C-139 Basin Phosphorus Water Quality and Hydrology Analysis

Deliverable 5.4 – Phase 1 Report

(Contract No. CN040914-WO07 Phase 1)

Prepared for:

South Florida Water Management District (SFWMD)
3301 Gun Club Road
West Palm Beach, FL 33406
(561) 686-8800

Prepared by:

A.D.A. Engineering, Inc.
Consulting Engineers & Planners

1800 Old Okeechobee Road, Suite 102
West Palm Beach, Florida 33409
(561) 615-8880

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EXECUTIVE SUMMARY

Background

Florida's 1994 Everglades Forever Act (EFA), F.S. 373.4592, establishes long-term water quality goals designed to restore and protect the Everglades Protection Area (EPA). The EFA mandates that landowners within the C-139 Basin should not collectively exceed the average annual historic total phosphorus (TP) load adjusted for rainfall. In 2002, the C-139 Basin Best Management Practices (BMPs) Regulatory Program was adopted to ensure that TP load requirements would be met. This BMP program is defined in Chapter 40E-63, F.A.C. ("Rule 40E-63").

During the 2003 legislative session, a Long-Term Plan objective was adopted for the C-139 Basin to identify urban and agricultural discharges within the basin that are candidates for cost-effective implementation of source controls. After three years of implementing the mandatory BMP program, the C-139 Basin has not been able to meet the historic TP load required by Rule 40E-63. Both the South Florida Water Management District (District) and permittees are interested in additional TP load reduction programs within the basin that will be prioritized and addressed in future BMP program optimization plans, as necessary to meet rule requirements.

The objective of the C-139 Basin Phosphorus Water Quality and Hydrology Analysis is to assess the current hydrologic and water quality conditions of the basin, identify locations where additional water quality and flow data is required, and identify and evaluate opportunities for water quality improvement. The project is to be completed in two phases. The District contracted ADA through Work Order CN040912-WO07 to completed Phase I, and this phase included the following four tasks and covered the following objectives:

Task	Objective
1. Records Review and Action Plan	Describe the current drainage configuration including an inventory of farm-level offsite discharge locations and structure types, primary internal farm surface water features and hydrology.
2. Field Review and Data Collection	Characterize flow along main C-139 canals, including direction of flow, flow rates and contributing tributaries, and District structures operation and its influence on basin hydrology.
3. Subwatershed Segmentation and Screening Level TP Assessment	Segment the C-139 Basin into subwatersheds and catchments based on existing hydrologic conditions. Provide screening-level assessment of the spatial distribution of potential TP loads within the C-139 Basin.
4. Location of Monitoring Stations	Identify feasible locations for the installation of permanent flow and TP monitoring stations to be representative of the subwatersheds identified above.

This report presents the results of the implementation of Phase I of the C-139 Basin Phosphorus Water Quality and Hydrology Analysis. Phase II will include a hydrology analysis, assessment of water quality improvement projects, and regulatory feasibility evaluation for the basin and will be documented in a separate report.

Records Review and Action Plan

The review of available and relevant documentation included 17 literature sources, approximately 25 Works of the District (WOD) permits, 40 Storm Water and Environmental Resources Permits (SW/ERP), and all other previous and concurrent activities that relate to the C-139 Basin. The records review also included interviews with District Everglades Regulation Division staff, field visits and a helicopter surveillance trip.

Upon review of available literature, an Action Plan was developed for the collection of additional archived and field data. This Action Plan described the available historical stage, flow and water quality data, and it included the methodology for collecting event-based flow measurements and bathymetric surveys of canal cross-sections within the C-139 Basin.

Field Review and Data Collection

This task included basic and detailed data collection. Basic data collection included a description of the regional hydrology within the C-139 Basin, as well as a review of the historical stage and flow data collected at major water control structures. The basic data collection also included a summary of the farm discharge structures and reservoirs compiled from the review of available literature, interviews with District regulatory staff and field visits.

The detailed data collection portion of this task included field reconnaissance, another helicopter surveillance trip, a farm-level hydrologic assessment of private canals and overland flow processes, event-based flow monitoring, and canal cross-section surveys. The event-based flow monitoring consisted of measurements of flow at 12 locations within the basin during four large runoff events in the 2005 wet season. These measurements were made using a variety of techniques including Doppler-based instrumentation.

Subwatershed Segmentation and Screening-Level Phosphorus Assessment

Based on the review of available documentation and the basic and detailed data collection performed as part of this project, the C-139 Basin was divided into eight subwatersheds, and those eight subwatersheds were subdivided into 44 catchments. A subwatershed or catchment represents a geographic extent of an area that shares the same drainage outfall. By segmenting the C-139 Basin into subwatersheds and catchments, future analyses can be focused to specific areas upstream of the study area. The subwatershed segmentation utilized a digital elevation map of the region to define the boundaries of areas that could not be otherwise defined by using the information compiled for the project.

A screening-level TP assessment was performed for the C-139 Basin. This analysis utilized a spreadsheet approach to compute average annual runoff volumes and potential TP loads for each catchment. The screening-level assessment utilized the spatial distributions of land-use and soil data to generate a runoff coefficient and an event mean concentration (EMC) for each catchment. Once the runoff coefficient and EMC of each catchment was determined, the annual runoff and TP load was computed for each catchment using average rainfall from water years 1995 to 2004. These values were compared with the values published in the Everglades Agricultural Area (EAA) Regional Feasibility Study.

In addition to the screening-level TP assessment, an analysis of two sources of measured data was performed. The two measured data sources were the flow measurements performed within the detailed data collection and a set of concurrent water quality measurements provided by the District. The purpose of this analysis was to identify the potential distribution of runoff and TP load within the C-139 Basin and not to describe the actual spatial distribution of runoff or TP loading within the C-139 Basin.

Location of Monitoring Stations

The scope for the Location of Monitoring Stations included the identification of up to six (6) monitoring locations that capture or are representative of the spatial distribution of flow and TP load within the C-139 Basin. In cooperation with District Everglades Regulation Division staff, ADA identified four (4) monitoring locations that meet the objectives established by the District. Based upon discussions with District staff, there were two primary objectives when determining monitoring locations. The primary objectives were:

- Determine the runoff from each of the identified subwatersheds and
- Reduce potential access concerns.

Two individual monitoring scenarios were identified based on each of these objectives. These scenarios were used to determine the optimal location of the four monitoring stations to be installed as soon as practicable. The locations of the four proposed monitoring stations are listed in the **Figure ES-1** and described in **Table ES-1** below.

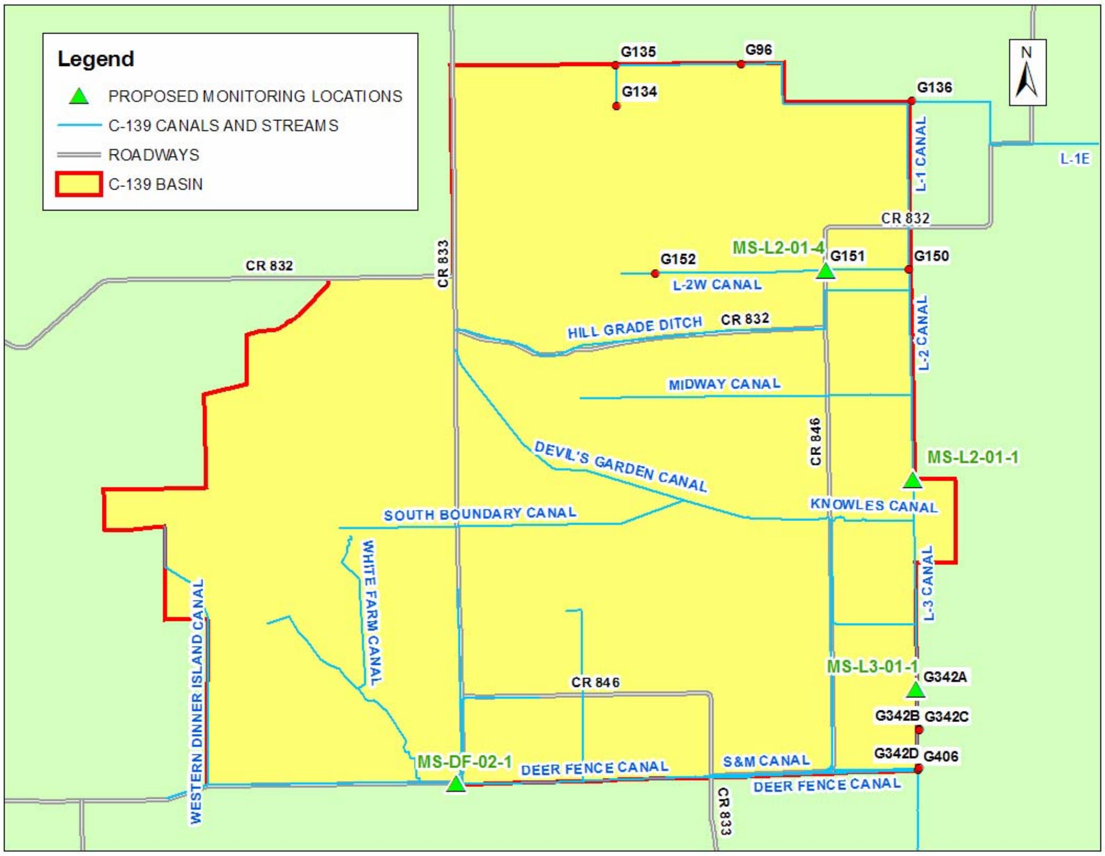

Figure ES-1: Locations of the Proposed Flow and TP Load Monitoring Stations

Table ES-1: Location and naming convention for the proposed monitoring stations

PROPOSED LOCATION	SFWMD NAMING CONVENTION	LATITUDE	LONGITUDE
MS-DF-02-1	DF11.3TW01	26° 25.71'	-81° 7.64'
MS-L2-01-1	L207.0TN	26° 32.12'	-80° 56.91'
MS-L2-01-4	G-151	26° 36.52'	-80° 58.96'
MS-L3-01-1	L202.0TN	26° 27.71'	-80° 56.84'

The proposed monitoring stations are to be used in combination with the three (3) existing monitoring stations (at the G-150 structure, the Deer-Fence Canal and S&M Canal) and the monitored District control structures (G-135, G-136, G-342A, G-342B, G-342C, G-342D and G-406) to better understand the spatial distribution of flows and TP loads that exist within the C-139 Basin.

A planning level cost-estimate was prepared for the monitoring location installations. Hydrologic and water quality analysis results of Phase II will also be used to optimize the location of the monitoring stations to be installed at a later date.

Phase II Objectives

Phase II consists of developing a hydrologic and water quality model and to evaluate the technical and regulatory feasibility of water quality improvement projects. At the time of the publishing of this report, the following preliminary objectives help to define the scope of Phase II.

1. Develop a screening level water quality model to optimize location of monitoring station identified in Phase I, and develop, calibrate, and verify a hydrologic and water quality modeling tool to analyze flows and phosphorus loads in the C-139 Basin.
2. Identify and evaluate a maximum of five water quality improvement projects. The recommendations/needs or project types described by C-139 Basin landowners shall be considered.
3. Describe regulatory constraints that may affect implementation of water quality improvement projects within the C-139 Basin, evaluate the regulatory feasibility of the selected water quality improvement projects or types of projects, and provide recommendations for pursuing viable rule or policy changes.
4. Identify technical issues, cost and schedule considerations for the selected projects.
5. Note uncertainties and limitations associated with project implementation.

1.0 INTRODUCTION

1.1 Background

Florida's 1994 Everglades Forever Act (EFA), F.S. 373.4592, establishes long-term water quality goals designed to restore and protect the Everglades Protection Area (EPA). The C-139 Basin is an approximately 170,000-acre tributary to the EPA. **Figure 1.1** depicts the C-139 Basin and other tributary basins to the EPA. The EFA mandates that landowners within the C-139 Basin should not collectively exceed an average annual historic total phosphorus (TP) load adjusted for rainfall. In 2002, the C-139 Basin Best Management Practices (BMPs) Regulatory Program was adopted to ensure that TP load requirements would be met. This BMP program is defined in Chapter 40E-63, F.A.C. ("Rule 40E-63").

During the 2003 legislative session, the 1994 EFA was amended to include reference to the March 17, 2003, Conceptual Plan for Achieving Long-term Water Quality Goals (Long-Term Plan), which includes the C-139 Basin. A Long-Term Plan objective for the C-139 Basin is to identify urban and agricultural discharges within the basin that are candidates for cost-effective implementation of source controls.

After three years of implementing the mandatory BMP program, the C-139 Basin has not been able to meet the historic TP load required by Rule 40E-63. In accordance with the EFA, if the basin is determined to be out of compliance in a given year, remedial action shall be based on landowners' proportional share of the total TP load. Rule 40E-63, requires that all permittees within the basin uniformly increase the level of BMP implementation in response to an out of compliance determination. In addition, some permittees have expressed interest in TP load reduction programs that can be implemented economically or with funding assistance, such that the basin has the best overall opportunity to comply with the rule. Rule 40E-63 also provides that, should the basin exceed the compliance requirements more than four times, the rule can be revised to address compliance. Both the South Florida Water Management District (District) and permittees are interested in additional TP load reduction programs within the basin that will be prioritized and addressed in future BMP program optimization plans, as necessary to meet rule requirements.

For compliance determination, TP load data are recorded by the District at the three discharge locations from the basin. To date, permittees in the C-139 Basin have elected not to participate in an optional farm-level monitoring program in part on the basis that this type of monitoring may not be feasible because of the hydrology of their farm basins and economic considerations. Therefore, TP concentrations and flow data within the basin are limited.

Basic knowledge of current basin hydrology is necessary for establishing a water quality and quantity monitoring network within the basin. The monitoring network will serve to gather continued TP concentration and flow data to develop prioritized source control strategies, consistent with EFA and Long-Term Plan requirements.

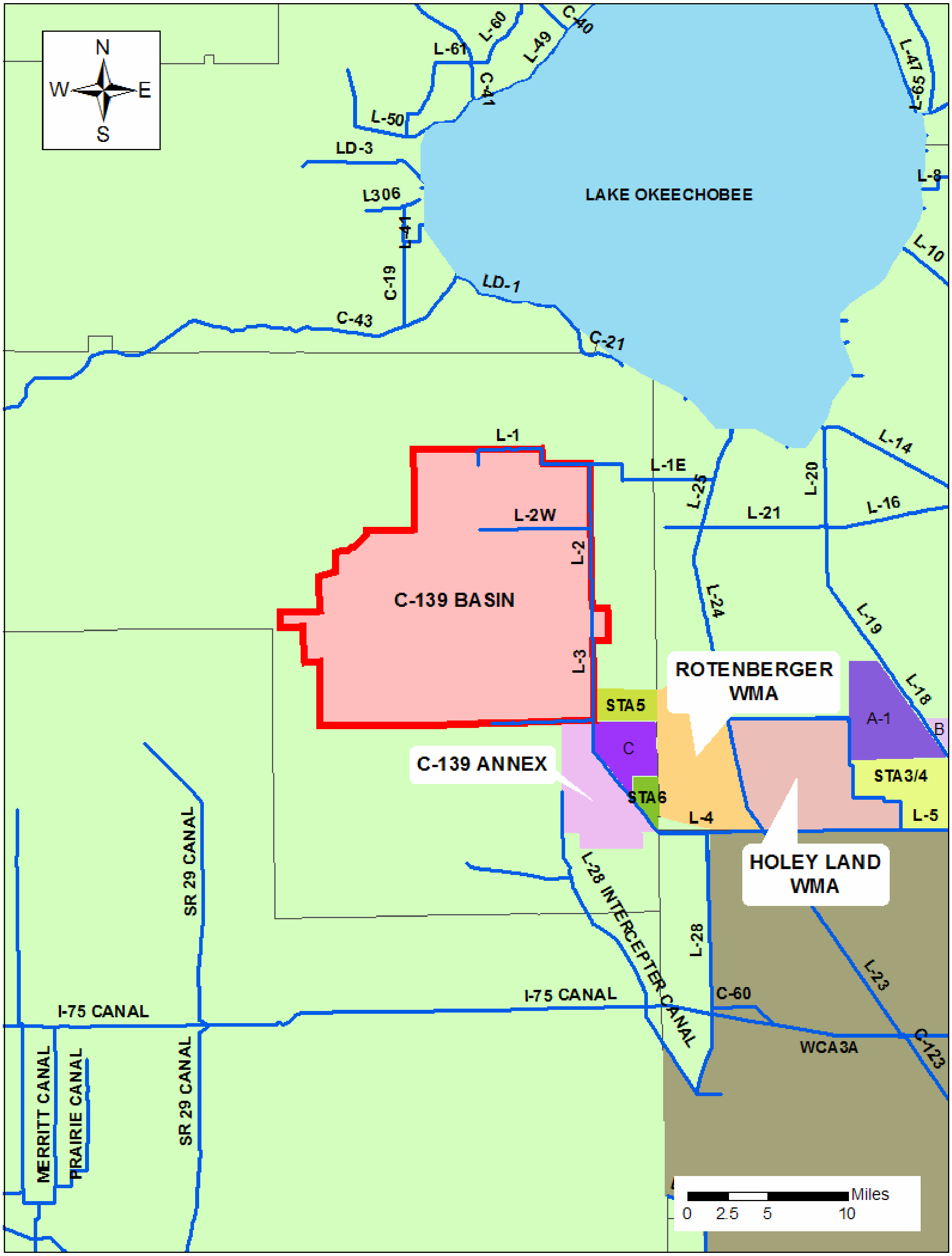

Figure 1.1: C-139 Basin Location Map

1.2 Objectives

The objective of the C-139 Basin Phosphorus Water Quality and Hydrology Analysis is to assess the current hydrologic and water quality conditions of the basin, identify locations where additional water quality and flow data is required, and identify and evaluate opportunities for water quality improvement. The project is to be completed in two phases covering the following objectives:

Phase I:

1. Describe the current drainage configuration including an inventory of farm-level offsite discharge locations and structure types, primary internal farm surface water features and hydrology.
2. Characterize flow along main C-139 canals, including direction of flow, flow rates and contributing tributaries, and District structures operation and its influence on basin hydrology.
3. Segment the C-139 Basin into drainage subwatersheds based on existing hydrologic conditions and the reasons for the subwatershed delineation.
4. Identify feasible locations for the installation of permanent flow and TP monitoring stations to be representative of the subwatersheds identified above.

Phase II:

1. Develop a screening level water quality model to optimize location of monitoring stations identified in Phase I, and develop, calibrate, and verify a hydrologic and water quality modeling tool to analyze flows and phosphorus loads in the C-139 Basin.
2. Identify and evaluate a maximum of five water quality improvement projects. The recommendations/needs or project types described by C-139 Basin landowners shall be considered.
3. Describe regulatory constraints that may affect implementation of water quality improvement projects within the C-139 Basin, evaluate the regulatory feasibility of the selected water quality improvement projects or types of projects, and provide recommendations for pursuing viable rule or policy changes.
4. Identify technical issues, cost and schedule considerations for the selected projects.
5. Note uncertainties and limitations associated with project implementation.

1.3 Phase I Scope

The District contracted A.D.A. Engineering, Inc. (ADA) under the General Engineering Services Contract (CN04912), between the District and ADA, to complete the work items associated with Phase I (Work Order No. CN040912-WO07). ADA assembled a team comprised of professional staff knowledgeable in hydraulics and hydrology, water quality, and Everglades Restoration to accomplish the following key work items:

- Perform extensive review of available water quantity and quality data, technical reports, aerial photography, and permit information for individual landowners within the basin;

- Consolidate and summarize all relevant technical and regulatory information in progress reports;
- Draft a field data collection plan and conduct field data collection to identify surface water structures, current drainage configuration, measure flow volumes, document canal characteristics, and other relevant information to complete the tasks;
- Segment the C-139 Basin into drainage subwatersheds and catchments based on data collected;
- Perform a screening-level phosphorus assessment to identify potential locations of permanent flow and TP monitoring stations;
- Identify feasible locations for the installation of permanent flow and TP monitoring stations to be representative of the subwatersheds;
- Schedule meetings with District staff and accessible landowners to gather information;
- Organize workshops/presentations; and
- Prepare technical reports including maps and photo documentation to describe key work items.

The Phase I scope of work was executed in a series of five separate tasks, and a total of 15 deliverables were prepared to document the work accomplished, as outlined in **Table 1.1**. The Phase I Report summarizes the work items and findings documented in the final deliverables of Task 2 through 5 (Deliverables 2.3, 3.3, 4.4 and 5.4). Work items associated with Phase II will be completed by ADA under a separate work order and documented as part of the Phase II Report.

Table 1.1: Phase I Tasks and Deliverables

Task/ Deliverable	Task/ Deliverable Description
Task 1	**Kick-Off Meeting**
1.1	Kick-Off Meeting Notes
Task 2	**Records Review**
2.1	Draft Records Review and Action Plan Report
2.2	Records Review and Action Plan Technical Review Meeting Notes
2.3	Final Records Review and Action Plan Report
Task 3	**Field Verification and Data Collection**
3.1	Draft Field Review and Data Collection Summary Report
3.2	Field Review and Data Collection Technical Review Meeting Notes
3.3	Final Field Review and Data Collection Summary Report
Task 4	**Subwatershed Segmentation**
4.1	Draft Subwatershed Segmentation Map
4.2	Draft Subwatershed Segmentation Report
4.3	Subwatershed Segmentation Technical Review Meeting Notes
4.4	Final Subwatershed Segmentation Report and Final Map
Task 5	**Location of Monitoring Stations**
5.1	Draft Monitoring Location Map
5.2	Monitoring Location Technical Memorandum and Final Map
5.3	Monitoring Location Monitoring Location and Phase II Scoping Technical Review Presentation Notes
5.4	Phase I Report with Final Segmentation Analysis and Monitoring Locations

2.0 RECORD REVIEW AND ACTION PLAN

2.1 General

The review of available and relevant documentation described in the scope of Work Order CN040912-WO07 details 17 literature sources, which included the review of approximately 25 Works of the District (WOD) permits, 40 Storm Water and Environmental Resources Permits (SW/ERP), and all other previous and concurrent activities that relate to the C-139 Basin. In addition to reviewing available literature, the records review included interviews with District Everglades Regulation Department staff, field visits and a helicopter surveillance trip.

Upon review of available literature, an Action Plan was defined for the collection of additional archived and field collected data. This action plan described the available historical stage, flow and water quality data as well as the methodology for collecting event-based flow measurements and bathymetric surveys of canal cross-sections within the C-139 Basin.

2.2 Review of Available and Relevant Documentation

2.2.1. Available Data

The District collected and provided available relevant data for review and analysis. **Table 2.1** below describes a summary of the information that is readily available. Most of this information has already been collected and reviewed; the remaining data collection will be performed as described in the action plan to follow.

Table 2.1: Summary of Available Data

Item	Available Data	Format	Date	Source	Description
1	Construction Plan Set for the L-3 and L-28 levees	Digital Plans	08/1952, 11/1987	SFWMD	Images created by scanning the original construction plans of the L-3 and L-28 levees
2	Settlement Agreement between SFWMD and C-139 Landowner	Settlement Agreement	05/1990	SFWMD	Agreement which defines the operational criteria of G-96, G-136, and G150
3	Western Basins Environmental Assessment	Report	07/1991 - 09/1992	Mock, Roos & Associates	Study of drainage, land-use, water quality, pollutant assimilation capacity and wetland quality for the entire western basins.
4	Water Quality Assessment for the C-139, L28I, Feeder Canal and L-28 Gap Basins	Report	10/1992	ES&E	Results of quarterly and synoptic water quality sampling performed from 1990 until 1992

5	Everglades Protection Project Conceptual Design	Report	02/1994	Burns & McDonnell	Conceptual plan document for the entire Everglades Protection Area
6	General Desing Memorandum for STA-5, STA-6, Rotenberger Tract Restoration, and West WCA Hydropattern Restoration	Report	07/1996	Burns & McDonnell	Preliminary designs for STA-5, STA-6, and hydroperiod restoration work within the Rotenberger Tract and WCA 3A
7	Final Design Report for STA-5, STA-5 Discharge Canal and STA-5 Outlet Canal	Report	09/1997	Burns & McDonnell	Refinement of the original General Design Report and the subsequent Detailed Design Report
8	Technical Report on the Determination of the Seminole Big Cypress Reservation Entitlement	Technical Memorandum	09/1998	SFWMD	Report which describes the quantification of the entitlement water rights of the Seminole Tribe in the Big Cypress Reservation
9	STA-5 Assessment of Operational Impacts	Report	11/1999	Burns & McDonnell	Description of potential flooding impacts, gage validation, and evaluation of operations for STA-5
10	Western Boundary Flows at the L-1 and L-3 Canals for the Simulation of the ECP Base, ECP Future Base and CERP Update	Technical Memorandum	06/2002	SFWMD	Description of methodologies used to determine the Western Boundary flows at the L-1 and L-3 canals for the SFWMM
11	C-139 Works of the District Permits and Post-permit Compliance Files	Permits	2002 - Present	SFWMD	See **Table 2.2** for description of Works of the District permits.
12	C-139 Environmental Resource Permit and Surface Water Permits	Permits	N/A	SFWMD	All pertinent ERP and SW permits that have been approved in the C-139 Basin
13	Bathymetric surveys of the S&M Canal and Deer-Fence Canal	Electronic	03/2005	SFWMD	Three cross-sections available on each canal east of the S&M Bridge
14	Stage and Flow data from all major SFWMD structures (L3BRN, G96, G134, G135, G136, G150, G151, G152, G342, G406)	Electronic	1994 - Present	SFWMD DBHYDRO	DBHYDRO makes daily data available for download. Hourly data is available on request.
15	NEXRAD Rainfall Data for the C-139 Basin	Electronic	1/2002 - 8/2005	SFWMD	NEXRAD data from 196 pixels that cover the C-139 Basin
16	LIDAR Topography Data	Electronic		USACE	Light Detection And Ranging topographic data
17	SFWMD Simulations for the Hydrologic Conditions in the C-139 Basin	Electronic	Present	SFWMD	Model set-up and parameterization used in both the SFWMM and RSM for the C-139 Basin

2.2.2. Helicopter Site Tour

On August 29, 2005, ADA participated in a District helicopter surveillance flight of the C-139 Basin. This trip was coordinated to provide field reconnaissance of the current conditions of the basin to be used in the hydrology analysis. In attendance were two ADA staff members and one District staff member from the Clewiston Field Station. The District staff member has worked for the Operations and Regulations Departments within Hendry County for several years and has extensive field knowledge of the basin. Pictures that were taken from the helicopter are incorporated into **Appendix A** of this document where appropriate.

2.2.3. Meetings with District staff

The Everglades Works of the District Permit Program was implemented for the C-139 Basin in 2002 pursuant to the provisions of the EFA. The Rule requires C-139 Basin landowners holding property that discharges water to District "works" to obtain a “Works of the District Permit.”

For the C-139 Basin, WOD permits require a BMP Plan and an optional Water Quality (WQ) Monitoring Plan. The BMP Plan outlines activities to be taken to reduce P loading to the Works of the District. Four members of the District Everglades Regulation Division staff are assigned to carry on BMP verification activities in farms within the C-139 Basin. These staff members are also responsible for WOD permit application review and issuance. **Table 2.2** describes each WOD permit holder and the staff member assigned to the permit at the time this report was prepared. As defined in the scope of work, ADA met with these four District staff members in an attempt to gather site-specific information pertinent to the hydrologic and hydraulic operations of each farm.

Table 2.2: Works of the District Permits and District Staff Assignments

Permit Number	Landowner	District Team Leader
26-00301-E	William G. Culligan	Jose Gomez
26-00302-E	Collier Groves, Ltd.	Bill Donovan
26-00303-E	ABC Ranch	Marta Edwards
26-00304-E	Jackman Cane & Cattle Company	Marta Edwards
26-00305-E	Collier Enterprises, Ltd.	Marta Edwards
26-00306-E	Southern Garden Groves Corporation	Bill Donovan
26-00307-E	United States Sugar Corporation	Bill Donovan
26-00308-E	Myrick And Rou Farms	Jose Gomez
26-00309-E	United States Sugar Corporation	Ching Garvey
26-00310-E	Hilliard Brothers of Florida, Ltd.	Jose Gomez
26-00312-E	Farmland Reserve, Inc.	Marta Edwards
26-00313-E	J&J Ag Products, Inc.	Ching Garvey
26-00314-E	Crooks Ranch, Inc.	Ching Garvey
26-00315-E	Zipperer Farms, L.L.C.	Marta Edwards
26-00316-E	Ray C. Hull Ranch, Inc.	Ching Garvey
26-00317-E	Cotton Brothers	Jose Gomez

26-00318-E	Southern Garden Groves Corporation	Bill Donovan
26-00319-E	C&B Farms, Inc.	Ching Garvey
26-00320-E	J Seven Ranch, Inc.	Jose Gomez
26-00321-E	Sunshine Agriculture, Inc.	Jose Gomez
26-00322-E	Jackman Cattle, Inc.	Bill Donovan
26-00323-E	ALICO, Inc.	Bill Donovan
26-00324-E	Devil's Garden Golden Ox	Ching Garvey
26-00326-E	K.T. John Little Cypress Grove	Marta Edwards
26-00327-E	Duck Curve Farm	Jose Gomez
26-00328-E	Seminole Tracks, Inc.	Jose Gomez

2.2.4. Records Review

Appendix A provides the compiled documentation from the review of available data in a farm-by-farm format as defined by the WOD Permits. This compilation includes the following information:

- Location Map
- Summaries of the SW/ERP and Water Use (WU) permits
- Land use
- Total area
- Narrative describing the current farm drainage
- Discharge structures
- Other characteristics that are relevant to Phases I and II of this contract

This compilation represents the information obtained from an initial review of the WOD permits. The information within **Appendix A** is also supplemented with some descriptions found in a preliminary review of the SW/ERP permits, the first helicopter surveillance trips, initial interviews with District regulation staff and preliminary site-visits.

2.3 Data Collection Action Plan

2.3.1. Basic Data Collection and Methodologies and Tools

The data collection process was performed in two-phases: basic and detailed. The basic data collection phase involves understanding the general configuration of the main C-139 canals (L-1, L-2, L-3, S&M Canal and Deer Fence Canal) and farm discharge structures, type and characteristics.

Through the process of records review, helicopter surveillance, preliminary site visits and interviews with District staff, an understanding of the general configuration of the main C-139 canals has been compiled. As is shown in **Figure 2.1** and **Figure 2.1a** below, the primary conveyance canals within the C-139 Basin are the L-1, L-2 and L-3 canals along the northern and eastern boundaries. The G-150 structure divides the L-1 canal from the L-2 Canal. The headwater side (south side) of the G-150 structure is just upstream of the junction of the L-2 and L-2W Canals. Since the G-150 structure is closed during large storm events, the structure divides the basin into northern and southern sub-basins (Mock-Roos, 1991). A large percentage of the runoff from farms north of the L-2W Canal drains either north to the C-43 Basin through the G-135 structure or east to the Miami Canal via the L-1E Canal through the G-136 structure. Runoff from farms south of the L-2W Canal drains to the southeast corner of the basin through several private canals (ALICO Midway, ALICO South Boundary, S&M, Deer Fence and other canals). The headwaters of the S&M Canal is at the intersection of CR 846 and CR 833 and extends eastward separated from the Deer Fence Canal by CR 846 for approximately 3 miles and a District owned dirt road for 2 miles before intersecting the L-3 Canal. Both the S&M Canal and the Deer Fence Canal act as the primary conveyance canals for drainage from the southernmost farms in the C-139 Basin.

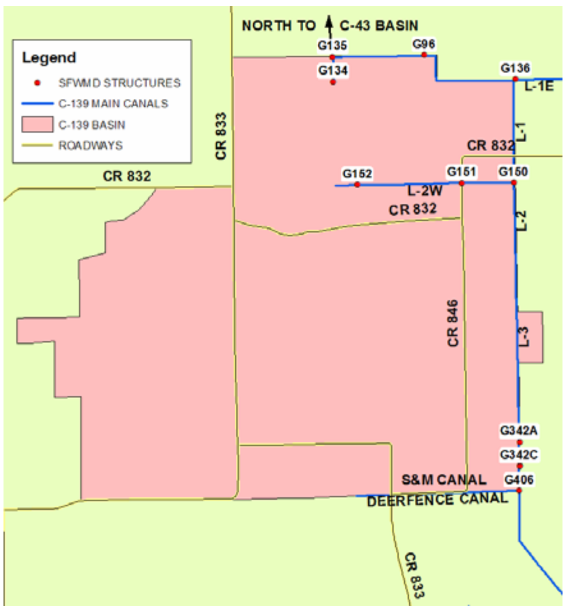

Figure 2.1: Main Canals in the C-139 Basin

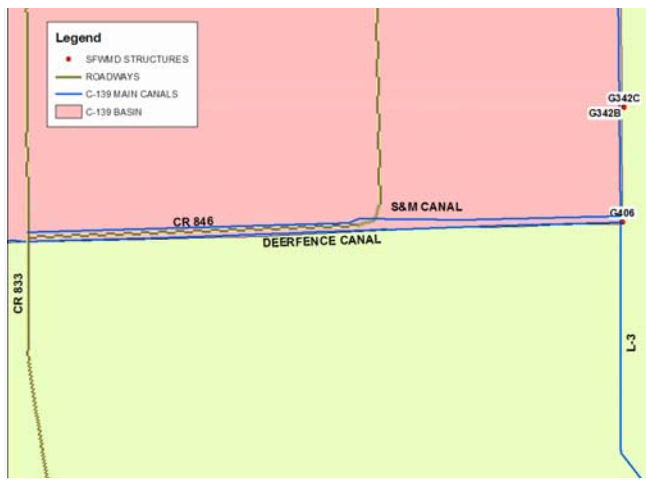

Figure 2.1a: Detailed Map of the S&M Canal

Additionally, the basic data collection included a description of the main C-139 canal network with respect to the direction of flow, flowrates and contributing tributaries, and District structures operation and its influence on basin hydrology. The basic data collection also included compiling a detailed summary of all farm discharge structures, type and characteristics. The results of the basic data collection are described in Section 3.0 (Field Verification and Data Collection

2.3.2. Detailed Data Collection and Methodologies and Tools

Permit reviews and helicopter surveillance cannot provide all of the farm-level hydrology parameters that are necessary to create an existing condition model of the C-139 basin. Therefore the detailed data collection process involved additional field reconnaissance including, meetings with land-owners, flow monitoring and canal cross-section surveys. Meetings with land-owners were performed in coordination with the District. Farms with a well defined drainage system within a single catchment and a single discharge point did not require field reconnaissance. However, farms with either multiple discharge points or locations with sheet-flow as a primary runoff process may have required meetings with land-owners.

2.3.2.1 Flow Monitoring

The intent of the flow monitoring was to capture a full range of flow events including high flows. As such, the measurements were made after rainfall events based on antecedent conditions. When real-time District stage recorders reported canal stages within the watershed were greater than the median value from the available period of record, then the antecedent conditions were deemed ideal for high flow conditions. In this case, measurements were made after rainfall events of 0.5 inches or greater in a 24 hour period. If antecedent conditions were below the median value, flow measurements were made after 1.0 inch of rainfall during a 24-hour period. The flow monitoring surveys were intended to consist of five surveys, each two days in length. However, due to hydraulic conditions there were four rainfall events surveyed for varying lengths of time. A complete description of the flow monitoring results can be found in Section 3.0.

There were eighteen locations that were being monitored for water quality by the Everglades Regulatory Program under contract CN040927-WO03, which was concurrent with this project. There were twelve flow monitoring locations originally selected by ADA and District staff. Ten of the twelve locations identified for flow measurement coincide with the eighteen water quality sampling sites for the water quality monitoring project. Although many of the locations were the same, it was difficult to correlate the measurements since the sampling frequency for the water-quality monitoring is defined as a weekly routine sampling, and the frequency for the flow monitoring is event-based in an attempt to capture high runoff events. The 12 monitoring locations originally identified for flow monitoring were based on the following considerations:

- Locations where flow cannot be calculated based on existing District monitoring stations
- Coordination with the concurrent water quality monitoring being performed under the Everglades Regulation Program Contract CN040927-WO03
- Provision of event-based flow data at large internal canals such as the ALICO Midway Canal, Deer Fence Canal and S&M Canal
- Inclusion of upstream areas with a variety of land use intensification (e.g. native, pasture, row-crop, etc)

Table 2.3 presents detailed information regarding the 12 originally proposed stations location and description. **Table 2.4** provides the dimensions of the structures where each of the proposed stations is located (Note: the dimensions of SM02.2TN02 and SMWEIR were not included since the measurements are not taken at any structure, but are taken in a natural channel).

Table 2.3: Recommended Flow Monitoring Stations

Station #	Station	Description	Miles
L209.1TW01	Midway Canal	Downstream side (east side)	0
L206.0TW01	Alico South	Downstream side (east side)	3
SM02.2TN02	Zipperer Canal	Mouth of Zipperer cutoff-canal, when risers are closed	11
SMWEIR	S&M Canal Weir	Intersection of S&M Canal and L-3 Canal	11
SM02.2TW02	Zipperer Culvert	Gate Outfall East Side	13
DF02.0TW	Hilliard Bridge	DF Canal Gate Outfall 846 to 835 curve	13
SM05.0TW	J7 S/M	2 Box Culv East side of 833 at 835	16
SM05.0TN	Culvert along 833	North and East side of 833 at 835	16
DF08.1TN01	South Bay	North side, facing South	20
DF11.3TW01	Duck Curve B	Bridge, South side	25
DF11.4TN01	Dinner Island SE	Culverts – downstream side	27
L206.0TW02	Alico Southwest	Culverts – upstream side	31
Notes: DF – Deerfence Canal			
Stations L209.1TW01, L206.0TW01, DF11.3TW01 and DF02.0TW have large drainage areas			
Stations SM02.2TN02, SMWEIR, SM02.2TW02, DF11.4TN01 and L206.0TW02 have moderate drainage areas			
Stations SM05.0TW, SM05.0TN and DF08.1TN01 have small drainage areas			
Miles are cumulative. It is approx. 17 miles from Clewiston to Station L209.1TW01 and 26 miles from station L206.0TW02 back to Clewiston			

Table 2.4: Structure Dimensions (units in feet)

Station #	Station	Height	Width	Number of Boxes	Culvert Diameter	Number of Culverts
L209.1TW01	Midway	7	6	2		
L206.0TW01	Alico S	10	8	4		
SM02.2TN01	Zipperer Cutoff Canal	N/A	N/A			
SMWEIR	S&M Canal Weir	N/A	N/A			
SM02.2TW02	Zipperer Culvert				5	2
DF02.0TW	Hilliard Bridge				5	4
SM05.0TN	J7 S/M				4	1
SM05.0TW	Culvert by 833	4	4	2		
DF08.1TN01	South Bay	2	12			
DF11.3TW01	Duck Curve	12	12	2		
L206.0TW02	Alico SW				5.5	3
DF11.4TN01	Dinner Island SE				5	3

The station numbers used are identical to the numbers being used for the parallel water quality sampling effort being conducted by the Everglades Regulatory Program. There were eight locations where water quality monitoring is underway that are not locations chosen for the flow measurements used in this project. These were determined based on a preliminary site visit by ADA and District Everglades Regulatory Division staff. The reason these locations were not chosen varied depending on location. Often the flows were predicted to be negligible due to small contributing areas. Other reasons locations were omitted included: the land-use in the contributing area was too similar to other locations, concerns about safe access during high-flow events, and culverts that were too small (indicative of insufficient flow). The deleted stations and reasons for deletion are listed below in **Table 2.5**.

Table 2.5: Water Quality Stations Not Included in Flow Measurement Stations

Station #	Name	Why Not Included
L212.1TW13	Devils Garden	Flow insufficient
L209.6TW02	ALICO Structure 1	Similar to ALICO Southwest
L207.6TW02	ALICO Gator	Small drainage area
DF12.3TS	Crows Nest	Small drainage area
DF12.2TS	Duck Curve Pasture	Small drainage area
DF11.1TN01	Crooks	Flow insufficient (Small culvert)
SM02.1TW	S&M Bridge	Can be derived by adding SM02.2TN02 and SM02.2TW02
SM02.1TN01	Zipperer A	Inflows downstream make this less useful for flow monitoring

The 12 locations proposed were based on the initial review of available data. However, after the first flow monitoring survey there was one location which was noted to have very negligible flows. SM05.0TW is a concrete double-box culvert under County Road (CR) 833 on the S&M Canal. The flow at this location is minimal due to the operations in Basin 26-320-01. It was determined that a better location for flow measurement would be L209.1TW02 along CR 833 on the west side of Basin 26-323-04. **Figure 2.2** illustrates all twelve of the original and the one additional flow measurement locations within the C-139 basin. **Figure 2.2a** clarifies two locations where the proposed flow measurement locations were too close together to distinguish between in the basin-wide figure. **Appendix B** contains digital photographs of each of the flow measurement locations.

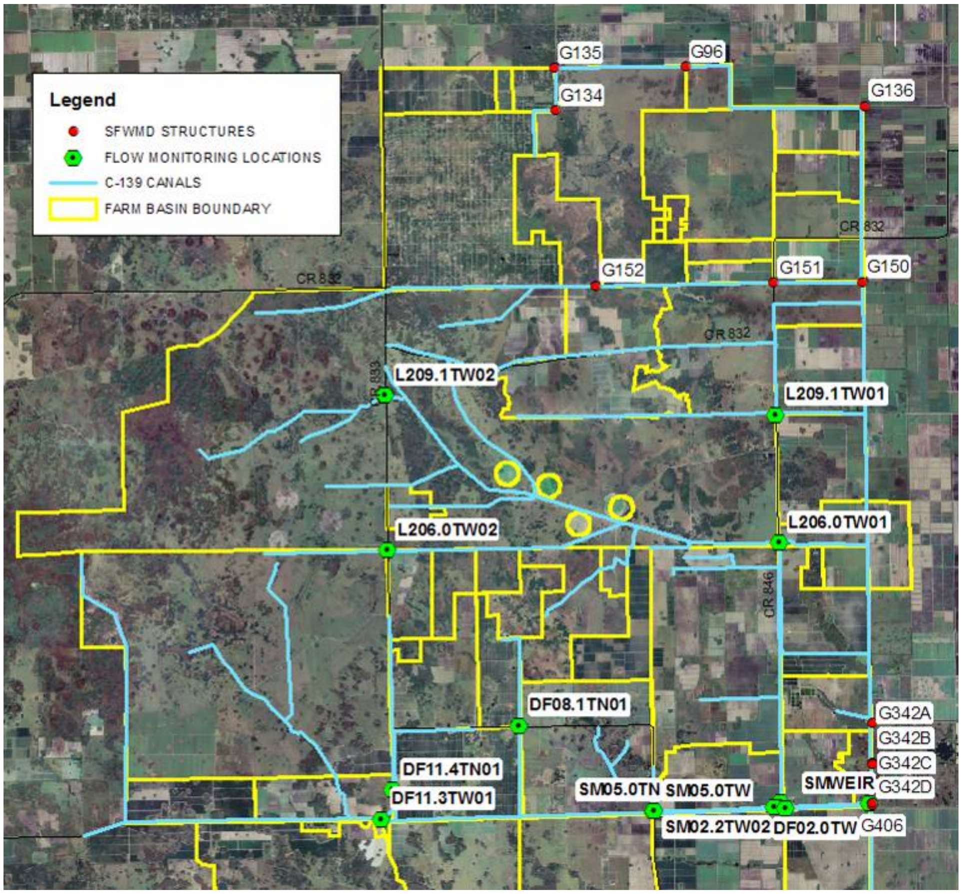

Figure 2.2: Proposed Flow Monitoring Stations

Figure 2.2a: Detailed View of Close Proximity Locations

The flow monitoring was completed by the subcontractor Hydrogage, Inc. Section 3.0 details the methodologies, results and preliminary analysis of the event-based flow monitoring performed at each of the 12 locations within the C-139 Basin.

2.3.2.2 Topographic and Bathymetric Data Collection

Superior Consultants Inc. (SCI) was sub-contracted to obtain critical canal cross sections to support the required hydrologic modeling to be performed in Phase II. These measurements utilized satellite measurements from the U.S. G.P.S. system through a SCI

Topcon Differential Positioning System using real-time, centimeter accurate positioning. The results of the canal cross-section survey are described in Section 3.0.

2.4 Coordinating with the EAA Regional Feasibility Study

The Everglades Agricultural Area (EAA) Regional Feasibility Study (RFS) included tasks that partially address the C-139 Basin. EAA RFS Deliverable 1.1 described the South Florida Water Management Model (SFWMM) results for the hydrology of the EAA and tributary basins such as the C-139. The SFWMM is an integrated surfacewater/groundwater hydrology and hydraulics model of the Everglades watershed south of Lake Okeechobee. The SFWMM domain does not include the C-139 Basin, but includes empirically derived inflows from the C-139 Basin canals. EAA RFS Deliverable 1.2 evaluated the SFWMM simulation results for 2010 and 2015 conditions. EAA RFS Deliverable 1.3 summarized the historic flows and volumes from all EAA basins including the C-139 since C-139 runoff is treated by EAA stormwater treatment areas (STAs). EAA RFS Deliverable 1.4 provided a methodology for estimating total P concentrations so that an approved dataset of flows and loads could be calculated using the SFWMM flows. EAA RFS Deliverable 1.5 provided approved datasets for flows and loads that were used for water quality modeling to determine the optimum distribution of inflows to the STAs.

Tasks 2 and 3 of the EAA RFS developed recommended flows and loads to the STAs for 2006-2009 and 2010-2014 so that a balanced minimum STA outflow and load could be achieved. In Task 2 and 3, STA 5, Compartment C, and STA 6 were modeled for hydrology, hydraulics, and water quality. The hydrology incorporated expected peak rates of runoff from the C-139 Basin. There were five alternatives considered for balancing flows and loads to the STAs and achieving a minimum overall discharge concentration to the Water Conservation Areas. Task 4 provided an alternative analysis where selected alternatives considered additional runoff to the STA 5/Compartment C/STA 6 complex. Draft Deliverables for all of these tasks have been submitted.

There are several analysis results that have been determined as a part of the EAA RFS that apply to the C-139 Basin, including:

- An analysis the STA 5/Compartment C/STA 6 complex performed using the Dynamic Model for Stormwater Treatment Areas (DMSTA) found that significant variability in expected total P outfall concentrations is possible. DMSTA is a spreadsheet based model specifically designed to calculate nutrient removal in STAs. Based on the analysis, the Total P (TP) removal rate for the STA 5/Compartment C/STA 6 complex is less than optimum, however the cause for this poor performance is unknown.
- The operation of the STA 5/Compartment C/STA 6 complex may result in elevated stages in the L-2, L-3, S&M and Deer Fence Canals during wet weather events. However these stages would be lower than the measured stages in these canals during historical wet weather events.
- Research is underway to determine the long-term removal efficiency of the STA 5/Compartment C/STA 6 complex. Until the research is completed it will not be

possible to determine the magnitude of additional flows that can be treated in the STA 5/Compartment C/STA 6 complex.

- The RFS considered diversion of additional flows from the Miami Canal basin to the L-2 Canal north of G-406 in order to reduce pollutant inputs to STA3/4. This approach will not be implemented until it is demonstrated that the assimilative capacity of the STA 5/Compartment C/STA 6 complex is sufficient to handle this Miami Canal diversion. Additionally, the RFS recommended a pump station in the L-2 canal north of G-406, should this diversion be implemented to prevent the potential for increased flooding.

Because ADA was integrally involved in the hydrologic and hydraulic modeling portion of the EAA RFS there was a strong coordination of the C-139 Basin Phosphorus Water Quality and Hydrology Analysis with the goals and objectives of the Long-Term Plan for the EAA. Relevant findings or progress will be provided to the Everglades Regulation Division data throughout the District.

3.0 FIELD VERIFICATION AND DATA COLLECTION

3.1 General

The scope of the Field Review and Data Collection included the review of the available regional data, field surveillance of farm-level infrastructure, SW/ERP and WOD permit review, flow monitoring and site survey. Additionally, interviews with C-139 landowners and a helicopter surveillance trip were also part of this task. The Action Plan (Section 2.0) described the Field Review and Data Collection Summary containing two parts: the basic data collection and detailed field verification. The following section includes both the basic and detailed data collected along with the relevant collection methodologies.

3.2 Basic Data Collection

The passage of the Flood Control Act of 1948 authorized the Central and Southern Florida Project (C&SF). One of the components of the original project was a system of levees along the western edge of the EAA for flood control purposes. The L-1, L-2 and L-3 levees were constructed under this congressional authorization. The Flood Control Act of 1958 was the first Act to specifically authorize a project designed to provide flood protection for a 64 square mile area west of the L-1, L-2 and L-3 levees. The Flood Control Act of 1965 authorized a new plan for Hendry County which increased the flood protection improvement area to a 261 square mile area west of the L-1, L-2 and L-3 levees. These plans made use of the L-1, L-2 and L-3 borrow canals as the main conveyance elements of the drainage network within the C-139 Basin. A Hendry County Plan was introduced in the 1970s, which attempted to increase the conveyance capacity of this network by enlarging the cross-sectional area of these canals and creating a single conveyance element which would be the C-139 Canal. However, this plan was not implemented. These projects and the degree to which these projects were implemented have defined the characteristics of the drainage network for the present day C-139 Basin. In order to describe the general hydrology of the C-139 Basin, the following sections describe in detail the major structures, a discussion of sub-regional hydrology, preliminary analysis of available data and a description of farm surface water management systems.

3.2.1. Understanding of C-139 Basin Canals and Control Structures

There are 12 District control structures that help to define the hydrologic and hydraulic characteristics of the C-139 Basin. **Table 3.1** describes the geometry of these structures including: G-134, G-135, G-96, G-136, G-150, G-151, G-152, G-342A, G-342B, G-342C, G-342D and G-406. The first seven structures listed are made of corrugated metal pipe (CMP) with flashboard riser control on the upstream side, whereas the last four are concrete box culverts (CBC) with automated metal gates used for operation. All elevations are relative to the National Geodetic Vertical Datum (NGVD) of 1929. Many of the hydrologic characteristics of the C-139 Basin are based on the operation of these structures. **Figure 3.1** illustrates the location of these structures within the C-139 Basin.

Table 3.1: Geometry of Major District Control Structures within the C-139 Basin

STRUCTURE	TYPE	NUMBER OF BARREL(S)	SIZE OF BARRELS	FLOW LINE ELEVATION*	CREST ELEVATION*
G-96	CMP w/ risers	2	66"	7.28' and 7.85'	18.74'
G-134	CMP w/ risers	1	72"	12.24'	25.0'
G-135	CMP w/ risers	1	84"	12.13'	26.0'
G-136	Gate and CMP	3	84"	8.0'	27.5'
G-150	CMP w/ risers	3	84"	8.5'	24.0'
G-151	Gate and CBC	2	10' x 8'	9.0'	21.0'
G-152	CMP w/ risers	4	72"	14.5'	N/A
G-342A	Gate and CBC	1	10' x 6'	7.25'	N/A
G-342B	Gate and CBC	1	10' x 6'	7.25'	N/A
G-342C	Gate and CBC	1	10' x 6'	7.25'	N/A
G-342D	Gate and CBC	1	10' x 6'	7.25'	N/A
G-406	Gate	2	10' x 9'	6.0'	21.75' **

* All elevations are feet NGVD. The flow line elevation represents the invert of the CMP or CBC.

** G-406 – Gates open at an upstream elevation of 15 ft-NGVD. The width of the emergency overflow weir is 28 ft.

Sources: see SFWMD (2000) for G-342 (A-D) and G-406, SFWMD (2004) for G-96 through G-151, and Johnson-Pruitt (2001) for G-152

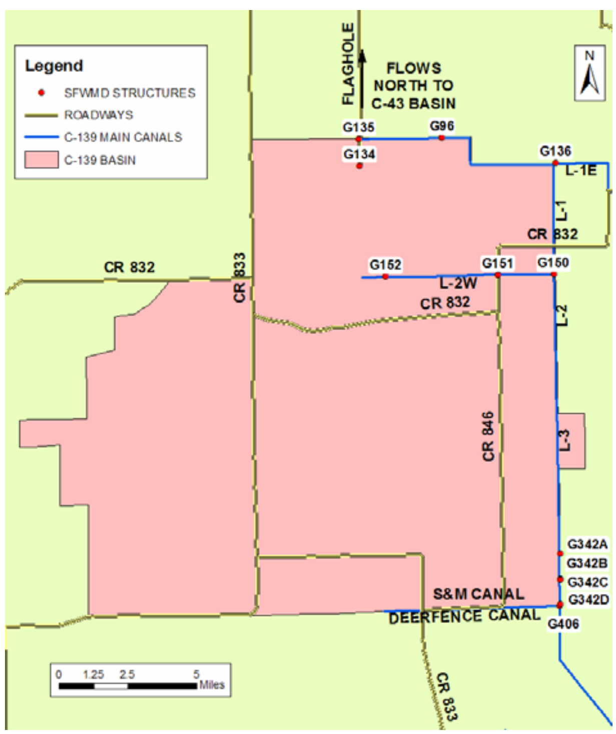

Figure 3.1: Main Canals and Structure Locations in the C-139 Basin

3.2.1.1 Northwest Sub-region of the C-139 Basin

For the purposes of this discussion, the northwest sub-region of the C-139 Basin includes Basins 26-312-01, 26-317-01, 26-303-01, Montura Ranch Estates and the Central County

Drainage District Reservoir. Because the operation of the G-134, G-135 and G-96 structures are generally open (see **Figure 3.2** and **3.3**) the general drainage pattern of this sub- region of the watershed is to the north and to the east as is illustrated in **Figure 3.4**.

Figure 3.2: Upstream G-135 Looking North

Figure 3.3: Upstream G-96 Looking Northeast

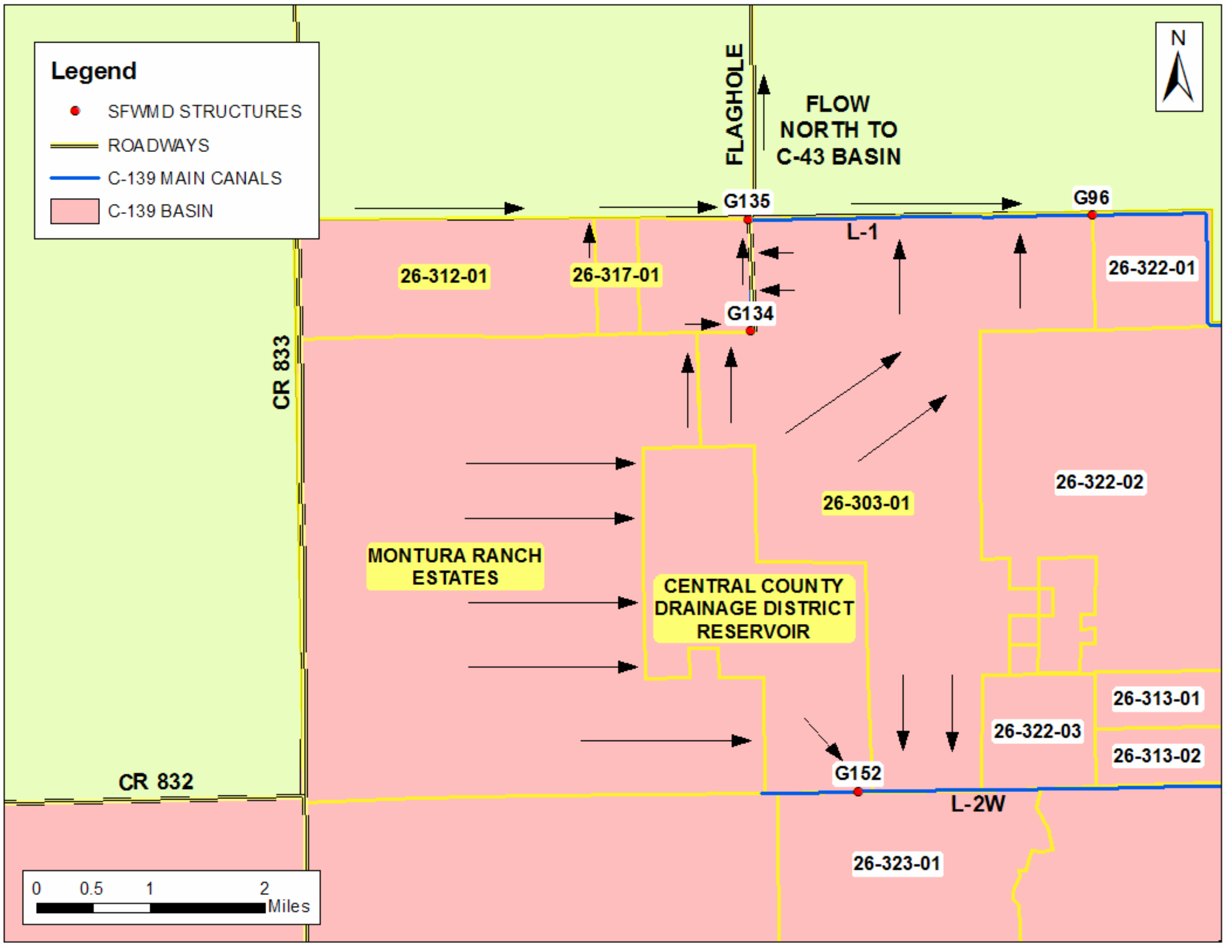

Figure 3.4: Flow Patterns in the Northwest Sub-region C-139 Basin

3.2.1.2 Northeast Sub-region of the C-139 Basin

For the purposes of this discussion, the northeast sub-region of the C-139 Basin includes Basins 26-322-01, 26-322-02, 26-304-01, 26-304-02, 26-304-03 and 26-309-01. Because the operation of the G-136 structure (see **Figure 3.5**) is generally open and the operation of the G-150 structure is generally closed, the general drainage pattern of this sub-region of the watershed is to the northeast as is illustrated in **Figure 3.6**. Water that exits the basin through the G-136 structure is transported to the Miami Canal via the L-1E Canal.

Figure 3.5: Downstream G-136 Looking West

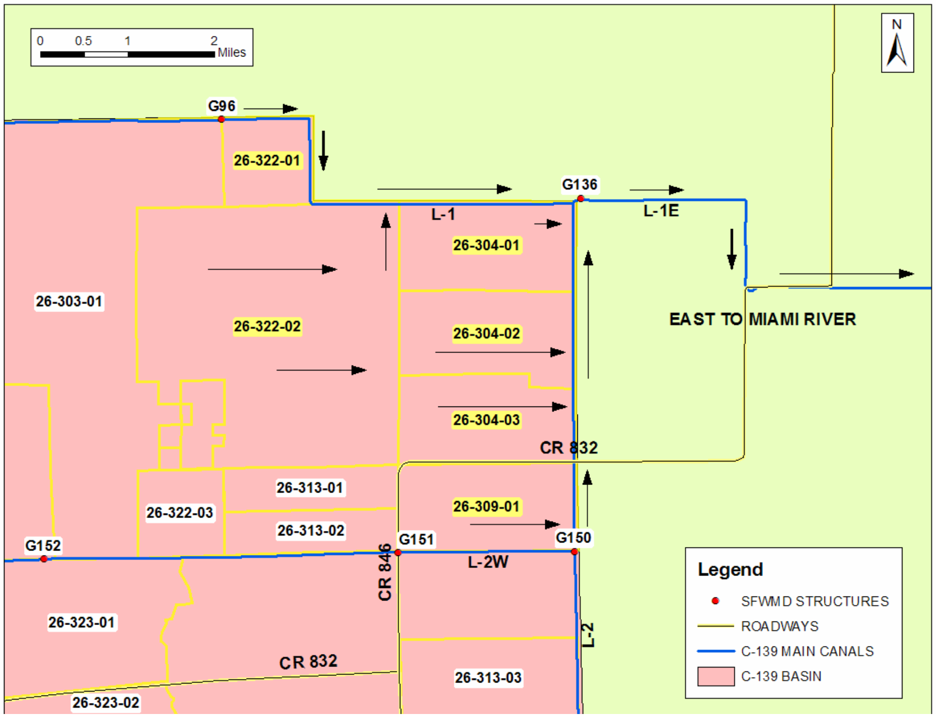

Figure 3.6: Flow Patterns in the Northeast Sub-region of the C-139 Basin

3.2.1.3 Western L-2W Canal Sub-region of the C-139 Basin

For the purposes of this discussion, the western L-2W Canal sub-region of the C-139 Basin includes portions of Basins 26-303-01, 26-322-03, 26-323-01, 26-323-02, 26-323-04, Montura Ranch Estates and the Central County Drainage District Reservoir. The general drainage pattern of this sub-region of the watershed is to the east as is illustrated in **Figure 3.7**. Runoff from this sub-region is transported east along the L-2W Canal to the L-2 Canal at the upstream (south) side of the G-150 structure. Since the G-150 structure is generally closed, the runoff is then transported south via the L-2 and L-3 canals to Stormwater Treatment Area 5 (STA 5) or through the G-406 structure.

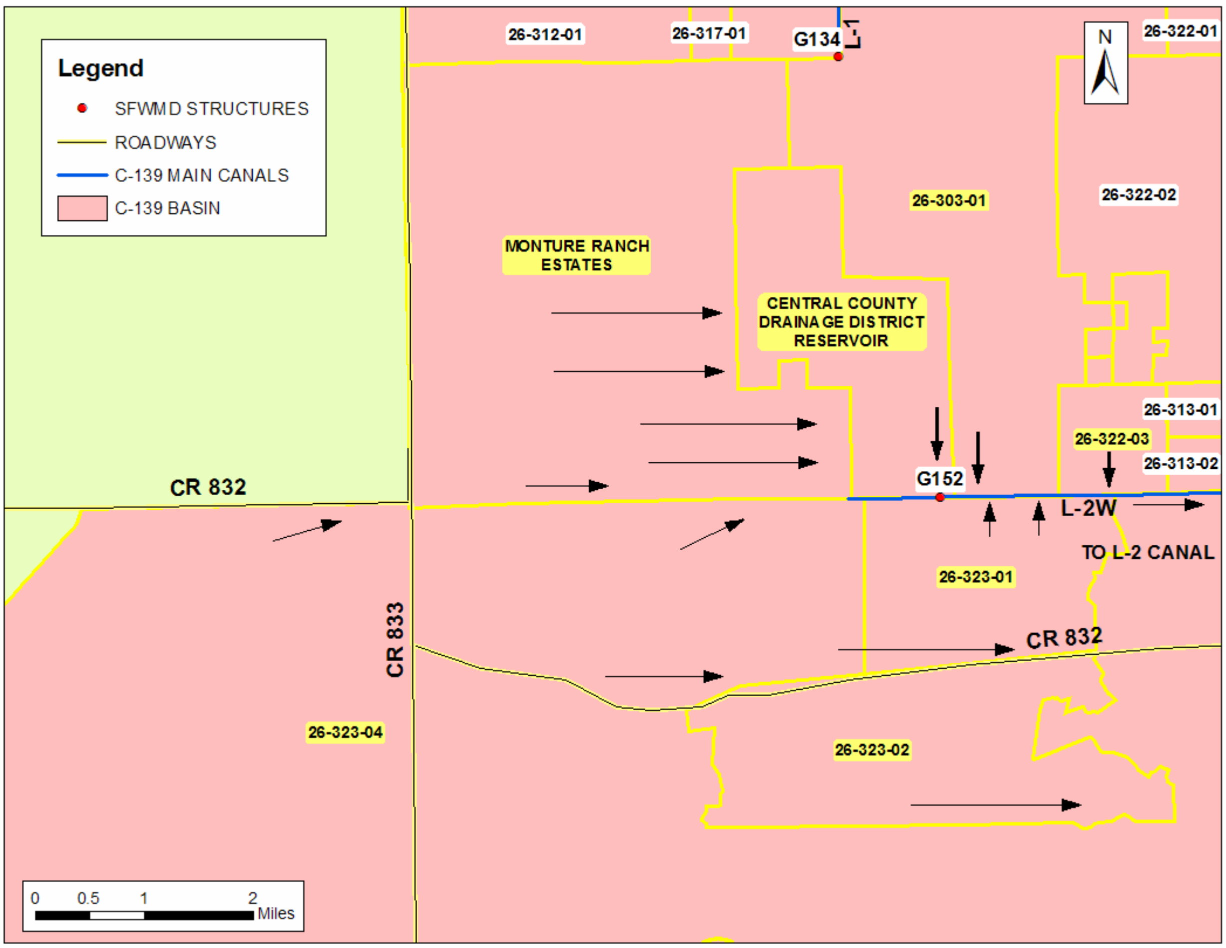

Figure 3.7: Flow Patterns in the Western L-2W Canal Sub-region of the C-139 Basin

3.2.1.4 L-2 Canal Sub-region of the C-139 Basin

For the purposes of this discussion, the L-2 Canal sub-region of the C-139 Basin includes portions of Basins 26-303-01, 26-322-03, 26-313-01, 26-313-02, 26-313-03, 26-307-02, 26-323-01, 26-323-02, 26-323-03, 26-323-04, 26-323-05, 26-310-01, 26-310-02, 26-310-03, 26-308-01, 26-303-03 and 26-328-01. The general drainage pattern of this sub-region of the watershed is to the southeast as is illustrated in **Figure 3.8.** Runoff from this sub-region is transported east along the internal farm canals to the L-2 Canal. Flows in the L-2 Canal are directed to the L-3 Canal and then either into STA 5 through G-342A, G-342B, G-342C and G-342D or through G-406 towards Water Conservation Area 3A (WCA-3A).

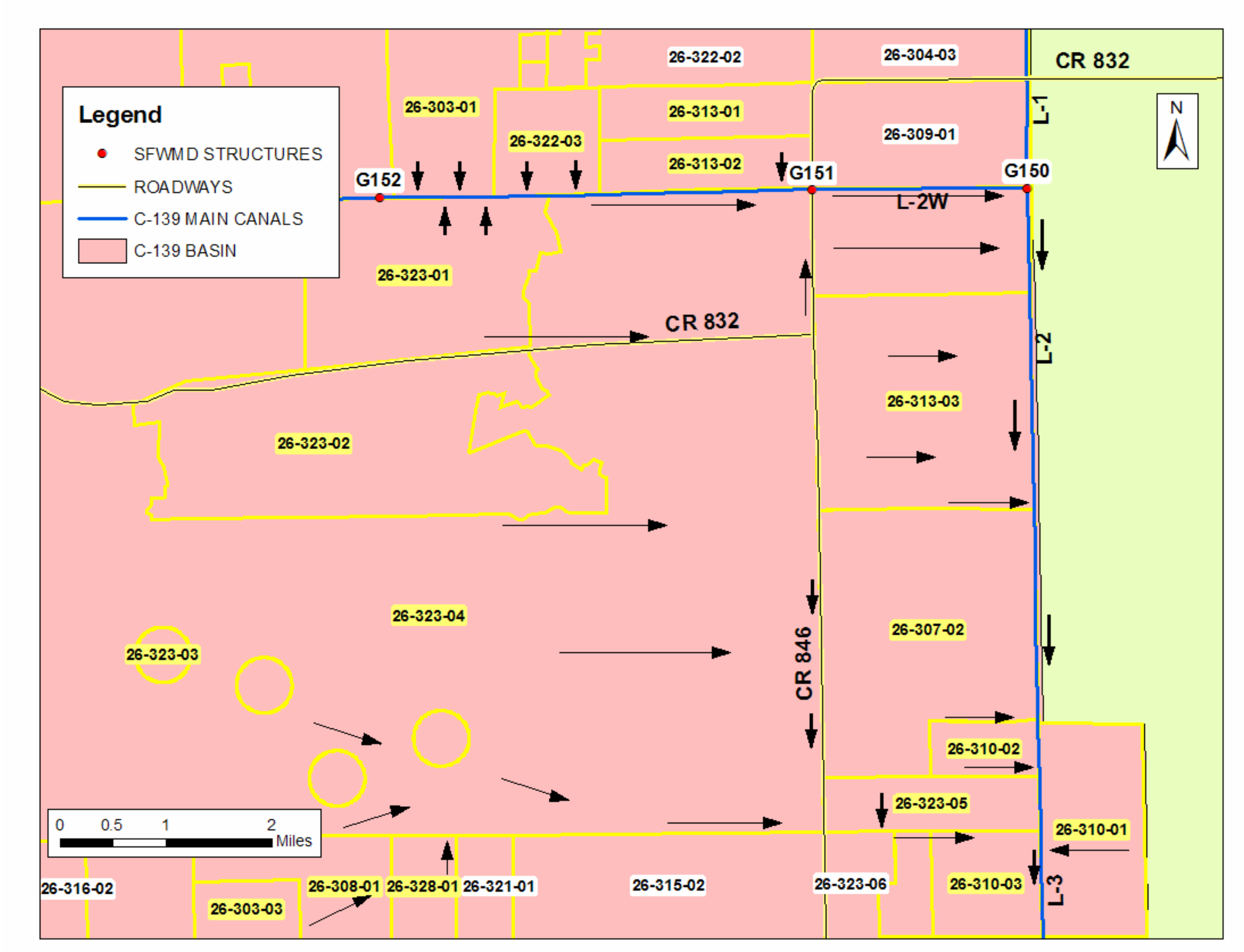

Figure 3.8: Flow Patterns West of the L-2 Canal

3.2.1.5 L-3 Canal Sub-region of the C-139 Basin

For the purposes of this discussion, the L-3 Canal region of the C-139 Basin includes Basins 26-310-01, 26-310-03, 26-323-06, 26-326-01, 26-325-01, 26-319-01, 26-319-02, 26-315-01, 26-315-02, 26-320-01, 26-321-01, 26-318-01, 26-328-01 and 26-308-01. The general drainage pattern of this sub-region of the watershed is to the southeast as is illustrated in **Figure 3.9.** Runoff from this sub-region is transported by internal drainage networks to the L-2 and L-3 Canals along the east and the Deer Fence or S&M Canals on the south. All of these conveyance systems bring excess runoff to the southeast corner of the C-139 Basin where it is directed either into STA 5 through G-342A, G-342B, G-342C and G-342D or through G-406 towards WCA-3A.

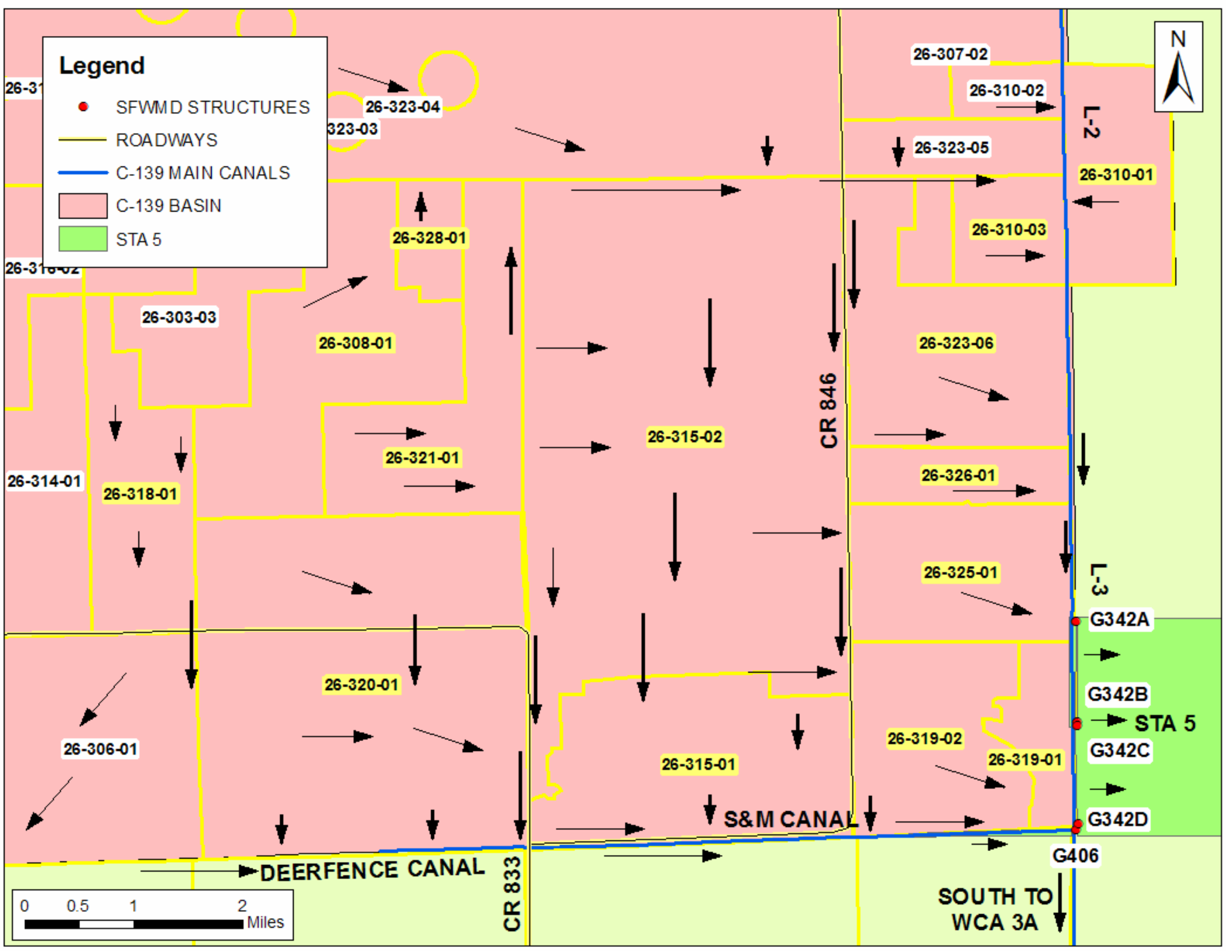

Figure 3.9: Flow Patterns West of the L-3 Canal

3.2.1.6 Western Deer Fence Canal Region of the C-139 Basin

For the purposes of this discussion, the Deer Fence Canal region of the C-139 Basin includes Basins 26-306-01, 26-314-01, 26-301-01, 26-316-01, 26-316-02, 26-323-04, 26-324-01, 26-310-04, 26-302-01, 26-302-02, 26-305-01, 26-327-01 and 26-327-02. The general drainage pattern of this sub-region of the watershed is to the southeast as is illustrated in **Figure 3.10**. Runoff from this sub-region is transported by internal drainage networks to the Deer Fence Canal along the southern boundary of the C-139 Basin. Excess runoff is then routed east towards the southeast corner of the C-139 Basin.

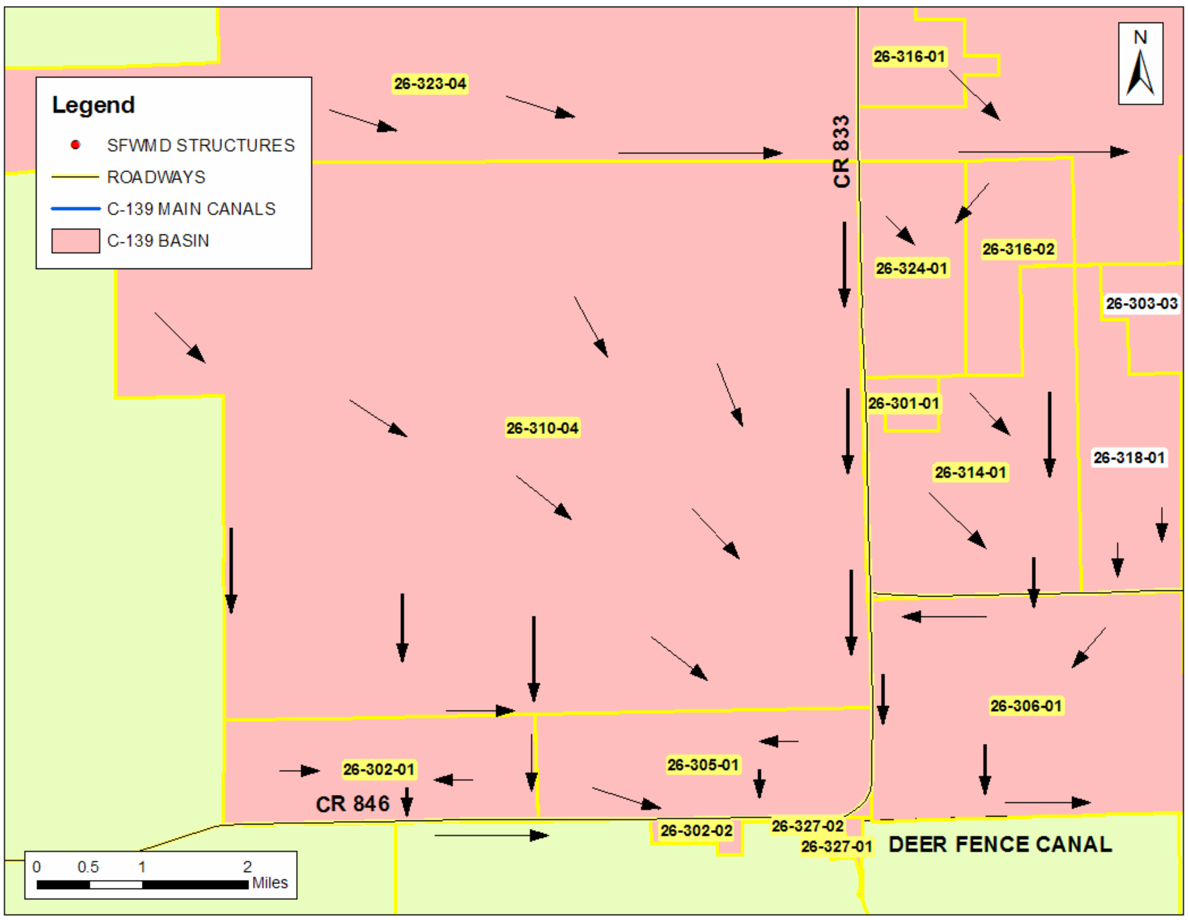

Figure 3.10: Flow Patterns North of the Deer Fence Canal

3.2.2. Analysis of C-139 Basin Available Measured Data

As mentioned above in Section 2.1, the north portion (north of G-150 at the junction with L-2W) of the C-139 Basin operates somewhat separately from the south C-139 Basin. This is due to the operation of G-135, G-136, and G-150. G-135 is a gate that controls flows from L-1 in the C-139 Basin to the Flaghole Canal in the C-43 Basin. The flashboards at G-135 are normally left open, allowing runoff from the northwest corner of the basin to flow north into the C-43 Basin. The boards are left open because the invert elevation of two privately owned existing CMP culverts in L-1 at Flaghole Road are 15 ft-NGVD. This elevation restricts runoff from the C-139 Basin via the L-1 canal, which causes flooding in neighboring properties. The headwater side of G-150 structure is on the south side of the gate, therefore positive flows at G-150 are northerly flows towards G-136. The G-136 is also a gated structure that permits runoff from the C-139 Basin to enter the EAA Basin. There is essentially no runoff during the dry part of the season in the north C-139 Basin due to irrigation withdrawals.

Flows from the north C-139 Basin for the second half of 2004 are presented below in **Figure 3.11**. It can be seen that the south C-139 basin received no flows from the north C-139 Basin. Most of the runoff from the north C-139 Basin entered the EAA basin, while C-43 received approximately 1/3 of the north C-139 Basin runoff.

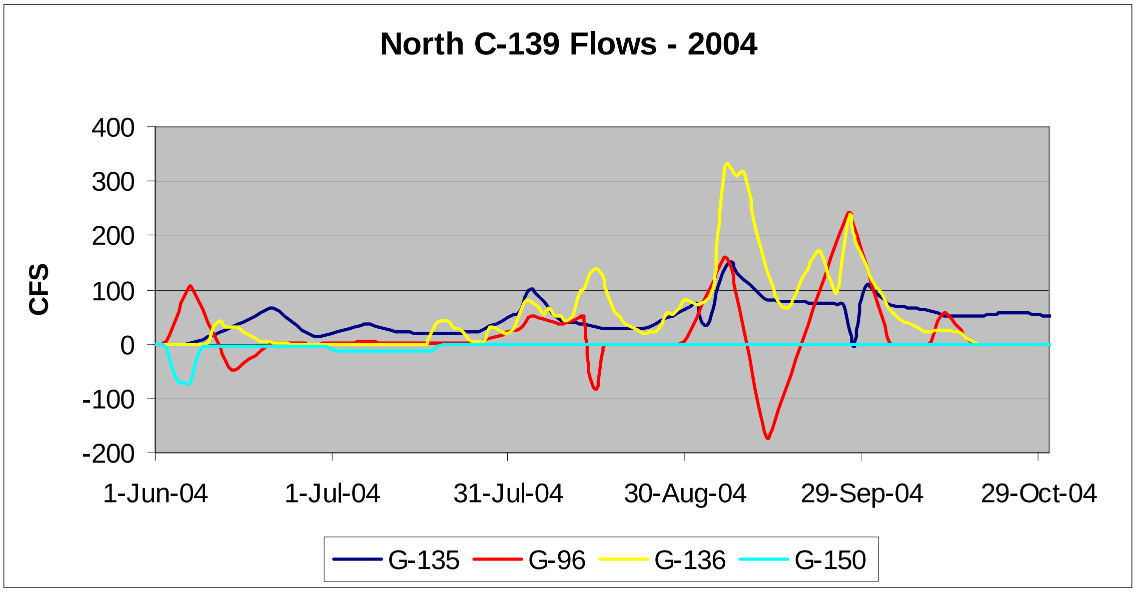

Figure 3.11: Flows in the North C-139 Basin

The south C-139 Basin receives runoff from L-2W, the Midway Canal, the ALICO South Boundary Canal, the S&M Canal, and the Deer Fence Canal. Runoff from the south C-139 Basin enters STA 5 or flows south to WCA3A. Flows to WCA3A were recorded by Station L3DF until late 1999, when the G-406 structure gate was constructed. After that point, the L3DF station was discontinued and was replaced by the G-406 station. The G-406 structure is kept closed for headwater stages less than 16 ft-NGVD, which forces C-139 Basin runoff into STA 5. When headwater stages rise above 16 ft-NGVD, G-406 opens to maintain stages in the range of 16 ft-NGVD to 17 ft-NGVD. **Figure 3.12** illustrates that peak stages are not negatively affected by the installation of G-406 (G-406 headwater stages are represented by monitoring station L3DF until late 1999, after which G-406 headwater stages are represented by the monitoring station at G-342A headwater). The comparison illustrates that G-151 headwater stages are unaffected by conditions at G-406 and illustrate that the difference in stages after construction of G-406 are not influenced by regional rainfall patterns.

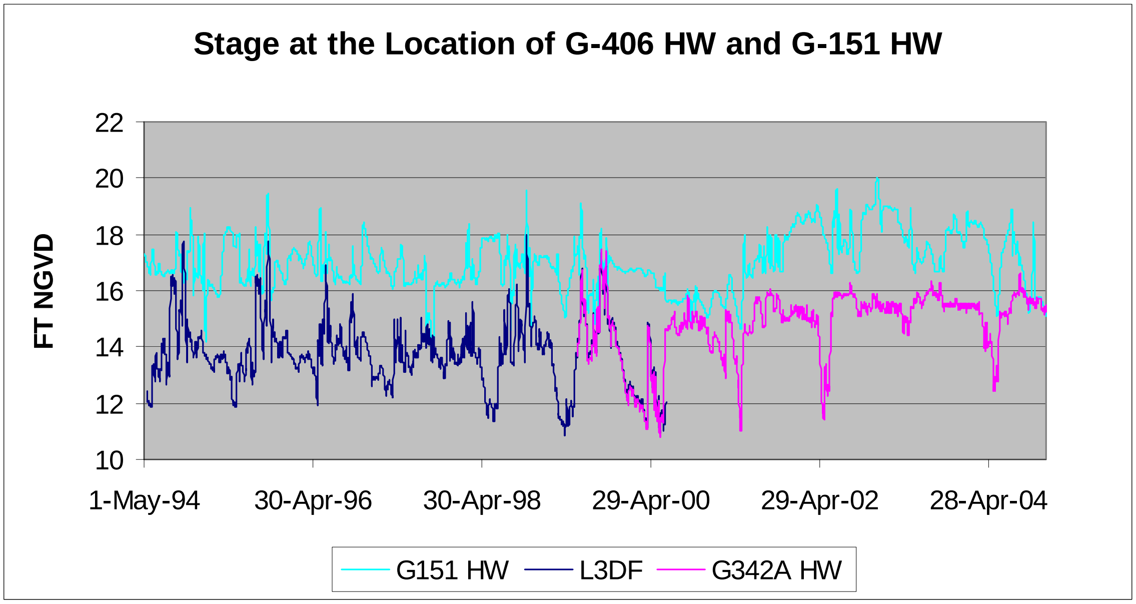

Figure 3.12: Stages in L-2 Upstream of G-406

The EAA RFS provided approved inflow data sets for analysis of STA performance for both historical conditions and anticipated future conditions. EAA RFS Deliverable 1.3 provided approved inflow data sets for historical conditions. In the EAA RFS analysis (Deliverable 1.3), C-139 Basin flows were calculated using the following assumptions:

- C-139 Basin runoff = [G136]+[G342A,G342B,G342C,G342D]+[G406]
    - Prior to Jan 1996, [L3] = [G88]+[G89]+[G155]
    - Between Jan 1996 and June 2000, [L3] = [L3DF]
    - After June 2000, [L3]=[G406]

Figures 3.13 and 3.14 present EAA RFS flows for the C-139 Basin for the period 1994 through 2004. **Figure 3.13** illustrates that most of the C-139 Basin runoff flowed south through L-3, and STA 5 began treating C-139 Basin runoff in late 1999. Runoff rates were high in 1994, 1995, 1998, and 1999, primarily influenced by hurricanes during those years. The peak discharge was during the period 1994 through 2005, the highest discharge was 2,200 cubic feet per second (cfs) on October 20, 1995 due to a rapidly advancing cold front in mid-October that generated 7.6 – 13.6 inches of rain in the C-139 Basin (Surface Water Conditions Detail Report, October, 1994; also rainfall data from Alico, Devils Garden, and G-136 gages). 1995 was a wet year, with high rainfall due to Tropical Storm Chantal, Hurricane Erin, Tropical Storm Jerry, eight inches of rainfall in September, and Tropical Storm Opal in early October (Surface Water Conditions Detail Reports, July-October, 1995). **Figure 3.14** illustrates that G-406 was opened each year during the wet season.

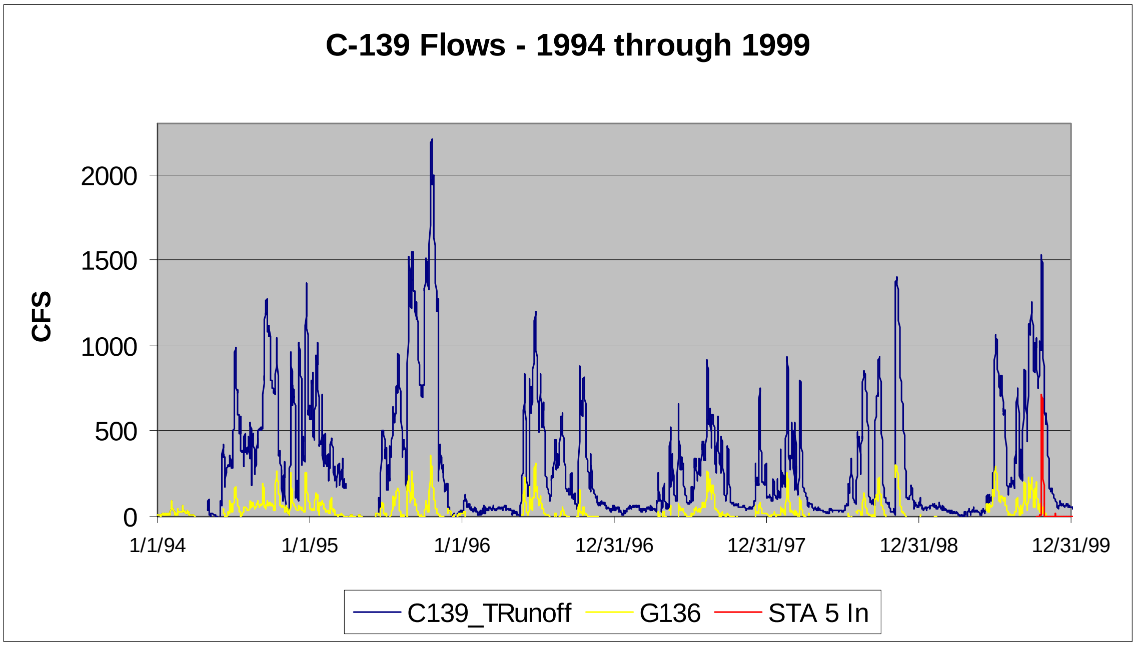

Figure 3.13: EAA RFS C-139 Basin Flows, 1994 through 1999

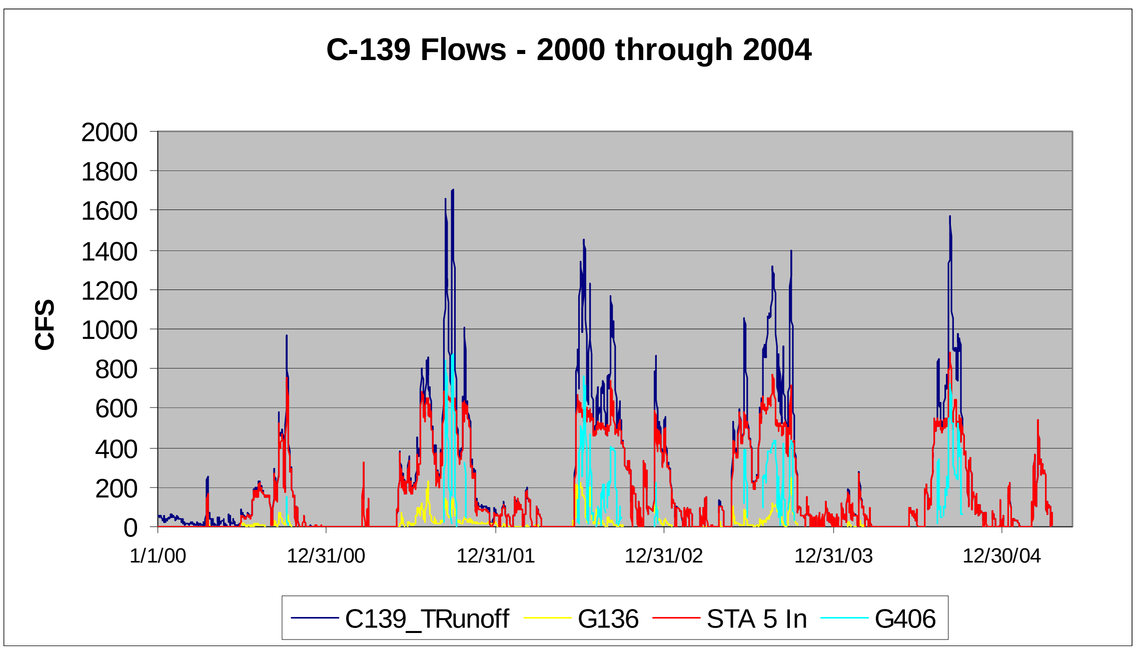

Figure 3.14: EAA RFS C-139 Basin Flows, 2000 through 2004

3.2.3. Understanding of Farm Discharge Structures, Types and Characteristics

Many of the farm basins within the C-139 Basin contain a surface water management system which discharges through an outfall(s) to the District canal network. Farm discharges are typically controlled by flashboard riser structures upstream of culvert outfalls. Some farms also have reservoirs that are used for treatment of farm runoff. The reservoir discharge is controlled by a flashboard riser structure based on the applicable District permits. If the farm does not have a reservoir, canal discharges are usually also controlled by a flashboard riser structure. The farm discharge is therefore controlled by the farm operator who will manually lift an underflow gate (e.g. S&M Canal at CR 846) or pull wooden flashboards. Farms either release or hold water according to a multitude of factors including:

- Gates are pulled when heavy rainfall is anticipated on the farm during a period when interior canal levels are high.
- Gates remain closed when minor amounts of rainfall are anticipated during a period when interior canal levels are normal or low.
- Gates remain closed during the end of the wet season when interior canal levels are normal to high.

Based on informal discussions with consultants who work for C-139 farmers, farmers maintain internal canal water levels because a reliable external irrigation source is not available and groundwater irrigation supplies are costly and unreliable. Discharges are not initiated during low to moderate rainfall events because the farmers store this runoff for subsequent irrigation. When heavy rainfall occurs, discharge rates are higher than normal due to high interior canal elevations.

ADA has prepared two spatial datasets which describe the farm basin surface water management systems within the C-139 Basin. The first dataset describes the surface water reservoirs which were permitted, completely constructed and are operating as of the end of 2005. **Figure 3.15** illustrates the number of reservoirs currently operating within the C-139 Basin, and **Table 3.2** describes the attributes of the reservoirs. The area of the reservoirs described in **Table 3.2** does not represent the acreage described in the SW or ERP permit documentation, but is a calculation based on aerial photography.

The second spatial dataset created by ADA describes the location and geometry of all of the farm-level outfall structures. This dataset is compiled from various sources including SW/ERP and WOD permits, interviews with District staff, helicopter surveillance and site visits. **Figure 3.16** illustrates the location of these outfall structures, and **Tables 3.3** and **3.4** describes the 79 farm-level discharge structures currently included within this dataset.

Appendices A and **E** illustrate farm-level and basin-wide aerial photography that includes reservoir and outfall structure symbology. For detailed descriptions of the information contained in **Appendices A** and **E**, the symbology can be related to **Tables 3.2, 3.3** and **3.4**.

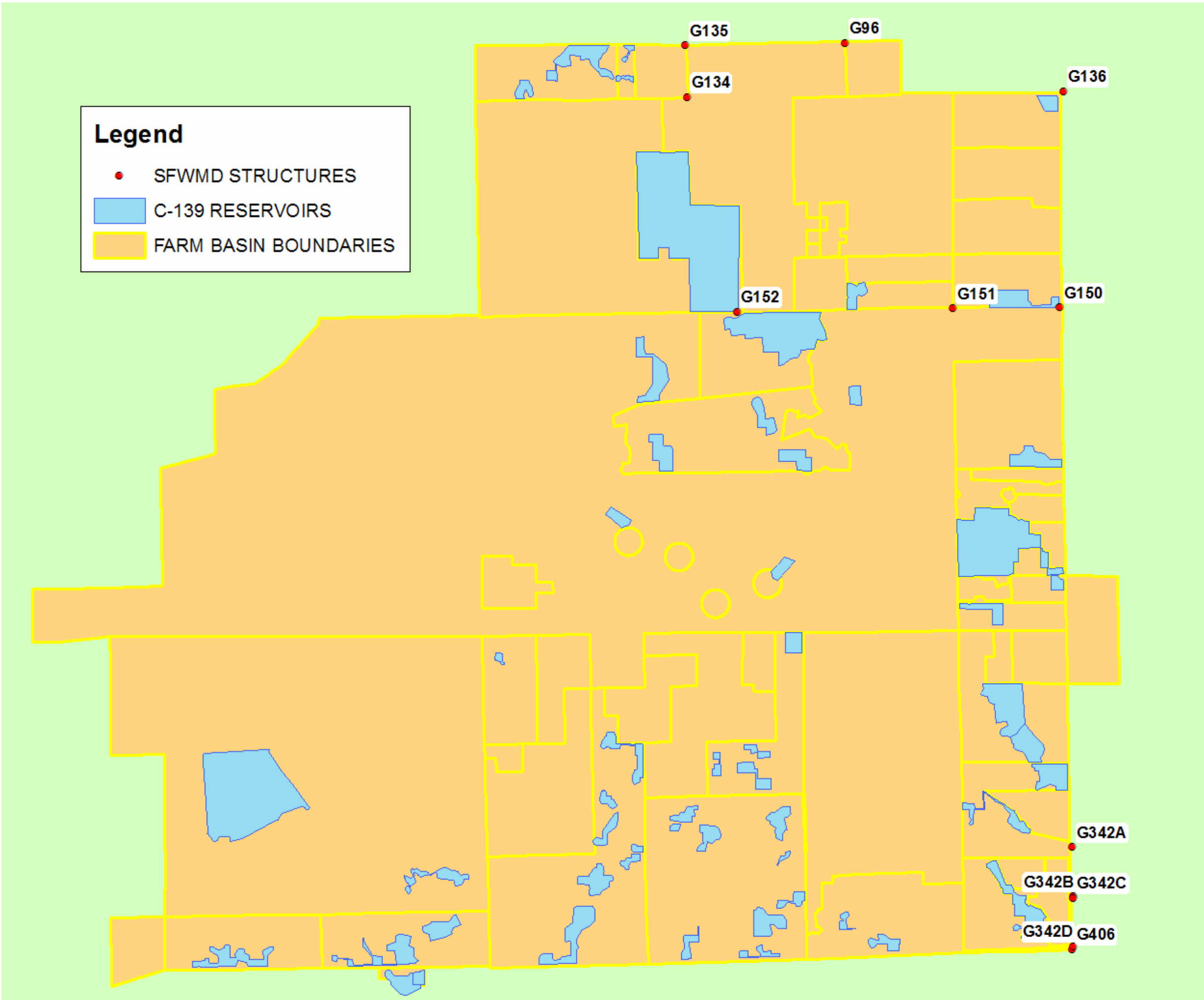

Figure 3.15: Reservoirs within the C-139 Basin

Table 3.2: Description of Reservoirs within the C-139 Basin

WOD PERMIT	FARM LOCATION	AREA (AC)
26-00302-E	COLLIER GROVES LTD (CROW'S NEST GROVE NORTH)	187
26-00302-E	COLLIER GROVES LTD (CROW'S NEST GROVE SOUTH)	35
26-00302-E	COLLIER GROVES LTD (CROW'S NEST GROVE SOUTH)	107
26-00304-E	JACKMAN CANE AND CATTLE COMPANY (SECS 17 & 18)	61
26-00305-E	COLLIER ENTERPRISES LTD (JOINER & SONS FARM)	130
26-00305-E	COLLIER ENTERPRISES LTD (JOINER & SONS FARM)	33
26-00305-E	COLLIER ENTERPRISES LTD (JOINER & SONS FARM)	18
26-00305-E	COLLIER ENTERPRISES LTD (JOINER & SONS FARM)	114
26-00306-E	SOUTHERN GARDENS GROVES CORP (DEVIL'S GARDEN CITRUS SOUTH)	49
26-00306-E	SOUTHERN GARDENS GROVES CORP (DEVIL'S GARDEN CITRUS SOUTH)	69
26-00306-E	SOUTHERN GARDENS GROVES CORP (DEVIL'S GARDEN CITRUS SOUTH)	37
26-00306-E	SOUTHERN GARDENS GROVES CORP (DEVIL'S GARDEN CITRUS SOUTH)	18
26-00306-E	SOUTHERN GARDENS GROVES CORP (DEVIL'S GARDEN CITRUS SOUTH)	34
26-00306-E	SOUTHERN GARDENS GROVES CORP (DEVIL'S GARDEN CITRUS SOUTH)	131
26-00306-E	SOUTHERN GARDENS GROVES CORP (DEVIL'S GARDEN CITRUS SOUTH)	233
26-00307-E	MILLS WEST	53
26-00307-E	MILLS WEST	951
26-00309-E	USSC - JACKMAN	188
26-00310-E	DINNER ISLAND RANCH (CITRUS GROVES)	114
26-00310-E	DINNER ISLAND RANCH (SUGARCANE FIELDS)	1523
26-00310-E	HILLIARD BROTHERS (WHITEHURST WEST SEC 32)	36
26-00312-E	FARMLAND RESERVE, INC (DESERET FARMS)	53
26-00312-E	FARMLAND RESERVE, INC (DESERET FARMS)	23
26-00312-E	FARMLAND RESERVE, INC (DESERET FARMS)	185
26-00313-E	J&J AG PRODUCTS INC (ASPRING)	156
26-00313-E	J&J AG PRODUCTS INC (ROSBOUGH)	81
26-00315-E	ZIPPERER FARMS LLC (DEVIL'S GARDEN FARM SOUTH)	27
26-00315-E	ZIPPERER FARMS LLC (DEVIL'S GARDEN FARM SOUTH)	65
26-00317-E	COTTON BROTHERS	18
26-00317-E	ROY AND ROBERT COTTON (COTTON BROTHERS)	16
26-00318-E	DEVILS GARDEN CITRUS NORTH	62
26-00319-E	C&B FARMS	264
26-00320-E	J SEVEN RANCH INC	55
26-00320-E	J SEVEN RANCH INC	47
26-00320-E	J SEVEN RANCH INC	142
26-00320-E	J SEVEN RANCH INC	50
26-00320-E	J SEVEN RANCH INC	96
26-00320-E	J SEVEN RANCH INC	14
26-00320-E	J SEVEN RANCH INC	54
26-00320-E	J SEVEN RANCH INC	82
26-00320-E	J SEVEN RANCH INC	13
26-00321-E	SUNSHINE AGRICULTURE INC (SUGAR TREE GROVE)	32
26-00321-E	SUNSHINE AGRICULTURE INC (SUGAR TREE GROVE)	41
26-00321-E	SUNSHINE AGRICULTURE INC (SUGAR TREE GROVE)	77
26-00321-E	SUNSHINE AGRICULTURE INC (SUGAR TREE GROVE)	77
26-00323-E	ALICO INC (HILL GRADE FARM)	109
26-00323-E	ALICO INC (HILL GRADE FARM)	49
26-00323-E	ALICO INC (HILL GRADE FARM)	96
26-00323-E	ALICO INC (HILL GRADE FARM)	132
26-00323-E	ALICO INC (KT GROVE SOUTH)	346
26-00323-E	ALICO INC (KT GROVE SOUTH)	166
26-00323-E	ALICO INC (PASTURE)	186
26-00323-E	ALICO INC (PASTURE)	58
26-00323-E	ALICO KT GROVES	99
26-00323-E	ALICO NORTH HILL GRADE FARM	729
26-00323-E	ALICO ROTARY FARMS	59
26-00324-E	JAMES DAVID HULL (DEVIL'S GARDEN GOLDEN OX)	14
26-00326-E	LITTLE CYPRESS GROVE (KT JOHN)	166
NA	OCEANBOY FARMS	100
NA	CENTRAL COUNTY DRAINAGE DISTRICT	2399

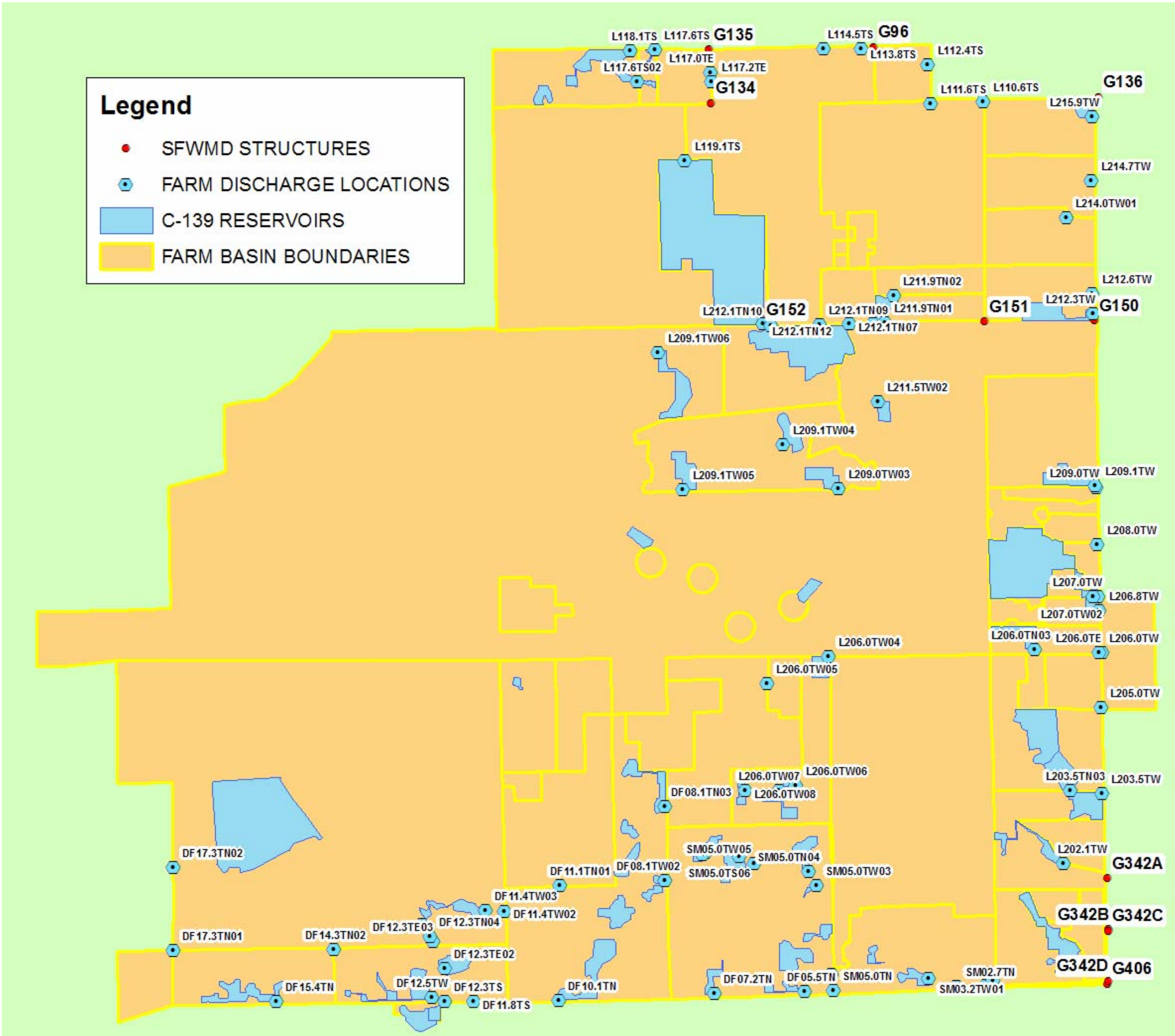

Figure 3.16: Farm Discharge Structures within the C-139 Basin

Table 3.3: Geometry of Farm-Level Offsite Discharge Structures within the C-139 Basin

NAME	DESCRIPTION	DIAMETER 1	DIAMETER 2	CREST 1	CREST 2	WEIR LENGTH 1	WEIR LENGTH 2	V-NOTCH INVERT	ORIFICE INVERT	PUMP CAPACITY
DF05.5TN	J-7 RANCH - RESERVOIR F-2, STRUCTURE 1	15.0	0.0	24.3	0.0	7.9	0.0	0.0	22.6	0
DF07.2TN	J-7 RANCH - RESERVOIR E-4, STRUCTURE 1	54.0	0.0	23.0	0.0	18.8	0.0	0.0	0.0	0
DF08.1TN03	DEVILS GARDEN CITRUS NORTH - RESERVOIR 2	36.0	0.0	26.5	0.0	1.0	0.0	0.0	0.0	0
DF08.1TW02	DEVILS GARDEN CITRUS NORTH - RESERVOIR 5	36.0	0.0	26.5	0.0	1.0	0.0	0.0	0.0	0
DF10.1TN	DEVILS GARRDEN CITRUS SOUTH - OUTFALL FROM RESERVOIR	48.0	0.0	25.0	0.0	3.5	0.0	0.0	0.0	0
DF11.1TN01	CROOKS RANCH - OPEN CONNECTION WITH THE SOUTH BAY CANAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF11.4TW02	HILLIARD BROTHERS DINNER ISLAND	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF11.4TW03	DINNER ISLAND - CITRUS RESERVOIR OUTFALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF11.8TS	DUCK CURVE FARM - OPEN CONNECTION WITH DEER FENCE CANAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF12.3TE02	COLLIER ENTERPRISES - RESERVOIR OUTFALL TO WHITE FARM CANAL	54.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0
DF12.3TE03	PUMPED DISCHARGE FROM DINNER ISLAND CITRUS GROVE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF12.3TE05	DINNER ISLAND - CITRUS RESERVOIR	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF12.3TN04	DINNER ISLAND - CULVERT ON WHITE FARM CANAL GENERALLY CLOSED	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF12.3TS	COLLIER GROVES (CROW"S NEST SOUTH) - CONNECTION TO DF FROM SEPARATION BASIN	12.0	0.0	22.0	0.0	0.8	0.0	0.0	0.0	0
DF12.5TW	COLLIER ENTERPRISES - RESERVOIR OUTFALL TO WETLAND THAT FLOWS TO DEER FENCE	8.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0
DF14.3TN02	DINNER ISLAND - VEGETABLE FARM WEIR CREST UNKNOWN	72.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF15.4TN	CONSOLIDATED CITRUS - CROWS NEST NORTH	30.0	0.0	24.5	0.0	0.0	0.0	0.0	0.0	0
DF17.3TN01	DINNER ISLAND - CULVERT DRAINING PASTURE AND SUGARCANE FIELD	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DF17.3TN02	DINNER ISLAND - CULVERT DRAINING FROM NORTH PASTURE	72.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L110.6TS	JACKMAN CATTLE (322-02) - CULVERTS AND PUMP STATION (ON @ 15.5 NGVD)	54.0	54.0	0.0	0.0	0.0	0.0	0.0	0.0	102000
L111.6TS	JACKMAN CATTLE - PUMP FROM ORIGINAL SW PERMIT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L112.4TS	JACKMAN CATTLE - CULVERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L113.8TS	ABC RANCH - MILLS - WEIR SEEN FROM HELICIOPTER AND AERIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L114.5TS	ABC RANCH - MILLS - WEIR SEEN FROM HELICIOPTER AND AERIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L117.0TE	ABC RANCH - MILLS - NOT SEEN IN FIELD OR AERIAL, BASED ON DISCUSSION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L117.2TE	ABC RANCH - MILLS - NOT SEEN IN FIELD OR AERIAL, BASED ON DISCUSSION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L117.6TS	COTTON BROTHERS - NORTH RESERVOIR	15.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5	0
L117.6TS02	COTTON BROTHERS - SOUTH RESERVOIR	15.0	0.0	0.0	0.0	0.0	0.0	0.0	21.5	0
L118.1TS	DESERET FARMS - OUTFALL FROM LARGEST RESERVOIR, W/ BLEEDER	0.0	0.0	22.3	0.0	2.0	0.0	21.8	0.0	0
L119.1TS	CENTRAL COUNTY WATER CONTROL DISTRICT RESERVOIR NORTH OUTFALL	72.0	72.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L202.1TW	LITTLE CYPRESS FARMS - BASIN 1 (PERMIT 26-00303-S-02)	48.0	0.0	16.5	0.0	6.0	0.0	0.0	0.0	0
L203.5TN03	ALICO (KT GROVE SOUTH)	0.0	0.0	21.0	0.0	6.0	0.0	17.5	0.0	0
L203.5TW	KT JOHN - LITTLE CYPRESS FARM	0.0	0.0	16.5	0.0	3.0	0.0	0.0	0.0	0
L205.0TW	HILLIARD BROTHERS BASIN 310-03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17000
L206.0TE	HILLIARD BROTHERS BASIN 310-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24000
L206.0TN03	ALICO (KT GROVE NORTH)	0.0	0.0	22.0	0.0	4.0	0.0	20.0	18.0	0
L206.0TW	ALICO SOUTH CANAL CULVERT AT BREACH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L206.0TW04	SUNSHINE AGRICULTURE - RESERVOIR D - STRUCTURE 1, W/ TRIANG ORIFICE	54.0	0.0	24.0	0.0	0.5	0.0	0.0	23.0	0
L206.0TW05	MYRICK AND ROU FARMS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L206.0TW06	SUNSHINE AGRICULTURE - RESERVOIR C - STRUCTURE 1, W/ TRIANG ORIFICE	54.0	0.0	24.0	0.0	0.3	0.0	0.0	23.0	0
L206.0TW07	SUNSHINE AGRICULTURE - RESERVOIR B - STRUCTURE 1, W/ TRIANG ORIFICE	54.0	0.0	24.0	0.0	0.5	0.0	0.0	23.0	0
L206.0TW08	SUNSHINE AGRICULTURE - RESERVOIR A - STRUCTURE 1, W/ CIRC ORIFICE	15.0	0.0	27.0	0.0	1.3	0.0	0.0	23.5	0
L206.8TW	HILLIARD BROTHERS BASIN 310-02, W/ BLEEDER	0.0	0.0	22.0	0.0	1.5	0.5	0.0	18.0	0
L207.0TW	MILLS WEST - OUTFALL FROM DETENTION AREA	36.0	0.0	20.0	0.0	1.8	0.0	0.0	0.0	0
L207.0TW02	USSC MILLS WEST - (307-02) OUTFALL FROM RESVR TO WQ DITCH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L208.0TW	MILLS WEST PUMP OUTFALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18000
L209.0TW	MILLS WEST GRAVITY OUTFALL FROM FIELD H	24.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0
L209.0TW03	ALICO (HILL GRADE FARM)	24.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0
L209.1TW	J&J AG PRODUCTS - PERMIT LISTS A 20' WIDE WEIR	36.0	0.0	17.0	0.0	20.0	0.0	0.0	0.0	0
L209.1TW04	ALICO (HILL GRADE FARM)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L209.1TW05	ALICO (HILL GRADE FARM)	24.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0
L209.1TW06	ALICO (NORTH HILL GRADE FARM) STRUCTURE NUMBER UNCLEAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L211.5TW02	ALICO (HILL GRADE FARM)	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L211.9TN01	J&J AG (313-02) - SOUTH OUTFALL FROM RESERVOIR, W/ V-NOTCH & ORIFICE	0.0	0.0	23.0	0.0	2.0	0.0	20.5	19.0	0
L211.9TN02	J&J AG (313-02) - NORTH OUTFALL FROM RESERVOIR , W/ ORIFICE	0.0	0.0	22.8	0.0	2.5	0.0	0.0	19.0	0
L212.1TN06	JACKMAN CATTLE (322-03) - DESCRIBED IN APPLICATION 05198-B	30.0	0.0	19.0	0.0	3.5	0.0	0.0	0.0	0
L212.1TN07	JACKMAN CATTLE CULVERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L212.1TN09	ABC RANCH - MILLS - CULVERT INSTALLED DURING 1982 EMERGENCY ACTION PLAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L212.1TN10	ALICO NORTH HILL GRADE FARM OUTFALL (DETENTION 4-5-6: STRUCTURE #4)	48.0	0.0	23.4	0.0	7.0	0.0	0.0	20.7	0
L212.1TN11	ABC RANCH - MILLS - CULVERT INSTALLED DURING 1982 EMERGENCY ACTION PLAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L212.1TN12	CENTRAL COUNTY WATER CONTROL DISTRICT RESERVOIR SOUTH OUTFALL	72.0	72.0	0.0	0.0	0.0	0.0	0.0	0.0	0
L212.3TW	JACKMAN - USSC - PERMITTED OUTFALL FOR SOUTH RESERVOIR LOCATION UNKNOWN	42.0	42.0	16.5	16.5	1.5	1.5	0.0	0.0	0
L212.6TW	JACKMAN CANE AND CATTLE - PUMP FROM ORIGINAL SW PERMIT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30000
L214.0TW01	JACKMAN CANE AND CATTLE - PUMP FROM ORIGINAL SW PERMIT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66000
L214.7TW	JACKMAN CANE AND CATTLE - PUMP FROM ORIGINAL SW PERMIT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50000
L215.9TW	JACKMAN CANE AND CATTLE - NORTH RESERVOIR OUTFALL FROM PERMIT	42.0	42.0	14.5	14.5	2.5	2.5	0.0	0.0	0
SM00.5TN	C&B FARMS - RESERVOIR 6 DISCHARGE STRUCTURE 6	36.0	0.0	18.0	0.0	3.8	0.0	0.0	0.0	0
SM02.2TN01	ZIPPERER FARMS - NORTH CULVERTS AT SM BRIDGE	72.0	72.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SM02.2TW01	ZIPPERER FARMS - WEST CULVERTS AT SM BRIDGE	72.0	72.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SM02.7TN	ZIPPERER FARMS - STRUCTURE J-5	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SM03.2TW01	ZIPPERER FARMS - OUTFALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SM05.0TN	ZIPPERER FARMS	48.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SM05.0TN02	J-7 RANCH (DISCHARGE FROM MAIN CONVEYANCE CANAL FOR BASIN)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SM05.0TN04	J-7 RANCH - RESERVOIR D-2, STRUCTURE 1	18.0	0.0	24.1	0.0	18.8	0.0	0.0	0.0	0
SM05.0TN07	J-7 RANCH - RESERVOIR A-2, STRUCTURE 1	18.0	0.0	24.4	0.0	18.8	0.0	0.0	0.0	0
SM05.0TS06	J-7 RANCH - RESERVOIR B, STRUCTURE 1	18.0	0.0	24.0	0.0	9.4	0.0	0.0	0.0	0
SM05.0TS08	J-7 RANCH - RESERVOIR A-3, STRUCTURE 1	18.0	0.0	24.4	0.0	18.8	0.0	0.0	0.0	0
SM05.0TW03	J-7 RANCH - RESERVOIR G, STRUCTURE 1	12.0	0.0	27.8	0.0	3.1	0.0	0.0	24.0	0
SM05.0TW05	J-7 RANCH - RESERVOIR C-2, STRUCTURE 1, NOT CONSTRUCTED	24.0	0.0	25.6	0.0	7.9	0.0	0.0	24.0	0

Table 3.4: Data Sources for Farm-Level Offsite Discharge Structures within the C-139 Basin

NAME	DESCRIPTION	LOCATION SOURCE	MEASUREMENT SOURCE	NORTHING	EASTING
DF05.5TN	J-7 RANCH - RESERVOIR F-2, STRUCTURE 1	PERMIT AND AERIAL	PERMIT 26-00669-P	762531.1	644429.3
DF07.2TN	J-7 RANCH - RESERVOIR E-4, STRUCTURE 1	PERMIT AND AERIAL	PERMIT 26-00669-P	762336.9	635631.4
DF08.1TN03	DEVILS GARDEN CITRUS NORTH - RESERVOIR 2	PERMIT AND AERIAL	PERMIT 26-00282-S	780329.4	630811.8
DF08.1TW02	DEVILS GARDEN CITRUS NORTH - RESERVOIR 5	PERMIT	PERMIT 26-00282-S	773229.2	630807.8
DF10.1TN	DEVILS GARRDEN CITRUS SOUTH - OUTFALL FROM RESERVOIR	PERMIT AND AERIAL	PERMIT 26-00299-S	761694.6	620580.6
DF11.1TN01	CROOKS RANCH - OPEN CONNECTION WITH THE SOUTH BAY CANAL	AERIAL AND SITE VISIT	UNKNOWN	772682.7	620643.8
DF11.4TW02	HILLIARD BROTHERS DINNER ISLAND	SITE VISIT AND AERIAL	FWCC DOCUMENTATION	770250.8	615281.6
DF11.4TW03	DINNER ISLAND - CITRUS RESERVOIR OUTFALL	SITE VISIT	UNKNOWN	770289.3	613416.8
DF11.8TS	DUCK CURVE FARM - OPEN CONNECTION WITH DEER FENCE CANAL	PERMIT AND AERIAL	PERMIT 26-00533-S	761594.2	612257.5
DF12.3TE02	COLLIER ENTERPRISES - RESERVOIR OUTFALL TO WHITE FARM CANAL	PERMIT	PERMIT 26-00440-S	764705.7	609491.8
DF12.3TE03	PUMPED DISCHARGE FROM DINNER ISLAND CITRUS GROVE	HELICOPTER	UNKNOWN	767333.6	608371.3
DF12.3TE05	DINNER ISLAND - CITRUS RESERVOIR	SITE VISIT AND FWCC DOCUMENTATION	FWCC DOCUMENTATION	768941.1	607301.2
DF12.3TN04	DINNER ISLAND - CULVERT ON WHITE FARM CANAL GENERALLY CLOSED	SITE VISIT AND AERIAL	FWCC DOCUMENTATION	767799.8	608034.0
DF12.3TS	COLLIER GROVES (CROW"S NEST SOUTH) - CONNECTION TO DF FROM SEPARATION BASIN	AERIAL	PERMIT 26-00300-S	761580.5	609480.1
DF12.5TW	COLLIER ENTERPRISES - RESERVOIR OUTFALL TO WETLAND THAT FLOWS TO DEER FENCE	PERMIT	PERMIT 26-00732-P	761994.0	608227.2
DF14.3TN02	DINNER ISLAND - VEGETABLE FARM WEIR CREST UNKNOWN	SITE VISIT AND AERIAL	FWCC DOCUMENTATION	766596.5	598778.0
DF15.4TN	CONSOLIDATED CITRUS - CROWS NEST NORTH	BASED ON AERIAL	PERMIT 26-00300-S	761551.7	593208.2
DF17.3TN01	DINNER ISLAND - CULVERT DRAINING PASTURE AND SUGARCANE FIELD	AERIAL AND FWCC DOCUMENTATION	FWCC DOCUMENTATION	766490.9	583175.7
DF17.3TN02	DINNER ISLAND - CULVERT DRAINING FROM NORTH PASTURE	SITE VISIT AND AERIAL	FWCC DOCUMENTATION	774481.5	583164.6
L110.6TS	JACKMAN CATTLE (322-02) - CULVERTS AND PUMP STATION (ON @ 15.5 NGVD)	PERMIT AND AERIAL	PERMIT 26-00115-S-01	848033.8	661719.3
L111.6TS	JACKMAN CATTLE - PUMP FROM ORIGINAL SW PERMIT	HELICOPTER	UNKNOWN	847851.6	656601.3
L112.4TS	JACKMAN CATTLE - CULVERT	HELICOPTER	UNKNOWN	851579.9	656302.2
L113.8TS	ABC RANCH - MILLS - WEIR SEEN FROM HELICIOPTER AND AERIAL	BASED ON AERIAL	UNKNOWN, APPEARS TO BE A WEIR	853148.6	649826.4
L114.5TS	ABC RANCH - MILLS - WEIR SEEN FROM HELICIOPTER AND AERIAL	BASED ON AERIAL	UNKNOWN, APPEARS TO BE A WEIR	853074.1	646216.4
L117.0TE	ABC RANCH - MILLS - NOT SEEN IN FIELD OR AERIAL, BASED ON DISCUSSION	BASED ON DISCUSSION WITH SFWMD	UNKNOWN	850840.2	635305.8
L117.2TE	ABC RANCH - MILLS - NOT SEEN IN FIELD OR AERIAL, BASED ON DISCUSSION	BASED ON DISCUSSION WITH SFWMD	UNKNOWN	849910.1	635334.5
L117.6TS	COTTON BROTHERS - NORTH RESERVOIR	PERMIT AND HELICOPTER	PERMIT 26-00383-S	853025.6	629862.4
L117.6TS02	COTTON BROTHERS - SOUTH RESERVOIR	PERMIT AND HELICOPTER	PERMIT 26-00383-S	849913.7	628126.9
L118.1TS	DESERET FARMS - OUTFALL FROM LARGEST RESERVOIR, W/ BLEEDER	PERMIT AND AERIAL	PERMIT 26-00318-S	852958.4	627439.2
L119.1TS	CENTRAL COUNTY WATER CONTROL DISTRICT RESERVOIR NORTH OUTFALL	SITE VISIT AND AERIAL	SITE VISIT	842355.3	632761.5
L202.1TW	LITTLE CYPRESS FARMS - BASIN 1 (PERMIT 26-00303-S-02)	PERMIT AND AERIAL	PERMIT 26-00303-S-02	774868.6	669421.7
L203.5TN03	ALICO (KT GROVE SOUTH)	PERMIT DOCUMENTATION AND AERIAL	PERMIT 26-0455-S	781841.9	670149.0
L203.5TW	KT JOHN - LITTLE CYPRESS FARM	AERIAL	DISCUSSION WITH SFWMD	781607.3	673167.0
L205.0TW	HILLIARD BROTHERS BASIN 310-03	PERMIT AND AERIAL	PERMIT 26-00563-S	789803.0	673078.6
L206.0TE	HILLIARD BROTHERS BASIN 310-01	PERMIT	PERMIT 26-00563-S, 26-00557-S	795139.3	673233.6
L206.0TN03	ALICO (KT GROVE NORTH)	PERMIT DOCUMENTATION AND HELICOPTER	PERMIT 26-0455-S	795397.9	666620.8
L206.0TW	ALICO SOUTH CANAL CULVERT AT BREACH	HELICOPTER	UNKNOWN	795069.8	672911.8
L206.0TW04	SUNSHINE AGRICULTURE - RESERVOIR D - STRUCTURE 1, W/ TRIANG ORIFICE	PERMIT AND AERIAL	PERMIT 26-00385-S	794719.3	646699.0
L206.0TW05	MYRICK AND ROU FARMS	AERIAL	UNKNOWN	792156.4	640716.8
L206.0TW06	SUNSHINE AGRICULTURE - RESERVOIR C - STRUCTURE 1, W/ TRIANG ORIFICE	PERMIT AND AERIAL	PERMIT 26-00385-S	782299.9	643547.1
L206.0TW07	SUNSHINE AGRICULTURE - RESERVOIR B - STRUCTURE 1, W/ TRIANG ORIFICE	PERMIT AND AERIAL	PERMIT 26-00385-S	781815.0	641898.6
L206.0TW08	SUNSHINE AGRICULTURE - RESERVOIR A - STRUCTURE 1, W/ CIRC ORIFICE	PERMIT AND AERIAL	PERMIT 26-00385-S	781809.8	638583.8
L206.8TW	HILLIARD BROTHERS BASIN 310-02, W/ BLEEDER	PERMIT AND AERIAL	PERMIT 26-00563-S	799110.9	672906.5
L207.0TW	MILLS WEST - OUTFALL FROM DETENTION AREA	PERMIT - EXACT LOCATION UNKNOWN	PERMIT 26-00535-S DISCHARGE STRUCTURE 5	800525.0	672857.3
L207.0TW02	USSC MILLS WEST - (307-02) OUTFALL FROM RESVR TO WQ DITCH	HELICOPTER	PERMIT 26-00535-S	800487.2	672286.8
L208.0TW	MILLS WEST PUMP OUTFALL	PERMIT AND AERIAL	PERMIT 26-00535-S PUMP ON/OFF = 17.5 / 17.0	805459.9	672753.0
L209.0TW	MILLS WEST GRAVITY OUTFALL FROM FIELD H	PERMIT AND AERIAL	PERMIT 26-00535-S	810997.7	672612.9
L209.0TW03	ALICO (HILL GRADE FARM)	SITE VISIT	SITE VISIT	810840.6	647654.9
L209.1TW	J&J AG PRODUCTS - PERMIT LISTS A 20' WIDE WEIR	PERMIT AND HELICOPTER	PERMIT 26-00068-S	811170.0	672571.8
L209.1TW04	ALICO (HILL GRADE FARM)	PERMIT DOCUMENTATION	SITE VISIT	815076.6	642281.6
L209.1TW05	ALICO (HILL GRADE FARM)	SITE VISIT	SITE VISIT	810786.2	632602.5
L209.1TW06	ALICO (NORTH HILL GRADE FARM) STRUCTURE NUMBER UNCLEAR	UNKNOWN	UNKNOWN (PERMIT 26-00522-S)	823902.6	630173.9
L211.5TW02	ALICO (HILL GRADE FARM)	SITE VISIT	SITE VISIT	819190.6	651450.0
L211.9TN01	J&J AG (313-02) - SOUTH OUTFALL FROM RESERVOIR, W/ V-NOTCH & ORIFICE	PERMIT - EXACT LOCATION UNKNOWN	PERMIT 26-00368-S	826836.7	652150.6
L211.9TN02	J&J AG (313-02) - NORTH OUTFALL FROM RESERVOIR , W/ ORIFICE	PERMIT - EXACT LOCATION UNKNOWN	PERMIT 26-00368-S	829415.7	653027.2
L212.1TN06	JACKMAN CATTLE (322-03) - DESCRIBED IN APPLICATION 05198-B	PERMIT - EXACT LOCATION UNKNOWN	PERMIT MODIFICATION 26-00115-S	826751.4	650968.8
L212.1TN07	JACKMAN CATTLE CULVERT	DISCUSSION WITH SFWMD	UNKNOWN	826712.4	648680.4
L212.1TN09	ABC RANCH - MILLS - CULVERT INSTALLED DURING 1982 EMERGENCY ACTION PLAN	BASED ON DISCUSSION WITH SFWMD	UNKNOWN	826648.4	645779.8
L212.1TN10	ALICO NORTH HILL GRADE FARM OUTFALL (DETENTION 4-5-6: STRUCTURE #4)	SITE VISIT AND AERIAL	PERMIT 26-00522-S	826480.2	641072.4
L212.1TN11	ABC RANCH - MILLS - CULVERT INSTALLED DURING 1982 EMERGENCY ACTION PLAN	BASED ON SITE VISIT	UNKNOWN	826683.1	640395.0
L212.1TN12	CENTRAL COUNTY WATER CONTROL DISTRICT RESERVOIR SOUTH OUTFALL	SITE VISIT AND AERIAL	SITE VISIT	826701.5	640332.7
L212.3TW	JACKMAN - USSC - PERMITTED OUTFALL FOR SOUTH RESERVOIR LOCATION UNKNOWN	PERMIT AND HELICOPTER	PERMIT 26-00115-S-02	827621.4	672311.3
L212.6TW	JACKMAN CANE AND CATTLE - PUMP FROM ORIGINAL SW PERMIT	PERMIT	PERMIT 26-00115-S PUMP NUMBER 5	829630.3	672265.4
L214.0TW01	JACKMAN CANE AND CATTLE - PUMP FROM ORIGINAL SW PERMIT	PERMIT	PERMIT 26-00115-S PUMP NUMBER 4	836925.4	669703.7
L214.7TW	JACKMAN CANE AND CATTLE - PUMP FROM ORIGINAL SW PERMIT	PERMIT AND AERIAL	PERMIT 26-00115-S PUMP NUMBER 3	840395.2	672139.1
L215.9TW	JACKMAN CANE AND CATTLE - NORTH RESERVOIR OUTFALL FROM PERMIT	PERMIT AND HELICOPTER	PERMIT 26-00115-S-02	846610.1	672267.4
SM00.5TN	C&B FARMS - RESERVOIR 6 DISCHARGE STRUCTURE 6	UNKNOWN	PERMIT 26-00303-S	764710.5	671257.5
SM02.2TN01	ZIPPERER FARMS - NORTH CULVERTS AT SM BRIDGE	AERIAL AND SITE VISIT	UNKNOWN	763585.9	662603.4
SM02.2TW01	ZIPPERER FARMS - WEST CULVERTS AT SM BRIDGE	AERIAL AND SITE VISIT	UNKNOWN	763124.2	661918.2
SM02.7TN	ZIPPERER FARMS - STRUCTURE J-5	NOTES	PERMIT DOCUMENTATION	763047.2	659105.3
SM03.2TW01	ZIPPERER FARMS - OUTFALL	AERIAL	UNKNOWN	763805.0	656407.9
SM05.0TN	ZIPPERER FARMS	SITE VISIT	SITE VISIT	762671.0	647133.3
SM05.0TN02	J-7 RANCH (DISCHARGE FROM MAIN CONVEYANCE CANAL FOR BASIN)	SITE VISIT	UNKNOWN	764192.7	646998.7
SM05.0TN04	J-7 RANCH - RESERVOIR D-2, STRUCTURE 1	PERMIT AND AERIAL	PERMIT 26-00669-P	774072.7	644768.2
SM05.0TN07	J-7 RANCH - RESERVOIR A-2, STRUCTURE 1	PERMIT	PERMIT 26-00669-P	775901.3	634795.9
SM05.0TS06	J-7 RANCH - RESERVOIR B, STRUCTURE 1	PERMIT	PERMIT 26-00669-P	775536.1	638049.5
SM05.0TS08	J-7 RANCH - RESERVOIR A-3, STRUCTURE 1	PERMIT	PERMIT 26-00669-P	775743.4	634530.5
SM05.0TW03	J-7 RANCH - RESERVOIR G, STRUCTURE 1	PERMIT AND AERIAL	PERMIT 26-00669-P	772717.4	645508.6
SM05.0TW05	J-7 RANCH - RESERVOIR C-2, STRUCTURE 1, NOT CONSTRUCTED	PERMIT	PERMIT 26-00669-P	774854.0	639528.3

3.3 Detailed Data Collection

3.3.1. Farm and Field Reconnaissance

As described in Section 2.0 (Records Review and Action Plan), there are some locations where on-site reconnaissance is required in coordination with the District and landowners. On October 18th, 2005, ADA and District staff visited with the landowners or structure operators for Devil's Garden Golden Ox (26-324-01), Dinner Island (26-310-04) and J Seven Ranch, Inc. (26-320-01).Due to local topographic relief and historic reference information, Basin 26-324-01 was identified as a farm where sheet-flow is a primary runoff process in large parts of the farm. The site visit to Basin 26-324-01 illustrated the hydrologic significance of the Devil's Garden Slough. The Devil's Garden Slough originally had its headwaters within the Basin 26-323-04 and weaved south through Basin 26-316-01 and 26-316-02, then through Basin 26-324-01 and ending within Basins 26-301-01 and 26-314-01. Currently, the ALICO South Boundary Canal transports runoff from the northern portion of the slough east towards the L-2 Canal. **Figure 3.17** illustrates the location of the Devil's Garden Slough with respect to the regional farm basins. **Figure 3.18** is a photograph taken of the slough within Basin 26-324-01.

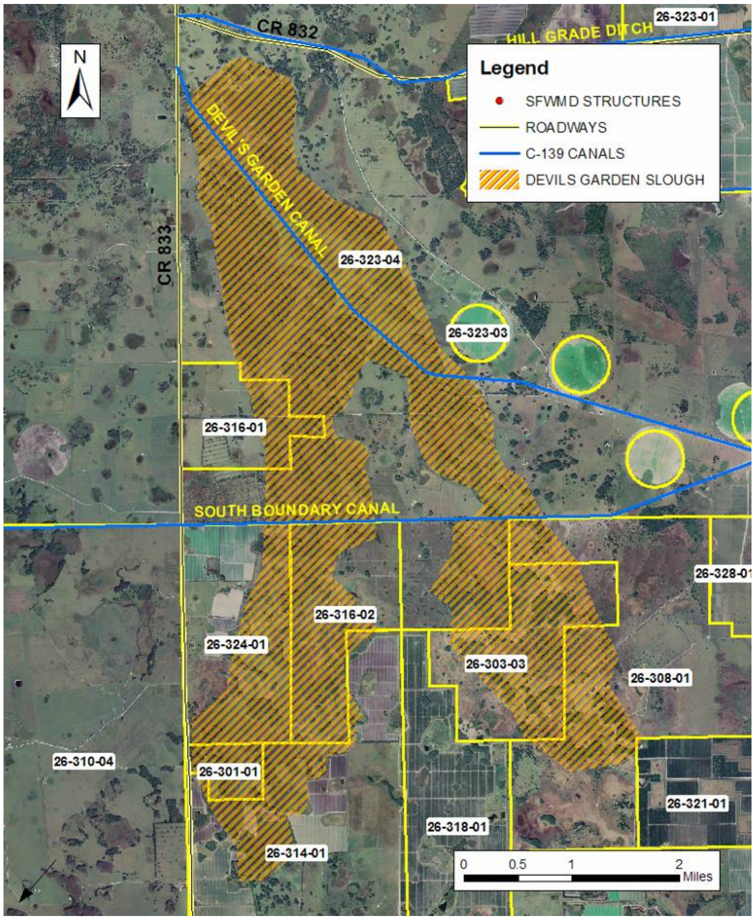

Figure 3.17: Location of the Devil's Garden Slough

Figure 3.18: Devil's Garden Slough at the Boundary of Basins 26-324-01 and 26-316-02

Due to the multiple off-site discharge points as well as the sheet-flow processes evident within the pasture land, Basin 26-310-04 (Dinner Island Ranch) was identified for a site visit. The Dinner Island Ranch was purchased by the Trustees of the Internal Improvement Trust Fund (TIITF) and managed by the Florida Fish and Wildlife Conservation Commission (FWCC). The site visit illustrated the operations of each of the four land-uses: citrus, vegetables, sugarcane and pasture. **Figure 3.19** illustrates the location and size of each land use within the Dinner Island Ranch property.

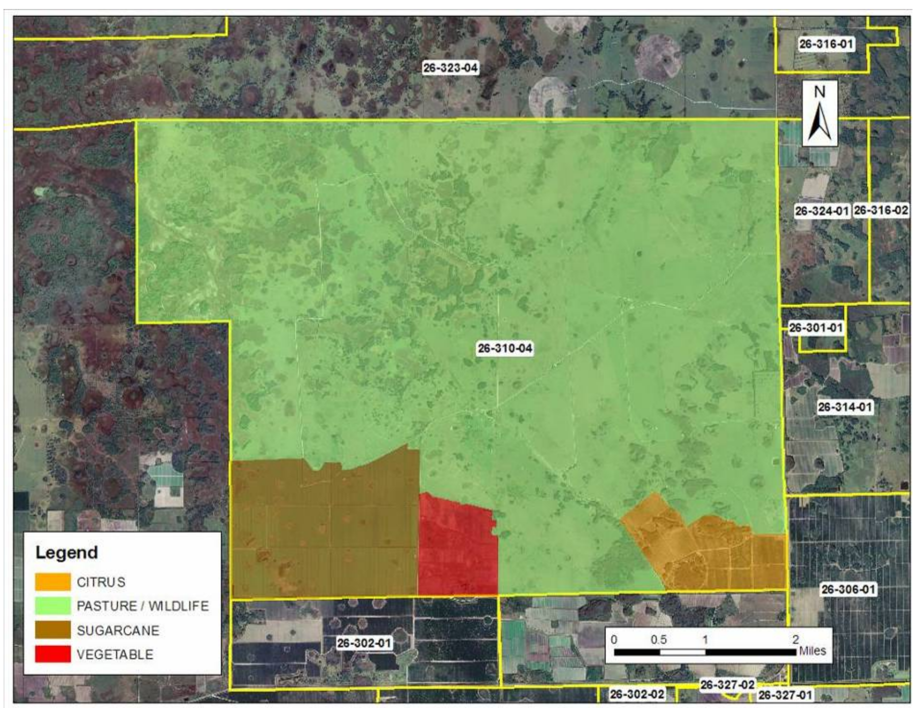

Figure 3.19: Land-uses within Dinner Island Ranch

A site visit demonstrated that the surface water within the citrus groves is drained via internal farm canals and pumped into the reservoirs. Discharge from the reservoirs is via gravity discharge structures. However, upon visual inspection it appears that these gravity outfall structures were installed for very high control elevations and, therefore, discharge is rare. **Figures 3.20** and **3.21** illustrate the high elevations of the outfall structures and the lack of runoff impounded within the reservoirs despite the high rainfall and wet antecendent conditions that characterize the time at which the site visit was made.

Figure 3.20: Gravity Discharge for the Dinner Island Citrus Grove

Figure 3.21: Dry Reservoir within the Dinner Island Citrus Grove

The site visit also demonstrated the operation of the surface water management systems for the pasture, vegetable and sugarcane land-uses. Although the White Farm Canal provides the potential for significant runoff conveyance to the Dinner Island Ranch pasture land, the downstream gates are maintained closed, as is shown in **Figure 3.22**. The vegetable farm discharge structures that allow runoff south to the Deer Fence Canal are maintained closed, as shown in **Figure 3.23**, and discharges are instead directed north and east to the pasture land.

Figure 3.22: Closed Gates on the White Farm Canal within the Dinner Island Ranch

Figure 3.23: Closed Gates on Internal Farm Canal for the Vegetable Farm within Dinner Island Ranch

Although runoff from the sugarcane field is directed north into the pasture land, there is a canal along the western edge of the sugarcane field that drains the western portion of the pasture land and has its headwaters in the Okaloacoochee Slough. The control structure for this canal is maintained open as is illustrated in **Figure 3.24**.

Figure 3.24: Open Gates Providing Drainage to Western Pasture Land of Dinner Island Ranch

A site visit to J Seven Ranch, Inc. (Basin 26-320-01) confirmed the closed culverts along CR 833 that would provide off-site discharge to the basin. **Figure 3.25** illustrates the structure where the property would discharge if the flashboards were removed. The receiving body for this discharge would be the S&M Canal via a concrete box culvert underneath CR 833.

Figure 3.25: Off-site Discharge Outfall for Basin 26-320-01

On October 20, 2005, ADA and District staff participated in a District helicopter surveillance flight of the C-139 Basin. This trip was coordinated to provide field reconnaissance of the current conditions of the basin to be used in the hydrology analysis. In attendance were two ADA staff members and one District staff member from the Everglades Regulation Division.

3.3.2. Farm-level Hydrologic Assessment

The objectives defined within the detailed data collection containing the following information with respect to the farm-level hydrologic assessment:

- Investigation of private/shared internal canals and sheet flow drainage patterns
- Determination of overland flow affecting adjacent farms
- Identification of offsite farm discharge points and structure types not identified in existing maps or permits existing maps or permits

3.3.2.1 Identification of Private/Shared Internal Canals

In combination with permit information and field reconnaissance, there are 10 private or internal canals that are significant to the drainage system of the C-139 Basin including, four ALICO canals (Midway, South Boundary, Knowles and the Hill Grade Ditch Canal), the Devil's Garden Canal, the S&M Canal, the White Farm Canal, the Crooks Easement, Devil's Garden Citrus East Canal and an unnamed canal along the western edge of the Dinner Island Preserve. **Figures 3.26 – 3.28** illustrate the locations of these canals.

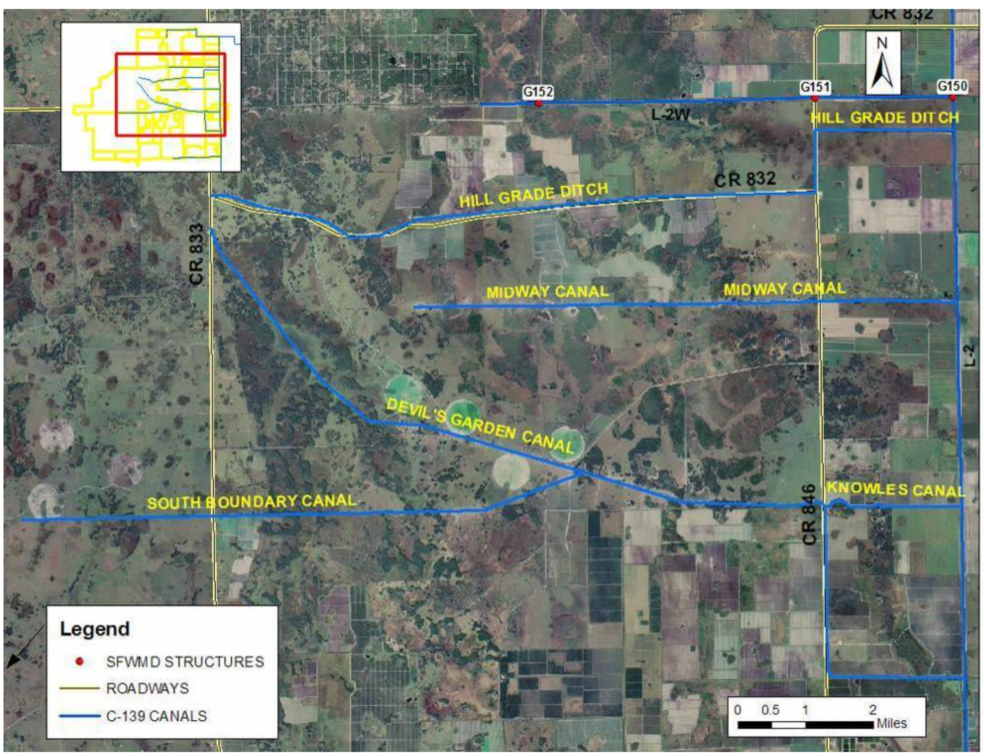

Figure 3.26: Private/Shared Internal Canals within ALICO Inc Properties

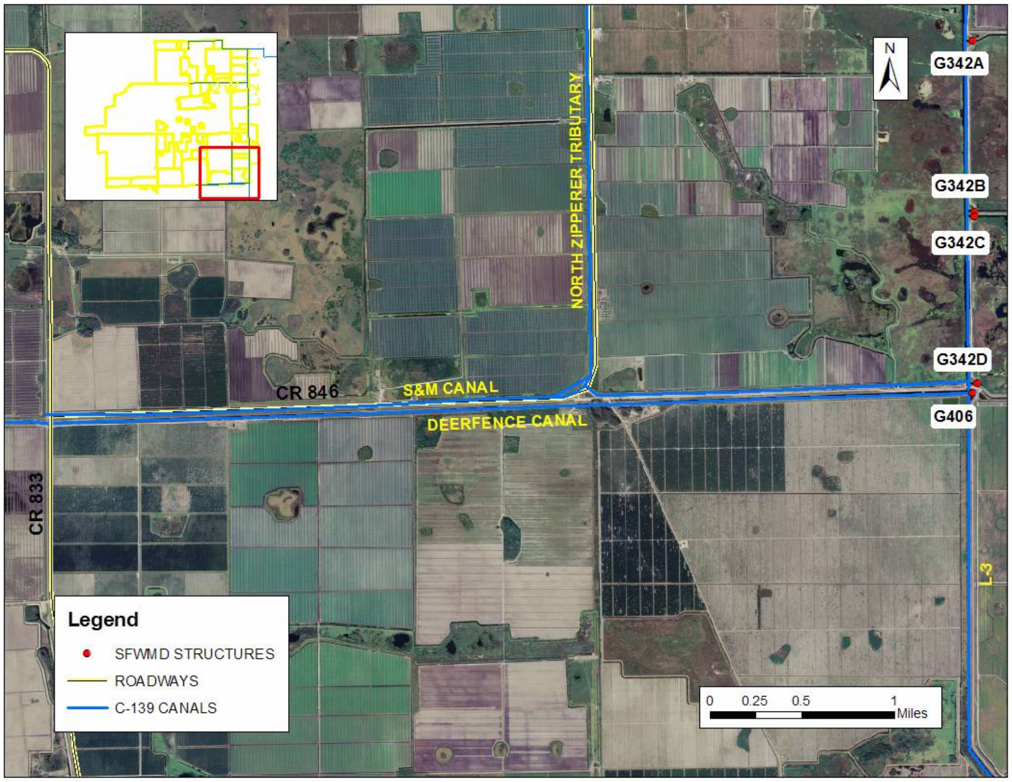

Figure 3.27: S&M and Deer Fence Canals

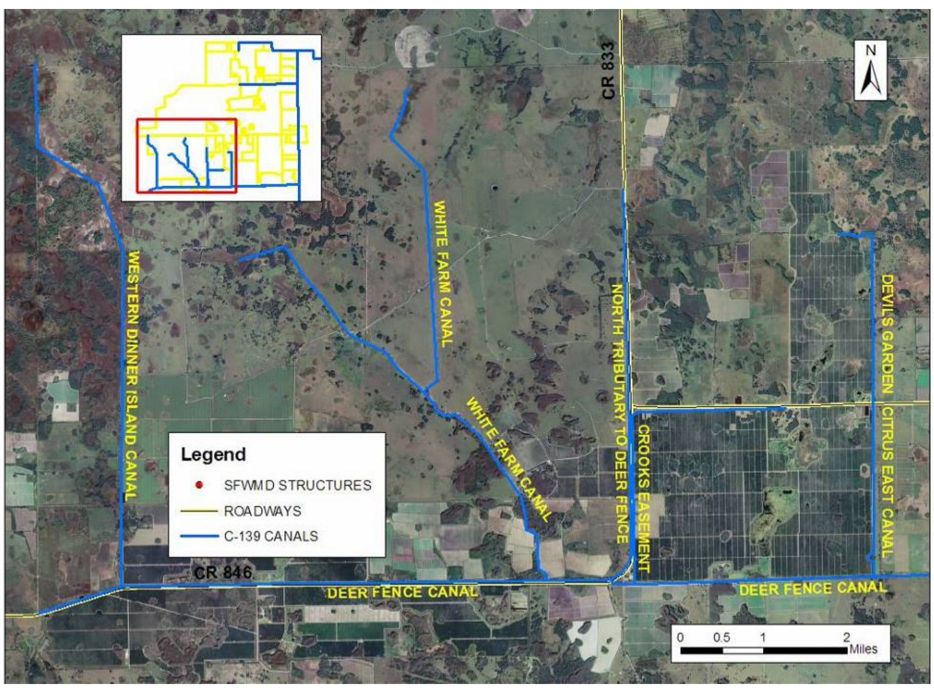

Figure 3.28: Private/Shared Internal Canals within the Southwest Region

3.3.2.2 Locations where Overland Flow Affects Adjacent Farms

There are four regions that have been identified where topographic and operational conditions allow for the potential of overland flow characteristics affecting adjacent farms. These locations are:

- The southeastern border of Basin 26-303-01 with Basin 26-322-02
- The western boundary of Basin 26-324-01 with Basin 26-316-02 and the southern boundary of these two basins with Basin 26-301-01 and 26-314-01
- The boundaries of Basin 26-303-03 with 26-308-01 and 26-323-04
- The western boundaries of Basins 26-310-04 and 26-323-04 with the Okaloacoochee Slough.

The first region illustrated in **Figure 3.29** is a location where there is a substantially large depressional wetland that crosses the boundaries of Basins 26-303-01 and 26-322-02. In some locations there is a berm defining the boundary between these two properties, however this berm is not continuous and does not preclude the potential for overland flow across the farm boundaries.

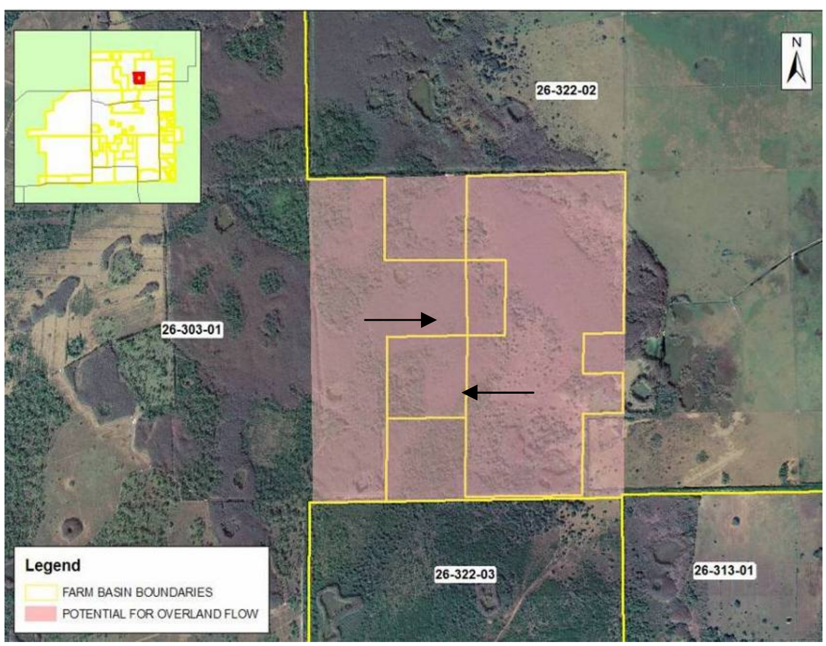

Figure 3.29: Location of Potential Overland Flow between Basins 26-303-01 and 26-322-02

The second region within the C-139 Basin where there is a potential for overland flow between basins is illustrated in **Figure 3.30**. The conditions for overland flow are created by the Devil's Garden Slough which historically drained through this area. There is a berm south of the boundary of Basin 26-324-01, however it does not prevent overland flow because there are openings designed to redirect the water as is shown in **Figure 3.31**.

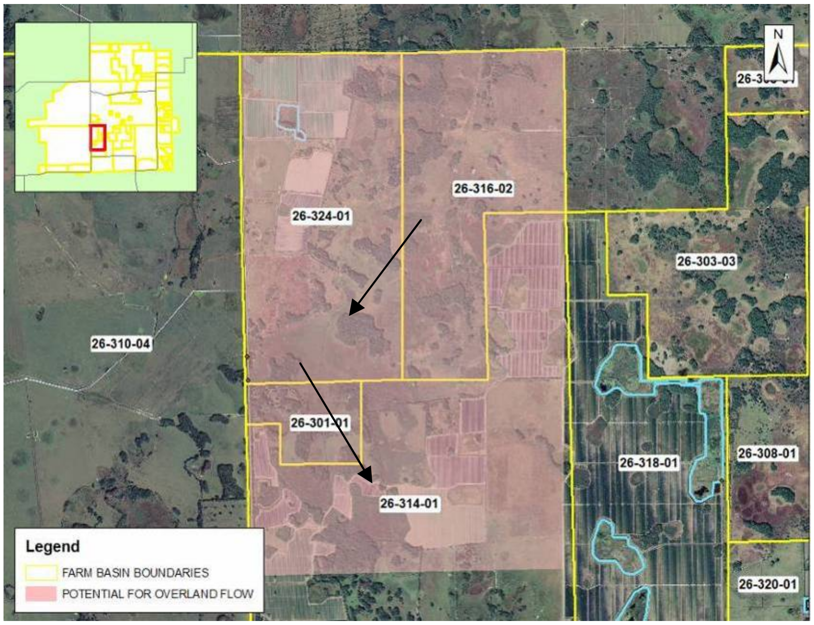

Figure 3.30: Location of Potential Overland Flow between Basins 26-316-02, 26-324-01, 26-301-01 and 26-314-01

Figure 3.31: Looking West Along Berm within Basin 26-301-01

The third region within the C-139 Basin where there is a potential for overland flow between basins is illustrated in **Figure 3.32**. The conditions for overland flow are also created by the Devil's Garden Slough which historically drained through this area. Although this region may have historically drained south through Basin 26-320-01, the region currently drains north and east through Basin 26-328-01 into the ALICO South Boundary Canal and out to the L-2 Canal.

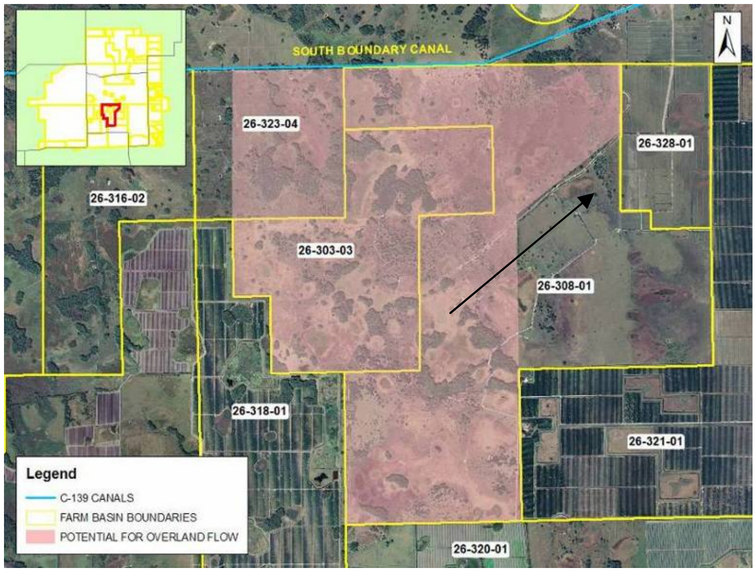

Figure 3.32: Location of Potential Overland Flow between Basins 26-323-04, 26-303-03 and 26-308-01

The fourth region within the C-139 Basin where there is a potential for overland flow is illustrated in **Figure 3.33**. The western portions of Basins 26-310-04 and 26-323-04 are very wet as is characteristic of the neighboring Okaloacoochee Slough to the west. In examining the area during helicopter surveillance there is a high potential for overland flow which could potentially contribute to intra-basin transfer of runoff along the western boundaries of the basins. Portions of this area within Basin 26-310-04 drain south to the Deer Fence Canal via an internal farm canal.

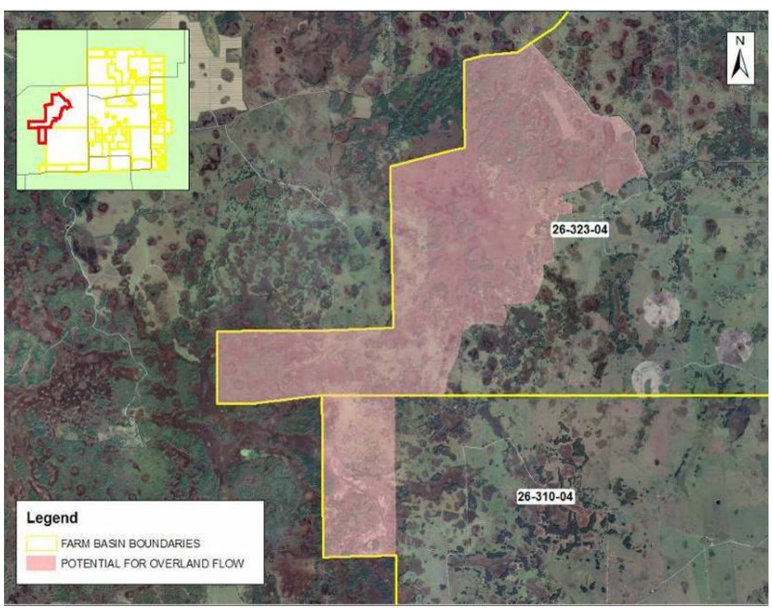

Figure 3.33: Location of Potential Overland Flow and Intra-Basin Transfer of Runoff at the Western Boundaries of Basins 26-323-04 and 26-310-04

3.3.3. Flow Monitoring

All flow measurements were performed by Hydrogage, Inc in accordance with the action plan described in Section 2.0. The flow measurement techniques used varied depending on the station and the characteristics of the flow at the time of the measurement. The two basic methodology types used were either mechanical or Doppler devices. The two instruments used in mechanical measurements were the Pygmy and Price AA meter. These were generally used at SM05.0TN, because all flow attributed to this location is from a culvert with a known cross-sectional area. The instruments used in Doppler measurements are the StreamPro ADCP, the Sontek ADP and the Sontek Handheld ADV Flowtracker. The ADCP and the ADP instruments were used at most other locations in open channels where the cross-section varies greatly. These devices measure the velocity of suspended sediments within the water column and average these velocity measurements over a number of finite horizontal and vertical volumes of water depending on the geometry of the channel. Additional information and specifications for these instruments are available in Appendix C.

3.3.3.1 Environmental Conditions

After the first two separate event measurements on September 8th and 21st, 2005, there was a lack of consistency in the results, potentially due to farm-level surface water management systems. Therefore, ADA and the District staff decided to use the remaining 6 days of flow monitoring optimally to capture at least one high flow event.

The third measurement was taken based on antecedent conditions and a forecast that projected the tropical wave that became tropical storm Tammy to cross the state on October 5th and 6th, 2005. The storm was also forecasted to be stalled by an incoming cold front causing it to stay over central Florida or return across the state in an easterly track. In either scenario there was a significant amount of rainfall expected in the C-139 Basin. ADA notified the District that there would be flow measurements taken starting on October 5, for 2005 as many as four consecutive days per previous agreement.

Upon arrival in the field, the control structures were closed at DF02.0TW, SM02.2TW02 and SM02.2TN02. These operations impacted several other upstream stations within the Deer Fence and S&M Canal watersheds. Flow measurement activities were on stand-by until more rainfall warranted gate openings. The gates were opened on October 7th and 8th, 2005, at which time measurements were made. This four-day monitoring event was counted as two separate two-day measurements and only one sampling event measurement remained. The final measurement was started on October 26th after Hurricane Wilma. Because of high-stages, downed power lines, and post-hurricane availability, the measurements were taken over a three-day period and measurements were not available at all 12 locations.

3.3.3.2 Flow Measurement Surveys

As described above, there were four flow measurements made, one less than the scope of work described due to a longer duration measurement for the third measured event. The measurement dates and the corresponding weather system is described below:

- September 8th and 9th (Hurricane Ophelia)
- September 20th (Hurricane Rita)
- October 5th-8th (Tropical Storm Tammy)
- October 26th and 27th (Hurricane Wilma)

Table 3.5 describes the daily rainfall totals as reported on DBHYDRO at several District stations, which surround the C-139 Basin during the months of September and October. These rainfall amounts are reported from the following four stations:

- G136_R: L-1 control culvert at bend in L-1, 3 miles north of CR 832
- STA5WX: STA5 weather station on the east-west interior levee
- DEVILS_R: Devil's Garden Tower
- BCSI: Big Cypress at the Seminole Indian Reservation

Table 3.5: Daily Rainfall (Inches) in C-139 Basin during September and October 2005

DATE	G136_R	STA5WX	DEVILS_R	BCSI
1-Sep-05	0.24	0	0	0
2-Sep-05	1.3	0.47	0.3	3.09
3-Sep-05	0.01	0	1.25	0
4-Sep-05	0.31	0.05	0	0
5-Sep-05	1.1	0.68	0	0.82
6-Sep-05	0.02	0.32	0	0.47
7-Sep-05	0.04	0.14	0	0.14
8-Sep-05	0.01	0	0.4	0
9-Sep-05	0	0	0	0
10-Sep-05	0.47	0	0	0
11-Sep-05	0	0	0	0
12-Sep-05	0	0	0	0
13-Sep-05	0	0	0	0
14-Sep-05	0	0	0	0
15-Sep-05	0	0	0	0
16-Sep-05	0	0	0	0
17-Sep-05	0	0	0	0
18-Sep-05	0	0.05	0	0
19-Sep-05	0.15	0.05	0	0.11
20-Sep-05	0.82	0.51	0.5	0.69
21-Sep-05	0.37	0.07	0	0.06
22-Sep-05	0	0	0	0.02
23-Sep-05	0.28	0.01	0	0
24-Sep-05	0	0	0	0
25-Sep-05	0	0	0.4	0
26-Sep-05	0.79	0.03	0	1.98
27-Sep-05	0.44	0	0.1	0.21
28-Sep-05	2.02	0.2	0	0.15
29-Sep-05	0	0.11	0	0
30-Sep-05	0	0	0.5	0
1-Oct-05	0	0.04	0	0.02
2-Oct-05	0.25	0.36	0	0.09
3-Oct-05	0.07	0	0	0.08

4-Oct-05	0.87	0.31	0	1.03
5-Oct-05	0	0	0.2	0
6-Oct-05	0.35	0.13	0	0.48
7-Oct-05	0.49	0.18	0.5	1.01
8-Oct-05	0	0	0.2	0
9-Oct-05	0	0.02	0	0.02
10-Oct-05	0	0	0	0.01
11-Oct-05	0	0.5	0	0
12-Oct-05	0	0.5	0	0
13-Oct-05	0.05	0	0	0
14-Oct-05	0.01	0	0.2	0
15-Oct-05	0	0	0	0.02
16-Oct-05	0	0	0	0
17-Oct-05	0	0	0	0
18-Oct-05	0	0	0	0
19-Oct-05	0.54	0.02	0	0
20-Oct-05	0	0	0	0.02
21-Oct-05	0	0.01	0	0.04
22-Oct-05	0.23	0.01	0	0.01
23-Oct-05	0.01	0	0	0
24-Oct-05	3.89	2.9	0	5.72
25-Oct-05	0	0	0	0
26-Oct-05	0	0	0	0
27-Oct-05	0	0	0	0
28-Oct-05	0	0	0	0

NOTES

(yellow)	=	RAINFALL EVENT
(orange)	=	FLOW SAMPLING EVENT
N/A	=	NOT YET AVAILABLE ON DBHYDRO

3.3.3.3 Data Summary and Preliminary Analyses

The normalization of cubic feet per second flows with respect to drainage area is a useful method for comparing synoptic flows at different stations. In order to perform this type of analysis the contributing drainage area for each of the flow monitoring locations must be determined. **Table 3.6** presents runoff data for the four flow sampling events described in the above sections. Flows are described in the units cubic feet per second (cfs). **Tables 3.7** and **3.8** illustrate the cubic feet per second per square mile calculation.

Table 3.6: Flow Monitoring Location Contributing Areas

FLOW MONITORING LOCATION	AREA (SQ MI)
DF08.1TN01	2.52
DF11.3TW01	35.01
DF11.4TN01	8.06
L206.0TW01	36.07
L206.0TW02	5.70
L209.1TW01	16.62
L209.1TW02	14.30
SM05.0TN	0.50
SM05.0TW	9.34
SMBRIDGE	17.51
DF02.0TW	49.77
SMWEIR	20.12

For purposes of the normalization technique the contributing area cannot be defined for SM02.2TN02 separate from SM02.2TW02, therefore the contributing area for SMBRIDGE is used, which is the combined runoff from both locations.

Table 3.7: Measured Runoff (cfs) at Flow Monitoring Locations within the C-139 Basin

DATE*	SM05.0TN	SM05.0TW	DF08.1TN01	DF11.4TN01	DF11.3TW01	DF02.0TW	SM02.2TW02	SM02.2TN02	SMBRIDGE**	SMWEIR	L206.0TW02	L206.0TW01	L209.1TW01	L209.1TW02
Sept 8,9	7.4	0.217	18.7	28.7	81	177	79.6	53.8	133.4	96.7	22.1	216	40.2	
Sept 21	3.08	0	8.82	8.04	46.8	99.9	1.27		1.27	0	3.1	41.8	25	4.97
Oct 5				7.59		0		0	0		1.42	36.6	18.4	2.19
Oct 7	0		0	0		308		53.2	53.2	87.1			18.4	0
Oct 8	13.5		9.83	13.6	79.5		58	137	195	211		70.9		0
Oct 26,27	13.6		26.4	108	325	427				208	58.7	259		

Table 3.8: Measured Runoff (cfs) per Square Mile at Flow Monitoring Locations

DATE	SM05.0TN	SM05.0TW	DF08.1TN01	DF11.4TN01	DF11.3TW01	DF02.0TW	SM02.2TW02	SM02.2TN02	SMBRIDGE**	SMWEIR	L206.0TW02	L206.0TW01	L209.1TW01	L209.1TW02
Sept 8,9	14.9	0.0	7.4	3.6	2.3	3.6	SMBRIDGE	SMBRIDGE	7.6	4.8	3.9	6.0	2.4	NA
Sept 21	6.2	NA	3.5	1.0	1.3	2.0	SMBRIDGE	SMBRIDGE	0.1	0.0	0.5	1.2	1.5	0.3
Oct 5,7,8***	27.2	NA	3.9	1.7	2.3	0.0	SMBRIDGE	SMBRIDGE	11.1	10.5	0.2	2.0	1.1	0.2
Oct 26,27	27.4	NA	10.5	13.4	9.3	8.6	SMBRIDGE	SMBRIDGE	NA	10.3	10.3	7.2	NA	NA

* All measurements were made in September and October of 2005
* SMBRIDGE = SM02.2TW02 = SM02.2TN02
** Values in the row Oct 5,7,8 represent the CFS/SM calculation for the highest flow measured over the period

Flows from the measurements on October 5th, 7th and 8th and October 26th and 27th were the highest measured flows. Flows on September 21st and October 5th through 7th may not be representative of an accurate rainfall versus runoff relationship due to higher than normal on-site retention of farm runoff. Flows at DF02.0TW on October 7th were very high when compared to tributary flows at DF08.1TN01 and DF11.4TN01 on October 8th. This was due to structural operating conditions, because the gates at DF02.0TW were open during measurements on October 7th, and closed during measurements on the 8th.

For all measured events there was a significant difference in magnitude between the flow at L206.0TW01 and L206.0TW02. This illustrated the large runoff contribution from farms east of CR 833 discharging to either the Devil's Garden Canal or the ALICO South Boundary Canal.

The runoff from stations within the S&M Canal subwatershed had on average the highest rate of runoff (e.g. 27.4 cfs/mi^2 for SM05.0TN on October 26 and 27, 11.1 cfs/mi^2 for SMBRIDGE on Oct 8). Unit area flows at S&M Weir (SMWEIR) on October 27th were 20% higher than Deer Fence Canal at Hilliard Bridge (DF02.0TW).

3.3.4. Field Topographic Survey

Superior Consultants Inc. (SCI) provided 24 canal cross-section surveys of major and minor canals within the C-139 Basin. The horizontal datum for these measurements was the North American Datum of 1983 (NAD83) and the vertical datum for these measurements was the National Geodetic Vertical Datum of 1929 (NGVD29). The vertical datum can be converted to the North American Vertical Datum of 1988 (NAVD88) utilizing the software package Corpscon provided by the US Army Corps of Engineers. The measurements were based on the existing National Geodetic Survey (NGS) monumentation along with District monumentation at major water control structures, Department of Transportation Benchmark stations, Hendry County monuments and City of Clewiston Benchmark stations. For the C-139 Basin the average correction between NGVD29 and NAVD88 is -1.33 ft. **Appendix D** includes a location map of the surveyed cross-sections and detailed drawings for each cross-section.

4.0 SUBWATERSHED SEGMENTATION AND SCREENING LEVEL TP ASSESSMENT

4.1 General

The scope of the Subwatershed Segmentation and Screening Level TP Assessment included the sub-division of the C-139 Basin into a total of six subwatersheds and the subdivision of those subwatersheds into up to 50 catchments. Based on the information described in Sections 2.0 and 3.0 as well as discussions with District Everglades Regulation Division staff, the C-139 Basin was divided into eight subwatersheds, and those eight subwatersheds were subdivided into 44 catchments.

The scope also included a screening-level TP assessment of the C-139 Basin using GIS, Excel and database tools. The analysis described in Section 4.2 used a spreadsheet approach to compute average annual runoff volumes and potential TP loads for each catchment. The screening-level assessment utilized the spatial distributions of land-use and soil data to generate a runoff coefficient and an event mean concentration (EMC) for each catchment. Once the runoff coefficient and EMC of each catchment was determined, the annual runoff and TP load was computed for each catchment using average rainfall from water years 1995 to 2004.

4.1.1. Subwatershed Segmentation

Since each subwatershed represents an extent of geographic area that shares the same drainage outfall, it is important to identify the major drainage outfalls from the C-139 Basin and the major canals or streams which convey runoff to these outfalls. The knowledge required to create the flow patterns described within Section 3.2 provide the necessary framework for the segmentation of the C-139 Basin into the 6 main subwatersheds and any smaller catchments found at smaller scales.

In some western portions of the basin the regional topography is very important in segmentation of the subwatersheds. ADA utilized the Spatial Analyst extension within ArcGIS 9.0 to delineate the basins in the western regions of the basin where there were no major features such as roads, levees, canals or control structures. Spatial Analyst can be used to create a stream network, flow paths and contributing areas based on a digital elevation model (DEM). However because of the minimal topographic relief within the C-139 basin this tool is inadequate for creating subwatersheds without corrections using local knowledge and engineering judgment. **Figure 4.1** illustrates a 100-ft grid-resolution DEM that was used mainly in delineating the subwatersheds within the undeveloped and native portions of the basin. This dataset was created from a composite of Light Detection And Ranging (LIDAR) data, USGS 5-foot contours and available spot elevations.

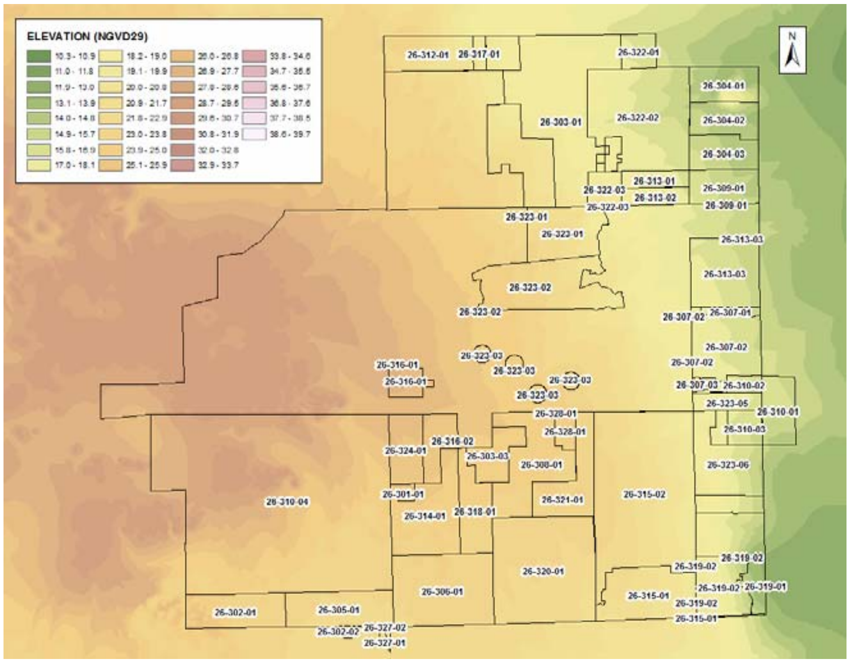

Figure 4.1: C-139 Topography

Upon District review of the draft subwatershed segmentation it was determined that two additional subwatersheds would be required to appropriately describe the hydrology of the C-139 Basin. **Figure 4.2** illustrates the basic configuration of the eight (8) subwatersheds identified by ADA, based on all available data. **Appendix E-1** is a large format subwatershed segmentation map for reference purposes. Below **Table 4.1** describes the eight subwatersheds within the C-139 Basin identified by ADA and labeled based on the receiving body for each subwatershed. The subwatershed receiving body identified in **Table 4.1** assumes no changes to the current operational practices of the major District water control structures.

Table 4.1: C-139 Subwatershed Area and Receiving Body

SUBWATERSHED	AREA [AC]	DISCHARGE STRUCTURE OR RECEIVING BODY
L1-01	15,505	Discharges east through G-136
L1-02	3,611	Discharges north through G-135
L2-01	33,436	Runoff transported east to the L-2 Canal (via the L-2W Canal, Hill Grade Ditch and Midway Canal)
L2-02	11,283	Runoff from Montura Ranches transported east to the L-2 Canal or north to G-135
L3-01	48,969	Runoff transported east to the L-3 Canal (via the Devil's Garden and ALICO South Boundary Canal)
DF-01	11,052	Runoff transported east by the Deer Fence Canal
DF-02	25,919	Runoff transported east and south into the Deer Fence Canal underneath the Duck Curve Bridge
SM-01	19,175	Runoff transported east by the S&M Canal

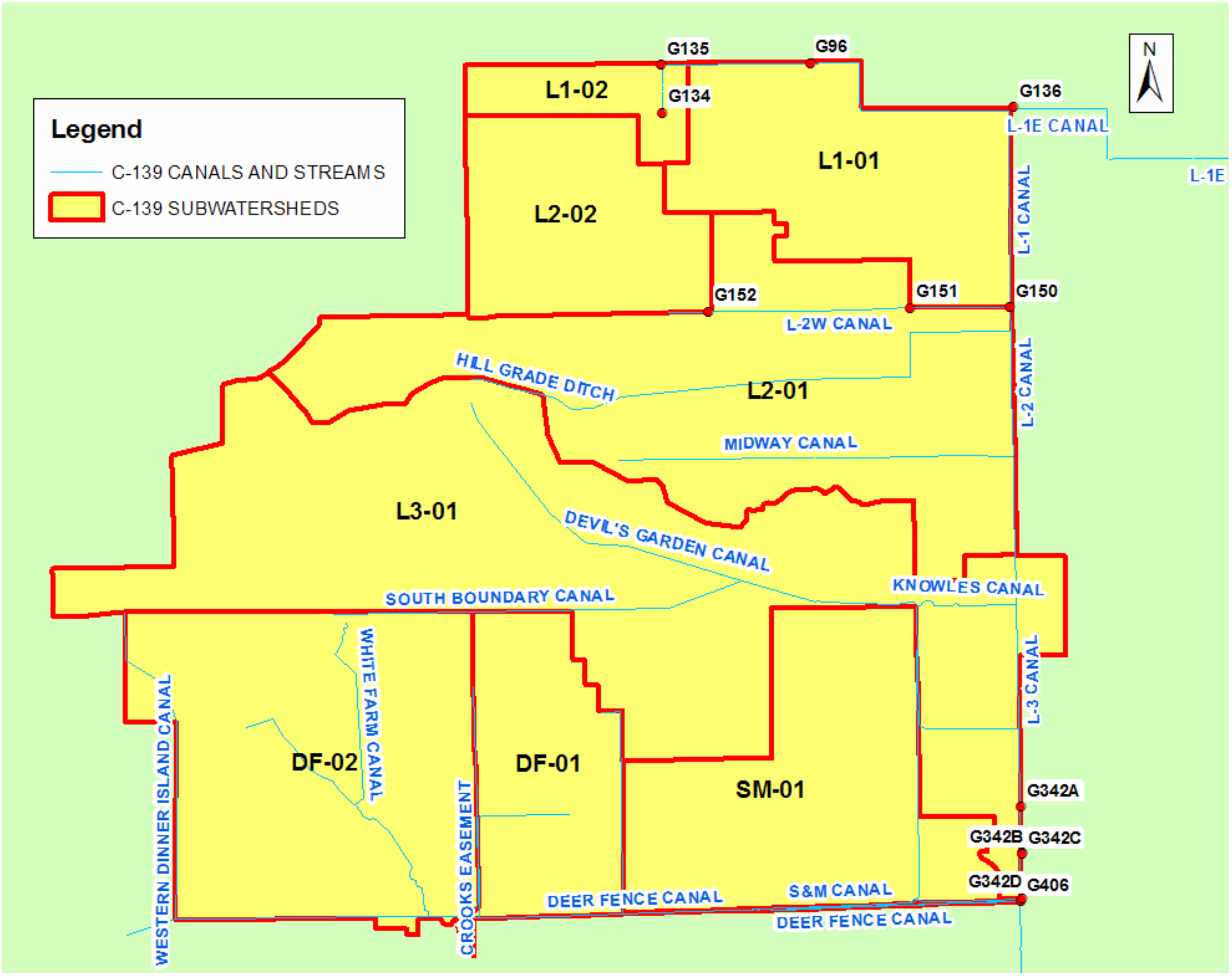

Figure 4.2: C-139 Subwatersheds

Basin L2-02 was added after District review because of its unique operational capabilities. The Central County Drainage District reservoir is the major hydraulic feature within Basin L2-02. The infrastructure of the reservoir allows for discharge to either the north or south or both. Therefore, it was determined that the reservoir and the contributing Montura Ranches subdivision should be made into an individual basin allowing more operational capability for future modeling phases.

Based upon District comment, the size of Basin L3-01 was increased to include contributing area north of the Devil's Garden Canal within Basin 26-323-04 along with all of the center pivot irrigation farms (Basin 26-323-03). This revision was supported by information gathered during a site visit by staff of both District and ADA.

4.1.2. Catchment Segmentation

The scope also describes a subdivision of the main subwatersheds into as many as 50 catchments to support the hydrologic modeling efforts. **Figure 4.3** illustrates the 44 catchments. These basins help define the contributing area for each of the proposed flow monitoring locations. **Appendix E-2** is a large format catchment segmentation map and **Appendix E-3** is a large format map illustrating the location of reservoirs and farm discharge locations with respect to the catchment boundaries.

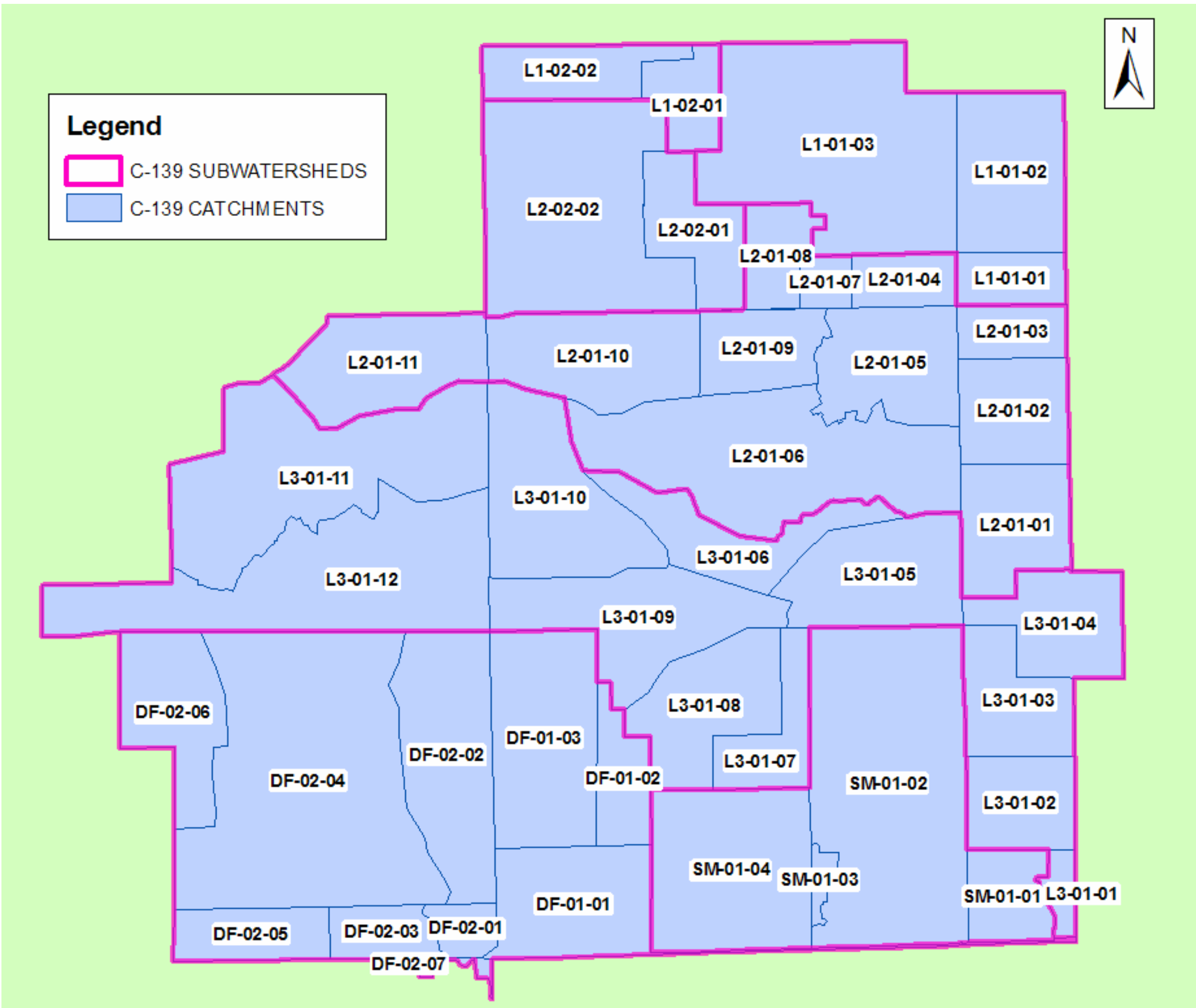

Figure 4.3: C-139 Catchments

Table 4.2 describes the characteristics of each of the catchments including: name, downstream monitoring location or receiving body, total basin area (acres) and the acreage of reservoirs internal to the catchments. This information is useful when determining the extent to which the runoff from each catchment can be controlled by farming operations and whether a natural rainfall-runoff relationship can be expected at the downstream monitoring location or receiving body.

Table 4.2: Characteristics of the C-139 Catchments

CATCHMENT NAME	AREA (AC)	MONITORING LOCATION OR RECEIVING BODY	TOTAL AREA OF RESERVOIRS WITHIN CATCHMENT (AC)
DF-01-01	4159.2	DF02.0TW-DF11.3TW01	398.5
DF-01-02	1613.2	DF08.1TN01	234.4
DF-01-03	5281.4	DF02.0TW-DF11.3TW01	13.6
DF-02-01	745.0	DF11.3TW01	113.9
DF-02-02	5158.3	DF11.4TN01	114.3
DF-02-03	1302.0	DF11.3TW01	294.0
DF-02-04	13144.5	DF11.3TW01	1637.3
DF-02-05	1881.2	DF11.3TW01	187.5
DF-02-06	3418.7	DF11.3TW01	1523.0
DF-02-07	267.1	DF11.3TW01	142.1
L1-01-01	1325.3	G136	187.8
L1-01-02	3977.7	G136	60.9
L1-01-03	10203.1	G136	2399.1
L1-02-01	1446.7	G135	2399.1
L1-02-02	2160.3	G135	296.1
L2-01-01	3037.9	L2	1103.1
L2-01-02	2691.0	L2	156.3
L2-01-03	1342.9	L2	187.8
L2-01-04	1273.9	L2W	81.0
L2-01-05	3606.2	L2	777.8
L2-01-06	8909.6	L209.1TW01	337.4
L2-01-07	630.6	L2W	0.0
L2-01-08	1523.6	L2W	0.0
L2-01-09	2274.4	L2W	729.3
L2-01-10	4198.3	L2W	186.3
L2-01-11	3953.4	L2W	0.0
L2-02-01	2479.1	L2W	2399.1
L2-02-02	8805.2	L2W	0.0
L3-01-01	574.7	L3	0.0
L3-01-02	2350.7	L3	266.6
L3-01-03	2623.2	L2	511.6
L3-01-04	2973.1	L2	134.1
L3-01-05	4067.9	L206.0TW01	0.0
L3-01-06	2902.4	L206.0TW01	59.4
L3-01-07	1902.8	L206.0TW01	226.9
L3-01-08	3710.1	L206.0TW01	0.0
L3-01-09	4900.1	L206.0TW01	0.0
L3-01-10	5153.5	L206.0TW01	57.8
L3-01-11	8747.9	L206.0TW02	0.0
L3-01-12	9059.4	L206.0TW02	0.0
SM-01-01	1674.5	SMWEIR-SMBRIDGE	264.3
SM-01-02	11204.0	SMBRIDGE	192.6
SM-01-03	317.3	SM05.0TN	0.0
SM-01-04	5980.5	SM05.0TW	553.6

4.2 Screening Level TP Assessment

The screening level TP assessment included the analysis of flows and loads within the C-139 Basin with a specific focus on TP. The purpose of the screening level TP assessment was to provide additional information to be used in the location of permanent monitoring stations. The assessment was performed using GIS, Excel and Database tools to focus on TP as the pollutant of interest. The TP load assessment was performed by establishing Event Mean Concentrations (EMCs) for up to 30 applicable land uses and BMPs in the basin from available information. These concentrations along with available rainfall data were used to determine the average annual P load distributions for the catchments. These loads were compared to available measured water quality data, and this information will provide a basis for potential monitoring locations, future hydrology model development and water quality improvement project/feasibility analysis.

4.2.1. Available Data

The District maintains a network of telemetered stage monitoring locations, precipitation gages and water quality sampling locations within the C-139 Basin. Hourly flows through the main District control structures are calculated using the geometry of each structure and the average hourly upstream and downstream stages. Sections 2.0 and 3.0 describe the long-term stage and flow records which are available from the District, as well as the event-based monitoring performed as part of the C-139 Hydrology and Phosphorus Water Quality Analysis.

Within the C-139 Basin there are precipitation records available from 1956 to present day. Water quality sampling at several locations within the C-139 Basin provides measurements of TP concentrations and loads that are used within this screening level assessment. Additionally, computations performed as part of the EAA RFS, described in Section 2.4, are used for verification of the screening level assessment the results of flow and load assessments performed as part of the EAA RFS are included within this report.

4.2.1.1 Precipitation Data

There are several precipitation gauging stations within the C-139 Basin, illustrated in **Figure 4.4**. These locations identified as G-136, DEVILS, PAIGE and ALICO, provide hourly rainfall accumulation at locations around the C-139 Basin.

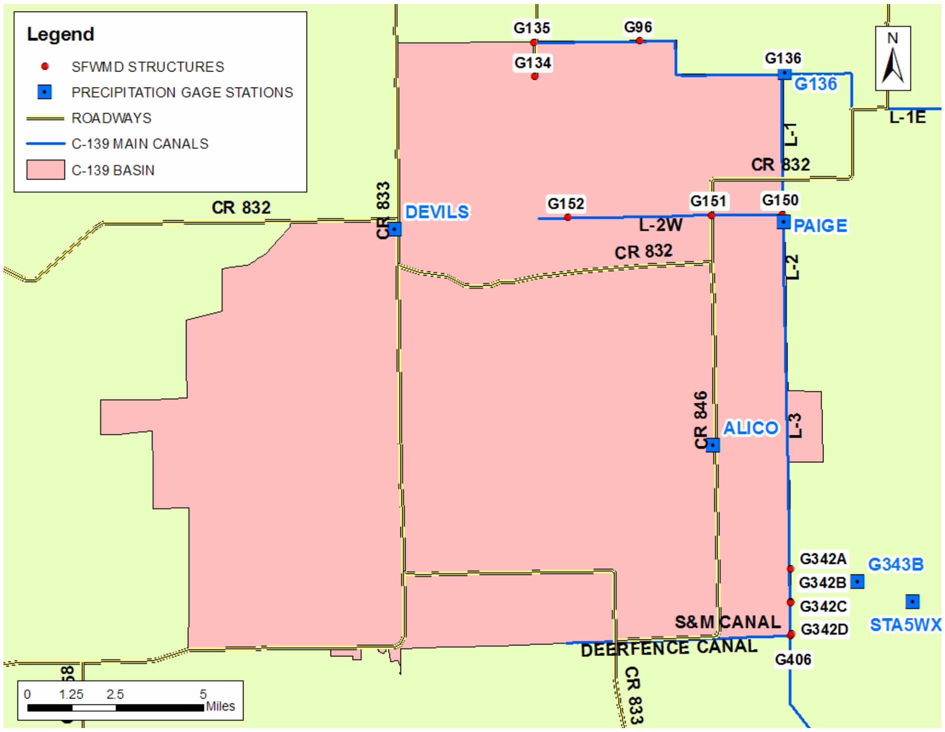

Figure 4.4: Precipitation Monitoring Stations in the C-139 Basin

4.2.1.2 Water Quality Data

There are water quality measurements taken throughout the year at both G-136 and the intersection of the Deer Fence and L-3 Canals. The determination of basin compliance is made utilizing this data. Currently, there are 18 additional water quality monitoring locations as part of the Everglades Regulatory Program contract CN040927-WO03. This dataset consists of surface water samples and in-situ physical parameters during flow conditions at a weekly frequency beginning on April 1 and continuing through October 31 during 2005. The locations of these measurements are illustrated in **Figure 4.5**.

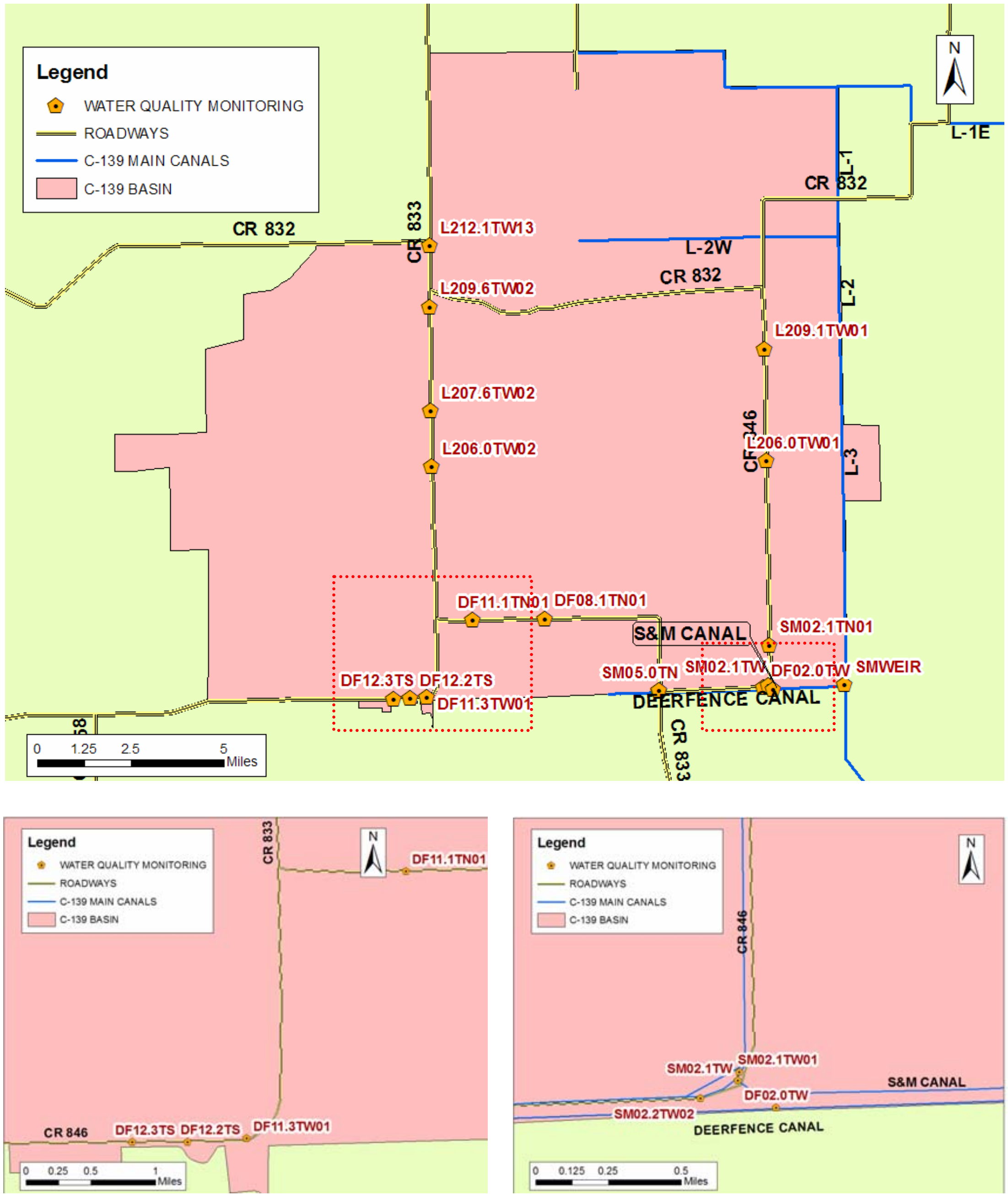

Figure 4.5: Water Quality Monitoring Locations in the C-139 Basin

4.2.2. Evaluation of Measured Data

There are several methods for evaluating the potential for TP loading within a watershed, including elaborate hydrologic, hydraulic and water quality models. In any case, measured data is necessary to construct a useful tool for the evaluation of nutrient transport in any watershed. Sections 2.0 and 3.0 describe the types of measured data that have been recorded for the C-139 Basin, and the following sections interpret how the data collected relates to a screening level phosphorus assessment of the basin.

4.2.2.1 Measured Flow Data

As discussed in Section 3.2, there are seven locations where hourly flow data is measured by the District. These locations are along the boundaries of the C-139 Basin and represent the accumulation of all runoff from the entire basin. In order to be able to disaggregate the total flow at the District structures into smaller separate flows from catchments, ADA performed event-based flow monitoring. This flow monitoring was scheduled to coincide with periods of significant rainfall to better understand the rainfall runoff process in the C-139 Basin.

This flow monitoring consisted of temporally discrete measurements during four runoff events at 12 locations. The collection methodology for these measurements is described in Section 3.3. Because the measurements are not continuous, the shape of the runoff hydrograph for each catchment area must be estimated using a prorated approach. All of the ADA flow measurements were within the drainage area of five District control structures: G-342A, G-342B, G-342C, G-342D and G-406 (STA5 Inflow and G-406). For the purposes of this analysis it was assumed that the shape of the runoff hydrograph for each catchment would resemble the runoff hydrograph generated through the summation of all the flows at all four structures. The following equation was used to prorate the shape of the total runoff hydrograph into individual hydrographs at each ADA flow measurement location.

$$Q_{Estimated}(ADA) = Q_{Meas\left(STA5_{Inflow}+G406\right)} \times \left(\frac{DrainageArea_{ADALocation}}{DrainageArea_{STA5+G406}} \right)$$

The prorated flows at the ADA flow measurement locations assume that the upstream contributing area has similar hydrologic characteristics to the average hydrologic characteristics of the entire basin. As such the prorated flows are expected to be inaccurate under the following conditions:

1. Measured runoff from the station is higher or lower than the prorated discharge due to spatial variability in rainfall.
2. Measured runoff from the station is higher or lower than the prorated discharge due to land-use intensities that are notably higher or lower than the basin average.
3. Measured runoff from the station is higher or lower than the prorated discharge due to farm operations and on site BMPs.

As the size of the upstream drainage area decreases, the likelihood that the catchment area upstream of the ADA flow measurement will include one or more of the above conditions increases. This is apparent when analyzing a comparison of measured with prorated flows. **Figure 4.6** shows the flow out of subwatersheds L2-01, L2-02, L3-01, SM-01, DF-01 and DF-02 (total of STA5 Inflow and G-406 flow). **Figure 4.7** compares measured and prorated flows for ADA flow measurement locations with contributing areas larger than 30 square miles. **Figure 4.8** illustrates the comparison of ADA measured flows with prorated flows for locations where the upstream contributing area is between 10 and 30 square miles. **Figure 4.9** illustrates the same comparison for locations with an upstream contributing area less than 10 square miles. In **Figure 4.8** the ADA flow measurements at SM02.2TN02 and SM02.2TW02 were added together into one measurement value titled SMBRIDGE since both share the same upstream drainage area. Therefore there are only 11 ADA flow measurement locations shown in **Figures 4.7 – 4.9**.

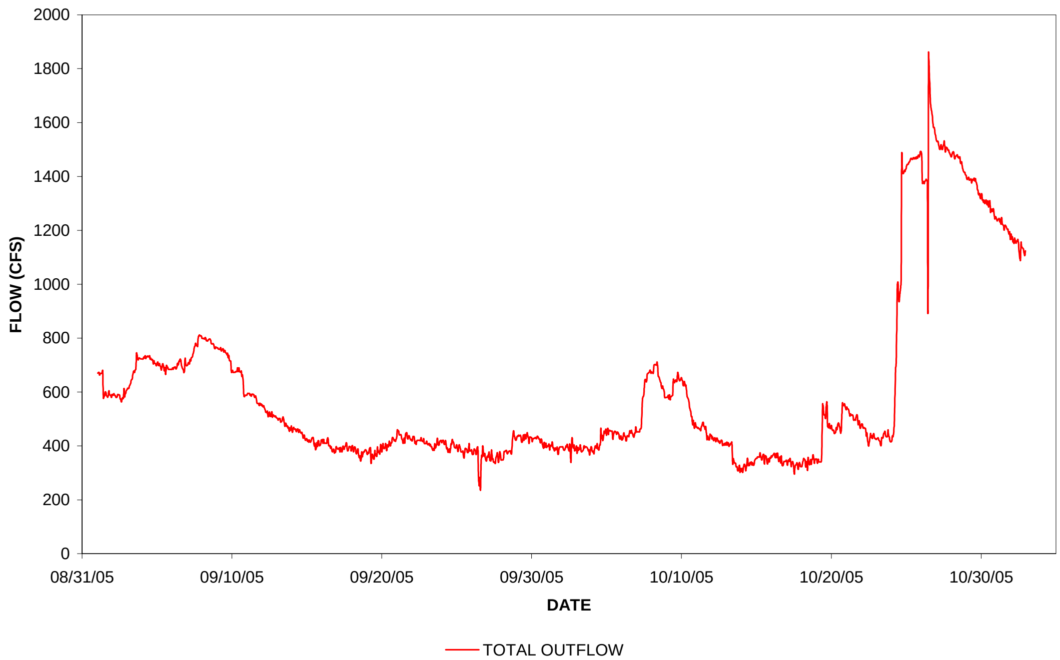

Figure 4.6: Total Outflow at G-342A, G-342B, G-342C, G-342D and G406

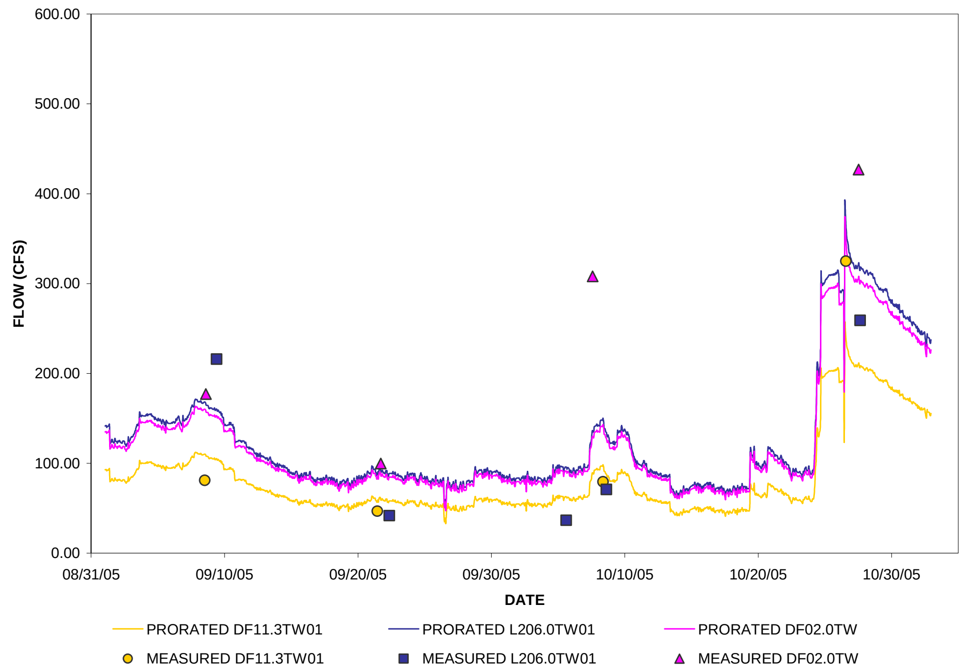

Figure 4.7: ADA Measured and Prorated Flows for Contributing Areas Greater than 30 Square Miles

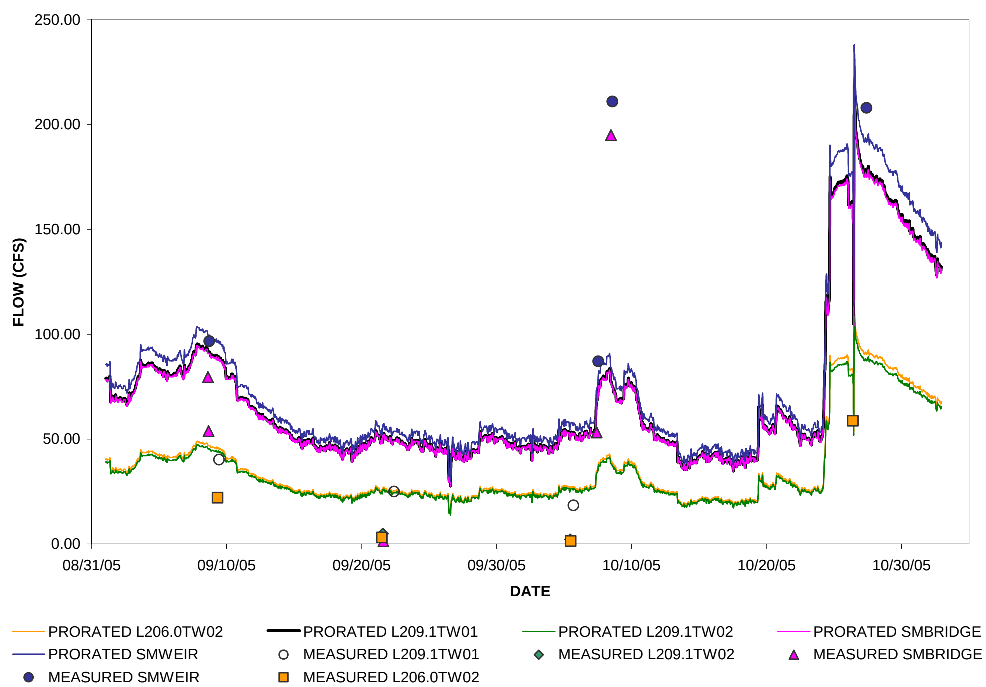

Figure 4.8: ADA Measured and Prorated Flows for Contributing Areas Between 10 and 30 Square Miles

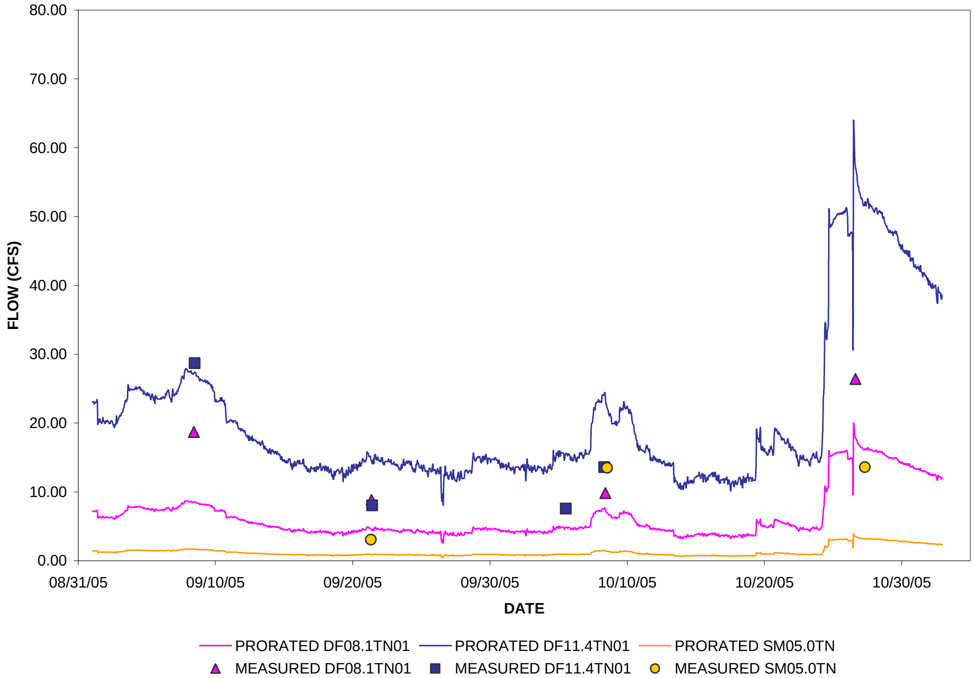

Figure 4.9: ADA Measured and Prorated Flows for Contributing Areas Less than 10 Square Miles

The locations where ADA measured flows are consistently higher than the prorated flows the upstream area is considered to have lower than average storage capacity. Conversely, locations where the ADA measured flows are consistently lower than the prorated flows the upstream area is considered to have lower than average storage capacity. The TP load seen at the outfall of a basin is a function of both the TP concentration and the volume of runoff. Drainage areas that have low storage capacities are more likely to have high runoff volumes and proportionally high TP loads.

Figures 4.7, 4.8 and **4.9** identified locations where measured runoff consistently exceeded prorated runoff. These locations were described as having low storage within the upstream contributing area. **Table 4.3** describes the average differences between the ADA measured flow and the prorated flow as the average error. The mean absolute error (MAE) describes the average of all differences at each station taken as a positive value. The MAE is an indication of the total deviation of the ADA flow measurements from the prorated values. **Table 4.3** also describes the MAE divided by the upstream contributing area in order to provide a similar basis to compare the errors shown at each location.

Table 4.3: Disparities between Monitored and Prorated Runoff Rates

STATION	MEAN ERROR [CFS]	MEAN ABSOLUTE ERROR [CFS]	CONTRIBUTING AREA [SQ MI]	MEAN ABSOLUTE ERROR PER AREA
DF02.0TW	82.05	82.05	47.19	1.74
DF08.1TN01	6.32	6.32	2.52	2.51
DF11.3TW01	7.37	36.46	32.44	1.12
DF11.4TN01	4.19	13.99	8.06	1.74
L206.0TW01	-33.73	55.98	49.53	1.13
L206.0TW02	-24.20	24.20	14.16	1.71
L209.1TW01	-35.62	35.62	27.59	1.29
L209.1TW02	-22.10	22.10	13.67	1.62
SMBRIDGE	0.91	46.39	27.35	1.70
SM05.0TN	8.24	8.24	0.50	16.61
SMWEIR	37.32	38.70	29.96	1.29

Based solely upon the assumptions described above, the smallest upstream contributing areas also had the highest average disparity between prorated and monitored flow, SM05.0TN and DF08.1TN01. The third highest MAE per square mile is DF02.0TW followed by DF11.4TN01. These locations are within the DF-01 and DF-02 subwatersheds as defined in Section 4.1. SMBRIDGE has the fifth highest MAE per square mile. This is due in large part to the very high runoff measured on October 8 2005. Other measured values were near or below the prorated flows. This outlier is indicative of the operations of the on-site drainage infrastructure internal to the farms upstream of the monitoring location. SMWEIR and DF11.3TW01 are the locations that show the least deficiency in on-site storage upstream of the measurement point. All of the monitoring locations within the L2-01 and the L3-01 subwatershed demonstrate sufficient on-site storage.

4.2.2.2 Measured Total Phosphorus Concentrations

As described in Section 3.3 there are 18 stations that are being monitored for water quality by the Everglades Regulatory Program under contract CN040927-WO03 which is concurrent with this project. This sampling program was conducted by the consulting firm Metcalfe & Eddy. The monitoring plan included a single weekly sample of TP concentration at 18 individual stations within the basin. At the time of publication of this report, there were 13 stations where at least 6 samples were taken between August and November of 2005. The average measured TP concentration for these locations over this period is illustrated in **Table 4.4**. TP loads can only be calculated when both concentrations and flows are available. When concentration data will be used to calculate a TP load, any data averaging should be performed using a flow weighted mean. However, since this sampling plan does not include flow monitoring a simple arithmetic mean is the only method available for location comparison as is illustrated in **Table 4.4**. The number of samples taken at each location is also included in **Table 4.4**.

Table 4.4: Average Measured TP Concentrations

STATION	AVERAGE TPO_4 CONCENTRATION [mg/L]	NUMBER OF MEASUREMENTS
DF02.0TW	0.15	8
DF08.1TN01	0.17	9
DF11.1TN01	0.22	10
DF11.3TW01	0.14	10
DF12.3TS	0.05	9
L206.0TW01	0.15	13
L206.0TW02	0.40	9
L209.1TW01	0.13	11
L212.1TW13	0.09	8
SM02.1TN01	0.61	7
SM02.2TW02	0.62	6
SM05.0TN	0.19	7
SMWEIR	0.48	8

Figure 4.10 illustrates the temporal variability of the TP concentrations found at the 13 locations for which at least six measurements were available during the peak of the wet season for 2005.

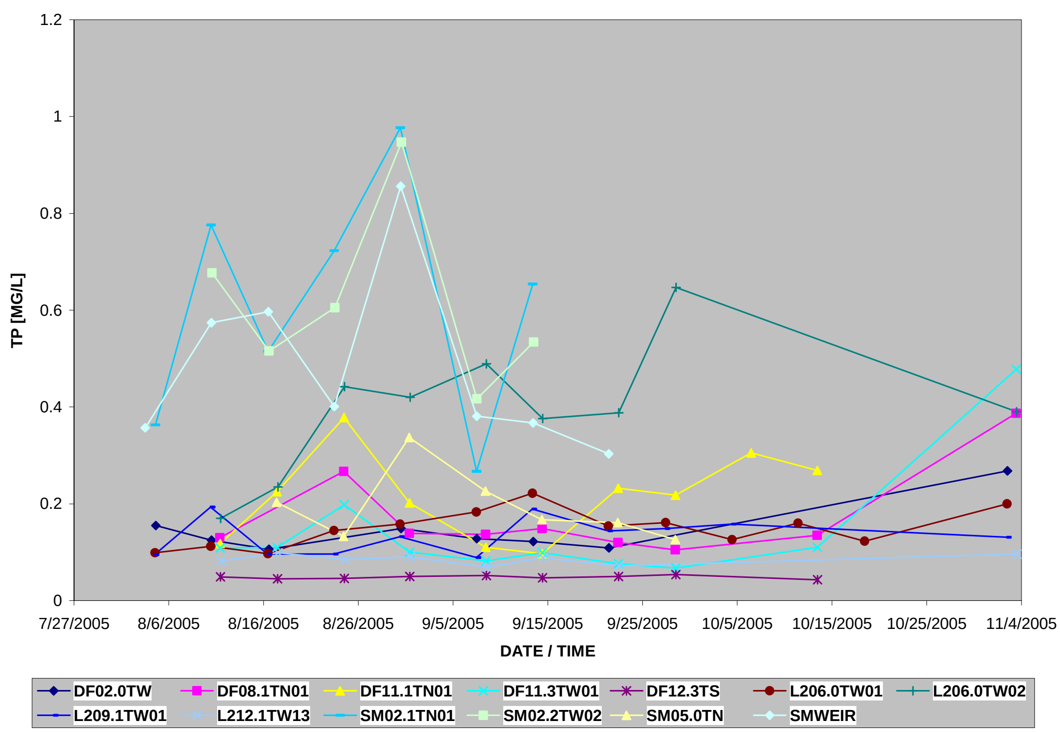

Figure 4.10: Measured TP Concentrations

The three locations with the highest average concentrations were observed in the SM-01 subwatershed at monitoring locations SM02.1TN01, SM02.2TW02 and SMWEIR. These results are consistent with the high levels of agricultural development within the SM-01 subwatershed. The percentage of land-use that is classified as sugarcane/field/row crop within the SM-01 Basin is 44%. The next highest percentage of area classified as sugarcane/field/row crop within a basin is 20% within the L1-01 subwatershed.

The next highest average concentration observed was at L206.0TW02 within the L3-01 subwatershed. Although a large percentage of the upstream contributing area is wetland and native there is a pasture that is near the monitoring location. As shown in **Figures 4.11** and **4.12** there were cattle observed near the major conveyance tributary (ALICO South Boundary Canal) directly upstream of the monitoring location (west of CR 833).

Figure 4.11: Looking West from CR 833 at L206.0TW02

Figure 4.12: Cattle West of CR 833 North of L206.0TW02

The lowest concentrations were observed in L212.1TW13 and DF12.3TS, within the L2-01 and DF-02 subwatersheds, respectively. The L212.1TW13 station is located on L-2W at SR 833 in the Devil's Garden WCD. The predominant land uses upstream of this station are native wetlands, forested lands, and pasture. DF12.3TS monitors runoff from outflow from agricultural operations that have permitted reservoirs upstream of the monitoring site.

4.2.3. Spreadsheet Based TP Screening Level Analysis

Because the monitored data cannot delineate the flows or loads into individual catchments which are divided upstream of a flow monitoring location, a spreadsheet was created to determine flows and loads from each catchment based on several parameters such as land-use, Event Mean Concentrations (EMCs) and Best Management Practices (BMP) data. The spreadsheet was designed to reflect the annual runoff volumes and TP loads defined for the C-139 Basin during the water years of 1995 to 2004. This 10 year period represents the most recent period for which annual data is available and includes a variety of wet average and dry years. This period was also used for comparison with the flows and TP loads documented within the EAA RFS.

4.2.3.1 Land-uses within the C-139 Basin

According to the most recent District land-use dataset (1999), the C-139 Basin contains 50 different land-uses. **Figure 4.13** illustrates the various land-uses and the spatial variability of these land-uses within the basin. **Table 4.5** describes the comparative areas of each of the 50 land-uses within the C-139 Basin sorted from most prevalent to least common within the basin.

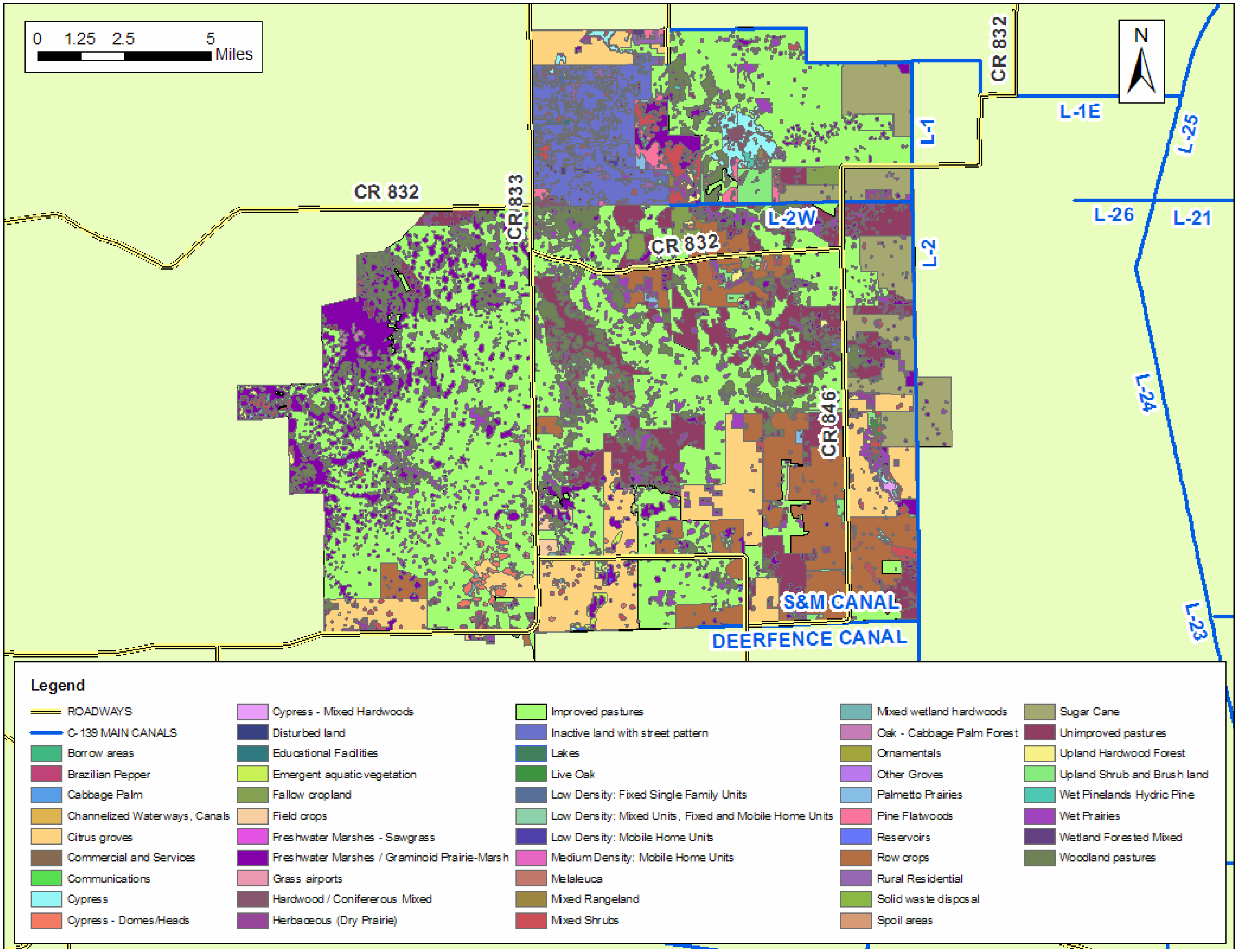

Figure 4.13: C-139 Land-uses (1999)

Table 4.5: Land-Use Distribution within the C-139 Basin

LUCODE	DESCRIPTION	AREA (AC)	PERCENTAGE OF BASIN AREA
2110	Improved pastures	63117.5	37.30%
2120	Unimproved pastures	14803.4	8.75%
6410	Freshwater Marshes / Graminoid Prairie - Marsh	13900.6	8.21%
2210	Citrus groves	13652.1	8.07%
2140	Row crops	13148.1	7.77%
2130	Woodland pastures	12279.3	7.26%
2156	Sugar Cane	8642.1	5.11%
6430	Wet Prairies	7028.5	4.15%
4110	Pine Flatwoods	5069.2	3.00%
3100	Herbaceous (Dry Prairie)	4151.5	2.45%
6172	Mixed Shrubs	3585.2	2.12%
3200	Upland Shrub and Brush land	1621.4	0.96%
6210	Cypress	1387.1	0.82%
6215	Cypress - Domes/Heads	925.5	0.55%
7430	Spoil areas	670.4	0.40%
1110	Low Density: Fixed Single Family Units	623.0	0.37%
3210	Palmetto Prairies	593.9	0.35%
4200	Upland Hardwood Forest	438.0	0.26%
3300	Mixed Rangeland	437.9	0.26%
5120	Channelized Waterways, Canals	404.9	0.24%
2150	Field crops	403.0	0.24%
4340	Hardwood / Conifererous Mixed	360.6	0.21%
6170	Mixed wetland hardwoods	340.6	0.20%
6440	Emergent aquatic vegetation	327.7	0.19%
4271	Oak-Cabbage Palm Forest	261.8	0.15%
4220	Brazilian Pepper	179.9	0.11%
6250	Wet Pinelands Hydric Pine	155.4	0.09%
6216	Cypress - Mixed Hardwoods	141.3	0.08%
1120	Low Density: Mobile Home Units	121.0	0.07%
4270	Live Oak	110.9	0.07%
5300	Reservoirs	100.9	0.06%
6300	Wetland Forested Mixed	48.6	0.03%
1400	Commercial and Services	28.0	0.02%
8115	Grass airports	24.8	0.01%
1220	Medium Density: Mobile Home Units	19.5	0.01%
8350	Solid waste disposal	17.8	0.01%
4280	Cabbage Palm	17.0	0.01%
5200	Lakes	13.4	0.01%
1710	Educational Facilities	10.4	0.01%
7420	Borrow areas	9.4	0.01%
2230	Other Groves	7.9	0.00%
2430	Ornamentals	7.9	0.00%
1130	Low Density: Mixed Units, Fixed and Mobile Home Units	6.2	0.00%
6411	Freshwater Marshes - Sawgrass	5.7	0.00%
8200	Communications	5.4	0.00%
7400	Disturbed land	3.6	0.00%
4240	Melaleuca	2.5	0.00%

4.2.3.2 Calculation of Runoff within the C-139 Basin

A common technique for calculating runoff in a basin is the Soil Conservation Service Curve Number (CN) approach. This methodology is widely used in the design calculations for sizing drainage infrastructure. The value for CN is dependent on the land-uses within the basin of interest and the SCS Soil Hydrologic Group. The Florida Department of Transportation (FDOT) recommends the CN values found the TR-55 design manual. **Table 4.6** describes the CN values for various land-uses found in the TR-55 design manual for the four different Soil Hydrologic Group type.

Table 4.6: Curve Number Values from the TR-55 Design Manual

LANDUSE	HYDROGROUP A	HYDROGROUP B	HYDROGROUP C	HYDROGROUP D
Fallow	77	86	91	94
Row Crop				
Poor	72	81	88	91
Good	67	78	85	89
Pasture/Range				
Poor	68	79	86	89
Fair	49	69	79	84
Good	39	61	74	80
Meadow				
Good	30	58	71	78
Woods				
Poor	45	66	77	83
Fair	36	60	73	79
Good	25	55	70	77
Brush				
Poor	48	67	77	83
Fair	35	56	70	77
Good	30	48	65	73
Residential				
1 acre	51	68	79	84
1/2 acre	54	70	80	85
Commercial	89	92	94	95
Water	100	100	100	100

Although the soils in the C-139 Basin are very sandy, the soils within the C-139 Basin are almost exclusively Hydrogroup D soils due to the high water table environment that is commonly found in the region, according to the Soil Survey Geographic database (SSURGO) made available by District.

The most common method for calculating runoff using the CN approach uses the equation:

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

where,

$$S = \frac{1000}{CN} - 10$$

However, this methodology is intended to be used for event-based calculations. In order to incorporate the CN method for annual runoff calculations, the CN must be converted into a runoff coefficient. In 2003, Environmental Research & Design, Inc. (ERD) prepared a report for the Water Enhancement & Restoration Coalition, Inc. titled "Evaluation of Stormwater Regulations for Southwest Florida." This report developed an alternative methodology for stormwater treatment criteria to be used in the design of wet and dry detention systems in Southwest Florida. The report includes a table that calculates runoff coefficients based on a combination of CN and Directly Connected Impervious Area (DCIA).

Once the runoff coefficient has been computed for each land-use ADA calculated a single spatially averaged runoff coefficient for each catchment. This coefficient was then multiplied by the volume of rainfall in each water year between 1995 and 2004 to determine runoff volumes as is shown below:

$$Q_{ANNUAL} = Area_{Basin} \times P_{ANNUAL} \times \frac{1\,ft}{12\,inches} \times Coefficient_{Runoff}$$

Utilizing this methodology, the annual runoff volume is calculated for each of the 44 catchments. The total annual runoff at each of the basin outflow locations (G-135, G-136 and the G-406/STA5 Inflow) is then determined by summing the annual runoff volume from all contributing catchments. The results of this calculation are compared to the annual runoff volumes documented in the EAA RFS, and are illustrated in **Table 4.7**.

Table 4.7: Comparison of Calculated and Documented Annual Runoff Volumes [ac-ft]

WATER YEAR	PREDICTED RUNOFF			CALCULATED IN EAA RFS			ERROR			PERCENT ERROR		
	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135
WY1995	188967	22010	4280	183002	35986	1785	5965	-13976	2495	3%	-39%	140%
WY1996	140626	16380	3185	181183	20790	856	-40557	-4410	2329	-22%	-21%	272%
WY1997	129004	15026	2922	151440	13091	4489	-22436	1935	-1567	-15%	15%	-35%
WY1998	157282	18320	3562	149152	20776	4731	8130	-2456	-1169	5%	-12%	-25%
WY1999	154739	18023	3504	122058	13732	4957	32681	4291	-1453	27%	31%	-29%
WY2000	104999	12230	2378	176867	24859	10570	-71868	-12629	-8192	-41%	-51%	-78%
WY2001	114738	13364	2599	53198	3294	386	61540	10070	2213	116%	306%	573%
WY2002	116773	13601	2645	182608	17061	4865	-65835	-3460	-2220	-36%	-20%	-46%
WY2003	133149	15509	3016	209265	15155	4834	-76116	354	-1818	-36%	2%	-38%
WY2004	120511	14037	2729	190702	13221	3750	-70191	816	-1021	-37%	6%	-27%

The values from the EAA RFS were calculated using flow and concentration data made available by the District through DBHYDRO. The EAA RFS utilizes the District program EAATPLD (Everglades Agricultural Area Total Phosphorus Load) to estimate TP concentration and load at each of the major water control structures. EAATPLD was developed to provide a standardized procedure for estimating TP loads from the EAA Basin. This procedure and the source code for the EAATPLD program are codified in the specific District administrative rule referred to as Rule 40E-63.

4.2.3.3 Literature based Event Mean Concentrations (EMCs)

In order to approximate TP loads for each catchment ADA collected EMCs for differing land-uses from peer-reviewed literature. In December 2004, the Journal of the American Water Resources Association published an article titled "Water Quality Characteristics of Storm Water from Major Land-uses in South Florida" (Graves, Wan and Fike). This publication described the result of a 30 month runoff sampling project in watersheds tributary to the Indian River Lagoon. The results of this study include a calculation of EMCs for TP for six land-uses as is shown in **Table 4.8**.

Table 4.8: Summary of TP Concentrations from Graves, Wan and Fike (2004)

LANDUSE	MEAN TP [mg/L]	MEDIAN TP [mg/L]
Citrus	0.29	0.16
Pasture	0.29	0.22
Urban	0.22	0.09
Golf Course	0.24	0.19
Wetland	0.02	0.01
Row Crop	0.63	0.45
Residual	0.26	0.2
Dairy	12.54	8.86

Unfortunately the study did not provide any information concerning the EMCs for any forested land-uses.

The 2003 ERD report also includes a literature search of available EMC data for differing land-uses. The EMCs described in this dataset include results from a previous ERD study performed in 1994 in Central and South Florida. **Table 4.9** exhibits the EMC dataset that was compiled by ERD.

Table 4.9: Summary of TP Concentrations from ERD (2003)

LANDUSE	TOTAL P [mg/L]
Low-Density Residential	0.191
Single-Family	0.335
Multi-Family	0.49
Low-Intensity Commercial	0.18
High-Intensity Commercial	0.43
Industrial	0.31
Highway	0.27
Pasture	0.476
Citrus	0.183
Row Crop	0.638
General Agriculture	0.344
Undeveloped Rangeland/Forest	0.046
Mining	0.15
Wetland	0.09
Open Water/Lake	0.067

Many of the values shown in **Table 4.9** were obtained through the literature search from a previous document from ERD titled "Stormwater Loading Rate Parameters for Central and South Florida" (1994). The values shown in the 1994 report often display a bias towards higher TP concentrations due to high levels of phosphorus within the soils of Central Florida.

For the purposes of this analysis ADA referenced both **Tables 4.8** and **4.9** to determine appropriate EMCs to be used to approximate TP loads within the C-139 Basin. **Table 4.10** shows the values assumed for the land-uses of the C-139 Basin.

The scope of work describes that the TP load assessment will establish Event Mean Concentrations (EMCs) for up to 30 applicable land uses and BMPs in the basin from available information. **Table 4.10** describes the EMCs for 47 land-uses based upon established literature. Unfortunately, ADA was unable to obtain any values from literature which demonstrate the effects of various BMPs on individual land-uses.

Table 4.10: TP EMCs for Land-Uses within the C-139 Basin

LUCODE	DESCRIPTION	AREA [AC]	PERCENTAGE OF BASIN AREA	EMC [mg/L]
2110	Improved pastures	63117.5	37.30%	0.22
2120	Unimproved pastures	14803.4	8.75%	0.22
6410	Freshwater Marshes / Graminoid Prairie - Marsh	13900.6	8.21%	0.02
2210	Citrus groves	13652.1	8.07%	0.63
2140	Row crops	13148.1	7.77%	0.29
2130	Woodland pastures	12279.3	7.26%	0.29
2156	Sugar Cane	8642.1	5.11%	0.63
6430	Wet Prairies	7028.5	4.15%	0.02
4110	Pine Flatwoods	5069.2	3.00%	0.05
3100	Herbaceous (Dry Prairie)	4151.5	2.45%	0.29
6172	Mixed Shrubs	3585.2	2.12%	0.02
3200	Upland Shrub and Brush land	1621.4	0.96%	0.63
6210	Cypress	1387.1	0.82%	0.02
6215	Cypress - Domes/Heads	925.5	0.55%	0.02
7430	Spoil areas	670.4	0.40%	0.02
1110	Low Density: Fixed Single Family Units	623.0	0.37%	0.22
3210	Palmetto Prairies	593.9	0.35%	0.29
4200	Upland Hardwood Forest	438.0	0.26%	0.05
3300	Mixed Rangeland	437.9	0.26%	0.05
5120	Channelized Waterways, Canals	404.9	0.24%	0.05
2150	Field crops	403.0	0.24%	0.29
4340	Hardwood / Coniferous Mixed	360.6	0.21%	0.05
6170	Mixed wetland hardwoods	340.6	0.20%	0.02
6440	Emergent aquatic vegetation	327.7	0.19%	0.02
4271	Oak-Cabbage Palm Forest	261.8	0.15%	0.05
4220	Brazilian Pepper	179.9	0.11%	0.05
6250	Wet Pinelands Hydric Pine	155.4	0.09%	0.02
6216	Cypress - Mixed Hardwoods	141.3	0.08%	0.29
1120	Low Density: Mobile Home Units	121.0	0.07%	0.22
4270	Live Oak	110.9	0.07%	0.05
5300	Reservoirs	100.9	0.06%	0.05
6300	Wetland Forested Mixed	48.6	0.03%	0.02
1400	Commercial and Services	28.0	0.02%	0.22
8115	Grass airports	24.8	0.01%	0.22
1220	Medium Density: Mobile Home Units	19.5	0.01%	0.22
8350	Solid waste disposal	17.8	0.01%	0.22
4280	Cabbage Palm	17.0	0.01%	0.05
5200	Lakes	13.4	0.01%	0.05
1710	Educational Facilities	10.4	0.01%	0.22
7420	Borrow areas	9.4	0.01%	0.02
2230	Other Groves	7.9	0.00%	0.63
2430	Ornamentals	7.9	0.00%	0.29
1130	Low Density: Mixed Units, Fixed and Mobile Home Units	6.2	0.00%	0.22
6411	Freshwater Marshes - Sawgrass	5.7	0.00%	0.02
8200	Communications	5.4	0.00%	0.22
7400	Disturbed land	3.6	0.00%	0.02
4240	Melaleuca	2.5	0.00%	0.05

4.2.3.4 Calculation of TP Loads within the C-139 Basin

Using the EMCs from **Table 4.10** in combination with the catchment land-use and area dataset ADA created a spatially weighted average of EMC for each catchment. This spatially averaged subwatershed EMC was then multiplied by the runoff volume from each catchment in order to calculate the TP load. These loads were calculated in units of kilograms for comparison with the TP loads calculated within the EAA RFS, as described in Section 4.2.3.6, as is illustrated in **Table 4.11** below. The resulting load represents an un-managed load with no BMPs in place.

Table 4.11: Comparison of Calculated and Documented Annual TP Loads [kg]

WATER YEAR	PREDICTED LOAD			CALCULATED IN EAA RFS			ERROR			PERCENT ERROR		
	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135
WY1995	66624	9112	1210	39662	5336	90	26962	3776	1120	68%	71%	1245%
WY1996	49580	6781	901	40360	3381	34	9220	3400	867	23%	101%	2549%
WY1997	45483	6221	826	42704	2459	1005	2779	3762	-179	7%	153%	-18%
WY1998	55452	7584	1007	30211	5327	890	25241	2257	117	84%	42%	13%
WY1999	54556	7462	991	31376	4165	1119	23180	3297	-128	74%	79%	-11%
WY2000	37019	5063	673	44417	7948	2121	-7398	-2885	-1448	-17%	-36%	-68%
WY2001	40453	5533	735	16642	244	27	23811	5289	708	143%	2168%	2622%
WY2002	41170	5631	748	61521	4239	1291	-20351	1392	-543	-33%	33%	-42%
WY2003	46944	6421	853	71032	4965	1284	-24088	1456	-431	-34%	29%	-34%
WY2004	42488	5811	772	64534	3335	751	-22046	2476	21	-34%	74%	3%

4.2.3.5 Reduction of TP Loads by BMPs

The scope of work describes that the TP load assessment will establish Event Mean Concentrations (EMCs) for up to 30 applicable land uses and BMPs in the basin from available information. **Table 4.10** describes the EMCs for 47 land-uses based upon established literature. Unfortunately, ADA was unable to obtain any values from literature which demonstrate the effects of various BMPs on individual land-uses. In order to incorporate this affect into the calculations ADA compared the area of land-uses classified as wetland or open water within each catchment with the total area of that basin. This was used as an indicator of the land-owners on-site retention or natural treatment processes. It was determined that TP loads within catchments with larger than 10% of the total area classified as wet would be decreased by 25%. Catchments with less than 10% of the total area classified as wet were determined to have a TP load reduction of 15% due to the other BMPs instituted by land-owners such as soil-testing and reduced cattle densities.

Additionally, if the information collected in Sections 2.0 and 3.0 demonstrate that all agricultural runoff is retained on-site within a permitted impoundment prior to release, the TP load reduction for that catchment was determined to be 50%. The results of this calculation are demonstrated in **Table 4.12**.

Table 4.12: Comparison of Reduced Loads with Documented Annual TP Loads [kg]

WATER YEAR	PREDICTED LOAD			CALCULATED IN EAA RFS			ERROR			PERCENT ERROR		
	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135	L-3 OUT	G-136	G-135
WY1995	46013	6829	1029	39662	5336	90	6351	1493	939	16%	28%	1043%
WY1996	34242	5082	766	40360	3381	34	-6118	1701	732	-15%	50%	2152%
WY1997	31412	4662	702	42704	2459	1005	-11292	2203	-303	-26%	90%	-30%
WY1998	38298	5684	856	30211	5327	890	8087	357	-34	27%	7%	-4%
WY1999	37679	5592	842	31376	4165	1119	6303	1427	-277	20%	34%	-25%
WY2000	25567	3795	572	44417	7948	2121	-18850	-4153	-1549	-42%	-52%	-73%
WY2001	27939	4147	625	16642	244	27	11297	3903	598	68%	1599%	2214%
WY2002	28434	4220	636	61521	4239	1291	-33087	-19	-655	-54%	0%	-51%
WY2003	32422	4812	725	71032	4965	1284	-38610	-153	-559	-54%	-3%	-44%
WY2004	29344	4355	656	64534	3335	751	-35190	1020	-95	-55%	31%	-13%

The flows and loads calculated with and without BMPs by the screening level P assessment spreadsheet are not meant to be representative of actual loads seen within the C-139 Basin. These calculations reflect the potential spatial distribution of loads within the basin based on land-uses and an estimate of the effect of BMPs assuming all other factors are held constant. The results of these calculations are meant to be incorporated with the evaluation of monitored results and all additional data collected as part of Sections 2.0 and 3.0 to identify potential locations for permanent water quality monitoring stations.

4.2.4. Discussion of Screening Level TP Assessment

Both the evaluation of monitored data and the spreadsheet based analysis described in Section 4.0 provide tools for the screening level phosphorus assessment of the C-139 Basin. Since the monitored data is based on events during the 2005 wet-season and the spreadsheet analysis is based on total annual runoff and TP loads, the two methods cannot be compared. However, the purpose of the screening level assessment is to provide tools to assist in the identification of locations for permanent monitoring stations. The results of each methodology can identify locations where monitoring locations would be most effective, and in the case that both methods support the same location the two tools can be used collaboratively during Task 5 (Work Order CN CN040912-WO07) to define the locations of the permanent monitoring stations.

The screening level TP assessment was an initial step in the process of creating a detailed methodology for analyzing the hydrology and water quality within the C-139 Basin. Phase II of Work Order CN040912-WO07 will include an in-depth water quality modeling effort. This modeling effort will provide an analysis of TP load distribution and an assessment of water quality improvement projects.

5.0 LOCATION OF MONITORING STATIONS

5.1 General

The scope for the Location of Monitoring Stations included the identification of up to six (6) monitoring locations that capture or are representative of the spatial distribution of flow and TP load within the C-139 Basin. In cooperation with District Everglades Regulation Division staff, ADA identified four (4) monitoring locations that meet the objectives established by the District. Based upon discussions with District staff, there were two primary objectives when determining monitoring locations. The primary objectives were:

- Determine the runoff from each of the identified subwatersheds and
- Reduce potential access concerns.

Within this section two individual monitoring scenarios are identified based on each of these objectives. These scenarios are used to determine the optimal location of the four monitoring locations to be installed as soon as practicable. The proposed monitoring locations are to be used in combination with the three (3) existing monitoring locations (at the G-150 structure, the Deer-Fence Canal and S&M Canal) and the monitored District control structures (G-135, G-136, G-342A, G-342B, G-342C, G-342D and G-406) to better understand the spatial distribution of flows and TP loads that exist within the C-139 Basin.

5.1.1. District Control Structures

Currently all runoff leaving the C-139 Basin is monitored by the District at the following major water control structures:

- G-135
- G-136
- G-342A
- G-342B
- G-342C
- G-342D
- G-406

At each of these structures the volume of runoff passing through the structure is calculated using headwater and tailwater stage measurements in combination with a flow-rating curve computation. At G-135 this computation is provided only on a daily timestep, since the gate opening is performed manually. These calculated flow measurements are combined with water quality measurements from auto-samplers or manual grab samples to compute the TP load at each location. The location of the District water control structures described above along with the subwatershed delineation described in CN040912-WO07 Task 4.4 is illustrated below in **Figure 5.1**.

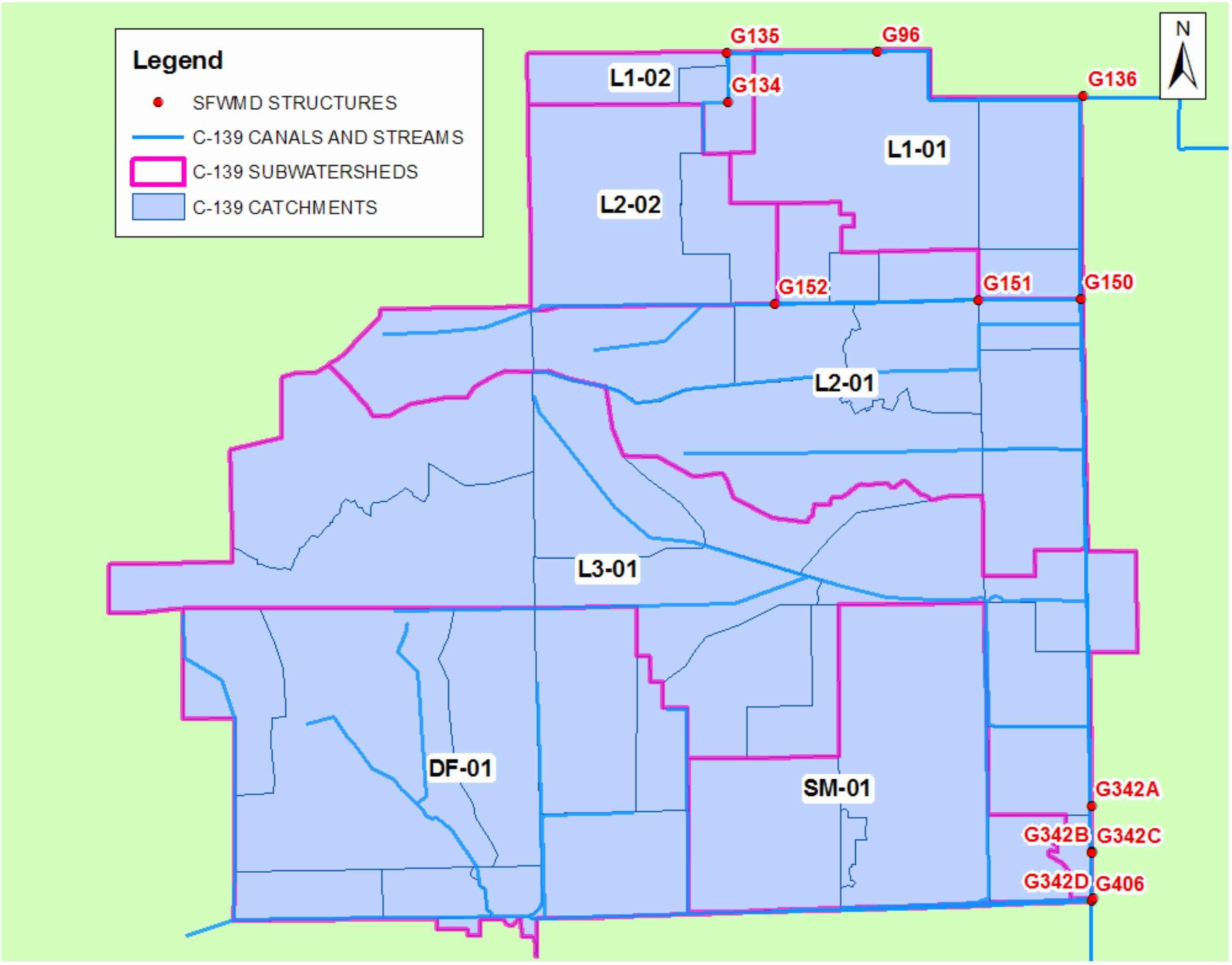

Figure 5.1: C-139 Subwatersheds and SFWMD Water Control Structures

5.1.2. Existing Monitoring Stations

Monitoring was initiated at three new permanent monitoring stations that were installed by the Everglades Regulation Division of District in 2005 to monitor subwatershed flows and loads within the C-139 Basin. The new installations at these locations include side-looking Doppler velocity measurement and water quality auto-sampler instrumentation that records in-channel measurements from a wooden platform. For the purposes of this technical memorandum these locations are: MS-L1-01-1, MS-SM-01-1 and MS-DF-01-1. The locations of these monitoring stations are illustrated in **Figure 5.2**.

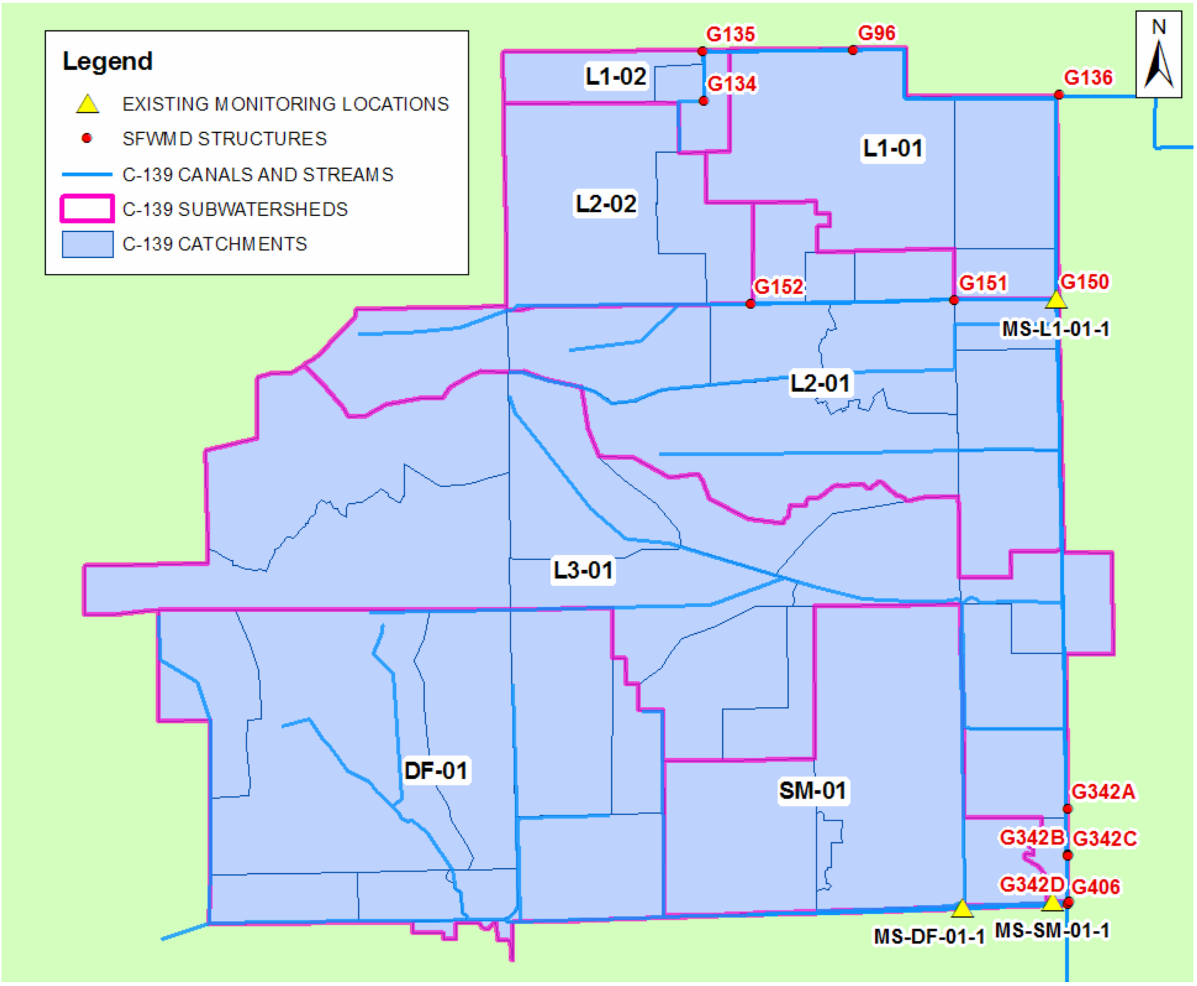

Figure 5.2: Location of Existing Water Quantity and Quality Monitoring Locations

The monitoring station MS-L1-01-1 measures the quantity and quality of water that passes through the G-150 structure. Historically, on-site stage telemetry provided flow measurements via a rating curve for the G-150 structure. The MS-L1-01-1 monitoring station provides water quality information and actual flow measurements which can be correlated to structure flow calculations. Under normal operations the G-150 structure remains closed and acts as a divide within the C-139 Basin between the L-1 and L-2 canal. The monitoring station MS-SM-01-1 was installed on private property along the S&M Canal and measures the quantity and quality of runoff from the SM-01 subwatershed. The monitoring station MS-DF-01-1 was installed on private property along the Deer Fence Canal and measures the quantity and quality of runoff from the DF-01 and DF-02 subwatersheds.

5.2 Monitoring Location Alternatives

5.2.1. Description

As described in Section 5.1, the District currently measures the water quality and quantity of runoff leaving the C-139 Basin. This information can be used to determine the TP load contributed by the C-139 Basin to external watersheds. However, it does not provide any description of the spatial distribution of TP loads within the C-139 Basin. Although the analysis provided within Sections 2.0, 3.0 and 4.0 describes an estimate of the distribution of potential TP load, the only method for determining the actual water quality within the C-139 Basin is through a permanent monitoring plan.

A water quality monitoring plan can be used to describe the effects of several different hydrologic and anthropomorphic factors on basin runoff. In the following sections, two conceptual monitoring scenarios are presented focusing on two different objectives. Each of these monitoring plans serves to provide a discussion point for examining the hydrology of the watershed. The final proposed monitoring plan, discussed below in Section 5.3, presents four monitoring locations to be installed as soon as practicable. This final monitoring plan addresses both objectives.

For the purposes of this report, the naming convention for proposed monitoring locations will be based on the subwatershed and increase in number with distance from the subwatershed outlet. For example the third monitoring station upstream of the basin outlet within the L2-01 subwatershed will be named MS-L2-01-3.

5.2.2. Scenario 1 – Monitor the Runoff from Each Identified Subwatershed

Since each subwatershed represents a geographic area that shares the same discharge location, one method for monitoring the spatial distribution of TP loads would be to locate a monitoring station at the outfall for each subwatershed. As described in Section 4.0 above, there are 8 subwatersheds within the C-139 Basin. Due to the locations of the existing District structures and monitoring stations only 4 additional monitoring stations would be required to monitor the runoff and TP loads from all 8 subwatersheds. The location of these 4 proposed monitoring stations is shown in **Figure 5.3**. **Tables 5.1** and **5.2** describe the upstream and incremental area monitored at each of the existing and proposed locations, as well as the connectivity between the proposed locations and other monitoring sites and catchments upstream.

Both **Tables 5.1** and **5.2** list the total upstream area and incremental upstream area for each monitoring location. The incremental upstream area is defined as the area upstream of the monitoring location that is not monitored by any of the other proposed or existing locations. **Table 5.1** describes which of the existing and proposed monitoring locations are upstream of other monitoring location. **Table 5.2** describes which of the catchments, as described in Section 4.1, are both upstream of the proposed or existing location and within the incremental upstream area not monitored by any other locations. In order to determine the spatial distribution of TP loads within the C-139 Basin, the load monitored at MS-DF-02-1 will need to be subtracted from the load monitored at MS-DF-01-1 in order to determine the TP load from the DF-01 subwatershed. As such, the relationships defined in **Tables 5.1** and **5.2** are important for analysis purposes.

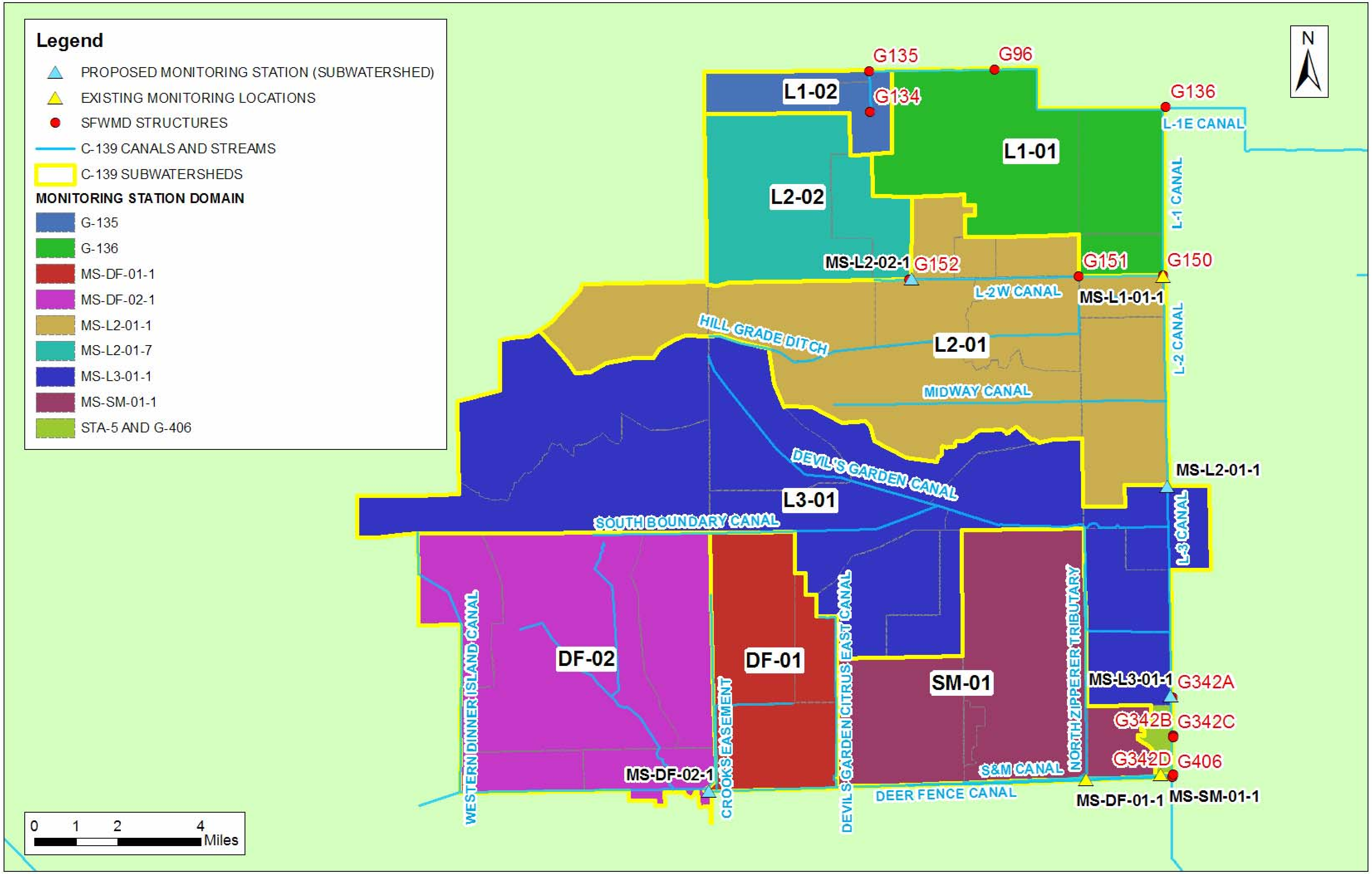

Figure 5.3: Proposed Monitoring Locations Defined for the Subwatershed Monitoring Alternative

Table 5.1: Characteristics and Connectivity of the Monitoring Locations Defined for the Subwatershed Monitoring Alternative

MONITORING LOCATION	STATUS	UPSTREAM MONITORING LOCATION(S)	TOTAL UPSTREAM AREA [AC]	INCREMENTAL UPSTREAM AREA [AC]
G-135	EXISTING		3,607	3,607
G-136	EXISTING		15,506	15,506
MS-DF-01-1	EXISTING	MS-DF-02-1	36,971	11,054
MS-DF-02-1	PROPOSED		25,917	25,917
MS-L2-01-1	PROPOSED	MS-L2-02-1	44,726	33,442
MS-L2-02-1	PROPOSED		11,284	11,284
MS-L3-01-1	PROPOSED	MS-L2-01-1, MS-L2-02-1	93,116	48,391
MS-SM-01-1	EXISTING		19,176	19,176
STA-5 AND G-406	EXISTING	MS-DF-01-1, MS-DF-02-1, MS-SM-01-1, MS-L3-01-1, MS-L2-01-1, MS-L2-02-1	149,838	48,966
TOTAL				168,952

Table 5.2: Upstream Catchments of the Monitoring Locations Defined for the Subwatershed Monitoring Alternative

MONITORING LOCATION	STATUS	CONTRIBUTING CATCHMENTS TO BE MONITORED BY LOCATION	TOTAL UPSTREAM AREA [AC]	INCREMENTAL UPSTREAM AREA [AC]
G-135	EXISTING	L1-02-01, L1-02-02	3,607	3,607
G-136	EXISTING	L1-01-01, L1-01-02, L1-01-03	15,506	15,506
MS-DF-01-1	EXISTING	DF-01-01, DF-01-02, DF-01-03	36,971	11,054
MS-DF-02-1	PROPOSED	DF-02-01, DF-02-02, DF-02-03, DF-02-04, DF-02-05, DF-02-06, DF-02-07	25,917	25,917
MS-L2-01-1	PROPOSED	L2-01-01, L2-01-02, L2-01-03, L2-01-04, L2-01-05, L2-01-06, L2-01-07, L2-01-08, L2-01-09, L2-01-10, L2-01-11	44,726	33,442
MS-L2-02-1	PROPOSED	L2-02-01, L2-02-02	11,284	11,284
MS-L3-01-1	PROPOSED	L3-01-02, L3-01-03, L3-01-04, L3-01-05, L3-01-06, L3-01-07, L3-01-08, L3-01-09, L3-01-10, L3-01-11, L3-01-12	93,116	48,391
MS-SM-01-1	EXISTING	SM-01-01, SM-01-02, SM-01-03, SM-01-04	19,176	19,176
STA-5 AND G-406	EXISTING	L3-01-01	149,838	575
TOTAL				168,952

5.2.2 Scenario 2 – Reduce Potential Access Concerns

One significant concern with respect to the location of permanent monitoring stations is accessibility. The District maintains access to rights-of-way alongside all District canals within the C-139 Basin (the L-1, L-2, L-2W, L-3 and a portion of the Deer Fence Canals). If the optimal location for a monitoring station is not within these rights-of-way, it will be necessary for the District to obtain an agreement with the private landowner or public agency who maintains rights to the land before constructing the monitoring location on their land. Because acquiring agreements with private landowners to locate monitoring stations can be difficult this alternative presents five potential monitoring locations which are within the District right-of-way. Although, the two previous alternatives present six locations, only five locations would be effective under the assumption that all of the locations are required to be located within District right-of-way.

Figure 5.4 illustrates the location of the five proposed monitoring locations that reduce potential access concerns. Since all of the monitoring locations within this alternative are within the right-of-way the spatial distribution of the upstream area cannot be as proportional as the first two alternatives. For the five proposed monitoring location there is a range in incremental upstream area to be monitored from 2,351 acres to 35,650 acres.

Tables 5.3 and **5.4** describe the characteristics for each of the existing and proposed monitoring locations. **Table 5.3** describes which of the existing and proposed monitoring locations are upstream of other monitoring locations. **Table 5.4** describes which of the catchments, as described in Section 4.1, are both upstream of the proposed or existing location and within the incremental upstream area not monitored by any other locations.

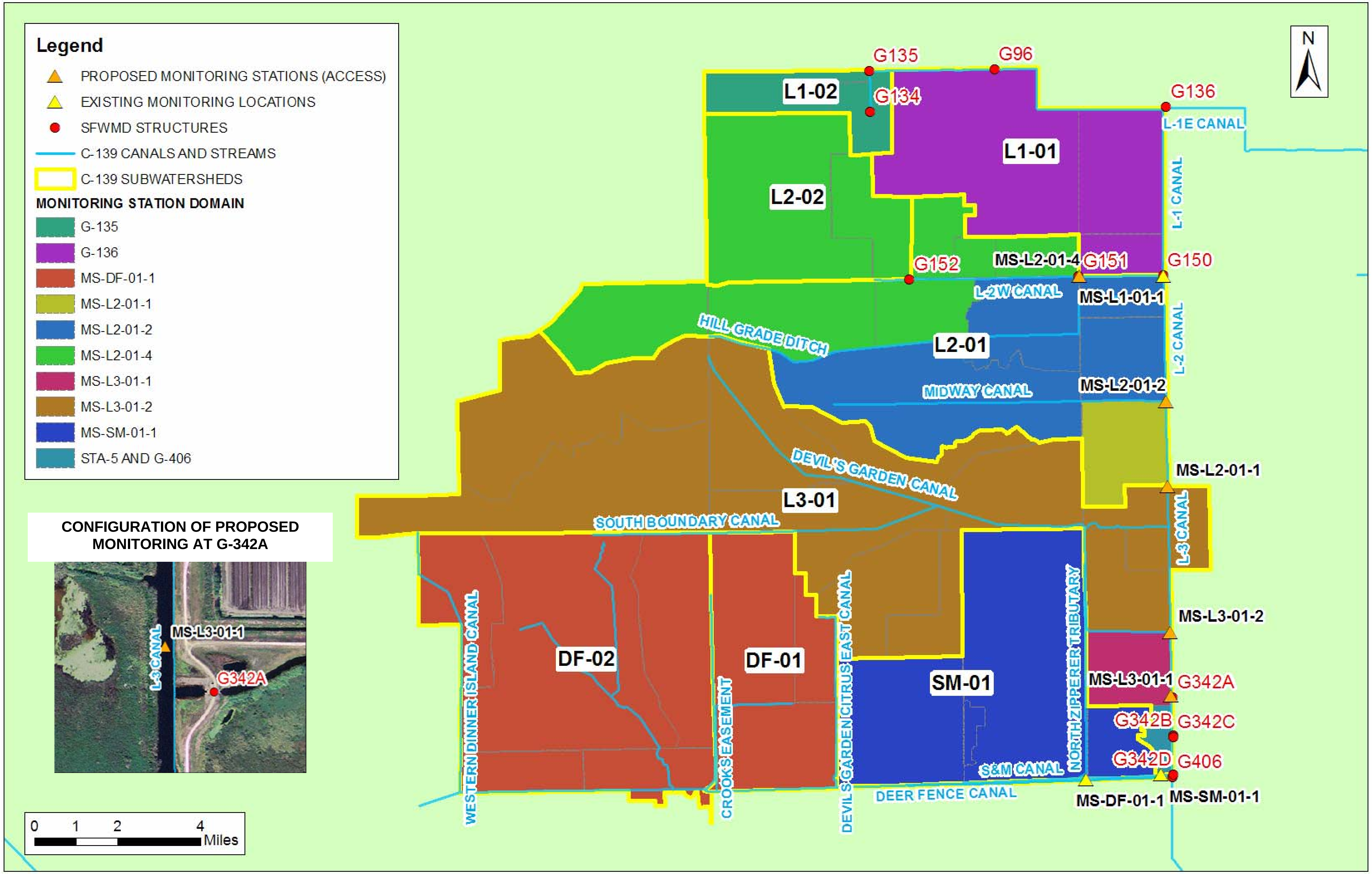

Figure 5.4: Proposed Monitoring Locations Assuming the Reduction of Potential Access Concerns Objective

Table 5.3: Characteristics and Connectivity of the Monitoring Locations Assuming the Reduction of Potential Access Concerns

MONITORING LOCATION	STATUS	UPSTREAM MONITORING LOCATION(S)	TOTAL UPSTREAM AREA [AC]	INCREMENTAL UPSTREAM AREA [AC]
G-135	EXISTING		3,607	3,607
G-136	EXISTING		15,506	15,506
MS-DF-01-1	EXISTING		36,971	36,971
MS-L2-01-1	PROPOSED	MS-L2-01-2, MS-L2-01-3	44,726	3,038
MS-L2-01-2	PROPOSED	MS-L2-01-3	41,688	16,550
MS-L2-01-4	PROPOSED		25,139	25,139
MS-L3-01-1	PROPOSED	MS-L3-01-2, MS-L2-01-1, MS-L2-01-2, MS-L2-01-3	93,116	2,351
MS-L3-01-2	PROPOSED	MS-L2-01-1, MS-L2-01-2, MS-L2-01-3	90,766	46,040
MS-SM-01-1	EXISTING		19,176	19,176
STA-5 AND G-406	EXISTING	MS-DF-01-1, MS-SM-01-1, MS-L3-01-1, MS-L3-01-2, MS-L2-01-1, MS-L2-01-2, MS-L2-01-3	149,838	575
TOTAL				168,952

Table 5.4: Upstream Catchments of the Proposed Monitoring Locations Assuming the Reduction of Potential Access Concerns

MONITORING LOCATION	STATUS	CONTRIBUTING CATCHMENTS TO BE MONITORED BY LOCATION	TOTAL UPSTREAM AREA [AC]	INCREMENTAL UPSTREAM AREA [AC]
G-135	EXISTING	L1-02-01, L1-02-02	3,607	3,607
G-136	EXISTING	L1-01-01, L1-01-02, L1-01-03	15,506	15,506
MS-DF-01-1	EXISTING	DF-01-01, DF-01-02, DF-01-03, DF-02-01, DF-02-02, DF-02-03, DF-02-04, DF-02-05, DF-02-06, DF-02-07	36,971	36,971
MS-L2-01-1	PROPOSED	L2-01-01	44,726	3,038
MS-L2-01-2	PROPOSED	L2-01-02, L2-01-03, L2-01-05, L2-01-06	41,688	16,550
MS-L2-01-4	PROPOSED	L2-01-04, L2-01-07, L2-01-08, L2-01-09, L2-01-10, L2-01-11, L2-02-01, L2-02-02	25,139	25,139
MS-L3-01-1	PROPOSED	L3-01-02	93,116	2,351
MS-L3-01-2	PROPOSED	L3-01-03, L3-01-04, L3-01-05, L3-01-06, L3-01-07, L3-01-08, L3-01-09, L3-01-10, L3-01-11, L3-01-12	90,766	46,040
MS-SM-01-1	EXISTING	SM-01-01, SM-01-02, SM-01-03, SM-01-04	19,176	19,176
STA-5 AND G-406	EXISTING	L3-01-01	149,838	575
TOTAL				168,952

5.2.3. Recommended Monitoring Locations

The four proposed monitoring stations recommended for installation are based on the consideration of both scenarios above as well as discussion with staff from the Everglades Regulation Division of District.

The four locations recommended for the installation of monitoring stations are MS-L2-01-1, MS-L2-01-4, MS-L3-01-1 and MS-DF-02-1. In order to identify the locations of the proposed monitoring locations, **Table 5.5** relates the monitoring locations to the District naming convention. **Figures 5.5, 5.6, 5.7** and **5.8** demonstrate the location of these proposed monitoring sites with respect to the surrounding landscape. **Figure 5.9** illustrates the location of these three stations with respect to the C-139 Basin, as well as the extent of the upstream area to be monitored by each of the existing and proposed monitoring locations.

Table 5.5: District Naming Conventions and Location for the Recommended Primary Stations

PROPOSED LOCATION	DISTRICT NAMING CONVENTION	LATITUDE	LONGITUDE
MS-DF-02-1	DF11.3TW01	26° 25.71’	-81° 7.64’
MS-L2-01-1	L207.0TN	26° 32.12’	-80° 56.91’
MS-L2-01-4	G-151	26° 36.52’	-80° 58.96’
MS-L3-01-1	L202.0TN	26° 27.71’	-80° 56.84’

Figure 5.5: Aerial of Proposed Location MS-L2-01-1

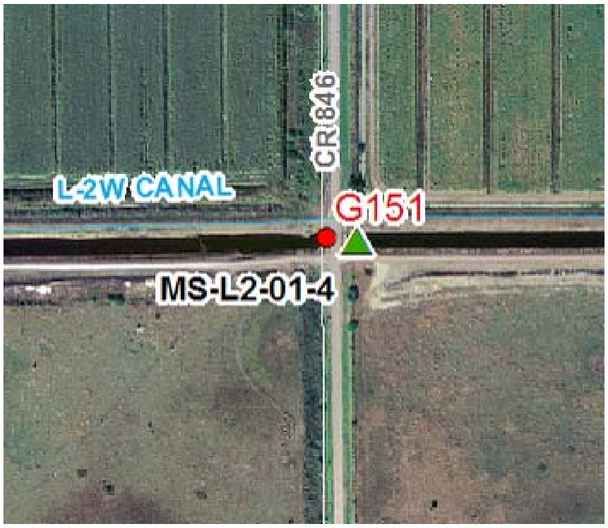

Figure 5.6: Aerial of Proposed Location MS-L2-01-4

Figure 5.7: Aerial of Proposed Location MS-DF-02-1

Figure 5.8: Aerial of Proposed Location MS-L3-01-1

Each of these four proposed locations will provide measurements that accomplish several objectives. MS-L2-01-1 is positioned to monitor the runoff volume and TP load that results from all of the hydrologic subwatersheds within the L2-01 and L2-02 subwatersheds. These subwatersheds represent 26% of the total area of the C-139 Basin. Additionally the proposed location allows the monitored results from location MS-L2-01-1 to be subtracted from the measurements at proposed location MS-L3-01-1 to determine the volume of runoff in the L3-01 subwatershed, which represents 29% of the total area of the C-139 Basin. The proposed location of MS-L2-01-4 is at the District G-151 structure. This location allows for examining the contribution of runoff and TP load from subwatershed L2-02 (which is 78% low density residential and 22% reservoir). Additionally, if stage telemetry is the monitoring methodology chosen at MS-L2-01-4, then the District will be able to provide stage telemetry at this location in perpetuity. The fourth proposed location, MS-DF-02-1, will provide runoff volume and TP load monitoring of the DF-02 subwatershed. Additionally, by subtracting these measurements from the existing MS-DF-01-1 station the District will be able to isolate the runoff volume and TP load generated by the DF-01 subwatershed. As is illustrated in **Figures 5.4, 5.5, 5.6** and **5.7**, each proposed monitoring location presents different physical characteristics which allow for different monitoring techniques. The preferred monitoring methodologies will be described in following section of this document.

Tables 5.6 and **5.7** describe the characteristics for each of the existing and proposed monitoring locations. **Table 5.6** describes which of the existing and proposed monitoring locations are upstream of other monitoring locations. **Table 5.7** describes which of the catchments, as described in Section 4.1, are both upstream of the proposed or existing location and within the incremental upstream area not monitored by any other locations.

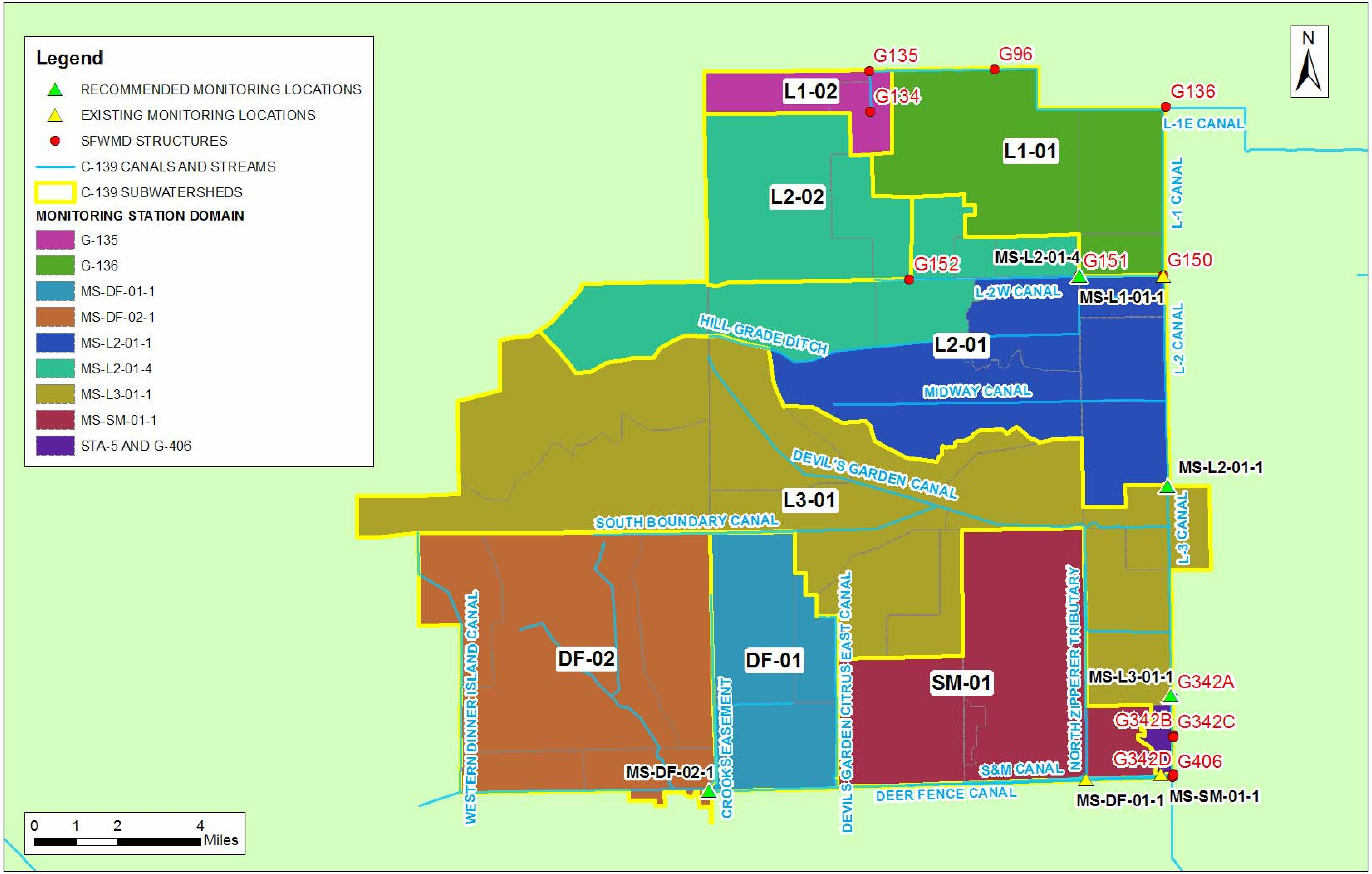

Figure 5.9: Recommended Monitoring Locations

Table 5.6: Characteristics and Connectivity of the Recommended Monitoring Locations

MONITORING LOCATION	STATUS	UPSTREAM MONITORING LOCATION(S)	TOTAL UPSTREAM AREA [AC]	INCREMENTAL UPSTREAM AREA [AC]
G-135	EXISTING		3,607	3,607
G-136	EXISTING		15,506	15,506
MS-DF-01-1	EXISTING	MS-DF-02-1	36,971	11,054
MS-DF-02-1	PROPOSED		25,917	25,917
MS-L2-01-1	PROPOSED	MS-L2-01-4	44,726	19,588
MS-L2-01-4	PROPOSED		25,139	25,139
MS-L3-01-1	PROPOSED	MS-L2-01-4, MS-L2-01-1	93,116	48,391
MS-SM-01-1	EXISTING		19,176	19,176
STA-5 AND G-406	EXISTING	MS-DF-01-1, MS-DF-02-1, MS-SM-01-1, MS-L2-01-1, MS-L2-01-4	149,838	575
TOTAL				168,952

Table 5.7: Upstream Catchments of the Recommended Monitoring Locations

MONITORING LOCATION	STATUS	CONTRIBUTING CATCHMENTS TO BE MONITORED BY LOCATION	TOTAL UPSTREAM AREA [AC]	INCREMENTAL UPSTREAM AREA [AC]
G-135	EXISTING	L1-02-01, L1-02-02	3,607	3,607
G-136	EXISTING	L1-01-01, L1-01-02, L1-01-03	15,506	15,506
MS-DF-01-1	EXISTING	DF-01-01, DF-01-02, DF-01-03	36,971	11,054
MS-DF-02-1	PROPOSED	DF-02-01, DF-02-02, DF-02-03, DF-02-04, DF-02-05, DF-02-06, DF-02-07	25,917	25,917
MS-L2-01-1	PROPOSED	L2-01-01, L2-01-02, L2-01-03, L2-01-05, L2-01-06	44,726	19,588
MS-L2-01-4	PROPOSED	L2-01-04, L2-01-07, L2-01-08, L2-01-09, L2-01-10, L2-01-11, L2-02-01, L2-02-02	25,139	25,139
MS-L3-01-1	PROPOSED	L3-01-02, L3-01-03, L3-01-04, L3-01-05, L3-01-06, L3-01-07, L3-01-08, L3-01-09, L3-01-10, L3-01-11, L3-01-12	93,116	48,391
MS-SM-01-1	EXISTING	SM-01-01, SM-01-02, SM-01-03, SM-01-04	19,176	19,176
STA-5 AND G-406	EXISTING	L3-01-01	149,838	575
TOTAL				168,952

5.3 Monitoring Methodology and Cost Estimate

5.3.1 Monitoring Methodology

Each monitoring location requires an examination of feasible monitoring methodology. The method for monitoring water quantity and quality at each location takes into account the geometry of the channel, cost and access concerns.

5.3.2 Runoff Monitoring

With respect to water quantity monitoring there are two main options for measurement method. The first option is a side-looking Doppler device. Since Doppler devices monitor only the velocity of the particulates in the water column, the proposed location should have a fairly uniform cross-section with surveyed bathymetry. The flow rate is then calculated by multiplying the average velocity of particulate matter passing the station by the cross-section of the channel at that location. The second option for flow measurement is by stage monitoring. In a location where the cross-section is constant, such as a box-culvert, the flow rate can be calculated by monitoring the stages on the upstream and downstream sides of the structure. The flow rate is then calculated using a rating curve developed for that structure based on the structure geometry and the head difference between the upstream and downstream stages.

5.3.3 Water Quality Monitoring

With respect to water quality monitoring there are two main options for measurement method. The first option is an auto-sampler. The auto-sampler can collect water samples based on time-intervals between samples or flow rate within the channel. When the auto sampler is co-located with a side-looking Doppler flow measurement device, the auto sampler will collect water quality samples only during runoff events. However if an auto-sampler is co-located with stage monitoring equipment, then the water quality samples must be taken at a specified time interval. This method requires additional data post-processing. The second method for collecting water quality samples is via a manual grab sampling plan. This method would require a District staff member or contractor to measure the water quality at a specified time interval, such as weekly or bi-weekly. The manual grab sampling plan does not guarantee that the water quality measurements will coincide with high-runoff events. Based on the alternatives available for water quantity and quality monitoring **Table 5.8** describes the following recommendations for the monitoring locations.

Table 5.8: Monitoring Methodology for the Recommended Primary and Secondary Monitoring Locations

PROPOSED LOCATION	DISTRICT NAMING CONVENTION	WATER QUANTITY MEASUREMENT	WATER QUALITY MEASUREMENT
MS-DF-02-1	DF11.3TW01	DOPPLER	AUTO-SAMPLER
MS-L2-01-1	L207.0TN	DOPPLER	AUTO-SAMPLER
MS-L2-01-4	G-151	STAGE TELEMETRY	AUTO-SAMPLER
MS-L3-01-1	L202.0TN	DOPPLER	AUTO-SAMPLER

5.3.4 Monitoring Methodology

The total cost of a monitoring location incorporates several components including:

- Water quantity monitoring equipment (stage recorder(s) and side-looking Doppler device),
- Water quality monitoring equipment (water quality auto-sampler),
- Monitoring infrastructure (catwalk construction, stilling well, auto-sampler platform, shelter, solar panel, associated conduit, trenching and conduit burial, mounting brackets and other hardware),
- Streamgaging and Calibration (developing the flow rating curves and calibration of the Doppler, survey of the canal cross-section or culvert where the monitoring site is located and QA/QC analysis),
- Water Quality Sampling and Analysis (lab analysis, data processing and upload to DBHYDRO), and
- Annual Operation & Maintenance (telemetry and sensor maintenance).

Since the recommended stations have two monitoring configurations, a planning level cost estimate is developed for each configuration. There are two Everglades Regulatory Program documents available from District for reference with respect to the planning level cost estimate: the BMP Source Control Monitoring Request FY06 titled, Critical FY06 "New" Projects – Planned Needs and the BMP Source Control Monitoring document C139 Annex Pump Station – Monitoring Proposal & Cost Estimates. The first document describes the costs of set-up, calibration and annual operation and maintenance for a generic water quantity monitoring site with a water quality auto-sampler installed.

For the purposes of this planning level cost estimate, it is assumed that the costs outlined in the first document (Request FY06 "New" Projects) are representative of the costs associated with the installation of a side-looking Doppler flow monitoring site. The second document outlines the costs of set-up, calibration, annual operation and maintenance and life-cycle replacement for a stage and water quality monitoring station at the C-139 Annex pump station. **Table 5.9** describes the itemized and total cost for each monitoring methodology based on this documentation.

Table 5.9: Planning Level Cost-Estimate for Installation, Calibration and Maintenance of Proposed Monitoring Locations

MONITORING LOCATION COMPONENTS	SIDE-LOOKING DOPPLER	STAGE TELEMETRY
Flow Monitoring Equipment (with installation)	$ 16,500	$ 25,000
Water Quality Monitoring Equipment (with installation)	$ 3,500	$ 3,500
Monitoring Infrastructure	$ 25,000	$ 50,000
Streamgaging and Calibration	$ 26,960	$ 23,500
Water Quality Analysis	$ 7,766	$ 8,230
Ongoing Operations & Maintenance	$ 1,666	$ 4,230
Total	$ 81,392	$ 114,460
Reference	Request FY06 “New” Projects	C139 Annex Pump Station

The subtotal costs associated with the water quantity and quality equipment and infrastructure match the documented subtotal costs of $45,000 for the side-looking Doppler and $78,500 for the stage telemetry from the BMP Source Control Monitoring documents.

In order to verify the planning level cost estimate for the side-looking Doppler station, ADA contacted staff from the Lee County East County Water Control District (ECWCD) where a Doppler-based flow monitoring station was installed. The ECWCD Doppler-based flow monitoring station cost $38,000 to construct, calibrate and maintain. Because the technical specifications of the ECWCD are significantly different than the technical specifications of the District, the ECWCD cost is assumed to be a low estimate of total cost.

The cost of streamgaging and calibration for each monitoring methodology is based on an estimate of 10 calibration measurements of approximately $2,000 each. In the case of multiple monitoring sites the mobilization costs are reduced and the cost per station can be decreased significantly.

The difference in cost between stage telemetry and Doppler-based flow monitoring is largely based on the difference in infrastructure costs. A stage telemetry location requires the construction of a wooden catwalk and platform at the upstream and downstream side of the monitored culvert. In addition to larger costs, a stage telemetry monitoring location is a less accurate method for calculating flows within the channel. The advantage of stage telemetry at the G-151 structure is that the resulting data will be consistent with other structure data throughout the District.

6.0 REFERENCES

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