flooding problem to the west of Michigan Street. This alternative provides a second option by upgrading the side-drains and cross-drains along the west side of Michigan Street to drain the runoff northward to the Imperial River. As presented in the conceptual sketch in Figure 11-10, the following side drains and cross-drains are recommended to be added along Michigan Street:

- Add two 19"x30" ERCPs cross-drains (or the equivalent) under Carolina Street and the existing 19"x30" ERCPs under Carolina Street and Michigan Street are to remain.
- Add two 34"x54" ERCPs cross-drains (or the equivalent) under Kentucky Street
- Add two 36" RCPs cross-drains (or the equivalent) under Connecticut Street
- Add two 34"x54" ERCPs side-drains (or the equivalent) from Carolina Street to Kentucky Street
- Add two 34"x54" ERCPs side-drains (or the equivalent) from Kentucky Street to Connecticut Street

To relieve the flooding problem east of Washington Street, an 18" cross-drain included in Alternative No. 1 will also be proposed for this alternative.

As summarized in Table 11-3, for Alternative No. 3, the proposed LOS of Subbasins A0284 and A0296 are evaluated as "D", with a peak stage reduction of 0.53 foot and 0.30 foot respectively. For Subbasin B0029, the proposed LOS is evaluated as "E"; the peak is reduced about 0.1 foot. The preliminary engineering cost of Alternative No. 3 is estimated as $302,000 and a detailed cost breakdown is presented in Table 11-12.

11.6 Figure & Tables Descriptions

The figures and tables discussed in this section are summarized below:

Figure #	Description
11-1	Windsor Road Area – Recommended Maintenance
11-2	Windsor Road Area – Alternative No. 1
11-3	Windsor Road Area – Alternative No. 2
11-4	Windsor Road Area – Alternative No. 3
11-5	Imperial Harbor Subdivision – Alternative No. 1
11-6	Imperial Harbor Subdivision – Alternative No. 2
11-7	Imperial Harbor Subdivision – Alternative No. 3
11-8	Michigan Street Area – Alternative No. 1
11-9	Michigan Street Area – Alternative No. 2
11-10	Michigan Street Area – Alternative No. 3

Table #	Description
11-1	Summary of Alternatives Analysis - Windsor Road Area
11-2	Summary of Alternatives Analysis - Imperial Harbor Subdivision
11-3	Summary of Alternatives Analysis - Michigan Street Area
11-4	Cost Estimate of Windsor Road Area - Alternative No. 1
11-5	Cost Estimate of Windsor Road Area - Alternative No. 2
11-6	Cost Estimate of Windsor Road Area - Alternative No. 3
11-7	Cost Estimate of Imperial Harbor Subdivision - Alternative No. 1
11-8	Cost Estimate of Imperial Harbor Subdivision - Alternative No. 2
11-9	Cost Estimate of Imperial Harbor Subdivision - Alternative No. 3
11-10	Cost Estimate of Michigan Street Area - Alternative No. 1
11-11	Cost Estimate of Michigan Street Area - Alternative No. 2
11-12	Cost Estimate of Michigan Street Area - Alternative No. 3

Legend

Feet

0 100 200 400

ICPR Basins

Road

City Canal

Ditch Cleaning

City of Bonita Springs Stormwater Master Plan

Windsor Road Area Recommended Maintenance

Project: 4600000955W003

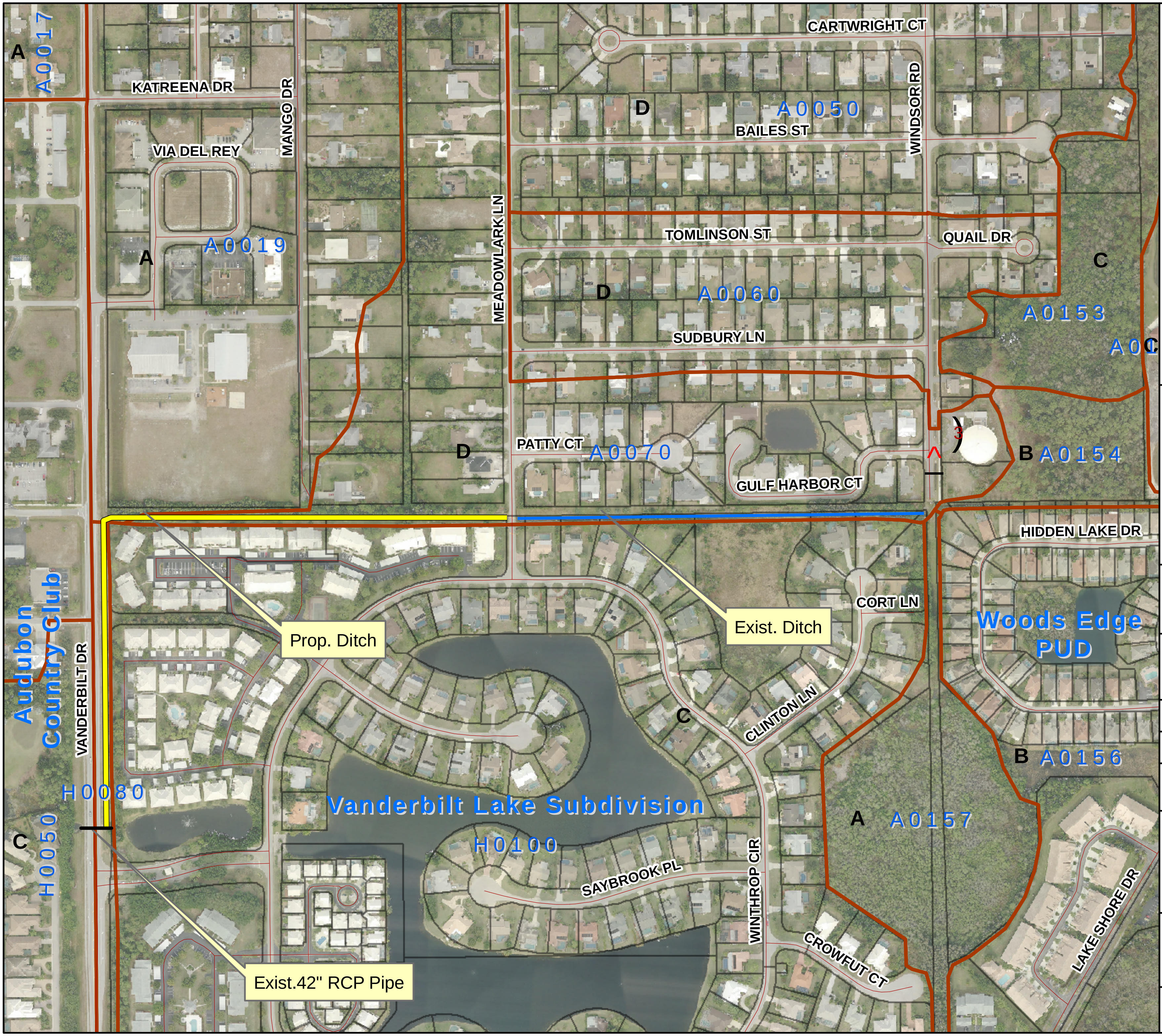
Date: 12/10/2010

File: COBS_SMP_Fig11_1

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 11-1



Legend

Feet

0 100 200 400

- ICPR Basins
- Road
- City Canal
- Proposed Ditch
- A Proposed LOS

City of Bonita Springs Stormwater Master Plan

Windsor Road Area Alternative No. 1

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig11_2

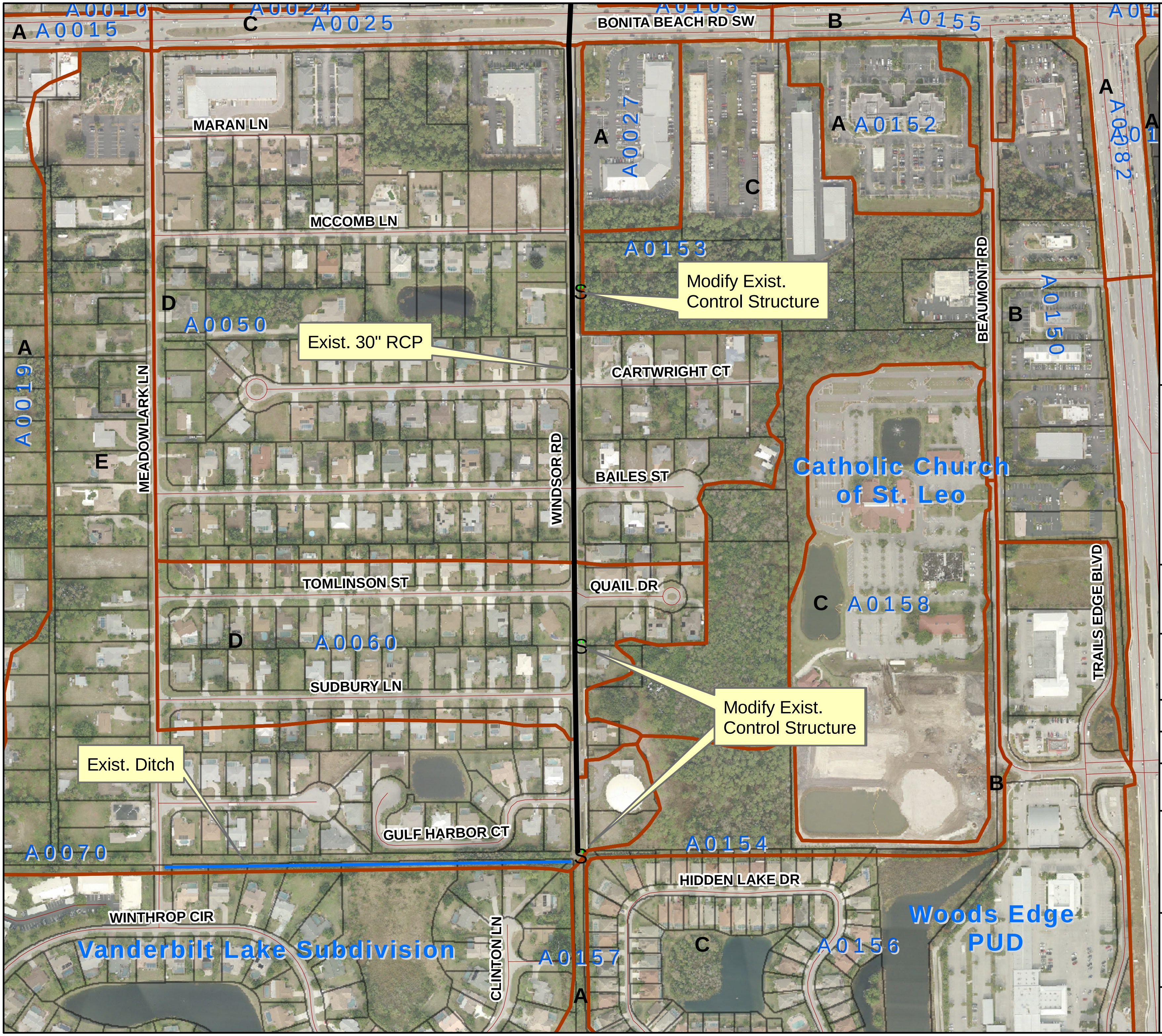
INTERA

Firm PE Registration Number: 4722

EAS

Firm PE Registration Number: 7174

Figure 11-2



Legend

Feet

0 100 200 400

- ICPR Basins
- Road
- City Canal
- A Proposed LOS

City of Bonita Springs Stormwater Master Plan

Windsor Road Area Alternative No. 2

Project: 4600000955W003

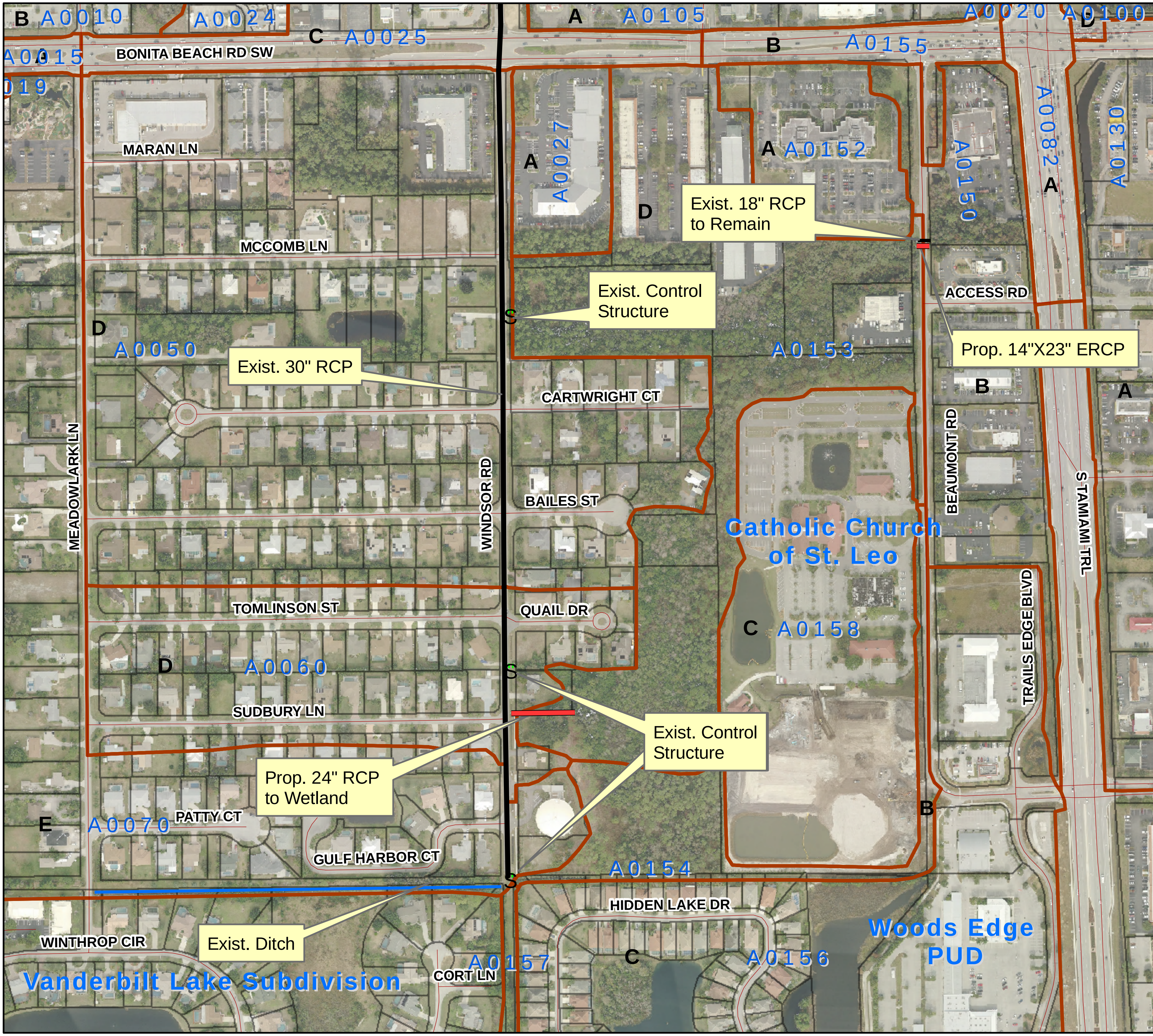
Date: 12/10/2010

File: COBS_SMP_Fig11_3

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 11-3



Legend

Feet
0 100 200 400

ICPR Basins
Road
City Canal
Proposed Pipe
A Proposed LOS

City of Bonita Springs
Stormwater
Master Plan

Windsor Road Area
Alternative No. 3

Project: 4600000955W003

Date: 12/10/2010

File:
COBS_SMP_Fig11_4

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 11-4

Legend

Feet
0 100 200 400

Road
Proposed Pipe
A Proposed LOS

City of Bonita Springs Stormwater Master Plan

Imperial Harbor Subdivision Alternative No. 1

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig11_5

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 11-5

City of Bonita Springs
Stormwater
Master Plan

Imperial Harbor Subdivision
Alternative No. 2

Project: 4600000955W003

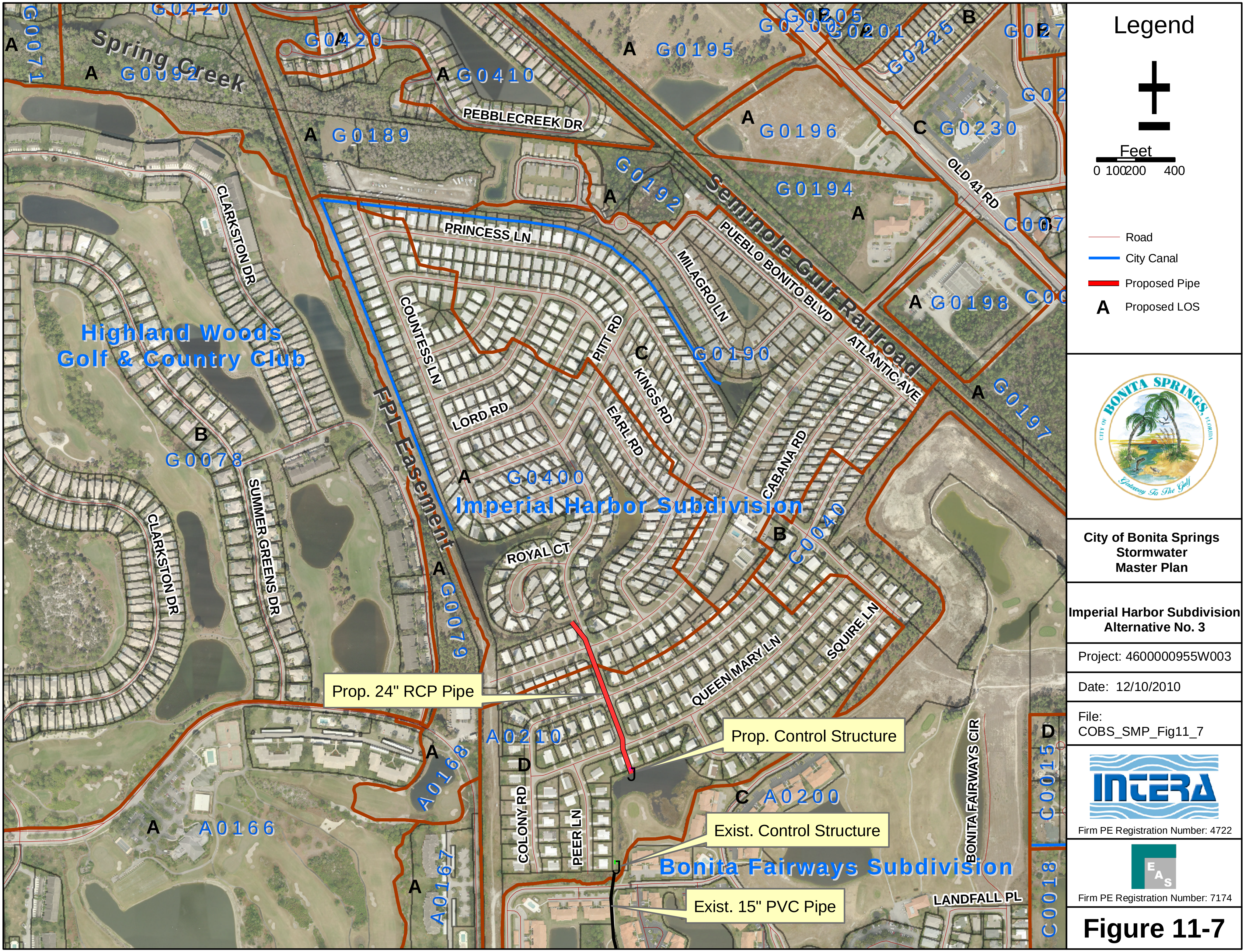
Date: 12/10/2010

File:
COBS_SMP_Fig11_6

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 11-6



City of Bonita Springs Stormwater Master Plan

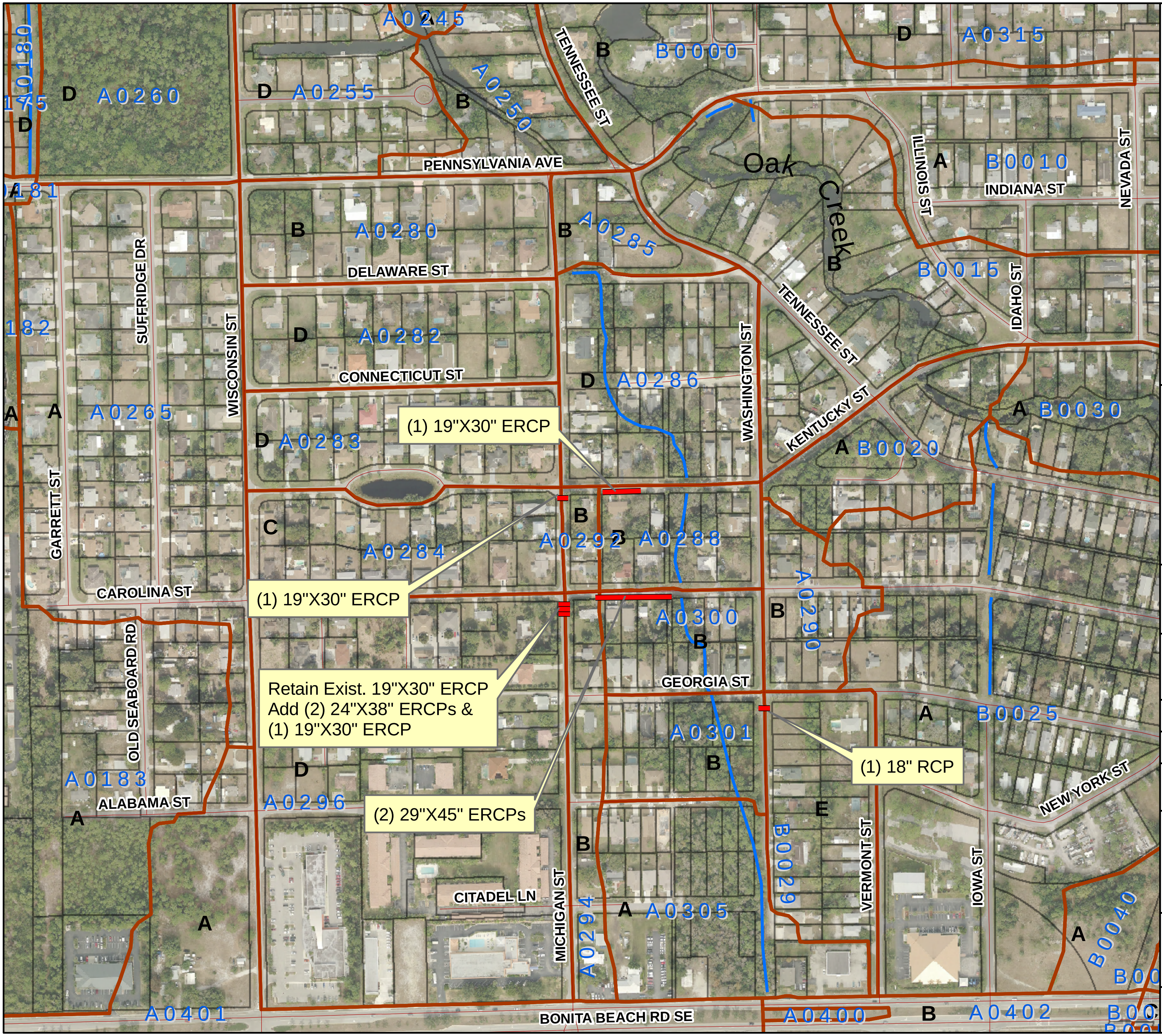
Imperial Harbor Subdivision Alternative No. 3

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig11_7

Figure 11-7



Legend

Feet
0 100 200 400

ICPR Basins
Road
City Canal
Proposed Pipe
A Proposed LOS

City of Bonita Springs
Stormwater
Master Plan

Michigan Street Area
Alternative No. 1

Project: 4600000955W003

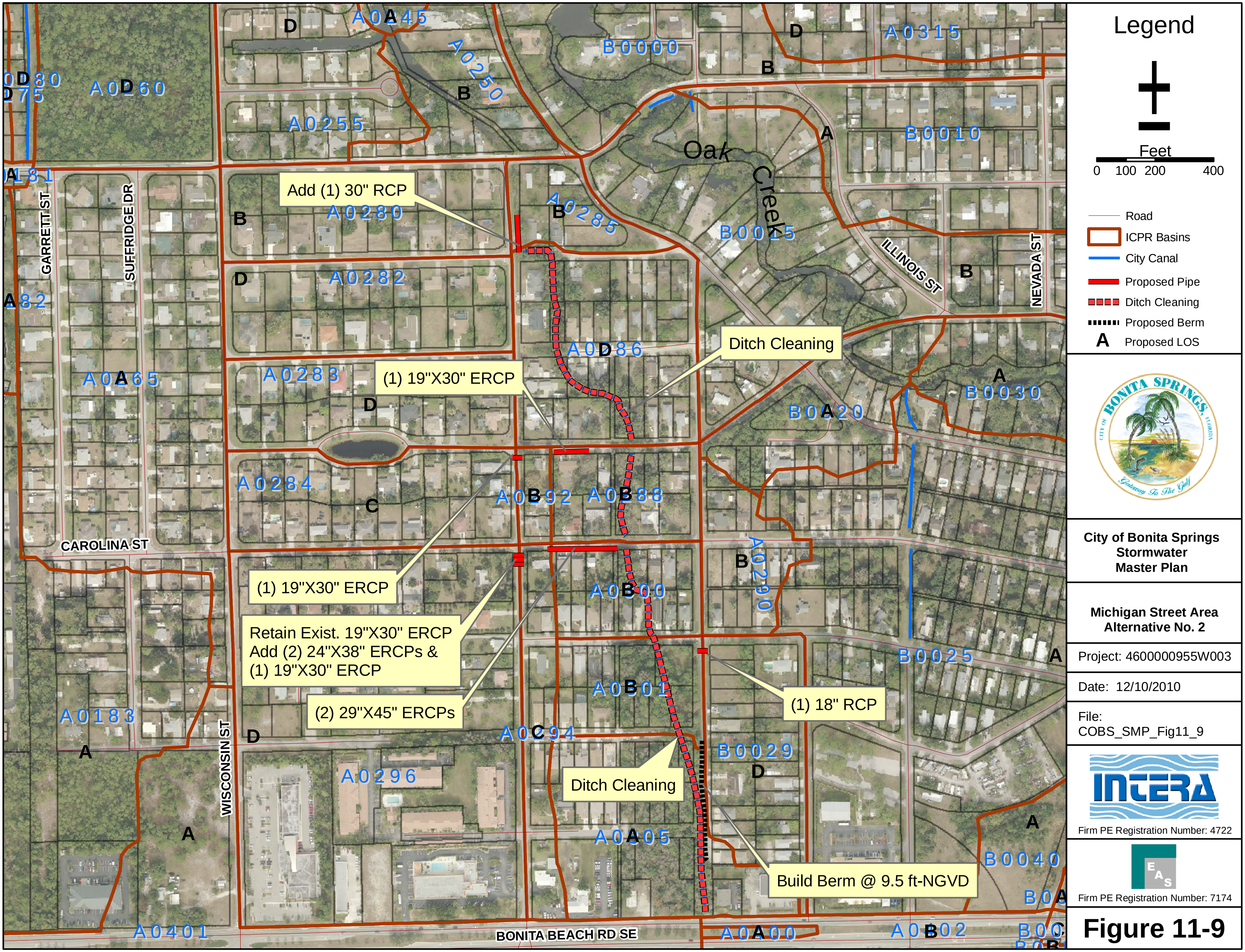
Date: 12/10/2010

File:
COBS_SMP_Fig11_8

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 11-8



City of Bonita Springs
Stormwater
Master Plan

Michigan Street Area
Alternative No. 2

Project: 4600000955W003

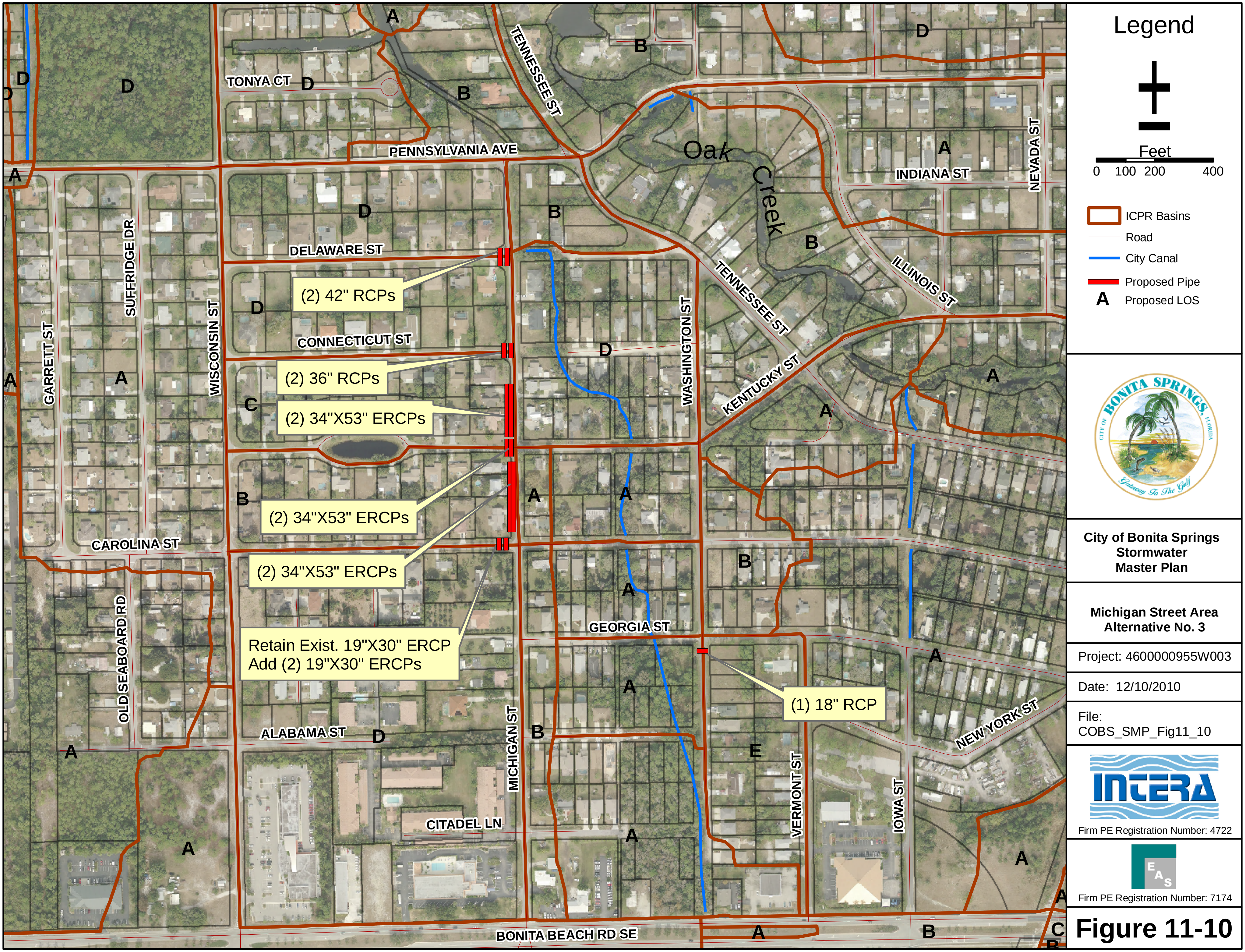
Date: 12/10/2010

File:
COBS_SMP_Fig11_9

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 11-9



City of Bonita Springs Stormwater Master Plan

Michigan Street Area Alternative No. 3

Project: 4600000955W003

Date: 12/10/2010

File: COBS_SMP_Fig11_10

Firm PE Registration Number: 4722

Firm PE Registration Number: 7174

Figure 11-10

Table 11-1
Summary of Alternatives Analysis – Windsor Road Area

ID	Description	Subbasin	Exist. LOS	Prop. LOS	Road Crown Elevation	Exist. Peak Stage[1] (ft-NGVD)	Prop. Peak Stage[1] (ft-NGVD)	Variance Post vs. Exist. (ft)	Cost[2]	Comments
1	Open Ditch to Vanderbilt Drive	A0050	E	D	11.6	11.73	11.65	-0.08	$ 107,000	Most favorite alternative. Restore to the historical flow pattern by draining stormwater to Little Hickory Bay.
		A0060		D	11.6	11.71	11.59	-0.12		
		A0070		D	11.4	11.65	11.31	-0.34		
2	Upgrade Existing Control Structures Along Windsor Road	A0050	E	D	11.6	11.73	11.64	-0.09	$ 83,000	Lowest cost. ERP permit modification is needed to upgrade the existing control structures. Due to the limit capacity of 30" RCP, LOS of A0070 is not improved significantly.
		A0060		D	11.6	11.71	11.61	-0.10		
		A0070		E	11.4	11.65	11.53	-0.12		
3	Pipe to the Wetland Area to the East and US 41 Box Culverts	A0050	E	D	11.6	11.73	11.62	-0.11	$ 95,000	Permit issue of draining the stormwater directly into the wetland area. LOS of A0153 is lowered to "D", but no roadway overtopping at Beaumont Rd.
		A0060		D	11.6	11.71	11.58	-0.13		
		A0070		E	11.4	11.65	11.55	-0.10		
		A0153	C	D	11.3	11.18	11.29	0.11		

[1] Existing and proposed peak stage values are simulated for the 10-year design storm events, according to the LOS rating criteria established in Table 9-1.

[2] Detailed break-down of the preliminary engineering cost estimate is included in Tables 11-4 thru 11-6.

Table 11-2
Summary of Alternatives Analysis – Imperial Harbor Subdivision

ID	Description	Subbasin	Exist. LOS	Prop. LOS	Road Crown Elevation	Exist. Peak Stage[1] (ft-NGVD)	Prop. Peak Stage[1] (ft-NGVD)	Variance Post vs. Exist. (ft)	Cost[2]	Comments
1	Replace Existing 15" PVC with 30" RCP pipes	A0210	E	D	9.0	9.61	8.96	-0.65	$ 235,000	Highest cost. Bonita Fairways HOA may not support the construction thru their golf course to replace the existing 15" PVC pipes.
2	Open Ditches along North and West Property Lines of Bonita Fairways Subdivision	A0210	E	D	9.0	9.61	8.96	-0.65	$ 122,000	Most favorite alternative. Lowest cost. Need to obtain the drainage easement in FPL Easement and Bonita Fairways HOA.
3	Pipe Northward to Spring Creek	A0210	E	D	9.0	9.61	8.94	-0.67	$ 168,000	No easement issue. Stormwater pipes and manholes to be installed under the roadway. Utility conflict is expected along the pipe route. Cost may run up if a different route is selected.

[1] Existing and proposed peak stage values are simulated for the 10-year design storm events, according to the LOS rating criteria established in Table 9-1.

[2] Detailed break-down of the preliminary engineering cost estimate is included in Tables 11-7 thru 11-9.

Table 11-3
Summary of Alternatives Analysis - Michigan Street Area

ID	Description	Subbasin	Exist. LOS	Prop. LOS	Road Crown Elevation	Exist. Peak Stage[1] (ft-NGVD)	Prop. Peak Stage[1] (ft-NGVD)	Variance Post vs. Exist. (ft)	Cost[2]	Comments
1	Pipe to natural flow way system	A0283	E	D	7.7	7.89	7.77	-0.12	$ 207,000	Lowest cost, but the flooding problem in the Washington St. area (B0029) is not relieved.
		A0284		D	8.5	8.65	8.37	-0.28		
		A0294		B	9.3	9.48	9.07	-0.41		
		A0296		D	9.4	9.70	9.36	-0.34		
		B0029		E	9.2	9.51	9.42	-0.09		
2	Pipe to natural flow way system & Ditch cleaning	A0283	E	D	7.7	7.89	7.77	-0.12	$ 262,000	Most favorite alternative. The ditch cleaning could be scheduled as part of the City maintenance and operation program.
		A0284		D	8.5	8.65	8.37	-0.28		
		A0294		B	9.3	9.48	9.12	-0.36		
		A0296		D	9.4	9.70	9.40	-0.30		
		B0029		D	9.2	9.51	9.16	-0.35		
3	Pipe along Michigan Street	A0283	E	C	7.7	7.89	7.58	-0.31	$ 302,000	Highest cost for longer and larger pipes required. No cross-drain to be constructed under Michigan Street.
		A0284		B	8.5	8.65	8.12	-0.53		
		A0294		B	9.3	9.48	8.96	-0.52		
		A0296		D	9.4	9.70	9.40	-0.30		
		B0029		E	9.2	9.51	9.41	-0.10		

[1] Existing and proposed peak stage values are simulated for the 10-year design storm events, according to the LOS rating criteria established in Table 9-1.

[2] Detailed break-down of the preliminary engineering cost estimate is included in Tables 11-10 thru 11-12.

Table 11-4 Cost Estimate of Windsor Road Area - Alternative No. 1

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 10,000	1	$ 10,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 2,000	1	$ 2,000
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	4600	$ 6,210
110-1-1	CLEARING AND GRUBBING	AC	$ 7,500	1.5	$ 11,250
120-1	REGULAR EXCAVATION	CY	$ 5	1630	$ 8,150
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2	5000	$ 10,000
	CONSTRUCTION SUBTOTAL				$ 47,610
	CONTINGENCY			20%	$ 9,522
	CONSTRUCTION TOTAL				$ 57,132
	ENGINEER FEES				$ 50,000
				TOTAL	$ 107,132
				USE	**$ 107,000**

Table 11-5 Cost Estimate of Windsor Road Area - Alternative No. 2

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 10,000	1	$ 10,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 5,000	1	$ 5,000
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	200	$ 270
110-1-1	CLEARING AND GRUBBING	AC	$ 8,000	0.2	$ 1,600
425-1-529	INLETS, DT BOT, TYPE C, MODIFY	EA	$ 2,000	2	$ 4,000
425-1-589	INLETS, DT BOT, TYPE H, MODIFY	EA	$ 6,000	1	$ 6,000
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2	150	$ 300
	CONSTRUCTION SUBTOTAL				$ 27,170
	CONTINGENCY			20%	$ 5,434
	CONSTRUCTION TOTAL				$ 32,604
	ENGINEER FEES				$ 50,000
				TOTAL	$ 82,604
				USE	**$ 83,000**

Table 11-6 Cost Estimate of Windsor Road Area - Alternative No. 3

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 10,000	1	$ 10,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 3,000	1	$ 3,000
104-11	FLOATING TURBIDITY BARRIER	LF	$ 6.50	60	$ 390
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	400	$ 540
110-1-1	CLEARING AND GRUBBING	AC	$ 8,000	0.3	$ 2,400
285-701	OPTIONAL BASE, BASE GROUP 01 (TYPE B-12.5)	SY	$ 5	50	$ 250
334-1-13	SUPERPAVE ASPHALTIC CONC, TRAFFIC C (SP-9.5)	TN	$ 75	15	$ 1,125
430-175-101	PIPE CULV, OPT MATL, ROUND, 0-24"S/CD	LF	$ 40	200	$ 8,000
430-175-201	PIPE CULV, OPT MATL, OTHER, 0-24"S/CD	LF	$ 50	40	$ 2,000
430-982-125	MITERED END SECT, OPTIONAL RD, 18" CD	EA	$ 800	2	$ 1,600
430-982-129	MITERED END SECT, OPTIONAL RD, 24" CD	EA	$ 1,000	2	$ 2,000
430-984-625	MITERED END SECT, OPT / OTHER, 18" SD	EA	$ 850	2	$ 1,700
530-3-4	RIPRAP, RUBBLE, F&I, DITCH LINING	TN	$ 70.00	40	$ 2,800
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2.00	700	$ 1,400
	CONSTRUCTION SUBTOTAL				$ 37,205
	CONTINGENCY			20%	$ 7,441
	CONSTRUCTION TOTAL				$ 44,646
	ENGINEER FEES				$ 50,000
				TOTAL	$ 94,646
				USE	**$ 95,000**

Table 11-7 Cost Estimate of Imperial Harbor Subdivision - Alternative No. 1

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 8,000	1	$ 8,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 2,000	1	$ 2,000
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	1600	$ 2,160
110-1-1	CLEARING AND GRUBBING	AC	$ 10,000	1.5	$ 15,000
285-701	OPTIONAL BASE, BASE GROUP 01 (TYPE B-12.5)	SY	$ 5	60	$ 300
334-1-13	SUPERPAVE ASPHALTIC CONC, TRAFFIC C (SP-9.5)	TN	$ 75	15	$ 1,125
400--2-2	CONC CLASS II, ENDWALLS	CY	$ 650	3.3	$ 2,145
425-1-541	INLETS, DT BOT, TYPE D, <10'	EA	$ 2,500	1	$ 2,500
425-2-41	MANHOLES, P-7, <10'	EA	$ 2,500	8	$ 20,000
430-175-102	PIPE CULV, OPT MATL, ROUND, 25-36"S/CD	LF	$ 60	1550	$ 93,000
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2	3500	$ 7,000
	CONSTRUCTION SUBTOTAL				$ 153,230
	CONTINGENCY			20%	$ 30,646
	CONSTRUCTION TOTAL				$ 183,876
	ENGINEER FEES				$ 50,000
				TOTAL	$ 233,876
				USE	**$ 235,000**

Table 11-8 Cost Estimate of Imperial Harbor Subdivision - Alternative No. 2

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 10,000	1	$ 10,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 1,000	1	$ 1,000
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	1600	$ 2,160
110-1-1	CLEARING AND GRUBBING	AC	$ 8,000	1.5	$ 12,000
120-1	REGULAR EXCAVATION	CY	$ 5	3000	$ 15,000
430-175-101	PIPE CULV, OPT MATL, ROUND, 0-24"S/CD	LF	$ 40	80	$ 3,200
430-982-129	MITERED END SECT, OPTIONAL RD, 24" CD	EA	$ 1,000	2	$ 2,000
530-3-4	RIPRAP, RUBBLE, F&I, DITCH LINING	TN	$ 70	40	$ 2,800
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2	6000	$ 12,000
	CONSTRUCTION SUBTOTAL				$ 60,160
	CONTINGENCY			20%	$ 12,032
	CONSTRUCTION TOTAL				$ 72,192
	ENGINEER FEES				$ 50,000
				TOTAL	$ 122,192
				USE	**$ 122,000**

Table 11-9 Cost Estimate of Imperial Harbor Subdivision - Alternative No. 3

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 10,000	1	$ 10,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 5,000	1	$ 5,000
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	650	$ 878
110-1-1	CLEARING AND GRUBBING	AC	$ 5,000	0.6	$ 3,000
285-701	OPTIONAL BASE, BASE GROUP 01 (TYPE B-12.5)	SY	$ 5	1500	$ 7,500
334-1-13	SUPERPAVE ASPHALTIC CONC, TRAFFIC C (SP-9.5)	TN	$ 75	300	$ 22,500
425-1-531	INLETS, DT BOT, TYPE C, MOD, <10'	EA	$ 2,500	1	$ 2,500
425-2-41	MANHOLES, P-7, <10'	EA	$ 2,500	4	$ 10,000
430-175-101	PIPE CULV, OPT MATL, ROUND, 0-24"S/CD	LF	$ 40	850	$ 34,000
430-982-129	MITERED END SECT, OPTIONAL RD, 24" CD	EA	$ 1,000	1	$ 1,000
530-3-4	RIPRAP, RUBBLE, F&I, DITCH LINING	TN	$ 70	20	$ 1,400
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2	260	$ 520
	CONSTRUCTION SUBTOTAL				$ 98,298
	CONTINGENCY			20%	$ 19,660
	CONSTRUCTION TOTAL				$ 117,957
	ENGINEER FEES				$ 50,000
				TOTAL	$ 167,957
				USE	**$ 168,000**

Table 11-10 Cost Estimate of Michigan Street Area - Alternative No. 1

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 8,000	1	$ 8,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 5,000	1	$ 5,000
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	1000	$ 1,350
110-1-1	CLEARING AND GRUBBING	AC	$ 5,000	0.5	$ 2,500
120-1	REGULAR EXCAVATION	CY	$ 5	150	$ 750
285-701	OPTIONAL BASE, BASE GROUP 01 (TYPE B-12.5)	SY	$ 5	200	$ 1,000
334-1-13	SUPERPAVE ASPHALTIC CONC, TRAFFIC C (SP-9.5)	TN	$ 75	40	$ 3,000
430-174-201	PIPE CULV, OPT MATL, OTHER, 0-24"SD	LF	$ 45	120	$ 5,400
430-174-202	PIPE CULV, OPT MATL, OTHER, 25-36"SD	LF	$ 75	480	$ 36,000
430-175-101	PIPE CULV, OPT MATL, ROUND, 0-24"S/CD	LF	$ 40	40	$ 1,600
430-175-201	PIPE CULV, OPT MATL, OTHER, 0-24"S/CD	LF	$ 52	80	$ 4,160
430-175-202	PIPE CULV, OPT MATL, OTHER, 25-36"S/CD	LF	$ 75	80	$ 6,000
430-982-125	MITERED END SECT, OPTIONAL RD, 18" CD	EA	$ 800	2	$ 1,600
430-982-629	MITERED END SECT, OPT - OTHER, 24" CD	EA	$ 850	4	$ 3,400
430-982-633	MITERED END SECT, OPT - OTHER, 30" CD	EA	$ 1,000	4	$ 4,000
430-984-629	MITERED END SECT, OPT/ELLIP/ARCH, 30" SD	EA	$ 1,328	12	$ 15,936
430-984-633	MITERED END SECT, OPT/ELLIP/ARCH, 36" SD	EA	$ 1,720	12	$ 20,640
522-2	SIDEWALK CONC, 6" THICK	SY	$ 35	180	$ 6,300
530-3-4	RIPRAP, RUBBLE, F&I, DITCH LINING	TN	$ 70	40	$ 2,800
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2	700	$ 1,400
	CONSTRUCTION SUBTOTAL				$ 130,836
	CONTINGENCY			20%	$ 26,167
	CONSTRUCTION TOTAL				$ 157,003
	ENGINEER FEES				$ 50,000
				TOTAL	$ 207,003
				USE	**$ 207,000**

Table 11-11 Cost Estimate of Michigan Street Area - Alternative No. 2

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 15,000	1	$ 15,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 5,000	1	$ 5,000
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	1600	$ 2,160
110-1-1	CLEARING AND GRUBBING	AC	$ 8,000	2	$ 16,000
120-1	REGULAR EXCAVATION	CY	$ 5	900	$ 4,500
120-6	EMBANKMENT	CY	$ 10	50	$ 500
285-701	OPTIONAL BASE, BASE GROUP 01 (TYPE B-12.5)	SY	$ 5	200	$ 1,000
334-1-13	SUPERPAVE ASPHALTIC CONC, TRAFFIC C (SP-9.5)	TN	$ 75	40	$ 3,000
430-174-102	PIPE CULV, OPT MATL, ROUND,25-36"SD	LF	$ 55	120	$ 6,600
430-174-201	PIPE CULV, OPT MATL, OTHER, 0-24"SD	LF	$ 45	120	$ 5,400
430-174-202	PIPE CULV, OPT MATL, OTHER, 25-36"SD	LF	$ 75	480	$ 36,000
430-175-101	PIPE CULV, OPT MATL, ROUND, 0-24"S/CD	LF	$ 40	40	$ 1,600
430-175-201	PIPE CULV, OPT MATL, OTHER, 0-24"S/CD	LF	$ 52	80	$ 4,160
430-175-202	PIPE CULV, OPT MATL, OTHER, 25-36"S/CD	LF	$ 75	80	$ 6,000
430-982-125	MITERED END SECT, OPTIONAL RD, 18" CD	EA	$ 800	2	$ 1,600
430-982-629	MITERED END SECT, OPT - OTHER, 24" CD	EA	$ 850	4	$ 3,400
430-982-633	MITERED END SECT, OPT - OTHER, 30" CD	EA	$ 1,000	4	$ 4,000
430-984-138	MITERED END SECT, OPTIONAL RD, 30" SD	EA	$ 2,000	2	$ 4,000
430-984-629	MITERED END SECT, OPT/ELLIP/ARCH, 30" SD	EA	$ 1,328	12	$ 15,936
430-984-633	MITERED END SECT, OPT/ELLIP/ARCH, 36" SD	EA	$ 1,720	12	$ 20,640
522-2	SIDEWALK CONC, 6" THICK	SY	$ 35	200	$ 7,000
530-3-4	RIPRAP, RUBBLE, F&I, DITCH LINING	TN	$ 70	40	$ 2,800
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2	950	$ 1,900
	CONSTRUCTION SUBTOTAL				$ 168,196
	CONTINGENCY			20%	$ 33,639
	CONSTRUCTION TOTAL				$ 201,835
	ENGINEER FEES				$ 60,000
				TOTAL	$ 261,835
				USE	**$ 262,000**

Table 11-12 Cost Estimate of Michigan Street Area - Alternative No. 3

Item #	Description	Unit	Unit Cost	Quantity	Cost
101-1	MOBILIZATION	LS	$ 8,000	1	$ 8,000
102-1	MAINTENANCE OF TRAFFIC	LS	$ 5,000	1	$ 5,000
104-13-1	STAKED SILT FENCE (TYPE III)	LF	$ 1.35	1300	$ 1,755
110-1-1	CLEARING AND GRUBBING	AC	$ 5000	0.6	$ 3,000
120-1	REGULAR EXCAVATION	CY	$ 5	150	$ 750
285-701	OPTIONAL BASE, BASE GROUP 01 (TYPE B-12.5)	SY	$ 5	250	$ 1,250
334-1-13	SUPERPAVE ASPHALTIC CONC, TRAFFIC C (SP-9.5)	TN	$ 75	50	$ 3,750
430-174-203	PIPE CULV, OPT MATL, OTHER, 37-48"SD	LF	$ 85	840	$ 71,400
430-175-102	PIPE CULV, OPT MATL, ROUND, 25-36"S/CD	LF	$ 60	100	$ 6,000
430-175-103	PIPE CULV, OPT MATL, ROUND, 37-48"S/CD	LF	$ 95	124	$ 11,780
430-175-201	PIPE CULV, OPT MATL, OTHER, 0-24"S/CD	LF	$ 52	84	$ 4,368
430-175-203	PIPE CULV, OPT MATL, OTHER, 37-48"S/CD	LF	$ 15	120	$ 13,800
430-982-138	MITERED END SECT, OPTIONAL RD, 36" CD	EA	$ 1,600	4	$ 6,400
430-982-140	MITERED END SECT, OPTIONAL RD, 42" CD	EA	$ 2,000	4	$ 8,000
430-982-629	MITERED END SECT, OPT - OTHER, 24" CD	EA	$ 850	4	$ 3,400
430-982-640	MITERED END SECT, OPT - OTHER, 42" CD	EA	$ 3,000	4	$ 12,000
430-984-640	MITERED END SECT, OPT/ELLIP/ARCH, 42" SD	EA	$ 4,000	8	$ 32,000
522-2	SIDEWALK CONC, 6" THICK	SY	$ 35	112	$ 3,920
530-3-4	RIPRAP, RUBBLE, F&I, DITCH LINING	TN	$ 70	40	$ 2,800
570-1-2	PERFORMANCE TURF, SOD (BAHIA)	SY	$ 2	1100	$ 2,200
	CONSTRUCTION SUBTOTAL				$ 201,573
	CONTINGENCY			20%	$ 40,315
	CONSTRUCTION TOTAL				$ 241,888
	ENGINEER FEES				$ 60,000
				TOTAL	$ 301,888
				USE	**$ 302,000**

12 Stormwater Management Program Funding

12.1 Evaluation of Funding Sources

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

Since 1984 the State of Florida has gone through several large scale changes of policy regarding stormwater and pollution control. Most recently, in 2009, new regulations for monitoring Total Maximum Daily Loads (TMDL) in stormwater have become policy. Each new change in regulation adds complexities and costs to new stormwater management projects. With oversight from both State and Federal agencies, local governments are held more accountable and are requiring that all projects be compliant with current policy and regulation.

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

Since these programs are continuously changing, it is entirely possible that a single project may have more than one source as a funding option. All funding sources may not necessarily be suitable for specific projects. Careful evaluation by legal teams, agency staff, and public endorsement should be conducted before choosing a funding source. Operating costs, direct capital costs, and cost benefits may be factors in choosing or declining funding options. Projects can also meet criteria for funding sources through demonstrations of secondary impacts. For example, if a project is addressing flooding concerns, the flooding could generate risk to water quality to adjacent lands or ecosystems making flooding projects eligible for water quality funding.

12.1.1 Local Funding Sources – City of Bonita Springs

12.1.1.1 Ad Valorem

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

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

12.1.1.2 Municipal Services Benefit Taxing Unit (MSBU/MSTU)

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

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

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

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

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

12.1.1.3 Private Community Funding

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

12.1.2 State Funding Sources

12.1.2.1 Clean Water Act Section 319 (h)

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

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

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

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

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

12.1.2.2 Community Budget Issue Request (CBIR)

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

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

The SFWMD convenes each August to prioritize each City and county’s project requests. The SFWMD continuously evaluates criteria in effort to achieve consistency of project requirements and selection processes. Projects with multiple component benefits score the highest and get a higher priority. For example a project having a water quality benefit, a flood mitigation component, and recreational components may have an advantage over a single component water quality project.

SFWMD subdivides int’s jurisdiction into regions to manage CBIR funding and project eligibility. The City of Bonita Springs falls under the jurisdiction of the SFWMD Central District. Steve Sentes oversees projects requesting CBIR funding for the Central District. Mr. Sentes was contacted and he was able to confirm the program requirements and provided information regarding the application process, forms, and required documentation.

12.1.3 Federal Funding Sources

12.1.3.1 Florida Forever Act

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

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

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

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

12.1.3.2 Community Development Block Grant Program

The Community Development Block Grant Program is a federal program targeted to provide funding for community development, including housing projects. Congress created the program in 1974 by passing the Housing and Community Development Act, Title I. The program is federally funded and administered at the state level through the Florida Department of Community Affairs (DCA). The objectives of the program at the national level are:

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

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

Eligibility is classified into three categories:

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

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

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

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

12.1.3.3 Federal Emergency Management Agency (DHS/FEMA)

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

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

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

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

12.2 Recommendations

The typical process for the City of Bonita Springs to approve and implement recommendations for capital improvement projects begins with establishing the financial budget, usually in the late spring. The staff develops and submits their respective drafts by the middle of the summer. Approval of the financial budget drafts are finalized by the City Council in August and September. The budget year will then begin fiscally on October 1st and run until the following September 30th.

The annual financial budget report will identify the funding for approved Capital Improvement Plan (CIP) projects and O&M and R&R costs. The annual report will include a projection for 5 additional years that will identify the CIP projects and planned sources of funding. The report will also include CIP projects that are targeted for the 5-10 years timeframe but do not identify funding sources for these CIP projects. Each year the CIP projects are to be re-examined by the City staff to update their priorities and the City Council will then make the adjustment to the CIP projects during the budget process.

The City has adopted an existing Stormwater Master Plan (SMP) since 2002. The following steps are recommended for implementation of the updated SMP:

1. City Council acceptance of the updated SMP.
2. Integrate the updated SMP into the City's Financial Program.
3. Pursue funding from local, State and Federal to reduce the burden on the City's general fund.
4. Initiate funding for the top three CIP projects among the current eight identified CIP projects as part of the City's 5-year timeframe Financial Program.
5. Implementation of an updated O&M and R&R Program by the City’s Public Works staff, primarily the Maintenance Coordinator.

As discussed above, the City needs about 4 to 6 months to put in place a financial program; approximately 8 months for engineering design and permitting of the top three CIP projects; and approximately 6 to 8 months for the construction and final certification. The timeframe is approximately 2 years before the top three CIP projects are completed. By then, the City may start implement the remaining identified CIP projects when funding is available.